BNSF Railway Company

2023 Operation and Maintenance Manual Update for the Hydraulic Control and Containment System

Former Maintenance and Fueling Facility

Skykomish, Washington

April 14, 2023

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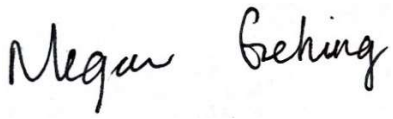

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Appendix A. 2011 O&M Manual

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Acronyms and Abbreviations

µg/L	micrograms per liter
Arcadis	Arcadis U.S., Inc.
BNSF	BNSF Railway Company
DMRs	Discharge Monitoring Reports
Ecology	Washington State Department of Ecology
GAC	granular activated carbon
GPM	gallons per minute
HCC	Hydraulic Control and Containment
LNAPL	light nonaqueous-phase liquid
NPDES	National Pollution Discharge Elimination System
NWTPH-Dx	total petroleum hydrocarbon concentrations, diesel-range organics and oil-range organics
O&M	Operations & Maintenance
OWS	oil-water separator
PLC	Programmable Logic Controller
RL	Remediation Level

1 Introduction

On behalf of BNSF Railway Company (BNSF), Arcadis U.S., Inc. (Arcadis) has prepared this 2023 Operation and Maintenance Manual Update for the Hydraulic Control and Containment (HCC) System at the BNSF Former Maintenance and Fueling Facility located within the Town of Skykomish, Washington (Site) (Facility/Site ID No.: 2104, Cleanup Site ID No.: 34).

This document discusses operation and maintenance (O&M) of the HCC system while in passive mode (no active pumping or NPDES discharge). Operation of the HCC system in active pumping mode, including the Treatment System Operating Plan, is discussed in the previous O&M Manuals (AECOM 2011 and Farallon 2014), which are included as Appendices A and B, respectively. This manual update is being submitted to the Washington State Department of Ecology (Ecology) pursuant to National Pollution Discharge Elimination System (NPDES) Permit No. WA0032123, Section S4.A, which requires submittal of an updated O&M manual by April 15, 2023.

This HCC System O&M Manual update presents the plan for passive HCC operation as approved by Ecology and measures to be undertaken to ensure that the water treatment system can be restarted in a timely manner if needed. This document also provides updates to the HCC System Groundwater Performance Monitoring Plan based on groundwater performance monitoring results since the time that the plan was developed in 2011. These activities are part of a cleanup action being undertaken by BNSF in accordance with Consent Decree No. 07-2-33672-9 SEA (Fourth Amendment). The overall cleanup approach for the Site is described in the Master Engineering Design Report (RETEC Group, Inc. 2008). Long-term performance and compliance monitoring for the Site is provided in the Final Long-Term Monitoring Plan (Farallon 2020).

2 HCC System

2.1 Overview

The HCC system was constructed in 2009, as documented in the 2009 Remediation – As-Built Completion Report (AECOM 2009). The primary objectives of the HCC system are to contain light non aqueous phase liquid (LNAPL) and to ensure that groundwater meets the appropriate remediation level (477 micrograms per liter [µg/L]) for diesel- and oil-range petroleum hydrocarbons as it leaves the BNSF property.

The HCC system consists of the following components, as shown on Figure 1:

- A 1,183-foot-long sheet pile wall barrier and interception trench with four flow-through treatment gates, which each contain an oil-water separator (OWS) and a mixture of granular activated carbon (GAC) and pea gravel media.
- Nine groundwater extraction/LNAPL recovery wells (RW-1 through RW-9).
- Eleven HCC system monitoring wells (gate wells GW-1 through GW-4; end wells EW-1 and EW-2A; and downgradient monitoring wells 5-W-43, 2A-W-40, 2A-W-41, 1B-W-23, and 2A-W-42).
- Fourteen piezometers (PZ-1, PZ-2N, PZ-2S, PZ-3N, PZ-3S, PZ-4N, PZ-4S, PZ-5N, PZ-5S, PZ-6N, PZ-6S, PZ-7N, PZ-7S, PZ-8).

- Twenty HCC system sentry wells (see Table 1).
- Two inactive groundwater injection wells (IW-1 and IW-2).
- A water treatment system, which includes aboveground and underground water conveyance piping, an OWS, a hydrogen peroxide disinfectant system, sand filters, GAC vessels, a pH adjustment system, and influent and effluent water storage tanks.
- A computer-based programmable logic controller (PLC) that collects system operational data and is used to monitor, control, and adjust system operating parameters.

2.2 Previous HCC System Operations

The groundwater injection wells (IW01 and IW-2) were used intermittently in 2009 and 2010 to inject treated groundwater into the BNSF railyard subsurface. In September 2010, the discharge of treated groundwater to the injection wells was stopped, and the discharge at one of the injection wells was rerouted to an up-gradient OWS chamber in the East Gate of the barrier wall. The discharge of treated groundwater to the East Gate OWS chamber was discontinued at the end of 2012. Since the end of 2012, all groundwater treated by the HCC system has been discharged to the municipal storm system (pursuant to NPDES Permit No. WA0032123), which discharges to the Skykomish River (Farallon 2023).

Operations of the HCC are documented in annual reports that are submitted to Ecology. The most recent HCC annual report dated March 23, 2023 documented the extraction and treatment of 8.47 million gallons of groundwater in 2022 from recovery wells RW-02, RW-03, RW-04, RW-06, RW-07, and RW-08. Daily average flow rates ranged from 1 gallon per minute (GPM) to 32 GPM, with an annual average flow rate of approximately 19.5 GPM. Approximately 52 gallons of LNAPL were recovered by the recovery well oil skimmers in RW-07 and RW-08 in 2022. No LNAPL was recovered by the belt skimmer at recovery well RW-04 in 2022

Since system startup in 2009 through the end of 2022, 151,834,735 gallons of groundwater were treated and discharged in accordance with NPDES Permit No WA 0032123 requirements (Farallon 2023).

2.3 HCC System Passive Operation Pilot Study

A pilot test was conducted from January 19, 2019 through December 31, 2020 to evaluate operation of the HCC system without active pumping. The pilot test consisted of turning the extraction pumps and water treatment system off and allowing groundwater to flow passively through the HCC system gates.

Key findings from the Passive Operation Pilot Testing are summarized below (Farallon 2018).

- Groundwater flow through the Center Gate is restricted due to biofouling. The total groundwater flow rate through all three vaults of the Center Gate was estimated to be approximately 1 GPM or less under both pumping and no-pumping conditions.
- Most of the groundwater that flows through the HCC barrier wall treatment gates passes through the West Gate.
- Estimated total groundwater flow rates through the two vaults (east and west) of the West Gate during the Phase I pilot test (low-water conditions) were on the order of 10 to 13 GPM under both pumping and no-pumping conditions. The total pumping rate from recovery wells during the pumping portion of the Phase I pilot test was approximately 40 GPM.

- Estimated total groundwater flow rates through the two vaults of the West Gate during the Phase II pilot test (high-water conditions) ranged from 38 GPM under no-pumping conditions to 0 GPM under pumping conditions. The total pumping rate from recovery wells during the pumping portion of the Phase II pilot test was approximately 80 GPM (the HCC system's maximum attainable pumping rate), which was sufficiently high to reverse the hydraulic gradient across the West Gate during the pilot test.
- Under normal HCC pumping conditions (i.e., 20 to 30 GPM total pumping rate), the estimated groundwater flow rate through the east vault of the West Gate, averaged across low- and high-water conditions, is approximately 6 GPM. Under no-pumping conditions, the estimated groundwater flow rate through the east vault of the West Gate, averaged across low- and high-water conditions, is approximately 7.5 GPM.
- The groundwater flow through the West Gate that occurs under normal HCC conditions and no-pumping conditions prevents LNAPL and groundwater with total petroleum hydrocarbon concentrations exceeding the Site-specific remediation level (RL) of 477 µg/L from migrating west beyond the West Gate.
- Total petroleum hydrocarbon concentrations ranging from 520 to 1,130 µg/L were detected in three groundwater samples collected from the OWS chamber of the east vault of the West Gate between September 2014 and April 2015. In addition, trace amounts of LNAPL have been observed in the east vault OWS of the West Gate. Total petroleum hydrocarbon concentrations detected in three groundwater samples collected from the OWS chamber of the west vault of the West Gate were lower: 56 to 260 µg/L. These data indicate that only groundwater flowing in the east vault of the West Gate contains petroleum hydrocarbon concentrations exceeding the RL; petroleum hydrocarbon concentrations in groundwater flowing into the west vault of the West Gate do not exceed the RL.
- The OWS and GAC-filled treatment chambers of the West Gate prevent LNAPL and groundwater with total petroleum hydrocarbon concentrations exceeding the RL from migrating north through the West Gate.

Based on historical groundwater monitoring data and groundwater flux data from the previous pilot testing conducted at the West Gate, the minimum effective lifespan of the GAC installed in the east vault of the West Gate in September 2016 was estimated to be 5 years (Farallon 2018). The GAC media was most recently changed out in the west gate in Fourth Quarter of 2022. No GAC changeouts in the other gates are anticipated in the future based on groundwater performance monitoring data (Farallon 2018).

2.4 Barrier Wall and Passive Gates

2.4.1 Physical Barrier

The barrier wall and passive treatment gates will be the primary hydraulic control and treatment process while the HCC system operates in passive mode. The barrier is made of interlocking sheet piles and extends horizontally beyond the limits of impacted soil and vertically from the ground surface to the underlying silt layer, except where the silt layer does not exist in the vicinity of 5th Street. At this location, the barrier extends sufficiently deep to contain impacted groundwater. Where the silt layer is present, the barrier keys at least 2 feet into the silt layer.

2.4.2 Hydraulic Control and Containment Passive Flow through Gates

A series of four passive flow-through gates (East Gate, Center Gate, West Gate, Far West Gate) filled with a mixture of GAC and pea gravel media are installed along the barrier alignment to provide treatment of groundwater while the system is in passive mode. The location of the gates is shown on Figure 1.

The gate locations were selected to minimize petroleum loading to treatment systems within the gate by avoiding areas with free product and prevent flow underneath the wall in the vicinity of 5th Street, where the underlying silt layer is absent by minimizing hydraulic head build-up. Construction of the gates are summarized in Section 3.2 of the 2011 HCC O&M Manual (Appendix A).

While the HCC system is in passive mode, natural groundwater flow gradients will direct groundwater flow through the gates. LNAPL, if any, will accumulate upgradient of the underflow baffle and dissolved phase constituents will adsorb to the GAC media filling the gates. The gates extend to the same grades as the recovery wells. The gates were designed to have sufficient hydraulic conductivity (1 x 10^{-2} centimeters per second) to prevent significant groundwater mounding behind the low permeability barrier. However, as discussed in Section 2.4, subsequent monitoring has shown that the Center gate is biofouled and minimal amounts of groundwater (1 GPM or less) flow through the Center Gate.

2.5 LNAPL Removal

Nine recovery wells (RW-01 through RW-09) provide hydraulic control along the HCC barrier while in active pumping mode (Figure 1). Belt skimmers are installed in five recovery wells (RW-03, RW-04, RW-05, RW-07 and RW-08) to facilitate the removal of LNAPL. Approximately 52 gallons of LNAPL were recovered in 2023 from recovery wells RW-07 and RW-08. No LNAPL was recovered from the other belt skimmers. LNAPL thicknesses in the recovery wells and nearby monitoring points will continue to be monitored and the belt skimmers operated if recoverable LNAPL is present.

Each skimmer system is controlled by a local control panel that has a timer to control belt skimming operations, and an integral heater to decrease the viscosity of recovered product. Each LNAPL storage tank is fitted with a level gauge and a High-Level switch which shuts down the skimmer and triggers an alarm to the PLC panel (located inside the HCC treatment building) when the storage tank level is too high for the belt skimmer to continue to operate. Materials collected and stored in the storage tanks, if any, will be consolidated and stored in drums located on site pending off-site disposal at an appropriately licensed facility approved by BNSF.

3 Passive System O&M

3.1 Operations of Water Treatment System in Standby Mode

As discussed above, the water treatment system will not be operated during passive operations, except periodically for short durations (no discharge to outfall 003) to keep the system in a ready condition should future operations be warranted. The water treatment system and down-well pumps will be

operated in recirculation mode on a quarterly basis to confirm that the system is ready to restart if necessary. No groundwater will be treated or discharged to Outfall 003 in passive mode.

A process flow diagram of the water treatment system showing the modifications for operating the system in passive mode is shown in Figure 2. The following items will be performed to place the water treatment system in standby condition.

- All groundwater extraction pumps will be turned off. Down-well piping in the recovery wells will be reconfigured to allow for self-contained recirculation of well water, as shown on Figure 3.
- Belt skimmers in recovery wells RW-07 and RW-08 will continue to run, independent of the water treatment system. The belt skimmers in the other recovery wells will be turned off. The belt skimmers will be restarted if LNAPL gauging data indicate the presence of LNAPL that could potentially be recovered by the skimmers.
- Pumps associated with the water treatment system will be disabled by turning the hand-off-automatic switches to off.
- The T-04 backwash holding tank will be emptied and cleaned.
- The OWS will be emptied and cleaned.
- Tank T-05 will be emptied, cleaned, and refilled with potable water.
- Pump P-05 will be disconnected from the sand filter and GAC vessels and will be routed directly to Tank T-03.

3.2 Conditions for Restarting Groundwater Recovery and Water Treatment System

Groundwater monitoring data in 2022 indicate no exceedances of the 477 µg/L NWTPH-Dx RL in any of the HCC performance monitoring wells. In 2021, there were only exceedances of the RL in wells GW-3 (Center Gate) and 2A-W-41(Center/West Gates). In 2020, there was an RL exceedance in only well GW-3. Monitoring and testing have confirmed that the Center Gate is plugged due to biological fouling and minimal amounts of groundwater (1 GPM or less) flow through the Center Gate. Therefore, this plan focuses on measures to address potential exceedances of the RLs downstream of the West Gate (GW-2 and GW-1). The following actions will be taken if the RL is exceeded in wells GW-2 and/or GW-1.

1. Confirm result with the laboratory within 24-hours of being notified.
2. Notify Ecology within 24-hours of laboratory verification.
3. Resample affected well(s) within 72 hours of verification and place on expedited 72-hour turnaround.
4. Restart the water treatment system within 48 hours of receiving second confirmation sample result if result is above the RL. If the confirmation sample is below the RL then resume passive system operations.
5. If GAC breakthrough is confirmed, conduct GAC change-out in the treatment gates or otherwise investigate the cause of the exceedance.
6. If groundwater concentrations are below the RLs after resampling, then the water treatment system may be turned off and the system returned to passive operations.
7. Resume passive operations with concurrence from Ecology once the GAC is replaced or the cause of the exceedance has been addressed.

8. Resume sampling per the HCC System Performance Monitoring Plan (Table 1).

When operating the extraction pumps and water treatment system, O&M of the HCC system will be conducted in accordance with the 2011 O&M Manual (Appendix A) and 2014 updates to the 2011 O&M Manual (Appendix B).

3.3 Procedure to Restart Groundwater Recovery and Water Treatment System

The procedure for restarting the groundwater recovery and water treatment system is outlined in Section 7.0 of the 2011 HCC O&M Manual (Appendix A).

The following measures will be taken to maintain the groundwater extraction and water treatment system in a standby “ready” mode.

- The groundwater extraction pumps in the recovery wells will be restarted on a quarterly basis and operated for approximately 5 to 10 minutes. Water will be pumped through the flow meter to allow for flow rate readings and then recirculated back into the well (Figure 3).
- Potable water will be recirculated in closed loop fashion through the water treatment system GAC vessels for a minimum of 2 hours on a quarterly basis.
- One hydrogen peroxide tank (T-07) will be kept on site. Tank T-07 and associated pump P-08 will be activated during the quarterly recirculation process as needed.

3.4 NPDES Monitoring, Sampling, and Reporting Requirements

The HCC system water treatment system is operated under NPDES Permit No WA0032123 dated October 1, 2022. The NPDES permit authorizes BNSF to discharge treated groundwater (Outfall 003), to the South Fork of the Skykomish River. Effluent limits for outfall 003 are provided in Table 2. Monitored parameter and schedule information is presented in Table 3. Reporting requirements (including NPDES and other required reports for the Site) are summarized in Table 4.

4 LNAPL Removal and HCC System Groundwater Performance Monitoring

4.1 LNAPL Removal

Belt skimmers within recovery wells RW-07 and RW-08 will remain in service unless no recoverable product is present in these recovery wells (<1-inch). LNAPL collected in the belt skimmer storage tanks will no longer be discharged to the OWS located within the HCC treatment building. Recovered LNAPL will be containerized in 55-gallon drums and stored on site pending off-site disposal at an appropriately licensed facility approved by BNSF.

4.2 HCC System Groundwater Performance Monitoring

HCC system groundwater performance monitoring will be conducted to assess whether groundwater discharging from the railyard meets the RL of 477 µg/L for NWTPH-Dx and has an absence of sheen or measurable LNAPL. Additional Site-wide groundwater monitoring will be conducted in accordance with the Long-Term Monitoring Plan, which is not covered in this report.

The HCC System Performance Monitoring Plan is summarized in Table 1 and discussed below.

- **End Wells:** EW-1 and EW-2A, installed at each end of the HCC wall will be monitored semi-annually to evaluate whether groundwater flowing past the ends of the trench meet the RL of 477 µg/L. Groundwater monitoring in the end wells will consist of fluid level gauging, groundwater sampling using low flow purge method, and analytical testing using the NWTPH-Dx method.
- **Gate Wells:** Wells GW-1, GW-2, GW-3 and GW-4 installed downgradient of the gates will be monitored to evaluate whether NWTPH-Dx concentrations passing through the gates meet the RL of of 477 µg/L. Groundwater monitoring in the end wells will consist of fluid level gauging, groundwater sampling using low flow purge method, and analytical testing using the NWTPH-Dx method on a quarterly basis (GW-2 and GW-3) and semi-annual basis (GW-1 and GW-4).
- **Gate Sentry Wells:** Twenty wells installed in the reactive material in the gates will be monitored to evaluate reactive media performance over time. Groundwater monitoring in the Gate Sentry Wells will consist of fluid level gauging, groundwater sampling following a 15-minute purge, and analytical testing using the NWTPH-Dx Method. West Gate Sentry Wells (S2-AD, S2-AU, S2-BD, S2-BU [located near West Gate]) will be monitored on a quarterly basis; all other Gate Sentry Wells will be monitored on a semi-annual basis.
- **Piezometers:** Fourteen piezometers installed hydraulically up- and downgradient of the HCC wall will be monitored to assess the hydraulic gradient across the wall. Groundwater monitoring of the piezometers will consist of fluid level measurements on a quarterly basis for piezometers near the west gate (PZ-6N, PZ-6S, PZ-7N, PZ-7S) and semi-annual basis (all other piezometers).
- **Recovery Wells:** Ten recovery wells will be monitored. Wells will consist of fluid level measurements on a quarterly basis for recovery wells near the West Gate (RW-04, RW-05, RW-06, RW-07, and RW-08) and semi-annual basis (all other recovery wells).
- **Downgradient Monitoring Wells:** Five HCC system downgradient wells (5-W-43, 2A-W-40, 2A-W-41, 1B-W-23, and 2A-W-42) will be monitored on a quarterly basis (2A-W-40, near west gate) and semi-annual basis (all other downgradient wells). Monitoring of the HCC system downgradient wells will consist of fluid level gauging, groundwater sampling using low flow purge method, and analytical testing using the NWTPH-Dx method.
- **Barrier Wall Oil-Water Separator Chambers:** Twenty locations within the 10 OWS chamber vaults in the Gates will be monitored for fluid levels on a quarterly basis (OWS chambers near West Gate) and semi-annual basis (all other OWS chambers).

In addition to HCC groundwater performance monitoring, site-wide groundwater monitoring will be performed on a semi-annual basis in accordance with the Long-Term Monitoring Plan (Farallon 2020). The Long-Term Monitoring Plan is summarized in Table 1.

The HCC System Performance Monitoring Plan in this O&M Manual has been updated to include quarterly monitoring of wells and observation points near the West Gate and semi-annual monitoring of wells near the Far West, Central, and East Gates (Table 1). HCC system performance monitoring results will continue to be documented in annual HCC Monitoring Reports that will be submitted to Ecology by

the end of March of each year (e.g., data from January 1 through December 31 will be reported by March 31).

It is anticipated that the number of wells sampled, and frequency of sampling may be reduced as petroleum hydrocarbon concentrations further diminish over time. Ecology approved changes to the HCC System Groundwater Performance Monitoring Plan and/or Long-Term Monitoring Plan will be documented in future updates to this O&M Manual and Long-Term Monitoring Plan, as appropriate. Changes to the monitoring frequency, monitored locations, or monitored parameters will be implemented upon Ecology's written approval.

5 Maintenance and Troubleshooting

5.1 Groundwater Recovery and Water Treatment System Maintenance

Minimal maintenance will be required since the water treatment system will be turned off and no groundwater will be discharged to Outfall 003 during passive operations. Discharge Monitoring Reports will continue to be submitted per NPDES requirements.

On a quarterly basis, potable water will be recirculated through the water treatment system GAC vessels for a minimum of 2 hours to ensure the system is functioning properly. To accomplish this, potable water within Tank T-05 will be transferred via Pump P-05 into Tank T-03 and then pumped through the GAC vessels and back to Tank T-05, as shown in Figure 2. Recirculation of water through the GAC vessels will continue for approximately two hours to ensure the system is functioning properly. No treated water will be discharged to outfall 003 during this closed loop process.

The maintenance procedure described in Section 8 of the 2011 HCC O&M Manual will be followed if the water treatment system is restarted (Appendix A).

5.2 LNAPL Skimmer Maintenance

LNAPL belt skimmers will continue to operate in recovery wells RW-07 and RW-08., where measured LNAPL thicknesses have historically been highest. Quarterly visual inspections, including the inspection of the discharge troughs and hose, will be performed on each belt skimmer unit to ensure proper operation. If the LNAPL storage tank attached to the skimmer either fills up more than monthly or does not fill up within a month, the on/off timer located on the inside of the control panel door should be adjusted to maximize LNAPL recovery. If the belt needs to be replaced, follow the instructions in the 2011 O&M Manual (AECOM 2011).

If the LNAPL storage tank experiences a high-level condition, the material within the tank should be inspected for quantity of LNAPL. If LNAPL is present, a licensed recovery company should be dispatched to remove the tank contents. If only impacted water is present in the tank, it should be disposed of in 55-gallon drums on site.

6 Health and Safety

Health and Safety procedures will be performed in accordance with the site-specific health and safety plan meeting the requirements of CFR 1910.120 (Arcadis 2023). A copy of the health and safety plan is included as Appendix C.

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Tables

Table 1
Sitewide Groundwater Monitoring Plan
Former Maintenance and Fueling Facility
Skykomish, Washington

Zone	Nearest Gate	Location	Monitoring Program	Sampling Frequency	Monitoring Type	NWTPH-Dx w/o SGC	NWTPH-Dx w/ SGC
HCC Monitoring Wells (11)	Far West Gate	GW-1	HCC	SA	Low-Flow Sampling	X	X
	West Gate	GW-2	HCC	Q	Low-Flow Sampling	X	X
	Center Gate	GW-3	HCC	Q	Low-Flow Sampling	X	X
	East Gate	GW-4	HCC	SA	Gauging Only	--	--
	Far West Gate	EW-1	HCC	SA	Low-Flow Sampling	X	--
	East Gate	EW-2A	HCC	SA	Low-Flow Sampling	X	--
	Far West Gate	5-W-43	HCC and LTM	SA	Low-Flow Sampling	X	--
	West Gate	2A-W-40	HCC and LTM	SA	Low-Flow Sampling	X	--
	West/Center Gate	2A-W-41	HCC and LTM	SA	Low-Flow Sampling	X	X
	Center Gate	1B-W-23	HCC and LTM	Q	Low-Flow Sampling	X	--
	Center/East Gate	2A-W-42	HCC and LTM	SA	Low-Flow Sampling	X	--
Gate Sentry Wells (20)	Far West Gate	S1-AD	HCC	SA	Short Purge Sampling	X	--
		S1-AU	HCC	SA	Short Purge Sampling	X	--
		S1-BD	HCC	SA	Short Purge Sampling	X	--
		S1-BU	HCC	SA	Short Purge Sampling	X	--
	West Gate	S2-AD	HCC	Q	Short Purge Sampling	X	--
		S2-AU	HCC	Q	Short Purge Sampling	X	--
		S2-BD	HCC	Q	Short Purge Sampling	X	--
		S2-BU	HCC	Q	Short Purge Sampling	X	--
	Center Gate	S3-AD	HCC	SA	Short Purge Sampling	X	X
		S3-AU	HCC	SA	Short Purge Sampling	X	X
		S3-BD	HCC	SA	Short Purge Sampling	X	X
		S3-BU	HCC	SA	Short Purge Sampling	X	X
		S3-CD	HCC	SA	Short Purge Sampling	X	X
		S3-CU	HCC	SA	Short Purge Sampling	X	X
	East Gate	S4-AD	HCC	SA	Short Purge Sampling	X	--
		S4-AU	HCC	SA	Short Purge Sampling	X	--
		S4-BD	HCC	SA	Short Purge Sampling	X	--
		S4-BU	HCC	SA	Short Purge Sampling	X	--
		S4-CD	HCC	SA	Short Purge Sampling	X	--
		S4-CU	HCC	SA	Short Purge Sampling	X	--
Piezometers (14)	East Gate	PZ-1A	HCC	SA	Gauging Only	--	--
	Center/East Gate	PZ-2N	HCC	SA	Gauging Only	--	--
		PZ-2S	HCC	SA	Gauging Only	--	--
	Center Gate	PZ-3N	HCC	SA	Gauging Only	--	--
		PZ-3S	HCC	SA	Gauging Only	--	--
		PZ-4N	HCC	SA	Gauging Only	--	--
		PZ-4S	HCC	SA	Gauging Only	--	--
	West/ Center Gate	PZ-5N	HCC	SA	Gauging Only	--	--
		PZ-5S	HCC	SA	Gauging Only	--	--
	West Gate	PZ-6N	HCC	Q	Gauging Only	--	--
		PZ-6S	HCC	Q	Gauging Only	--	--
	Far West/ West Gate	PZ-7N	HCC	Q	Gauging Only	--	--
		PZ-7S	HCC	Q	Gauging Only	--	--
	Far West End	PZ-8	HCC	SA	Gauging Only	--	--
Recovery Wells (10)	Center Gate	RW-01	HCC	SA	Gauging Only	--	--
		RW-02	HCC	SA	Gauging Only	--	--
		RW-03	HCC	SA	Gauging Only	--	--
	West/Center Gate	RW-04	HCC	Q	Gauging Only	--	--
	West Gate	RW-05	HCC	Q	Gauging Only	--	--
		RW-06	HCC	Q	Gauging Only	--	--
	--	RW-07	HCC	Q	Gauging Only	--	--
	--	RW-08	HCC	Q	Gauging Only	--	--
	East Gate	RW-09	HCC	Q	Gauging Only	--	--
	--	RW-10	HCC	SA	Gauging Only	--	--

Table 1
Sitewide Groundwater Monitoring Plan
Former Maintenance and Fueling Facility
Skykomish, Washington

Zone	Nearest Gate	Location	Monitoring Program	Sampling Frequency	Monitoring Type	NWTPH-Dx w/o SGC	NWTPH-Dx w/ SGC
Barrier Wall Oil-Water Separator Chamber Vaults (20)	Far West Gate	FWG-WV-NORTH	HCC	SA	Gauging Only	--	--
		FWG-WV-SOUTH	HCC	SA	Gauging Only	--	--
		FWG-EV-NORTH	HCC	SA	Gauging Only	--	--
		FWG-EV-SOUTH	HCC	SA	Gauging Only	--	--
	West Gate	WG-WV-NORTH	HCC	Q	Gauging Only	--	--
		WG-WV-SOUTH	HCC	Q	Gauging Only	--	--
		WG-EV-NORTH	HCC	Q	Gauging Only	--	--
		WG-EV-SOUTH	HCC	Q	Gauging Only	--	--
	Center Gate	CG-WV-NORTH	HCC	SA	Gauging Only	--	--
		CG-WV-SOUTH	HCC	SA	Gauging Only	--	--
		CG-CV-NORTH	HCC	SA	Gauging Only	--	--
		CG-CV-SOUTH	HCC	SA	Gauging Only	--	--
		CG-EV-NORTH	HCC	SA	Gauging Only	--	--
		CG-EV-SOUTH	HCC	SA	Gauging Only	--	--
	East Gate	EG-WV-NORTH	HCC	SA	Gauging Only	--	--
		EG-WV-SOUTH	HCC	SA	Gauging Only	--	--
		EG-CV-NORTH	HCC	SA	Gauging Only	--	--
		EG-CV-SOUTH	HCC	SA	Gauging Only	--	--
		EG-EV-NORTH	HCC	SA	Gauging Only	--	--
		EG-EV-SOUTH	HCC	SA	Gauging Only	--	--
Levee Zone Wells	--	5-W-14	LTM	SA	Low-Flow Sampling	X	--
		5-W-16	LTM	SA	Low-Flow Sampling	X	--
		5-W-17	LTM	SA	Low-Flow Sampling	X	--
		5-W-18	LTM	SA	Low-Flow Sampling	X	--
		5-W-19	LTM	SA	Low-Flow Sampling	X	--
Schoolyard Property Wells	--	5-W-51	LTM	SA	Low-Flow Sampling	X	--
		5-W-55	LTM	SA	Low-Flow Sampling	X	--
		5-W-56	LTM	SA	Low-Flow Sampling	X	--
Site Wide Wells	--	1A-W-4	LTM	SA	Gauging Only	--	--
		2A-W-3	LTM	SA	Gauging Only	--	--
		2A-W-9	LTM	SA	Low-Flow Sampling	X	--
		1B-W-2	LTM	SA	Gauging Only	--	--
		1C-W-4	LTM	SA	Gauging Only	--	--
		1C-W-7[1]	LTM	--	--	--	--
		1C-W-8	LTM	SA	Low-Flow Sampling	X	--
		MW-4[2]	LTM	SA	Gauging Only	--	--
		MW-11	LTM	SA	Gauging Only	--	--
		MW-14	LTM	SA	Gauging Only	--	--
		MW-47	LTM	SA	Gauging Only	--	--
		BRIDGE	LTM	SA	Gauging Only	--	--

Table 1
Sitewide Groundwater Monitoring Plan
Former Maintenance and Fueling Facility
Skykomish, Washington

Abbreviations:
HCC = Hydraulic Containment and Control System Performance Monitoring Plan location
LTM = Long-Term Monitoring Plan location
NWTPH-Dx = Northwest Total Petroleum Hydrocarbon - Diesel
Q = quarterly
SA = semiannual
SGC = silica gel cleanup
w/o SGC = without silica gel cleanup

Notes:
[1] Well will be decommissioned per recommendation of 2021 Annual Long-Term Monitoring Report (Farallon 2022)
[2] Well will be gauged only per recommendation of 2021 Annual Long-Term Monitoring Report (Farallon 2022).
(Farallon 2022).

References:
AECOM. 2011. Operation and Maintenance Manual for the Hydraulic Control and Containment System, BNSF Former Maintenance and Fueling Facility, Skykomish, Washington. Prepared for BNSF Railway Company. April 8.

Farallon. 2014. Addendum to the Operation and Maintenance Manual for the Hydraulic Control and Containment System, BNSF Former Maintenance and Fueling Facility, Skykomish, Washington. Prepared for BNSF Railway Company. September 2014.

Farallon. 2020. Final Long-Term Monitoring Plan, BNSF Former Maintenance and Fueling Facility, Skykomish, Washington. Prepared for BNSF Railway Company. November 9.

Farallon. 2022. 2021 Annual Long-Term Monitoring Report, BNSF Former Maintenance and Fueling Facility, Skykomish, Washington. Prepared for BNSF Railway Company. March 25.

Table 2
Effluent Limits of Outfall 003
NPDES Permit No. WA0032123
Former Maintenance and Fueling Facility
Skykomish, Washington

Parameter [a]	Maximum Daily Effluent Limit [b]
Flow, when river level <928.56 feet [c]	10 gpm [d]
pH (s.u.)	Between 6.6 and 8.5 standard units
Dissolved Oxygen	Minimum 8 mg/L
Oily Sheen	No visible sheen
Total Petroleum Hydrocarbons	208 µg/L

Abbreviations:
µg/L = micrograms per liter
gpm = gallons per minute
mg/L = milligrams per liter
s.u. = standard units

Notes:
[a] Point of compliance is after treatment system prior to discharge to the Skykomish River.

[b] Maximum daily effluent limit means the highest allowable daily discharge. The daily discharge means the discharge of a pollutant measured during the calendar day. For units of concentration, the daily discharge is the average measurement of the pollutant over the day.

[c] Outfall 002: The Permittee must cease discharge to the Skykomish River when the river level exceeds 928.56 feet. Outfall 003 is connected to the city storm sewer located along 3rd Street. This outfall receives treated water from the HCC system.

[d.] Since the treatment system for the hydraulic control and containment system is designed for a maximum of 100 GPM, the summer limit is set at 100 GPM. The maximum capacity available in the 3rd Street storm sewer during a 2-year, 24-hour storm event is 377 GPM. Should the Permittee upgrade the treatment system to

References:
Ecology 2022. National Pollutant Discharge Elimination System Waste Discharge Permit No. WA0032123. Effective Date: October 1, 2022. September 12.

Table 3
Monitoring Schedule for Outfall 003
NPDES Permit No. WA0032123
Former Maintenance and Fueling Facility
Skykomish, Washington

Parameter [a]	Units	Minimum Sampling Frequency	Sample Type	Analytical Method
Flow	gpm	Once per defined event	Metered	N/A
Oily Sheen	N/A	Weekly	Observed	Visual
pH (s.u.)	Standard Units	Every 2 weeks	Grab	pH meter [b]
Total Petroleum Hydrocarbon [c]	µg/L	Every 3 weeks (Two samples: one before and one after the GAC treatment)	Grab	NWTPH-Dx
Lead (T) [d]	µg/L	Quarterly	Grab	EPA 200.8
Arsenic (T) [d]	µg/L	Quarterly	Grab	EPA 200.8

Abbreviations:
µg/L = micrograms per liter
gpm = gallons per minute
mg/L = milligrams per liter
N/A = not applicable
s.u. = standard units

Notes:
[a] The final effluent sample point is defined as the nearest accessible point after granular activated carbon treatment, prior to discharge to Skykomish River via the City of Seattle's storm drain line.

[b] pH must be measured using a pH meter in the field. The calibration frequency specifications and method must be followed in accordance with the manufacturer's recommendations. A logbook must be kept to log all the readings and must be made available to Ecology's inspector(s) during inspections.

[c] Outfall 002: The Permittee must cease discharge to the Skykomish River when the river level exceeds 928.56 feet. Outfall 003 is connected to the city storm sewer located along 3rd Street. This outfall receives treated water from the HCC system.

[d] T defines as total. Lead and arsenic are required to be reported as total metals.

References:
Ecology 2022. National Pollutant Discharge Elimination System Waste Discharge Permit No. WA0032123. Effective Date: October 1, 2022. September 12.

Table 4
Reporting Requirements
Former Maintenance and Fueling Facility
Skykomish, Washington

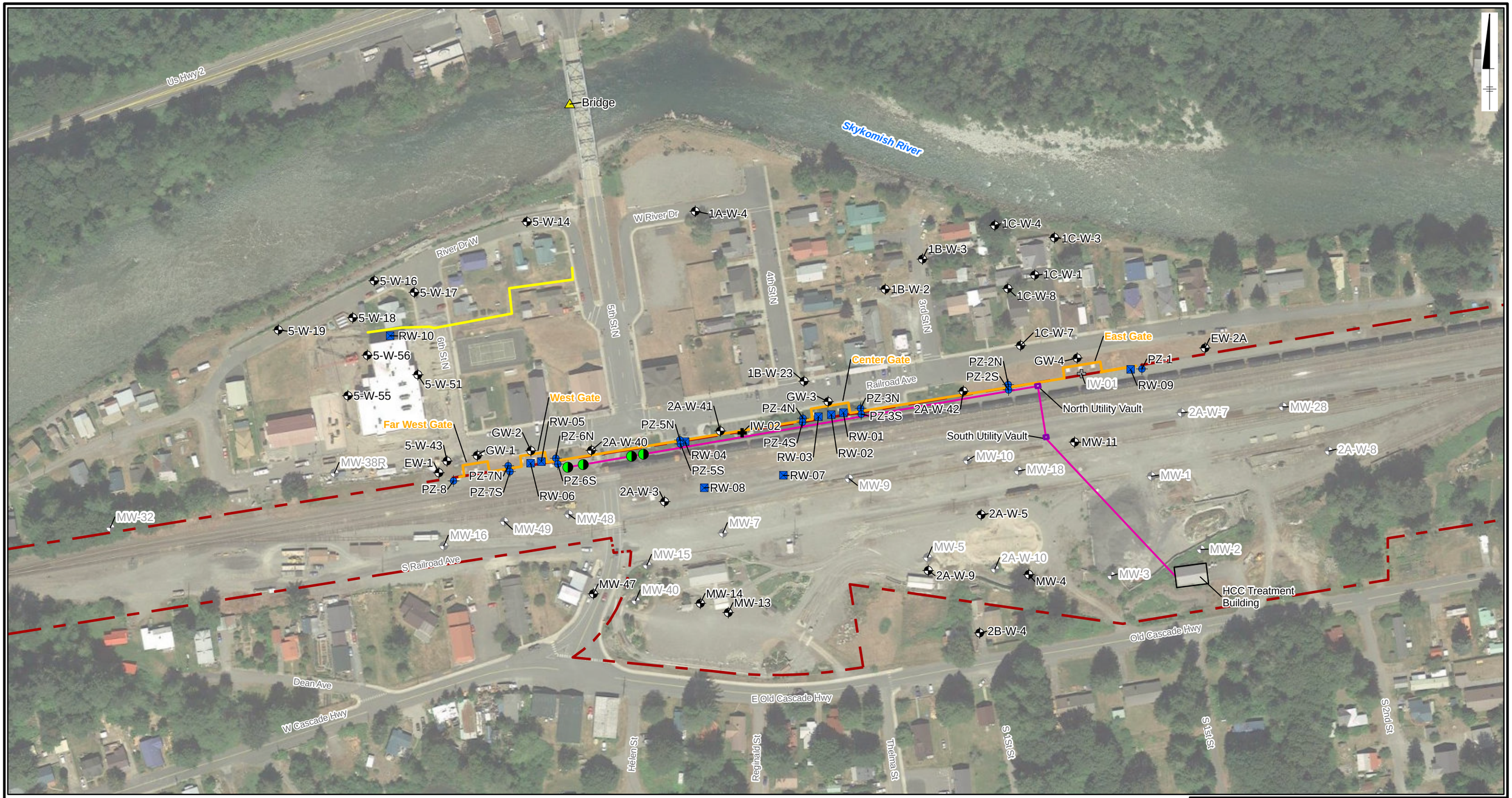
Report or Document	Required By	Frequency	Due By	Contents
Monthly and Quarterly DMRs	NPDES Permit (Ecology 2022)	Quarterly	Q1 - April 28 Q2 - July 28 Q3 - October 28 Q4 - January 28	Monthly and quarterly NPDES monitoring data during the months in the quarter
O&M Manual Update	NPDES Permit (Ecology 2022)	Annual	April 15	Review O&M Manual annually and update as necessary
Application for NPDES permit renawal	NPDES Permit (Ecology 2022)	Every 5-Years	March 30, 2027	NPDES permit renewal application
Long-Term Monitoring Report	Long-Term Monitoring Plan (Farallon 2020) and NPDES Permit (Ecology 2022)	Annual	March 31	Results of semi-annual site-wide groundwater monitoring. Report will satisfy requirements of NPDES Permit, Section S7
HCC Monitoring Report	Consent Decree	Annual	March 31	HCC system performance monitoring results
Progress Reports	Consent Decree	Quarterly	Q1 - April 15 Q2 - July 15 Q3 - October 15 Q4 - January 15	Summary of activities conducted under consent degree during the quarter

Abbreviations:
DMRs = Discharge Monitoring Report
NPDES = National Pollution Discharge Elimination System
O&M = Operations & Maintenance

References:
Ecology 2022. National Pollutant Discharge Elimination System Waste Discharge Permit No. WA0032123. Effective Date: October 1, 2022. September 12.

Farallon. 2020. Final Long-Term Monitoring Plan. BNSF Former Maintenance and Fueling Facility. Skykomish, Washington. Prepared for BNSF Railway Company. November 9.

Figures



Legend

- Monitoring Well
- Injection Well
- Recovery Well
- Piezometer
- Bridge Gauge
- Abandoned Monitoring Well
- Abandoned Injection Well
- Proposed Biosparge Well
- Mechanically Stabilized Earth Wall
- Hydraulic Control and Containment System Sheet Pile Barrier Wall and Gates
- Existing System Piping to be Used for Proposed Biosparge System
- BNSF Railyard Boundary
- Utility Vault

0 160 320

SCALE IN FEET

Notes:
1) Aerial Imagery from Google Earth

BNSF RAILWAY COMPANY
FORMER MAINTENANCE AND FUELING FACILITY
SKYKOMISH, WASHINGTON
2023 OPERATION AND MAINTENANCE MANUAL FOR THE HYDRAULIC CONTROL AND CONTAINMENT SYSTEM

SITE MAP

ARCADIS

FIGURE 1

CITY:(DEN-TECH) DIV/GROUP:(ENV/GIS) DB: DHOLMES LD: PIC: PM: TM:
PROJECT: PATH: T:_ENV\BNSF\BNSF_Skykomish_WA\ArcPro_ProjectFiles\2023\HCC_OMM\HCC_OMM_Report.aprx

P-01 (A-H) — DOWN WELL SUBMERSIBLE PUMP

CS-01 (A-H) — COOLING SHROUD DOWN WELL SUBMERSIBLE PUMP

SK-01 (A-H) — OIL RECOVERY BELT SKIMMER PACKAGE

T-01 (A-H) — RECOVERED OIL STORGE TANK & OVERPACK

OWS-01 — OIL/WATER SEPARATOR

T-02 — RECOVERED OIL STORAGE TANK & OVERPACK

T-03 — INFLUENT EQUALIZATION TANK

P-02A,B — INFLUENT EQUALIZATION TANK TRANSFER PUMP

F-01A,B — SAND FILTER PACKAGE

F-02A,B — GRANULAR ACTIVATED CARBON PACKAGE

T-05 — EFFLUENT EQUALIZATION TANK

T-04 — BACKWASH TANK

P-03 — TREATED WATER NPDES DISCHARGE PUMP

P-04 — TREATED WATER INJECTION PUMP

P-05 — BACKWASH PUMP

P-06A — BUILDING SUMP PUMP

P-07A,B — UTILITY VAULT SUMP PUMP

S-01A,B — UTILITY VAULT SUMP

S-02 — BUILDING FLOOR SUMP

C-01 — AIR SPARGE BLOWER

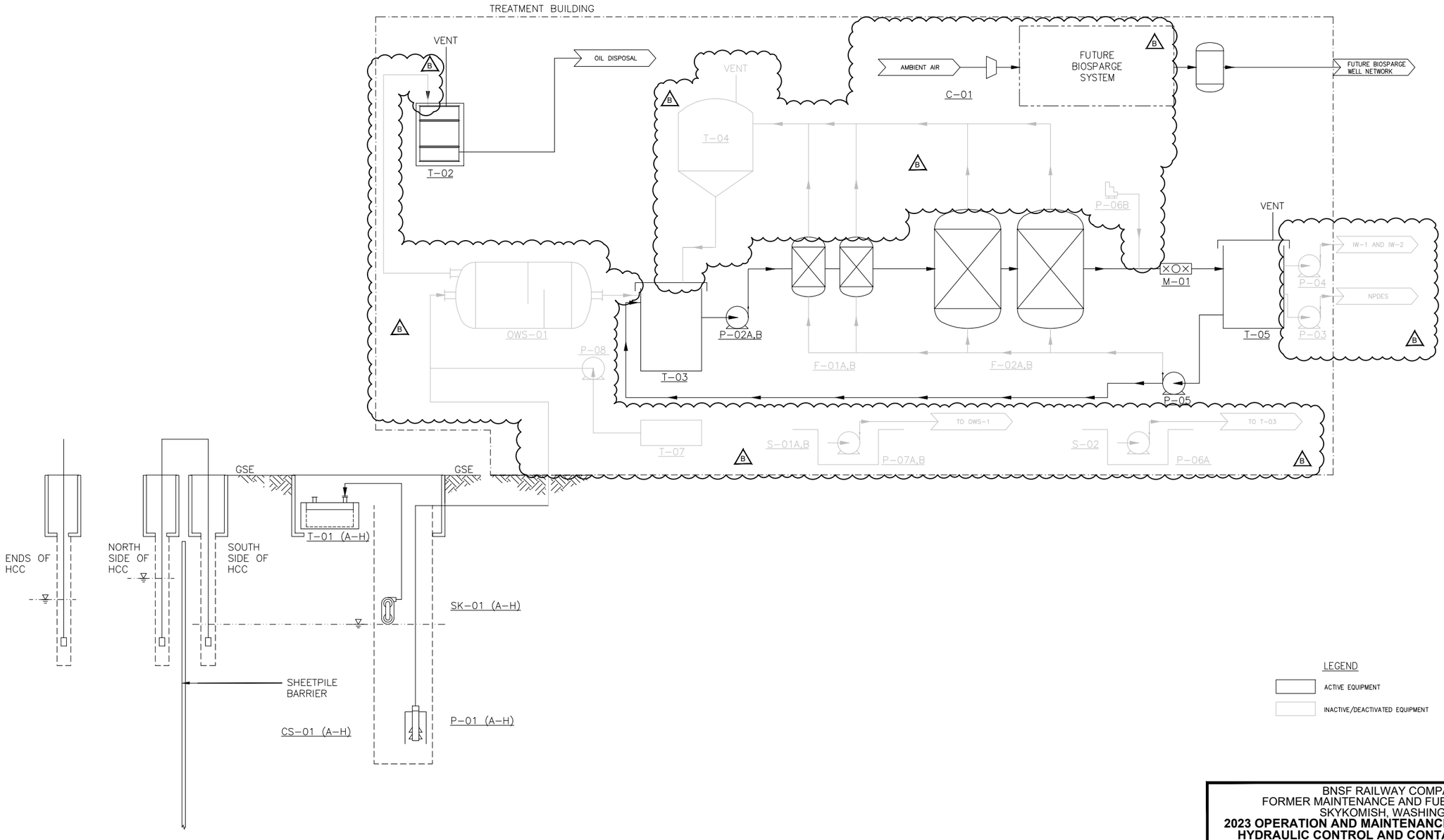
T-06 — REMOVED

M-01 — STATIC MIXER

P-06B — NaOH METERING PUMP

P-08 — METERING PUMP 0.5 GPH, 250 PSI 115V

T-07 — HYDROGEN PEROXIDE SOLUTION TANK 55 GALLONS



LEGEND

ACTIVE EQUIPMENT

INACTIVE/DEACTIVATED EQUIPMENT

B	3/14/2023	O&MM ADDENDUM CHANGES BY ARCADIS	JH	PM
A	8/15/2014	2014 O&MM ADDENDUM CHANGES BY FARALLON CONSULTING LLC		

BNSF RAILWAY COMPANY
FORMER MAINTENANCE AND FUELING FACILITY
SKYKOMISH, WASHINGTON
2023 OPERATION AND MAINTENANCE MANUAL FOR THE HYDRAULIC CONTROL AND CONTAINMENT SYSTEM

PROCESS FLOW DIAGRAM

ARCADIS

FIGURE 2

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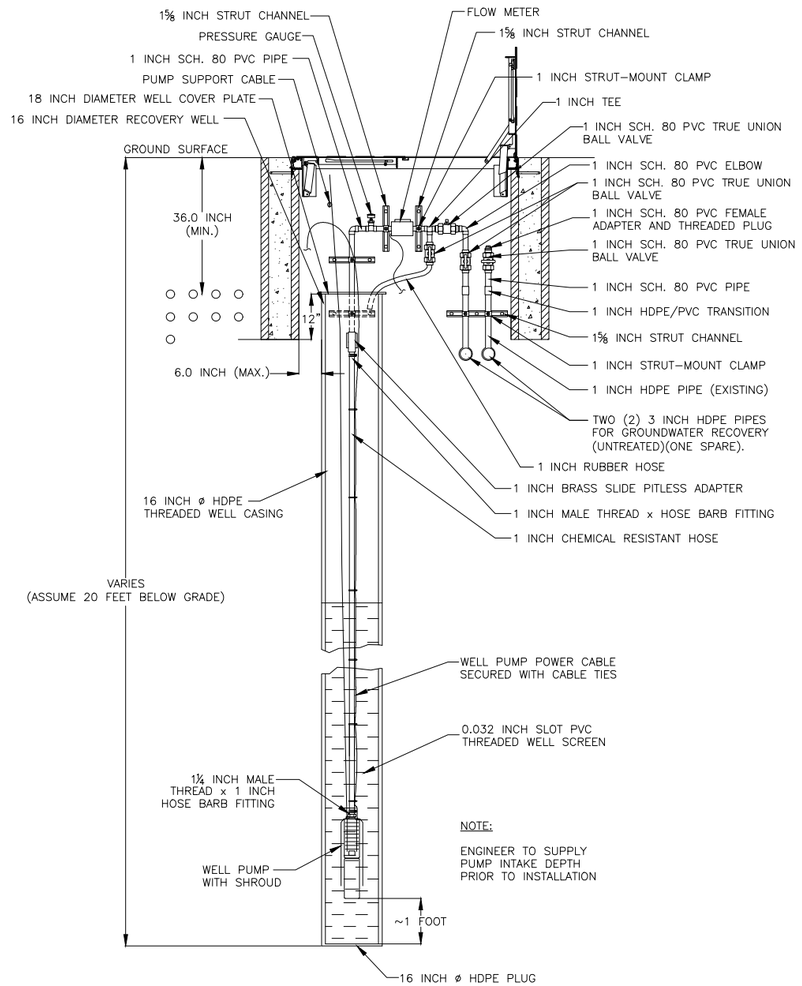

NOTES:

1. HDPE WELL CASING LENGTH TO BE DETERMINED IN FIELD BASE ON THE BOTTOM ELEVATION OF WELL.

2. SEE C–300 DRAWINGS FOR TOP & BOTTOM ELEVATION OF THE RECOVERY WELL SCREEN INTERVALS.

3. SK–01 (OIL RECOVERY BELT SKIMMER PACKAGE) NOT SHOWN FOR SIMPLIFICATION OF DRAWING. NO MODIFICATIONS TO SK–01 ARE PROPOSED.

BNSF RAILWAY COMPANY
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SKYKOMISH, WASHINGTON
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REVISED RECOVERY WELL DETAIL

ARCADIS

FIGURE
3

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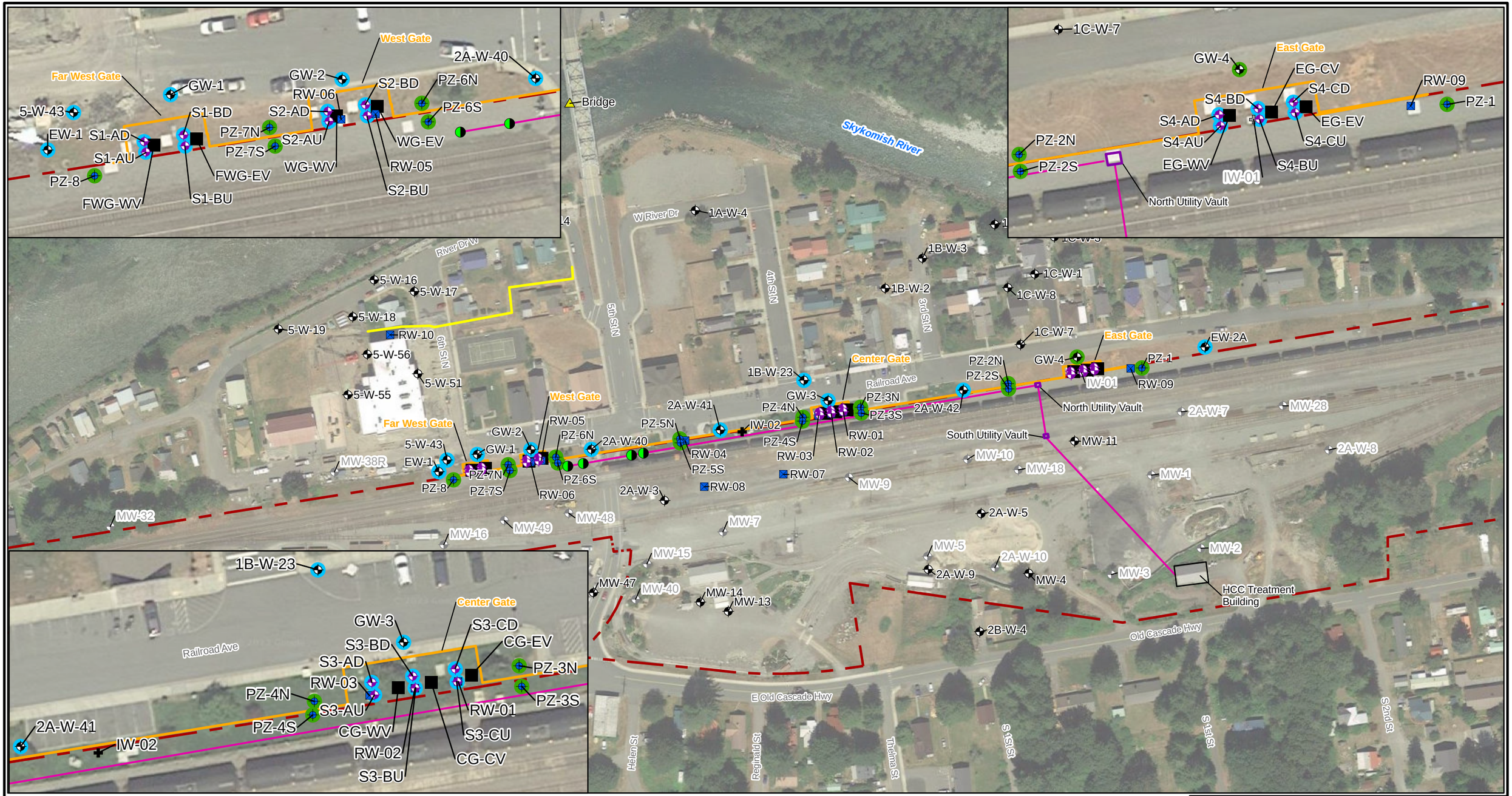

Legend

- Monitoring Well
- Injection Well
- Recovery Well
- Piezometer
- Bridge Gauge
- Abandoned Monitoring Well
- Abandoned Injection Well
- Sentry Well
- Proposed Biosparge Well
- Location Sampled for NWTPH-Dx
- Location Gauged Only
- Barrier Wall Gate Vault
- Mechanically Stabilized Earth Wall
- Hydraulic Control and Containment System Sheet Pile Barrier Wall and Gates
- Existing System Piping to be Used for Proposed Biosparge System
- BNSF Railyard Boundary
- Utility Vault

0 80 160 240 320
MAIN MAPSCALE IN FEET

0 25 50 75 100
INSET MAP SCALE IN FEET

Notes:
1) Aerial Imagery from Google Earth

BNSF RAILWAY COMPANY
FORMER MAINTENANCE AND FUELING FACILITY
SKYKOMISH, WASHINGTON
2023 OPERATION AND MAINTENANCE MANUAL FOR THE HYDRAULIC CONTROL AND CONTAINMENT SYSTEM

GROUNDWATER MONITORING PLAN

ARCADIS

FIGURE
4

CITY:(DEN-TECH) DIV/GROUP:(ENV/GIS) DB: DHOLMES LD: PIC: PM: TM:
PROJECT: PATH: T:_ENV\BNSF\BNSF_Skykomish_WA\ArcPro_ProjectFiles\2023\HCC_OMM\HCC_OMM_Report.aprx

Appendix A

2011 O&M Manual

AECOM Environment

Prepared for:
The BNSF Railway Company
Seattle, WA

Prepared by:
AECOM
Seattle, WA
60191113.0510
April 8, 2011

2011 Operation and Maintenance Manual for the Hydraulic Control and Containment System

Former Maintenance and Fueling Facility – Skykomish, WA

AECOM Environment

Prepared for:
The BNSF Railway Company
Seattle, WA

Prepared by:
AECOM
Seattle, WA
60191113.0510
April 8, 2011

2011 Operation and Maintenance Manual for the Hydraulic Control and Containment System

Former Maintenance and Fueling Facility – Skykomish, WA

Prepared by Paul V. Bianco, P.E.

Reviewed by Mark Havighorst, P.E. Project Engineer

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Appendix F HCC Treatment System NPDES Permit

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Appendix H Electric Motor Load Table

Appendix I Electrical Permit

1.0 Introduction

This Operation and Maintenance (O&M) Manual was prepared for the hydraulic control and containment (HCC) system in Skykomish Washington. The HCC system will be operated as part of remediation activities described in the *2008 Engineering Design Report* (2008 EDR) and *Hydraulic Control and Containment System Special Design Report* (February 2008) for the Former Maintenance and Fueling Facility (facility) and surrounding area located within the Town of Skykomish (Town), Washington (Site). The 2008 EDR and HCC Special Design Report were submitted by BNSF Railway Company (BNSF) and approved by the Department of Ecology (Ecology) pursuant to a Consent Decree (CD, *State of Washington v. BNSF Railway Company*, King County Superior Court Cause No. 07-2-33672-9SEA) between BNSF and Washington State Department of Ecology (Ecology), and the Corrective Action Plan (CAP), which is Exhibit B of the CD and is an integral and enforceable part of the CD.

The primary objective of the HCC is to contain non-aqueous phase liquid (NAPL) and impacted groundwater, ensuring that groundwater meets the appropriate remediation level as it leaves the BNSF property (CAP, Section 4.1.6). A secondary benefit of the HCC is to flush contamination underlying the CAP-defined Railyard Zone to collection points for treatment.

The HCC system includes a segmented sheet-pile wall that extends horizontally beyond the limits of impacted soil and vertically from the ground surface to the underlying silt layer, as well as interceptor trench. The barrier impedes the flow of NAPL and impacted groundwater and the interceptor trench facilitates hydraulic control and groundwater recovery. As a fully redundant backup to the primary hydraulic controls, the barrier wall is constructed with passive gates loaded with adsorptive media that will treat impacted groundwater in the unlikely event that the primary hydraulic control system is not functional for long periods of time. The HCC treatment system is installed within a building on BNSF property. Refer to Figure 1-1 for the plan view of the HCC system layout and location of treatment system building.

The HCC treatment system is designed to treat the extracted groundwater to achieve the required effluent limits described in the National Pollutant Discharge Elimination System (NPDES) Discharge Permit No. WA-003212-3 issued on May 4, 2006 and modified on August 15, 2006, June 30, 2008, and June 23, 2010. This O&M Manual has been prepared pursuant to the NPDES permit and meets the requirements of WAC-173-240-150(1) and (2). This manual also meets the requirements of the CD for systems installed in calendar year 2008, 2009, and 2010.

2.0 Treatment System Operating Plan

This Treatment System Operating Plan (TSOP) provides a brief description of the baseline operating procedures and parameters, emergency procedures, and basic maintenance of the HCC barrier and related collection and treatment systems installed for BNSF at the Site. This TSOP is included to fulfill the specific requirements of the Site NPDES Discharge Permit No. WA-003212-3, Section S4.A. A more detailed description of each mechanical device and control instrument and how the system will respond when the instrument is engaged, is provided in Sections 3.0 through 8.0.

System operations and related controls can essentially be grouped into ten major sub-systems. These are:

- Barrier Wall and Passive Gates
- Groundwater Recovery Operation
- NAPL Recovery Operations
- Primary Treatment Process
- Particulate Removal Process
- Secondary Treatment Process
- Effluent Aeration
- pH Adjustment
- Treated Water Discharge Operations
- Sump Pump Operations.

For a more complete description of each system refer to Section 4.0 of this manual.

2.1 Baseline Operating Procedures and Parameters

2.1.1 Barrier Wall and Passive Gates

A physical barrier, located along the northern boundary of the railyard, impedes the flow of NAPL and impacted groundwater off railyard property. The barrier is made of interlocking sheet piles and extends horizontally beyond the limits of impacted soil and vertically from the ground surface to the underlying silt layer, except where the silt layer does not exist in the vicinity of 5th Street. A series of passive flow-through gates filled with adsorptive media are installed along the barrier alignment to provide backup treatment should the mechanical hydraulic control system shut down for an extended period of time. The HCC system site plan and the location of the physical barrier and gates are shown on Figures 1-1 and 1-2, respectively.

2.1.2 Groundwater Recovery Operation

Nine down-well recovery wells (RW-01 through RW-09) provide hydraulic control along the HCC barrier. Groundwater is pumped from recovery wells along the HCC to create a gradient from the northern (downgradient) to southern (upgradient) side of the HCC barrier. These pumps are controlled

based on groundwater level measurements from transducers located in a network of north-south piezometer pairs (PZ-2S and -2N through PZ-7S and -7N). Pumping rates are adjusted by a programmable logic controller (PLC) to maintain an adequate differential level across the HCC barrier.

The north piezometers are located downgradient of the HCC barrier and the south piezometers are located upgradient of the HCC barrier. Two additional piezometers, PZ-1 and PZ-8, are located on the eastern and western ends of the HCC barrier, respectively. A site map depicting well, piping, and system locations is presented as Figure 1.1.

Groundwater is pumped from recovery wells along the HCC to create a gradient from the northern (downgradient) to southern (upgradient) side of the HCC barrier. Each groundwater pump has a 5 horse-power (Hp) variable frequency drive (VFD), and sine wave filter, to operate and protect the 1 Hp down-well pump. Groundwater recovery rates from each well are monitored by a dedicated flow transducer (FIT-112A through FIT-112I), that is located in the recovery well vaults and provides an analog input to the system's PLC panel. Well level transducers located in the fourteen (14) piezometers provide analog inputs of groundwater levels to the system PLC. The operator inputs which piezometer pair or pairs, will be used as a basis for controlling each individual pump speed. The differential level set point is also adjustable by the operator. The down-well groundwater pumps operation, and groundwater pumping rate, will be automatically adjusted to maintain the desired differential level set point, thus maintaining a targeted gradient and hydraulic control at the HCC barrier. Two additional level transducers (LT-109 and LT-110) are installed in RW-02 and RW-05 as a backup level control mechanism to prevent down well pumps from running dry from excess localized drawdown. The differential level setting should be observed on a weekly basis and adjusted as necessary to maintain the targeted gradient.

2.1.3 NAPL Recovery Operation

All nine of the recovery wells (RW-01 through RW-09) are set up to allow for the installation of NAPL belt skimming systems in the well vaults. Currently, only five belts skimming systems are installed in recovery well vaults RW-03, RW-04, RW-05, RW-07, and RW-08. NAPL is recovered from recovery well via belt skimmers (SK-01A through SK-01I). Collected NAPL will flow to and be stored within 20-gallon capacity NAPL storage tanks (T-01A through T-01I), which are equipped with secondary containment and installed within the five skimmer equipped recovery well vaults.

Each skimmer system is controlled by a locally-mounted control panel that has a timer to control belt skimming operations, and an integral heater to decrease the viscosity of recovered product. Each NAPL storage tank is fitted with a level gauge and a High Level switch (LSH-111). The High Level Switch shuts down the skimmer and triggers an alarm at the PLC panel (located inside the HCC treatment building) when the storage tank level is too high for the belt skimmer to continue to operate. Materials collected and stored in the storage tanks will be consolidated and taken off-site to an approved disposal facility.

The skimmer units operate independently of the PLC panel. A weekly operational check is performed on the skimmer system and belt speed adjusted to minimize water collection inside the storage tank.

2.1.4 Primary Treatment Process

The recovered groundwater may have trace amounts of NAPL present. Groundwater is pumped to the HCC treatment building and into an oil/water separator (OWS; OWS-01) located at the northwest corner inside the treatment building. NAPL accumulating in the OWS gravity drains into a 55-gallon

drum (T-02) stored in a 95 gallon over-pack drum located adjacent to OWS-01. Collected NAPL will be removed from T-02 by licensed waste disposal contractors on an as-needed basis.

Due to the operational principles of OWS-01, no adjustments are necessary. However, monthly checks should be performed to verify the NAPL tank level and valve positions are open.

2.1.5 Particulate Removal Process

Recovered groundwater leaving OWS-01 is gravity-fed into the Equalization Tank (T-03). Water is then pumped from T-03 through sand filters, which perform particulate removal. The Sand Filter Package (F-01A and F-01B) is configured to run in parallel during normal operations.

The Sand Filter Package is backwashed with treated groundwater from the Effluent Equalization Tank (T-05) by a Backwash Pump (P-05). Particulate laden backwash water is directed to the Backwash Tank
(T-04). The Backwash Tank allows sediments to settle out, and clarified water is then gravity decanted back to T-03. Accumulated sediments collected in T-04 are cleaned out manually as needed by the operator and disposed of by a licensed waste disposal contractor. The backwash tank is also fitted with a level transducer (LT-213), that will send a analog signal back to the PLC, but will also control the MOV-214 that will open (as necessary) to drain water from Tank T-04 to Tank T-03 to make room for the next backwash cycle.

The sand filters are backwashed based on a differential pressure switch (DPSH-204) that monitors the differential pressure across the sand filter beds. A high differential pressure, as indicated by this pressure switch, triggers an automatic backwash of the vessels in a lead-lag fashion. While backwash is occurring on the lead vessel, system influent water continues to be processed through the lag vessel. Backwashing occurs for a user-programmable period of time, which is adjusted by the system operator based on system conditions. Then the sequence is reversed such that influent flows through the lead vessel while the lag is backwashed. When both vessels have been flushed, the system returns to its normal operating state (parallel flow). This sequence can also be manually initiated by the operator.

Digital outputs from the PLC are utilized to control a series of eight motor operated valves (MOV-205 through MOV-212) located on the influent and effluent lines of each sand filter. The PLC controls these valves as necessary to allow automatic backwashing and system water treatment to occur as described above without the need for manual operations by the system operator.

Backwash cycles are recorded by the PC-based man-machine-interface (MMI) automatically and stored on the MMI PC in a Microsoft Excel spreadsheet file. Monthly data review should be performed to assess quantity and duration of the backwash cycles. In the event that the backwash duration requires adjustment the operator will adjust the time on the backwash screen on the MMI.

2.1.6 Secondary Treatment Process

After passing through the sand filters, the groundwater is treated for residual organics by a Liquid Phase Granular Activated Carbon (LPGAC) Package (F-02A and F-02B) which are configured in series, but could be operated in parallel if desired based on system conditions. The operator must change valve positions manually in order to operate the LPGAC Package in a parallel configuration.

The operating pressure of the LPGAC Package is monitored by a differential pressure switch (DPS-301), which issues a discrete input to the PLC. The PLC is programmed to alert the operator on the

screen in the event that a high pressure is reached. The LPGAC are then backwashed manually by the operator changing the necessary valve positions and engaging the backwash pump.

The LPGAC adsorber valves are labeled individually to indicate the proper position for operating in series configuration, operating in parallel configuration, backwashing the primary adsorber (F-02A), and backwashing the secondary adsorber (F-02B).

2.1.7 Effluent Aeration

After passing through the LPGAC adsorbers, the groundwater is aerated to increase the dissolved oxygen by a Mazzei 2081 injector, which is installed on the discharge piping of the secondary LPGAC adsorber. The injector is installed with a bypass line in the event that aeration is not necessary and if the total flow of the system rises above 60 gpm. The operator must adjust the bypass valve manually in the event of flows above 60 gpm to prevent an increase in backpressure. Manufacturers' information for the injector is presented in Appendix A.

2.1.8 pH Adjustment

After passing through the aerator, the groundwater pH is adjusted to meet the NPDES permit limits.

The pH adjustment system consists of an automated sodium hydroxide (NaOH) injection system. The automated NaOH injection system is installed to the effluent piping of the secondary liquid phase granular activated carbon (LPGAC) adsorber and prior to the effluent equalization tank (T-05). The pH adjustment equipment installed is as follows:

- 1 – 300-gallon capacity, horizontal polyethylene NaOH storage tank
- 1 – pH controller to provide real time effluent pH measurements and automatically adjust the NaOH injection
- 1 – pH probe to measure the effluent from the pH adjustment system
- 1 – 3-inch in-line static mixer
- 1 – 110 volt chemical feed pump with a capacity of 30 gallons per day at a pressure of 100 pounds per square inch (psi).

The injection solution concentration is a 50% NaOH solution to increase the effluent pH of the HCC system above a minimum of 6.5 SU.

2.1.9 Treated Water Discharge Operations

Treated groundwater is collected in the Effluent Equalization Tank (T-05), from which it is discharged to NPDES Outfall 003 at Latitude 47° 42' 35" N and Longitude 121° 21' 49" W using pump P-03 or pumped using Treated Water Injection Pump (P-04) to an injection well manifold, and then discharged to the East Gate at approximately 20 gpm. The treated groundwater in Tank T-05, also supplies water for backwashing of the sand filters and LPGAC systems, and for re-injection purposes. P-03 will generally continuously operate at a flow rate of approximately 20 gpm. Pump P-04 will generally run continuously at a flow rate of approximately 20 gpm.

2.1.10 Sump Pump Operations

The HCC system has installed a total of three sump pumps. One sump pump is located in the north utility vault, one sump pump is located in the south utility vault, and one sump pump is located in the HCC building floor sump. The north and south utility vault sump pumps are plumbed to the inlet of the OWS and controlled by float level switches located in each vault (LSL-114 and LSH-114 A&B). The HCC building sump pump is plumbed to the Backwash Tank (T-04) and is independently controlled by a float level switch (LSL-215 and LSH-215) installed in the HCC building floor sump. Each sump pump is connected to an input on the PLC and an operational indication is displayed on the operations screen of the PLC when running.

2.2 System Treatment Efficiency

The HCC treatment system is designed to treat variable flows up to 100 gpm. The efficiency of the system should not change in the event of flow rates below the system capacity. The most likely causes of reduced system efficiency are:

1. Excessive amount of free product, silt, or biological growth in the OWS tank.
2. Excessive amount of silt build-up in the Influent Equalization Tank (T-03).
3. Excessive amount of silt build-up in the Backwash Tank (T-04)
4. Automatic sand filter function not operating properly causing clogging of the filter beds.
5. LPGAC clogging with silt or biological growth and needing backwashing.
6. LPGAC adsorbers have reached treatment capacity and are exhausted.

To ensure maximum efficiency of the system, monitoring is performed in accordance with Section 6.0 of this O&M Plan. In the event of a discharge that exceeds effluent limits in the NPDES Permit, reporting will be performed as outlined in Section 6.4 of this O&M Plan and the Permit.

2.3 System Upset and Emergency Procedures

System upsets would include equipment failure, power failure, breakage, PLC failure, and an emergency condition that would require shutting down the HCC treatment system. In the event of a system upset, the emergency redundant treatment system (Section 3.2) is employed to ensure impacted groundwater does not go off-site. In addition the on-site auto-dialer alerts the necessary personnel listed in Section 2.5 of any system shut down.

System upsets can occur at any time and extend for long durations. Proper monitoring and maintenance should be performed as detailed in Sections 6.0 and 8.0 to prevent system upsets. In an emergency situation the necessary personnel listed in Section 2.5 should be contacted and the system shut down to prevent a non-compliance or hazardous situation. All care should be taken to restart the system as soon as practicable and reduce the time of the shut down.

In the event of a system upset, monitoring and reporting should be performed as outlined in Section 6.4 of this O&M Plan.

2.4 System Maintenance and Repair

A detailed description of system maintenance is described in Section 8.0. System maintenance includes, but is not limited to monitoring system flows and pressures, visual observation of the treatment system, cleaning of y-strainers, backwashing the LPGAC and sand filters, emptying of the free product drum, and monitoring of the system electrical performance. These maintenance items should not use any cleaning or chemical products. However, in the event of the use of a cleaning product, it should be disposed of as directed on the product label and not in the HCC treatment system.

On a yearly basis, tanks should be checked and cleaned of dirt and silt, gaskets inspected for failure or cracking, the inside of the sand filters and LPGAC adsorbers inspected, field vaults thoroughly inspected, and all equipment tested.

2.5 HCC System Responsible Individuals and Contacts

In the event of an HCC system emergency, the following individuals should be contacted in the following order.

	Name	Company	Telephone Number	Cell Number
1.	Mr. Paul Bianco, PE	AECOM	(206) 624-9349 x2554226	(206) 947-0444
2.	Mr. Eric Storkerson	AECOM	(206) 624-9349 x2554248	(206) 450-0444
3.	Mr. Greg Chase	AECOM	(206) 624-9349 x2554263	(206) 462-0373
4.	Mr. Mark Havighorst, PE	AECOM	(503) 227-1042 x24	(503) 360-3308

3.0 Hydraulic Control and Containment Barrier Wall and Backup Gate Treatment

3.1 Physical Barrier

The physical barrier extends horizontally beyond the limits of impacted soil and vertically from the ground surface to the underlying silt layer along the horizontal alignment except where the silt layer does not exist in the vicinity of 5th Street. At this location, the barrier extends sufficiently deep to contain impacted groundwater. Where the silt layer is present, the barrier keys at least 2 feet into the silt.

The barrier impedes the flow of NAPL and impacted groundwater and ensures these are collected in the hydraulic control system or that flow is routed through the passive gates, when the hydraulic control system is not functioning.

Interlocking Z-shaped steel sheet piles were driven along the HCC alignment. The pile interlocks are sealed with a grout or gasket material to achieve a hydraulic conductivity several orders of magnitude less than 10^{-5} cm/sec. The location of the physical barrier is presented in Figure 1.2.

3.2 Hydraulic Control and Containment Passive Flow through Gates

A series of passive flow-through gates are installed along the HCC alignment to provide backup treatment should the mechanical hydraulic control system shut down for an extended period of time. The gate locations were selected to:

- Avoid areas with free product to minimize petroleum loading to treatment systems within the gate
- Minimize hydraulic head build-up in the vicinity of 5th Street to prevent flow underneath the wall where the underlying silt layer is absent.

The gates are constructed of pre-cast concrete with interior dimensions of 20 feet wide by 12 feet deep by 12 feet long (along the groundwater flow path). The concrete is 8 inches thick. Each gate consists of two or three of these sections to obtain the overall length of 40 or 60 feet. Inside each vault, from upgradient to downgradient, is an underflow baffle wall that collects any free product that makes it to the vault followed by two 3-foot long adsorptive material cells. The adsorptive material is contained on each end and between the two cells by perforated metal and wire screen connected to a frame system within the vault. Each end of the pre-cast concrete vault includes 8-inch square openings at 16 inches on center in both directions and angled to prevent stabilization aggregate from entering the vaults through these openings.

The subsurface beneath each vault was prepared by digging down to and into the silt and placing a minimum 2-foot thick lift of concrete to allow level placement of each vault and to seal the contact between the vault and the silt. Space between the vaults is also filled with concrete, as was the space between the vaults and the ‘L’ in the sheet pile wall at each end of each gate.

If the hydraulic control system fails to operate, then the physical barrier will force groundwater flow through the gates. NAPL will accumulate upgradient of the underflow baffle and dissolved phase constituents will adsorb to the media filling the gates. The gates extend to the same grades as the recovery wells. In

addition, the gates have sufficient hydraulic conductivity (1×10^{-2} cm/sec) to prevent significant groundwater mounding behind the low permeability barrier. Once the hydraulic containment system is reactivated, groundwater flow will be reversed through the gates to prevent further downgradient migration. Design figures for the HCC gates are presented in Appendix B.

The gates are filled with a combination of granular activated carbon and granolithic rock to prevent conglomeration. The initial granular activated carbon and granolithic mixture placed in the vaults is presented in Table 3.1. Operational data over the gate vault granular activated carbon lifespan should be used in addition to the initial calculations to determine later mixtures. Manufacturer specifications for the GAC contained in the gate vaults is presented in Appendix D.

Table 3-1 Gate Vault GAC/Granolithic Material Summary

Gate Location	Vault Location	Cell Location	Media Depth	Carbon Volume (ft^3)	Gravel Volume (ft^3)	Carbon Weight (lbs)	Gravel Weight (lbs)	As-Built Ratio GAC to Granolithic	Calculated Ratio GAC to Granolithic	Calculated Breakthrough Time Without Pumping (Days)
East	West	RR Side	8 FT	417	66	12,500	6,600	86	60	887
		Road Side	8 FT	417	66	12,500	6,600	86	60	887
	Central	RR Side	8 FT	400	83	12,000	8,300	83	60	856
		Road Side	8 FT	334	150	10,000	15,000	69	60	712
	East	RR Side	8 FT	334	150	10,000	15,000	69	60	712
		Road Side	8 FT	334	150	10,000	15,000	69	60	712
Central	West	RR Side	11 FT	483	183	14,500	18,300	73	80	494
		Road Side	11 FT	483	183	14,500	18,300	73	80	494
	Central	RR Side	11 FT	483	183	14,500	18,300	73	80	494
		Road Side	11 FT	483	183	14,500	18,300	73	80	494
	East	RR Side	11 FT	417	233	12,500	23,300	64	80	433
		Road Side	11 FT	417	233	12,500	23,300	64	80	433
West	West	RR Side	11 FT	417	233	12,500	23,300	64	60	574
		Road Side	11 FT	417	233	12,500	23,300	64	60	574
	East	RR Side	11 FT	417	233	12,500	23,300	64	60	574
		Road Side	11 FT	417	233	12,500	23,300	64	60	574
Far West	West	RR Side	11 FT	417	233	12,500	23,300	64	30	1,290
		Road Side	11 FT	417	233	12,500	23,300	64	30	1,290
	East	RR Side	11 FT	417	233	12,500	23,300	64	30	1,290
		Road Side	11 FT	417	233	12,500	23,300	64	30	1,290

4.0 HCC Treatment System Details

This O&M manual provides technical information necessary to properly operate, maintain the HCC system installed for BNSF at the Former Maintenance and Fueling Facility located within the town of Skykomish, Washington. The report provides an overview of system operations and a more detailed summary of each control instrument and how the system will respond when the instrument is engaged.

The HCC Treatment system has been designed for an anticipated average flow rate of 43 gpm, based on groundwater modeling done by S.S. Papadopulos & Associates, Inc. with a maximum treatment capability of 100 gpm. Refer to Appendix C for the groundwater modeling report. The NPDES discharge pump, has been sized to pump up to 200 gpm, to manage the groundwater recovery of 100 gpm and additional flow during backwashing operations.

4.1 Organization of System Operations

System operations and related controls can essentially be grouped into ten major sub-systems. These are:

1. **Barrier Wall and Passive Gates –** The HCC system includes a sheet-pile barrier wall that extends horizontally beyond the limits of impacted soil and vertically from the ground surface to the underlying silt layer. The barrier impedes the flow of NAPL and impacted groundwater and ensures these are collected in the hydraulic control system. As a fully redundant backup to the primary hydraulic controls, the barrier wall is constructed with passive gates loaded with adsorptive media which will treat impacted groundwater in the unlikely event that the primary hydraulic control system is not functional for long periods of time (i.e. extended power loss etc.).
2. **Groundwater Recovery Operation –** Groundwater Recovery Well Pumps (P-01A through P-01I) controlled by Piezometer Level Transducers (PZ-1, PZ-2S through PZ-7S, PZ-2N through PZ-7N, and PZ-8);
3. **NAPL Recovery Operations –** Oil Belt Skimmer (SK-01A through SK-01I) with Oil Storage Tank (T-01A through T-01I);
4. **Primary Treatment Process –** Oil Water Separation (OWS-01), Influent Equalization Tank (T-03) and Influent Equalization Transfer Pump (P-02A and P-02B);
5. **Particulate Removal Process –** Particulate removal via a Sand Filter Package (F-01A and F-01B), automatic backwash operation and Backwash Pump (P-05), and Backwash Tank (T-04);
6. **Secondary Groundwater Treatment Process –** Groundwater treatment via liquid phase Granular Activated Carbon Package (F-02A and F-02B);
7. **Aeration –** A Mazzei 2081 injector used to increase DO in the HCC effluent installed on the discharge line of the secondary LPGAC adsorber;
8. **pH Adjustment –** A pH adjustment system utilizing NaOH to increase pH in the HCC effluent installed on the discharge line of the secondary LPGAC adsorber;
9. **Treated Water Discharge Operations –** Effluent Equalization Tank (T-05) and Treated Water NPDES Discharge Pump (P-03) and Treated Water Injection Pump (P-04);

10. **Sump Pump Operations –** Northern and Southern Utility Vault Sumps (P-07A, B) and Building Sump (P-06).

System operations involve a variety of analog and digital instruments and control loops. Control logic is managed via a PLC which resides in a custom control enclosure that also houses an auto-dialer for remote alarm notification. A separate desktop PC-based man-machine-interface (MMI) is used for operator interface, data acquisition, data logging, and set point adjustments. The HCC system is equipped to allow for remote monitoring, control and data acquisition through a network based broadband connection.

Individual system motors are controlled by either VFDs mounted and wired in a separate VFD Rack or motor starters mounted and wired in the PLC panel, which are both located in the HCC Treatment System Building. A series of discrete and analog signals are field-wired between the PLC enclosure and VFD Rack. These I/O are pre-wired within the PLC cabinets and VFD Rack to labeled terminal strips to facilitate field connections. A Process and Instrumentation Diagram is presented as Figure 4.1. The manufacturer's specifications for field devices are presented in Appendix D. The manufacturer's specifications for the building treatment devices are presented in Appendix A. The HCC Treatment Control Logic Report, provided in Appendix E, provides an overview of system operation, a more detailed summary of each control instrument and how the system will respond when the instruments are engaged. The HCC system electric motor load table is presented in Appendix H and the electrical permit is presented in Appendix I.

4.1.1 Groundwater Recovery Operation

Nine recovery wells (RW-01 through RW-09) provide hydraulic control along the HCC barrier. Groundwater is pumped from recovery wells along the HCC to create an artificial gradient at the gates from the northern (down-gradient) to the southern (upgradient) side of the HCC barrier. Each groundwater pump has a 5 Hp VFD, and sine wave filter, to operate and protect the 1 Hp down-well pump. The down well pumps, are also fitted with a pump shroud (CS-01A through CS-01I), to keep water moving over the pumps motor to minimize pump failure. Groundwater recovery rates from each well are monitored by a flow transducer (FIT-112A through FIT-112I), which are located in the recovery well vaults that provides an analog input to the system's PLC panel. The down-well pumps are controlled by level transducers located in a network of north-south piezometer pairs (PZ-2S and -2N through PZ-7S and -7N). The north piezometers are located downgradient of the HCC barrier and the south piezometers are located upgradient of the HCC barrier. Piezometers PZ-1 and PZ-8 are located on the eastern and western ends of the HCC barrier, respectively. A site map depicting well, piping, and system locations is presented as Figure 2.1.

Level transducers located in the fourteen (14) piezometers provide analog inputs of groundwater levels to the system PLC. The operator inputs which piezometer pair is used as a basis for controlling each individual pump's speed. The differential level set point is also adjustable by the operator. The down-well groundwater pumps operation, and groundwater pumping rate, will be automatically adjusted to maintain the desired differential level set point thus maintaining a targeted gradient and hydraulic control at the HCC barrier. In addition, pump speed can be set using the Recovery Well Setup Screen on the MMI. Two additional level transducers (LT-109 and LT-110) are installed in RW-02 and RW-05 as a backup level control mechanism to prevent down well pumps from running dry from excess localized drawdown. Each RW pump is interlocked with the PLC in the event of a low flow condition. The PLC shuts down the RW pump based on the operator low flow set point. In the event of a low flow alarm, the operator must clear the alarm on the PLC prior to restarting the RW pump. A RW Vault Detail is presented as Figure 4.2.

Based on 2009 operational data, computer limitations of the PLC, and site conditions the speeds of the RWs are currently set by the operator to achieve a North to South groundwater gradient through each gate. To perform this adjustment groundwater levels are collected at the following locations and frequencies:

Table 4-1 Groundwater Gauging Summary to Determine RW Pump Speeds

Gate Location	Location Identification	Site Location	Measurement Collection Method	Frequency of Measurement
Far West Gate	GW-1	North Side of Far West Gate	Manual Gauging	Weekly
	FWV	Inside Far West Gate Vault	Manual Gauging	Weekly
West Gate	GW-2	North Side of West Gate	Manual Gauging	Weekly
	RW-5	South Side of West Gate	PLC Measurement	Weekly
Central Gate	GW-3	North Side of Central Gate	Manual Gauging	Weekly
	RW-2	South Side of Central Gate	PLC Measurement	Weekly
East Gate	GW-4	North Side of East Gate	Manual Gauging	Weekly
	PW-04	South Side of East Gate	Manual Gauging	Weekly

The data collected in Table 4.1 above is used to calculate the North-South gradient across each gate. The gradient required across each gate is 0.1 feet. Therefore, if the calculated gradient is less than 0.1 feet, the speed of the RWs in the vicinity of the gate are increased and if the calculated gradient is more than 0.1 feet, the speed of the RWs in the vicinity of the gate are decreased based on the operators experience.

To calculate the groundwater gradient across each gate, perform the following calculations:

1. Far West Gate GW Gradient = GW Elevation at FWV – GW Elevation at GW-1
2. West Gate GW Gradient = GW Elevation at RW-5 – GW Elevation at GW-2
3. Central Gate GW Gradient = GW Elevation at RW-2 – GW Elevation at GW-3
4. East Gate GW Gradient = GW Elevation at PW-04 – GW Elevation at GW-4

4.1.2 NAPL Recovery Operation

All nine of the recovery wells (RW-01 through RW-09) are set up to allow for the installation of NAPL belt skimming systems in the well vaults, but only five belts skimming systems are installed initially. NAPL is recovered from the recovery well via belt skimmers (SK-01A through SK-01I). Each skimmer system is controlled by a locally-mounted control panel that has a timer to control belt skimming operations, and an integral heater to decrease the viscosity of recovered product. Collected oils will flow to and be stored within a 20-gallon capacity NAPL storage tank (T-01A through T-01I), with secondary containment, installed within each of the recovery well vaults. Each tank is fitted with a level gauge and a High Level switch (LSH-111A-I). The High Level Switch shuts down the skimmer and triggers an alarm at the PLC panel (located inside the HCC treatment building) when the storage tank level is too high for the belt skimmer to continue to operate.

4.1.3 Primary Treatment Process

The recovered groundwater may have trace amounts of NAPL present. Groundwater is pumped to the treatment building and into OWS-01. OWS-1 is fitted with a High Level switch (LSH-117) that sends an alarm signal to the PLC, which shuts down the system and alerts the operator that a high level is reached in order to prevent an overflow condition. NAPL accumulating in the OWS gravity drains into a 55-gallon drum (T-02) stored in a 95-gallon over-pack drum located adjacent to OWS-01. Tank T-02 is equipped with a High Level switch (LSH-116), that sends an alarm condition to the PLC, which shuts down the system and alerts the operator that a high level is reached, in order to prevent an overflow condition. NAPL separated groundwater gravity drains from the OWS into a 1,500 gallon Influent Equalization Tank (T-03).

Floating oil is collected in a horizontally cut pipe at the fluid surface of OWS-01, and this material drains to T-02. Collected oil will be removed from T-02 by licensed waste disposal contractors on an as needed basis, based on the operator's observations and recommendations.

Tank T-03 is fitted with a level transducer (LT-202) that provides an analog input to the system's PLC. The PLC provides outputs to separate VFDs which controls two Influent Equalization Transfer Pumps (P-02A and P-02B) piped in a parallel configuration. The system programming controls the VFDs to P-02A and P-02B such that one pump is running continuously in order to maintain a user programmable level set point in T-03. The PLC also uses the level transmitter's (LT-202) signal to generate programmed low and high level alarms. These are warning alarms only and will not shut down the system. Equalization Tank (T-03) is fitted with a High-High Level switch (LSHH-201), that sends an alarm signal to the PLC, which shuts down the system and alerts the operator in the event that a high level is reached, in order to prevent an overflow condition.

The system design dictates that each pump P-02A and P-02B shall each be capable of discharging the system design flow rate of 100 gpm. The system's control logic includes programming such that pumps P-02A and P-02B alternate operation on a daily basis.

4.1.4 Particulate Removal Process

Water is pumped from T-03 through sand filters which perform particulate removal. The Sand Filter Package (F-01A and F-01B) is configured to run in parallel during normal operations.

The sand filters are backwashed based on a differential pressure switch (DPSH-204) that monitors the differential pressure across the sand filter beds. A high differential pressure, as indicated by this pressure switch, triggers an automatic backwash of the vessels in a lead-lag fashion. While backwash is occurring on the lead vessel, system influent water continues to be processed through the lag vessel. Backwashing occurs for a user programmable period of time which is adjusted by the system operator based on system conditions. Then the sequence is reversed such that influent flows through the lead vessel while the lag is backwashed. When both vessels have been flushed, the system returns to its normal operating state (parallel flow). This sequence can also be manually initiated by the operator using the PLC.

The Sand Filter Package is backwashed with treated groundwater from the Effluent Equalization Tank (T-05) by a Backwash Pump (P-05). Particulate laden backwash water is directed to the Backwash Tank (T-04). The 2,500 gallon Backwash Tank allows sediments to settle out, and clarified water is then gravity decanted back to T-03. Accumulated sediments collected in T-04 are cleaned out manually as needed by the operator and disposed of by a licensed waste disposal contractor. The backwash tank is also fitted with a level transducer (LT-213), that will send a analog signal back to the PLC, but will also control the MOV-214 that will open (as necessary) to drain water from T-04 to T-03. This process will only occur if there is not sufficient capacity in T-04 to handle the pending backwash cycle.

Digital outputs from the PLC are utilized to control a series of eight motor operated valves (MOV-205 through MOV-212) located on the influent and effluent lines of each sand filter. The PLC controls these valves as necessary to allow automatic backwashing and system water treatment to occur as described above without the need for manual operations by the system operator. A manual backwash of the sand filters can be initiated on the Backwash Screen by the operator.

4.1.5 Secondary Treatment Process

After passing through the sand filters, the groundwater is treated for residual organics by a LPGAC Package (F-02A and F-02B), which are configured in series, but could be operated in parallel if desired based on system conditions. The operator must changed valves position manually in order to operate the GAC Package in a parallel configuration. The correct valve positions for backwashing and series and parallel operations are labeled on each valve in the field.

The operating pressure of the LPGAC Package is monitored by a differential pressure switch (DPS-301), which issues a discrete input to the PLC. The PLC is programmed to shut the system down and alert the operator in the event that a high pressure is reached.

4.1.6 Effluent Aeration

After passing through the LPGAC adsorbers, the groundwater is aerated to increase the dissolved oxygen by a Mazzei 2081 injector installed on the discharge piping of the secondary LPGAC adsorber. The injector is installed with a bypass line in the event that aeration is not necessary and if the total flow of the system rises above 60 gpm. The operator must adjust the bypass valve manually in the event of flows above 60 gpm to prevent an increase in backpressure. Manufacturers' information for the injector is presented in Appendix A.

4.1.7 pH Adjustment

After passing through the aerator, the groundwater pH is adjusted to meet NPDES permit requirements.

The pH adjustment system consists of an automated NaOH injection system. The automated NaOH injection system is installed to the effluent piping of the secondary liquid phase granular activated carbon (LPGAC) adsorber and prior to the effluent equalization tank (T-05). The pH adjustment equipment installed is as follows:

- 1 – 300-gallon capacity, horizontal polyethylene NaOH storage tank
- 1 – pH controller to provide real time effluent pH measurements and automatically adjust the NaOH injection
- 1 – pH probe to measure the effluent from the pH adjustment system
- 1 – 3-inch in-line static mixer
- 1 – 110 volt chemical feed pump with a capacity of 30 gallons per day at a pressure of 100 pounds per square inch.

The injection solution concentration is a 50% NaOH solution to increase the effluent pH of the HCC system above a minimum of 6.5 Standard Units (SU).

4.1.8 Treated Water Discharge Operations

Treated groundwater is collected in the Effluent Equalization Tank (T-05), with a 2,500-gallon capacity, and supplies water for backwashing and re-injection, while the remainder of the treated groundwater is discharged to the NPDES outfall if necessary.

Tank T-05 is fitted with a High-High level switch (LSHH-303) that shuts down the system and alerts the operator in the event that a high level is reached. T-05 is also fitted with a level transducer (LT-304) that provides an analog input to the system's PLC. The PLC provides outputs to a VFD which controls the NPDES discharge pump (P-03). The system programming controls the VFD to P-03 such that the pump runs continuously in order to maintain a user programmable set point in T-03. The PLC also uses the level transmitter's (LT-303) signal to generate programmed low and high level alarms. These are warning alarms only and will not shut down the system.

The Treated Water Injection Pump (P-04) runs continuously at a flow rate of approximately 20 gpm. Treated water discharge from P-04 is directed to the injection well manifold where it's directed to the East Gate at approximately 20 gpm. Flow control to the East Gate is measured by the flow transducer (FT-310B) which provides an analog input to the system's PLC. The discharge from the Injection Pump supplies the East Gate by using valves that are manually adjusted to control the injection rate. The manifold leg for the East Gate is fitted with a solenoid valve (SV309B).

4.1.9 Sump Pump Operations

Sump pumps (P-07A and P-07B) located in the northern and southern utility vaults, pump water that may accumulate in the vaults, into the groundwater return header pipe. This water is directed to OWS-01 where it is sent through the treatment plant. P-07A and P-07B operates based on a dual acting Low Level/High Level switch (LSL-114A, B and LSH-114A, B) installed in each vault that turn the sump pump on/off. Each sump is also fitted with a High-High Level switch (LSHH-114A, B), that sends an alarm condition to the PLC, which shuts down the system and alerts the operator that a high level is reached.

The building sump pump (P-06) located at the north wall of the HCC building pumps any water accumulating in the building drain/sump into the Influent Equalization Tank (T-03) or the Backwash Tank (T-04), depending on the position of hand valves. In normal operation the sump pump drains to Tank T-03. Pump P-06 operates based on a dual acting Low Level/High Level switch (LSL-215 and LSH-215), installed in each vault, that turn the sump pumps on/off. The sump is also fitted with a High-High Level switch (LSHH-215), that sends an alarm condition to the PLC, which shuts down the system and alerts the operator that a high level is reached.

Power supply for each sump pump is interlocked via the PLC, such that they are not permitted to operate, if there is a related alarm condition in the treatment plant (i.e., High Level Alarm).

4.1.10 HCC System Typical Operating Parameters

Based on the design criteria and operations of the system during 2010, a list of operational baseline parameters is presented in Table 4.1 to assist an operator in setting up the system in the event of a shut-down or data loss. This list is not intended to supersede the operators' experience and knowledge to changing operating parameters nor will it necessarily be correct in the event that site conditions change significantly.

Table 4-2 Typical Operating Parameters of the HCC System

Parameter	Typical Reading or Measurement	Typical System Setting	Notes
Inlet Flow	30 to 70 gpm	Inlet valve completely open	Influent typically greater in winter and spring and less in summer and fall
Influent Equalization Tank Level	2.00 ~ 2.25 Feet	2.00 ~ 2.25 feet input on Main MMI screen	Keep above influent transfer pump inlet to keep pumps primed
Sand Filter Inlet Pressure	~20 PSI	Influent transfer pump valves open 4 turns on discharge side of pump.	Inlet pressure above 40 PSI usually indicates backwash needed
Sand Filter Discharge Pressure	~5 to 10 PSI	All valves completely open; backwash valve ½ open.	Discharge pressure of sand filters equals inlet pressure of primary LPGAC adsorber
LPGAC Discharge Pressure	~5 to 10 PSI	All valves marked in field with proper open/closed setting	
Effluent Tank Level	4.5 Feet	4.5 feet input on Equalization or Pump Setup screen	Effluent tank must retain enough water to backwash either LPGAC or sand filters
NPDES Discharge Flow	30 to 70 gpm	Discharge valve completely open	Effluent typically greater in winter and spring and less in summer and fall
East Gate Discharge Flow	~17 to 20 gpm	Discharge flow controlled by ball valve	Pump discharge valve fully open
Data Logging Time Interval	4 Hours	Interval input on Pump Setup screen	Must be collected twice per day minimum (minimum setting is 12 hours)
Operating Hertz (Hz) of Influent Transfer Pump	~20 to 30 Hz	Operating Hz dependent on flow rate	If operating Hz above 40, sometimes trips sand filter backwash when not needed
Operating Hertz (Hz) of Effluent NPDES Transfer Pump	~20 to 30 Hz	Operating Hz dependent on flow rate	
Backwash Level	1.75 Feet	1.75 feet input on Backwash screen	Must have enough capacity to retain water from backwashing of LPGAC or sand filters

5.0 Data Acquisition, Data Logging, and Alarms

A desk-top PC will function as the MMI for this project. A series of custom screens display operating status of equipment, present real-time operating data, and provide a format for the operator to monitor and adjust control parameters such as level set points, timer settings, and other parameters as described in detail below. The screens also include graphical trending for a limited set of key operating parameters, and maintain a log of recent alarm conditions.

The PC-based MMI provides data logging for a wide range of operating data and conditions. Data is stored in tabular format and each file manages one calendar month worth of logged data. Snapshots of real-time data are logged at timed intervals that are set by the operator on an MMI screen. A separate file generates log system alarm conditions as they occur. Each logged entry is date and time stamped.

The PLC, MMI, and auto-dialer are programmed to notify the operator of a range of alarm conditions that occur in the field or in the treatment building. Alarm notifications are displayed on the MMI, logged on the PC and trigger a dial-out to notify the operator, or a combination of these based on the nature/severity of the alarm condition. The dialer is programmed such that the operator can locally or remotely acknowledge an active alarm so that repeated dial-outs for the same alarm condition are avoided and/or minimized. It is necessary for the operator to be physically present and address the situation that created the alarm and reset the acknowledged alarm at the MMI before affected equipment of the collection and treatment system re-start or return to normal operations. The alarm log differentiates between “active” alarms that must be addressed and/or reset by the operator, and historic alarms that have already been addressed.

The MMI allows the system operator to engage “START PROCESS” and “STOP PROCESS” switches. When the system is started, PLC control logic sequences startup of collection and treatment system motors to avoid initial amperage surge. The sequence starts with the treated water pump (P-03) and works backwards through the plant finishing with groundwater pumps P-01A through H. A ramp sequence is implemented such that all variable speed motors will commence at a minimum setting (% scale, Hz) and ramp up to the appropriate control setting determined by PLC logic. All treatment system operation follows the control logic as described below after the “START PROCESS” is engaged and the ramp sequence is completed. The “STOP PROCESS” shuts down all operations that are under automatic control. Treatment system operations run in “Hand” mode when the process has been stopped where configured to do so.

In addition to the PC-based MMI, a continuously operating video camera is mounted on top of the effluent equalization tank (T-05) to allow the system operator to remotely check for the presence of a sheen on the surface of the water in this tank. The direct video display of the surface of the water in this tank is accessed using a remote login via the Internet. The owner’s manual for the video camera is included in Appendix A.

Typical operating screens are presented in the following figures.

Figure 5.1 Main Operating Screen of the HCC System MMI

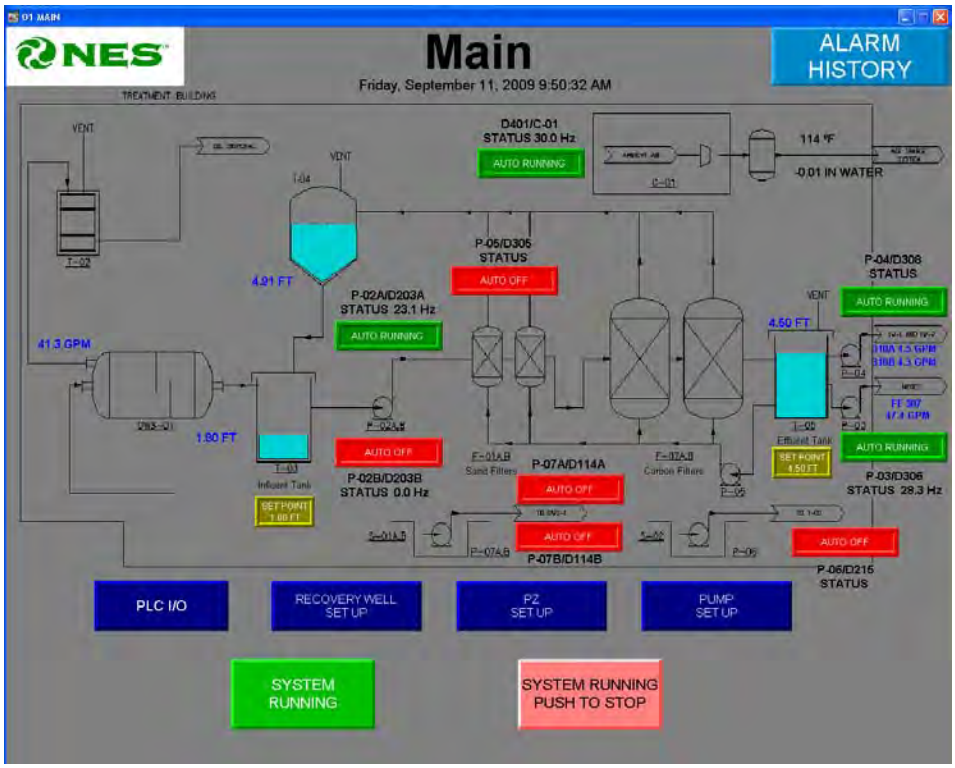


Figure 5.2 Pump Setup Screen of the HCC System MMI

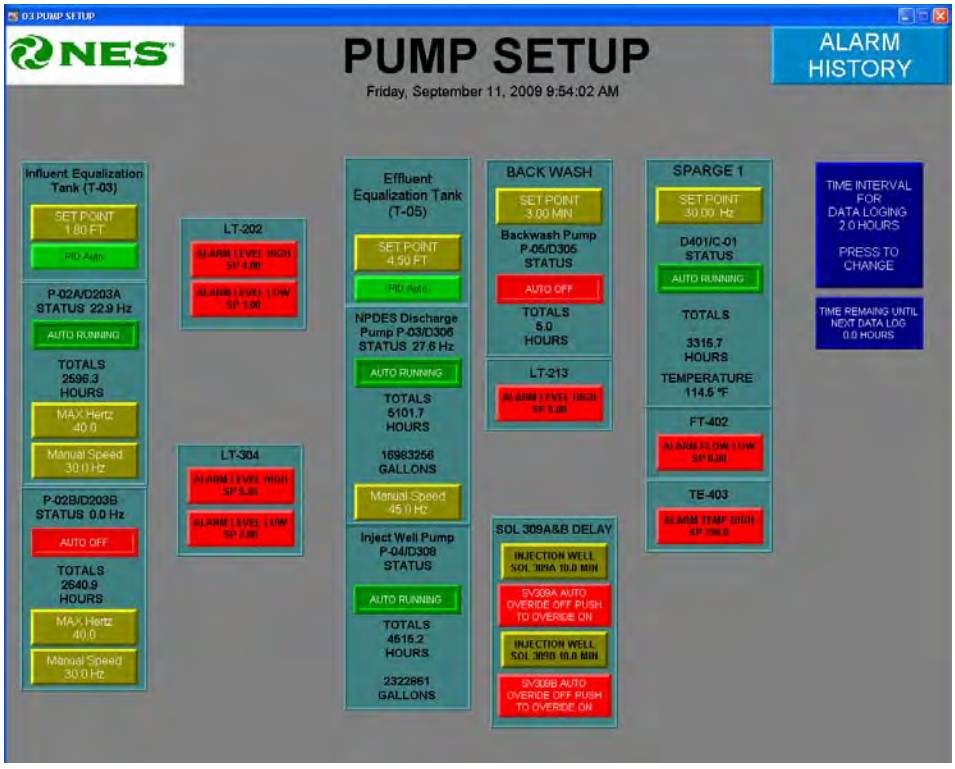


Figure 5.3 Piezometer Screen of the HCC System MMI

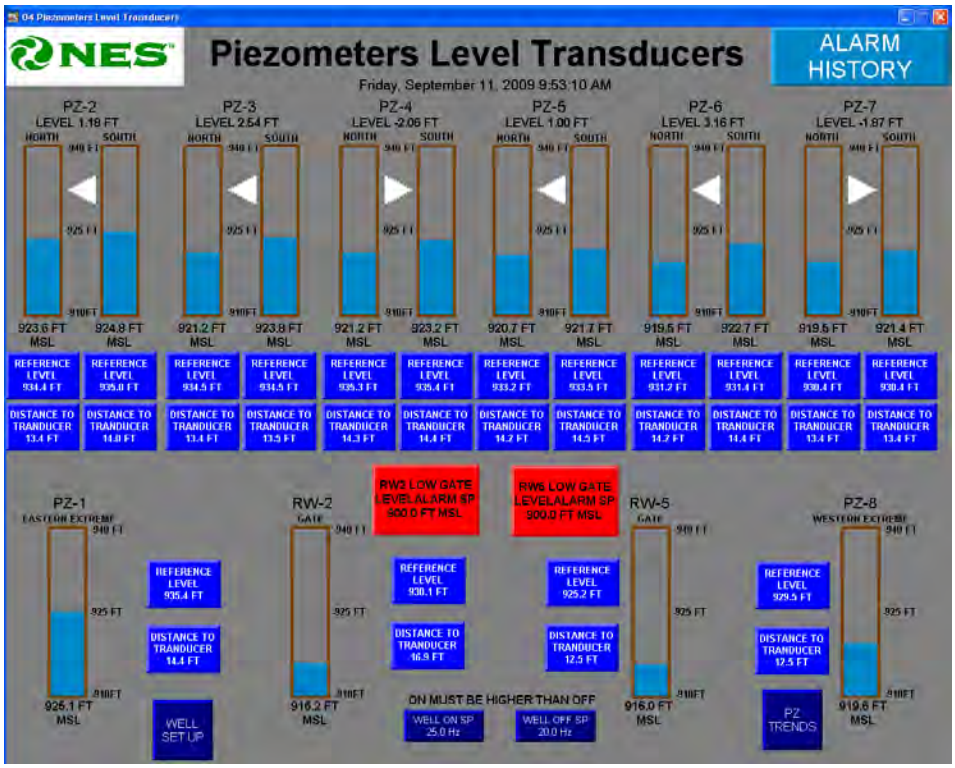


Figure 5.4 Recovery Well Screen of the HCC System MMI

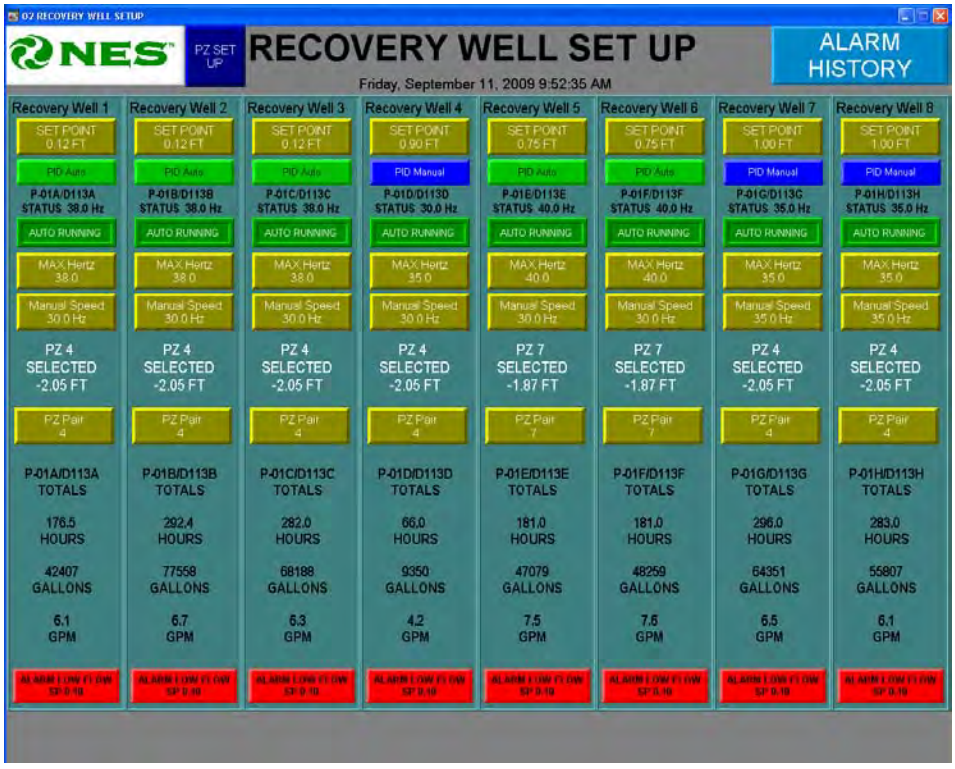


Figure 5.5 Influent Equalization Tank Screen of the HCC System MMI

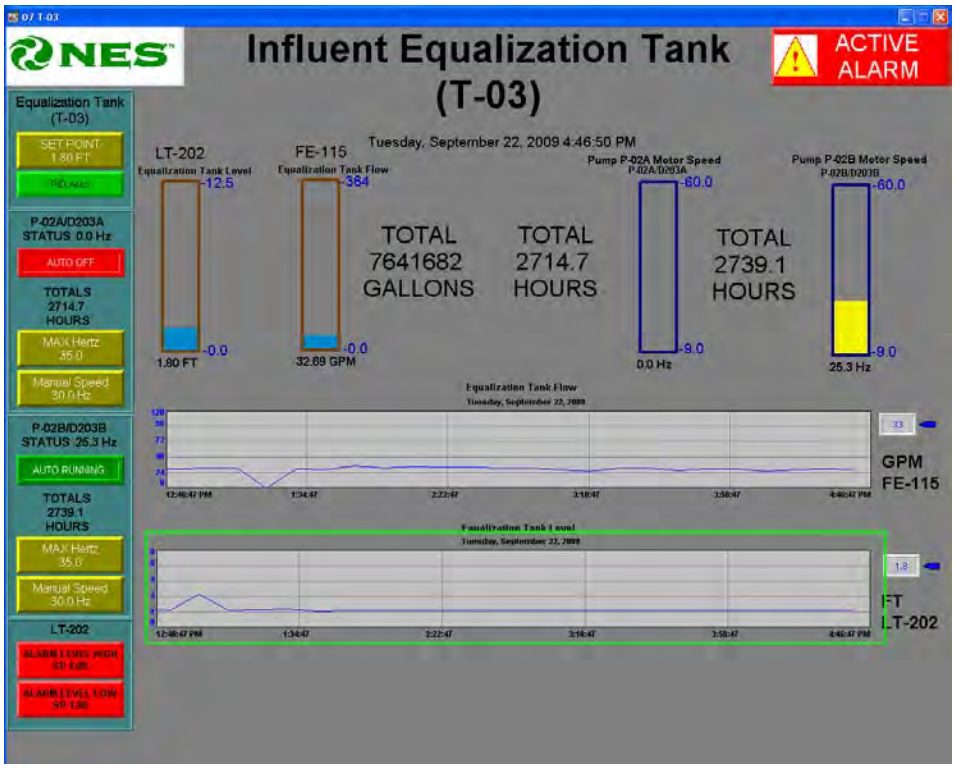


Figure 5.6 Effluent Equalization Tank Screen of the HCC System MMI

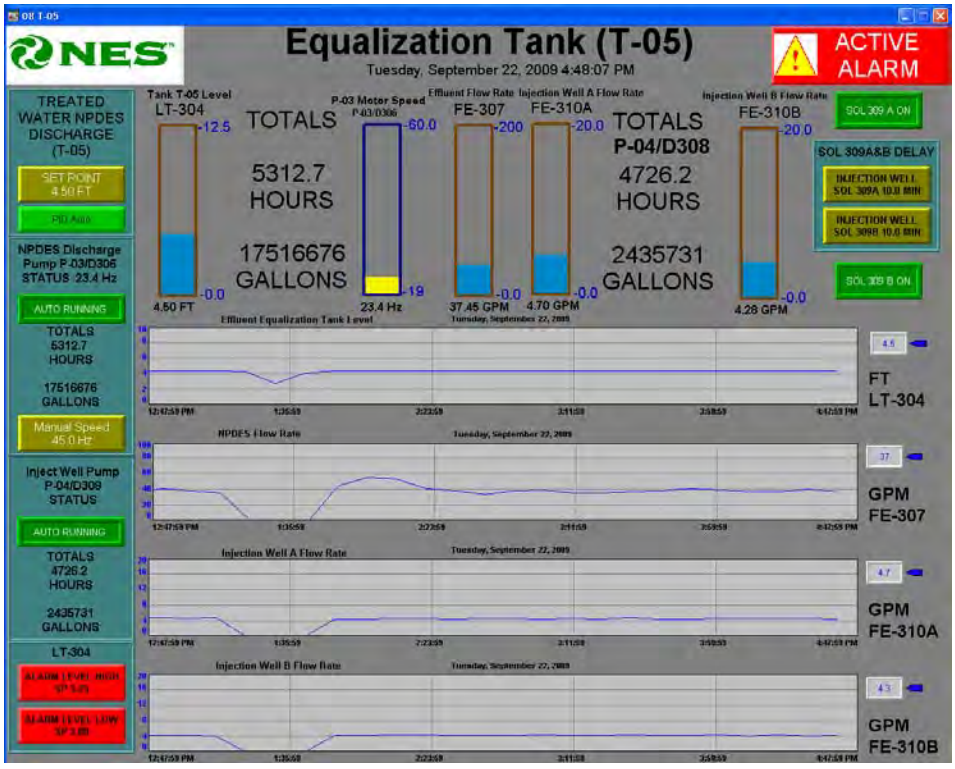


Figure 5.7 Backwash Screen of the HCC System MMI

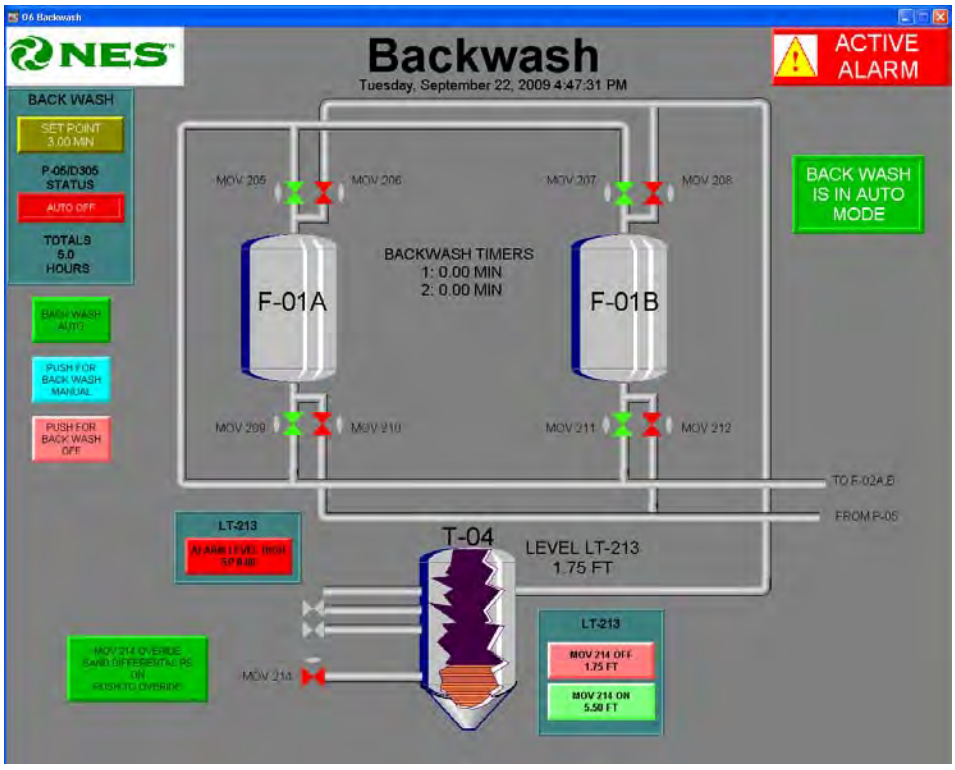


Figure 5.8 Input/Output Screen of the HCC System MMI

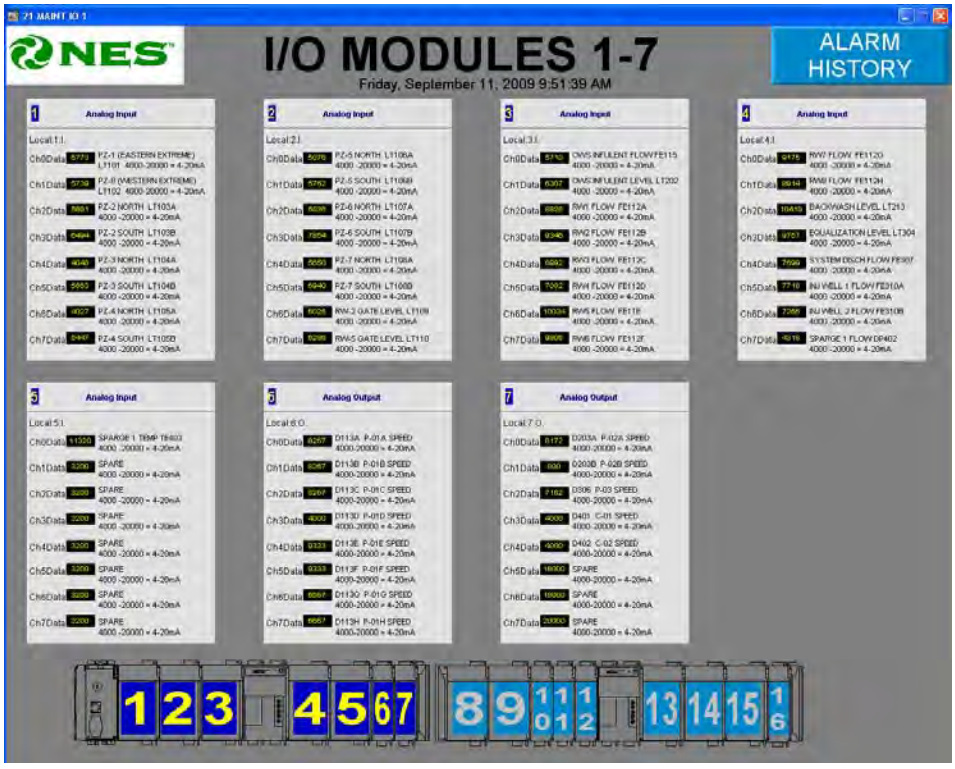
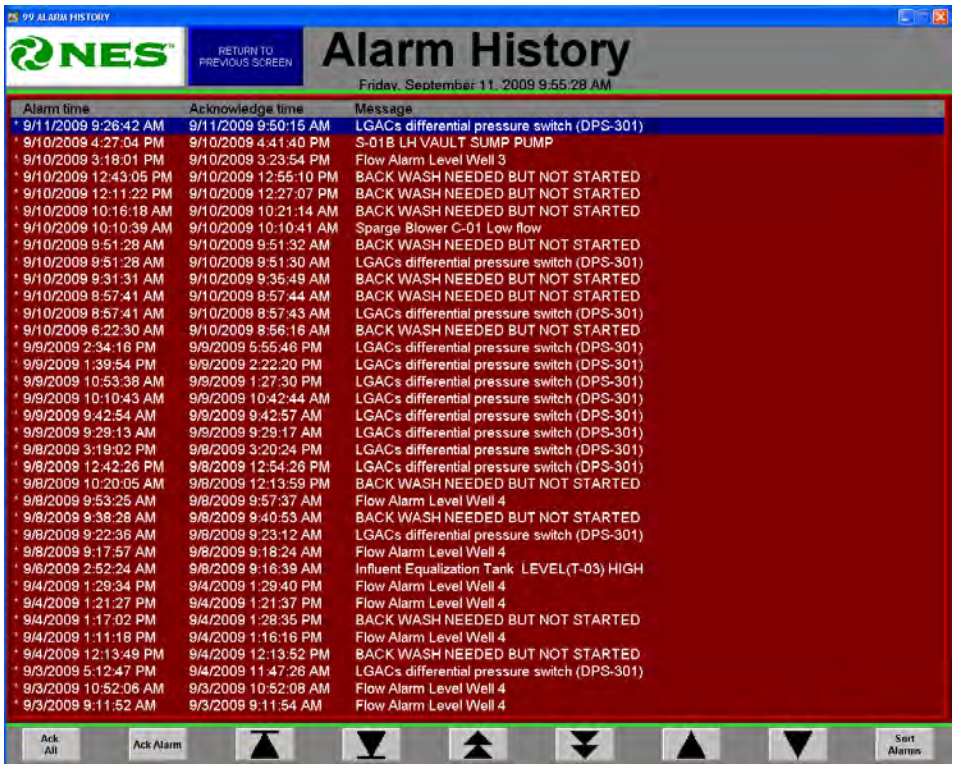


Figure 5.9 Alarm Screen of the HCC System MMI



6.0 Hydraulic Control and Containment System Monitoring

There are three types of system monitoring that will be conducted to ensure that HCC system effluent meets the discharge criteria outlined in the NPDES permit and that groundwater downgradient of the HCC barrier meets the groundwater Remediation Level (RL) outlined in the CAP. The three types of monitoring are the HCC NPDES monitoring, HCC system performance monitoring, and groundwater performance monitoring. These different types of system monitoring are described in more detail in the following subsections. The CMP should be referred to for more information.

6.1 HCC NPDES Monitoring

HCC NPDES monitoring is completed pursuant to the NPDES permit and is conducted to ensure that the discharge water criteria are within permitted limits. The NPDES monitoring requirements are detailed in the NPDES Discharge Permit No. WA-003212-3 attached as Appendix F.

6.1.1 HCC NPDES Monitoring Procedure

The following monitoring procedure has been written based on the 2010 procedures using Pace Analytical Services, Inc. in Seattle, WA and in accordance with NPDES Permit No. WA-003212-3 (3rd Modification) effective June 1, 2006 and expiring May 4, 2011. This should be used as reference only. Please check with the laboratory used for analyses and current NPDES permit to ensure all requirements are met.

1) Ensure that the laboratory has delivered coolers with the appropriate weekly or monthly kits. Monthly sampling occurs on the first Tuesday of the month and weekly sampling occurs on the remaining Tuesdays of the month. Each kit contains the following:

   Weekly:

   - 6 amber bottles, HCL preserved for NWTPH-Dx w/o silica gel cleanup analysis;
   - 1 poly bottle, HNO_3 preserved for total arsenic and lead 6020 and 200.8 analyses.

   Monthly:

   - Same as weekly kits, plus the following;
   - 2 amber bottles, unpreserved for PAH 8270 analyses;
   - 3 glass vials, HCL preserved for BTEX 8260B analyses.

2) When filling out the COC, Use the COC provided with the coolers and complete with the required information. See previous COCs for the correct information if necessary. All sampling is on a 24-hr Turn-Around-Time (TAT).

3) There are three locations to sample within the HCC treatment system. These locations are "Before GAC", "After Primary GAC" and "HCC-Effluent." When filling out COC, the sample ID is as follows: label appropriate previous name, followed by a dash and finally add that day's date. Example, if sampling on March 16, 2010, label: **Before GAC – 031610**

4) Sample locations:

    a. "Before GAC" in the treatment system is located in between the Sand Filter Units (F-01A, B) and the LPGAC vessels near the base of the Sand Filter platform. There is a clear tube running from a valve and has a label next to the valve that reads "Before GAC."

    b. "After Primary" in the treatment system is located in between the two LPGAC Adsorber Units (F-02A, B) near the base of the LPGAC platform. There is a clear tube running from a valve and has a label next to the valve that reads "After Primary."

    c. "HCC-Effluent" in the treatment system is located in the effluent line after the Effluent Equalization Tank Transfer Pump (P-03) near the base of the platform. There is a clear tube running from a valve and has a label next to the valve that reads "HCC-EFF."

5) Sample Procedures:

    a. When sampling the weekly event, collect water from the "Before GAC" with 2 amber bottles HCL preserved, from the "After Primary" with 2 amber bottles HCL preserved and from the "HCC-EFF" with 2 amber bottles HCL preserved and one poly bottle HNO_3 preserved.

    b. When sampling the monthly event, collect all samples as detailed in item 5a and then add at the "HCC-EFF" location with 2 amber bottles unpreserved and 3 glass vials HCL preserved.

6) Put all amber bottles and glass vials into bubble bags and poly bottle into Ziploc® bag that were provided in the laboratory kits.

7) Add ice and completed COC (in the provided Ziploc® bag) to the cooler. Make a copy of completed COC for record keeping.

8) Sign and attach custody seal to outside of cooler and use packaging tape over the custody seal to keep cooler lid shut.

9) Deliver the samples to Pace Analytical Services, Inc. at 940 South Harney Street, Seattle, WA 98108 within the required holding time frame.

6.2 HCC System Performance Monitoring

HCC system monitoring is monitoring that may be conducted to ensure that equipment inside the HCC building system is functioning as intended. Table 6.1 shows the different types of HCC system monitoring, the monitoring parameters and the suggested monitoring frequency.

6.2.1 Short Term HCC System Performance Monitoring

Short term system monitoring includes monitoring the system parameters shown in Table 6.1. Short term monitoring will be conducted for the first year of system operation. System monitoring after the first year is described in Section 6.3 of this manual. Monitoring data should be recorded in an on-site log book.

Short term system monitoring may consist of collecting grab samples of the influent, treated groundwater before the primary LPGAC adsorber, after the primary LPGAC adsorber, after the secondary LPGAC adsorber, and effluent after pH adjustment and aeration. Short term system monitoring also consists of recording the injection wells discharge rates. The water samples will be sent to an accredited laboratory under proper chain of custody, and analyzed for the parameters detailed in Section S2 of the NPDES permit

attached as Appendix F. Each HCC system performance monitoring sample will be analyzed with a five day turn-around-time. All sample results will be reported in accordance with the requirements of the NPDES permit. Table 6.1 gives a summary of the HCC system performance monitoring requirements. More information is given in the NPDES permit in Appendix F.

Table 6-1 Short Term HCC System Performance Monitoring

Location	Parameter(s)	Frequency
System Influent	Flow Rate	Daily by MMI
NPDES Outfall	Flow Rate	Daily by MMI
Sand Filter Influent	Pressure	Monthly
Primary LPGAC Adsorber Influent	Pressure	Monthly
Primary LPGAC Adsorber Effluent	Pressure	Monthly
Secondary LPGAC Adsorber Effluent	Pressure	Monthly
East Gate Injection	Flow Total	Monthly
Influent Sample	pH and Turbidity	Monthly
Backwash Tank	Sediment Depth	Monthly
Influent Equalization Tank	Sediment Depth	Monthly
Oil/Water Separator	Free Product Depth, Biological Growth, and Sediment	Monthly
Free Product Tank	Free Product Depth	Monthly

6.2.2 Long Term HCC System Performance Monitoring

The long term HCC system performance monitoring will begin after one year from startup. The frequency will be assessed based on the short term results. The long term monitoring will ensure system treatment meets NPDES requirements. Currently, the long term monitoring requirements are the same as the short term monitoring.

6.3 Groundwater Performance Monitoring

Groundwater performance monitoring will be performed in accordance with the CMP and will include groundwater monitoring to assess whether groundwater leaving the BNSF railyard facility meets the RL of 477 µg/L as measured using the Northwest Total Petroleum Hydrocarbons - Diesel Range (NWTPH-Dx) method and has an absence of sheen or free product, and that free product migration has been controlled.

Groundwater performance monitoring will be performed on a quarterly basis and will include the following monitoring wells.

- **End Wells:** EW-1 and EW-2, installed at each end of the HCC wall will be monitored to evaluate whether groundwater flowing past the ends of the trench meets the RL of 477

µg/L NWTPH-Dx. Groundwater monitoring in the end wells will consist of fluid level gauging and groundwater analytical testing using the NWTPH-Dx method.

- **Downgradient Wells:** Wells 5-A-43, 5A-W-44, 2A-W-40, 2A-W-41, 1B-W-23, 2A-W-42, and 1C-W-7 installed downgradient of the HCC wall will be monitored to evaluate whether groundwater flowing past the ends of the trench meets the RL of 477 µg/L NWTPH-Dx. Groundwater monitoring in downgradient wells will consist of NAPL gauging and groundwater analytical testing using the NWTPH-Dx method.
- **Gate Wells:** Wells GW-1, GW-2, GW-3, and GW-4 installed downgradient of the gates will be monitored to evaluate whether NWTPH-Dx concentrations in groundwater passing through the gates meets the RL of 477 µg/L NWTPH-Dx. Groundwater monitoring in the Gate Wells will consist of NAPL gauging and groundwater analytical testing using the NWTPH-Dx method.
- **Gate Sentry Wells:** Twenty wells installed in the reactive material in the gates will be monitored to evaluate treatment capacity and exhaustion rates. Groundwater monitoring in the Gate Sentry Wells will consist of groundwater analytical testing using the NWTPH-Dx method.
- **Piezometers:** Fourteen wells installed hydrogeologically up- and downgradient of the HCC wall will be monitored to demonstrate the inward gradient resulting from extraction well operation. Groundwater monitoring for piezometers will consist of measuring groundwater levels.

6.4 NPDES Discharge Sampling Violation

In the event sampling indicates an exceedence of an effluent limit in the NPDES permit, the following actions will be taken in accordance with the NPDES permit.

- The operator must take immediate action to stop, contain, and clean up unauthorized discharges or otherwise stop the noncompliance, correct the problem and, if applicable, repeat sampling and analysis of any non-complying discharges immediately and submit the results within five (5) days after becoming aware of the violation
- The operator must immediately notify the Department of Ecology.
- The operator must submit a detailed, written report to the Department of Ecology within five (5) days. The report shall contain a description of any noncompliance, including exact dates and times, and if any noncompliance has not been corrected, the anticipated time it is expected to continue; and the steps taken or planned to reduce, eliminate, and prevent reoccurrence of any noncompliance.
- Concurrent with reporting, the system operating data will be reviewed and the system will be repaired as soon as practicable.
- Once the system is restarted, grab samples of the inlet and discharge of the HCC treatment system must be collected and analyzed as detailed in Section S2 of The NPDES Permit (Appendix F), typically with a 24-hour turn-around time.
- The treatment system is then operated and monitored in accordance with normal operations upon successful results of the analytical samples.

7.0 Startup, Shutdown, and MMI Operational Procedures

The operational screens shown below are presented for the operator's general understanding of the MMI only. In the event that set points need to be adjusted, the project manager or Engineer should always be consulted.

7.1 Normal Startup

Operations of the system should be performed utilizing the MMI and PLC. Normal startup of the system is performed as follows.

1. Check to ensure all Hand/Off/Auto (HOA) switches on the control panel are in the "Auto" position.
2. Check to ensure the valves on the LPGAC skid are correctly positioned to operate in series configuration.
3. Check to ensure Tank T-03 is set at the set point level.
4. Check to ensure the ball valve for the system influent line is in the fully open position.
5. At the MMI on the MAIN screen (Figure 5.1), right click on the "System Stopped Push to Start" button in the lower left hand corner of the Main screen.
6. Check to ensure influent flow is occurring and continue to monitor T-03 and T-05 levels for a few minutes.

NOTE:

To return to the MAIN screen (Figure 5.3) from any sub-screen, left click on the NES button located on the top left hand side of each screen at any time.

7.2 Normal Shutdown

The system is designed to run continuously. If shutdowns are required for maintenance, routine cleaning, or other activities the following procedure should be followed:

1. If equipment is being repaired or maintenance performed, the piece of equipment being worked on needs to be properly isolated, following the LOTO procedure presented in Section 7.4

Operations of the system should be performed utilizing the MMI and PLC. Normal shutdown of the system is performed as follows.

1. On the MAIN screen (Figure 5.1), right click on the "System Running Push to Stop" button in the lower right hand corner of the screen.

2. Check to ensure the influent flow is not occurring.

7.3 Emergency Shutdown & E-Stop Buttons

There are five (5) Emergency Shutdown Switches (E-Stops) provided as part of the system. One (1) is located inside the Control Room/Office of the HCC Treatment System Building, while the other four (4) are located in the HCC Treatment System Building process area. When an E-Stop is triggered (pushed in) all system operations, are shut down, and the system auto dialer call out function is triggered alerting the operator. Before restart of the system can occur, the E-Stop that was triggered must be reset by physically pulling out the E-Stop button.

The system can also be shut down in an emergency by de-energizing (switching off) the Main Power Panel or using the MMI.

7.4 Using the MMI to Control Recovery Well Pumps

The RECOVERY WELL SET UP screen is shown in Figure 5.4. As shown, the RW pumps can operate in "PID Auto" (green) and "PID Manual" (blue) control. In "PID Manual" control the pumps operate at a user defined set point on the RECOVERY WELL SET UP screen. The user defined set point is in Hertz and determines the VFD output to the pump. The "PID Manual" operation can be seen in Figure 5.4 as RW-4, RW-7, and RW-8. To change the manual speed of the pump, left click on the "Manual Speed" screen button and input the desired speed and then click enter.

In "PID Auto" control the pumps operate based on the differential groundwater level across North/South piezometer pairs (PZ-2 through PZ-7) shown on the PIEZOMETERS LEVEL TRANSDUCER screen (Figure 5.3). The user defined set point is the differential in feet between the north piezometer and the south piezometer. This differential is set on the RECOVERY WELL SET UP screen (Figure 5.4) via the "Set Point" button at the top of the control screen. Pump speed is determined by how far off the actual groundwater differential is from the set point differential and is controlled by the PLC. To change the set point, left click on the "Set Point" button and input the desired set point and then press "Enter." The maximum speed of the pump can be controlled via the "MAX Hertz" button on the RECOVERY WELL SET UP screen. To change the set point, left click on the "MAX Hertz" button and input the desired hertz setting and then press "Enter." The "PID Auto" operation can be seen in Figure 5.4 as RW-1, RW-2, RW-3, RW-5, and RW-6.

NOTE:

In "PID Auto" mode, due to computer limitations, the differential groundwater level across a north/south piezometer pair must be a positive number. To correct this, a white triangular arrow was installed in the programming as shown on the PIEZOMETERS LEVEL TRANSDUCERS screen (Figure 5.3) between each piezometer pair. The arrow determines if the north piezometer level is subtracted from the south piezometer level or vice versa to ensure a correct calculation. The arrow direction can be changed in the event the differential becomes negative by left clicking the piezometer label (i.e. left click on PZ-3) on the PIEZOMETERS LEVEL TRANSDUCER screen.

7.5 Using the MMI to Control Tank Levels

Each tank set point level can set and adjusted using the MMI. The procedure for setting each tank level is described in the following sections.

7.5.1 Influent Equalization Tank Level (T-03)

From the MAIN screen (Figure 5.1), left click on the influent tank transfer pump (P-02A, B) icon. This will bring up the INFLUENT EQUALIZATION TANK screen (Figure 5.5). The level in the Influent Equalization

Tank (T-03) is controlled by the influent equalization transfer pumps (P-02A, B). The transfer pumps can operate in two modes, “PID Auto” and “PID Manual.”

In “PID Auto” mode the operator inputs the desired tank level and the computer controls the speed of the influent equalization pumps to maintain the set point level. This method of control should be used during normal operations. To change the set point, left click on the “Set Point” button at the top left hand side of the INFLUENT EQUALIZATION TANK screen (Figure 5.5) and input the desired set point and then press “Enter.” The set point should always be higher than the pump head to ensure the Influent Equalization Transfer Pump (P-02A, B) primes quickly. A typical range for this set point is between 1.80 feet and 2.00 feet.

In “PID Manual” mode the pump speed is determined by operator input. To place in “PID Manual” mode, left click on the “PID Auto/PID Manual” button on the top left hand side of the INFLUENT EQUALIZATION TANK screen (Figure 5.5) until it reads “PID Manual.” To change the set point, left click on the “Manual Speed” button and input the desired set point speed in Hertz and then press “Enter.”

The above changes can also be made on the PUMP SETUP screen. To get to the PUMP SETUP screen from the MAIN screen, left click on the “Pump Setup” button at the bottom right hand side of the screen. Follow the above procedures in the PUMP SETUP screen.

7.5.2 Effluent Equalization Tank Level (T-05)

From the MAIN screen (Figure 5.1), left click on the Effluent Tank Transfer Pump (P-03) icon. This will bring up the EQUALIZATION TANK screen (Figure 5.6). The level in the Effluent Equalization Tank (T-05) is controlled by the NPDES (P-03) and IW (P-04) transfer pumps. The NPDES transfer pump can operate in two modes, “PID Auto” and “PID Manual.”

In “PID Auto” mode the operator inputs the desired tank level and the computer controls the speed of the NPDES pump to maintain the set point level. This method of control should be used during normal operations. To change the set point, left click on the “Set Point” button at the top left hand side of the EQUALIZATION TANK screen (Figure 5.6) and input the desired set point and then press “Enter.” The set point should always be higher than the pump head to ensure the NPDES pump primes quickly. The typical set point is 4.50 feet.

In “PID Manual” mode the pump speed is determined by operator input. To place in “PID Manual” mode, left click on the “PID Auto/PID Manual” button on the top left hand side of the EQUALIZATION TANK screen (Figure 5.6) until it reads “PID Manual.” To change the set point, left click on the “Manual Speed” button and input the desired set point speed in Hertz and then press “Enter.”

The above changes can also be made on the PUMP SETUP screen. To get to the PUMP SETUP screen from the MAIN screen, left click on the “Pump Setup” button at the bottom right hand side of the screen. Follow the above procedures in the PUMP SETUP screen.

The IW Pump (P-04) speed is not controlled by a VFD. Therefore, it is an ON/OFF control and operates at 60 Hz. The IW Pump (P-04) is turned on at the main control panel inside the HCC Building. The flow to the East Gate is controlled by manually setting the ball valve located on the pump skid.

7.5.3 Backwash Tank Level (T-04)

From the MAIN screen (Figure 5.1), left click on the sand filter (F-01A, B) icon. This will bring up the BACKWASH screen (Figure 5.7). The backwash tank (T-04) is plumbed to the Influent Equalization Tank

(T-03) via four outlets on the Backwash Tank. The lowest outlet on the Backwash Tank (T-04) is controlled by an electrically actuated valve (MOV-214). The two outlets above the lowest outlet are controlled by manual ball valves. The highest outlet has no valve control and is installed as an overflow outlet. Only the lowest discharge outlet piping can be controlled by the MMI screen.

Water level in the Backwash Tank (T-04) is controlled by high and low level settings located to the right of the Backwash Tank (T-04) on the BACKWASH screen (Figure 5.7). The "MOV-214 Off" sets the low level in the Backwash Tank (T-04) and the "MOV-214 On" button sets the high level in the Backwash Tank (T-04). To change the set point on either button, left click on the desired button and input the desired set point level in feet and then press "Enter." Once a backwash cycle is initiated, the water level rises in the Backwash Tank (T-04) until the high set point is reached, MOV-214 opens to begin draining the Backwash Tank (T-04) until the low level is reached and MOV-214 closes.

To override the above procedure and open/close MOV-214, left click on the "MOV-214 Override Sand Differential On Push to Override" button located at the bottom left hand side of the BACKWASH screen (Figure 5.7).

7.6 Using the MMI to Control HCC Building Pumps

Limited control of each HCC system pump may be achieved through the MMI for operator convenience. The following sections describe which pumps and attributes can be controlled utilizing the MMI and which attributes must be controlled via the on-site control panel located in the HCC Building.

7.6.1 Using the MMI to Control the Influent Equalization Pumps (P-02A, B)

The Influent Equalization Transfer Pumps (P-02A, B) are a redundant system meaning only one pump operates at a time. The PLC automatically switches between operating pumps every 24 hours. The Influent Equalization Transfer Pumps (P-02A, B) can be operated in "PID Auto" mode or "PID Manual" mode. To change modes, from the MAIN screen left click on the Influent Equalization Transfer Pump (P-02A, B) icon to open the INFLUENT EQUALIZATION TANK (T-03) screen (Figure 5.5). Left click on the "PID Auto/Manual" button at the top left hand side of the INFLUENT EQUALIZATION TANK (T-03) screen (Figure 5.5). This button toggles between "PID Auto" mode and "PID Manual" mode. This can also be set on the PUMP SETUP screen (Figure 5.2) using the same procedure.

In "PID Auto" mode the operator inputs the desired tank level and the computer controls the speed of the influent equalization pumps to maintain the set point level. This method of control should be used during normal operations. However, there may be times when manual control of the Influent Equalization Transfer Pump (P-02A, B) is necessary. It should be noted that only the operating (based on the daily cycling by the PLC) pump (P-02A, B) can be controlled. The operator cannot switch between operating pumps using only the MMI. Switching between operating pumps can only be performed using the on-site control panel in the HCC Building.

To control the Influent Equalization Transfer Pump (P-02A, B) manually, place the pumps in "PID Manual" mode as outlined above. The pump speed is now determined by operator input. To change the set point (pump speed), left click on the "Manual Speed" button and input the desired set point speed in Hertz and then press "Enter." This will change the operating pump only.

From the PUMP SETUP screen both the operating and non-operating pump speeds can be changed as well as the maximum allowable speed of each pump. From the MAIN screen left click on the "Pump Setup" button located at the bottom right hand side of the screen. On the left hand side of the PUMP SETUP screen is the Influent Equalization Tank Transfer Pump (P-02A, B) controls. An indicator icon (Auto

Running/Auto Off" is displayed to indicate which pump (P-02A or P-02B) is operating. To change the speed of either pump, left click on the "Manual Speed" button for the pump, input the desired speed in Hertz and then press "Enter." To change the maximum speed of either pump, left click on the "Max Hertz" button for the pump, input the desired speed in Hertz and then press "Enter." The pump will not run higher than the maximum in either "PID Auto" or "PID Manual" modes.

7.6.2 Using the MMI to Control the NPDES Pump (P-03)

The NPDES Transfer Pump (P-03) can be operated in "PID Auto" mode or "PID Manual" mode. To change modes, from the MAIN screen left click on the NPDES Transfer Pump (P-03) icon to open the EQUALIZATION TANK (T-05) screen (Figure 5.6). Left click on the "PID Auto/Manual" button at the top left hand side of the EQUALIZATION TANK (T-05) screen (Figure 5.6). This button toggles between "PID Auto" mode and "PID Manual" mode. This can also be set on the PUMP SETUP screen (Figure 5.2) using the same procedure.

In "PID Auto" mode the operator inputs the desired tank level and the computer controls the speed of the NPDES Transfer pump (P-03) to maintain the set point level. This method of control should be used during normal operations. However, there may be times when manual control of the NPDES Transfer Pump (P-03) is necessary.

To control the NPDES Transfer Pump (P-03) manually, place the pumps in "PID Manual" mode as outlined above. The pump speed is now determined by operator input. To change the set point (pump speed), left click on the "Manual Speed" button and input the desired set point speed in Hertz and then press "Enter."

To change the NPDES Pump (P-03) speed from the PUMP SETUP screen (Figure 5.2), perform the following procedure. From the MAIN screen (Figure 5.1) left click on the "Pump Setup" button located at the bottom right hand side of the screen. On the center of the PUMP SETUP screen are the NPDES Discharge Pump (P-03) controls. An indicator icon (Auto Running/Auto Off" is displayed to indicate whether the NPDES Pump is operating. To change the speed of the NPDES Transfer Pump (P-03), left click on the "Manual Speed" button for the pump, input the desired speed in Hertz and then press "Enter."

7.6.3 Using the MMI to Control the IW Pump (P-04)

The IW Pump (P-04) is not controlled by the MMI. The IW Pump (P-04) speed is not controlled by a VFD. Therefore, it is an ON/OFF/AUTO control and operates at 60 Hz. The IW pump is turned on at the main control panel inside the HCC Building. The flow to the East Gate is controlled by manually setting the ball valve located on the pump skid.

7.6.4 Using the MMI to Control the Backwash Pump (P-05)

The Backwash Pump (P-05) provides the necessary flow to backwash the Sand Filters (F-01A, B) and the LPGAC adsorbers (F-02A, B). The influent of the Backwash Pump (P-05) is plumbed to the Effluent Equalization Tank (T-05) and is directed through the Sand Filters (F-01A, B) and LPGAC adsorbers (F-02A, B) based on valve positioning. The Sand Filters (F-01A, B) are backwashed by the PLC automatically based on a differential pressure reading between the influent and effluent of the Sand Filter bed. The LPGAC adsorbers (F-02A, B) are backwashed by the operator manually by adjusting necessary valve positions.

The Backwash Pump (P-05) can be operated in ON/OFF/AUTO mode. To change modes, from the MAIN screen left click on the Sand Filter (F-01A, B) icon to open the BACKWASH screen (Figure 5.7). This opens the BACKWASH screen (Figure 5.7). To place the Backwash Pump (P-05) in "Auto" mode left click on the "Backwash Auto" button. To place the Backwash Pump (P-05) to "On" mode left click on the "Push for

Backwash Manual" button. To place the Backwash Pump (P-05) in "Off" mode left click on the "Push for Backwash Off" button.

The backwashing of the Sand Filters (F-01A, B) is performed based on an operator time setting. To change the time each Sand Filter (F-01A, B) is backwashed left click on the "Setpoint" button located on the top left hand side of the BACKWASH screen. Input the desired backwash interval in minutes and then press "Enter." The current backwash set point time is displayed on the "Setpoint" button. This setpoint can also be input on the PUMP SETUP screen (Figure 5.2) using the same procedure. It should be noted that the backwash time should never exceed the holding capacity of the Backwash Tank (T-04) based on the backwash flow rate.

The backwashing of the LPGAC Adsorbers (F-02A, B) is performed manually. Therefore, the operator must turn on/off the Backwash Pump (P-05) utilizing the on-site control panel located in the HCC Building. The backwash timer will not shutdown the Backwash Pump (P-05) when backwashing the LPGAC Adsorbers (F-02A, B) manually.

7.6.5 Using the MMI to Control the Building Sump Pump (P-06)

The Building Sump Pump (P-06) is not controlled by the MMI. The Building Sump Pump speed is not controlled by a VFD. Therefore, it is an ON/OFF/AUTO control and operates at 60 Hz. The Building Sump Pump (P-06) is turned on at the main control panel inside the HCC Building. In "Auto" mode it operates off a floating level switch installed in the sump vault. All water pumped from the sump vault is pumped to the Backwash Tank (T-04). During normal operations this pump should be placed in "Auto" mode.

7.6.6 Using the MMI to Control the Utility Vault Sump Pumps (P-07A, B)

The Utility Sump Pumps (P-07A, B) are not controlled by the MMI. The Utility Sump Pumps (P-07A, B) speed is not controlled by a VFD. Therefore, it is an ON/OFF/AUTO control and operates at 60 Hz. The Utility Sump Pump (P-07A, B) is turned on at the main control panel inside the HCC Building. In "Auto" mode each pump operates off a floating level switch installed in the corresponding vault. All water pumped from the Utility Sump Pumps (P-07A, B) is pumped to the Oil/Water Separator (OWS-01). During normal operations this pump should be placed in "Auto" mode.

7.7 PLC/MMI Automatic Data Logging

7.7.1 Data Logging Files

The PLC automatically records data at a programmed time interval. These files are stored on the site PLC located in the HCC Building office in MS Excel format. The files are stored to the following location on the PLC:

C:\Documents and Settings\All Users\Documents\Data_Storage

The data collected is stored in five individual files named:

1. Alarm (Month Date Collected)
2. Alarm_Level (Month Date Collected)
3. Alarm_Motors (Month Date Collected)
4. Flow_Level (Month Date Collected)
5. Flow_Totals (Month Date Collected)

7.7.2 Information Contained in the Data Logging Files

The following parameters are recorded in the associated data files:

1. Alarm File
    a. A complete file of all alarms that records every time an alarm was active by means of a binary record (0 indicating off, 1 indicating active).

2. Alarm_Level File
    a. A file of the level alarms that records every time a level alarm was active by means of a binary record (0 indicating off, 1 indicating active).

3. Alarm_Motors
    a. A file of the motor alarms that records every time a motor alarm was active by means of a binary record (0 indicating off, 1 indicating active).

4. Flow_Level File
    a. A file of the HCC system flow rates in gpm for the Influent Equalization Tank Transfer Pump (P-02a, B), Effluent Equalization Tank Transfer Pump (P-03), IW -1, and IW-2.
    b. A file of the HCC system tank levels in feet for the Influent Equalization Tank (T-03), Backwash Tank (T-04), and Effluent Equalization Tank (T-05).

5. Flow_Totals File
    a. A file of the HCC system flow totals in gallons for the Influent Equalization Tank Transfer Pump (P-02A, B), Effluent Equalization Tank Transfer Pump (P-03), IW-1, and IW-2.

7.7.3 Using the MMI to Change the Data Logging Time Interval

The time interval between data logging intervals is set by the operator. From the MAIN screen (Figure 5.1), left click on the “Pump Setup” button located in the lower right hand corner of the screen. This will bring up the PUMP SETUP screen (Figure 5.2). The current data logging time interval is shown on the dark blue button located on the top right of the PUMP SETUP screen (Figure 5.2). To change the data logging interval left click on the button “Time Interval for Data Logging-Press to Change” button. Input the desired data logging interval in hours and then press “Enter.” The time interval setting should never exceed 12 hours.

8.0 Maintenance and Troubleshooting

Maintenance and troubleshooting are essential to the system operations to minimize system downtime and ensure discharge requirements are achieved consistently. To assist in troubleshooting the systems, an electrical schematic is presented as Appendix G.

8.1 Hydraulic Control and Containment Barrier Maintenance

8.1.1 Passive Gate Media Management

The media installed in the passive flow through gates will be assessed utilizing the groundwater analytical data collected from the upgradient and downgradient Gate Sentry Wells. In the event of NWTPH-Dx concentrations being detected in the downgradient Gate Sentry Wells a repeat sample should be collect and analyzed to confirm the previous detection prior to replacing the gate activated carbon.

8.1.2 Well Maintenance and Re-Development

Flow rates measured from the individual recovery wells is used to determine if redevelopment of the recovery wells is necessary during operations. In the event that redevelopment is necessary, only one recovery well should be shut down at a time for redevelopment.

8.2 Hydraulic Control and Containment Treatment System Maintenance

8.2.1 Down Well Pumps

Operation of the Grundfos Redi-Flo 4 submersible pump requires minimal scheduled maintenance. However, due to subsurface conditions the submersible pumps should be pulled from the RWs and cleaned every six months. In the event that the RW pump(s) require servicing, maintenance of the RW pumps should be performed in accordance with the manufacturers specifications provided in Appendix D.

The Grundfos Redi-Flo 4 submersible pumps installed in each RW consist of a close couple pump and Franklin Electric motor assembly within a cooling shroud. The specifications for the pump and motor are listed below.

Grundfos Redi-Flo 4 Pump Specifications:

Type: 10E05-8
Model: B9030008-P10831
RPM: 3450
Frequency: 60 Hertz
Flow: 19 gpm
Maximum Head: 155 Feet of Water

Franklin Electric Motor Specifications:

Model: 2345232303
Horsepower: 1 Hp
RPM: 3450
Full Load Amperage (FLA): 2.4 Amps

Electricity Type: 3-Phase
Power: 750 Watts (0.75 KW)
Voltage: 460 Volts
Frequency: 60 Hertz
Nominal Amperage: 2 Amps

Due to iron fouling, the RW pumps should be cleaned every six months or sooner if flow rates begin to decrease below design capacity (~8 gpm at 60Hz) to remove the iron buildup. Each pump should be pulled from the well disassembled and iron buildup removed.

8.2.2 Recovery Well Skimmers

Setup, operations, and maintenance of the Abanaki Skimmer systems are detailed in the manufacturer's literature presented in Appendix D. Regular maintenance is not required, however monthly visual inspections should be performed on each unit to assure proper operation. Inspection of the discharge troughs and hose should be performed monthly during the visual inspection. In addition, if the free product storage tank attached to the skimmer either fills up more than monthly or does not fill up within a month, the on/off timer located on the inside of the control panel door should be adjusted with the goal of filling the tank on a monthly basis. If the belt is in need of replacement follow the instructions on Page 6 of the manufacturer's literature presented in Appendix D.

In the event the free product storage tank experiences a high level condition, the material contained in the tank should be inspected for quantity of free product. If free product is present a licensed recovery company should be dispatched to remove the tank contents. If only impacted water is present in the tank it should be disposed of the in the OWS of the HCC system.

8.2.3 Transfer Piping

The transfer piping associated with the HCC system was designed to require little if any maintenance. However, piping will be visually inspected where practicable on a monthly basis. This inspection should be performed in each recovery well vault, injection well vault, and in the HCC treatment building. All piping should be visually inspected for integrity and leaks. In addition, during the down well pump cleaning, the inside of piping should be inspected for build-up of iron oxide and other materials.

The 1.25-inch piping, 1-inch check valve, and 1.25-inch ball valve located inside the RW vault above-grade should be cleaned every 6 months. The piping should be disassembled at the check valve and ball valve unions and the flow meter removed. The iron build-up on the inside of the pipe should be removed by a pipe snake or similar tool.

8.2.4 OWS (OWS-01)

The OWS is a gravity flow tank from inlet to outlet. It is constructed with an underflow baffle for water and an overflow baffle for separation of free product. In addition, packing material is installed within the tank facilitate the separation of water and free product. Maintenance on the OWS is determined by the influent of the system and should be assessed by the operator on a yearly basis. Based on the first year's performance the tank should be inspected on a monthly basis for silt and biofouling accumulation inside the tank. In addition, based on the first year performance it is anticipated that the tank should be drained, packing removed, and cleaned biannually.

8.2.5 Free Product Storage Tank (T-02)

The free product storage tank consists of a 55-gallon steel drum installed in an over-pack container that accepts free product from the OWS via a gravity line. The free product storage tank requires little maintenance, but should be visually inspected biannually to ensure integrity. In addition, the high level switch should also be tested biannually to ensure proper operation.

8.2.6 Influent Equalization Tank (T-03)

The influent equalization tank consists of a 1,500-gallon polyethylene tank and accepts the effluent flow of the OWS. The influent equalization tank requires little maintenance, but should be visually inspected on a weekly basis to ensure integrity and cleaned biannually removing any solids build-up. In addition, the high-high level switch should also be tested biannually to ensure proper operation.

8.2.7 HCC System Lubrication Procedures

Lubrication of the motors installed in the HCC Building should be performed in accordance with manufacturer's recommendations. The influent equalization transfer pump maintenance will be performed in accordance with the Baldor-Reliance Motor Manual #MN400 presented in Appendix A.

Acceptable lubrication grease is:

1. Polyrex EM (Mobil)
2. Texaco Polystar
3. Rykon Premium #2
4. Pennzoil Pen 2 Lube
5. Chevron SRI

Lubrication Procedure:

Be sure that the grease you are adding to the motor is compatible with the grease already in the motor. Consult a Baldor distributor or an authorized service center if a grease other than the recommended type is to be used.

Do not over-lubricate motor as this may cause excessive bearing temperatures, premature lubrication breakdown, and bearing failure.

1. With the motor stopped, clean all grease fittings with a clean cloth.
2. Remove grease outlet plug.
3. Add the recommended amount of grease.
4. Operate the motor for 15 minutes with grease plug removed. This allows excess grease to purge.
5. Re-install grease outlet plug.

8.2.8 Influent Equalization Transfer Pumps (P-02A, B)

The influent equalization transfer pump maintenance will be performed in accordance with the manufacturers' recommendation included in Appendix A. The Y-strainer located at the influent of the pump should be cleaned on a monthly basis. The lubrication procedures are detailed in Section 8.2.7 as well as the manufacturer's literature in Appendix A.

In accordance with the Baldor-Reliance Motor Manual #MN400 presented in Appendix A, Tables 3.1 through 3.3, using a severe operating condition, the schedule for lubrication of the motor bearings of the Influent Equalization Tank Transfer Pump (P-02A, B) is once every 1,800 hours (75 days).

Based on the bearings detailed in the specifications the quantity of grease needed for lubrication is 0.19 ounces or 0.7 cubic inches (2.5 teaspoons).

The name plate specifications for the P-02A motor are listed below.

Baldor-Reliance Super E Motor Specifications (Pump P-02A):

Catalog Number: EJMM2394T
Serial Number: Z0804150141
Spec.: 09P014Y599G1
HP: 15 Horsepower
Volts: 230/460 Volts
Amps: 34.4/17.2 Amps
Frequency: 60 Hertz
RPM: 3525 RPM
Frame: 254JM
Electricity Type: 3-Phase
Service Factor: 1.15; Code H; Des B; Class F
NEMA Nominal Efficiency: 91.7%
Power Factor: 88%
Rating: 40C Ambient-Continuous
Usable @ 208 Volts: 36.5 Amps
Bearings: DE=6309; ODE=6208
Enclosure: TEFC

The name plate specifications for the P-02B motor are listed below.

Baldor-Reliance Super E Motor Specifications (Pump P-02B):

Catalog Number: EJMM2394T
Serial Number: Z0804150091
Spec.: 09P014Y599G1
HP: 15 Horsepower
Volts: 230/460 Volts
Amps: 34.4/17.2 Amps
Frequency: 60 Hertz
RPM: 3525 RPM
Frame: 254JM
Electricity Type: 3-Phase
Service Factor: 1.15; Code H; Des B; Class F
NEMA Nominal Efficiency: 91.7%
Power Factor: 88%
Rating: 40C Ambient-Continuous
Usable @ 208 Volts: 36.5 Amps
Bearings: DE=6309; ODE=6208
Enclosure: TEFC

8.2.9 Sand Filter Package (F-01A, B)

Water is pumped from the influent equalization tank through sand filters, which perform particulate removal. The sand filter package is configured to run in parallel during normal operations.

The primary maintenance of the sand filters is backwashing. The sand filters are backwashed automatically by the PLC based on a differential pressure switch (DPSH-204) that monitors the differential pressure across the sand filter beds. A high differential pressure, as indicated by this pressure switch, triggers an automatic backwash of the vessels in a lead-lag fashion. Under normal operating conditions input from the operator is not necessary. The backwash flow rate for the individual sand filters should be between 85 and 100 gpm.

Due to normal operations over time the sand in the filters should be inspected, and replaced in the event that the efficiency of the unit deteriorates. Sand inspection is performed by removing the top man-way and visually inspecting the level and condition of the sand and inner tank. This inspection should be performed on a yearly basis. In the event that sand replacement is necessary, the existing sand should be removed and disposed of by a licensed waste contractor and replaced with the following:

- 450 pounds of 1/8 x 1/16 pea gravel (bottom layer)
- 500 pounds of 0.8 to 1.2 torpedo sand (middle layer)
- 850 pounds of 0.45 to 0.55 filter fine sand (top layer).

8.2.10 Liquid Phase Granular Activated Carbon Units (F-02A,B)

After passing through the sand filters, the groundwater is treated for residual organics by a LPGAC adsorber package (F-02A and F-02B), which are configured in series, but could be operated in parallel if desired based on system conditions.

The primary maintenance of the LPGAC adsorbers is backwashing. The LPGAC adsorbers are backwashed manually by the operator based on a differential pressure switch (DPSH-204) which monitors the differential pressure across the LPGAC adsorbers. A high differential pressure, as indicated by this pressure switch, triggers an alarm on the MMI alerting the operator. The primary and secondary LPGAC adsorbers are backwashed individually. The backwash flow rate for the individual adsorbers should be between 250 and 295 gpm.

The procedure for backwashing the LPGAC is as follows.

1. Turn off the HCC System as outlined in Section 7.2.
2. Manually change the valve positions on the LPGAC package as indicated on each valve for the desired unit. Typically the primary LPGAC adsorber is backwashed first. A total of 12 valves are located and labeled on the LPGAC skid package.
3. Close the backwash influent valve (labeled on the valve in the field) on the sand filter skid package.
4. Ensure the backwash tank is at the set-point.
5. On the control panel change the position of the backwash pump (P-05) HOA switch from Auto to Hand. This will start the backwash pump (P-05).
6. Backwash the LPGAC adsorber for a period of 6 minutes.

7. On the control panel change the position of the backwash pump (P-05) HOA switch from Hand to Auto. This will stop the backwash pump (P-05).
8. Manually change the valve positions on the LPGAC package as indicated on each valve to return to normal operations. A total of 12 valves are located and labeled on the LPGAC skid package.
9. Return the inlet backwash valve (labeled on the valve in the field) on the sand filter skid package to the half-open position.
10. Restart the HCC system as outlined in Section 7.1.

In the event that the secondary LPGAC adsorber requires backwashing, wait a minimum of 30 minutes to drain the backwash tank to allow settling of the particulates from the last backwash cycle. Once the backwash tank is drained to the set-point, repeat the backwash procedure for the secondary LPGAC adsorber.

In accordance with the NPDES permit, samples of the influent and effluent of the LPGAC adsorbers are collected on weekly basis and analyzed as described in Section 6.1. If the analyses show TPH concentrations above the permit limits, the LPGAC is exhausted and requires replacement. Replacement of the LPGAC should be coordinated and performed by a LPGAC vendor. The spent LPGAC removed from the LPGAC adsorbers is disposed of by a licensed contractor.

8.2.11 Aerator

Aeration is provided by a Mazzei 2081 injector installed on the discharge piping of the secondary LPGAC adsorber. The injector is installed with a bypass line in the event that aeration is not necessary and if the total flow of the system rises above 60 gpm. The aerator requires no regular maintenance; the manufacturers' information is contained in Appendix A.

8.2.12 Effluent Equalization Tank (T-05)

The effluent equalization tank consists of a 2,500-gallon polyethylene tank and accepts the effluent flow of the secondary LPGAC adsorber. The effluent equalization tank requires little maintenance, but should be visually inspected on a weekly basis to ensure integrity and cleaned biannually to remove any solids build-up. In addition, the low and high-high level switch should also be tested biannually by draining/filling the tank to ensure proper operation.

8.2.13 Treated Water NPDES Discharge Pump (P-03)

The treated water NPDES discharge pump requires minimal maintenance, which should be performed in accordance with the manufacturers' recommendation included in Appendix A. The Y-strainer located at the influent of the pump should be cleaned on a monthly basis. The lubrication procedures are detailed in Section 8.2.7 as well as the manufacturer's literature in Appendix A.

In accordance with the Baldor-Reliance Motor Manual #MN400 presented in Appendix A, Tables 3.1 through 3.3, using a severe operating condition, the schedule for lubrication of the motor bearings of the NPDES pump is once every 6,000 hours (250 days).

Based on the bearings detailed in the specifications the quantity of grease needed for lubrication is 0.19 ounces or 0.3 cubic inches (1 teaspoon).

The name plate specifications for the P-03 motor are listed below.

Baldor-Reliance Super E Motor Specifications (Pump P-03):

Catalog Number: EJMM3615T
Serial Number: F0809045124
Spec.: 36H017T031E7
HP: 5 Horsepower
Volts: 230/460 Volts
Amps: 13/6.5 Amps
Frequency: 60 Hertz
RPM: 1750 RPM
Frame: 184JM
Electricity Type: 3-Phase
Service Factor: 1.15; Code K; Des B; Class F
NEMA Nominal Efficiency: 90.2%
Power Factor: 80%
Rating: 40C Ambient-Continuous
Usable @ 208 Volts: 13.6 Amps
Bearings: DE=6207; ODE=6205
Enclosure: TEFC

8.2.14 Treated Water Injection Pump (P-04)

The treated water injection pump requires minimal maintenance, which will be performed in accordance with the manufacturers' recommendation included in Appendix A. The Y-strainer located at the discharge of the pump should be cleaned on a monthly basis. The lubrication procedures are detailed in Section 8.2.7 as well as the manufacturer's literature in Appendix A.

The name plate specifications for the P-04 motor are listed below.

Baldor-Reliance Super E Motor Specifications (Pump P-04):

Catalog Number: BM04876
Serial Number: W0801170931
Spec.: 34K674-3226G2
HP: 5 Horsepower
Volts: 190/380-415 Volts
Amps: 2.4/1.2-1.4 Amps
Frequency: 50 Hertz
RPM: 2850 RPM
Frame: 56CZ
Electricity Type: 3-Phase
Service Factor: 1.6; Code U; Des B; Class B
NEMA Nominal Efficiency: 68%
Power Factor: 52%
Rating: 40C Ambient-Continuous
Bearings: DE=6203; ODE=6203
Enclosure: TEFC

8.2.15 Backwash Tank (T-04)

The backwash tank consists of a 2,500-gallon polyethylene tank and accepts flow from the building sump pump and backwash water generated from backwashing the sand filters and LPGAC adsorbers. The

effluent equalization tank requires little maintenance, but should be visually inspected on a weekly basis to ensure integrity and cleaned biannually to remove any solids build-up generated by backwashing.

8.2.16 Backwash Pump (P-05)

The backwash pump requires minimal maintenance, which will be performed in accordance with the manufacturers' recommendation included in Appendix A. The Y-strainer located at the influent of the pump should be cleaned on a monthly basis. The lubrication procedures are detailed in Section 8.2.7 as well as the manufacturer's literature in Appendix A.

In accordance with the Baldor-Reliance Motor Manual #MN400 presented in Appendix A, Tables 3.1 through 3.3, using a severe operating condition, the schedule for lubrication of the motor bearings of the NPDES pump is once every 1,800 hours (75 days).

Based on the bearings detailed in the specifications the quantity of grease needed for lubrication is 0.19 ounces or 0.7 cubic inches (2.5 teaspoons).

The name plate specifications for the P-05 motor are listed below.

Baldor-Reliance Super E Motor Specifications (Pump P-05):

Catalog Number: JMM3711T
Serial Number: F0808113930
Spec.: 37M031T968
HP: 10 Horsepower
Volts: 208-230/460 Volts
Amps: 26.2-23.8/11.9 Amps
Frequency: 60 Hertz
RPM: 3450 RPM
Frame: 215JM
Electricity Type: 3-Phase
Service Factor: 1.15; Code H; Des B; Class F
NEMA Nominal Efficiency: 87.5%
Power Factor: 90%
Rating: 40C Ambient-Continuous
Bearings: DE=6309; ODE=6206
Enclosure: TEFC

8.3 Hydraulic Control and Containment Treatment System Calibration

Calibration of the HCC system instruments are described in Appendices A and D. Calibration of instruments should be performed once per year at a minimum or as described in the manufacturer's recommendations.

8.3.1 Recovery Well Flow Meter (FE-112)

Check to ensure operation of sensors FE-112 on a yearly basis. Compare flow readings with an actual timed flow rate. In the event of a discrepancy calibrate in accordance with the manufacturers procedures presented in Appendix A or if necessary replace.

8.3.2 Recovery Well and HCC System Pressure Gauges

Check to ensure operation of the pressure gauge on a yearly basis. Compare pressure readings with previous data to ensure accuracy. In the event of a pressure gauge failure replace with a like kind.

8.3.3 Recovery Well and Piezometer Pressure Transducers (LT-101 ~ LT-108)

Check to ensure operation of transducers LT-101 through LT-108 on a yearly basis. Compare level readings with the actual groundwater level data. In the event of a discrepancy calibrate in accordance with the manufacturers procedures presented in Appendix A.

8.3.4 HCC System Influent Flow Meter (FE-115)

Check to ensure operation of sensors FE-115 on a yearly basis. Compare flow readings with an actual timed flow rate. In the event of a discrepancy calibrate in accordance with the manufacturers procedures presented in Appendix A or if necessary replace.

8.3.5 HCC System Influent Equalization Tank Level Transducer (LT-202)

Check to ensure operation of the transducer LT-202 on a yearly basis. Compare level readings with the actual tank level. In the event of a discrepancy ensure there is no blockage in the transducer tubing and if necessary calibrate in accordance with the manufacturers procedures presented in Appendix A.

8.3.6 Sand Filter Differential Pressure Transducer (DPSH-204)

Check to ensure operation of the transducer DPSH-204 on a yearly basis. In the event of a failure ensure there is no blockage in the transducer tubing and if necessary calibrate in accordance with the manufacturers procedures presented in Appendix A.

8.3.7 LPGAC Adsorber Differential Pressure Transducer (DPSH-301)

Check to ensure operation of the transducer DPSH-301 on a yearly basis. In the event of a failure ensure there is no blockage in the transducer tubing and if necessary calibrate in accordance with the manufacturers procedures presented in Appendix A.

8.3.8 HCC System Effluent Equalization Tank Level Transducer (LT-304)

Check to ensure operation of the transducer LT-304 on a yearly basis. Compare level readings with the actual tank level. In the event of a discrepancy ensure there is no blockage in the transducer tubing and if necessary calibrate in accordance with the manufacturers procedures presented in Appendix A.

8.3.9 HCC System Injection Flow Meter (FE-310B)

Check to ensure operation of sensors FE-310B on a yearly basis. Compare flow readings with an actual timed flow rate. In the event of a discrepancy calibrate in accordance with the manufacturers procedures presented in Appendix A or if necessary replace.

8.3.10 HCC System Effluent Equalization Transfer Pump Flow Meter (FE-307)

Check to ensure operation of sensors FE-307 on a yearly basis. Compare flow readings with an actual timed flow rate. In the event of a discrepancy calibrate in accordance with the manufacturers procedures presented in Appendix A or if necessary replace.

8.3.11 HCC System Backwash Tank Level Transducer (LT-213)

Check to ensure operation of the transducer LT-213 on a yearly basis. Compare level readings with the actual tank level. In the event of a discrepancy ensure there is no blockage in the transducer tubing and if necessary calibrate in accordance with the manufacturers procedures presented in Appendix A.

8.4 Alarm Condition Solutions

Based on the first year of operations, Table 8.1 detailing frequent alarm conditions has been produced to assist the operating in troubleshooting an alarm condition.

Table 8-1 Alarm Troubleshooting

Alarm Condition	Possible Cause(s)	Possible Solution(s)
1) Flow Alarm Level Well (1 through 8)	Water level in well below pump inlet.	Allow recovery well to recover and restart pump.
	Flow meter not operating.	Check for flow in recovery well vault and pressure at RW pressure gauge in vault. If flow refer to flow meter manufacturer's troubleshooting procedures.
2) Backwash Needed But Not Started	Automatic backwash turned off.	On the Backwash screen left click the "Push For Backwash Auto" button.
	Backwash tank above set-point	Drain backwash tank until water level reaches set-point.
3) Sparge Blower C-01 Low Flow	Sparge blower started up.	Reset alarms and check to see if alarm condition continues. Upon blower startup this alarm condition occurs, but does not continue.
	Low flow to AS system	Increase flow to individual AS wells using the control valves in the AS vault.
4) LGACs Differential Pressure Switch (DPS-301)	LPGAC adsorber(s) need to be backwashed.	Backwash LPGAC adsorbers as detailed in Section 10.2.10.
5) Influent Equalization Tank Level (T-03) High	Y-Strainer clogged and does not allow flow into influent transfer pump (P-02A,B).	Shutdown HCC system, clean both y-strainers, and restart HCC system.
	Discharge pressure on influent transfer pump (P-02A,B) too high.	Check pressure gauges for high drops. Sand filters or LPGAC adsorbers may need backwashing.
	Pipe blockage between tank T-03 and effluent equalization tank (T-05)	Check pressure gauges for increased pressure and large pressure drops. Check lines for blockage and remove.
	Influent transfer pump (P-02A, B) has lost prime.	Prime pump.
	Influent flow above 100 gpm.	Reduce the speed of the RW pumps in the recovery wells on the "Recovery Well Setup Screen" until influent flow is less than 100 gpm.
	Backwash tank emptied too quickly into tank T-03.	Reduce the flow to tank T-03 from the backwash tank by slightly closing the ball valve in the pipe between the backwash tank and influent equalization tank.

Alarm Condition	Possible Cause(s)	Possible Solution(s)
5) Influent Equalization Tank Level (T-03) High *(continued)*	LPGAC adsorber(s) need to be backwashed.	Check pressure gauge on discharge of pump P-02A,B, pressure at inlet of primary LPGAC, outlet of primary LPGAC, and outlet of secondary LPGAC for high pressure drop. Backwash LPGAC adsorber(s) if needed as detailed in Section 10.2.10.
	Sand filters need to be backwashed.	Check pressure gauge on discharge of pump P-02A,B, pressure at inlet of sand filter, and pressure gauge at discharge of sand filters for high pressure drop. Backwash sand filters.
6) No Control Power	Power failure.	Reset alarm on MMI and check to see if condition continues. Call PSE if necessary.
	Control power switch off on control panel.	Turn on control panel switch, reset alarm on MMI.
7) No 120 VAC Input Power	Power failure.	Reset alarm on MMI and check to see if condition continues. Call PSE if necessary.
	Breaker or power switch turned off.	Check power switch and breakers for tripped condition. Turn on control power switch/reset breaker, reset alarm on MMI.
	480 V to 120 V Transformer *(located on concrete pad outside of HCC building by man door)* problem.	Check power switch to transformer and breaker to see if tripped. Turn on control power switch/reset breaker, reset alarm on MMI. Call electrician if necessary.
8) Motor Fault Alarm	Power failure.	Reset alarm on MMI and check to see if condition continues. Call PSE if necessary.
	Motor overload tripped.	Check motor overload on starter in control panel and reset. Reset alarm on MMI.
	Breaker tripped.	Check motor breaker and reset. Reset alarm on MMI. Call Electrician if necessary.
9) Equalization Tank (T-03) High-High	Float switch in tank tripped.	Check to ensure High-High level in tank T-03. Float switch may be caught. Reset alarm on MMI and check to see if condition continues.
	Tank water level at high-high condition.	Follow Item 5 Possible Solutions.
	Injection well transducer reading incorrectly.	

9.0 Safety

Safety is a function of procedures, maintenance, and management. It is the responsibility of all personnel. All personnel must be committed to accident avoidance and safe operations. Common sense and good judgment should be exercised at all times. At a minimum, the precautions listed below should be observed.

- Wear hard hats and steel-toed boots to protect against injuries from piping and equipment
- Wear safety glasses to protect eyes
- Wear goggles when handling chemicals and waste
- Wear rubber gloves to prevent unnecessary skin contact during sampling and maintenance, etc.
- No smoking, open flames, welding, or other activity that might produce ignition should be permitted near the system where a combustible mixture may be present
- Lock out power if work is required on equipment
- Practice good housekeeping.

Personnel should be aware of and observe applicable OSHA regulations and local codes. Refer to the site specific Health and Safety Plan (HASP) for details regarding site specific hazards and job specific safety procedures.

9.1 HCC Building Safety

Safety practices within the HCC building are described above and adherence to all AECOM, OSHA, and BNSF requirements is mandatory. It is the responsibility of all personnel. All personnel must be committed to accident avoidance and safe operations. Common sense and good judgment should be exercised at all times. At a minimum, the precautions listed below should be observed.

- Wear hard hats and steel toe boots to protect against injuries from piping and equipment
- Wear safety glasses to protect eyes
- Wear goggles when handling chemicals and waste
- Wear rubber gloves to prevent unnecessary skin contact during sampling and maintenance, etc.
- No smoking, open flames, welding, or other activity that might produce ignition should be permitted near the system where a combustible mixture may be present
- Lock out power if work is required on equipment
- Practice good housekeeping.

Personnel should be aware of and observe applicable OSHA regulations and local codes. Refer to the *Site Specific Health and Safety Plan* (HASP) and the *Emergency Action Plan for the Hydraulic Control and Containment System* (AECOM 2009).

9.2 HCC Vault Safety

Safety practices while working within the on-site vaults are detailed in the Job Safety Analysis for each type of vault and presented in the HASP.

9.3 Lock-Out/Tag-Out Procedure

9.3.1 De-energizing Equipment/Machine

Prior to working on any equipment, the operator must be certified by AECOM, to conduct LOTO procedures at which time a personal lock and key will be provided to the employee.

The following step-by-step procedure must be followed to shut down, isolate, block and secure this piece (or class) of equipment/machine:

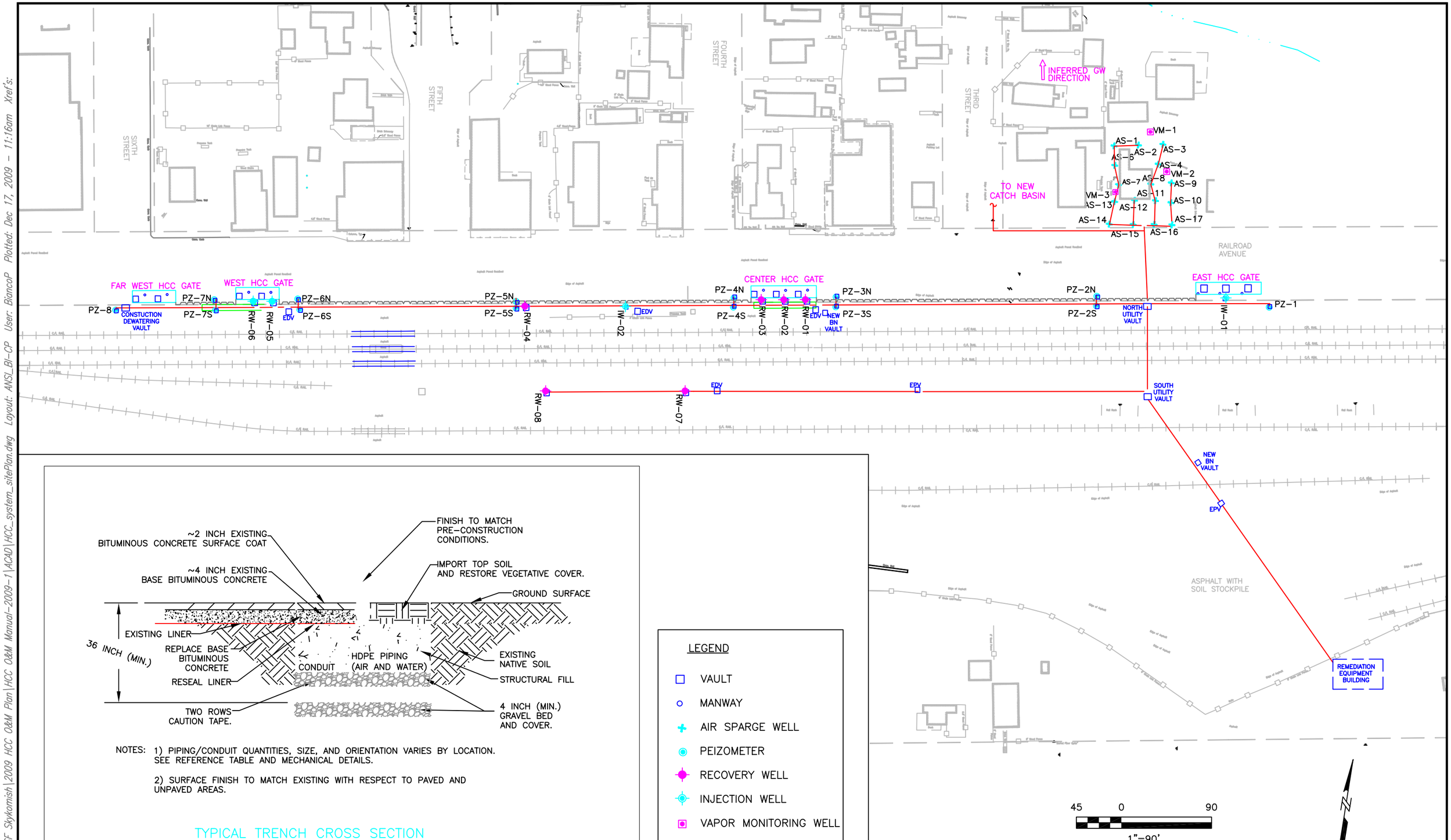
1. Notify all affected personnel (operators of machine/equipment, etc.) that LOTO procedures are in effect.
2. Turn off the machine or piece of equipment being serviced/repaired.
3. Activate all energy-isolating devices (i.e., circuit breaker) to block energy flow from every energy source that feeds the equipment.
4. Apply lock to each energy-isolating device so that the isolating device is held in a "safe" or "off" position.
5. Attempt activation to verify zero-energy state. If equipment doesn't start up, it can be serviced safely.

9.3.2 Re-energizing Equipment/Machine

Before lockout devices are removed and energy is restored, the following procedures will be followed:

1. Inspect the work are to verify all non-essential items have been removed.
2. Retrieve all loose tools.
3. Re-install all machine guards (if removed during maintenance/repair).
4. Notify all affected personnel that LOTO devices are being removed from equipment/machinery. Make sure personnel are safely positioned away from the equipment/machinery.
5. Verify that all equipment controls are in the OFF position
6. Remove all LOTO devices from energy isolating devices. The authorized employee who applied the lock is the only employee who is authorized to remove it.
7. Turn on the energy isolating devices to restore energy to the equipment/machine.

Figures



NOTES: 1) PIPING/CONDUIT QUANTITIES, SIZE, AND ORIENTATION VARIES BY LOCATION. SEE REFERENCE TABLE AND MECHANICAL DETAILS.

2) SURFACE FINISH TO MATCH EXISTING WITH RESPECT TO PAVED AND UNPAVED AREAS.

TYPICAL TRENCH CROSS SECTION

LEGEND

- VAULT
- MANWAY
- AIR SPARGE WELL
- PEIZOMETER
- RECOVERY WELL
- INJECTION WELL
- VAPOR MONITORING WELL

AECOM

THE BNSF RAILWAY COMPANY SKYKOMISH, WASHINGTON 60136319-0510			HCC SYSTEM SITE PLAN
DATE: 12/7/09	DRWN: E.M./SEA		FIGURE 1-1

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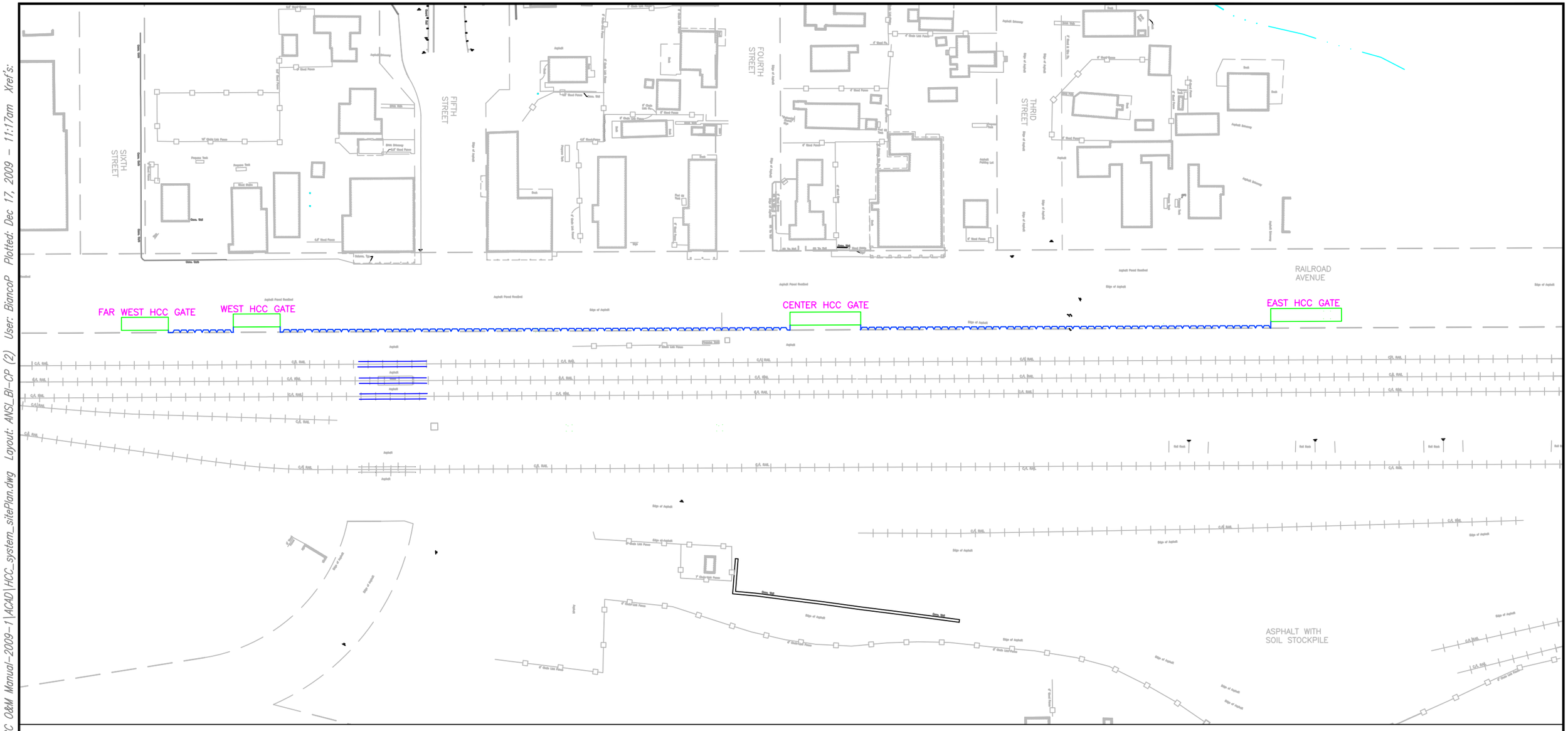

AECOM

THE BNSF RAILWAY COMPANY SKYKOMISH, WASHINGTON 60136319-0510			**PHYSICAL BARRIER SITE PLAN**
DATE: 12/7/09	DRWN: E.M./SEA		**FIGURE 2-1**

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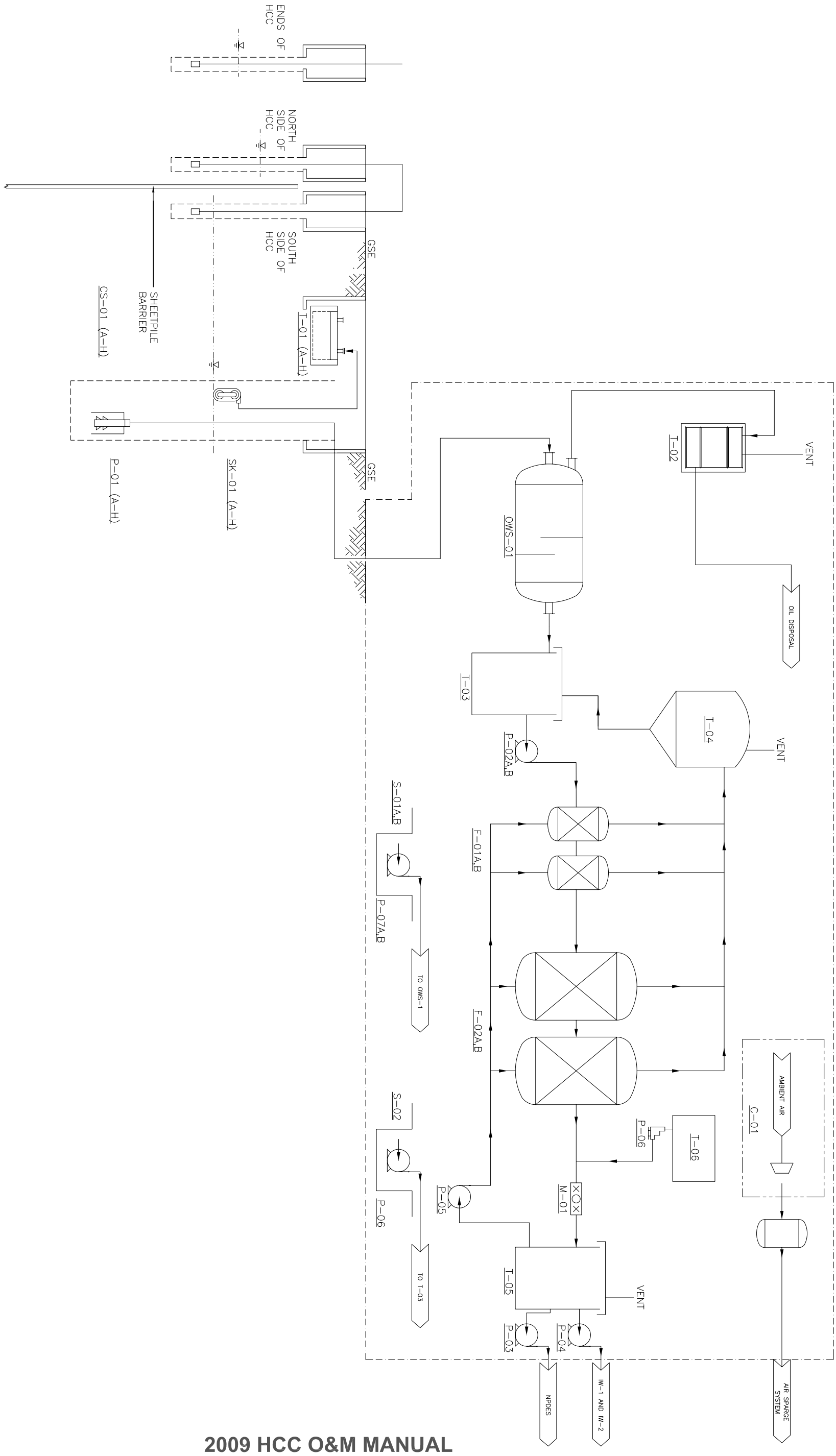

P-01 (A-H) DOWN WELL SUBMERSIBLE PUMP
CS-01 (A-H) COOLING SHROUD DOWN WELL SUBMERSIBLE PUMP
SK-01 (A-H) OIL RECOVERY BELT SKIMMER PACKAGE
T-01 (A-H) RECOVERED OIL STORGE TANK & OVERPACK
OWS-01 OIL/WATER SEPARATOR
T-02 RECOVERED OIL STORAGE TANK & OVERPACK
T-03 INFLUENT EQUALIZATION TANK
P-02A,B INFLUENT EQUALIZATION TANK FILTER PUMP
F-01A,B SAND FILTER PACKAGE
F-02A,B GRANULAR ACTIVATED CARBON PACKAGE
T-05 EFFLUENT EQUALIZATION TANK
T-04 BACKWASH TANK
P-03 TREATED WATER NPDES DISCHARGE PUMP
P-04 TREATED WATER INJECTION PUMP
P-05 BACKWASH PUMP
P-06 BUILDING SUMP PUMP
P-07A,B UTILITY VAULT SUMP PUMP
S-01A,B UTILITY VAULT SUMP
S-02 BUILDING FLOOR SUMP
C-01 AIR SPARGE BLOWER
T-06 NaOH STORAGE TANK
M-01 STATIC MIXER
P-06 NaOH METERING PUMP

2009 HCC O&M MANUAL

FIGURE NUMBER: 4-1a

DRAWING NUMBER: 1

PROCESS AND INSRUMENTATION DIAGRAM
REMEDIATION SYSTEM
PROCESS FLOW DIAGRAM

THE BNSF RAILWAY COMPANY
SKYKOMISH, WAHINGTON

SCALE:	DATE:	PROJECT NUMBER:
NTS	11/20/08	01140-222-0210

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DESIGNED BY:
DRAWN BY:
CHECKED BY:
APPROVED BY:

REVISIONS

NO.:	DESCRIPTION:	DATE:	BY:
1	ISSUED FOR BID	4/08	SAC
2	ISSUED FOR CONSTRUCTION	6/08	SAC
3	ISSUED FOR CONSTRUCTION-REV 1	7/08	SAC
4	FOR ELECTRICAL BID	9/08	RCW
5	ISSUED FOR CONSTRUCTION-REV2	10/08	RCW/BcV

P-01 (A-H)
DOWN WELL SUBMERSIBLE PUMP
1 HP VFD
460 VAC, 3ø, 0-60 Hz

CS-01 (A-H)
COOLING SHROUD DOWN WELL SUBMERSIBLE PUMP

SK-01 (A-H)
OIL RECOVERY BELT SKIMMER PACKAGE
460 VAC SUPPLY
INTEGRAL 460/120 TRANSFORMER
120 VAC, 1ø, 7 AMPS

T-01 (A-H)
RECOVERED OIL STORAGE TANK & OVERPACK

LEGEND

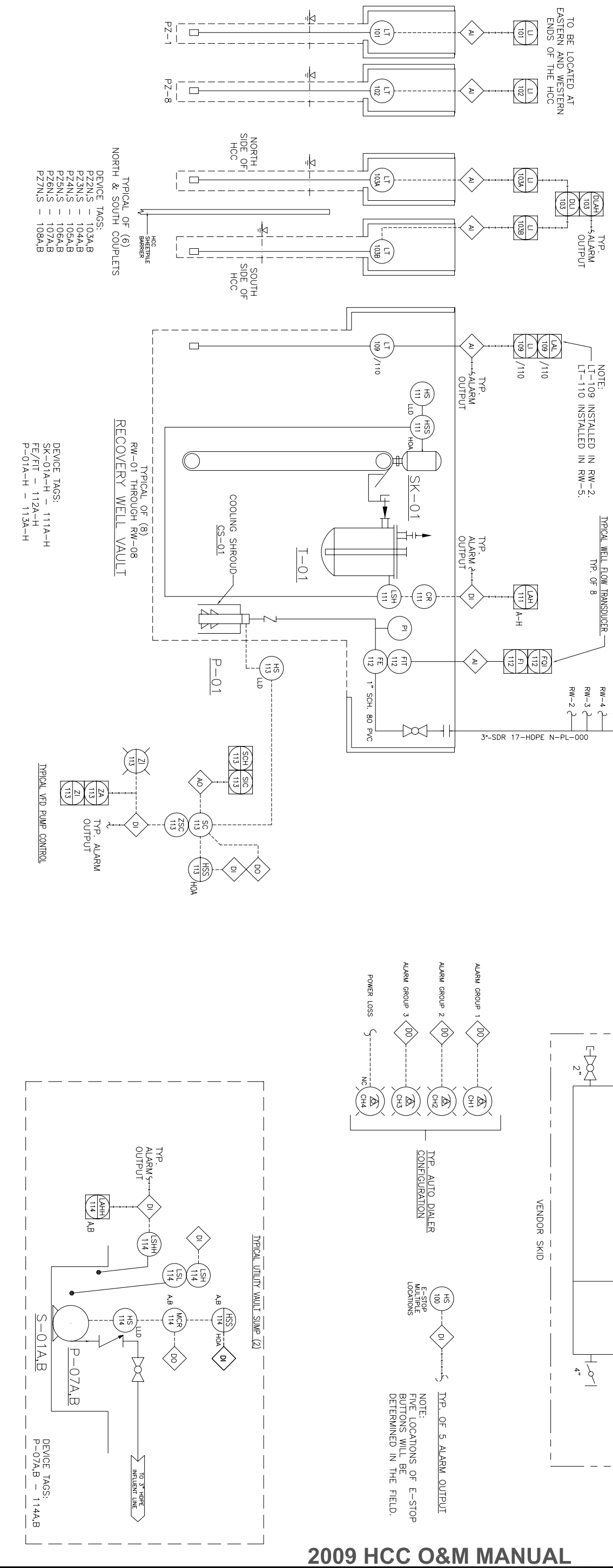
- SKIDS SHIPPED FROM ENCOTECH
- EQUIPMENT SHIPPED LOOSE AND SUPPLIED BY OTHERS
- FIELD PIPING (MATERIAL AND LABOR PROVIDED BY CONTRACTOR

OWS-01
OIL/WATER SEPARATOR
100 GPM

T-02
RECOVERED OIL STORAGE TANK & OVERPACK
55-GALLON w/95-GALLON OVERPACK

P-07A,B
UTILITY VAULT SUMP PUMP
53 GPM @ 15 FT TDH
1/2 HP, 1ø, 115 VAC

S-01A,B
UTILITY VAULT SUMP



2009 HCC O&M MANUAL

DRAWING NUMBER: 4-1b	FIGURE NUMBER:	

PROCESS AND INSRUMENTATION DIAGRAM
PUMP AND TREAT SYSTEM
RECOVERY AND OIL WATER SEPARATION
THE BNSF RAILWAY COMPANY
SKYKOMISH, WAHINGTON

SCALE:	DATE:	PROJECT NUMBER:
NTS	11/20/08	01140-222-0210

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RCW	2	ISSUED FOR CONSTRUCTION-REV2	10/08	RCW/BcV
CHECKED BY:	3	ISSUED FOR CONSTRUCTION-REV3	11/06/08	RCW/BcV
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APPROVED BY:				
SM				

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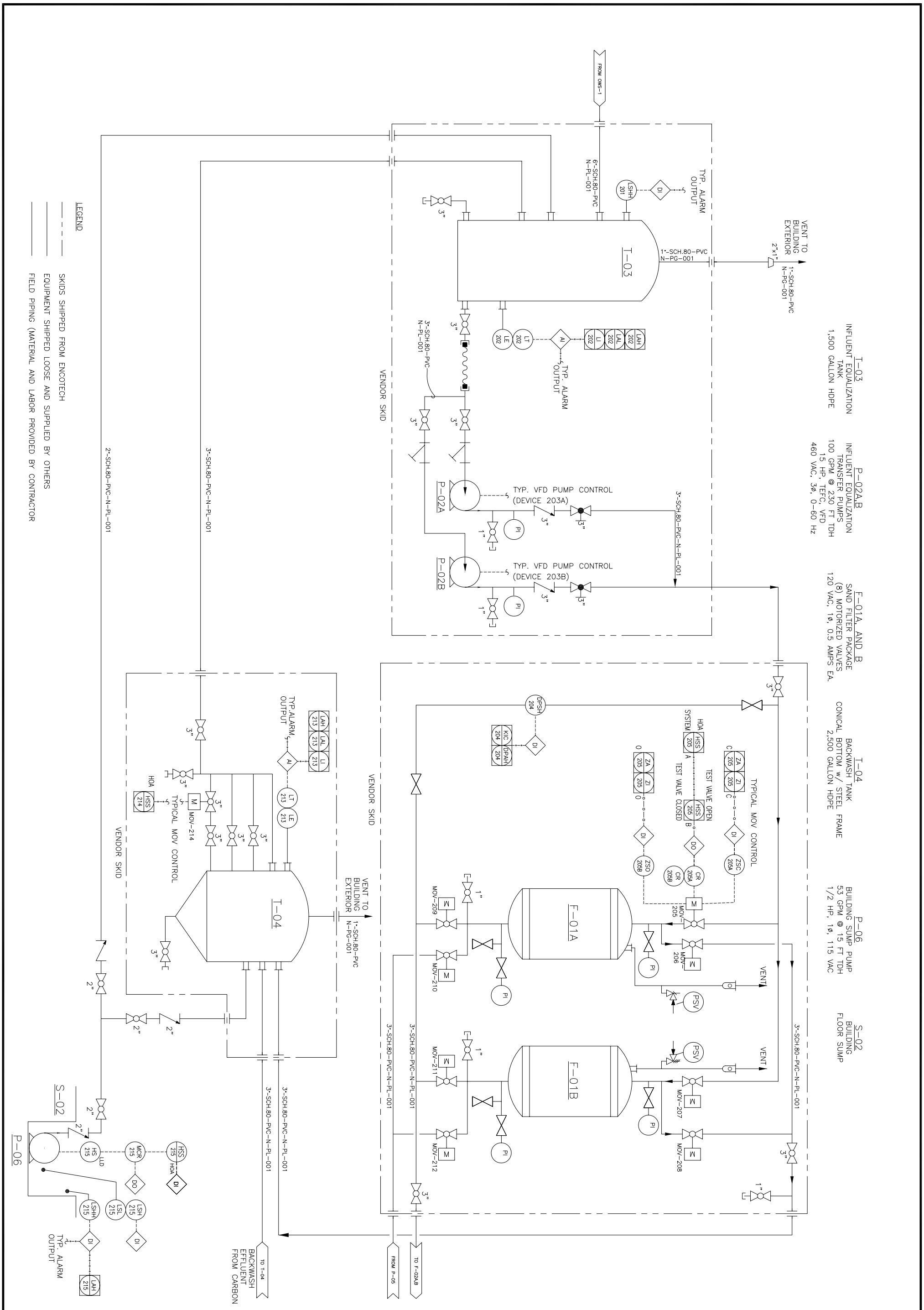

2009 HCC O&M MANUAL

DRAWING NUMBER: 4-1c
FIGURE NUMBER:

PROCESS AND INSRUMENTATION DIAGRAM PUMP AND TREAT SYSTEM IN FLOW AND PARTICULATE FILTRATION

THE BNSF RAILWAY COMPANY
SKYKOMISH, WAHINGTON

SCALE:	DATE:	PROJECT NUMBER:
NTS	11/20/08	01140-222-0210

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CHECKED BY:
DM
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DM

REVISIONS

NO.:	DESCRIPTION:	DATE:	BY:
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2	ISSUED FOR CONSTRUCTION-REV2	10/08	RCW/BcV
3	ISSUED FOR CONSTRUCTION-REV3	11/06/08	RCW/BcV
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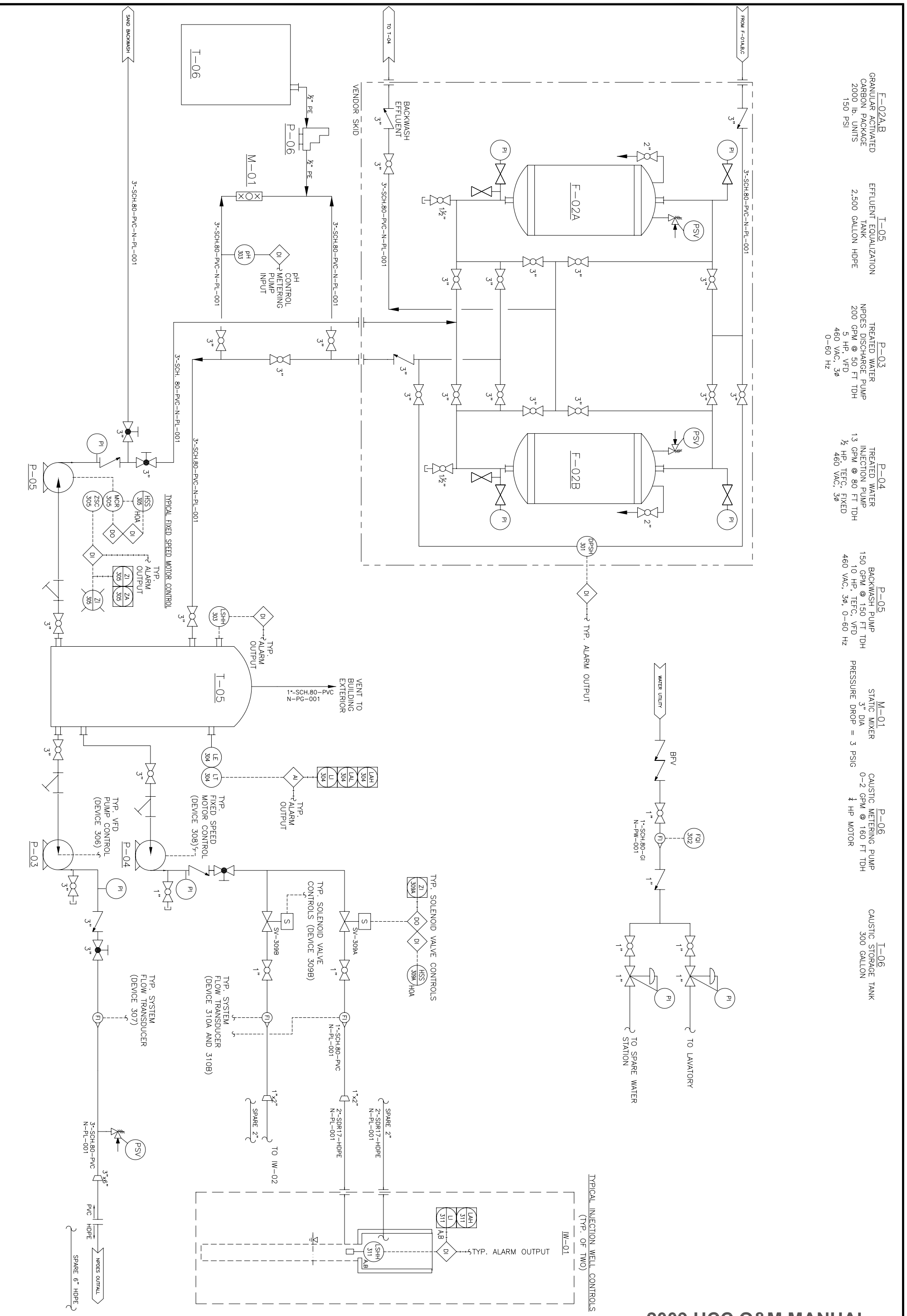

2009 HCC O&M MANUAL

FIGURE NUMBER: 4-1d

DRAWING NUMBER:

PROCESS AND INSRUMENTATION DIAGRAM PUMP AND TREAT SYSTEM CARBON TREATMENT AND EFFLUENT PIPING

THE BNSF RAILWAY COMPANY
SKYKOMISH, WAHINGTON

SCALE:	DATE:	PROJECT NUMBER:
NTS	5/8/09	01140-222-0210

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DESIGNED BY:	REVISIONS			
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RCW	2	ISSUED FOR CONSTRUCTION-REV2	10/08	RCW/BcV
CHECKED BY:	3	ISSUED FOR CONSTRUCTION-REV3	11/06/08	RCW/BcV
DM	4	ISSUED FOR CONSTRUCTION-REV4		BcV
APPROVED BY:	5	pH MODIFICATION SYSTEM - DRAFT	05/08/09	BcV
DM				

INSTRUMENT LEGEND

First-Letter	Initiating or Measured Variable *2	Primary Element	Transmitters		Readout Devices			Controllers			Alarm Devices			Control Valve	Self Actuated Control Valve	Switch
			Indicator	Blind	Recorder	Indicator	Integrating Indicator	Recorder	Indicator	Blind	HIGH	LOW	HIGH & LOW			
A	Analysis (*3)	AE	AIT	AT	AR	AI		ARC	AIC	AC	AAH	AAL	AAHL			AS
B	Burner/Combustion	BE	BIT	BT	BR	BI		BRC	BIC	BC	BAH	BAL	BAHL			BS
C	User's Choice															
D	User's Choise															
E	Voltage	EE	EIT	ET	ER	EI		ERC	EIC	EC	EAH	EAL	EAHL			ES
F	Flow Rate	FE	FIT	FT	FR	FI	FQI	FRC	FIC	FC	FAH	FAL	FAHL	FV	FCV	FS
G	User's Choice															
H	Hand								HIC	HC			HA	HV		HS
I	Current	IE	IIT	IT	IR	II	IQI	IRC	IIC		IAH	IAL	IAHL			IS
J	Power	JE	JIT	JT	JR	JI	JQI	JRC	JIC		JAH	JAL	JAHL			JS
K	Time	KE	KIT	KT	KR	KI	KQI	KRC	KIC	KC	KAH	KAL	KAHL		KCV	KS
L	Level	LE	LIT	LT	LR	LI		LRC	LIC	LC	LAH	LAL	LAHL	LV	LCV	LS
M	TORQUE	ME	MI	MT	MR	MI		MRC	MIC	MC	MAH	MAL	MAHL			
N	User's Choice															
O	User's Choice															
P	Pressure or Vacuum	PE	PIT	PT	PR	PI		PRC	PIC	PC	PAH	PAL	PAHL	PV	PCV	PS
Q	Quantity or Event	QE	QIT	QT	QR	QI	QQI	QRC	QIC		QAH	QAL	QAHL			QS
R	Radiation	RE	RIT	RT	RR	RI		RRC	RIC	RC	RAH	RAL	RAHL			RS
S	Speed or Frequency	SE	SIT	ST	SR	SI	SQI	SRC	SIC	SC	SAH	SAL	SSHL		SCV	SS
T	Temperature	TE	TIT	TT	TR	TI		TRC	TIC	TC	TAH	TAL	TAHL	TV	TCV	TS
U	Multivariable				UR	UI										
V	Vibration/Mach. Anal	VE	VIT	VT	VRC	VI					VAH	VAL	VAHL			VS
W	Weight or Force	WE	WIT	WT	WR	WI	WQI	WRC	WIC	WC	WAH	WAL	WAHL		WCV	WS
X	Unclassified															
Y	Event State Presence	YE		YT	YR	YI			YIC	YC	YAH	YAL		YZ		YS
Z	Position or Dimension	ZE	ZIT	ZT	ZR	ZI		ZRC	ZIC	ZC	ZAH	ZAL	ZAHL		ZCV	ZS

SPECIAL NOTES:

1. **Process equipment symbols may vary to show a better resemblance to equipment being used.**
2. **To simplify routing of process flow lines, some pieces of equipment may appear in more than one place on the flow diagram. Equipment so duplicated will be indicated by dashed lines.**

*NOTES:

* NOTES:
1. The instrument legend is based on ISA STANDARD S5.1–1984

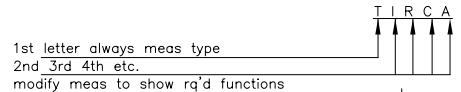
2. Any "First Letter" may be modified by the following letters,

D=	Differential	PD=	Pressure Differential
J=	Scan	TJR=	Scanning Temperature Recorder
Q=	Integrate or Totalize	FQI=	Flow Integrating Indicator
A=	Auto Mode	FO=	Flow Restriction Orifice
FF=	Flow Ratio	FFC=	Flow Ratio Controller
SS=	Speed Ratio	SSC=	Speed Ratio Controller
LL=	Level Ratio		

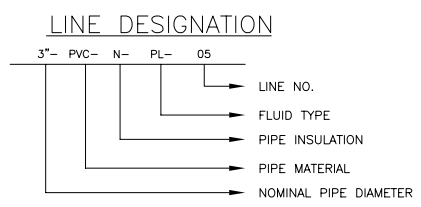
3. The letter "A" is to be used for all analysis variables. The following terms are placed outside the instrument circle of a loop to denote the specific variable.

CO	Carbon Monoxide	H2 S	Hydrogen Sulfide
CO_2	Carbon Dioxide	O_2	Gaseous Oxygen
Comb	Combustible	pH	pH
OP	Opacity	Smoke	Smoke Density
		FID	Flame Ionization Detector

TAG CONSTRUCTION



LINE DESIGNATION



MATERIAL
CS: CARBON STEEL
SS: STAINLESS STEEL
PVC : Rigid Poly–Vinyl –Chloride
ABS : Acrylonitrile Butadiene Styrene

PIPE RATING
RF: Raised Face Flange
FF: Flat Face Flange
T: Threaded

FLUID TYPE
PW: Potable Water
PL: Process Liquid
S: Sludge
PG: Process Gas
A: Compressed Air
IA: Instrument Air
NG: Natural Gas
C: Chemical

INSULATION TYPE
N: None
I: Insulation Hot
C: Insulation Cold
T: Steam Tracing

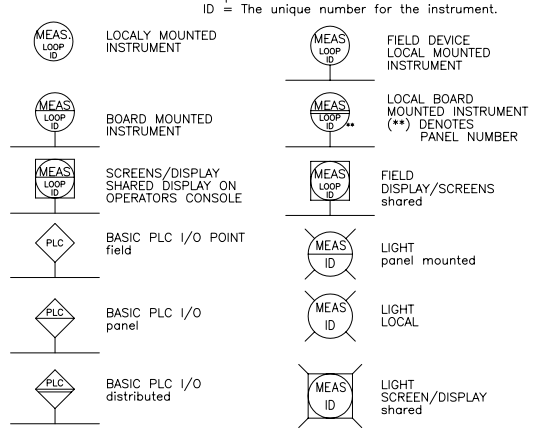
ABBREVIATIONS

CSO	Carr Seal Open	IAS	Iinstrument Air Supply
CSC	Carr Seal Closed	Iac	Insulation Acoustic
BF	Blind Flange	Ic	Insulation Cold
CO	Chain Operated	Ih	Insulation Hot
CW	Cooling Water	Is	Insulation Safety
CS	Carbon Steel	LC	Locked Closed
DE	De–Energize	LO	Locked Opened
(F)	Furnish	L.Pt	Low Point
FC	Fail Closed	NC	Normally Closed
FI	Fail Indeterminate	NDE	Normally De–Energized
FL	Fail Locked	NE	Normally Energized
FO	Fail Open	RW	Refrigerated Water
FP	Full Port	SO	Steam Out
FV	Full Vacuum	SP	Set Point
HOA	Hand–Off–Auto	SS	Stainless Steel
H.Pt	High Point	VB	Vortex Breaker
IAS	Instrument Air Supply		

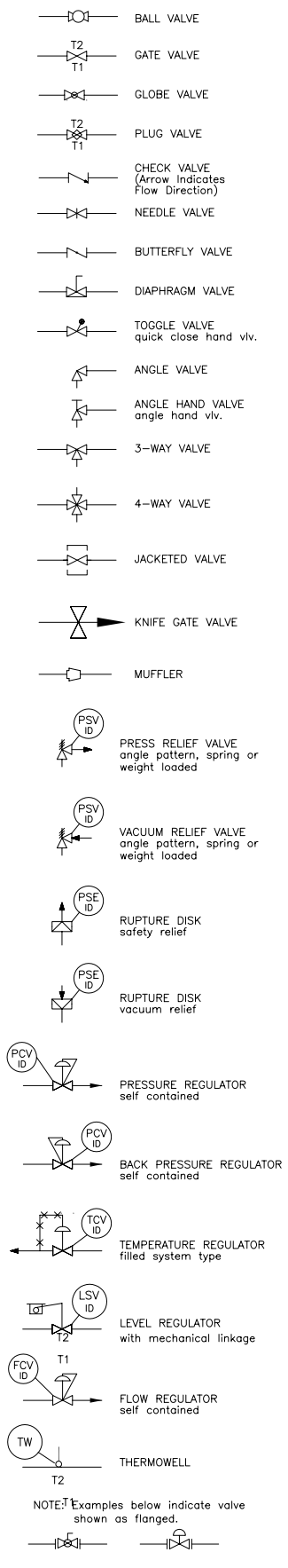
INSTRUMENTATION SYMBOLS

INSTRUMENT TAGGING

Measurement = instrument name.
Loop = Position or location of instrument.
ID = The unique number for the instrument.

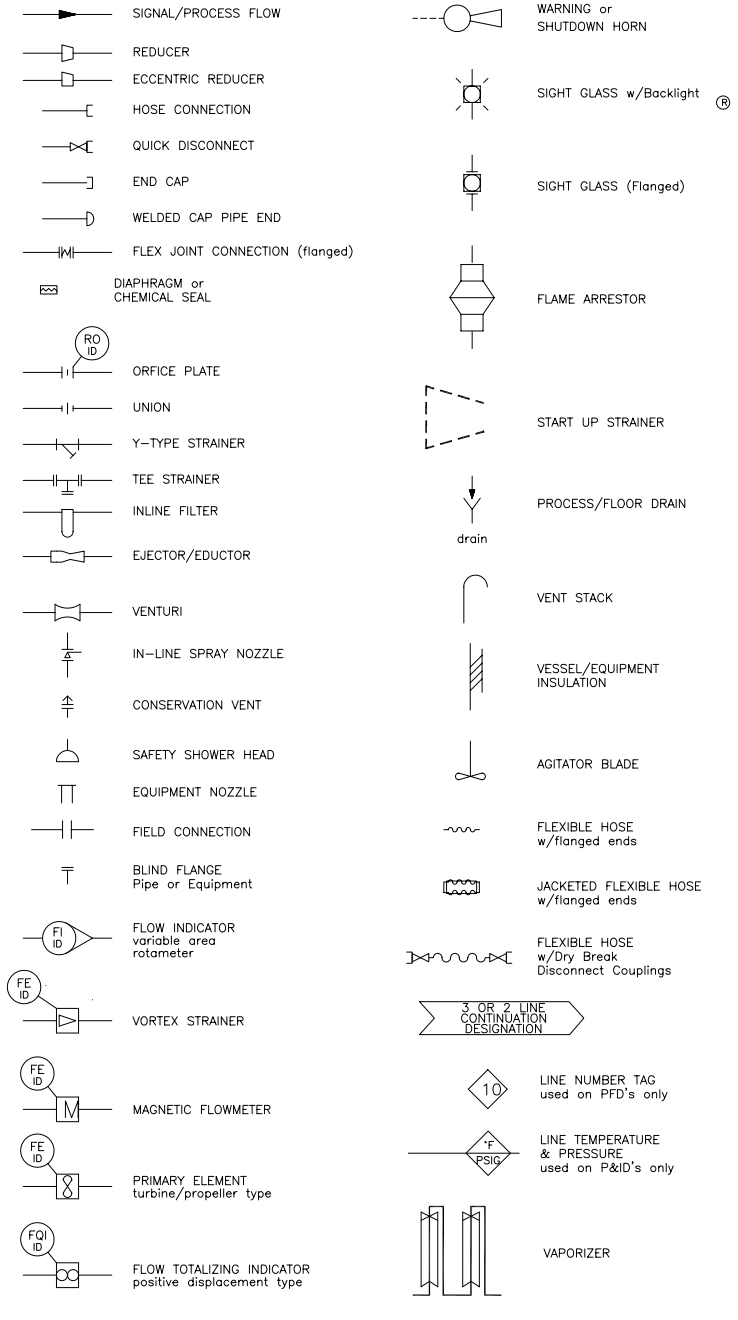


VALVE SYMBOLS

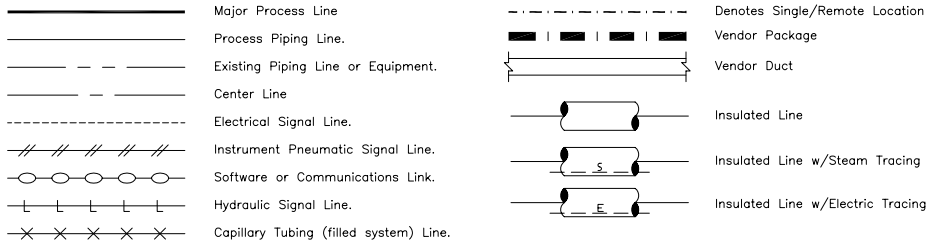


NOTE: Examples below indicate valve shown as flanged.

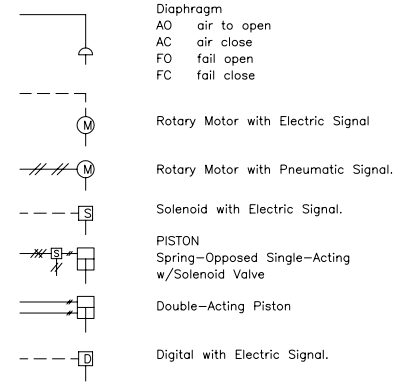
GRAPHIC SYMBOLS



LINE SYMBOLS



VALVE ACTUATOR SYMBOLS



2009 O&M MANUAL

REVISIONS

NO.:	DESCRIPTION:	DATE:	BY:
1	ISSUED FOR PIPING BID	09/24/08	RCW
2	ISSUED FOR CONSTRUCTION–REV2	10/08	RCW/BcV
3	ISSUED FOR CONSTRUCTION–REV3	11/06/08	RCW/BcV
4	ISSUED FOR CONSTRUCTION–REV4	11/20/08	BcV

DESIGNED BY: SAC
DRAWN BY: RCW
CHECKED BY: DM
APPROVED BY: SM

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FAX: (206) 624–2839
WEB: HTTP://WWW.ENSR.AECOM.COM

PROCESS AND INSRUMENTATION DIAGRAM

LEGEND

THE BNSF RAILWAY COMPANY
SKYKOMISH, WAHINGTON

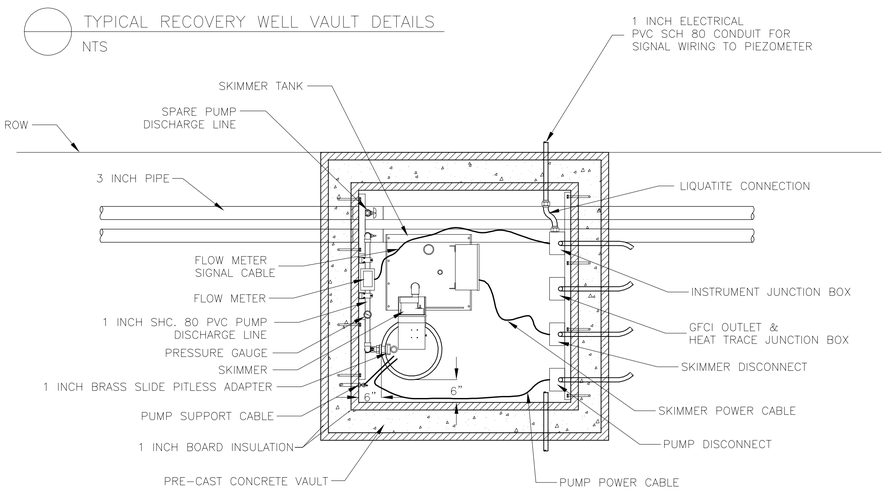
SCALE: NTS
DATE: 11/20/08
PROJECT NUMBER: 01140–222–0210

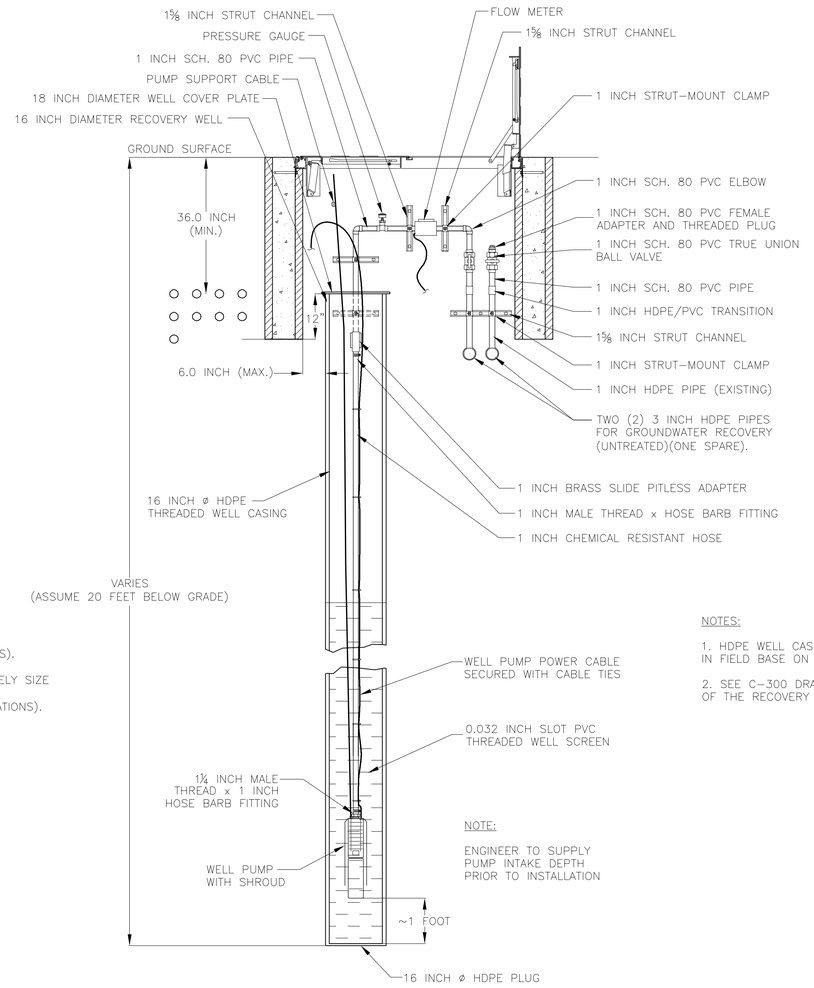
FIGURE NUMBER:
4–1e

DRAWING NUMBER:

File: F:\PROJECTS\BNSF Skykomish\2009 HCC O&M Plan\HCC O&M Manual–2009–11ACAD\Skykomish–PM&D–Construction_12–16–09_Block.dwg Layout: P–105 User: Blancolt Plotted: Dec 17, 2009 – 11:12am Xref's:

TYPICAL RECOVERY WELL VAULT DETAILS
NTS

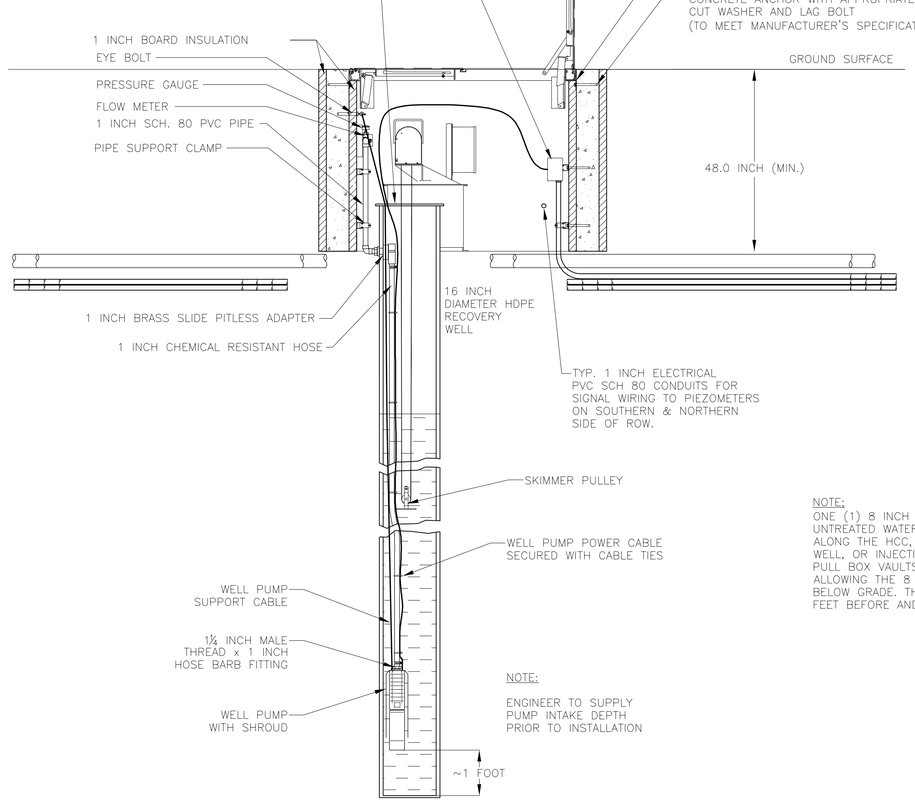




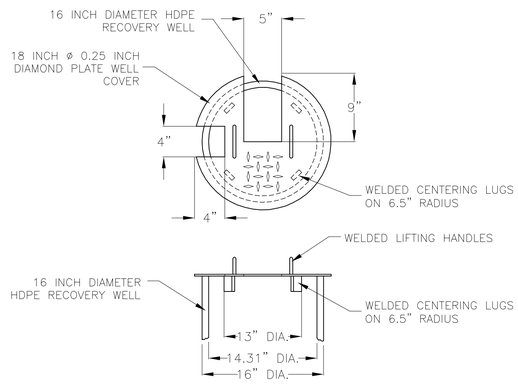
NOTES:

1. HDPE WELL CASING LENGTH TO BE DETERMINED IN FIELD BASE ON THE BOTTOM ELEVATION OF WELL.

2. SEE C-300 DRAWINGS FOR TOP & BOTTOM ELEVATION OF THE RECOVERY WELL SCREEN INTERVALS.



NOTE:
ONE (1) 8 INCH HDPE PIPE, FOR THE CONSTRUCTION DE-WATER UNTREATED WATER WILL BE APPROXIMATELY 2 FEET BELOW GRADE ALONG THE HCC, BUT WILL DROP BELOW ANY ELECTRICAL, RECOVERY WELL, OR INJECTION WELL VAULT ALONG THE HCC. THE ELECTRICAL PULL BOX VAULTS ARE APPROXIMATELY 1 FOOT OFF THE ROW, ALLOWING THE 8 INCH HDPE LINE TO STAY APPROXIMATELY 2 FEET BELOW GRADE. THE LINE WILL START ITS TRANSITION APPROXIMATELY 20 FEET BEFORE AND AFTER THE LAST VAULT IN EACH SERIES.



TYPICAL RECOVERY WELL COVER DETAILS
NTS

FOR PIPING BID ONLY

NO.	DRWN	DATE	REVISION	CHKD	DATE	APPVD	DATE
	RCW	09/24/08	ISSUED FOR PIPING BID	DM	09/24/08	SM	09/24/08

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SKYKOMISH, WASHINGTON

PROJ. NO.: 01140-222-0210 DATE: 09/24/08

RECOVERY WELL VAULT DETAILS

2008 REMEDIATION

DRAWING NUMBER:
V-101

SHEET NUMBER:

REVISION

File: c:\Revit_City\Project Files\P100 (10000 - 10999)\1040-Skycomish\Piping\Piping Bid (09-18-08)\01140-222-V-101-102 Piping Bid.rvty Layout: V101 User: wmeer Plotted: Sep 25, 2008 - 10:16am Revit

Appendices A – G

(Note: All appendices are provided on the attached CD-ROM)

- **Appendix A: Manufacturers' Equipment Information/Cut Sheets – Water Treatment System Equipment**
- **Appendix B: HCC Wall Gate Figures**
- **Appendix C: Groundwater Modeling Report**
- **Appendix D: Manufacturers' Equipment Information/Cut Sheets – Field Equipment**
- **Appendix E: HCC Treatment System Control Logic Report**
- **Appendix F: HCC Treatment System NPDES Permit**
- **Appendix G: HCC Treatment System Electrical Schematic**

Appendix A

Manufacturers' Equipment Information/Cut Sheets – Water Treatment System Equipment

IP-3G ConnectCam 1000™
Wireless Network Camera

SW211-WIP

USER MANUAL

Version 1.0

Contents

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To launch the program.....6
Item features.....7
To add a camera.....12
To remove a camera.....15
To link to the Web page of the camera.....15
To record video.....16
To configure the recording settings 18
To playback the recorded video.....20
To set up motion detection options.....21
Information.....23

INTRODUCTION

This *Software User Guide* provides detailed instructions on operating **Ultra View**, a customized software application with a user-friendly interface allowing you to access and control your camera(s). You can connect up to 16 cameras to monitor different places and record events for each camera. With Ultra View, you can also change some basic settings of the camera, such as schedule profiles and motion detecting. In addition, if your camera supports advanced features, such as audio or pan/tilt function, you can use these functions through the control panels of Ultra View.

To use Ultra View, you must install it on to your computer. It is recommended to use a high performance computer if you want to connect multiple cameras simultaneously. The following provides suggested system requirements:

Platform: Microsoft® Windows® 2000/XP/Vista.

Hardware Requirement:

1 camera connected: Intel Pentium III 800MHz; 512MB RAM

2 ~ 4 cameras connected: Intel Pentium 4 1.3GHz; 512MB RAM

5 ~ 8 cameras connected: Intel Pentium 4 2.4GHz; 1GB RAM

9 ~ 16 cameras connected: Intel Pentium 4 3.4GHz; 2GB RAM

Resolution: 1024x768 or above

NOTE When you use Ultra View to record video clips, store the recorded files to an exclusive hard disk drive in your computer to ensure there will be sufficient storage space.

INSTALLATION

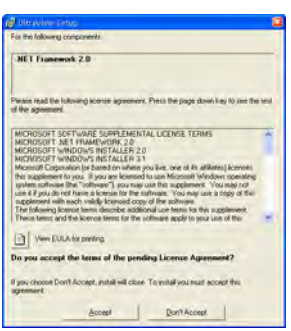
Firstly, insert the Installation CD-ROM into your CD drive to initiate the Auto-Run program. The Auto-Run screen provides the following options:

- **Quick Guide**
- **Advanced Guide**
- **Software Manual**
- **IP Finder**
- **Install Software**
- **Browse**
- **Exit**

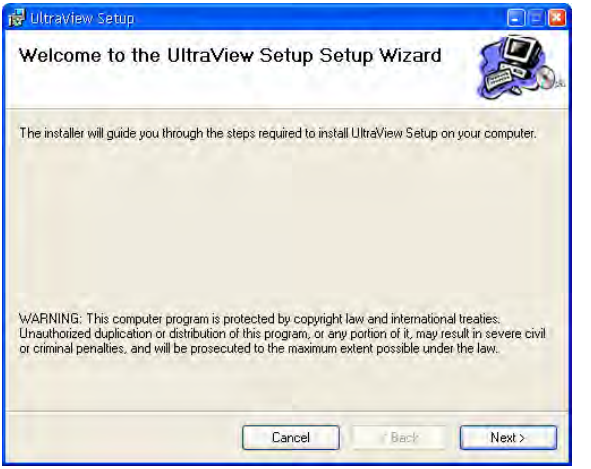
To begin installation:

1. Click **Install Software** and then select **Ultra View**. The setup wizard appears to help you complete the installation step-by-step.

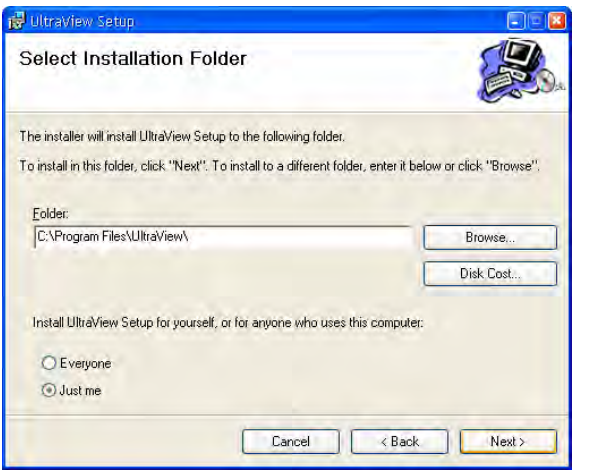
NOTE To use Ultra View, you must have Microsoft .NET Framework 2.0 installed in the computer. The setup wizard will detect it and, if the program is not installed yet, ask you to install it during the process of installing Ultra View.



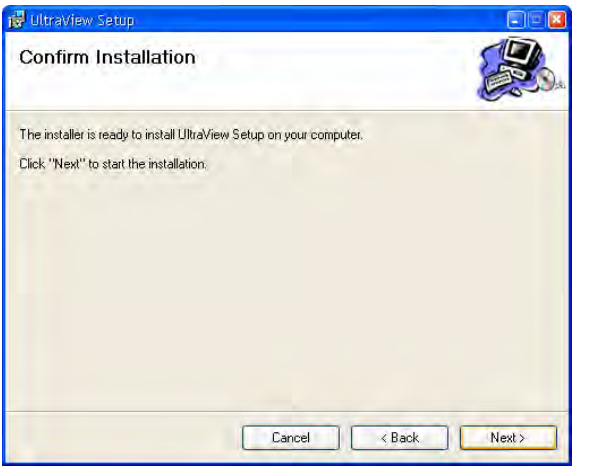
2. When the welcome screen appears, click **Next**.



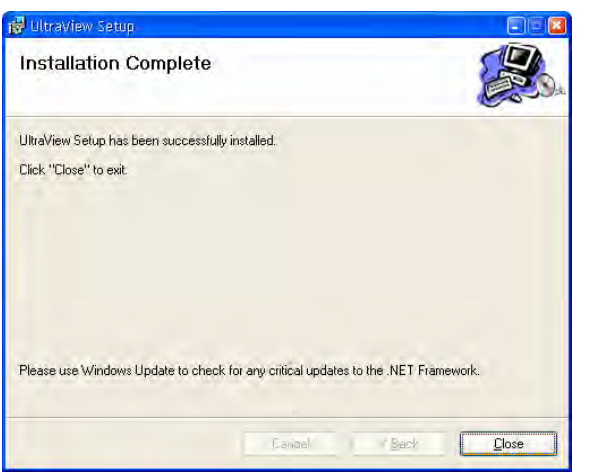
3. Click **Browse** to select the destination location to install the software or click **Next** to use the default settings.



4. Click **Next** again to confirm installation. The setup wizard starts to install the software and the progress bar indicates the installation is proceeding.



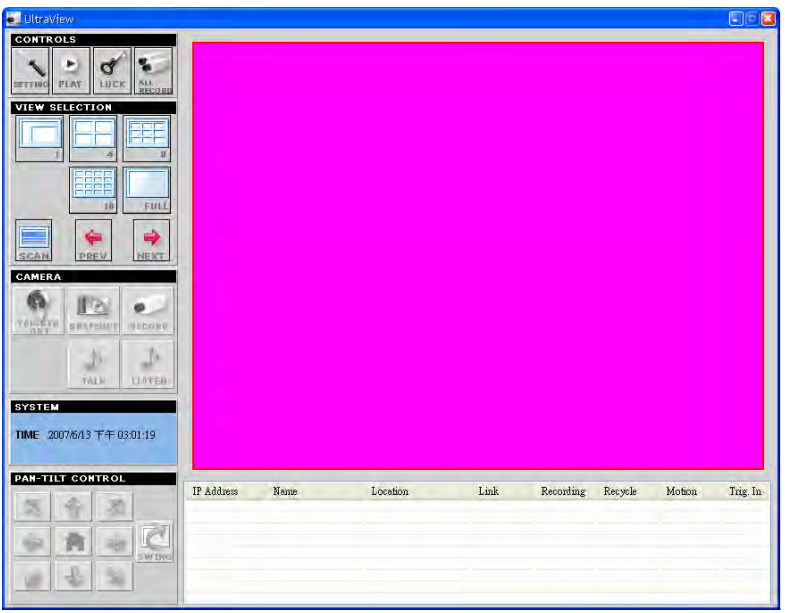
5. When installation is complete, click **Close**.



USING ULTRA VIEW

To launch the program

This section describes the user interface and operating instructions of Ultra View. To launch the program, click **Start > Programs > UltraView > UltraView;** the main screen will appear as below:



NOTE Please set the resolution to 1024x768 or above on your computer while using Ultra View; otherwise, the display screen may be distorted.

Item features

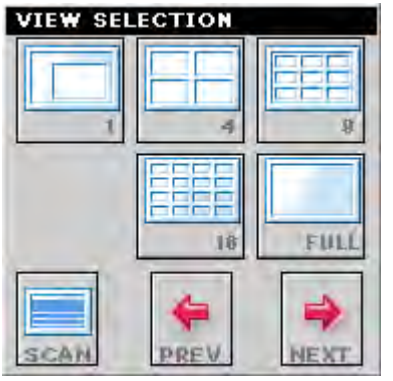
The following describes the function of each item on the main screen:

- **CONTROLS Panel**

  - **SETTING:** Click to enter the Setting screen of Ultra View. Click again to return to the main screen of Ultra View.
  - **PLAY:** Click to play the recorded video file using the media player on the computer (for example, Windows Media Player by default).
  - **LOCK:** Click to lock the camera controls. Click again to resume controls for the camera. If you have set ID and Password in **SETTING > Account**, you will be asked to enter the required information to unlock.
  - **ALL RECORD:** Click to start recording video clips using all connected cameras. Click again to stop recording and save the files in the computer. When you connect only one camera, this button's function is the same as the RECORD button.

TIP By default, the ID and Password boxes are "blank." Click **SETTING > Account** to change the ID and password of lock/unlock function.

- **VIEW SELECTION Panel**



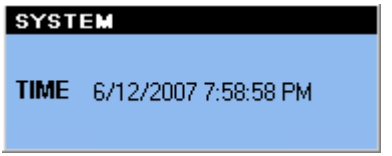
  - **View mode buttons:** Ultra View provides multiple view modes, including 1/4/9/16 windows and Full screen mode.
  - **SCAN:** When you connect multiple cameras, click this button to display the video views as the main window in turn.
  - **PREV:** When you connect multiple cameras, click this button to switch the video view to the previous camera.
  - **NEXT:** When you connect multiple cameras, click this button to switch the video view to the next camera.

TIP To set the time interval of scanning, click **SETTING > Other** and then adjust the time from 1 to 10 seconds in the **Time interval of scan** option.

- **CAMERA Panel**

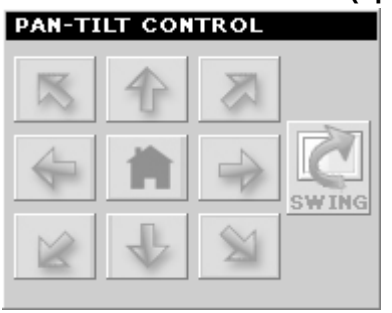
- **TRIGGER OUT:** Click to turn on the trigger out connector of the camera. This button is available only when the connected camera supports the trigger out connector, which is used to control the external device connected to the camera, such as a light.
- **SNAPSHOT:** Click to capture a still image using the selected camera and save the file in the computer.
- **RECORD:** Click to start recording a video clip using the selected camera. Click again to stop recording and save the file in the computer.
- **TALK:** Click to speak out through the camera. This button is available only when the connected camera supports 2-way audio function.
- **LISTEN:** Click to receive the on-site sound and voice from the camera.

- **SYSTEM Panel**



This panel displays the current date and time.

- **PAN-TILT CONTROL Panel (optional)**



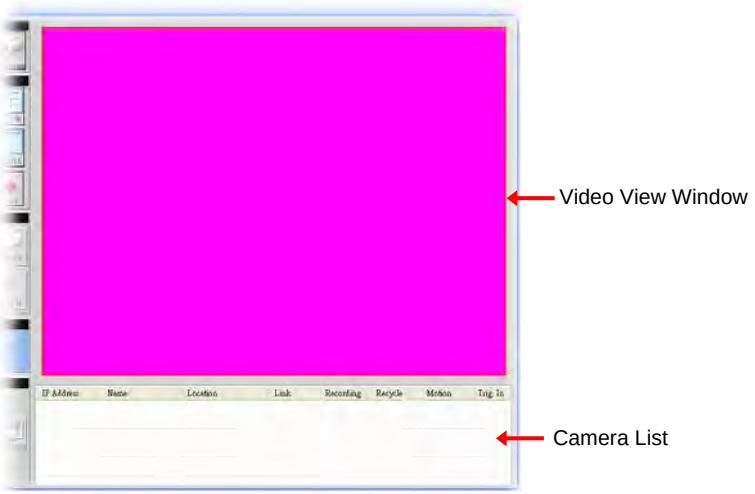
When you connect a pan/tilt camera, the system will detect the camera's function automatically and the PAN-TILT CONTROL buttons will become functional. Otherwise, these buttons are displayed as grayed out buttons.

- **Direction/Home buttons:** Click these buttons to adjust the camera's viewing angle to Up ( ) / Down ( ) / Left ( ) / Right ( ) / Left-Up ( ) / Left-Down ( ) / Right-Up ( ) / Right-Down ( ).

  Click the **Home** button ( ) to return the camera to the default position.

- **SWING:** If you have saved two or more positions for the selected camera, click this button to control the camera swinging from one position to another position.

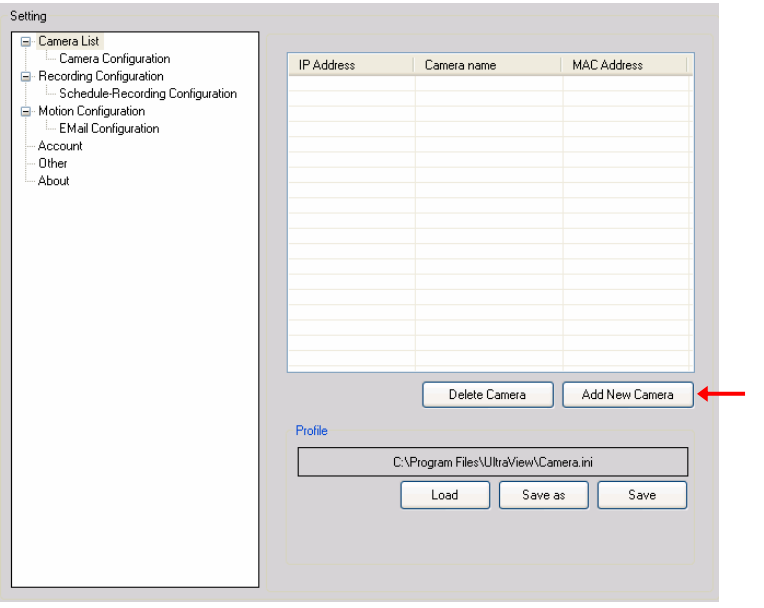
■ Video View Window and Camera List



- **Video View Window:** This window displays the video view of the selected camera, which can be divided into 4/9/16 windows according to your selection in VIEW SELECTION panel.
- **Camera List:** This list displays the information of the connected camera(s).

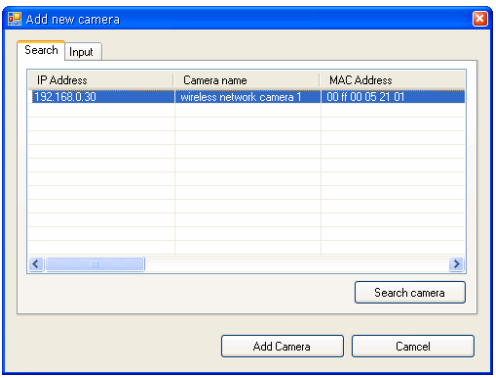
To add a camera

1. Click **SETTING** in the CONTROLS panel to display the Setting screen.
2. Click **Add New Camera**.

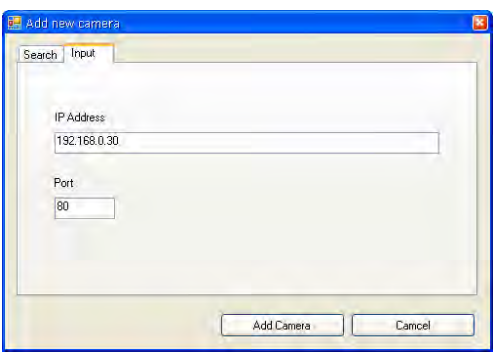


3. In the pop-up Add New Camera dialog window, you can:

- Select the **Search** tab if you are not sure of the camera's IP address. Click **Search camera** to search the available camera within the network. Once the camera is found and is shown in the list, select it and click **Add Camera**.



- Select the **Input** tab to add a camera by entering its IP address directly. Enter the camera's IP address (default: 192.168.0.30) and Port (default: 80), and then click **Add Camera**.

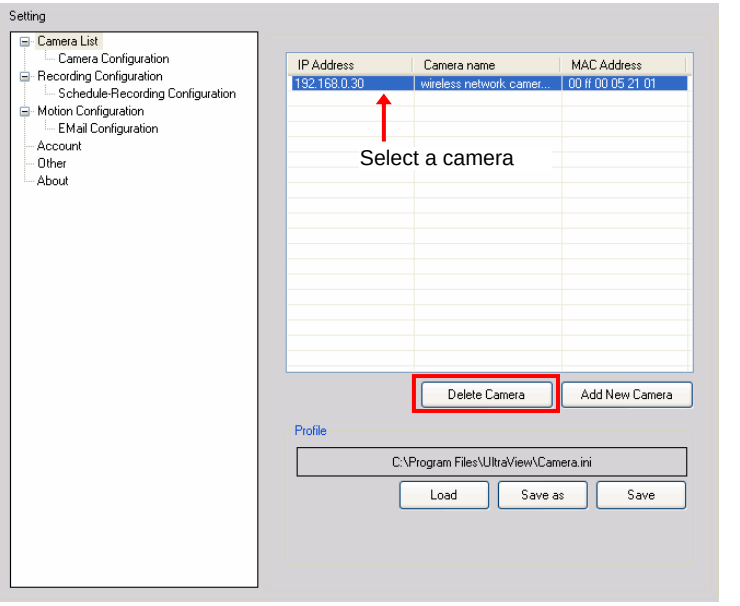


4. Enter the User name and Password for the camera, and then click **OK**. The connected camera will be displayed in the Camera List.

5. Click **SETTING** to return to the Video View Window. The video view of the selected camera will now be displayed.

To remove a camera

1. Click **SETTING** in the CONTROLS panel to display the Setting screen.
2. Select a camera from the list and click **Delete Camera**.



To link to the Web page of the camera

Click **SETTING > Camera List > Camera Configuration** and then **Link web page** to launch the Web browser that displays live view image and Web Configuration of the selected camera.

To record video

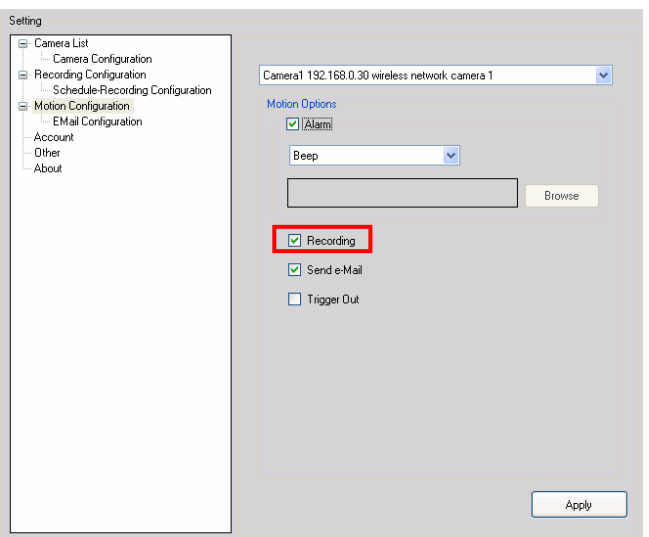
Ultra View provides three methods to record video clips; one is to click the **RECORD/ALL RECORD** button to record manually; the second is to record by motion detection; the third is to set the recording schedule in **Setting > Recording Configuration > Schedule Recording Configuration**.

- **Manual recording**

  Click **RECORD/ALL RECORD** and it starts recording. Click the button again to stop.

- **Trigger recording by motion detection**

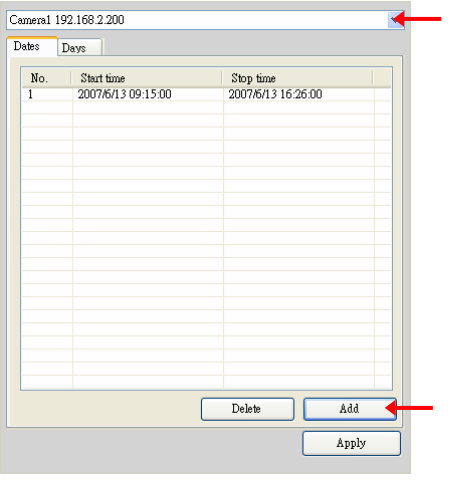
  When the motion detection function of the selected camera is enabled, you can configure the camera to start recording triggered by the motion detected. Click **SETTING > Motion Configuration**, and then select the **Recording** option to enable the selected camera to record by motion detection.



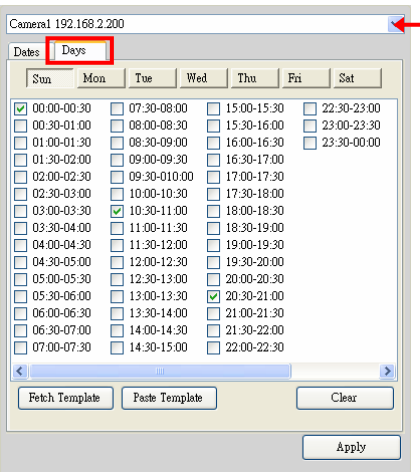
- **Schedule recording**

  This recording method will work after you have completed the required settings in **Schedule Recording Configuration**. The recording schedule can be defined by **Dates** or **Days**.

  - **Dates:** First, select the camera from the pull-down list. Then, click **Add** to set the Start/Stop date and time and then click **OK** to add the recording schedule to the list. Click **Apply** to save the settings.



- **Days:** First, select the camera from the pull-down list and select **Days** tab. Then, select the weekday from the day buttons and then set the time period. Click **Apply** to save the settings.

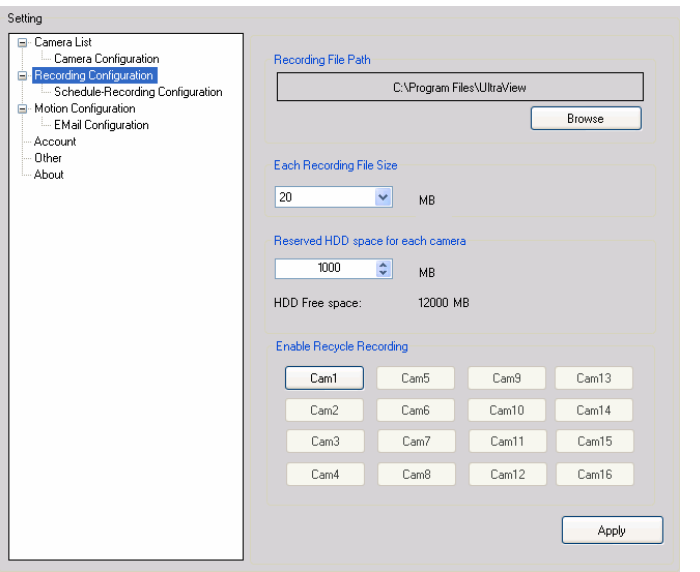


To configure the recording settings

To configure the recording settings, including the storage folder and storage options, click **SETTING > Recording Configuration**.

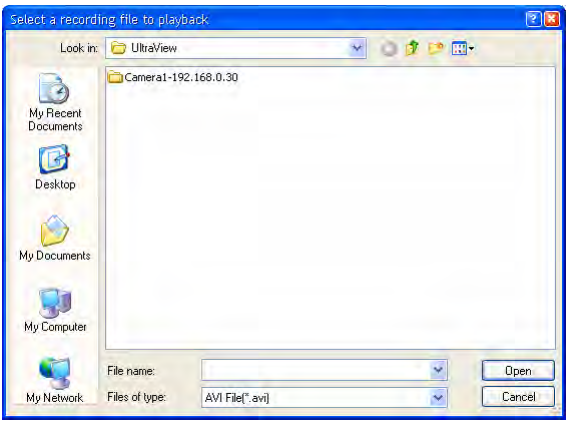
- **Recording File Path:** To change the destination folder to save the recorded video file, click **Browse** under the **Recording File Path** box to assign a new folder.
- **Each Recording File Size:** This option allows you to select from **20** to **200** MB so that the video will be recorded as another file automatically when the recording file reaches the specified size limit.

- **Reserved HDD space for each camera:** This option allows you to set to reserve the storage space on the hard disk drive for the recording of each camera. Before setting the reserve space on the hard disk drive, you can check the available storage space that is displayed in the **HDD Free space** field.
- **Enable Recycle Recording:** Click on the camera number to clear the files when the unreserved space of the hard disk drive is full.



To playback the recorded video

The recorded video clips are saved ro your computer, and can be played using the media player on the computer, such as Windows Media Player. To start playback, simply click the **PLAY** button on the CONTROLS panel, and the following dialog screen will appear, allowing you to select the file to playback.



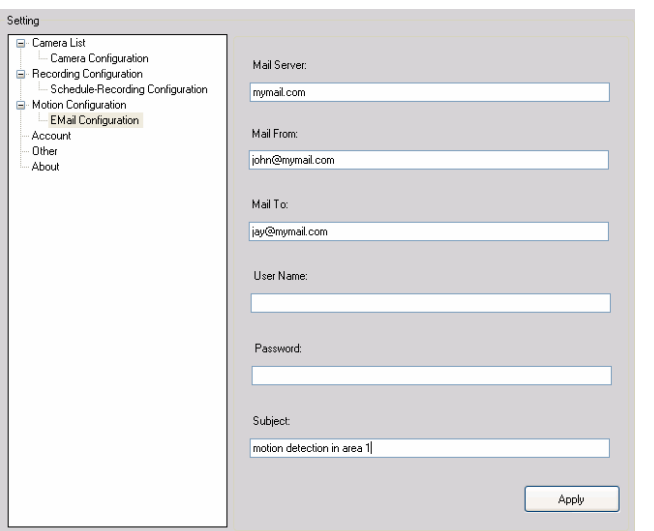
Select the recorded video file under the [camera] path and then click **Open** to launch the media player to playback.

NOTE If your player on the computer doesn't have the video codec to playback the recorded video. You can download video codecs from http://www.xvid.org/downloads.15.0.html

To set up motion detection options

When the motion detection function of the selected camera is enabled, you can set the **Motion Options** by selecting **Alarm**, **Recording**, **Send e-Mail**, and **Trigger Out** under **SETTING > Motion Configuration**.

- **Alarm:** Select **Beep** or **Music** to alert you for the motion detected. When you select **Music**, you can customize the sound by clicking **Browse** and then selecting your favorite music (*.wav or *.mp3 file) in the computer.
- **Recording:** Select this option to enable the camera to record by motion detected.
- **Send e-Mail:** Select this option so that the system will be able to send an email to the specified receiver. Once the option is selected, you have to complete the required information in **SETTING > Motion Configuration > Email Configuration**.

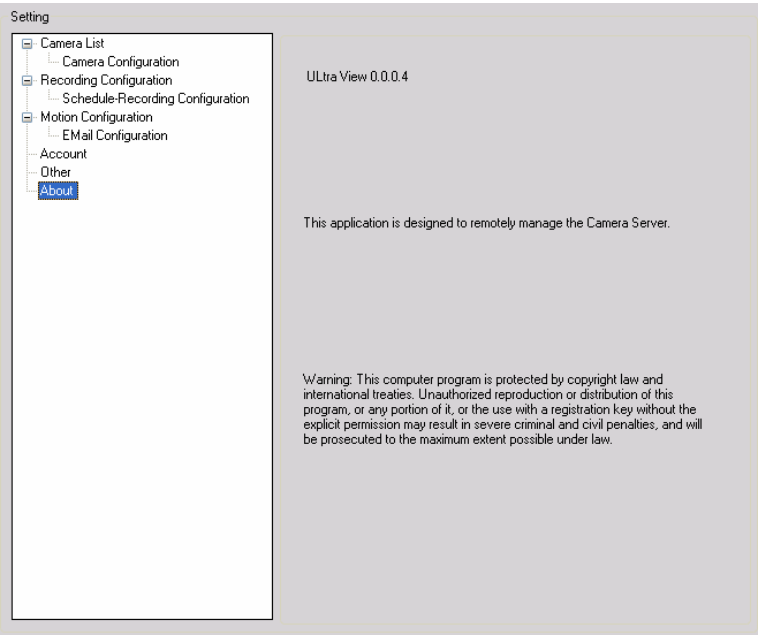


- **Mail Server:** Enter the mail server address. For example, mymail.com.
- **Mail From:** Enter an email address of the user who will send the email. For example, John@mymail.com.
- **Mail To:** Enter the email address of the user who will receive the email.
- **User Name:** Enter the user name to login the mail server.
- **Password:** Enter the password to login the mail server.
- **Subject:** Enter a subject for the notification email.

- **Trigger Out:** If the selected camera supports Trigger Out connector, select this option to enable the Trigger Out function.

Information

Click **SETTING > About** to display the information of the software application.



Installation Instructions

CompactLogix Controller

Catalog Numbers 1769-L32E, 1769-L35E

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Important User Information

Solid state equipment has operational characteristics differing from those of electromechanical equipment. Safety Guidelines for the Application, Installation and Maintenance of Solid State Controls (publication SGI-1.1 available from your local Rockwell Automation sales office or online at http://literature.rockwellautomation.com) describes some important differences between solid state equipment and hard-wired electromechanical devices. Because of this difference, and also because of the wide variety of uses for solid state equipment, all persons responsible for applying this equipment must satisfy themselves that each intended application of this equipment is acceptable.

In no event will Rockwell Automation, Inc. be responsible or liable for indirect or consequential damages resulting from the use or application of this equipment.

The examples and diagrams in this manual are included solely for illustrative purposes. Because of the many variables and requirements associated with any particular installation, Rockwell Automation, Inc. cannot assume responsibility or liability for actual use based on the examples and diagrams.

No patent liability is assumed by Rockwell Automation, Inc. with respect to use of information, circuits, equipment, or software described in this manual.

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Throughout this manual, when necessary, we use notes to make you aware of safety considerations.

WARNING	Identifies information about practices or circumstances that can cause an explosion in a hazardous environment, which may lead to personal injury or death, property damage, or economic loss.
IMPORTANT	Identifies information that is critical for successful application and understanding of the product.
ATTENTION	Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss. Attentions help you to identify a hazard, avoid a hazard and recognize the consequences.
SHOCK HAZARD	Labels may be on or inside the equipment, for example, a drive or motor, to alert people that dangerous voltage may be present.
BURN HAZARD	Labels may be on or inside the equipment, for example, a drive or motor, to alert people that surfaces may reach dangerous temperatures.

Environment and Enclosure

ATTENTION

This equipment is intended for use in a Pollution Degree 2 industrial environment, in overvoltage Category II applications (as defined in IEC publication 60664-1), at altitudes up to 2000 meters (6562 ft) without derating.

This equipment is considered Group 1, Class A industrial equipment according to IEC/CISPR Publication 11. Without appropriate precautions, there may be potential difficulties ensuring electromagnetic compatibility in other environments due to conducted as well as radiated disturbance.

This equipment is supplied as open-type equipment. It must be mounted within an enclosure that is suitably designed for those specific environmental conditions that will be present and appropriately designed to prevent personal injury resulting from accessibility to live parts. The enclosure must have suitable flame-retardant properties to prevent or minimize the spread of flame, complying with a flame spread rating of 5VA, V2, V1, V0 (or equivalent) if non-metallic. The interior of the enclosure must be accessible only by the use of a tool. Subsequent sections of this publication may contain additional information regarding specific enclosure type ratings that are required to comply with certain product safety certifications.

In addition to this publication, see:

- Industrial Automation Wiring and Grounding Guidelines, for additional installation requirements, Allen-Bradley publication 1770-4.1.
- NEMA Standards publication 250 and IEC publication 60529, as applicable, for explanations of the degrees of protection provided by different types of enclosure.

Prevent Electrostatic Discharge

ATTENTION

This equipment is sensitive to electrostatic discharge, which can cause internal damage and affect normal operation. Follow these guidelines when you handle this equipment:

- Touch a grounded object to discharge potential static.
- Wear an approved grounding wriststrap.
- Do not touch connectors or pins on component boards.
- Do not touch circuit components inside the equipment.
- Use a static-safe workstation, if available.
- Store the equipment in appropriate static-safe packaging when not in use.

North American Hazardous Location Approval

The following information applies when operating this equipment in hazardous locations:	Informations sur l'utilisation de cet équipement en environnements dangereux:
Products marked "CL I, DIV 2, GP A, B, C, D" are suitable for use in Class I Division 2 Groups A, B, C, D, Hazardous Locations and nonhazardous locations only. Each product is supplied with markings on the rating nameplate indicating the hazardous location temperature code. When combining products within a system, the most adverse temperature code (lowest "T" number) may be used to help determine the overall temperature code of the system. Combinations of equipment in your system are subject to investigation by the local Authority Having Jurisdiction at the time of installation.	Les produits marqués "CL I, DIV 2, GP A, B, C, D" ne conviennent qu'à une utilisation en environnements de Classe I Division 2 Groupes A, B, C, D dangereux et non dangereux. Chaque produit est livré avec des marquages sur sa plaque d'identification qui indiquent le code de température pour les environnements dangereux. Lorsque plusieurs produits sont combinés dans un système, le code de température le plus défavorable (code de température le plus faible) peut être utilisé pour déterminer le code de température global du système. Les combinaisons d'équipements dans le système sont sujettes à inspection par les autorités locales qualifiées au moment de l'installation.

WARNING

EXPLOSION HAZARD -

- Do not disconnect equipment unless power has been removed or the area is known to be nonhazardous.
- Do not disconnect connections to this equipment unless power has been removed or the area is known to be nonhazardous. Secure any external connections that mate to this equipment by using screws, sliding latches, threaded connectors, or other means provided with this product.
- Substitution of components may impair suitability for Class I, Division 2.
- If this product contains batteries, they must only be changed in an area known to be nonhazardous.

AVERTISSEMENT

RISQUE D'EXPLOSION –

- Couper le courant ou s'assurer que l'environnement est classé non dangereux avant de débrancher l'équipement.
- Couper le courant ou s'assurer que l'environnement est classé non dangereux avant de débrancher les connecteurs. Fixer tous les connecteurs externes reliés à cet équipement à l'aide de vis, loquets coulissants, connecteurs filetés ou autres moyens fournis avec ce produit.
- La substitution de composants peut rendre cet équipement inadapté à une utilisation en environnement de Classe I, Division 2.
- S'assurer que l'environnement est classé non dangereux avant de changer les piles.

European Hazardous Location Approval

European Zone 2 Certification (The following applies when the product bears the Ex or EEx Marking)

This equipment is intended for use in potentially explosive atmospheres as defined by European Union Directive 94/9/EC and has been found to comply with the Essential Health and Safety Requirements relating to the design and construction of Category 3 equipment intended for use in potentially explosive atmospheres, given in Annex II to this Directive.

Compliance with the Essential Health and Safety Requirements has been assured by compliance with EN 60079-15 and EN 60079-0.

WARNING

- This equipment must be installed in an enclosure providing at least IP54 protection when applied in Zone 2 environments.
- This equipment shall be used within its specified ratings defined by Allen-Bradley.
- Provisions shall be made to prevent the rated voltage from being exceeded by transient disturbances of more than 40% when applied in Zone 2 environments.
- Secure any external connections that mate to this equipment by using screws, sliding latches, threaded connectors, or other means provided with this product.
- Do not disconnect equipment unless power has been removed or the area is known to be nonhazardous.

ATTENTION

This equipment is not resistant to sunlight or other sources of UV radiation.

About the Controller

Use this document as a guide to install the CompactLogix controller, which must be the leftmost module in the first bank of the system. The 1769-L32E and 1769-L35E controllers offer an integrated EtherNet/IP port.

Before You Begin

Consider the following when planning your CompactLogix system:

- The CompactLogix controller is always the leftmost module in the system.
- The controller must be within four modules of the system power supply. Some I/O modules may be up to eight modules away from the power supply. See the documentation for your 1769 I/O modules for details.
- The 1769-L32E controller supports as many as 16 I/O modules and the 1769-L35E controller supports as many as 30 I/O modules. Both controllers can use a maximum of 3 I/O banks with 2 expansion cables.
- Each I/O bank requires its own power supply.
- Only one controller can be used in a CompactLogix system.
- A 1769-ECR right end cap or 1769-ECL left end cap is required to terminate the end of the communication bus.

Parts List

These components ship with the controller.

Component	Description
	1769-BA battery
	1747-KY controller key

You may also use these components with the controller.

If you want to	Then use this component
Connect a device to the RS-232 port	1756-CP3 or 1747-CP3 serial cable
Connect a device to the EtherNet/IP port	Standard Ethernet cable with RJ-45 connector
Add nonvolatile memory	1784-CF64 or 1784-CF128 Industrial CompactFlash card

Connect the 1769-BA Battery

The controller is shipped with the 1769-BA battery that is packed separately. To connect the battery, follow this procedure.

ATTENTION

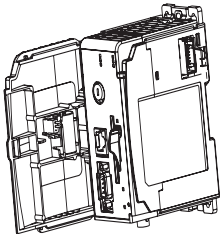
The 1769-BA battery is the only battery you can use with the 1769-L32E and 1769-L35E controllers. The 1747-BA battery is not compatible with the 1769-L32E and 1769-L35E controllers and may cause problems.

WARNING

When you connect or disconnect the battery, an electrical arc can occur. This could cause an explosion in hazardous location installations. Be sure that power is removed or the area is nonhazardous before proceeding.

For safety information on the handling of lithium batteries, including handling and disposal of leaking batteries, see Guidelines for Handling Lithium Batteries Technical Data, publication AG-5.4NOV04.

1. Remove the battery door by sliding it forward.



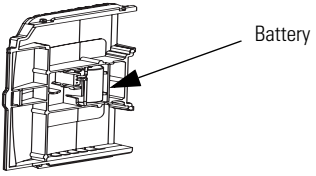
IMPORTANT

Do not remove the plastic insulation covering the battery. The insulation is necessary to protect the battery contacts.

2. Insert the battery connector into the connector port.

   The connector is keyed to be installed with the correct polarity.

3. Insert the battery into the battery port in the battery door.



4. Slide the battery door back until it clicks into position.

TIP At the end of its life, the used battery should be collected separately from any unsorted municipal waste and recycled.

Install a 1784-CF64 or 1784-CF128 CompactFlash Card (optional)

ATTENTION Do not remove the CompactFlash card while the controller is reading from or writing to the card, as indicated by a flashing green CF status indicator. This could corrupt the data on the card or in the controller, as well as corrupt the latest firmware in the controller.

The optional industrial CompactFlash card provides nonvolatile memory for a CompactLogix controller. The card is not required for controller operation.

WARNING When you insert or remove the CompactFlash card while power is on, an electrical arc can occur. This could cause an explosion in hazardous location installations.

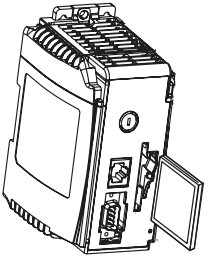
Be sure that power is removed or the area is nonhazardous before proceeding.

Follow these steps to install a CompactFlash card.

1. Push the locking tab to the right and insert the industrial CompactFlash card into the socket on the front of the controller.

   The label of the CompactFlash card faces toward the left. Match the orientation arrow on the card with the arrow on the front of the controller.

2. To remove the CompactFlash card, push the locking tab away from the CompactFlash card and pull the CompactFlash card from the socket.



44732

Assemble the System

The controller can be attached to an adjacent I/O module or power supply before or after mounting. For mounting instructions, see Ground the Wiring on page 12 or Mount the Panel on page 13.

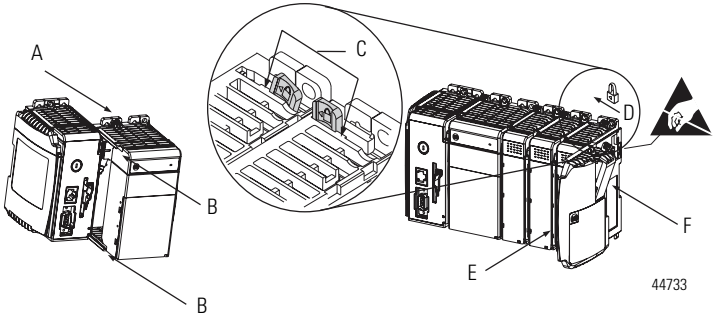
WARNING

The CompactLogix controller is not designed for removal and insertion under power.

If you insert or remove the module while backplane power is on, an electrical arc can occur. This could cause an explosion in hazardous location installations.

Be sure that power is removed or the area is nonhazardous before proceeding.

Refer to the illustration when installing a controller.



1. Disconnect line power.
2. Check that the lever of the adjacent module (A) is in the unlocked (fully right) position.
3. Use the upper and lower tongue-and-groove slots (B) to secure the modules together.
4. Move the module back along the tongue-and-groove slots until the bus connectors line up with each other.
5. Use your fingers or a small screwdriver to push the module's bus lever back slightly to clear the positioning tab (C).
6. Move the module's bus lever fully to the left (D) until it clicks, being sure it is locked firmly in place.

ATTENTION

When attaching the controller, power supply, and I/O modules, make sure the bus connectors are securely locked together to be sure of proper electrical connection.

This equipment is not resistant to sunlight or other sources of UV radiation.

7. Attach an end cap terminator (E) to the last module in the system by using the tongue-and-groove slots as before.

8. Lock the end cap bus terminator (F).

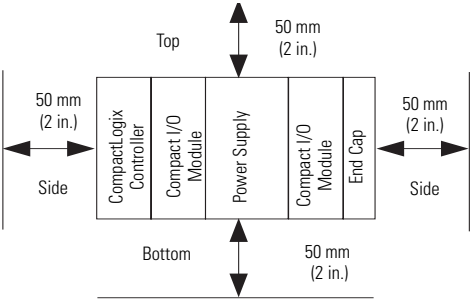
Mount the System

ATTENTION

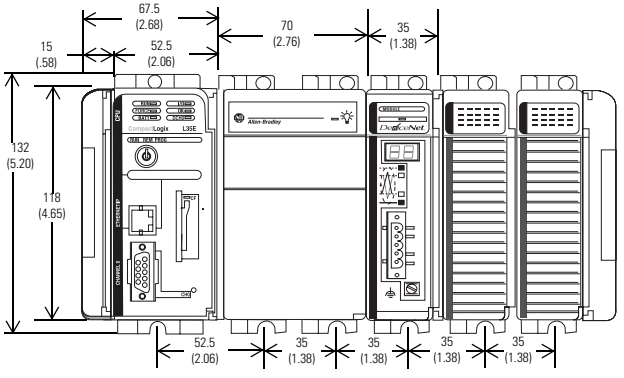
During panel or DIN rail mounting of all devices, be sure that all debris (such as metal chips or wire strands) is kept from falling into the controller. Debris that falls into the controller could cause damage while the controller is energized.

Minimum Spacing

Maintain spacing from enclosure walls, wireways, and adjacent equipment. Allow 50 mm (2 in.) of space on all sides, as shown. This provides ventilation and electrical isolation.



System Dimensions



Note: All dimensions are in mm (in.).

TIP Compact I/O expansion cables have the same dimensions as the end caps. Expansion cables can be used on either the right or left end. A 1769-ECR right end cap or 1769-ECL left end cap terminates the end of the communication bus.

Ground the Wiring

ATTENTION

This product is grounded through the DIN rail to chassis ground. Use zinc plated yellow-chromate steel DIN rail to assure proper grounding. The use of other DIN rail materials (such as aluminum or plastic) that can corrode, oxidize, or are poor conductors, can result in improper or intermittent grounding. Secure DIN rail to mounting surface approximately every 200 mm (7.8 in.) and use end-anchors appropriately.

This product is intended to be mounted to a well-grounded mounting surface such as a metal panel. Additional grounding connections from the controller's mounting tabs or DIN rail (if used) are not required unless the mounting surface cannot be grounded.

Refer to the Allen-Bradley publication 1770-4.1, Industrial Automation Wiring and Grounding Guidelines, for additional information.

Mount the Panel

Mount the controller to a panel by using two screws per module. Use M4 or #8 panhead screws. Mounting screws are required on every module.

This procedure lets you use the assembled modules as a template for drilling holes in the panel.

IMPORTANT Due to module mounting hole tolerance, it is important to follow these procedures.

1. On a clean work surface, assemble no more than three modules.
2. Using the assembled modules as a template, carefully mark the center of all module-mounting holes on the panel.
3. Return the assembled modules to the clean work surface, including any previously mounted modules.
4. Drill and tap the mounting holes for the recommended M4 or #8 screw.
5. Place the modules back on the panel and check for proper hole alignment.

TIP The grounding plate, that is, where you install the mounting screws, enables the module to be grounded when it is panel-mounted.

6. Attach the modules to the panel by using the mounting screws.

TIP If you are mounting more modules, mount only the last one of this group and put the others aside. This reduces remounting time when you are drilling and tapping the next group of modules.

7. Repeat steps 1...6 for any remaining modules.

Mount the Controller on the DIN Rail

The controller can be mounted on the following DIN rails:

- EN 50 022 - 35 x 7.5 mm (1.38 x 0.30 in.)
- EN 50 022 - 35 x 15 mm (1.38 x 0.59 in.)

ATTENTION

This product is grounded through the DIN rail to chassis ground. Use zinc plated yellow-chromate steel DIN rail to assure proper grounding. The use of other DIN rail materials (for example, aluminum or plastic) that can corrode, oxidize, or are poor conductors, can result in improper or intermittent grounding. Secure DIN rail to mounting surface approximately every 200 mm (7.8 in.) and use end-anchors appropriately.

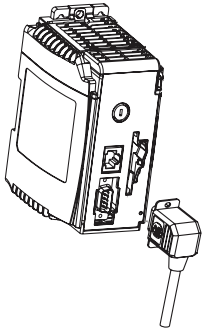
1. Before mounting the controller on a DIN rail, close the DIN rail latches.

2. Press the DIN rail mounting area of the controller against the DIN rail.

   The latches will momentarily open and lock into place.

Make RS-232 Connections to the Controller

Connect the 9-pin female end of the serial cable to the serial port of the controller.

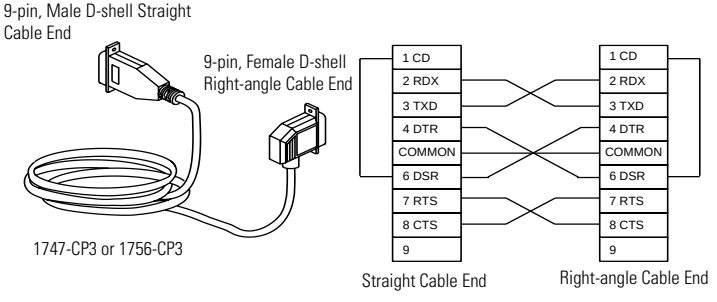


WARNING

If you connect or disconnect the serial cable with power applied to this module or the serial device on the other end of the cable, an electrical arc can occur. This could cause an explosion in hazardous location installations.

Be sure that power is removed or the area is nonhazardous before proceeding.

RS-232 Cable



TIP This cable must be shielded and tied to the connector housing.

Default Serial Configuration

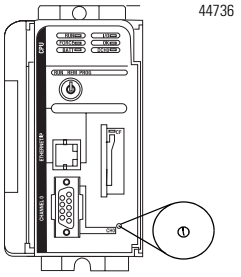
Channel 0 (serial port) has the following default communication configuration.

Parameter	Default
Protocol	DF1 full-duplex
Communication Rate	19.2 Kbps
Parity	None
Station Address	0
Control Lines	No Handshaking
Error Detection	BCC
Embedded Responses	Auto Detect
Duplicate Packet (Message) Detect	Enabled
ACK Timeout	50 (x 20 ms)
NAK Receive Limit	3 Retries
ENQ Transmit Limit	3 Retries
Data Bits	8
Stop Bits	1

TIP Only Channel 0 has a default communication push button (see page 17).

Use the Channel 0 Default Communication Push Button

The Channel 0 default communication push button is on the front of the controller in the lower right corner as shown in the illustration.



Use the Channel 0 default communication push button to change from the user-defined communication configuration to the default communication mode. The Channel 0 default communication (DCH0) status indicator turns on (green, steady) to indicate that the default communication configuration is active.

TIP

The default communication push button is recessed.

Before pressing the default communication push button, be sure to note the present communication configuration for Channel 0. Pushing the default communication push button resets all configured parameters to their default settings.

To return the channel to its user-configured parameters, you must enter them manually while online with the controller or download them as part of an RSLogix 5000 software project file. To do this online with RSLogix 5000 software, access the Controller Properties dialog and enter parameters on the Serial Port, System Protocol, and User Protocol tabs.

Make Ethernet Connections to the Controller

The 1769-L32E and 1769-L35E controllers ship with the BOOTP utility enabled. You must assign an IP address to the Ethernet port for the controller to communicate over an EtherNet/IP network.

WARNING

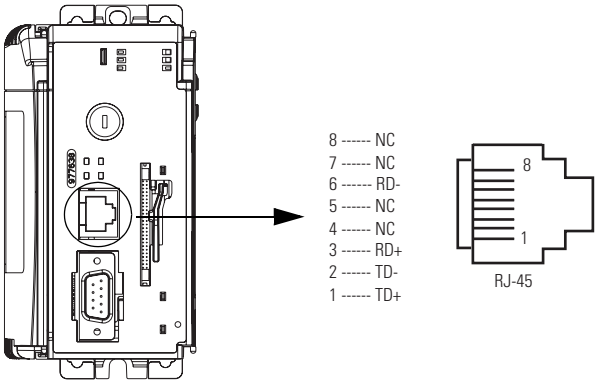
If you connect or disconnect the communications cable with power applied to this module or any device on the network, an electrical arc can occur. This could cause an explosion in hazardous location installations.

Be sure that power is removed or the area is nonhazardous before proceeding.

Connect the RJ-45 connector of the Ethernet cable to the Ethernet port (top port) on the controller.

ATTENTION

Do not plug a DH-485 network cable or a NAP cable into the Ethernet port. Undesirable behavior and/or damage to the port may result.



Assign an IP Address

You can set the IP address by using any of these utilities:

- Rockwell BOOTP Utility (available with RSLinx and RSLogix 5000 software)
- RSLinx software
- RSLogix 5000 software

Use BOOTP to Set the IP Address

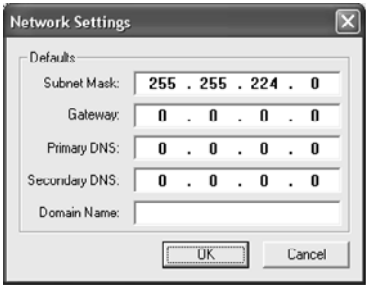
The BOOTP utility is a standalone program in one of the following directories:

- RSLinx Tools directory in the Rockwell Software program folder on the Start menu (the utility is automatically installed when you install RSLinx software)
- Utils directory on the RSLogix 5000 software installation CD

Follow this procedure to use the BOOTP utility.

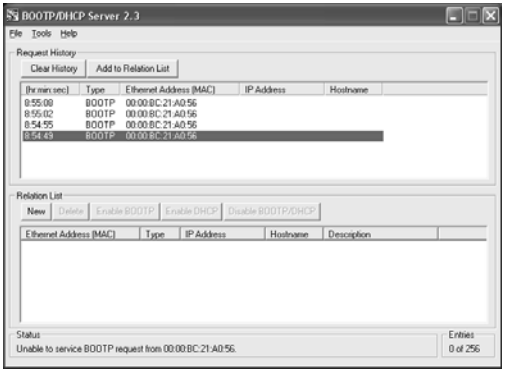
1. Start the BOOTP software.
2. Select Tools>Network Settings.
3. Enter the Ethernet mask and gateway.

4. Click OK.



In the BOOTP Request History dialog, you see the hardware addresses of devices issuing BOOTP requests.

5. Double-click the hardware address of the device you want to configure.



TIP

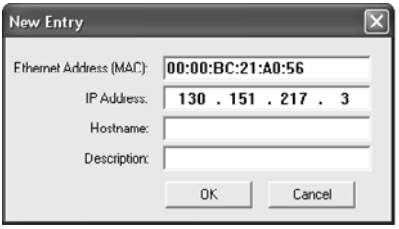
The hardware address is on the sticker on the left-side circuit board of the controller next to the battery. See Connect the 1769-BA Battery on page 7 for instructions on accessing this area.

The hardware address will be in this format: 00-0b-db-14-55-35.

The New Entry dialog displays the device's Ethernet Address (MAC).

6. Enter the IP address.

7. Click OK.



8. To permanently assign this configuration to the device, highlight the device and click Disable BOOTP/DHCP.

   When power is recycled, the device uses the configuration you assigned and does not issue a BOOTP request.

Use RSLinx Software to Set the IP Address

You can use RSLinx software, version 2.41 or later, to set the IP address.

1. Make sure the controller that uses the IP address is installed and running.

2. Connect to the controller via the serial connection (see page 15).

3. Start RSLinx software.

   The RSWho dialog opens.

4. Navigate to the Ethernet network via the Serial network.

5. Right-click the Ethernet port (not the controller) and select Module Configuration

6. Select the Port Configuration tab.

7. Click the appropriate radio button to choose the Network Configuration type.

8. Enter the IP address, network (subnet) mask, and gateway address (if needed).

Use RSLogix 5000 Software to Set the IP Address

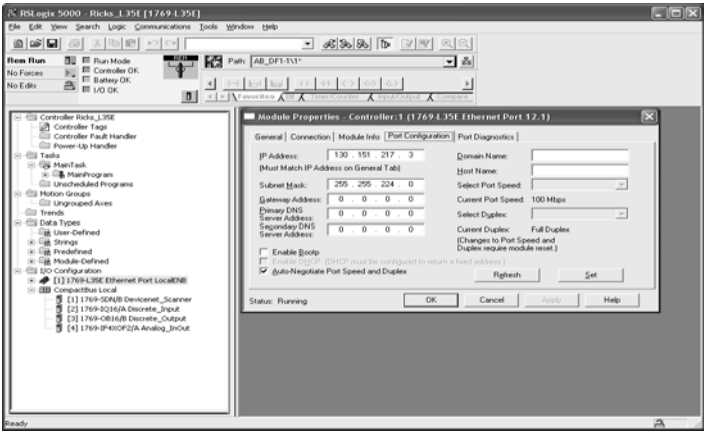
You can use RSLogix software to set the IP address.

1. Make sure the controller that uses the IP address is installed and running.

2. Connect to the controller via the serial connection (see page 15).

3. Start RSLogix 5000 software.

4. In the Controller Organizer, select properties for the Ethernet port.



5. Choose the Port Configuration tab.

6. Specify the IP address.

7. Click Apply.

8. Click OK.

   This sets the IP address in the hardware. This IP address should be the same IP address you assigned under the General tab.

Install the Appropriate EDS Files

If you have RSLinx software, version 2.42 or later, the most current EDS files were installed with the software. If you are using an earlier version of RSLinx software, you might need to install EDS files.

You need EDS files for these devices:

- 1769-L32E and 1769-L35E controllers
- 1769 CompactBus
- 1769 local adapter

All of these EDS files, except for the 1769 CompactBus file, are updated for each firmware revision. There is also a version 1 of the controller EDS file that you need for new controllers. Each controller ships with revision 1 firmware. To update the firmware, you must have the revision 1 EDS file (0001000E00410100.eds) installed for the controller.

The EDS files are available on the RSLogix 5000 Enterprise Series software CD. The files are also available at http://www.ab.com/networks/eds.

Load the Controller Firmware

You must download the current firmware before you can use the controller.

To load firmware, you can use any of the following:

- ControlFlash utility that ships with RSLogix 5000 programming software
- AutoFlash that launches through RSLogix 5000 software when you download a project and the controller does not have the matching firmware revision
- CompactFlash card (catalog number 1784-CF64 or 1784-CF128) with valid memory already loaded

If you use the ControlFlash or AutoFlash utilities, you need a network connection to the controller.

The firmware is available with RSLogix 5000 software or you can download it from the support website. Go to http://support.rockwellautomation.com.

Follow these steps to download firmware from the support website.

1. On the Rockwell Automation Support Page, click Software Updates, Firmware and Other Downloads under the Other Tools heading.
2. Click Firmware Updates.
3. Select the appropriate firmware update.
4. Select the firmware revision.
5. Click on a revision file to unzip the data.

Use the ControlFlash Utility to Load Firmware

You can use the ControlFlash utility to load firmware through a serial connection.

1. Make sure the appropriate network connection is made before starting.
2. Start the ControlFlash utility.
3. When the Welcome dialog appears, click Next.
4. Choose the catalog number of the controller and click Next.
5. Expand the network until you see the controller.
6. If the required network is not shown, first configure a driver for the network in RSLinx software.
7. Choose the controller and click OK.
8. Choose the revision level to which you want to update the controller and click Next.

9. To start the update of the controller, click Finish and then click Yes.

   After the controller is updated, the status dialog displays Update complete.

10. Click OK.

11. To close the ControlFlash utility, click Cancel and then click Yes.

Use AutoFlash to Load Firmware

You can use AutoFlash to load firmware through a network connection.

IMPORTANT

When upgrading your controller firmware, it is extremely important to allow the upgrade to complete without interruption.

If you interrupt the firmware upgrade either in the software or by distrubing the physical media, you may render the controller inoperable.

For more information about upgrading your CompactLogix controller firware, see information posted at http://www.rockwellautomation.com/knowledgebase/.

1. Make sure the appropriate network connection is made and your network driver is configured in RSLinx software.

2. Use RSLogix 5000 programming software to create a controller project.

3. Click RSWho to specify the controller path.

4. Select your controller and click Download.

   You may also choose to click Update Firmware to complete this process. If you do so, skip to step 8.

   A dialog box displays indicating that the project revision and controller firmware revision are different.

5. Click Update Firmware.

6. Use the checkbox and pull-down to select your controller and firmware revision.

7. Click Update.

8. Click Yes.

   The firmware upgrade begins.

IMPORTANT DO NOT INTERRUPT THE FIRMWARE UPGRADE ONCE IT HAS BEGUN. Interrupting the firmware upgrade may result in an inoperable controller.

9. When the firmware upgrade is complete, the Download dialog displays and you may continue by dowloading your project to the controller.

Use a CompactFlash Card to Load Firmware

If you have an existing controller that is already configured and has firmware loaded, you can store the current controller user program and firmware on the CompactFlash card and use that card to update other controllers.

1. Use RSLogix 5000 software to store the controller user program and firmware of a currently configured controller to the CompactFlash card.

2. Access the Nonvolatile Memory tab of the Controller Properties dialog.

   Be sure to select Load Image On Powerup when you save to the card.

3. Remove the card and insert it into a controller that will use the same firmware and controller user program.

   When you apply power to the second controller, the image stored on the CompactFlash card is loaded into the controller.

Select the Controller's Operating Mode

Use the keyswitch on the front panel of the controller to determine the controller's operating mode.

Keyswitch Position	Description
Run	• Upload projects. • Run the program and enable outputs. • You cannot create or delete tasks, programs, or routines. You cannot create or delete tags or edit online while the keyswitch is in the Run position. • You cannot change the mode by using the programming software while the keyswitch is in the Run position.
Prog	• Disable outputs. • Upload/download projects. • Create, modify, and delete tasks, programs, or routines. • The controller does not execute (scan) tasks while the keyswitch is in the Prog position. • You cannot change the mode through the programming software while the keyswitch is in the Prog position.

Keyswitch Position	Description	
Rem	• Upload/download projects. • Change between Remote Program, Remote Test, and Remote Run modes through the programming software.	
	Remote Run	• The controller executes (scans) tasks. • Enable outputs. • Edit online.
	Remote Program	• Disable outputs. • Create, modify, and delete tasks, programs or routines. • Download projects. • Edit online. • The controller does not execute (scan) tasks.
	Remote Test	• Execute tasks with outputs disabled. • Edit online.

Controller Status Indicators

Indicator	Status	Description
RUN	Off	The controller is in Program or Test mode.
	Solid green	The controller is in Run mode.
FORCE	Off	• No tags contain I/O force values. • I/O forces are inactive (disabled).
	Solid amber	• I/O forces are active (enabled). • I/O force values may or may not exist.
	Flashing amber	One or more input or output addresses have been forced to an On or Off state, but the forces have not been enabled.
BAT	Off	The battery supports memory.
	Solid red	Either the battery is: • not installed. • 95% discharged and should be replaced.
I/O	Off	Either: • There are no devices in the I/O configuration of the controller. • The controller does not contain a project (controller memory is empty).
	Solid green	The controller is communicating with all the devices in its I/O configuration.
	Flashing green	One or more devices in the I/O configuration of the controller are not responding.
	Flashing red	• The controller is not communicating to any devices.

Indicator	Status	Description
OK	Off	No power is applied.
	Flashing red	If the controller is new, the controller requires a firmware update. If the controller is not new, a major fault occurred. To clear the fault, do one of the following: • Turn the keyswitch from Prog to Run to Prog. • Go online with RSLogix 5000 software.
	Solid red	The controller detected a nonrecoverable fault, so it cleared the project from memory. Cycle power to the chassis. When the controller is ready, download the project and change to RUN mode. If the OK status indicator remains solid red, contact your Rockwell Automation representative or local distributor.
	Solid green	Controller is OK.
	Flashing green	The controller is storing or loading a project to or from nonvolatile memory.

RS-232 Serial Port Status Indicators (Channel 0)

Indicator	Status	Description
DCH0	Off	Channel 0 is configured differently than the default serial configuration.
	Solid green	Channel 0 has the default serial configuration.
CH0	Off	No RS-232 activity.
	Flashing green	RS-232 activity.

CompactFlash Card Status Indicator

ATTENTION

Do not remove the CompactFlash card while the controller is reading from or writing to the card, as indicated by a flashing green CF status indicator. This could corrupt the data on the card or in the controller, as well as corrupt the latest firmware in the controller.

Indicator	Status	Description
CF	Off	No activity.
	Flashing green	The controller is reading from or writing to the CompactFlash card.
	Flashing red	CompactFlash card does not have a valid file system.

Module Status (MS) Indicator

Condition	Status	Description
Off	No power	The controller does not have power. Check the controller power supply.
Flashing green	Standby	The controller does not have an IP address and is operating in BOOTP mode. Verify that the BOOTP server is running.
Solid green	OK	The controller is operating correctly. Normal operation. No action required.

Condition	Status	Description
Solid red	Held in reset	The controller is holding the port in reset or the controller is faulted. Clear the controller fault. If the fault will not clear, replace the controller.
	Self-test	The controller is performing its power-up self-test. Normal operation during power-up. No action required.
	Major fault	An unrecoverable fault has occurred. Cycle power to the controller. If the fault will not clear, replace the controller.
Flashing red	Duplicate address	A duplicate IP address has been detected. Make sure that the IP address assigned to this controller is not the same as that for any other device already on the network.
	Updating firmware	The controller firmware is being updated. Normal operation during firmware update. No action required.

Network Status (NS) Indicator

Condition	Status	Description
Off	No IP address	The controller does not have an IP address and is operating in BOOTP mode. Verify the BOOTP server is running.
Flashing green	No CIP connections established	The controller has an IP address, but no CIP connections are established. If no connections are configured, this is normal, an no action is required. If connections are configured, check connection originator for connection error code.
Solid green	Connections established	The controller has an IP address and CIP connections (Class 1 or Class 3) are established. Normal operation. No action required.
Solid red	Duplicate address	A duplicate address has been detected. Make sure the IP address assigned to this module is not the same as that for any other device already on the network.

Condition	Status	Description
Flashing red/green	Self-test	The controller is performing its power-up self-test. Normal operation, No action required.

Link Status (LNK) Indicator

Condition	Status	Description
Off	No link	The port is not connected to a powered Ethernet device. The controller cannot communicate on Ethernet. Verify that all Ethernet cables are connected. Verify that Ethernet switch is powered.
Flashing green	Self-test	The controller is performing its power-up self-test. Normal operation. No action required.
	Data transmission and reception	The controller is communicating on Ethernet. Normal operation. No action required.
Solid green	Link OK	The port is connected to a powered Ethernet device. The controller can communicate on Ethernet. Normal operation. No action required.

Specifications

1769-L32E, 1769-L35E - Technical Specifications

Attribute	1769-L32E	1769-L35E
Communication ports	Channel 0 Isolated RS-232 38.4 Kbaud max EtherNet/IP 10/100 BASE-T	
User memory	750 KB	1.5 MB
Nonvolatile memory	1784-CF64 or 1784-CF128 CompactFlash card	
Number of I/O modules, max	16 I/O modules	30 I/O modules
Number of I/O banks, max	3 banks	
Backplane current	660 mA at 5V DC 90 mA at 25 V DC	
Power consumption	5.5 W	
Power dissipation	5.5 W	
Power supply distance rating	4 (The controller must be within four slot positions of the power supply.)	
Isolation voltage	30V (continuous), Basic Insulation Type Type tested at 710V dc for 60 s, RS232 to system, ENET to system, RS232 to ENET	
North American temp code	T4A	
IEC temp code	T4	
Replacement battery	1769-BA	
Weight, approx.	0.30 kg (0.66 lb)	
Programming cable	1747-CP3 or 1756-CP3	

1769-L32E, 1769-L35E - Technical Specifications

Attribute	1769-L32E	1769-L35E
Panel mounting screw torque (using M4 or #8 screws)	1.1…1.8 N•m (10...16 in•lb)	
Enclosure type rating	None (open style)	
Wiring category	2 on communication ports[1]	
Wire type	Ethernet connections: RJ-45 connector according to IEC 60603-7, 2 or 4 pair Category 5e minimum cable according to TIA 568-B.1 or Category 5 cable according to ISO/IEC 24702	

(1) Use this Conductor Category information for planning conductor routing. Refer to Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1.

1769-L32E, 1769-L35E - Environmental Specifications

Attribute	1769-L32E	1769-L35E
Operating temperature IEC 60068-2-1 (Test Ad, Operating Cold) IEC 60068-2-2 (Test Bd, Operating Dry Heat) IEC 60068-2-14 (Test Nb, Operating Thermal Shock)	0...60 °C (32...140 °F)	
Nonoperating temperature IEC 60068-2-1 (Test Ab, Unpackaged Nonoperating Cold) IEC 60068-2-2 (Test Bb, Unpackaged Nonoperating Dry Heat) IEC 60068-2-14 (Test Na, Unpackaged Thermal Shock)	-40...85 °C (-40...185 °F)	

1769-L32E, 1769-L35E - Environmental Specifications

Attribute	1769-L32E	1769-L35E
Relative humidity IEC 60068-2-30 (Test Db, Unpackaged Damp Heat)	5...95% noncondensing	
Vibration IEC 60068-2-6 (Test Fc, Operating)	5 g @ 10...500 Hz	
Operating shock IEC 60068-2-27 (Test Ea, Unpackaged Shock)	DIN rail mount: 20 g; Panel mount: 30 g	
Nonoperating shock IEC 60068-2-27 (Test Ea, Unpackaged Shock)	DIN rail mount: 30 g; Panel mount: 40 g	
Emissions (CISPR 11)	Group 1, Class A	
ESD immunity IEC 61000-4-2	6 kV contact discharges 8 kV air discharges	
Radiated RF immunity IEC 61000-4-3	10V/m with 200 Hz 50% Pulse 100%AM at 900 MHz 10V/m with 200 Hz 50% Pulse 100%AM at 1890 MHz 10V/m with 1 kHz sine-wave 80%AM from 30…2000 MHz 3V/m with 1 kHz sine-wave 80%AM from 2000…2700 MHz	
EFT/B immunity IEC 61000-4-4	±2 kV at 5 kHz on communication ports	
Surge transient immunity IEC 61000-4-5	±2 kV line-earth(CM) on communication ports	
Conducted RF Immunity IEC 61000-4-6	10v rms with 1kHz sine-wave 80% AM from 150 kHz…80 MHz	

1769-L32E, 1769-L35E - Certifications[1]

Certifications[2]	Value
c-UL-us	UL Listed Industrial Control Equipment, certified for US and Canada. See UL File E65584.
c-UL-us	UL Listed for Class 1, Division 2 Group A,B,C,D Hazardous Locations, certified for U.S. and Canada. See UL File E194810.
CE	European Union 2004/108/EC EMCDirective, compliant with: • EN 61000-6-2; Industrial Immunity • EN 61000-6-4; Industrial Emissions
C-Tick	Australian Radio Communications Act, complaint with: • AS/NZS CISPR 11; Industrial Emissions
Ex	European Union 94/9/EC ATEX Directive, compliant with: • EN 60079-15; Potentially Explosive Atmospheres, Protection "n" (II 3 G Ex nA IIC T4 X) • EN 60079-0; General Requirements (Zone 2)
EtherNet/IP	ODVA conformance tested to EtherNet/IP specifications

(1) When product is marked.

(2) See the Production Certification link at http://www.ab.com for Declarations of Conformity, Certificates, and other certification details.,

Additional Resources

These documents contain additional information concerning related Rockwell Automation products.

Resource	Description
Logix5000 Controllers Common Procedures, publication 1756-PM001	Developing projects for Logix5000 controllers
Logix5000 Controllers General Instructions Reference Manual, publication 1756-RM003	Programming the controller for sequential applications
Logix5000 Controllers Process Control and Drives Instructions Reference Manual, publication 1756-RM006	Programming the controller for process or drives applications
CompactLogix System User Manual, publication 1769-UM0011	Planning, mounting, wiring, and troubleshooting the CompactLogix system
CompactLogix System Quick Start, publication IASIMP-QS001.	Understanding common user tasks for the CompactLogix system.
CompactLogix Controllers Selection Guide, publication 1769-SG001	A more detailed description of the 1769 CompactLogix controllers
Compact I/O Selection Guide, publication 1769-SG002	Understanding the 1769 I/O modules available with the Compact I/O system
Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1	Grounding and wiring Allen-Bradley programmable controllers

You can view or download publications at http://www.literature.rockwellautomation.com. To order paper copies of technical documentation, contact your local Rockwell Automation distributor or sales representative.

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The Time-saving Product Line

Quick Selection, Superior Design, Fast Mounting

Bulletin 800F

Allen-Bradley

Rockwell Automation

Quick Selection

Push Button, Non-illuminated, Momentary, Flush

Plastic	Metal
○ 800FP-F1	800FM-F1
● 800FP-F2	800FM-F2
● 800FP-F3	800FM-F3
● 800FP-F4	800FM-F4
● 800FP-F5	800FM-F5
● 800FP-F6	800FM-F6
Ø 800FP-F9	800FM-F9

Ø Push Button without Cap

Push Button, Non-illuminated, Momentary, Extended

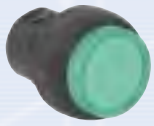
Plastic	Metal
○ 800FP-E1	800FM-E1
● 800FP-E2	800FM-E2
● 800FP-E3	800FM-E3
● 800FP-E4	800FM-E4
● 800FP-E5	800FM-E5
● 800FP-E6	800FM-E6
Ø 800FP-E9	800FM-E9

Ø Push Button without Cap

Push Button, Illuminated, Momentary, Flush

Plastic	Metal
● 800FP-LF3	800FM-LF3
● 800FP-LF4	800FM-LF4
● 800FP-LF5	800FM-LF5
● 800FP-LF6	800FM-LF6
○ 800FP-LF7	800FM-LF7
Ø 800FP-LF9	800FM-LF9

Ø Push Button without Cap



Push Button, Illuminated, Momentary, Extended

Plastic	Metal
● 800FP-LE3	800FM-LE3
● 800FP-LE4	800FM-LE4
● 800FP-LE5	800FM-LE5
● 800FP-LE6	800FM-LE6
○ 800FP-LE7	800FM-LE7
Ø 800FP-LE9	800FM-LE9

Ø Push Button without Cap

Reset Push Button

Plastic	Metal
Ⓡ 800FP-R611	800FM-R611
● 800FP-R6	800FM-R6

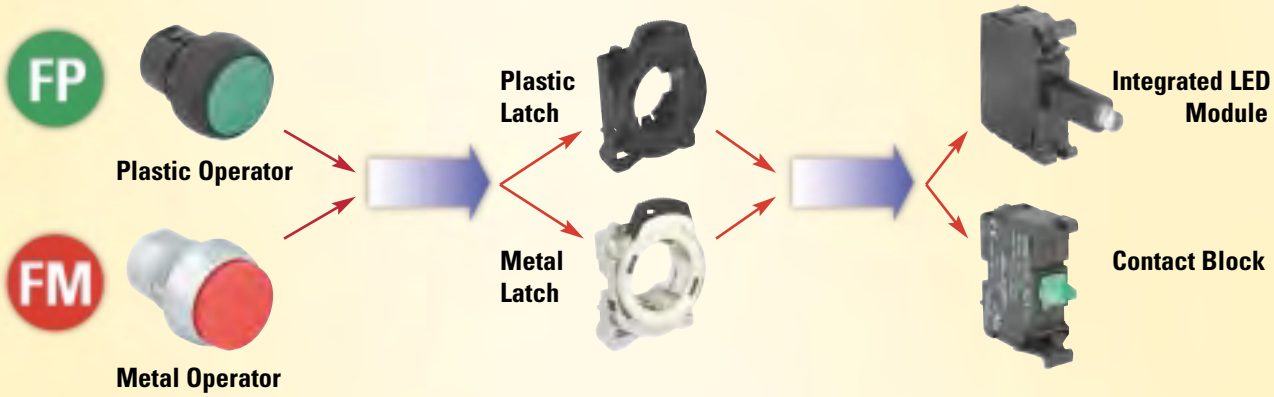
Pilot Light

Plastic	Metal
● 800FP-P3	800FM-P3
● 800FP-P4	800FM-P4
● 800FP-P5	800FM-P5
● 800FP-P6	800FM-P6
○ 800FP-P7	800FM-P7
Ø 800FP-P9	800FM-P9

Ø Pilot light without lens or diffuser

Multi-function, Non-illuminated

Plastic	Metal
800FP-U2FFFE	800FM-U2FFFE
800FP-U2EFFE	800FM-U2EFFE
800FP-U3F3F34	800FM-U3F3F34



Selector Switch, Non-illuminated, 2 Position, Maintained

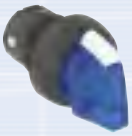
Plastic	Metal
● 800FP-SM22	800FM-SM22

Selector Switch, Non-illuminated, 2 Position, Spring Return from Right

Plastic	Metal
● 800FP-SR22	800FM-SR22

Selector Switch, Non-illuminated, 2 Position, Spring Return from Left

Plastic	Metal
● 800FP-SL22	800FM-SL22



Selector Switch, Illuminated, 2 Position, Maintained

Plastic	Metal
● 800FP-LSM23	800FM-LSM23
● 800FP-LSM24	800FM-LSM24
● 800FP-LSM25	800FM-LSM25
● 800FP-LSM26	800FM-LSM26
○ 800FP-LSM27	800FM-LSM27

Selector Switch, Illuminated, 2 Position, Spring Return from Right

Plastic	Metal
● 800FP-LSR23	800FM-LSR23
● 800FP-LSR24	800FM-LSR24
● 800FP-LSR25	800FM-LSR25
● 800FP-LSR26	800FM-LSR26
○ 800FP-LSR27	800FM-LSR27

Selector Switch, Illuminated, 2 Position, Spring Return from Left

Plastic	Metal
● 800FP-LSL23	800FM-LSL23
● 800FP-LSL24	800FM-LSL24
● 800FP-LSL25	800FM-LSL25
● 800FP-LSL26	800FM-LSL26
○ 800FP-LSL27	800FM-LSL27

Selector Switch, Non-illuminated, 3 Position, Maintained

Plastic	Metal
● 800FP-SM32	800FM-SM32

Selector Switch, Non-illuminated, 3 Position, Spring Return from Right

Plastic	Metal
● 800FP-SR32	800FM-SR32

Selector Switch, Non-illuminated, 3 Position, Spring Return from Left

Plastic	Metal
● 800FP-SL32	800FM-SL32

Selector Switch, Non-illuminated, 3 Position, Spring Return from Both

Plastic	Metal
● 800FP-SB32	800FM-SB32

Plastic Latch

800F-ALP

Metal Latch

800F-ALM

Integrated LED Module, Screw Terminations (latch not included)

800F-N3*	24V AC/DC
800F-N5*	120V AC
800F-N7*	240V AC

* Add LED color; R = red, G = green, Y = yellow, B = blue, W = white

Integrated LED Module, Spring-Clamp Terminations (latch not included)

800F-Q3*	24V AC/DC
800F-Q5*	120V AC
800F-Q7*	240V AC

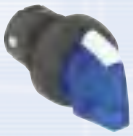
* Add LED color; R = red, G = green, Y = yellow, B = blue, W = white

Selector Switch, Illuminated, 3 Position, Maintained

Plastic	Metal
800FP-LSM33	800FM-LSM33
800FP-LSM34	800FM-LSM34
800FP-LSM35	800FM-LSM35
800FP-LSM36	800FM-LSM36
800FP-LSM37	800FM-LSM37

Selector Switch, Illuminated, 3 Position, Spring Return from Both

Plastic	Metal
800FP-LSB33	800FM-LSB33
800FP-LSB34	800FM-LSB34
800FP-LSB35	800FM-LSB35
800FP-LSB36	800FM-LSB36
800FP-LSB37	800FM-LSB37



Selector Switch, Illuminated, 3 Position, Spring Return from Right

Plastic	Metal
800FP-LSR33	800FM-LSR33
800FP-LSR34	800FM-LSR34
800FP-LSR35	800FM-LSR35
800FP-LSR36	800FM-LSR36
800FP-LSR37	800FM-LSR37

Key Selector Switch, Ronis, 2 Position

Plastic	Metal
800FP-KM21	800FM-KM21
800FP-KM23	800FM-KM23
800FP-KR21	800FM-KR21

Selector Switch, Illuminated, 3 Position, Spring Return from Left

Plastic	Metal
800FP-LSL33	800FM-LSL33
800FP-LSL34	800FM-LSL34
800FP-LSL35	800FM-LSL35
800FP-LSL36	800FM-LSL36
800FP-LSL37	800FM-LSL37

Key Selector Switch, Ronis, 3 Position

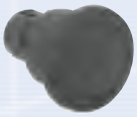
Plastic	Metal
800FP-KM31	800FM-KM31
800FP-KM33	800FM-KM33
800FP-KM34	800FM-KM34
800FP-KB34	800FM-KB34
800FP-KR35	800FM-KR35

Contact Block, Screw Terminations, (latch not included)

800F-X10	1NO
800F-X01	1NC
800F-X10E	1NO Early Make
800F-X01L	1NC Late Break
800F-X10V (1mA)	1NO QuadCONNECT™
800F-X01V (1mA)	1NC QuadCONNECT™
800F-X01S	1 Self-monitoring

Contact Block, Spring-Clamp Terminations, (latch not included)

800F-Q10	1NO
800F-Q01	1NC



Mushroom Push Button, Non-illuminated, 40 mm Momentary

	Plastic	Metal
●	800FP-MM42	800FM-MM42
●	800FP-MM43	800FM-MM43
●	800FP-MM44	800FM-MM44
●	800FP-MM45	800FM-MM45
●	800FP-MM46	800FM-MM46

E-STOP Push Button, Twist-to-release, 30 mm Mushroom

	Plastic	Metal
	800FP-MT34	800FM-MT34
	Complete unit	
1 SMCB	800FP-MT34PX01S	800FM-MT34MX01S
1 SMCB+ 1NO	800FP-MT34PX11S	800FM-MT34MX11S

E-STOP Push Button, Twist-to-release, 40 mm Mushroom

	Plastic	Metal
	800FP-MT44	800FM-MT44
	Complete unit	
1 SMCB	800FP-MT44PX01S	800FM-MT44MX01S
1 SMCB+ 1NO	800FP-MT44PX11S	800FM-MT44MX11S

E-STOP Push Button, Twist-to-release, 60 mm Mushroom

	Plastic	Metal
	800FP-MT64	800FM-MT64
	Complete unit	
1 SMCB	800FP-MT64PX01S	800FM-MT64MX01S
1 SMCB+ 1NO	800FP-MT64PX11S	800FM-MT64MX11S

E-STOP Push Button Key Release, 40 mm Mushroom

	Plastic	Metal
	800FP-MK44	800FM-MK44
	Complete unit	
1 SMCB	800FP-MK44PX01S	800FM-MK44MX01S
1 SMCB+ 1NO	800FP-MK44PX11S	800FM-MK44MX11S

Accessories

Reset Rod

800F-ATR01	40 mm
800F-ATR02	55 mm
800F-ATR04	85 mm
800F-ATR06	115 mm
800F-ATR08	145 mm
800F-ATR19	315 mm

Mounting Ring Wrench

800F-AW2

E-STOP Legend

800F-15Y
800F-16Y

Hole Adapter

800F-AHA1

Anti-Rotation Washer

800F-ALC1

Plastic Enclosures

Holes	Gray	Yellow
1	800F-1P M ❶	800E-1Y M ❶
2	800F-2P M	
3	800F-3P M	
4	800F-4P M	
6	800F-6P M	

Aluminum Enclosures

Holes	Gray
1	800F-1M M ❶
2	800F-2M M
3	800F-3M M
5	800F-5M M

❶ Replace "M" with "P" for PG conduit/through holes instead of metric.

Contact Block Base Mounted

800F-BX10	1NO
800F-BX01	1NC
800F-BX10E	1NO Early Make
800F-BX01L	1NC Late Break
800F-BX10V (1mA)	1NO QuadCONNECT™
800F-BX01V (1mA)	1NC QuadCONNECT™

Integrated LED Base Mounted

800F-BN3*	24V AC/DC
800F-BN5*	120V AC
800F-BN7*	240V AC

* Add LED color; R = red, G = green, Y = yellow, B = blue, W = white

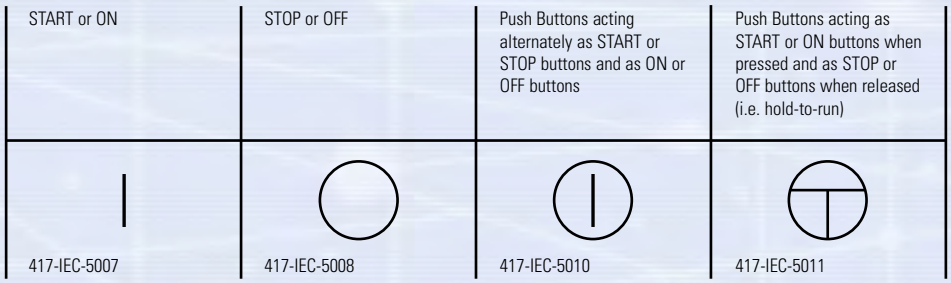
Color-coding for Push Button Actuators and their meanings according IEC 60204-1

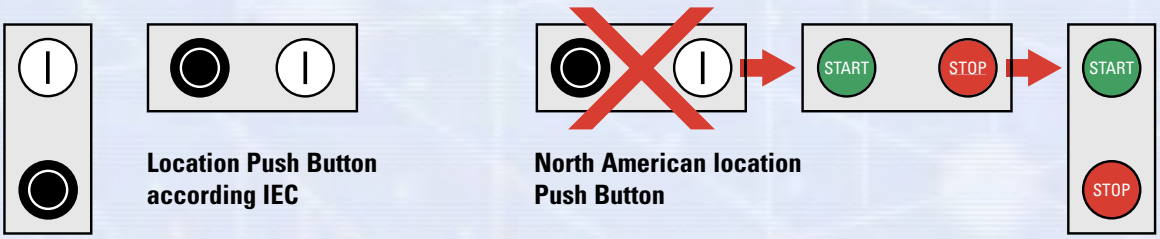
Color	Meaning	Explanation	Examples of application
RED	Emergency	Actuate in the event of a hazardous condition or emergency	Emergency stop, STOP/OFF Initiation of emergency function
YELLOW	Abnormal	Actuate in the event of an abnormal condition	Intervention to suppress abnormal condition Intervention to restart an interrupted automatic cycle
GREEN	Normal	Actuate to initiate normal conditions	START/ON
BLUE	Mandatory	Actuate for a condition requiring mandatory action	Reset function
WHITE	No specific meaning assigned	For general initiation of functions except for emergency stop	START/ON (preferred) STOP/OFF
BLACK	No specific meaning assigned	For general initiation of functions except for emergency stop	START/ON STOP/OFF (preferred)

Note – Where a supplemental means of coding (e.g. shape, position, texture) is used for the identification of Push Button Actuators, then the same color WHITE or BLACK may be used for various functions (e.g. White for START/ON and for STOP/OFF actuators.

Markings for Push Buttons

It is recommended that Push Buttons be marked, near to or preferably directly on the actuators, with the following symbols:





Location Push Button according IEC

North American location Push Button

Colors for Indicator Lights and their meanings with respect to the condition of the machine according IEC 60204-1

Color	Meaning	Explanation	Action by operator
RED	Emergency	Hazardous Condition	Immediate action to deal with hazardous condition (e.g. by operating emergency stop)
YELLOW	Abnormal	Abnormal condition Impending critical condition	Monitoring and/or intervention (e.g. by re-establishing the intended function)
GREEN	Normal	Normal condition	Optional
BLUE	Mandatory	Indication of a condition that requires action by the operator	Mandatory action
WHITE	Neutral	Other conditions; may be used whenever doubt exists about the application of RED, YELLOW, GREEN, BLUE	Monitoring

Indicator Lights and displays according IEC 60204-1

Modes of use

Indicator Lights and Displays serve to give the following types of information:

- **Indication:** to attract the operator's attention or to indicate that a certain task should be performed. The colors RED, YELLOW, GREEN and BLUE are normally used in this mode.
- **Confirmation:** to confirm a command, or a condition, or to confirm the termination of a change or transition period. The colors BLUE and WHITE are normally used in this mode and GREEN may be used in some cases.

Colors

Unless otherwise agreed between the supplier and the user, Indicator (Pilot) Light lenses shall be color-coded with respect to the condition (status) of the machine in accordance with above table.

Alternative meanings may be assigned (see IEC 60073) in accordance with one of the following criteria:

- the safety of persons and the environment;
- the state of the electrical equipment.

Illuminated Push Buttons according IEC 60204-1

Illuminated Push Button Actuators shall be color-coded in accordance with the tables above. Where there is difficulty in assigning an appropriate color, WHITE shall be used. The color RED for the emergency stop actuator shall not depend on the illumination of its light.

Superior Design

The 800F line is designed and manufactured to meet demanding performance specifications. Using state-of-the-art solid modeling techniques and finite element analysis, every component built into 800F Push Buttons is optimized for durability and performance.

Durable Materials

- 800FP operators are made of industrial grade thermoplastic for superior chemical resistance.
- 800FM operators are constructed of tough die cast zinc alloy, finished with chromate plating.

Switching Safety

- Rigid teeth inside all 800F selector switches provide positive detent which assures they will not hang-up between positions.
- Our constant energy solution adds an additional layer of protection to assure switching safety. Vibration will not cause a change in state.

Worldwide Solutions

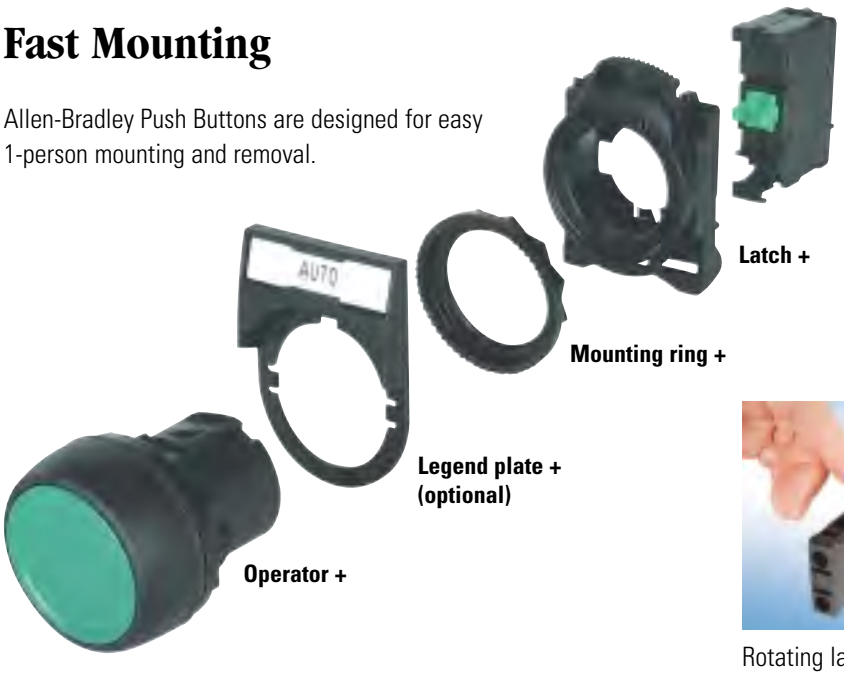
- Designed to meet worldwide standards.
- UL Listed, CSA Rated, CE Marked, Third party approval: KEMA.
- Operator caps, legend plates and inserts available with international symbols, foreign languages, and custom markings.

Dependable Sealing

- Our dependable sealing allows us to offer IP 66 and Type 4/13 across the 800F product line.
- Diaphragm seals are used on most linear travel devices. These seals flex with operation of the button and life/performance are not dependent on lubrication.
- K-seals are used on rotating devices such as twist-to-release E-stops. These seals offer dual wiping action that provides high pressure sealing performance.

Fast Mounting

Allen-Bradley Push Buttons are designed for easy 1-person mounting and removal.



Rotating latch collar for easy mounting and removal.

www.rockwellautomation.com

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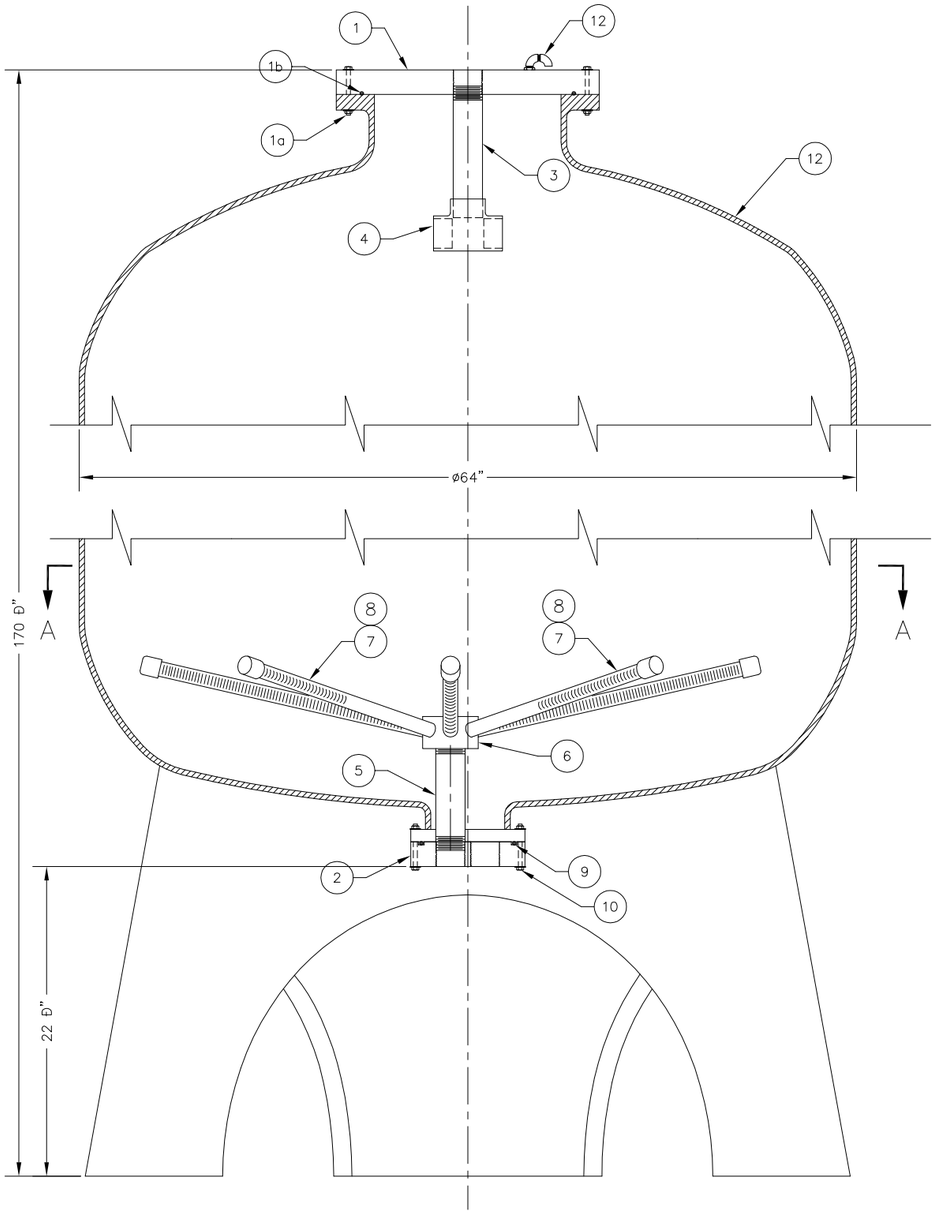
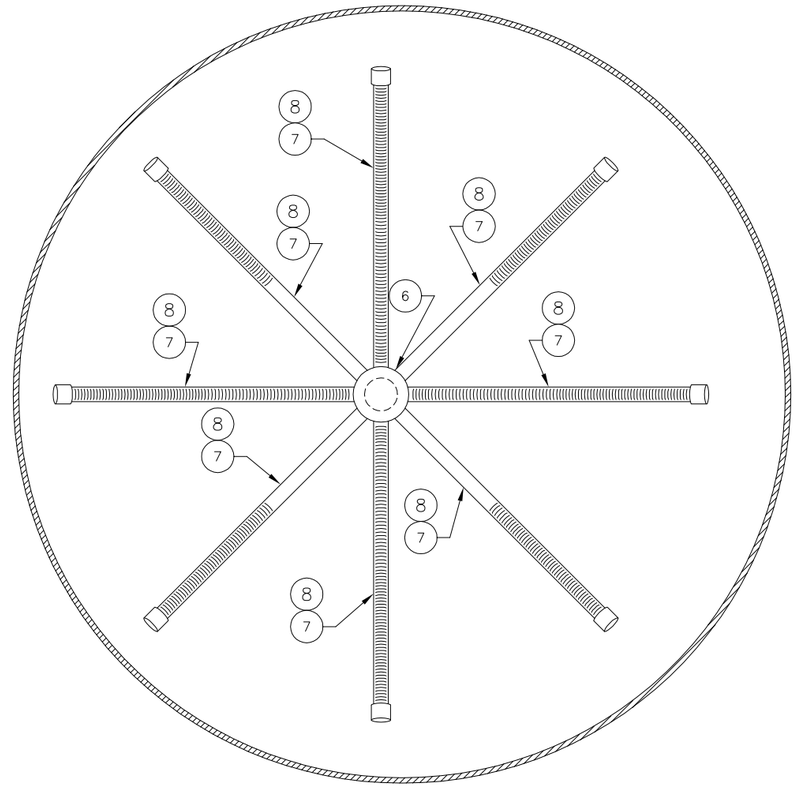
BILL OF MATERIAL

ITEM	QTY	DESCRIPTION	MAT'L	REMARKS
1	1	16" FLANGED ADAPTER	CPVC	SEE DWG. S80-124
1a	24	1/2"-13 x 4 1/2" HEX BOLT W/LW, 2 FW, HEX NUT	18-8 SS	
1b	1	O-RING, ø1/4" x 18 3/8" I.D.	VITON	
2	1	6" FLANGED ADAPTER	PVC	SEE DWG. S80-122 MK 02
3	1	2" x 1'-0" SCH 80 PIPE	PVC	THREAD ONE END
4	1	2" SCH 80 TEE SOC	PVC	
5	1	2" x 8" SCH 40 NIPPLE	304 SS	
6	1	UNDERDRAIN HUB	PVC	MATTSON WITT #DH3148A
7	4	1 1/4" X 22" SCH 40 SLOTTED PIPE	PVC	.010" SLOTS
8	4	1 1/4" SCH 80 MALE ADAPTER & CAP, SOC	PVC	
9	1	O-RING GASKET ø3/8" x 7 1/4" I.D.	VITON	
10	12	5/16"-18 x 3 1/2" HEX BOLT W/LW, 2 FW, HEX NUT	18-8 SS	
11	1	VACUUM BREAKER ASSY	--	SEE DWG. S80-105
12	1	63 x 144 POLYETHYLENE LINED FRP ADSORBER W/TRIPOD BASE	--	PENTAIR WATER #31664





SECTION A-A

NO.	REVISION	DATE	CHKD	APPD
01	UPDATE BOM	6/5/09		

DRAWN DATE CBH 7/24/96	CUSTOMER
CHECKED	JOB
APPROVED	CUSTOMER PO
SCALE 1"=1'	FILE NAME

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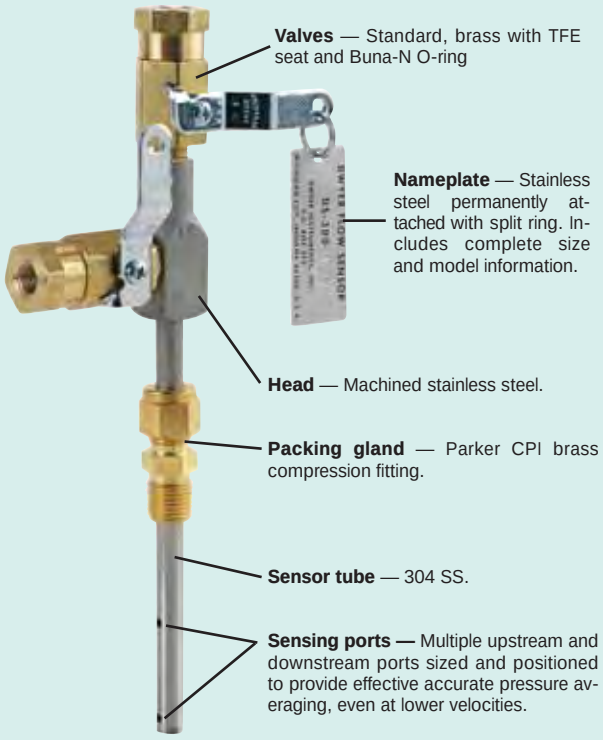
ENCOTECH
8th & Galiffa, MIDA Industrial Park
Donora, PA 15033 412-379-4555

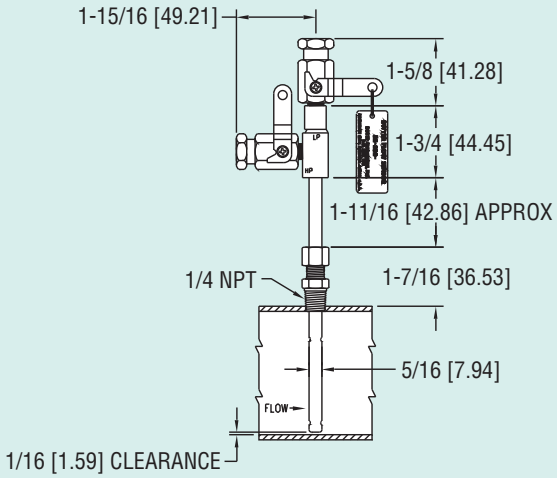
AQUA 5000 HP ADSORBER
16" x 6" FLANGED W/INTERNALS

DRAWING NO.	SHEET	REV.
AQ5000HP	1 OF 1	01

Series DS In-Line Flow Sensors

Use with the Dwyer® Differential Pressure Gages or Transmitters





In-Line Flow Sensors are averaging Pitot tubes that provide accurate and convenient flow rate sensing for schedule 40 pipe. When purchased with a Dwyer® Capsuhelic® differential pressure gage of appropriate range, the result is a flow indicating system delivered off the shelf at an economical price.

Pitot tubes have been used in flow measurement for years. Conventional pitot tubes sense velocity pressure at only one point in the flowing stream. Therefore, a series of measurements must be taken across the stream to obtain a meaningful average flow rate. The Dwyer® flow sensor eliminates the need for "traversing" the flowing stream because of its multiple sensing points and built-in averaging capability.

The Series DS-300 flow sensors are designed to be inserted in the pipeline through a compression fitting. They are furnished with instrument shut-off valves on both pressure connections. Valves are fitted with 1/8″ female NPT connections. Accessories include adapters with 1/4″ SAE 45° flared ends compatible with hoses supplied with the Model A-471 Portable Capsuhelic® gage kit. Standard valves are rated at 200 psig (13.7 bar) and 200°F (93.3°C). Where valves are not required, they can be omitted at reduced cost. Series DS-300 flow sensors are available for pipe sizes from 1″ to 10″.

DS-400 Averaging Flow Sensors are quality constructed from extra strong 3/4″ dia. stainless steel to resist increased forces encountered at higher flow rates with both air and water. This extra strength also allows them to be made in longer insertion lengths up to 24 inches (61 cm). All models include convenient and quick-acting quarter-turn ball valves to isolate the sensor for zeroing. Process connections to the valve assembly are 1/8″ female NPT. A pair of 1/8″ NPT X 1/4″ SAE 45° flared adapters are included, compatible with hoses used in the Model A-471 Portable Capsuhelic® Gage Kit. Supplied solid brass mounting adapter has a 3/4″ dia. compression fitting to lock in required insertion length and a 3/4″ male NPT thread for mounting in a Threaded Branch Connection.

Select model with suffix which matches pipe size

DS-300-1″
DS-300-1-1/4″
DS-300-1-1/2″
DS-300-2″
DS-300-2-1/2″
DS-300-3″
DS-300-4″
DS-300-6″
DS-300-8″
DS-300-10″

DS-400-6″
DS-400-8″
DS-400-10″
DS-400-12″
DS-400-14″
DS-400-16″
DS-400-18″
DS-400-20″
DS-400-24″

Options and Accessories

A-160 Threaded Branch Connection, 3/8″ NPT, forged steel, 3000 psi

A-161 Brass Bushing, 1/4″ x 3/8″

DS-300 Less Valves. To order, add suffix **-LV**

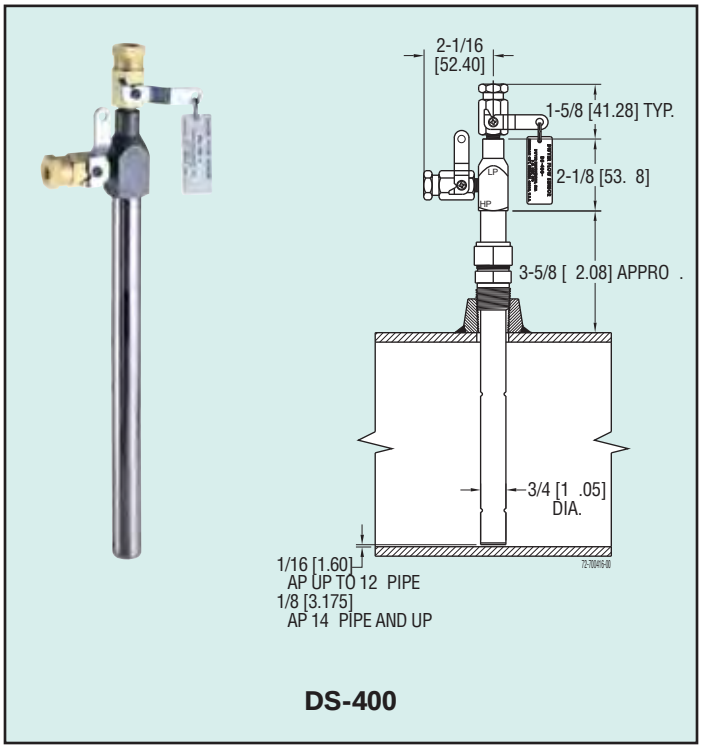
How To Order

Merely determine the pipe size into which the flow sensor will be mounted and designate the size as a suffix to Model DS-300. For example, a flow sensor to be mounted in a 2˝ pipe would be a Model No. DS-300-2˝.

For non-critical water and air flow monitoring applications, the chart below can be utilized for ordering a stock Capsuhelic® differential pressure gage for use with the DS-300 flow sensor. Simply locate the maximum flow rate for the media being measured under the appropriate pipe size and read the Capsuhelic® gage range in inches of water column to the left. The DS-300 sensor is supplied with installation and operating instructions, Bulletin F-50. It also includes complete flow conversion information for the three media conditions shown in the chart below. This information enables the user to create a complete differential pressure to flow rate conversion table for the sensor and differential pressure gage employed. Both the Dwyer® Capsuhelic® gage and flow sensor feature excellent repeatability so, once the desired flow rate is determined, deviation from that flow in quantitative measure can be easily determined. You may wish to order the adjustable signal flag option for the Capsuhelic® gage to provide an easily identified reference point for the proper flow.

Capsuhelic® gages with special ranges and/or direct reading scales in appropriate flow units are available on special order for more critical applications. Customer supplied data for the full scale flow (quantity and units) is required along with the differential pressure reading at that full flow figure. Prior to ordering a special Capsuhelic® differential pressure gage for flow read-out, we recommend you request Bulletin F-50 to obtain complete data on converting flow rates of various media to the sensor differential pressure output. With this bulletin and after making a few simple calculations, the exact range gage required can easily be determined.

Large 3/4 Inch Diameter for Extra Strength in Lengths to 24 Inches



DS-400

GAGE RANGE (IN. W.C.)	MEDIA @ 70°F	FULL RANGE FLOWS BY PIPE SIZE (APPROXIMATE)									
		1˝	1-1/4˝	1-1/2˝	2˝	2-1/2˝	3˝	4˝	6˝	8˝	10˝
2	W (PM) A 14.7 PSIA (SCFM) A 100 PSI (SCFM)	4.8 1 .0 50.0	8.3 33.0 0.5	11.5 42.0 120.0	20.5 65.0 210.0	30 113 325	4 183 510	86 330 20	205 760 2050	350 1340 3600	560 2130 6000
5	W (PM) A 14.7 PSIA (SCFM) A 100 PSI (SCFM)	7.7 30.0 83.0	14.0 51.0 142.0	18.0 66.0 1 0.0	34.0 118.0 340.0	47 178 610	78 28 820	138 510 1600	320 1200 3300	560 2150 5700	8 0 3400 10000
10	W (PM) A 14.7 PSIA (SCFM) A 100 PSI (SCFM)	11.0 41.0 120.0	1 .0 72.0 205.0	25.5 3.0 275.0	45.5 163.0 470.0	67 250 740	110 410 1100	1 5 725 2000	450 16 0 4600	800 3040 8100	1260 4860 15000
25	W (PM) A 14.7 PSIA (SCFM) A 100 PSI (SCFM)	18.0 63.0 185.0	32.0 112.0 325.0	40.5 155.0 430.0	72.0 255.0 760.0	108 3 0 1200	173 640 1800	310 1130 3300	720 2630 7200	1250 4860 13000	2000 7700 22000
50	W (PM) A 14.7 PSIA (SCFM) A 100 PSI (SCFM)	25.0 0.0 260.0	44.0 161.0 460.0	57.5 205.0 620.0	100.0 360.0 1050.0	152 560 1700	247 00 2600	435 1600 4600	1000 3700 10000	1800 6400 18500	
100	W (PM) A 14.7 PSIA (SCFM) A 100 PSI (SCFM)	36.5 135.0 370.0	62.0 230.0 660.0	82.0 300.0 870.0	142.0 505.0 1500.0	220 800 2300	350 12 0 3600	620 22 0 6500	1500 5000 15000		

Model A-471 Portable Kit

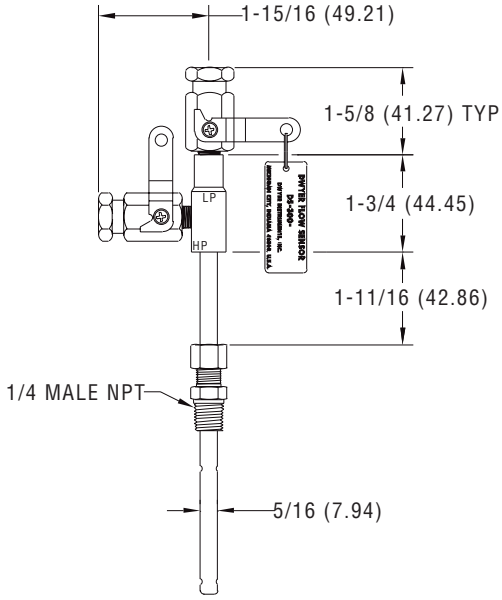
The Dwyer® Series 4000 Capsuhelic® differential pressure gage is ideally suited for use as a read-out device with the DS-300 Flow Sensors. The gage may be used on system pressures of up to 500 psig even when the flow sensor differential pressure to be read is less than 0.5˝ w.c. With accuracy of ±3% of full scale, the Capsuhelic® gage can be used in ambient temperatures from 32 to 200°F (0 to 93.3°C). Zero and range adjustments are made from outside the gage. The standard gage with a die cast aluminum housing can be used with the flow sensor for air or oil applications. For water flow measurements, the optional forged brass housing should be specified. The Capsuhelic® gage may be panel or surface mounted and permanently plumbed to the flow sensor if desired. The optional A-610 pipe mounting bracket allows the gage to be easily attached to any 1-1/4˝ - 2˝ horizontal or vertical pipe.

For portable operation, the A-471 Capsuhelic® Portable Gage Kit is available complete with tough polypropylene carrying case, mounting bracket, 3-way manifold valve, two 10' high pressure hoses, and all necessary fittings. See pages 8 and 9 for complete information on the Capsuhelic® gage.

CAPSUHELIC® GAGE SHOWN INSTALLED IN A-471 PORTABLE KIT

Series DS-300 Flow Sensors

Installation and Operating Instructions Flow Calculations



Series DS-300 Flow Sensors are averaging pitot tubes that provide accurate, convenient flow rate sensing. When purchased with a Dwyer Capsuhelic® for liquid flow or Magnehelic® for air flow, differential pressure gage of appropriate range, the result is a flow-indicating system delivered off the shelf at an economical price. Series DS-300 Flow Sensors are designed to be inserted in the pipeline through a compression fitting and are furnished with instrument shut-off valves on both pressure connections. Valves are fitted with 1/8″ female NPT connections. Accessories include adapters with 1/4″ SAE 45° flared ends compatible with hoses supplied with the Model A-471 Portable Capsuhelic® kit. Standard valves are rated at 200°F (93.3°C). Where valves are not required, they can be omitted at reduced cost. Series DS-300 Flow Sensors are available for pipe sizes from 1″ to 10″.

INSPECTION

Inspect sensor upon receipt of shipment to be certain it is as ordered and not damaged. If damaged, contact carrier.

INSTALLATION

General - The sensing ports of the flow sensor must be correctly positioned for measurement accuracy. The instrument connections on the sensor indicate correct positioning. The side connection is for total or high pressure and should be pointed upstream. The top connection is for static or low pressure.

Location - The sensor should be installed in the flowing line with as much straight run of pipe upstream as possible. A rule of thumb is to allow 10 - 15 pipe diameters upstream and 5 downstream. The table below lists recommended up and down piping.

PRESSURE AND TEMPERATURE

Maximum: 200 psig (13.78 bar) at 200°F (93.3°C).

Upstream and Downstream Dimensions in Terms of Internal Diameter of Pipe*

Upstream Condition	Minimum Diameter of Straight Pipe		
	Upstream		Downstream
	In-Plane	Out of Plane	
One Elbow or Tee	7	9	5
Two 90° Bends in Same Plane	8	12	5
Two 90° Bends in Different Plane	18	24	5
Reducers or Expanders	8	8	5
All Valves**	24	24	5

* Values shown are recommended spacing, in terms of internal diameter for normal industrial metering requirements. For laboratory or high accuracy work, add 25% to values.

** Includes gate, globe, plug and other throttling valves that are only partially opened. If valve is to be fully open, use values for pipe size change. **CONTROL VALVES SHOULD BE LOCATED AFTER THE FLOW SENSOR.**

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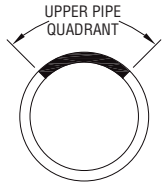
POSITION

Be certain there is sufficient clearance between the mounting position and other pipes, walls, structures, etc, so that the sensor can be inserted through the mounting unit once the mounting unit has been installed onto the pipe.

Flow sensors should be positioned to keep air out of the instrument connecting lines on liquid flows and condensate out of the lines on gas flows. The easiest way to assure this is to install the sensor into the pipe so that air will bleed into, or condensate will drain back to, the pipe.

For Air or Gas Flow

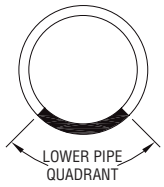
Install in upper quadrant of pipe



Condensate drains back to pipe

For Liquid or Steam Flow

Install in lower quadrant of pipe



Air bleeds back to pipe

INSTALLATION

1. When using an A-160 thred-o-let, weld it to the pipe wall. If replacing a DS-200 unit, an A-161 bushing (1/4˝ x 3/8˝) will be needed.

2. Drill through center of the thred-o-let into the pipe with a drill that is slightly larger than the flow sensor diameter.

3. Install the packing gland using proper pipe sealant. If the packing gland is disassembled, note that the tapered end of the ferrule goes into the fitting body.

4. Insert sensor until it bottoms against opposite wall of the pipe, then withdraw 1/16˝ to allow for thermal expansion.

5. Tighten packing gland nut finger tight. Then tighten nut with a wrench an additional 1-1/4 turns. Be sure to hold the sensor body with a second wrench to prevent the sensor from turning.

INSTRUMENT CONNECTION

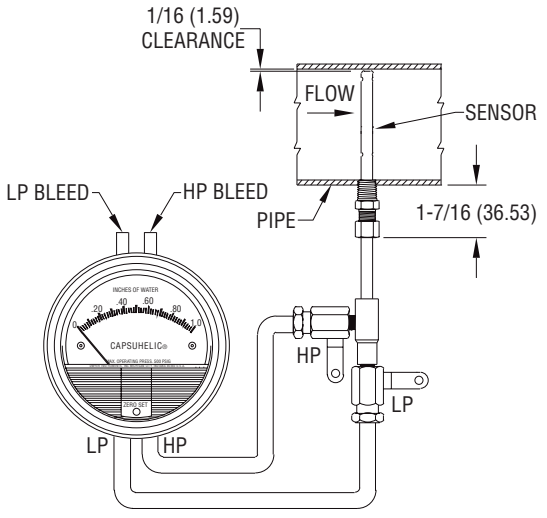
Connect the slide pressure tap to the high pressure port of the Magnehelic® (air only) or Capsuhelic® gage or transmitting instrument and the top connection to the low pressure port.

See the connection schematics below.

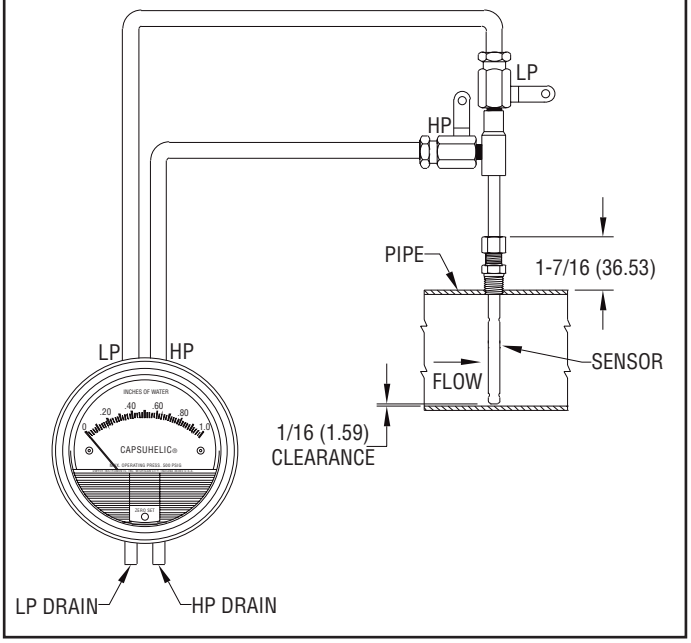
Bleed air from instrument piping on liquid flows. Drain any condensate from the instrument piping on air and gas flows.

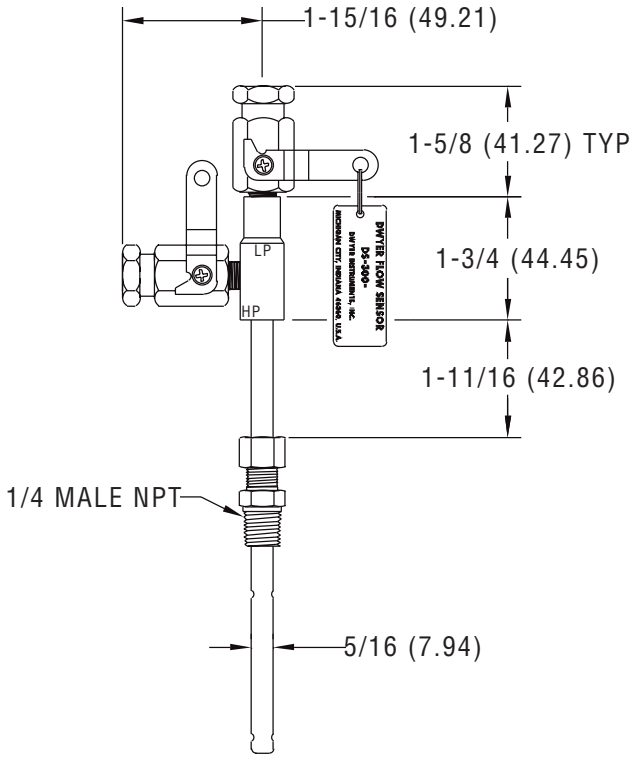
Open valves to instrument to place flow meter into service. For permanent installations, a 3-valve manifold is recommended to allow the gage to be zero checked without interrupting the flow. The Dwyer A-471 Portable Test Kit includes such a device.

Water Flow



Air or Gas Flow





Flow Calculations and Charts

The following information contains tables and equations for determining the differential pressure developed by the DS-300 Flow Sensor for various flow rates of water, steam, air or other gases in different pipe sizes.

This information can be used to prepare conversion charts to translate the differential pressure readings being sensed into the equivalent flow rate. When direct readout of flow is required, use this information to calculate the full flow differential pressure in order to specify the exact range of Dwyer Magnehelic® or Capsuhelic® gage required. Special ranges and calculations are available for these gages at minimal extra cost. See bulletins A-30 and F-41 for additional information on Magnehelic® and Capsuhelic® gages and DS-300 flow sensors.

For additional useful information on making flow calculations, the following service is recommended: Crane Valve Co. Technical Paper No. 410 "Flow of Fluids Through Valves, Fittings and Pipe." It is available from Crane Valve Company, www.cranevalve.com.

Using the appropriate differential pressure equation from Page 4 of this bulletin,calculate the differential pressure generated by the sensor under normal operating conditions of the system. Check the chart below to determine if this value is within the recommended operating range for the sensor. Note that the data in this chart is limited to standard conditions of air at 60°F (15.6°C) and 14.7 psia static line pressure or water at 70°F (21.1°C). To determine recommended operating ranges of other gases, liquids an/or operating conditions, consult factory.

Note: the column on the right side of the chart which defines velocity ranges to avoid. Continuous operation within these ranges can result in damage to the flow sensor caused by excess vibration.

Pipe Size (Schedule 40)	Flow Coefficient "K"	Operating Ranges Air @ 60°F & 14.7 psia (D/P in. W.C.)	Operating Ranges Water @ 70°F (D/P in. W.C.)	Velocity Ranges Not Recommended (Feet per Second)
1	0.52	1.10 to 186	4.00 to 675	146 to 220
1-1/4	0.58	1.15 to 157	4.18 to 568	113 to 170
1-1/2	0.58	0.38 to 115	1.36 to 417	96 to 144
2	0.64	0.75 to 75	2.72 to 271	71 to 108
2-1/2	0.62	1.72 to 53	6.22 to 193	56 to 85
3	0.67	0.39 to 35	1.43 to 127	42 to 64
4	0.67	0.28 to 34	1.02 to 123	28 to 43
6	0.71	0.64 to 11	2.31 to 40	15 to 23
8	0.67	0.10 to 10	0.37 to 37	9.5 to 15
10	0.70	0.17 to 22	0.60 to 79	6.4 to 10

FLOW EQUATIONS

1. Any Liquid

$$Q\ (GPM) = 5.668 \times K \times D^2 \times \sqrt{\Delta P / S_f}$$

2. Steam or Any Gas

$$Q\ (lb/Hr) = 359.1 \times K \times D^2 \times \sqrt{p \times \Delta P}$$

3. Any Gas

$$Q\ (SCFM) = 128.8 \times K \times D^2 \times \sqrt{\frac{P \times \Delta P}{(T + 460) \times S_s}}$$

DIFFERENTIAL PRESSURE EQUATIONS

1. Any Liquid

$$\Delta P\ (in.\ WC) = \frac{Q^2 \times S_f}{K^2 \times D^4 \times 32.14}$$

2. Steam or Any Gas

$$\Delta P\ (in.\ WC) = \frac{Q^2}{K^2 \times D^4 \times p \times 128{,}900}$$

3. Any Gas

$$\Delta P\ (in.\ WC) = \frac{Q^2 \times S_s \times (T + 460)}{K^2 \times D^4 \times P \times 16{,}590}$$

Technical Notations

The following notations apply:

ΔP = Differential pressure expressed in inches of water column
Q = Flow expressed in GPM, SCFM, or PPH as shown in equation
K = Flow coefficient— See values tabulated on Pg. 3.
D = Inside diameter of line size expressed in inches.

For square or rectangular ducts, use: $D = \sqrt{\frac{4 \times \text{Height} \times \text{Width}}{\pi}}$

P = Static Line pressure (psia)
T = Temperature in degrees Fahrenheit (plus 460 = °Rankine)
p = Density of medium in pounds per square foot
S_f = Sp Gr at flowing conditions
S_s = Sp Gr at 60°F (15.6°C)

SCFM TO ACFM EQUATION

$$SCFM = ACFM \times \left(\frac{14.7 + PSIG}{14.7}\right) \left(\frac{520^*}{460 + °F}\right)$$

$$ACFM = SCFM \times \left(\frac{14.7}{14.7 + PSIG}\right) \left(\frac{460 + °F}{520}\right)$$

$$\text{POUNDS PER CUBIC FOOT STD.} = \text{POUNDS PER CUBIC FOOT ACT.} \times \left(\frac{14.7}{14.7 + PSIG}\right) \left(\frac{460 + °F}{520^*}\right)$$

$$\text{POUNDS PER CUBIC FOOT ACT.} = \text{POUNDS PER CUBIC FOOT STD.} \times \left(\frac{14.7 + PSIG}{14.7}\right) \left(\frac{520^*}{460 + °F}\right)$$

1 Cubic foot of air = 0.076 pounds per cubic foot at 60° F (15.6°C) and 14.7 psia.
* (520°= 460 + 60°) Std. Temp. Rankine

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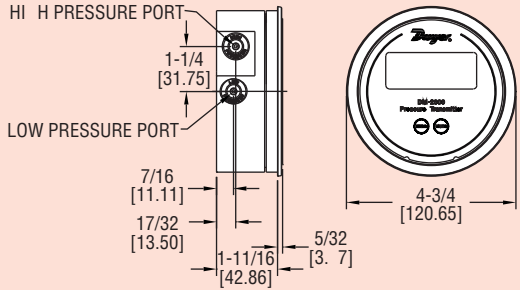
Series DM-2000

Differential Pressure Transmitter

Same Size as Standard Magnehelic® Differential Pressure Gage



The Dwyer Series DM-2000 Differential Pressure Transmitter senses the pressure of air and compatible gases and sends a standard 4-20 mA output signal. The DM-2000 housing is specifically designed to mount in the same diameter cutout as a standard Magnehelic® gage. A wide range of models are available factory calibrated to specific ranges.

Pressure connections are inherent to the glass filled plastic molded housing making installation quick and easy. Digital push-button zero simplifies calibration over typical turn-potentiometers. An optional 3.5 digit LCD shows process and engineering units. A single push button allows field selection of 4 to 6 engineering units depending on range LCD models.

Model Number	Range	Pa	mm wc	mBar	kPa	psi
DM-2001-LCD	.100	24.	2.54	.24		
DM-2002-LCD	.250	62.2	6.35	.622		
DM-2003-LCD	.500	124.3	12.70	1.243	.124	
DM-2004-LCD	1.000	24	25.4	2.4	.24	
DM-2005-LCD	2.00	4 7	50.8	4. 7	.4 7	
DM-2006-LCD	3.00	746	76.2	7.46	.746	.108
DM-2007-LCD	5.00	1243	127..0	12.43	1.243	.180
DM-2012-LCD	.250-0-.250	62.2-0-62.2	3.65-0-6.35	.622-0-.622		
DM-2013-LCD	.500-0-.500	124.3.0.124.3	12.70-0-12.70	1.243-0-1.243		

Note: Remove '-LCD' from the end of the model number if not needing the display.

SPECIFICATIONS

Service: Air and non-combustible, compatible gases.
Wetted Materials: Consult Factory.
Accuracy: ±1% F.S. at 70°F.
Stability: ±1% F.S./yr.
Temperature Limits: 20 to 120°F (-6.67 to 48.9°C).
Pressure Limits: 10 psig (0.69 bar).
Thermal Effect: ±0.055% F.S./°F (0.099% F.S./°C).
Power Requirements: 10-35 VDC (2 wire).
Output Signal: 4 to 20 mA.
Zero and Span Adjustments: Digital push-button zero and span.
Loop Resistance: DC: 0-1250 ohms maximum.
Current Consumption: DC: 38 mA maximum.
Electrical Connections: Screw-type terminal block.
Display: 3.5 digit LCD, 0.7" height.
Process Connections: 1/8" I.D. tubing.
Mounting Orientation: Vertical.
Weight: 4.8 oz (136 g).

APPLICATIONS

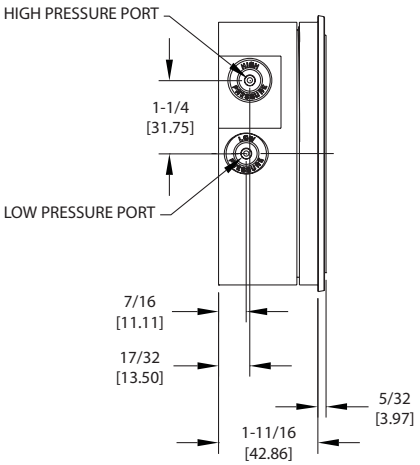
Differential Pressure across Filters.

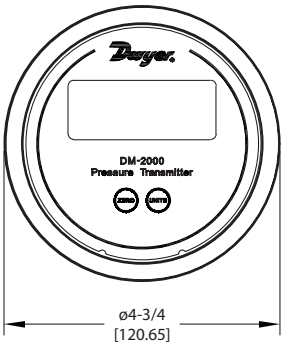
ACCESSORIES

A-299, Surface Mounting Bracket
A-300, Flat Flush Mounting Bracket

Series DM-2000 Differential Pressure Transmitter

Specifications – Installation and Operating Instructions





The Dwyer Series DM-2000 Differential Pressure Transmitter senses the pressure of air and compatible gases and sends a standard 4-20 mA output signal. The DM-2000 housing is specifically designed to mount in the same diameter cutout as a standard Magnehelic® differential gage. A wide range of models are available factory calibrated to specific ranges.

Pressure connections are inherent to the glass filled plastic molded housing making installation quick and easy. Digital push-button zero simplifies calibration over typical turn-potentiometers. Single push button allows field selection of 5 engineering units (LCD models only). An optional 3.5 digit LCD shows process and engineering.

Accessories
Mounting Lugs
6-20 x 2″ Screws - 3
6-19 x 1/2″ Screws - 3

INSTALLATION

1. Location
Select a clean, dry mounting location free from excess vibration where the temperature will remain between 20 and 120˚F (-6.7 and 48.9˚C). Distance from the receiver is limited only by total loop resistance. See Electrical Connections on next page. The tubing supplying pressure to the instrument can be practically any length required, but long lengths will increase response time slightly.

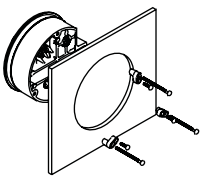
2. Position
A vertical position required. That is the position in which all standard models are spanned and zeroed at the factory.

Pressure Connections
Two integral tubing connections are provided. They are sized to fit 1/8″ (3.12 mm) I.D. tubing. Be sure the pressure rating of the tubing exceeds that of the operating ranges.

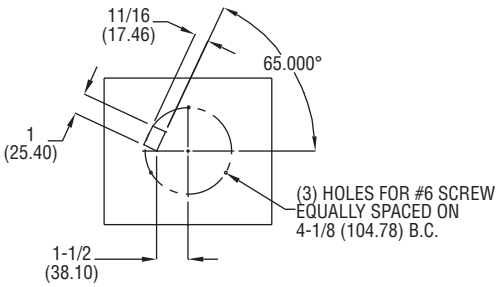
3. Mounting
Panel - Provide a 4-9/16″ diameter opening in panel. Insert gage and secure in place with provided screws and adapters.
Surface - Provide three 3/16″ diameter holes in panel on a 4-1/8″ diameter bolt circle. Cut opening for terminal block as shown in diagram to right.

SPECIFICATIONS
Service: Air and non-combustible, compatible gases.
Wetted Materials: Consult Factory.
Accuracy: ±1% F.S. at 70°F.
Stability: ±1% F.S./yr.
Temperature Limits: 20 to 120°F (-6.67 to 48.9°C).
Pressure Limits: 10 psig (0.69 bar).
Thermal Effect: ±0.055% F.S./°F (0.099% F.S./°C).
Power Requirements: 10-35 VDC (2 wire).
Output Signal: 4 to 20 mA.
Zero and Span Adjustments: Digital push-button zero and span.
Loop Resistance: DC: 0-1250 ohms maximum.
Current Consumption: DC: 38 mA maximum.
Electrical Connections: Screw-type terminal block.
Process Connections: 1/8″ I.D. tubing.
Mounting Orientation: Vertical.
Weight: 4.8 oz (136 g).
Agency Approvals: CE

Panel



Surface



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ELECTRICAL CONNECTIONS

CAUTION: Do not exceed specified supply voltage ratings. Permanent damage not covered by warranty will result. This unit is not designed for 120 or 240 volts AC line operation.

Electrical connections are made to the terminal block located in back of the transmitter. Terminals are marked + and - (see *Fig. B* below).

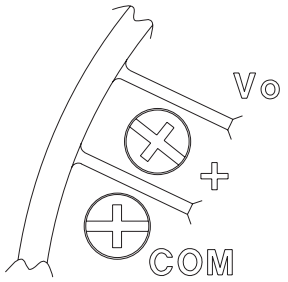

Figure B

Wire Length

The maximum length of wire connecting transmitter and receiver is a function of wire size and receiver resistance. Wiring should not contribute more than 10% of the receiver resistance to total loop resistance. For extremely long runs (over 1000 feet), choose receivers with higher resistance to minimize size and cost of connecting leads. Where wiring length is under 100 feet, hook-up wire as small as 22 AWG can be used.

2-Wire Operation

An external power supply delivering 10-35 VDC with minimum current capability of 40 mA DC (per transmitter) must be used to power the control loop. *See Fig. C for connection of the power supply, transmitter and receiver.* The range of appropriate receiver load resistance (R_L) for the DC power supply voltage available is expressed by the formula and graph in *Fig. D.* Shielded two wire cable is recommended for control loop wiring. If grounding is required, use the negative side of the control loop after the receiver.

2-Wire Connections

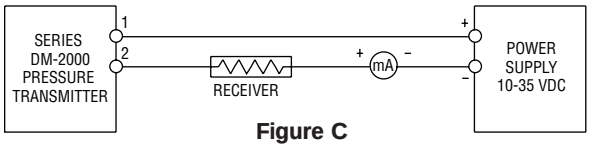

Figure C

Power Supply Voltage – VDC (2-wire)

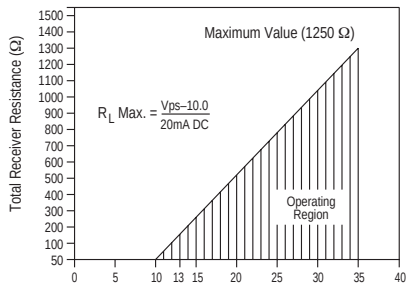

Figure D

USER CALIBRATION

The transmitter may be user calibrated with two buttons on the front. The standard models have buttons labeled “ZERO” and “SPAN”. LCD models have buttons labeled “ZERO” and “UNITS”. The “UNITS” button on the LCD models has 2 functions. If pushed for less than 2 seconds and released the pressure units that are displayed on the LCD will change when the button is released. If pushed and held for 4 - 5 seconds the “UNITS” button serves the same function as the “SPAN” button on the standard models.

To calibrate the transmitter you will need three pieces of equipment. You will need a calibrated pressure source capable of generating a stable pressure value for the maximum range of the unit under test, an instrument capable of validating the calibration pressure, and a milliameter to measure the current output from the unit under test. The transmitter is calibrated using the following procedure.

Preparation – Connect the Milliameter and power supply, being careful to observe polarities. The transmitter must be calibrated in a vertical position.

Calibrating Zero – Leaving the pressure connections vented, press and hold the “ZERO” button for 4 – 5 seconds. The zero point will now be set and the gage output will be 4 mA and if it is an LCD model the display will read zero. This zero calibration is done first as it can affect the span value.

Calibrating Span – Connect the pressure source and apply the high range rated pressure. When the pressure has stabilized, press and hold the “UNITS” button (for LCD models), or the “SPAN” button (on standard models), for 4 – 5 seconds. The span point will now be set and the gage output at full range will be 20 mA and if it is an LCD model will now read the full range calibration pressure. The zero and span setting are slightly interactive so recheck the zero calibration and repeat both zero and span calibration if necessary.

Restoring Factory Calibration Coefficients:

The user calibration coefficients are stored in non volatile memory, which retains Its content indefinitely without external power or batteries. Factory calibration can be easily restored if the user calibration must be “erased”. To do this simultaneously press both buttons on the front and hold them for 4 – 5 seconds. The factory calibration will now be restored.

MAINTENANCE

Upon final installation of the Series DM2000 Differential Pressure Transmitter and the companion receiver no routine maintenance is required. A periodic check of the system calibration is recommended following the procedures explained under *Calibration Check.* The Series DM2000 Transmitter is not field serviceable and should be returned, freight prepaid, to the factory if repair is required. Please enclose a description of the problems encountered plus any available application information.

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Signet 2536 Rotor-X Paddlewheel Flow Sensors

Standard Sensor (with blue cap)

Integral Sensor

Wet-Tap Sensor

Features

- **Flow rate range 0.1 to 6 m/s (0.3 to 20ft/s)**
- **Wide Turndown Ratio of 66:1**
- **Open-collector output**
- **Simple , economical design**
- **Highly repeatable output**
- **Installs into pipe sizes DN 15 to DN 900 (0.5 to 36 in.)**
- **High resolution and noise immunity**
- **7.6m (25 ft.) of cable for standard and Wet-tap sensors**
- **Chemically resistant materials**
- **Easy to replace rotor**

Description

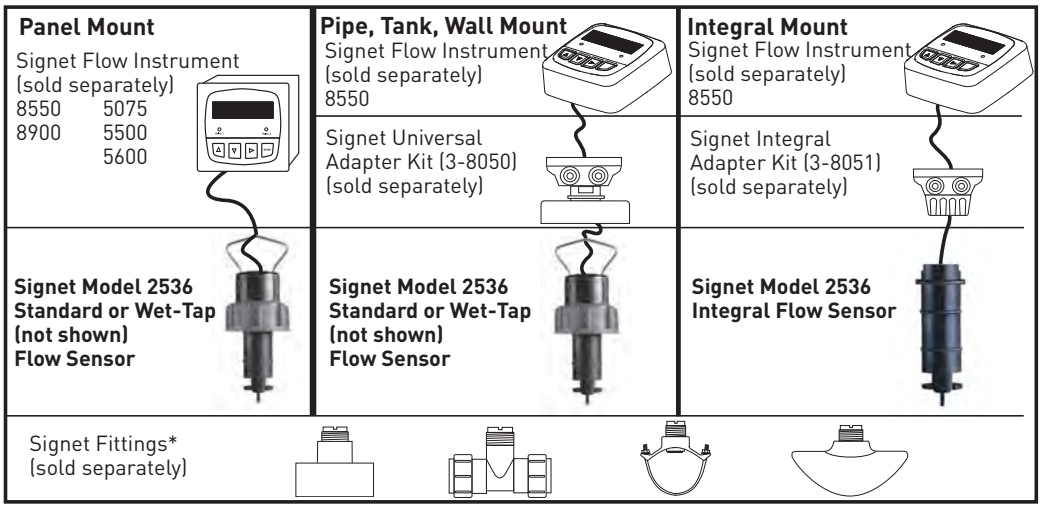
Simple to install with time-honored reliable performance, Signet 2536 Rotor-X Paddlewheel Flow Sensors are highly repeatable, rugged sensors that offer exceptional value with little or no maintenance. The Model 2536 has a process-ready open collector signal and has a wide dynamic flow range of 0.1 to 6 m/s (0.3 to 20 ft/s). The sensor measures liquid flow rates in full pipes and can be used in low pressure systems.

The Signet 2536 sensors are offered in a variety of materials for a wide range of pipe sizes and insertion configurations. The many material choices including PP, PVDF, and Tefzel® make this model highly versatile and chemically compatible to many liquid process solutions. Sensors can be installed in DN 15 to DN 900 (0.5 to 36 in.) pipes using Signet's comprehensive line of custom fittings. These custom fittings, which include tees, saddles, and weldolets, seat the sensor to the proper insertion depth into the process flow. The sensors are also offered in configurations for wet-tap installation requirements.

Applications

- **Pure Water Production**
- **Filtration Systems**
- **Chemical Production**
- **Liquid Delivery Systems**
- **Pump Protection**
- **Scrubbers/Gas stacks**
- **Gravity Feed Lines**
- **Not suitable for gases**

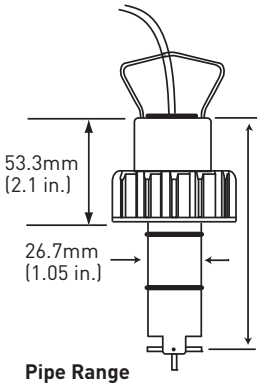
System Overview **(For overview of Wet-Tap System see page 20.)**



*See Fittings section for more information.

Dimensions

2536 Standard Mount Sensor

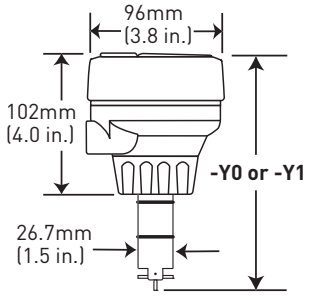


Pipe Range

0.5 to 4 in.	**-X0** = 104mm (4.1 in)
5 to 8 in.	**-X1** = 137mm (5.4 in.)
10 in. and up	**-X2** = 213mm (8.4 in.)

2536 Integral Mount Sensor shown with Transmitter

(sold separately)

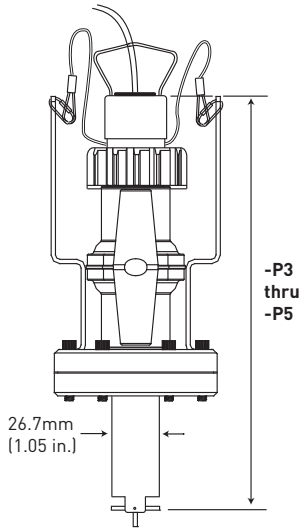


Pipe Range

0.5 to 4 in.	**-Y0** = 152mm (6.0 in.)
5 to 8 in.	**-Y1** = 185mm (7.3 in.)

2536 Wet-Tap Mount Sensor with 3519 Wet-Tap Valve

See 3519 product page for more information.



Pipe Range

0.5 to 4 in.	**-P3** = 297mm (11.7 in.)
5 to 8 in.	**-P4** = 333mm (13.1 in.)
10 in. and up	**-P5** = 409mm (16.1 in.)

Specifications

General

Flow Rate Range:
0.1 to 6 m/s (0.3 to 20 ft./s)
Pipe Size Range:
DN 15 to DN 900 (0.5 to 36 in.)
Linearity: ±1% of full range
Repeatability: ±0.5% of full range
Min. Reynolds Number Required: 4500

Wetted Materials

Sensor Body:
Glass-filled Polypropylene (black) or PVDF (natural)
O-rings:
FPM-Viton® (std)
optional EPDM or FFPM-Kalrez®
Rotor Pin:
Titanium, Hastelloy-C or PVDF; optional ceramic, Tantalum or stainless steel
Rotor:
Black PVDF or Natural PVDF; optional Tefzel® with or w/o Fluoraloy B® sleeve

Electrical

Frequency: 49Hz per m/s nominal (15 Hz per ft/s nominal)
Supply voltage: 3.3 to 24 VDC regulated
Supply current: <1.5 mA @ 3.3 to 6 VDC
<20 mA @ 6 to 24 VDC
Output Type:
Open collector transistor, sinking
Output Current: 10 mA max.
Cable Type:
2-conductor twisted pair with shield (22 AWG)
Cable Length:
7.6 m (25 ft.) standard/305 m (1,000 ft.) maximum

Max. Pressure/Temperature Rating

Standard and Integral Sensor

- PP: 12.5 bar @ 20°C, 1.7 bar @ 85°C (180 psi @ 68°F, 25 psi @185°F)
- PVDF: 14 bar @ 20°C, 1.7 bar @ 85°C (200 psi @ 68°F, 25 psi @ 185°F)

Operating Temperature:

- PP: -18°C to 85°C (0°F to 185°F)
- PVDF: -18°C to 85°C (0°F to 185°F)

Wet-Tap sensor
PP: 7 bar @ 20°C, 1.4 bar @ 66°C (100 psi @ 68°F, 20 psi @ 150°F)
Operating temperature:
-18°C to 66°C (0°F to 150°F)
Max. wet-tap sensor removal rating:
1.7 bar @ 22°C (25psi @ 72°F)

See Temperature and Pressure graphs for more information.

Shipping Weight:

3-2536-X0	0.454 kg	1 lb.
3-2536-X1	0.476 kg	1.04 lbs.
3-2536-X2	0.680 kg	1.50 lbs.
3-2536-X3	0.794 kg	1.75 lbs.
3-2536-X4	0.850 kg	1.87 lbs.
3-2536-X5	1 kg	2.20 lbs.
3-8512-X0	0.35 kg	0.77 lb.
3-8512-X1	0.37 kg	0.81 lbs.

Standards and Approvals

- CE
- Manufactured under ISO 9001:2000 for Quality and ISO 14001:2004 for Environmental Management

Application Tips:

- Use PVDF Rotor Pin for use in Deionized Water.
- Use the Conduit Adapter Kit to protect the cable-to-sensor connection when used in outdoor environments. See Accessories section for more information.
- Use a sleeved rotor in abrasive liquids to reduce wear.
- Sensor plug is used to plug installation fitting after extraction of sensor from pipe.
- For liquids containing particles, use only the Signet Magmeter.
- For systems with components of more than one material, the maximum temperature/pressure specification must always be referenced to the component with the lowest rating.

Please refer to Wiring, Installation, Accessories and Fittings sections for more information.

Ordering Information

Model 2536 Standard Mount Paddlewheel

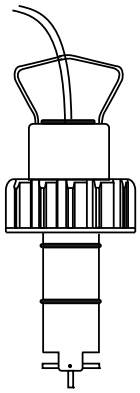
When choosing this style of sensor, the instrument can be mounted nearby on a pipe or wall or in a remote location up to 305 m/1000 ft (standard cable length is 7.6m/25 ft) by connecting the sensor through a standard junction box. Use Signet fittings for proper seating of the sensor into the process flow.

Sensor Part Number			
3-2536	Flow Sensor for use with remote mount instrument		
	Body/Rotor/Pin material-Choose one*		
	P	Polypropylene/Black PVDF/Titanium	
	T	Natural PVDF/Natural PVDF/Natural PVDF[1]	
	V	Natural PVDF/Natural PVDF/Hastelloy C[1]	
		Pipe size - Choose one	
		0	0.5 to 4 in.
		1	5 to 8 in.
		2	10 to 36 in.
		↓	
3-2536	**- P**	**0**	**Example Part Number**

[1] PVDF available 0.5 in. to 4 in. only

Mfr. Part No.*	Code	Mfr. Part No.*	Code
3-2536-P0	**198 840 143**	3-2536-T0	**198 840 149**
3-2536-P1	**198 840 144**	3-2536-V0	**198 840 146**
3-2536-P2	**198 840 145**	3-2536-V1	**198 840 147**

Model 2536 Standard Paddlewheel Flow Sensor



***Model 2536 Ordering Notes:**

1) Most common part number combinations shown. For all combinations, refer to the Part Number Index.

2) Other rotor and pin materials are available and can be easily replaced in the field. See accessories for parts listing.

Model 2536 Integral Mount Paddlewheel

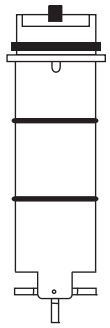
When choosing this style of sensor, the instrument is mounted directly onto the sensor for a local display. See Guidelines below for instructions.

Sensor Part Number			
3-8512	Flow Sensor for integral mounting on the 8150 or 8550 instrument using the 3-8051 adapter (instrument and adapter sold separately)		
	Body/Rotor/Pin material-Choose one*		
	P	Polypropylene/Black PVDF/Titanium	
	T	Natural PVDF/Natural PVDF/Natural PVDF[1]	
	V	Natural PVDF/Natural PVDF/Hastelloy C[1]	
		Pipe size - Choose one	
		0	0.5 to 4 in.
		1	5 to 8 in.
		↓	
3-8512	**- V**	**0**	**Example Part Number**

[1] PVDF available 0.5 in. to 4 in. only

Mfr. Part No.	Code	Mfr. Part No.	Code
3-8512-P0	**198 864 513**	3-8512-T0	**198 864 518**
3-8512-P1	**198 864 514**	3-8512-V0	**198 864 516**

Model 2536 Integral Mount Paddlewheel Flow Sensor



Guidelines: Combining a 2536 integral mount flow sensor with an integrally mounted instrument

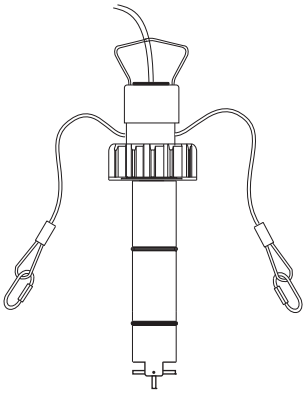
Once an integral mount sensor is chosen, it can be mounted directly to an instrument by following these guidelines:

a) Order the integral adapter kit 3-8051 (sold separately) to connect the sensor to an instrument.

b) Order an instrument (sold separately). The following instrument part numbers are compatible: 3-8550-1, 3-8550-2, 3-8550-3.

c) Assembling the sensor with the integral adapter and instrument is quick and simple. These parts can also be ordered as an assembled part. See "Integral Mount" data sheet for more information.

Model 2536 Wet-Tap sensor with the 3519 Wet-tap valve



Ordering Information (continued)

Model 2536 Wet-Tap Mount Paddlewheel Flow Sensor

When choosing this style of sensor, the instrument can be mounted nearby on a pipe or wall or in a remote location up to 1000 ft (305 m) by connecting the sensor through a standard junction box. Standard cable length is 7.6m (25 ft). This style of sensor uses the 3519 Wet-Tap valve only (see individual product page for more information).

Sensor Part Number - Choose one			
3-2536	Flow Sensor for wet-tap mounting with the 3519 Wet-Tap Valve (sold separately)		
	Body/Rotor/Pin material*		
	P	Polypropylene/Black PVDF/Titanium	
		Pipe size - Choose one	
		3	0.5 to 4 in.
		4	5 to 8 in.
		5	10 to 36 in.
		↓	
3-2536	**- P**	**3**	**Example Part Number**

***Model 2536 Ordering Notes:**

1) Most common part number combinations shown. For all combinations, refer to the Part Number Index.

2) Other rotor and pin materials are available and can be easily replaced in the field. See accessories for parts listing.

Mfr. Part No.*	Code
3-2536-P3	**159 000 758**
3-2536-P4	**159 000 759**
3-2536-P5	**159 000 760**

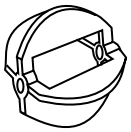
Guideline: Combining a 2536 Wet-Tap Sensor with a 3519 Wet-Tap Valve

a) Once a sensor is chosen, it can be mounted in a 3519 Wet-Tap Valve (sold separately)

b) Assembling a sensor with a 3519 Wet-Tap valve is quick and simple. These parts can also be ordered as complete assemblies. See 3519 product page.

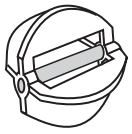
Accessories and Replacement Parts

Rotor

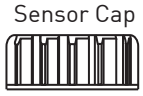


Rotor Pin

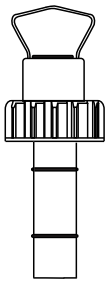
Sleeved Rotor (pin not included)



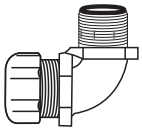
Sensor Cap



Sensor Plug



Conduit Adapter Kit



Mfr. Part No.	Code	Description
Rotors		
3-2536.320-1	**198 820 052**	Rotor, PVDF Black
3-2536.320-2	**159 000 272**	Rotor, PVDF Natural
3-2536.320-3	**159 000 273**	Rotor, Tefzel®
3-2536.321	**198 820 054**	Rotor and Pin (matched set), PVDF Natural
3-2536.322-1	**198 820 056**	Sleeved Rotor, PVDF Black
3-2536.322-2	**198 820 057**	Sleeved Rotor, PVDF Natural
3-2536.322-3	**198 820 058**	Sleeved Rotor, Tefzel®
Rotor Pins		
M1546-1	**198 801 182**	Pin, Titanium
M1546-2	**198 801 183**	Pin, Hastelloy-C
M1546-3	**198 820 014**	Pin, Tantalum
M1546-4	**198 820 015**	Pin, Stainless Steel
P51545	**198 820 016**	Pin, Ceramic
O-Rings		
1220-0021	**198 801 186**	O-Ring, FPM-Viton®
1224-0021	**198 820 006**	O-Ring, EPR
1224-0205	**159 000 869**	O-Ring, EPDM (Europe Only)
1228-0021	**198 820 007**	O-Ring, FFPM-Kalrez®
Miscellaneous		
P31536	**198 840 201**	Sensor Plug, Polypro
P31536-2	**159 000 649**	Sensor Plug, PVDF
P31542-3	**159 000 464**	Sensor Cap, Blue
P31934	**159 000 466**	Conduit Cap
P51589	**159 000 476**	Conduit Adapter Kit
5523-0222	**159 000 392**	Cable (per foot), 2 cond. w/shield, 22 AWG
3-8050	**159 000 184**	Universal Mount Kit
3-8051	**159 000 187**	Transmitter Integral Adapter

Signet 515/2536 Rotor-X Flow Sensors

English

Instructions for all versions of: 515/8510-xx and 2536/8512-xx

3-0515.090 E 8/04 English

SAFETY INSTRUCTIONS

1. Depressurize and vent system prior to installation or removal.
2. Confirm chemical compatibility before use.
3. Do not exceed maximum temperature/pressure specifications.
4. Wear safety goggles or faceshield during installation/service.
5. Do not alter product construction.

1. Specifications

General Data

Flow Rate Range:	515: 0.3 to 6 m/s (1 to 20 ft/s)
	2536: 0.1 to 6 m/s (0.3 to 20 ft/s)
Pipe Size Range:	DN15 to DN1000 (½ in. to 12 in.)
Linearity:	±1% of full range
Repeatability:	±0.5% full range
Cable Length:	7.6 m (25 ft) standard
	515: 60 m (200 ft.) maximum
	2536: 305 m (1000 ft) maximum
Cable Type:	2-conductor twisted pair w/shield (22 AWG)
Minimum Reynolds Number Required:	4500
Cap Material:	Glass Filled Polypropylene
	515: Red
	2536: Blue
Wetted Materials:	
• Sensor Body:	Glass filled Polypropylene (black) or PVDF (natural)
• O-Rings:	FPM (Std) or EPDM or FFKM
• Pin:	Titanium or Hastelloy-C or PVDF; other material options available
• Rotor:	Black PVDF or natural PVDF; optional Tefzel® with or w/o Fluoraloy B® sleeve
Shipping Weight:	-X0 0.454 kg (1 lb)
	-X1 0.476 kg (1.04 lbs)
	-X2 0.680 kg (1.50 lbs)
	-X3 0.794 kg (1.75 lbs)
	-X4 0.850 kg (1.87 lbs)
	-X5 1.0 kg (2.20 lbs)
	3519 1.3 kg (2.86 lbs)

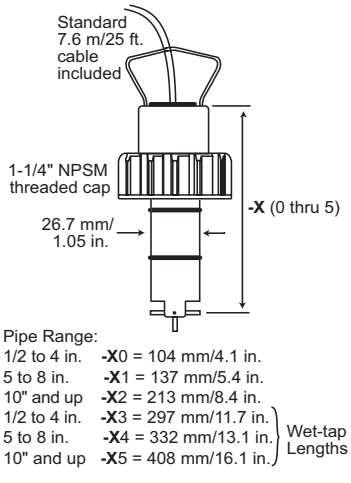
515 Sensor

Signal:

Frequency:	19.7 Hz per m/s nominal (6 Hz per ft/s)
Amplitude:	3.3 V p/p per m/s nominal (1 V p/p per ft/s)
Source Impedance:	8 kΩ

Dimensions

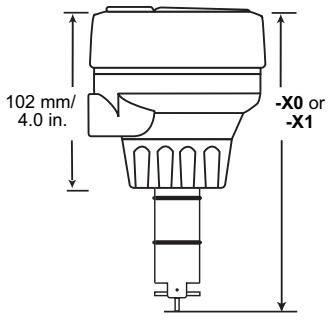
515/2536 Sensor



Pipe Range:

1/2 to 4 in.	-X0 = 104 mm/4.1 in.	
5 to 8 in.	-X1 = 137 mm/5.4 in.	
10" and up	-X2 = 213 mm/8.4 in.	
1/2 to 4 in.	-X3 = 297 mm/11.7 in.	Wet-tap Lengths
5 to 8 in.	-X4 = 332 mm/13.1 in.	
10" and up	-X5 = 408 mm/16.1 in.	

8510-XX/8512-XX Integral Sensor shown with Transmitter and Integral Adapter Kit (sold separately)



-X0 = 152 mm/6.0 in.
-X1 = 185 mm/7.3 in.

2536 Sensor

Signal:

Frequency:	49 Hz per m/s nominal (15 Hz per ft/s nominal)
Supply voltage:	3.5 to 24 VDC regulated
Supply current:	<1.5 mA @ 3.3 to 6 VDC
	<20 mA @ 6 to 24 VDC
Output Type:	Open collector transistor, sinking
Output current:	10 mA max.

Fluid Conditions

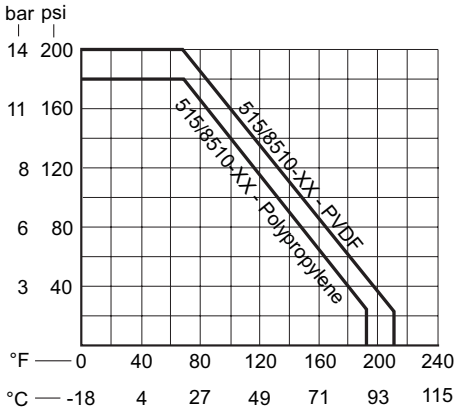
Rotor-X Sensor Pressure/Temperature Ratings:

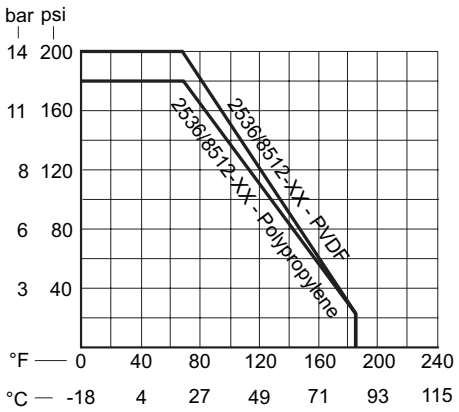
Polypropylene Body:

- 12.5 bar (180 psi) max. @ 20 °C (68 °F)
- 515: 1.7 bar (25 psi) max. @ 90 °C (194 °F)
- 2536: 1.7 bar (25 psi) max. @ 85 °C (185 °F)

PVDF Body:

- 14 bar (200 psi) max @ 20 °C (68 °F)
- 515: 1.7 bar (25 psi) max @ 100 °C (212 °F)
- 2536: 1.7 bar (25 psi) max @ 85 °C (185 °F)



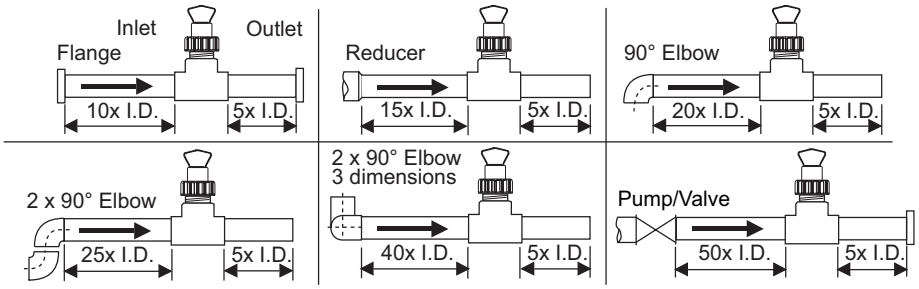


Standards & Approvals

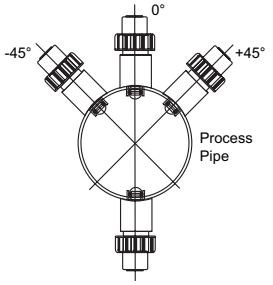
- Manufactured under ISO 9001 and ISO 14001
- CE
- 515 Only: FM Class I, II, III/Div. I/Groups A-G

2. Location of Fitting

Recommended sensor upstream/downstream mounting requirements



3. Sensor Mounting Position



- Horizontal pipe runs: Mount sensor in the upright (0°) position for best performance. Mount at a maximum of 45° when air bubbles are present (pipe must be full). Do not mount on the bottom of the pipe when sediments are present.
- Vertical pipe runs: Mount sensor in any orientation. Upward flow is preferred to ensure full pipe.

4. Standard Sensor Installation

1. Lubricate the sensor O-rings with a silicone lubricant (e.g. GE silicone compound #G632 or equivalent). Do not use any petroleum based lubricant that will attack the O-rings.

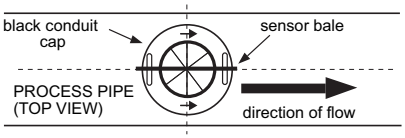


Figure A

2. Using an alternating/twisting motion, lower the sensor into the fitting, making sure the installation arrows on the black cap are pointing in the direction of flow, see Figure A.
3. Engage one thread of the sensor cap then turn the sensor until the alignment tab is seated in the fitting notch. Hand tighten the sensor cap. DO NOT use any tools on the sensor cap or the cap threads and/or fitting flange threads will be damaged, see Figure B.

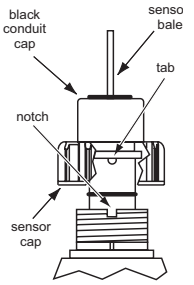


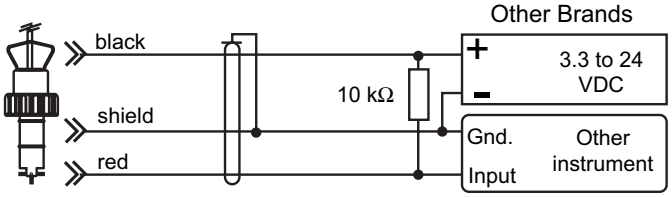
Figure B

5. Sensor Wiring

Technical Notes

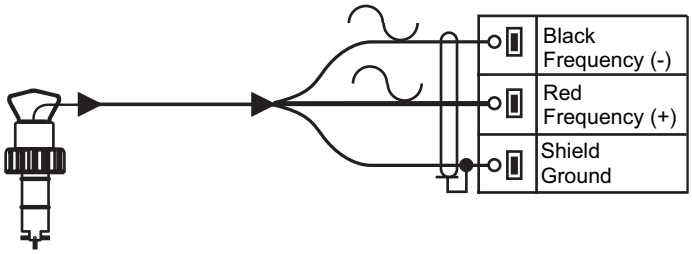
- Use 2-conductor shielded cable for cable extensions.
- Cable shield must be maintained through cable splice.
- Refer to your instrument manual for specific wiring details.

2536 Sensor Connections to Other Brand Instruments

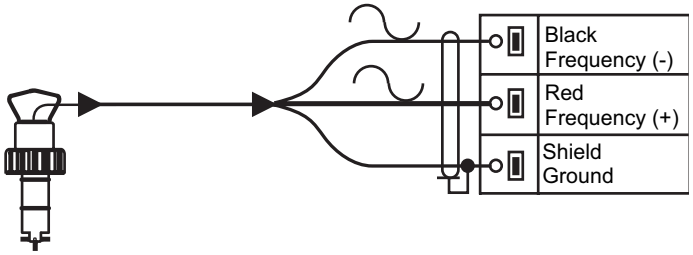


- DC sensor power supplied from Signet instrument.
  10KΩ Pull-up resistor may be required for non Signet brand instrument.

515 Sensor Connections to Signet Instruments

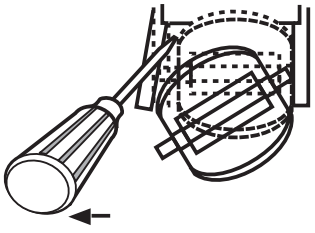


515 Sensor Connections to Signet Instruments



6. Rotor Replacement Procedure

1. To remove the rotor, insert a small screwdriver between the rotor and the ear of the sensor.
2. Twist the screwdriver blade to flex the ear outward enough to remove one end of the rotor and pin. DO NOT flex the ear any more than necessary! If it breaks, the sensor cannot be repaired.
3. Install the new rotor by inserting one tip of the pin into the hole, then flex the opposite ear back enough to slip rotor into place.



7. K-Factors

A **K-Factor** is the number of pulses a sensor will generate for each engineering unit of fluid which passes the sensor. K-factors for water are listed below in U.S. gallons and liters. For example, in a 1-inch PVC pipe, the 515 paddlewheel generates 174.67 pulses per gallon of water passing the rotor. K-factors are listed for pipes up to 12 inches. For pipes over 12 inches, consult your Signet distributor.

PIPE SIZE (IN.)	FITTING	515/8510-XX		2536/8512-XX	
		U.S. GAL	LITERS	U.S. GAL	LITERS
SCH 80 PVC TEES FOR SCH 80 PVC PIPE					
1/2	PV8T005	480.19	126.87	991.71	262.01
3/4	PV8T007	257.72	68.090	545.14	144.03
1	PV8T010	174.67	46.148	352.44	93.114
1-1/4	PV8T012	83.390	22.032	177.18	46.812
1-1/2	PV8T015	58.580	15.477	117.85	31.137
2	PV8T020	32.480	8.5812	66.739	17.633
2-1/2	PV8T025	21.833	5.7683	42.994	11.359
3	PV8T030	13.541	3.5775	26.652	7.0414
4	PV8T040	7.6258	2.0147	15.006	3.9645
SCH 80 CPVC TEES FOR SCH 80 CPVC PIPE					
1/2	CPV8T005	480.19	126.87	991.71	262.01
3/4	CPV8T007	257.72	68.090	545.14	144.03
1	CPV8T010	174.67	46.148	352.44	93.114
1-1/4	CPV8T012	83.390	22.032	177.18	46.812
1-1/2	CPV8T015	58.580	15.477	117.85	31.137
SCH 80 PVC SADDLES FOR SCH 80 PVC PIPE					
2	PV8S020	32.480	8.5812	66.739	17.633
2-1/2	PV8S025	21.833	5.7683	42.994	11.359
3	PV8S030	13.541	3.5775	26.652	7.0414
4	PV8S040	7.6258	2.0147	15.006	3.9645
6	PV8S060	4.1623	1.0997	8.3246	2.1994
8	PV8S080	2.3705	0.6263	5.0164	1.3253
10	PV8S100	1.5300	0.4042	3.0600	0.808
12	PV8S120	1.0600	0.2801	2.1600	0.571
SCH 80 PVC SADDLE ON SCH 40 PVC PIPE					
2	PV8S020	27.350	7.2259	54.700	14.452
2-1/2	PV8S025	18.874	4.9866	37.159	9.8175
3	PV8S030	12.638	3.3389	23.697	6.2608
4	PV8S040	6.7282	1.7776	13.456	3.5552
6	PV8S060	3.7297	0.9854	7.4594	1.9708
8	PV8S080	2.1527	0.5688	4.5292	1.1966
10	PV8S100	1.3500	0.3567	2.8000	0.740
12	PV8S120	0.9600	0.2536	1.9800	0.523
PP CLAMP-ON SADDLE ON SCH 80 PP PIPE					
10	PPS100	1.5300	0.4042	3.0600	0.808
12	PPS120	1.0600	0.2801	2.1600	0.571
PP CLAMP-ON SADDLE ON SCH 40 PP PIPE					
10	PPS100	1.3500	0.3567	2.8000	0.740
12	PPS120	0.9600	0.2536	1.9800	0.523

PIPE SIZE (IN.)	FITTING	515/8510-XX		2536/8512-XX	
		U.S. GAL	LITERS	U.S. GAL	LITERS
CARBON STEEL TEES ON SCH 40 PIPE					
1/2	CS4T005	370.20	97.808	756.00	199.74
3/4	CS4T007	212.06	56.027	438.69	115.90
1	CS4T010	141.14	37.289	286.78	75.768
1-1/4	CS4T012	60.655	16.025	121.22	32.026
1-1/2	CS4T015	45.350	11.982	91.139	24.079
2	CS4T020	26.767	7.0717	54.468	14.391
STAINLESS STEEL TEES ON SCH 40 PIPE					
1/2	CR4T005	358.96	94.838	734.20	193.98
3/4	CR4T007	202.61	53.530	412.10	108.88
1	CR4T010	127.14	33.590	252.70	66.764
1-1/4	CR4T012	61.910	16.357	128.12	33.849
1-1/2	CR4T015	40.410	10.676	77.320	20.428
2	CR4T020	22.300	5.8917	45.780	12.095
GALVANIZED IRON TEES ON SCH 40 PIPE					
1	IR4T010	104.54	27.619	213.01	56.277
1-1/4	IR4T012	62.979	16.639	127.75	33.751
1 1/2	IR4T015	46.688	12.335	94.401	24.941
2	IR4T020	29.459	7.7832	59.420	15.699
BRONZE TEES ON SCH 40 PIPE					
1	BR4T010	104.54	27.619	213.01	56.277
1-1/4	BR4T012	62.979	16.639	127.75	33.751
1-1/2	BR4T015	46.688	12.335	94.401	24.941
2	BR4T020	29.459	7.7832	59.420	15.699
COPPER TEE FITTINGS ON COPPER PIPE SCH K					
1/2	CUKT005	443.21	117.10	917.84	242.50
3/4	CUKT007	212.16	56.052	428.27	113.15
1	CUKT010	127.18	33.600	256.43	67.749
1-1/4	CUKT012	88.218	23.307	176.44	46.615
1-1/2	CUKT015	56.962	15.049	115.69	30.565
2	CUKT020	29.370	7.7595	63.385	16.746
COPPER TEE FITTINGS ON COPPER PIPE SCH L					
1/2	CUKT005	414.41	109.49	858.22	226.74
3/4	CUKT007	191.09	50.485	385.74	101.91
1	CUKT010	119.84	31.662	241.64	63.841
1-1/4	CUKT012	85.451	22.576	170.90	45.152
1-1/2	CUKT015	55.160	14.573	112.03	29.598
2	CUKT020	28.605	7.5575	61.74	16.310

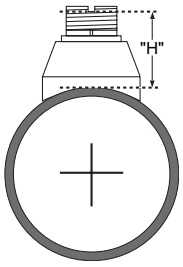
PIPE SIZE (IN.)	FITTING	515/8510-XX		2536/8512-XX	
		U.S. GAL	LITERS	U.S. GAL	LITERS
STAINLESS STEEL WELDOLETS ON SCH 40 PIPE					
2-1/2	CR4W025	18.800	4.9670	37.600	9.9339
3	CR4W030	12.170	3.2153	24.340	6.4306
4	CR4W040	6.9600	1.8388	13.920	3.6777
5	CR4W050	5.2600	1.3897	10.860	2.8692
6	CR4W060	3.6900	0.9749	7.5200	1.9868
8	CR4W080	2.1300	0.5627	4.3400	1.1466
10	CR4W100	1.3500	0.3567	2.7600	0.7292
12	CR4W120	0.9600	0.2536	1.9400	0.5125
CARBON STEEL WELDOLETS ON SCH 40 PIPE					
2-1/2	CS4W025	18.800	4.9670	37.600	9.9339
3	CS4W030	12.170	3.2153	24.340	6.4306
4	CS4W040	6.9600	1.8388	13.920	3.6777
5	CS4W050	5.2600	1.3897	10.860	2.8692
6	CS4W060	3.6900	0.9749	7.5200	1.9868
8	CS4W080	2.1300	0.5627	4.3400	1.1466
10	CS4W100	1.3500	0.3567	2.7600	0.7292
12	CS4W120	0.9600	0.2536	1.9400	0.5125
COPPER/BRONZE BRAZOLETS ON SCH 40 PIPE					
2-1/2	BR4B025	18.800	4.9670	37.600	9.934
3	BR4B030	12.170	3.2153	24.340	6.431
4	BR4B040	6.9600	1.8388	13.920	3.678
5	BR4B050	5.2600	1.3897	10.860	2.869
6	BR4B060	3.6900	0.9749	7.5200	1.987
8	BR4B080	2.1300	0.5627	4.3400	1.147
10	BR4B100	1.3500	0.3567	2.7600	0.729
12	BR4B120	0.9600	0.2536	1.9400	0.513
SCH 80 IRON SADDLES ON SCH 80 PIPE					
2	IR8S020	32.360	8.5495	64.720	17.099
2-1/2	IR8S025	22.220	5.8705	42.480	11.223
3	IR8S030	13.420	3.5456	26.420	6.980
4	IR8S040	7.6600	2.0238	14.700	3.884
5	IR8S050	5.8600	1.5482	12.180	3.218
6	IR8S060	4.0900	1.0806	8.4400	2.230
8	IR8S080	2.3300	0.6156	4.9000	1.295
10	IR8S100	1.5300	0.4042	3.0600	0.808
12	IR8S120	1.0600	0.2801	2.1600	0.571
SCH 80 IRON SADDLE ON SCH 40 PIPE					
2	IR8S020	26.820	7.0859	53.640	14.172
2-1/2	IR8S025	18.800	4.9670	37.600	9.934
3	IR8S030	11.990	3.1678	23.220	6.135
4	IR8S040	6.8500	1.8098	13.260	3.503
5	IR8S050	5.3300	1.4082	11.040	2.917
6	IR8S060	3.7600	0.9934	7.2400	1.913
8	IR8S080	2.1300	0.5627	4.4000	1.162
10	IR8S100	1.3500	0.3567	2.8000	0.740
12	IR8S120	0.9600	0.2536	1.9800	0.523

K-Factors DIN Pipes

PIPE SIZE	FITTING	515/8510-XX		2536/8512-XX		
		U.S. GAL	LITERS	U.S. GAL	LITERS	CODE
POLYPROPYLENE FITTINGS (DIN/ISO AND BS AND ANSI)						
DN 15	PPMT005	481.55	127.23	952.87	251.75	198.150.522
DN 20	PPMT007	277.09	73.207	563.10	148.77	198.150.523
DN 25	PPMT010	141.18	37.300	291.60	77.042	198.150.524
DN 32	PPMT012	83.540	22.071	169.22	44.709	198.150.525
DN 40	PPMT015	51.265	13.544	103.90	27.450	198.150.526
DN 50	PPMT020	29.596	7.8193	60.789	16.060	198.150.527
DN 65	PPMT025	20.658	5.4579	41.498	10.964	198.150.560
DN 80	PPMT030	13.330	3.5218	26.786	7.0769	198.150.561
DN 100	PPMT040	8.7077	2.3006	17.415	4.6011	198.150.562
DN 125	PPMT050	5.0667	1.3386	10.168	2.6864	198.150.563
DN 150	PPMT060	3.6892	0.9747	7.3119	1.9318	198.150.564
DN 200	PPMT080	2.0398	0.5389	3.9946	1.0554	198.150.565
PVDF FITTINGS (DIN/ISO AND BS AND ANSI)						
DN 15	SFMT005	420.87	111.19	827.26	218.56	198.150.529
DN 20	SFMT007	228.15	60.277	489.87	129.42	198.150.530
DN 25	SFMT010	136.70	36.116	283.55	74.915	198.150.531
DN 32	SFMT012	79.294	20.950	158.59	41.899	198.150.532
DN 40	SFMT015	43.490	11.490	86.980	22.980	198.150.533
DN 50	SFMT020	25.908	6.8450	50.385	13.312	198.150.534
DN 65	SFMT025	18.067	4.7732	36.133	9.5465	198.150.571
DN 80	SFMT030	12.357	3.2648	24.715	6.5297	198.150.572
DN 100	SFMT040	8.0599	2.1294	16.120	4.2589	198.150.573
DN 125	SFMT050	4.4312	1.1707	8.8624	2.3415	198.150.574
DN 150	SFMT060	3.2271	0.8526	6.4543	1.7052	198.150.575
DN 200	SFMT080	2.0360	0.5379	4.0720	1.0758	198.150.576
PVC FITTINGS (DIN/ISO) - EUROPE ONLY						
DN 15	PVMT005	486.18	128.45	972.37	256.90	198.150.480
DN 20	PVMT007	242.85	64.160	485.69	128.32	198.150.481
DN 25	PVMT010	148.64	39.270	297.274	78.540	198.150.482
DN 32	PVMT012	85.125	22.490	170.249	44.980	198.150.483
DN 40	PVMT015	51.855	13.700	103.709	27.400	198.150.484
DN 50	PVMT020	29.750	7.8600	59.500	15.720	198.150.485
DN 65	PVMT025	17.487	4.6200	34.9734	9.2400	198.150.538
DN 80	PVMT030	12.491	3.3000	24.9810	6.6000	198.150.539
DN 100	PVMT040	8.1377	2.1500	16.2754	4.3000	198.150.540
DN 150	PVMT060	4.0878	1.0800	8.1756	2.1600	198.150.543
DN 200	PVMT080	2.0439	0.5400	4.0878	1.0800	198.150.545

8. H-Dimensions

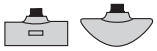
The plastic sensor insert in the Weldolet fitting MUST be removed during the welding process. When reinstalled, it is important that the insert be threaded to the proper height ("H" dimension).



Weldolet	"H" dimension		Weldolet	"H" dimension	
part number	inches	mm	part number	inches	mm
CS4W020	2.38	60.45	CS4W240	4.16	105.66
CS4W025	2.33	59.18	CS4W360	4.10	104.14
CS4W030	2.32	58.92			
CS4W040	2.30	58.42	CR4W020	2.38	60.45
CS4W050	3.09	78.48	CR4W025	2.33	59.18
CS4W060	2.96	75.18	CR4W030	2.32	58.92
CS4W080	2.73	69.34	CR4W040	2.30	58.42
CS4W100	5.48	139.19	CR4W050	3.09	78.48
CS4W120	5.25	133.35	CR4W060	2.96	75.18
CS4W140	5.10	129.54	CS4W080	2.73	69.34
CS4W160	4.85	123.19	CR4W100	5.48	139.19
CS4W180	4.60	116.84	CR4W120	5.25	133.35
CS4W200	4.38	111.25			

9. Signet Fittings

Type	Description
Plastic tees	• 0.5 to 4 inch versions • PVC or CPVC
PVC Glue-on Saddles	• Available in 10 and 12 inch sizes only • Cut 2-1/2 inch hole in pipe • Weld in place using solvent cement
PVC Saddles	• 2 to 4 inch, cut 1-7/16 inch hole in pipe • 6 to 8 inch, cut 2-1/8 inch hole in pipe
PP Clamp-on Saddles	• Available in 10 and 12 inch sizes only • Cut 2-1/8 inch hole in pipe
Iron Strap-on saddles	• 2 to 4 inch, cut 1-7/16 inch hole in pipe • Over 4 inch, cut 2-1/8 inch hole in pipe • Special order 12 in. to 36 in.

Type	Description
Iron, Carbon Steel, 316 SS Threaded tees	• 0.5 to 2 in. versions • Mounts on threaded pipe ends
Carbon steel & stainless steel Weld-on Weldolets	• 2 to 4 inch, cut 1-7/16 inch hole in pipe • Over 4 inch, cut 2-1/8 inch hole in pipe
Fiberglass tees & saddles:  FPT FPS	• 1.5 in. to 8 in. PVDF insert • > 8 in. PVC insert • Special order 12 in. to 36 in.
Metric Wafer Fitting	• For pipes DN 65 to 200 mm • PP or PVDF
Metric Union Fitting	• For pipes from DN 15 to 50 mm • PP or PVDF

515/8510-XX Ordering Information		2536/8512-XX Ordering Information		Product Description
Part No.	**Code**	**Part No.**	**Code**	
P51530-P0	198 801 620	3-2536-P0	198 840 143	Sensor, Polypropylene, Titanium Rotor Pin, PVDF Rotor (black), to 4 Inch Pipe
P51530-P1	198 801 621	3-2536-P1	198 840 144	Sensor, Polypropylene, Titanium Rotor Pin, PVDF Rotor (black) 5 to 8 Inch Pipe
P51530-P2	198 801 622	3-2536-P2	198 840 145	Sensor, Polypropylene, Titanium Rotor Pin, PVDF Rotor (black) 10 to 36 Inch Pipe
P51530-P3	198 840 310	3-2536-P3	159 000 758	Sensor, Wet-Tap, Polypropylene, Titanium Rotor Pin, PVDF Rotor (black), ½ to 4 Inch Pipe
P51530-P4	198 840 311	3-2536-P4	159 000 759	Sensor, Wet-Tap, Polypropylene, Titanium Rotor Pin, PVDF Rotor (black) 5 to 8 Inch Pipe
P51530-P5	198 840 312	3-2536-P5	159 000 760	Sensor, Wet-Tap, Polypropylene, Titanium Rotor Pin, PVDF Rotor (black) 10 to 36 Inch Pipe
P51530-V0	198 801 623	3-2536-V0	198 840 146	Sensor, PVDF (natural), Hastelloy Rotor Pin, PVDF Rotor (natural), ½ to 4 Inch Pipe
P51530-V1	198 801 624	3-2536-V1	198 840 147	Sensor, PVDF (natural), Hastelloy Rotor Pin, PVDF Rotor (natural), 5 to 8 Inch Pipe
P51530-V2	198 801 625	N/A	N/A	Sensor, PVDF (natural), Hastelloy Rotor Pin, PVDF Rotor (natural), 10 to 36 Inch Pipe
P51530-T0	198 801 663	3-2536-T0	198 840 149	Sensor, PVDF (natural), PVDF (nat.) Rotor Pin, PVDF Rotor (nat.), ½ to 4 Inch Pipe
P51530-T1	198 801 664	N/A	N/A	Sensor, PVDF (natural), PVDF (nat.) Rotor Pin, PVDF Rotor (nat.), 5 to 8 Inch Pipe
3-8510-P0	198 864 504	3-8512-P0	198 864 513	Sensor, Integral, PP, Titanium Rotor Pin, PVDF Rotor (black), ½ to 4 Inch Pipe
3-8510-P1	198 864 505	3-8512-P1	198 864 514	Sensor, Integral, PP, Titanium Rotor Pin, PVDF Rotor (black) 5 to 8 Inch Pipe
3-8510-T0	159 000 622	3-8512-T0	198 864 518	Sensor, Integral, PVDF (nat.), Hastelloy Rotor Pin, PVDF Rotor (nat.), ½ to 4 In. Pipe
3-8510-V0	198 864 506	3-8512-V0	198 864 516	Sensor, Integral, PVDF (nat.), PVDF (nat.) Rotor Pin, PVDF Rotor (nat.), ½ to 4 In. Pipe
3519/515-P3	159 000 819	3519/2536-P3	159 000 822	Sensor & Wet-Tap Assy., PP, Titanium Rotor Pin, PVDF Rotor (black), ½ to 4 In. Pipe
3519/515-P4	159 000 820	3519/2536-P4	159 000 823	Sensor & Wet-Tap Assy., PP, Titanium Rotor Pin, PVDF Rotor (black), 5 to 8 In. Pipe
3519/515-P5	159 000 821	3519/2536-P5	159 000 824	Sensor & Wet-Tap Assy., PP, Titanium Rotor Pin, PVDF Rotor (black), 10 to 36 In. Pipe
Accessories				
M1538-2	198 801 181	3-2536.320-1	198 820 052	Rotor, PVDF Black
P51547-3	159 000 474	3-2536.320-2	159 000 272	Rotor, PVDF Natural
M1538-4	198 820 018	3-2536.320-3	159 000 273	Rotor, Tefzel®
P51550-3	198 820 043	3-2536.321	198 820 054	Rotor and Pin, PVDF Natural
3-0515.322-1	198 820 059	3-2536.322-1	198 820 056	Sleeved Rotor, PVDF Black
3-0515.322-2	198 820 060	3-2536.322-2	198 820 057	Sleeved Rotor, PVDF Natural
3-0515.322-3	198 820 017	3-2536.322-3	198 820 058	Sleeved Rotor, Tefzel®
M1546-1	198 801 182	M1546-1	198 801 182	Rotor Pin, Titanium
M1546-2	198 801 183	M1546-2	198 801 183	Rotor Pin, Hastelloy-C
M1546-3	198 820 014	M1546-3	198 820 014	Rotor Pin, Tantalum
M1546-4	198 820 015	M1546-4	198 820 015	Rotor Pin, Stainless Steel
P51545	198 820 016	P51545	198 820 016	Rotor Pin, Ceramic
1220-0021	198 801 186	1220-0021	198 801 186	O-Ring, FPM
1224-0021	198 820 006	1224-0021	198 820 006	O-Ring, EPDM
1228-0021	198 820 007	1228-0021	198 820 007	O-Ring, FFKM
P31536	198 840 201	P31536	198 840 201	Sensor Plug, Polypro
P31536-1	198 840 202	P31536-1	198 840 202	Sensor Plug, PVDF Metric
P31536-2	159 000 649	P31536-2	159 000 649	Sensor Plug, PVDF
P31542	198 801 630	P31542	198 801 630	Sensor Cap, Red (for use w/515)
----	----	P31542-3	159 000 464	Sensor Cap, Blue (for use w/2536)
P31934	159 000 466	P31934	159 000 466	Conduit Cap
P51589	159 000 476	P51589	159 000 476	Conduit Adapter Kit
5523-0222	159 000 392	5523-0222	159 000 392	Cable (per foot), 2 cond. w/shield, 22 AWG

+GF+

George Fischer Signet, Inc., 3401 Aerojet Avenue, El Monte, CA 91731-2882 U.S.A. • Tel. (626) 571-2770 • Fax (626) 573-2057
For Worldwide Sales and Service, visit our website: www.gfsignet.com • Or call (in the U.S.): (800) 854-4090

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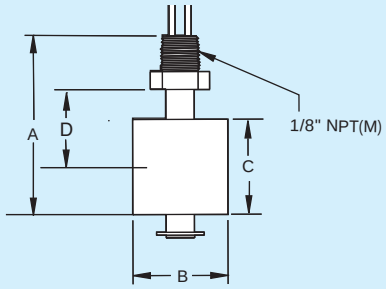
Series F6 & F7

Level Switches - Vertical

Low Cost, Reliable and Compact, Hermetically Sealed Contacts



Series F6 & F7 compact level switches combine low cost and reliability with fast, simple installation. Hermetically sealed reed switches are actuated by magnets permanently bonded inside the float and can be easily adapted to open or close a circuit on rising or falling levels. Vertical mount models are shipped with normally open switch contacts which close as the float rises toward the mounting threads. Reverse switch action by removing the float, rotating it end-for-end and replacing it on the stem. Vertical models mount internally, oriented within 30° of vertical, or select optional fittings for external mounting. Switch ratings are suitable for many solid state control systems and monitors or alarms. Simple relay interfaces can be used for higher current applications.

DIMENSIONS in Inches [mm]

Model Number	(A) Stem Length	(B) Float Diameter	(C) Float Height	(D) Actuation from Hex①
F7-SB	2.75 (70)	1.38 (35)	1.13 (29)	1.2 (31)
F7-SS2	2.06 (52)	1.0 (25)	1.0 (25)	0.73 (19)
F6-SS	2.17 (55)	1.11 (28)	1.11 (28)	–
F7-MPP	1.63 (41)	0.63 (16)	0.63 (16)	0.47 (12)
F7-PP	2.18 (55)	1.18 (30)	1.0 (25)	0.69 (18)
F7-BT	2.18 (55)	1.18 (30)	1.0 (25)	0.69 (18)
F7-K	2.13 (54)	1.0 (25)	1.0 (25)	0.65 (17)
F7-C11	2.06 (52)	1.0 (25)	1.0 (25)	0.56 (14)
F7-C21	2.06 (24)	1.0 (25)	1.0 (25)	0.56 (14)
F7-BB	3.19 (81)	1.88 (48)	1.81 (46)	1.19 (30)
F7-PS	3.38 (86)	1.88 (48)	1.88 (48)	1.25 (32)
F7-PVC	3.44 (87)	1.5 (38)	1.81 (46)	0.75 (19)
F7-T1	3.47 (88)	2.13 (54)	1.94 (49)	0.92 (22)
F7-ST713	3.38 (86)	2.06 (52	2.06 (52)	1.09 (28)
F7-ST714	3.38 (86)	2.06 (52)	2.06 (52)	1.09 (28)

Model Number	Applications	Material Float/Stem	Temp. Limits	Press. Limits	Min. S.G.	Electrical Rating	Wire Leads	Mtg NPT(M)	Weight oz (g)
F7-SB	General purpose	Buna-N & Epoxy/ 316 SS	220°F (105°C)	150 psig 10 bar	0.60	25 VA: 1A @ 220 VAC	22 AWG 18″ (45 cm)	1/8″	2 (58)
F7-SS2	High temp/pressure, corrosives	316 SS (CYC)/ 316 SS	300°F (149°C)	450 psig 31 bar	0.75	25 VA: 1A @ 200 VAC	22 AWG 18″ (45 cm)	1/8″	1.2 (34)
F6-SS	Corrosives	316 SS/ 316 SS	257°F (125°C)	218 psig 15 bar	0.65	20 VA: 0.08A @ 240 VAC	22 AWG 11.8″ (30 cm)	1/8″	1.59 (45)
F7-MPP**	Broad chemical compatibility	Polypropylene/ Polypropylene	180°F (82°C)	100 psig 6.89 bar	0.90	10 VA: 0.1A @ 100 VAC	22 AWG 24″ (61 cm)	1/8″	0.8 (23)
F-MPP-NO**	Broad chemical compatibility	Polypropylene/ Polypropylene	176°F (80°C)	100 psig 6.89 bar	0.90	50 VA: 0.2A @ 240 VAC	22 AWG 24″ (61 cm)	1/8″	0.8 (23)
F7-PP	Broad chemical compatibility	Polypropylene & Epoxy/Polypropylene	220°F (105°C)	100 psig 6.89 bar	0.60	30 VA: 0.14A @ 220 VAC	22 AWG 24″ (61 cm)	1/8″	0.8 (23)
F7-BT	Oils & Fuels	Buna-N & Epoxy/ PBT*	220°F (105°C)	150 psig 10 bar	0.45	30 VA: 0.14A @ 220 VAC	22 AWG 24″ (61 cm)	1/8″	0.7 (20)
F7-K	Food/beverage, corrosives	PVDF/ PVDF	180°F (82°C)	100 psig 6.89 bar	1.00	50 VA: 0.25A @ 150 VAC	22 AWG 24″ (61 cm)	1/8″	1.5 (43)
F7-C11	General purpose	Buna-N/ Brass	180°F (82°C)	150 psig 10 bar	0.45	20 VA: 0.08A @ 240 VAC	22 AWG 24″ (61 cm)	1/8″	1.5 (43)
F7-C21	Oils & water, general purpose	Buna-N/ 316 SS	180°F (82°C)	150 psig 10 bar	0.45	20 VA: 0.08A @ 240 VAC	22 AWG 24″ (61 cm)	1/8″	1.5 (43)
F7-BB	High viscosity liquids	Buna-N/ Brass	180°F (82°C)	150 psig 10 bar	0.55	20 VA: 0.08A @ 240 VAC	22 AWG 24″ (61 cm)	1/4″	5 (140)
F7-PS	Water-based liquids, complies with FDA	Polysulfone/ Polysulfone†	225°F (107°C)	50 psig 3 bar	0.55	20 VA: 0.08A @ 240 VAC	22 AWG 24″ (61 cm)	1/4″	4 (110)
F7-PVC	Chemical & plating	CPVC/ CPVC	180°F (82°C)	15 psig 1 bar	0.85	20 VA: 0.08A @ 240 VAC	22 AWG 24″ (61 cm)	1/4″	5 (140)
F7-T1	Viscous, sticky or corrosive liquids	PTFE/ TFE	300°F (149°C)	30 psig 2 bar	0.80	20 VA: 0.08A @ 240 VAC	22 AWG 24″ (61 cm)	1/4″	6 (170)
F7-ST713	Oils, water & chemicals	316 SS/ 316 SS	300°F (149°C)	750 psig 52 bar	0.80	20 VA: 0.08A @ 240 VAC	22 AWG 24″ (61 cm)	1/4″	6 (170)

① Distance between hex and liquid (S.G. = 1.0) level at actuation point will vary with specific gravity changes.
*PBT - Polybutylene Terephthalate.
† Incudes 316 SS clip.
‡ Spherical floats.
**F7-MPP is normally closed
F7-MPP-NO is normally open

UL Listed

Optional Fittings — For external mounting of vertical models
A-347, 1/8″ x 1-1/4″ NPT carbon steel adapter
A-347-SS, 1/8″ x 1-1/4″ NPT 316 SS adapter
A-348, 1/8″ x 1-1/2″ NPT carbon steel adapter
A-348-SS, 1/8″ x 1-1/2″ NPT 316 SS adapter

NS
FLOAT LEVEL SWITCHES

Flow
Pressure
Level
Temperature
measurement
monitoring
control

N1

- **For All Types of Liquids**
- **Mercury Switch or Microswitch**
- **Polypropylene, Polyethylene, Teflon® or SS Construction**
- **Maximum Temperature: 320°F**
- **Maximum Pressure: 220 PSIG**

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1801 Parkway View Drive
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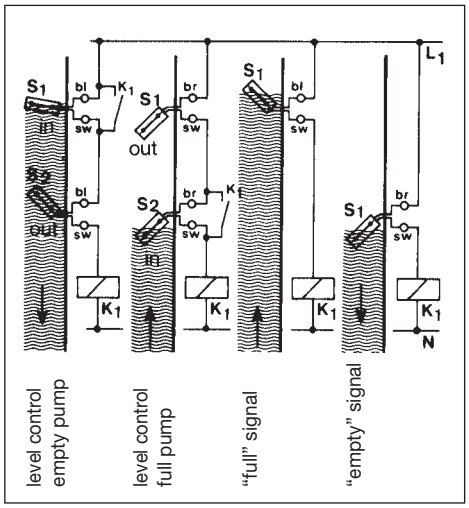
Visit KOBOLD Online at
www.kobold.com

Model:
NS

Kobold Series NSM, NSP, NSE and NST float switches enable liquid levels to be monitored easily. Filling levels may also be controlled by installing at least two floats, one as a minimum, the other as a maximum limit switch. The floats can be run to a latching relay (sold separately) for automatic level control.

These switches can be installed wherever magnetic liquid level switches are unsuitable due to the risk of the float jamming with dirt particles or coating.

Even extremely aggressive, hot, dirty or pulp-like media may be monitored with these float switches (depending on the shape and material of the float).



Description

The float consists of a hollow cylinder or sphere with an integral mercury or micro-switch. The switch supplied is a SPDT contact, and can be connected as normally open (N/O) or normally closed(N/C) contact.

The contact operates when the level rises above or falls below the horizontal float position. The switching point is fixed by installing the switch horizontally at the required position or by clamping the cable to the tank or vessel.

Contact Rating

Micro switch:
250 V, 4 A max.
Mercury switch:
220 V, 4 A max.

Summary of Models

Type NSM:

Material: Polypropylene
Contact: Microswitch
Maximum Temperature: 140°F
Maximum Pressure: 15 PSIG

Type NSP:

Material: Polyethylene
Contact: Mercury Switch
Maximum Temperature: 190°F
Maximum Pressure: 30 PSIG

Type NST:

Material: Teflon®
Contact: Mercury Switch
Maximum Temperature: 320°F
Maximum Pressure: 15 PSIG

Type NSE:

Material: 316 Ti SS
Contact: Mercury Switch
Maximum Temperature: 320°F
Maximum Pressure: 220 PSIG

Optional Cable Glands
Material: Nylon, Buna-N
Maximum Temperature: 250°F
Maximum Pressure: limited to the Switch rating

Order Information

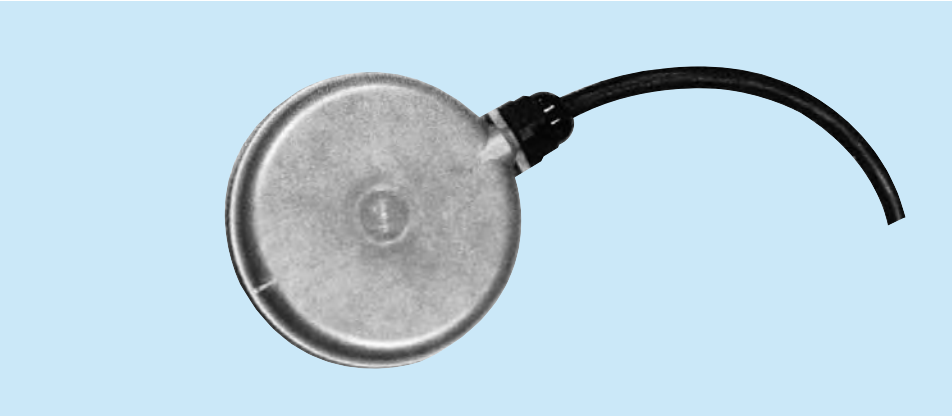
Order Number	Float Material	Switch Function	Cable Cladding
NSM-5101	Polypropylene	SPDT	Neoprene
NSP-5101	Polyethylene 0.9 kg/l	SPDT	PVC
NSP-5201	Polyethylene 0.8 kg/l	SPDT	PVC
NST-5101	Teflon	SPDT	Teflon
NSE-5101	316 Ti SS, 90 PSIG	SPDT	Silicone
NSE-5201	316 Ti SS, 220 PSIG	SPDT	Silicone
CG-CD 09 NRBK	3/8" NPT Cable Gland Tank Connection (except for Silicone cable)		

Options	Model# Suffix
Silicone Cable for NSP-Series	B02
Teflon Cable for NSP Series	B05
When Ordering Extended Cable Length, Specify Length	EC

Subject to change without prior notice.

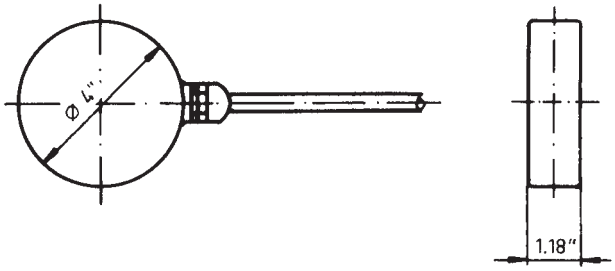
NSM-5...: Polypropylene

Reasonably priced float switch for liquids such as oils, solvents, weak acids and alkalis.



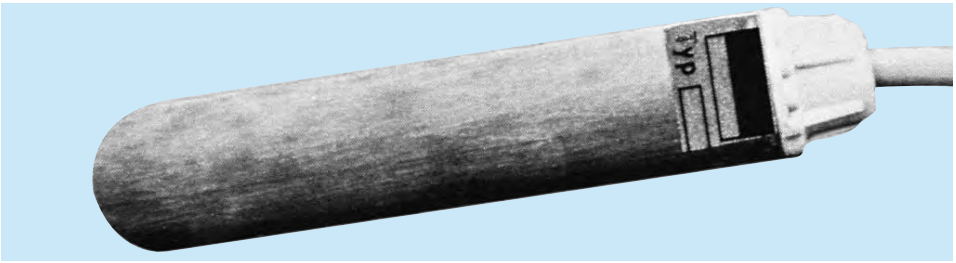
Installation:	From above in open container or from side with cable gland
Material:	
Float:	Polypropylene
Cable Penetration:	Polyamide (nylon)
Cable:	6 ft. Neoprene
Max. Pressure:	15 PSIG
Max. Temperature:	140°F
Switch:	SPDT Microswitch
Float Density:	0.6 g/ml

Float switch Model NSM-5101



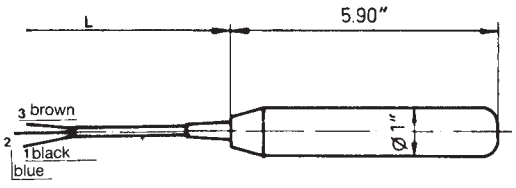
NSP-5...: Polyethylene

For all types of liquids. Eg.: dirty water, oil weak acids and alkalis.

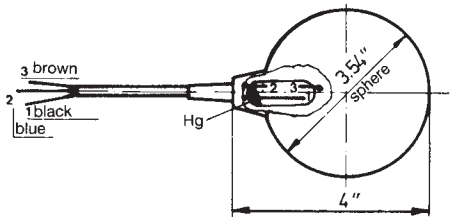


Installation:	From above in open container or through tank side with cable gland
Material:	
Float:	Polyethylene
Cable:	13 ft. PVC
Optional Cables:	Silicone, Oilflex, Teflon® on request
Maximum Pressure:	
NSP-5101:	15 PSIG
NSP-5201:	30 PSIG
Maximum Temp.:	140°F, 190° Silicone and Teflon Cable
Switch:	SPDT Mercury Switch
Float Density:	
NSP-5101:	0.9 g/ml
NSP-5201:	0.8 g/ml

Float switch Model NSP-5101

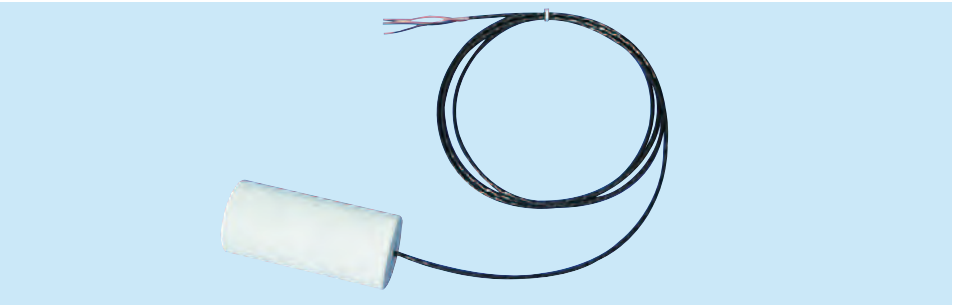


Float switch Model NSP-5201



NST-5...: Teflon®

Level switch for hot, extremely aggressive or dirty liquids.

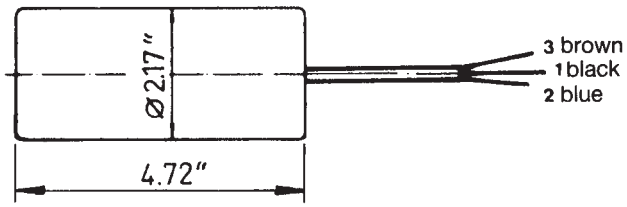


Installation: From above in open container or through tank side with cable gland

Material:
- Float: Teflon®
- Cable: Teflon® 6 Ft.

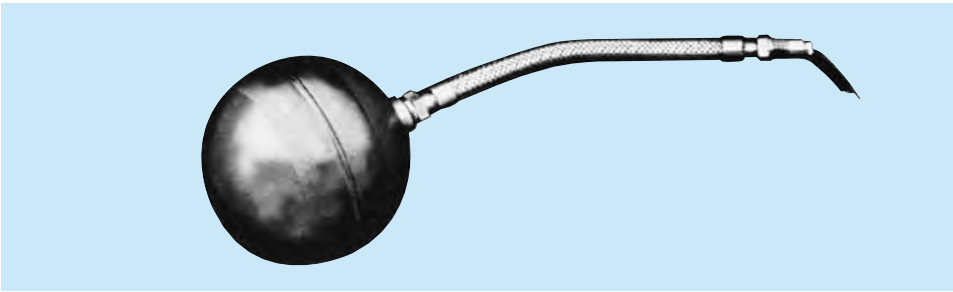
Maximum Pressure: 15 PSIG
Maximum Temperature: 320°F
Switch: SPDT Mercury Switch
Float Density: 0.85 gm/ml

Float switch Model NST-5101



NSE-5...: Stainless Steel

For highly aggressive, pulp-like, or hot liquids.



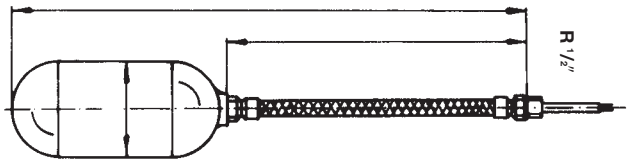
Installation: Through tank side ½" NPT

Material:
- Float: 316 Ti SS
- Cable: 6 ft. Silicone with 10 inches of SS braid

Maximum Pressure:
- NSE-5101: 90 PSIG
- NSE-5201: 220 PSIG

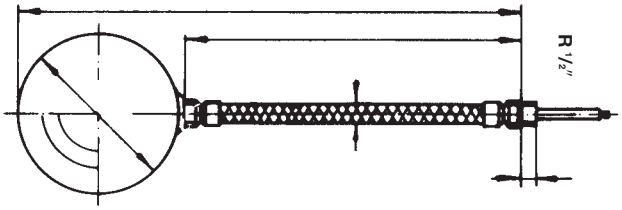
Maximum Temperature: 320°F
Switch: SPDT Mercury Switch N/O or N/C
Float Density: 0.8 g/ml

Float switch Model NSE-5101



Metal hose

Float switch Model NSE-5201



Metal hose

Subject to change without prior notice.

Displacer Type Liquid Level Switches

DESCRIPTION

Magnetrol's displacement type level switches offer the industrial user a wide choice of alarm and control configurations. Every unit utilizes a simple buoyancy principle and is well suited for simple or complex applications, such as foaming or surging liquids or agitated fluids, and usually costs less than other types of level switches.

FEATURES

- Narrow or wide level ranges achieved through multiple switch mechanism capability.
- Displacers adjustable at any point along the suspension cable.
- 10 ft (3 m) suspension cable standard
- Anti-surge design eliminates the possibility of switch shortcycling
- Flanged or threaded mounting available
- Easy installation
- Field adjustable set point and switch differential
- NACE models
- Floating roof top models
- Proof-er® ground check
- Choice of displacers: Porcelain, 316 Stainless steel, Karbate, Lead
- Choice of switch mechanisms: Mercury, Dry contact, Pneumatic, Hermetically sealed
- Available housings: NEMA 1, carbon steel for pneumatics; NEMA 4X/7/9, Class I, Div. 1, Groups C & D, polymer coated aluminum; NEMA 4X/7/9, Class I, Div. 1, Group B, polymer coated aluminum

Displacer Level Switch

Displacer Level Switch with Proof-er

APPLICATIONS

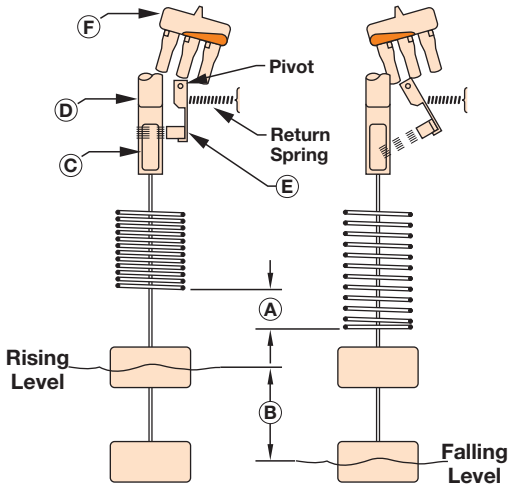
- Foaming or surging liquids
- Agitated fluids
- Sewage handling
- Dirty liquids
- Paints
- Varnishes
- Heavy oils
- Liquids with solids

TECHNOLOGY

Operation is based upon simple buoyancy, whereby a spring is loaded with weighted displacers which are heavier than the liquid. Immersion of the displacers in the liquid results in buoyancy force change, which moves the spring upward.

Since the spring moves only when the level moves on a displacer, spring movement **A** is always a small fraction of the level travel between displacers **B**.

A magnetic sleeve **C** is connected to the spring and operates within a non-magnetic barrier tube **D**. Spring movement causes the magnetic sleeve to attract a pivoted magnet **E**, actuating a switch mechanism **F** located outside the barrier tube. Built-in limit stops prevent over stroking of the spring, under level surge conditions.



PROOF-ER CONTROLS

The purpose of the Proof-er is to check the operation of a displacer control without having to raise the level in the tank. This is accomplished by pulling downward on the Proof-er chain. A spring-loaded lever arm then lifts the switch actuator simulating a high or high-high level condition. When the chain is released, the Proof-er returns the actuator to its previous position to resume normal operation.

PROOF-ER ROOF TOP CONTROLS

The Proof-er roof top control is designed for installation on "barrier" (floating roof) tanks. The control may be furnished with a lead displacer to prevent sparking. A stainless steel displacer is required if the control is to actuate in liquid as well as by the barrier. Consult factory for this option.

DISPLACERS

Stainless steel displacers are rated 720 psig @ +100° F (50 bar @ +38° C).

Karbate displacers are limited to a minimum temperature of +32° F (0° C) and a maximum temperature of +300° F (+149° C).

Do not use porcelain displacers on non-vented boiler water condensate systems over +200° F (+93° C). Stainless steel or Karbate is recommended.

DISPLACERS SUSPENSION CABLE

Displacers are field adjustable at any point along the suspension cable. 10 feet (3 meters) 316 stainless steel is standard. Monel® and Hastelloy® materials are available. Consult the factory for longer lengths.

AGENCY APPROVALS

AGENCY	APPROVED MODEL	AREA CLASSIFICATION
FM	All with an electric switch mechanism and a housing listed as Type 4X/7/9 ①	Class I, Div 1, Groups C & D Class II, Div 1, Groups E, F & G
	All with an electric switch mechanism and a housing listed as Type 4X/7/9 Class I, Div 1, Group B	Class I, Div 1, Groups B, C & D Class II, Div 1, Groups E, F & G
CSA	All with a Series A, E, HS, N or T electric switch mechanism and a housing listed as CSA Type 4X	Class I, Div 2, Groups B, C & D
	All with an electric switch mechanism and a housing listed as Type 4X/7/9 ①	Class I, Div 1, Groups C & D Class II, Div 1, Groups E, F & G
	All with an electric switch mechanism and a housing listed as Type 4X/7/9 Class I, Div 1, Group B	Class I, Div 1, Groups B, C & D Class II, Div 1, Groups E, F & G
ATEX	All with an electric switch mechanism and an ATEX housing ②	ATEX II 2 G EEx d IIC T6
CE	All models	Installation Category II Pollution Degree 2 Low Voltage Directives 73/23/EEC & 93/68/EEC per Harmonized Standard EN 61010-1/1993 & Amendment No. 1

① With drain, CSA drops Group E and FM drops Group C.

② Models B10 and B15 with HS switches and all Model C10 and C15 not ATEX approved.

PRESSURE/TEMPERATURE RATINGS

Threaded Models ①	800 psig @ +100° F (55 bar @ +38° C)
	250 psig @ +400° F (17 bar @ +204° C)
Flanged Models	Limited to the pressure rating of the selected flange
	or displacer. Cast iron flanges are flat face type
	conforming to ANSI dimensional specifications.
Low Pressure Proof-er Models	25 psig @ +200° F (1.7 bar @ +93° C)
Medium Pressure Proof-er Models	125 psig @ +300° F (8.6 bar @ +149° C)

①Models with stainless steel displacers are rated 720 psig @ +100° F (50 bar @ 38° C).

SPECIFICATIONS

SWITCH MECHANISMS AND ENCLOSURES

AVAILABLE SWITCH MECHANISMS

Displacer level switches are available with a range of different switch mechanisms — each designed for specific service conditions. Brief descriptions of the individual switch mechanisms and their application are given below.

SERIES A, E, N & T MERCURY SWITCHES

- Quick visual inspection of contact conditions
- Series “A” and “N” are heavy duty units with high load carrying capability
- Series “E” and “T” switches are designed to provide greater vibration resistance

SERIES B, C, D, O & Q DRY CONTACT SWITCHES

- For applications where mercury must be avoided
- Series “B”, “C”, “O” and “Q” switches are general purpose units with a selection of maximum liquid temperature ratings
- Series “D” switch is designed for high DC current applications

BASIC ELECTRICAL RATINGS

Voltage	Switch Series and Non-Inductive Ampere Rating									
	A	B	C	D	E	HS	N	O	Q	T
120 VAC	13.00	15.00	15.00	10.00	4.00	5.00	13.00	15.00	15.00	4.00
240 VAC	6.50	15.00	15.00	—	2.00	5.00	6.50	15.00	15.00	2.00
24 VDC	10.00	6.00	10.00	10.00	—	5.00	—	—	6.00	—
120 VDC	10.00	0.50	1.00	10.00	4.00	0.50	10.00	1.00	0.50	4.00
240 VDC	5.00	0.25	0.50	3.00	2.00	0.25	5.00	0.50	0.25	2.00

SERIES J & K PNEUMATIC SWITCHES

- Suited for process industry applications in hazardous locations or where electrical power is not available
- Series “J” bleed type switch is intended for general purpose applications
- Series “K” switch is specially designed to provide non-bleed operation with a high degree of vibration resistance

SERIES HS HERMETICALLY SEALED SWITCHES

- Entire mechanism and contacts are contained within a positively pressurized capsule.
- Ideal for use in salt and other corrosive atmospheres
- Available in two models, one with easy access terminals, another with 12" (305 mm) long exposed wiring leads which may be field connected away from the switch enclosure

SWITCH ENCLOSURES

- NEMA 4X/7/9 aluminum enclosures
- Designed and approved for Class I, Div. 1, Groups C & D and Class I, Div. 1 Group B
- Optional housing heaters and drains available for some enclosures
- Pneumatic switch mechanisms available with a NEMA 1 enclosure

SPECIFICATIONS

MODEL A10 DIMENSIONAL DATA AND ACTUATION LEVELS

INCHES (MM)

Outline Dimensions				
Displacer Type	Threaded Mounting		Flanged Mounting	
	A	B	A	B
Porcelain	5.00 (127)	122.00 (3098)	7.00 (177)	124.00 (3149)
Stainless Steel or Karbate	4.75 (120)	122.00 (3098)	6.75 (171)	124.00 (3149)

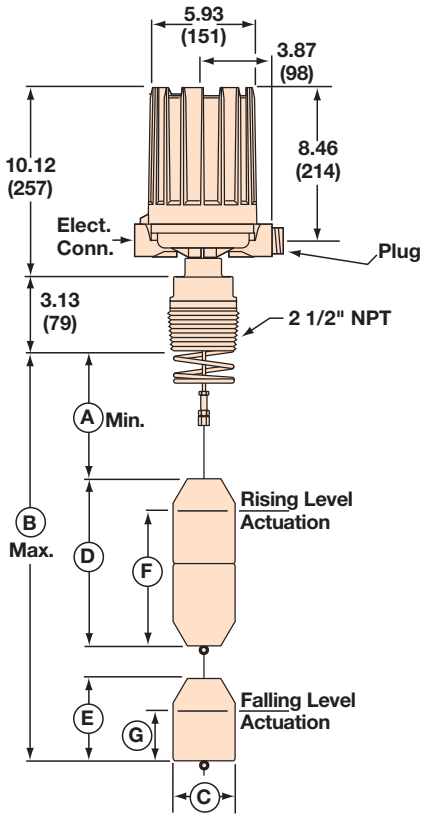
Displacer Type	C	D	E
Porcelain	2.56 (65)	7.25 (184)	3.62 (91)
Stainless Steel or Karbate	2.50 (63)	9.00 (228)	4.50 (114)

Electrical Connections
NEMA 4X/7/9, Group B: 1" NPT NEMA 1 Pneumatic: ¼" NPT

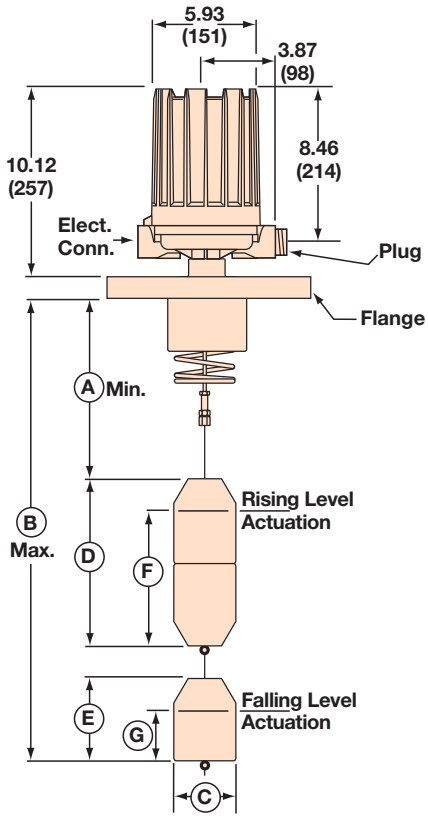
STANDARD ACTUATING LEVELS AND LIQUID SPECIFIC GRAVITY

Displacer Type	Liquid Temp. °F	0.60		0.70		0.80		0.90		1.00	
		F	G	F	G	F	G	F	G	F	G
Porcelain	100	5.30 (134)	1.50 (38)	4.10 (104)	1.20 (30)	3.20 (81)	1.10 (27)	2.50 (63)	1.00 (25)	2.00 (50)	0.90 (22)
	200	—	—	4.80 (121)	2.00 (50)	3.80 (96)	1.80 (45)	3.00 (76)	1.60 (40)	2.50 (63)	1.50 (38)
	300	—	—	—	—	4.30 (109)	2.40 (60)	3.40 (86)	2.10 (53)	2.90 (73)	1.90 (48)
	400	—	—	—	—	—	—	3.40 (86)	2.60 (66)	2.90 (73)	2.40 (60)
Stainless Steel or Karbate	100	7.00 (177)	2.40 (60)	5.30 (134)	2.00 (50)	4.10 (104)	1.80 (45)	3.10 (78)	1.60 (40)	2.40 (60)	1.40 (35)
	200	—	—	5.90 (149)	2.80 (71)	4.70 (119)	2.50 (63)	3.60 (91)	2.20 (55)	2.80 (71)	2.00 (50)
	300	—	—	—	—	5.10 (129)	3.10 (78)	4.00 (101)	2.70 (68)	3.20 (81)	2.40 (60)
Stainless Steel	400	—	—	—	—	—	—	4.40 (111)	3.20 (81)	3.60 (91)	2.90 (73)
	500	—	—	—	—	—	—	—	—	3.90 (99)	3.30 (83)

Note: All levels ±0.25" (6).



Model A10 with Threaded Mounting



Model A10 with Flanged Mounting

SPECIFICATIONS

MODEL A15 DIMENSIONAL DATA AND ACTUATION LEVELS

INCHES (MM)

Outline Dimensions				
Displacer Type	Threaded Mounting		Flanged Mounting	
	A	B	A	B
Porcelain	5.62 (142)	122.00 (3098)	7.62 (193)	124.00 (3149)
Stainless Steel or Karbate	5.62 (142)	122.00 (3098)	7.62 (193)	124.00 (3149)

Displacer Type	C	D
Porcelain	2.56 (65)	7.25 (184)
Stainless Steel or Karbate	2.50 (63)	9.00 (228)

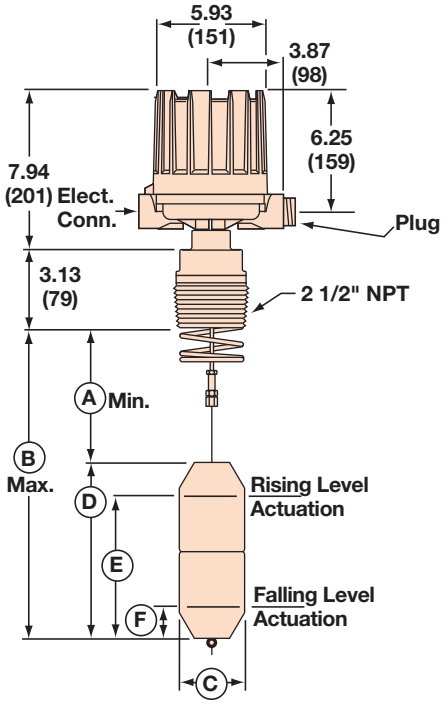
Electrical Connections
NEMA 4X/7/9, Group B: 1" NPT NEMA 1 Pneumatic: ¼" NPT

STANDARD ACTUATING LEVELS AND LIQUID SPECIFIC GRAVITY

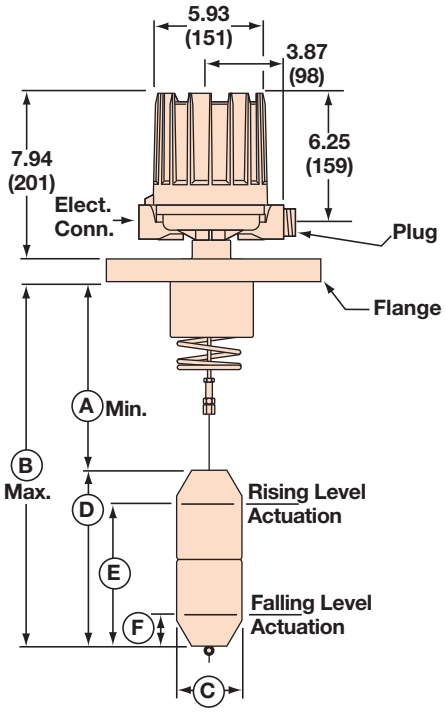
Displacer Type	Liquid Temp. °F	0.50		0.60		0.70		0.80		0.90		1.00	
		E	F	E	F	E	F	E	F	E	F	E	F
Porcelain	100	—	—	5.10 (129)	2.10 (53)	4.50 (114)	1.70 (43)	3.90 (99)	1.70 (43)	3.50 (88)	1.50 (38)	3.20 (81)	1.40 (35)
	200	—	—	5.60 (142)	2.60 (66)	4.90 (124)	2.10 (53)	4.30 (109)	2.10 (53)	3.80 (96)	1.80 (45)	3.50 (88)	1.70 (43)
	300	—	—	—	—	5.20 (132)	2.40 (60)	4.50 (114)	2.30 (58)	4.10 (104)	2.10 (53)	3.70 (93)	1.90 (48)
	400	—	—	—	—	5.60 (142)	2.80 (71)	4.80 (121)	2.60 (66)	4.30 (109)	2.30 (58)	3.90 (99)	2.10 (53)
	500	—	—	—	—	—	—	5.10 (129)	2.90 (73)	4.60 (116)	2.60 (66)	4.20 (106)	2.40 (60)
Stainless Steel or Karbate	100	5.40 (137)	2.00 (50)	4.50 (114)	1.60 (40)	3.90 (99)	1.40 (35)	3.40 (86)	1.20 (30)	3.00 (76)	1.10 (27)	2.70 (68)	1.00 (25)
	200	6.00 (152)	2.60 (66)	5.00 (127)	2.10 (53)	4.30 (109)	1.80 (45)	3.70 (93)	1.60 (40)	3.30 (83)	1.40 (35)	3.00 (76)	1.30 (33)
	300	6.40 (162)	3.00 (76)	5.30 (134)	2.40 (60)	4.60 (116)	2.10 (53)	4.00 (101)	1.80 (45)	3.60 (91)	1.70 (43)	3.20 (81)	1.50 (38)
Stainless Steel	400	6.90 (175)	3.50 (88)	5.70 (144)	2.80 (71)	4.90 (124)	2.40 (60)	4.30 (109)	2.10 (53)	3.80 (96)	1.90 (48)	3.40 (86)	1.70 (43)
	500	—	—	6.10 (154)	3.20 (81)	5.20 (132)	2.80 (71)	4.60 (116)	2.40 (60)	4.10 (104)	2.20 (55)	3.70 (93)	2.00 (50)

Note: All levels ±0.25" (6).

*See page 20 for proof-er and/or floating roof top switch dimensions.



Model A15 with Threaded Mounting



Model A15 with Flanged Mounting

SPECIFICATIONS

MODEL B10 DIMENSIONAL DATA

INCHES (MM)

Outline Dimensions				
Displacer Type	Threaded Mounting		Flanged Mounting	
	A	B	A	B
Porcelain	4.88 (123)	122.00 (3098)	6.88 (174)	124.00 (3149)
Stainless Steel or Karbate	4.75 (120)	122.00 (3098)	6.75 (171)	124.00 (3149)

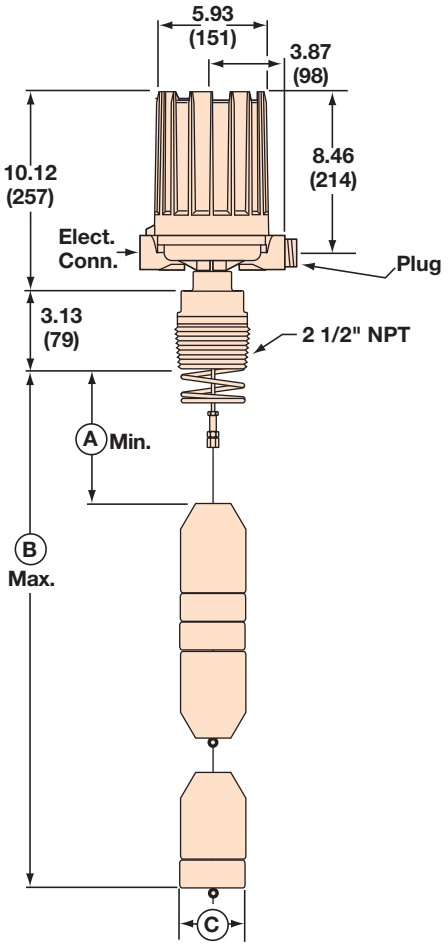
MODEL B10 WITH DISPLACER ARRANGEMENTS 1 AND 2

Displacer Type	C	D	E
Porcelain	2.56 (65)	10.04 (255)	5.02 (127)
Stainless Steel or Karbate	2.50 (63)	12.00 (304)	6.00 (152)

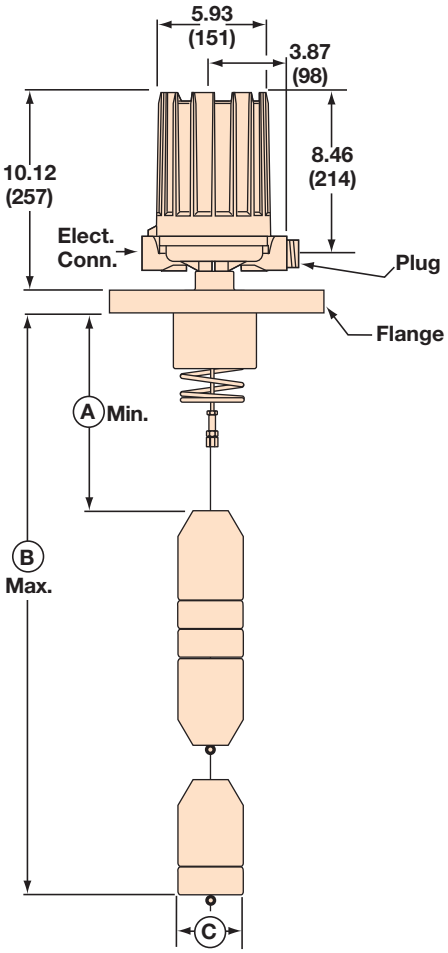
MODEL B10 WITH DISPLACER ARRANGEMENTS 3, 4, AND 5

Displacer Type	C	D	E	F
Porcelain	2.56 (65)	5.02 (127)	5.02 (127)	5.02 (127)
Stainless Steel or Karbate	2.50 (63)	6.00 (152)	6.00 (152)	6.00 (152)

Electrical Connections
NEMA 4X/7/9 Group B: 1" NPT



Model B10
with Threaded Mounting

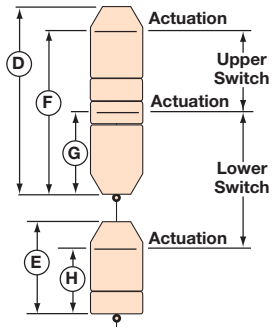


Model B10
with Flanged Mounting

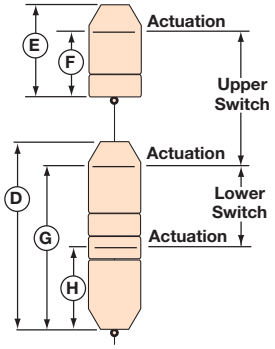
SPECIFICATIONS

MODEL B10 ACTUATION LEVELS

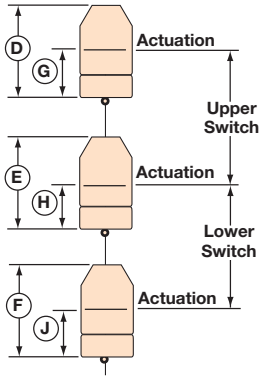
INCHES (MM)



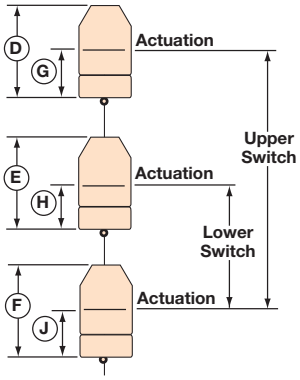
Model B10
Displacer Arrangement 1



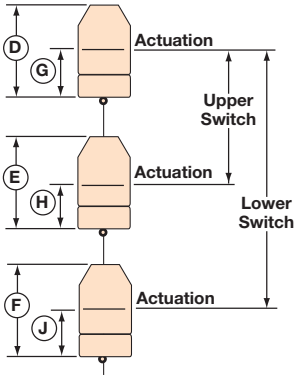
Model B10
Displacer Arrangement 2



Model B10
Displacer Arrangement 3



Model B10
Displacer Arrangement 4



Model B10
Displacer Arrangement 5

B10 STANDARD ACTUATING LEVELS AND LIQUID SPECIFIC GRAVITY WITH DISPLACER ARRANGEMENT 1

Displacer Type	Liquid Temp. ° F	Level	0.60 - 0.64	0.65 - 0.71	0.72 - 0.73	0.74 - 0.82	0.83 - 0.92	0.93 - 1.00	1.01 - 1.07
Porcelain	100	F	7.79 - 7.04 (197 - 178)	7.66 - 6.65 (194 - 168)	7.22 - 7.06 (133 - 179)	6.91 - 5.81 (175 - 147)	6.73 - 5.65 (180 - 143)	5.55 - 4.86 (140 - 123)	4.97 - 4.53 (126 - 115)
		G	2.62 - 2.19 (56 - 55)	2.88 - 2.28 (73 - 57)	2.91 - 2.81 (73 - 71)	2.71 - 2.03 (68 - 51)	2.99 - 2.28 (75 - 57)	2.21 - 1.76 (56 - 44)	1.90 - 1.63 (48 - 41)
		H	2.01 - 1.89 (51 - 48)	1.86 - 1.70 (47 - 43)	1.68 - 1.65 (42 - 41)	1.63 - 1.47 (41 - 37)	1.45 - 1.31 (36 - 33)	1.30 - 1.21 (33 - 30)	1.02 - 0.97 (25 - 24)
	200	F	7.91 (200)	7.72 - 6.71 (196 - 170)	6.56 - 6.41 (166 - 162)	6.73 - 5.66 (170 - 143)	6.37 - 5.33 (161 - 135)	6.15 - 5.42 (156 - 137)	5.02 - 4.57 (127 - 116)
		G	3.06 (77)	2.95 - 2.34 (74 - 59)	2.25 - 2.16 (57 - 54)	2.54 - 1.87 (64 - 47)	2.63 - 1.95 (66 - 49)	2.81 - 2.32 (71 - 58)	1.94 - 1.67 (49 - 42)
		H	2.76 (70)	2.72 - 2.49 (69 - 63)	2.45 - 2.42 (62 - 61)	2.39 - 2.15 (60 - 54)	2.13 - 1.92 (54 - 48)	1.90 - 1.77 (48 - 44)	1.58 - 1.49 (40 - 37)
	300	F	—	—	—	7.48 - 6.34 (189 - 161)	7.04 - 5.93 (178 - 150)	6.75 - 5.98 (171 - 151)	5.57 - 5.10 (141 - 129)
		G	—	—	—	3.29 - 2.55 (83 - 64)	3.30 - 2.56 (83 - 65)	3.41 - 2.87 (86 - 72)	2.50 - 2.19 (63 - 55)
		H	—	—	—	3.14 - 2.83 (79 - 71)	2.80 - 2.53 (71 - 64)	2.50 - 2.32 (63 - 58)	2.13 - 2.01 (54 - 51)
	400	F	—	—	—	—	—	—	6.12 - 5.62 (155 - 142)
		G	—	—	—	—	—	—	3.05 - 2.72 (77 - 69)
		H	—	—	—	—	—	—	2.68 - 2.53 (68 - 64)

Note: All levels ±0.25" (6).

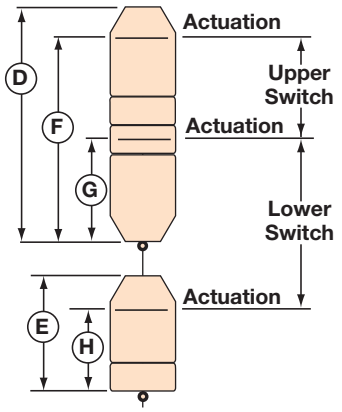
MODEL B10 ACTUATION LEVELS (cont.)

INCHES (MM)

B10 STANDARD ACTUATING LEVELS AND LIQUID SPECIFIC GRAVITY WITH DISPLACER ARRANGEMENT 1

Displacer Type	Liquid Temp. ° F	Level	1.08 - 1.12	1.13 - 1.17	1.18 - 1.27	1.28 - 1.30	1.31 - 1.39	1.40 - 1.50
Porcelain	100	F	4.47 - 4.20 (113 - 106)	4.90 - 4.64 (124 - 117)	4.57 - 4.05 (116 - 102)	3.99 - 3.89 (101 - 98)	4.23 - 3.82 (107 - 97)	3.77 - 3.33 (95 - 84)
		G	1.59 - 1.43 (40 - 36)	2.16 - 1.99 (54 - 50)	1.94 - 1.60 (49 - 40)	1.57 - 1.50 (39 - 38)	1.86 - 1.59 (47 - 40)	1.56 - 1.26 (39 - 32)
		H	0.96 - 0.92 (24 - 23)	0.92 - 0.88 (23 - 22)	0.88 - 0.81 (22 - 20)	0.81 - 0.80 (20 - 20)	0.79 - 0.74 (20 - 18)	0.74 - 0.69 (18 - 17)
	200	F	4.66 - 4.39 (118 - 111)	4.33 - 4.08 (109 - 103)	4.32 - 3.81 (109 - 96)	4.29 - 4.18 (108 - 106)	4.13 - 3.73 (104 - 94)	3.93 - 3.47 (99 - 88)
		G	1.79 - 1.62 (45 - 41)	1.58 - 1.43 (40 - 36)	1.69 - 1.36 (42 - 34)	1.87 - 1.80 (47 - 45)	1.76 - 1.49 (44 - 37)	1.71 - 1.40 (43 - 35)
		H	1.48 - 1.42 (37 - 36)	1.41 - 1.36 (35 - 34)	1.35 - 1.25 (34 - 31)	1.24 - 1.23 (31 - 31)	1.22 - 1.15 (30 - 29)	1.14 - 1.06 (28 - 26)
	300	F	5.18 - 4.89 (131 - 124)	4.82 - 4.56 (122 - 115)	4.79 - 4.25 (121 - 107)	4.73 - 4.61 (120 - 117)	4.56 - 4.13 (115 - 104)	4.32 - 3.84 (109 - 97)
		G	2.31 - 2.12 (58 - 53)	2.08 - 1.91 (52 - 48)	2.16 - 1.80 (54 - 45)	2.31 - 2.23 (58 - 56)	2.19 - 1.90 (55 - 48)	2.11 - 1.78 (53 - 45)
		H	1.99 - 1.92 (50 - 48)	1.90 - 1.84 (48 - 46)	1.82 - 1.69 (45 - 42)	1.68 - 1.66 (42 - 42)	1.64 - 1.55 (41 - 39)	1.54 - 1.43 (39 - 36)
	400	F	5.70 - 5.39 (144 - 136)	5.32 - 5.04 (135 - 128)	5.26 - 4.69 (133 - 119)	5.17 - 5.04 (131 - 128)	4.98 - 4.53 (126 - 115)	4.72 - 4.22 (119 - 107)
		G	2.82 - 2.62 (71 - 66)	2.57 - 2.39 (65 - 60)	2.63 - 2.24 (66 - 56)	2.74 - 2.66 (69 - 67)	2.61 - 2.30 (66 - 58)	2.51 - 2.15 (63 - 54)
		H	2.51 - 2.42 (63 - 61)	2.40 - 2.32 (60 - 58)	2.30 - 2.13 (58 - 54)	2.12 - 2.08 (53 - 52)	2.07 - 1.95 (52 - 49)	1.94 - 1.81 (49 - 45)
	500	F	6.22 - 5.89 (157 - 149)	5.81 - 5.52 (147 - 140)	5.74 - 5.13 (145 - 130)	5.60 - 5.47 (142 - 138)	5.41 - 4.93 (137 - 125)	5.12 - 4.59 (130 - 116)
		G	3.34 - 3.12 (84 - 79)	3.07 - 2.86 (77 - 72)	3.11 - 2.68 (78 - 68)	3.18 - 3.09 (80 - 78)	3.04 - 2.70 (77 - 68)	2.91 - 2.52 (73 - 64)
		H	3.03 - 2.92 (76 - 74)	2.89 - 2.79 (73 - 70)	2.77 - 2.57 (70 - 65)	2.55 - 2.51 (64 - 63)	2.50 - 2.35 (63 - 59)	2.33 - 2.18 (59 - 55)

Note: All levels ±0.25" (6).



Model B10
Displacer Arrangement 1

MODEL B10 ACTUATION LEVELS (cont.)

INCHES (MM)

B10 STANDARD ACTUATING LEVELS AND LIQUID SPECIFIC GRAVITY WITH DISPLACER ARRANGEMENT 1 (cont.)

Displacer Type	Liquid Temp. ° F	Level	0.50 - 0.58	0.59 - 0.71	0.72 - 0.79	0.80 - 0.85	0.86 - 1.00	1.01 - 1.03
Stainless Steel and Karbate	100	F	9.91 - 7.72 (251 - 196)	9.19 - 6.62 (233 - 168)	8.44 - 7.16 (214 - 181)	7.66 - 6.86 (194 - 174)	6.71 - 4.93 (170 - 125)	4.82 - 4.61 (122 - 117)
		G	3.46 - 2.16 (86 - 54)	3.72 - 2.08 (94 - 52)	3.96 - 3.07 (100 - 77)	3.63 - 3.07 ((92 - 77)	2.96 - 1.71 (75 - 43)	1.63 - 1.48 (41 - 37)
		H	2.51 - 2.16 (63 - 54)	2.13 - 1.77 (54 - 44)	1.74 - 1.59 (44 - 40)	1.57 - 1.48 (39 - 37)	1.46 - 1.25 (37 - 31)	1.24 - 1.22 (31 - 30)
	200	F	10.22 - 7.98 (259 - 202)	7.74 - 7.44 (196 - 188)	7.50 - 6.30 (190 - 160)	6.15 - 5.44 (156 - 138)	6.97 - 5.15 (177 - 130)	—
		G	3.76 - 2.42 (95 - 61)	2.27 - 1.89 (57 - 48)	3.02 - 2.22 (76 - 56)	2.12 - 1.64 (53 - 41)	3.22 - 1.93 (81 - 49)	—
		H	3.67 - 3.16 (93 - 80)	3.11 - 2.58 (78 - 65)	2.55 - 2.32 (64 - 58)	2.29 - 2.16 (58 - 54)	2.13 - 1.84 (54 - 46)	—
	300	F	—	9.68 - 7.25 (245 - 184)	8.31 - 7.04 (211 - 178)	6.88 - 6.12 (174 - 155)	7.65 - 5.73 (194 - 145)	—
		G	—	4.30 - 2.70 (109 - 68)	3.83 - 2.96 (97 - 75)	2.84 - 2.32 (72 - 58)	3.89 - 2.51 (98 - 63)	—
		H	—	4.03 - 3.40 (102 - 86)	3.36 - 3.06 (85 - 77)	3.02 - 2.84 (76 - 72)	2.81 - 2.42 (71 - 61)	—
Stainless Steel	400	F	—	—	9.11 - 7.77 (231 - 197)	7.60 - 6.80 (193 - 172)	8.32 - 6.32 (211 - 160)	—
		G	—	—	4.63 - 3.69 (117 - 93)	3.57 - 3.01 (90 - 76)	4.57 - 3.09 (116 - 78)	—
		H	—	—	4.16 - 3.79 (105 - 96)	3.75 - 3.53 (95 - 89)	3.48 - 3.00 (88 - 76)	—
	500	F	—	—	—	—	9.00 - 6.90 (228 - 175)	—
		G	—	—	—	—	5.24 - 3.67 (133 - 93)	—
		H	—	—	—	—	4.16 - 3.58 (105 - 90)	—

Note: All levels ±0.25" (6).

MODEL B10 ACTUATION LEVELS (cont.)

INCHES (MM)

B10 STANDARD ACTUATING LEVELS AND LIQUID SPECIFIC GRAVITY WITH DISPLACER ARRANGEMENT 2

Displacer Type	Liquid Temp. ° F	Level	0.60 - 0.64	0.65 -0.71	0.72 - 0.73	0.74 - 0.82	0.83 - 0.92	0.93 - 1.00	1.01 - 1.07
Porcelain	100	F	2.77 - 2.01 (70 - 51)	2.63 - 1.62 (66 - 41)	2.67 - 2.51 (67 - 63)	2.58 - 1.42 (65 - 36)	3.16 - 1.94 (80 - 49)	1.82 - 1.04 (45 - 26)	1.69 - 1.23 (42 - 31)
		G	7.27 - 6.84 (184 - 173)	7.54 - 6.93 (191 - 176)	7.56 - 7.46 (192 - 189)	7.36 - 6.68 (186 - 169)	7.64 - 6.93 (194 - 176)	6.86 - 6.41 (174 - 162)	5.15 - 4.89 (130 - 124)
		H	2.67 - 2.53 (67 - 64)	3.29 - 3.05 (83 - 77)	3.73 - 3.68 (94 - 93)	3.64 - 3.32 (92 - 84)	4.32 - 3.93 (109 - 99)	3.90 - 3.65 (99 - 92)	2.42 - 2.31 (61 - 58)
	200	F	3.15 (80)	2.96 - 1.93 (75 - 49)	1.77 - 1.62 (44 - 41)	2.64 - 1.47 (67 - 37)	2.79 - 1.61 (70 - 40)	2.79 - 1.94 (70 - 49)	1.56 - 1.11 (39 - 28)
		G	7.71 (195)	7.60 - 6.99 (193 - 177)	6.90 - 6.81 (175 - 172)	7.19 - 6.52 (182 - 165)	7.28 - 6.60 (184 - 167)	7.46 - 6.97 (189 - 177)	5.19 - 4.92 (131 - 124)
		H	3.40 (86)	3.36 - 3.10 (85 - 78)	3.07 - 3.03 (77 - 76)	3.46 - 3.16 (87 - 80)	3.96 - 3.61 (100 - 91)	4.50 - 4.21 (114 - 106)	2.46 - 2.35 (62 - 59)
	300	F	—	—	—	3.39 - 2.15 (86 - 54)	3.47 - 2.22 (88 - 56)	3.39 - 2.50 (86 - 63)	2.11 - 1.63 (53 - 41)
		G	—	—	—	7.94 - 7.20 (201 - 182)	7.95 - 7.21 (201 - 183)	8.06 - 7.53 (204 - 191)	5.75 - 5.45 (146 - 138)
		H	—	—	—	4.21 - 3.84 (106 - 97)	4.63 - 4.21 (117 - 106)	5.10 - 4.77 (129 - 121)	3.02 - 2.87 (76 - 72)
	400	F	—	—	—	—	—	—	2.67 - 2.15 (67 - 54)
		G	—	—	—	—	—	—	6.30 - 5.97 (160 - 151)
		H	—	—	—	—	—	—	3.57 - 3.39 (90 - 86)

Displacer Type	Liquid Temp. ° F	Level	1.08 - 1.12	1.13 - 1.17	1.18 - 1.27	1.28 - 1.30	1.31 - 1.39	1.40 - 1.50
Porcelain	100	F	1.16 - 0.89 (29 - 22)	2.04 - 1.75 (51 - 44)	1.68 - 1.10 (42 - 27)	1.04 - 0.92 (26 - 23)	2.05 - 1.56 (52 - 39)	1.50 - 0.97 (38 - 24)
		G	4.84 - 4.68 (122 - 118)	5.41 - 5.24 (137 - 133)	5.20 - 4.85 (132 - 123)	4.82 - 4.75 (122 - 120)	5.11 - 4.84 (129 - 122)	4.81 - 4.51 (122 - 114)
		H	2.29 - 2.22 (58 - 56)	2.97 - 2.88 (75 - 73)	2.86 - 2.68 (72 - 68)	2.66 - 2.63 (67 - 66)	3.01 - 2.85 (76 - 72)	2.84 - 2.67 (72 - 67)
	200	F	1.68 - 1.38 (42 - 35)	1.31 - 1.05 (33 - 26)	1.71 - 1.13 (43 - 28)	1.75 - 1.62 (44 - 41)	1.56 - 1.09 (39 - 27)	1.53 - 1.00 (38 - 25)
		G	5.04 - 4.88 (128 - 123)	4.84 - 4.68 (122 - 118)	4.94 - 4.62 (125 - 117)	5.12 - 5.05 (130 - 128)	5.01 - 4.75 (127 - 120)	4.96 - 4.65 (125 - 118)
		H	2.49 - 2.41 (63 - 61)	2.39 - 2.33 (60 - 59)	2.60 - 2.44 (66 - 61)	2.97 - 2.93 (73 - 70)	2.91 - 2.76 (73 - 70)	2.99 - 2.82 (75 - 77)
	300	F	2.19 - 1.88 (55 - 47)	1.81 - 1.52 (45 - 38)	2.19 - 1.57 (55 - 39)	2.18 - 2.05 (50 - 37)	1.98 - 1.49 (50 - 37)	1.93 - 1.37 (49 - 34)
		G	5.56 - 5.37 (141 - 136)	5.33 - 5.16 (135 - 131)	5.41 - 5.06 (137 - 128)	5.56 - 5.48 (138 - 130)	5.44 - 5.15 (138 - 130)	5.36 - 5.03 (136 - 127)
		H	3.01 - 2.91 (76 - 73)	2.89 - 2.80 (73 - 71)	3.07 - 2.88 (77 - 73)	3.40 - 3.36 (84 - 80)	3.33 - 3.16 (84 - 80)	3.39 - 3.19 (86 - 81)
	400	F	2.71 - 2.38 (68 - 60)	2.30 - 2.00 (58 - 50)	2.66 - 2.01 (67 - 51)	2.62 - 2.48 (61 - 48)	2.41 - 1.90 (61 - 48)	2.33 - 1.74 (59 - 44)
		G	6.08 - 5.87 (154 - 149)	5.82 - 5.64 (147 - 143)	5.89 - 5.49 (149 - 139)	5.99 - 5.91 (152 - 150)	5.87 - 5.55 (149 - 140)	5.76 - 5.40 (146 - 137)
		H	3.52 - 3.41 (89 - 86)	3.38 - 3.28 (85 - 83)	3.55 - 3.32 (90 - 84)	3.84 - 3.79 (97 - 96)	3.76 - 3.56 (95 - 90)	3.79 - 3.56 (96 - 90)
	500	F	3.23 - 2.88 (82 - 73)	2.80 - 2.48 (71 - 62)	3.13 - 2.45 (79 - 62)	3.05 - 2.91 (77 - 73)	2.84 - 2.30 (72 - 58)	2.73 - 2.11 (69 - 53)
		G	6.59 - 6.37 (167 - 161)	6.32 - 6.12 (160 - 155)	6.36 - 5.93 (161 - 150)	6.43 - 6.34 (163 - 161)	6.29 - 5.95 (159 - 151)	6.16 - 5.77 (156 - 146)
		H	4.04 - 3.91 (102 - 99)	3.88 - 3.76 (98 - 95)	4.02 - 3.76 (102 - 95)	4.28 - 4.21 (108 - 106)	4.19 - 3.97 (106 - 100)	4.19 - 3.93 (106 - 99)

Note: All levels ±0.25" (6).

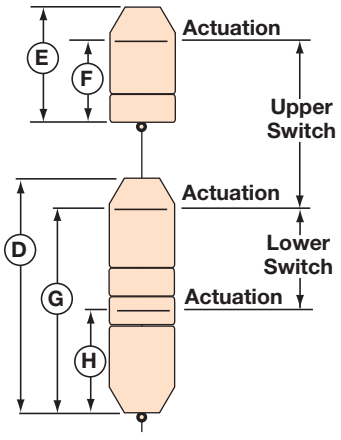
MODEL B10 ACTUATION LEVELS (cont.)

INCHES (MM)

B10 STANDARD ACTUATING LEVELS AND LIQUID SPECIFIC GRAVITY WITH DISPLACER ARRANGEMENT 2 (cont.)

Displacer Type	Liquid Temp. ° F	Level	0.50 - 0.58	0.59 - 0.71	0.72 - 0.79	0.80 - 0.85	0.86 - 1.00	1.01 - 1.03
Stainless Steel and Karbate	100	F	3.77 - 1.60 (95 - 40)	4.10 - 1.38 (104 - 35)	4.43 - 2.97 (112 - 75)	4.58 - 3.60 (24 - 91)	3.42 - 1.26 (86 - 31)	1.13 - 0.88 (28 - 22)
		G	9.46 - 8.16 (240 - 207)	9.72 - 8.08 (246 - 205)	9.96 - 9.07 (252 - 230)	9.63 - 9.07 (244 - 230)	8.96 - 7.71 (227 - 195)	7.63 - 7.48 (193 - 189)
		H	3.73 - 3.21 (94 - 81)	4.86 - 4.04 (123 - 102)	5.97 - 5.44 (151 - 138)	6.05 - 5.69 (153 - 144)	5.63 - 4.84 (143 - 122)	4.79 - 4.70 (121 - 119)
	200	F	4.22 - 1.98 (107 - 50)	1.74 - 1.44 (44 - 36)	3.74 - 2.35 (94 - 59)	2.17 - 1.33 (55 - 33)	3.89 - 1.66 (98 - 42)	—
		G	9.76 - 8.42 (247 - 213)	8.27 - 6.88 (210 - 174)	9.02 - 8.22 (229 - 208)	8.12 - 7.64 (206 - 194)	9.22 - 7.93 (234 - 201)	—
		H	4.03 - 3.47 (102 - 88)	3.41 - 2.84 (86 - 62)	5.04 - 4.59 (128 - 116)	4.53 - 4.27 (115 - 108)	5.88 - 5.06 (149 - 128)	—
	300	F	—	4.87 - 2.26 (123 - 57)	4.55 - 3.08 (115 - 78)	2.89 - 2.02 (73 - 51)	4.56 - 2.24 (115 - 56)	—
		G	—	10.30 - 8.70 (261 - 220)	9.83 - 8.96 (249 - 227)	8.84 - 8.32 (224 - 211)	9.89 - 8.51 (251 - 216)	—
		H	—	5.52 - 4.66 (140 - 118)	5.84 - 5.33 (148 - 135)	5.26 - 4.95 (133 - 125)	6.56 - 5.64 (166 - 131)	—
Stainless Steel	400	F	—	—	5.35 - 3.82 (135 - 97)	3.62 - 2.70 (91 - 68)	5.24 - 2.82 (133 - 71)	—
		G	—	—	10.63 - 9.69 (270 - 246)	9.57 - 9.01 (243 - 228)	10.57 - 9.09 (183 - 157)	—
		H	—	—	6.65 - 6.06 (168 - 153)	5.99 - 5.63 (152 - 143)	7.24 - 6.22 (183 - 157)	—
	500	F	—	—	—	—	5.91 - 3.41 (150 - 86)	—
		G	—	—	—	—	11.24 - 9.67 (285 - 245)	—
		H	—	—	—	—	7.91 - 6.80 (200 - 172)	—

Note: All levels ±0.25" (6).



Model B10
Displacer Arrangement 2

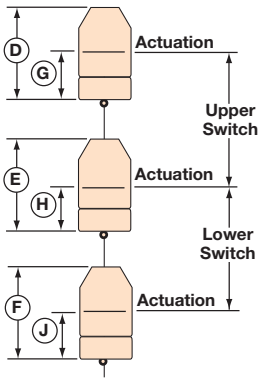
MODEL B10 ACTUATION LEVELS (cont.)

INCHES (MM)

B10 STANDARD ACTUATING LEVELS AND LIQUID SPECIFIC GRAVITY WITH DISPLACER ARRANGEMENTS 3, 4, AND 5

Displacer Type	Liquid Temp. ° F	Level	0.60 - 0.64	0.65 - 0.71	0.72 - 0.73	0.74 - 0.82	0.83 - 0.92	0.93 - 1.00	1.01 - 1.07
Porcelain	100	G	2.77 - 2.01 (70 - 51)	2.63 - 1.62 (66 - 41)	2.67 - 2.51 (67 - 63)	2.58 - 1.42 (65 - 36)	3.16 - 1.94 (80 - 49)	1.82 - 1.04 (45 - 26)	1.69 - 1.23 (42 - 31)
		H	2.24 - 1.81 (56 - 45)	2.51 - 1.90 (63 - 48)	2.53 - 2.43 (64 - 61)	2.34 - 1.66 (59 - 42)	2.62 - 1.91 (66 - 48)	1.84 - 1.38 (46 - 35)	1.53 - 1.26 (38 - 32)
		J	2.01 - 1.89 (51 - 48)	1.86 - 1.70 (47 - 43)	1.68 - 1.65 (42 - 41)	1.63 - 1.47 (41 - 37)	1.45 - 1.31 (36 - 33)	1.30 - 1.21 (33 - 30)	1.02 - .097 (25 - 24)
	200	G	3.15 (80)	2.96 - 1.93 (75 - 49)	1.77 - 1.62 (44 - 41)	2.64 - 1.47 (67 - 37)	2.79 - 1.61 (70 - 40)	2.79 - 1.94 (70 - 49)	1.56 - 1.11 (39 - 28)
		H	2.69 (68)	2.57 - 1.96 965 - 49)	1.87 - 1.78 (47 - 45)	2.16 - 1.50 (54 - 38)	2.25 - 1.58 (57 - 40)	2.44 - 1.94 (61 - 49)	1.40 - 1.14 (35 - 28)
		J	2.76 (70)	2.72 - 2.49 (69 - 63)	2.45 - 2.42 (62 - 61)	2.39 - 2.15 (60 - 54)	2.13 - 1.92 (54 - 48)	1.90 - 1.77 (48 - 44)	1.58 - 1.49 (40 - 37)
	300	G	—	—	—	3.39 - 2.15 (86 - 54)	3.47 - 2.22 (88 - 56)	3.39 - 2.50 (86 - 63)	2.11 - 1.63 (53 - 41)
		H	—	—	—	2.92 - 2.18 (74 - 55)	2.93 - 2.18 (74 - 55)	3.04 - 2.50 (77 - 63)	1.95 - 1.66 (49 - 42)
		J	—	—	—	3.14 - 2.83 (79 - 71)	2.80 - 2.53 (71 - 64)	2.50 - 2.32 (63 - 58)	2.13 - 2.01 (54 - 51)
	400	G	—	—	—	—	—	—	2.67 - 2.15 (67 - 54)
		H	—	—	—	—	—	—	2.68 - 2.34 (68 - 59)
		J	—	—	—	—	—	—	2.68 - 2.53 (68 - 64)

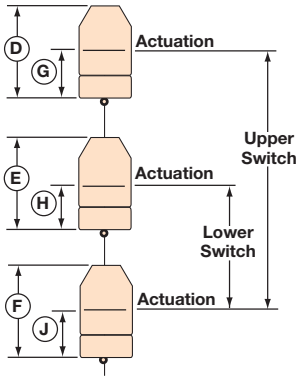
Note: All levels ±0.25" (6).



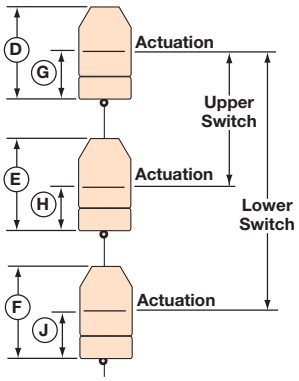
Model B10 Displacer Arrangement 3

Displacer Type	Liquid Temp. ° F	Level	1.08 - 1.12	1.13 - 1.17	1.18 - 1.27	1.28 - 1.30	1.31 - 1.39	1.40 - 1.50
Porcelain	100	G	1.16 - 0.89 (29 - 22)	2.04 - 1.75 (51 - 44)	1.68 - 1.10 (42 - 27)	1.04 - 0.92 (26 - 23)	2.05 - 1.56 (52 - 39)	1.50 - 0.97 (38 - 24)
		H	1.22 - 1.06 (30 - 26)	1.78 - 1.61 (45 - 40)	1.57 - 1.23 (39 - 31)	1.19 - 1.12 (30 - 28)	1.49 - 1.21 (37 - 30)	1.18 - 0.89 (29 - 22)
		J	0.96 - 0.92 (24 - 23)	0.92 - 0.88 (23 - 22)	0.88 - 0.81 (22 - 20)	0.81 - 0.80 (20 - 20)	0.79 - 0.74 (20 - 18)	0.74 - 0.69 (18 - 17)
	200	G	1.68 - 1.38 (42 - 35)	1.31 - 1.05 (33 - 26)	1.71 - 1.13 (43 - 28)	1.75 - 1.62 (44 - 41)	1.56 - 1.09 (39 - 27)	1.53 - 1.00 (38 - 25)
		H	1.42 - 1.25 (36 - 31)	1.21 - 1.06 (30 - 26)	1.31 - 0.99 (33 - 25)	1.50 - 1.42 (38 - 36)	1.39 - 1.12 (35 - 28)	1.33 - 1.03 (33 - 26)
		J	1.48 - 1.42 (37 - 36)	1.41 - 1.36 (35 - 34)	1.35 - 1.25 (34 - 31)	1.24 - 1.23 (31 - 31)	1.22 - 1.15 (30 - 29)	1.14 - 1.06 (28 - 26)
	300	G	2.19 - 1.88 (55 - 47)	1.81 - 1.52 (45 - 38)	2.19 - 1.57 (55 - 39)	2.18 - 2.05 (50 - 37)	1.98 - 1.49 (50 - 37)	1.93 - 1.37 (49 - 34)
		H	1.93 - 1.75 (49 - 44)	1.70 - 1.53 (43 - 38)	1.79 - 1.43 (45 - 36)	1.93 - 1.85 (49 - 46)	1.81 - 1.52 (45 - 38)	1.73 - 1.40 (43 - 35)
		J	1.99 - 1.92 (50 - 48)	1.90 - 1.84 (48 - 46)	1.82 - 1.69 (45 - 42)	1.68 - 1.66 (42 - 42)	1.64 - 1.55 (41 - 39)	1.54 - 1.43 (39 - 36)
	400	G	2.71 - 2.38 (68 - 60)	2.30 - 2.00 (58 - 50)	2.66 - 2.01 (67 - 51)	2.62 - 2.48 (61 - 48)	2.41 - 1.90 (61 - 48)	2.33 - 1.74 (59 - 44)
		H	2.45 - 2.25 (62 - 57)	2.20 - 2.01 (55 - 51)	2.26 - 1.87 (57 - 47)	2.37 - 2.28 (60 - 57)	2.24 - 1.92 (56 - 23)	2.13 - 1.77 (54 - 44)
		J	2.51 - 2.42 (63 - 61)	2.40 - 2.32 (60 - 58)	2.30 - 2.13 (58 - 54)	2.12 - 2.08 (53 - 52)	2.07 - 1.95 (52 - 49)	1.94 - 1.81 (49 - 45)
	500	G	3.23 - 2.88 (82 - 73)	2.80 - 2.48 (71 - 62)	3.13 - 2.45 (79 - 62)	3.05 - 2.91 (77 - 73)	2.84 - 2.30 (72 - 58)	2.73 - 2.11 (69 - 53)
		H	2.97 - 2.75 (75 - 69)	2.69 - 2.49 (68 - 63)	2.73 - 2.31 (69 - 58)	2.80 - 2.71 (71 - 68)	2.67 - 2.33 (67 - 59)	2.53 - 2.15 (64 - 54)
		J	3.03 - 2.92 (76 - 74)	2.89 - 2.79 (73 - 70)	2.77 - 2.57 (70 - 65)	2.55 - 2.51 (64 - 63)	2.50 - 2.35 (63 - 59)	2.33 - 2.18 (59 - 55)

Note: All levels ±0.25" (6).



Model B10 Displacer Arrangement 4



Model B10 Displacer Arrangement 5

SPECIFICATIONS

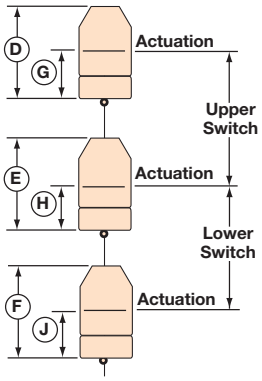
MODEL B10 ACTUATION LEVELS (cont.)

INCHES (MM)

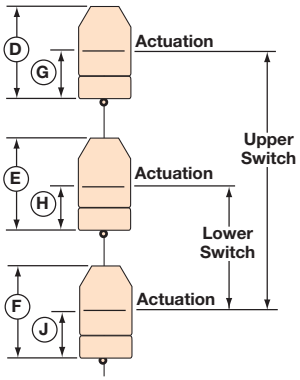
B10 STANDARD ACTUATING LEVELS AND LIQUID SPECIFIC GRAVITY WITH DISPLACER ARRANGEMENTS 3, 4,AND 5

Displacer Type	Liquid Temp. ° F	Level	0.50 - 0.58	0.59 - 0.71	0.72 - 0.79	0.80 - 0.85	0.86 - 1.00	1.01 - 1.03
Stainless Steel and Karbate	100	G	3.77 - 1.60 (95 - 40)	4.10 - 1.38 (104 - 35)	4.43 - 2.97 (112 - 75)	4.58 - 3.60 (24 - 91)	3.42 - 1.26 (86 - 31)	1.13 - 0.88 (28 - 22)
		H	3.46 - 2.16 (87 - 54)	3.72 - 2.08 (94 - 52)	3.96 - 3.07 (100 - 77)	3.63 - 3.07 (92 - 77)	2.96 - 1.71 ((75 - 43)	1.45 - 1.31 (36 - 33)
		J	2.51 - 2.16 (63 - 54)	2.13 - 1.77 (54 - 44)	1.74 - 1.59 (44 - 40)	1.57 - 1.48 (39 - 37)	1.46 - 1.25 (37 - 31)	1.24 - 1.22 (31 - 30)
	200	G	4.22 - 1.98 (107 - 50)	1.74 - 1.44 (44 - 36)	3.74 - 2.35 (94 - 59)	2.17 - 1.33 (55 - 33)	3.89 - 1.66 (98 - 42)	—
		H	3.76 - 2.42 (95 - 61)	2.27 - 1.89 (57 - 48)	3.02 - 2.22 (76 - 56)	2.12 - 1.64 (53 - 41)	3.22 - 1.93 (81 - 49)	—
		J	3.67 - 3.16 (93 - 80)	3.11 - 2.58 (78 - 65)	2.55 - 2.32 (64 - 58)	2.29 - 2.16 (58 - 54)	2.13 - 1.84 (54 - 46)	—
	300	G	—	4.87 - 2.26 (123 - 57)	4.55 - 3.08 (115 - 78)	2.89 - 2.02 (73 - 51)	4.56 - 2.24 (115 - 56)	—
		H	—	4.30 - 2.70 (109 - 68)	3.83 - 2.96 (97 - 75)	2.84 - 2.32 (72 - 58)	3.89 - 2.51 (98 - 63)	—
		J	—	4.03 - 3.40 (102 - 86)	3.36 - 3.06 (85 - 77)	3.02 - 2.84 (76 - 72)	2.81 - 2.42 (71 - 61)	—
Stainless Steel	400	G	—	—	5.35 - 3.82 (135 - 97)	3.62 - 2.70 (91 - 68)	5.24 - 2.82 (133 - 71)	—
		H	—	—	4.63 - 3.69 (117 - 93)	3.57 - 3.01 (90 - 76)	4.57 - 3.09 (116 - 78)	—
		J	—	—	4.16 - 3.79 (105 - 96)	3.75 - 3.53 (95 - 89)	3.48 - 3.00 (88 - 76)	—
	500	G	—	—	—	—	5.91 - 3.41 (150 - 86)	—
		H	—	—	—	—	5.24 - 3.67 (133 - 93)	—
		J	—	—	—	—	4.16 - 3.58 (105 - 90)	—

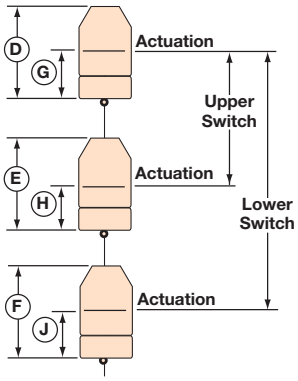
Note: All levels ±0.25" (6).



Model B10 Displacer Arrangement 3



Model B10 Displacer Arrangement 4



Model B10 Displacer Arrangement 5

SPECIFICATIONS

MODEL B15 DIMENSIONAL DATA AND ACTUATION LEVELS

INCHES (MM)

Outline Dimensions				
Displacer Type	Threaded Mounting		Flanged Mounting	
	A	B	A	B
Porcelain	5.50 (139)	123.00 (3124)	7.50 (190)	125.00 (3175)
Stainless Steel or Karbate	5.88 (149)	123.00 (3121)	7.88 (200)	125.00 (3175)

Displacer Type	C	D	E
Porcelain	2.56 (65)	7.25 (184)	5.02 (127)
Stainless Steel or Karbate	2.50 (63)	10.50 (266)	6.00 (152)

Electrical Connections
NEMA 4X/7/9, Group B: 1" NPT

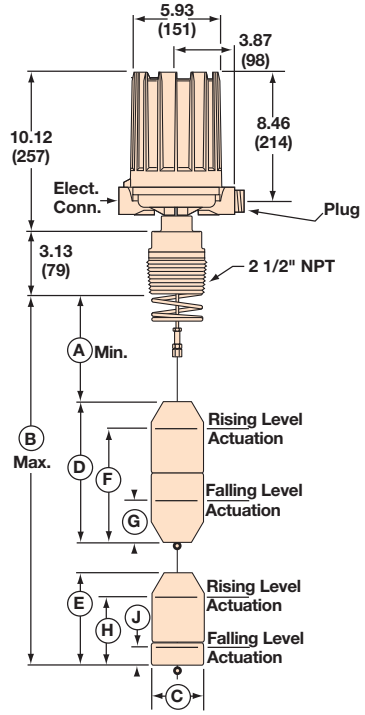
B15 STANDARD ACTUATING LEVELS AND LIQUID SPECIFIC GRAVITY

Displacer Type	Liquid Temp. ° F	0.70				0.80			
		F	G	H	J	F	G	H	J
Stainless Steel or Karbate	100	9.50 (241)	5.00 (127)	4.90 (124)	1.30 (33)	7.60 (193)	3.70 (93)	4.30 (109)	1.10 (27)
	200	—	—	—	—	8.20 (208)	4.30 (109)	5.00 (127)	1.80 (45)

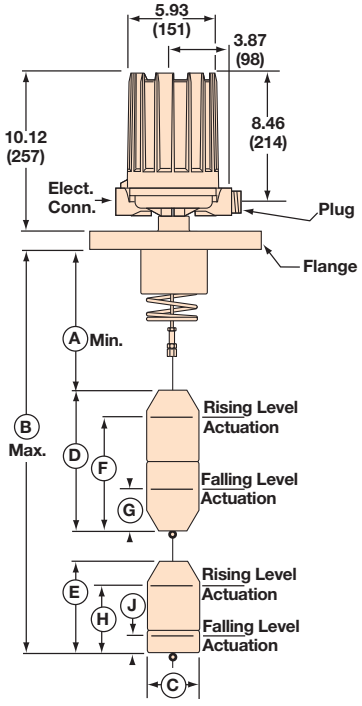
Displacer Type	Liquid Temp. ° F	0.95				1.00			
		F	G	H	J	F	G	H	J
Porcelain	100	5.50 (139)	2.00 (50)	3.70 (93)	1.00 (25)	5.00 (127)	1.70 (43)	3.50 (88)	0.80 (20)
Stainless Steel	100	5.50 (139)	2.00 (50)	3.70 (93)	1.00 (25)	4.90 (124)	1.70 (43)	3.40 (86)	0.90 (22)
	200	6.00 (152)	2.70 (68)	4.20 (106)	1.50 (38)	5.40 (137)	2.20 (55)	4.00 (101)	1.50 (38)
	300	6.40 (162)	3.10 (78)	4.70 (119)	2.00 (50)	5.70 (144)	2.50 (63)	4.40 (111)	1.90 (48)
	400	—	—	—	—	6.10 (154)	2.90 (73)	4.90 (124)	2.40 (60)
Karbate	100	5.50 (139)	2.00 (50)	3.70 (93)	1.00 (25)	4.90 (124)	1.70 (43)	3.40 (86)	0.90 (22)
	200	6.00 (152)	2.70 (68)	4.20 (106)	1.50 (38)	5.40 (137)	2.20 (55)	4.00 (101)	1.50 (38)
	300	6.40 (162)	3.10 (78)	4.70 (119)	2.00 (50)	5.70 (144)	2.50 (63)	4.40 (111)	1.90 (48)

Note: All levels ±0.25" (6).

See page 20 for Proof-er and/or Floating roof top switch dimensions.



Model B15
with Threaded Mounting



Model B15
with Flanged Mounting

SPECIFICATIONS

MODEL C10 DIMENSIONAL DATA

INCHES (MM)

MODEL C10 WITH ALL DISPLACER ARRANGEMENTS

Outline Dimensions				
Displacer Type	Threaded Mounting		Flanged Mounting	
	A	B	A	B
Porcelain	6.38 (965)	123.00 (3124)	8.38 (212)	125.00 (3175)
Stainless Steel or Karbate	5.75 (146)	123.00 (3124)	7.75 (196)	125.00 (3175)

MODEL C10 WITH DISPLACER ARRANGEMENTS A, B, AND C

Displacer Type	C	D	E	F	G
Porcelain	2.56 (65)	6.42 (163)	5.02 (127)	5.02 (127)	3.62 (91)
Stainless Steel or Karbate	2.50 (63)	6.00 (152)	6.00 (152)	4.50 (114)	4.50 (114)

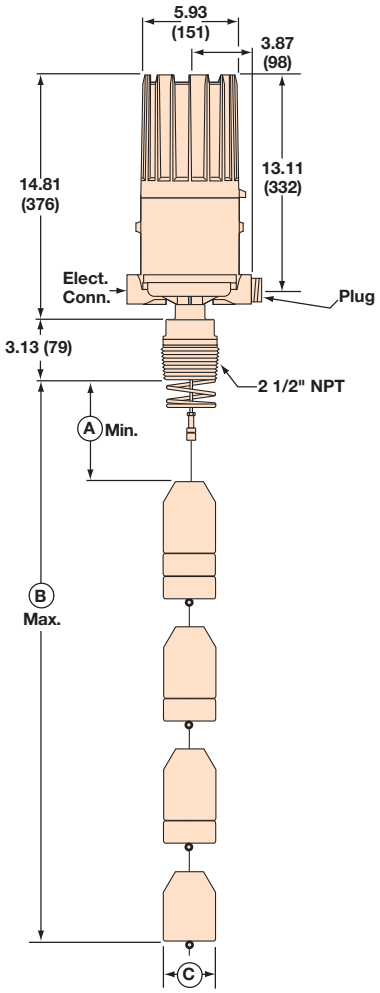
MODEL C10 WITH DISPLACER ARRANGEMENTS D AND F

Displacer Type	C	D	E	F
Porcelain	2.56 (65)	14.44 (367)	5.02 (127)	3.62 (91)
Stainless Steel or Karbate	2.50 (63)	12.00 (304)	4.50 (114)	4.50 (114)

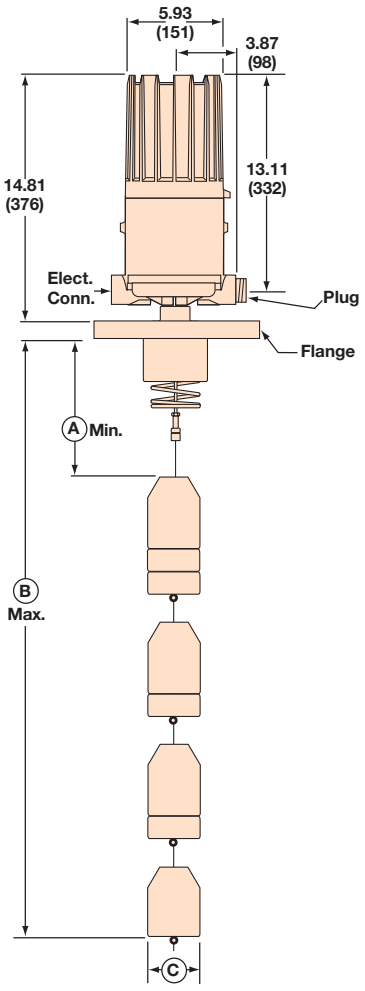
MODEL C10 WITH DISPLACER ARRANGEMENTS E AND G

Displacer Type	C	D	E	F
Porcelain	2.56 (65)	6.42 (153)	5.02 (127)	8.65 (219)
Stainless Steel or Karbate	2.50 (63)	6.00 (152)	6.00 (152)	9.00 (228)

Electrical Connections	
NEMA 4X/7/9, Group B:	1" NPT



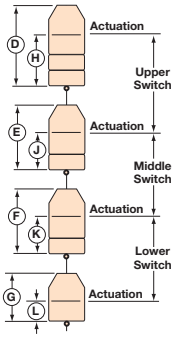
Model C10
with Threaded Mounting



Model C10
with Flanged Mounting

MODEL C10 ACTUATION LEVELS (cont.)

INCHES (MM)

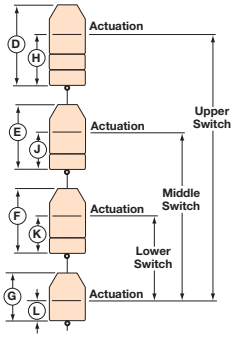


Model C10 Displacer Arrangement A

C10 STANDARD ACTUATING LEVELS AND LIQUID SPECIFIC GRAVITY WITH DISPLACER ARRANGEMENTS A, B, AND C

Displacer Type	Liquid Temp. ° F (° C)	0.58				0.60				0.70				0.80			
		H	J	K	L	H	J	K	L	H	J	K	L	H	J	K	L
Porcelain	100 (37.8)	—	—	—	—	—	—	—	—	2.5 (64)	2.2 (56)	2.2 (56)	2.0 (51)	2.3 (58)	2.0 (51)	1.9 (48)	1.7 (43)
	200 (93)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Stainless Steel or Karbate	100 (37.8)	4.5 (114)	3.7 (94)	3.2 (81)	2.3 (58)	3.8 (97)	3.2 (81)	3.0 (76)	2.2 (56)	4.2 (107)	3.8 (97)	2.1 (53)	1.9 (48)	1.8 (46)	2.2 (56)	1.3 (33)	1.7 (43)
	200 (93)	—	—	—	—	—	—	—	—	—	—	—	—	3.2 (81)	2.9 (74)	2.5 (64)	2.3 (58)
	300 (149)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

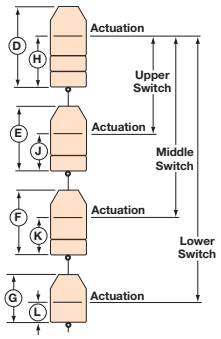
Note: All levels ±0.25" (6).



Model C10 Displacer Arrangement B

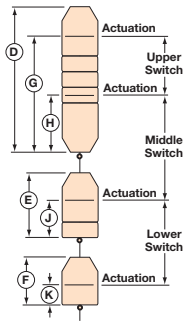
Displacer Type	Liquid Temp. ° F (° C)	0.90				1.00				1.10				1.20			
		H	J	K	L	H	J	K	L	H	J	K	L	H	J	K	L
Porcelain	100 (37.8)	3.0 (76)	2.4 (61)	2.7 (69)	1.5 (38)	1.4 (36)	1.4 (36)	2.1 (53)	1.4 (36)	3.0 (76)	2.6 (66)	2.5 (64)	1.2 (30)	1.7 (43)	1.7 (43)	2.1 (53)	1.1 (28)
	200 (93)	—	—	—	—	3.2 (157)	2.7 (78)	2.8 (71)	1.7 (43)	1.7 (132)	1.7 (53)	2.3 (58)	1.6 (40)	—	—	—	—
Stainless Steel or Karbate	100 (37.8)	3.1 (79)	3.2 (81)	2.5 (64)	1.5 (38)	1.3 (33)	1.9 (48)	1.8 (45)	1.3 (33)	3.1 (79)	3.2 (81)	2.5 (64)	1.3 (33)	1.6 (41)	2.2 (56)	1.9 (48)	1.2 (30)
	200 (93)	3.6 (91)	3.6 (91)	1.7 (43)	2.0 (51)	1.7 (43)	2.3 (58)	1.1 (27)	1.8 (46)	—	—	—	—	—	—	—	—
	300 (149)	3.4 (86)	3.0 (76)	2.4 (61)	2.7 (69)	1.6 (41)	1.8 (46)	1.7 (43)	2.4 (61)	—	—	—	—	—	—	—	—

Note: All levels ±0.25" (6).

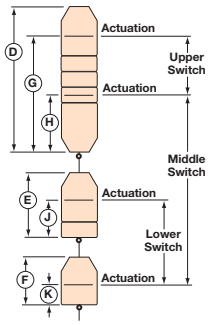


Model C10 Displacer Arrangement C

INCHES (MM)



Model C10 Displacer Arrangement D



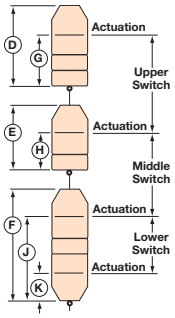
Model C10 Displacer Arrangement F

C10 STANDARD ACTUATING LEVELS AND LIQUID SPECIFIC GRAVITY WITH DISPLACER ARRANGEMENTS D AND F

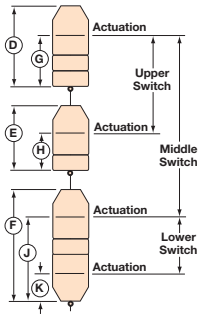
Displacer Type	Liquid Temp. ° F	0.58				0.60				0.70				0.80			
		G	H	J	K	G	H	J	K	G	H	J	K	G	H	J	K
Porcelain	100	—	—	—	—	—	—	—	—	7.50 (190)	2.60 (66)	2.20 (55)	2.00 (50)	6.90 (175)	2.40 (60)	1.90 (48)	1.70 (43)
Stainless Steel or Karbate	100	9.90 (251)	3.70 (93)	3.20 (81)	2.30 (58)	9.20 (233)	3.20 (81)	3.00 (76)	2.20 (55)	8.90 (226)	3.80 (96)	2.10 (53)	1.90 (48)	6.70 (170)	2.20 (55)	1.30 (33)	1.70 (43)
	200	—	—	—	—	—	—	—	—	—	—	—	—	7.40 (187)	2.90 (73)	2.50 (63)	2.30 (58)

Displacer Type	Liquid Temp. ° F	0.90				1.00				1.10				1.20			
		G	H	J	K	G	H	J	K	G	H	J	K	G	H	J	K
Porcelain	100	6.60 (167)	2.80 (71)	2.70 (68)	1.50 (38)	5.20 (132)	1.80 (45)	2.10 (53)	1.40 (35)	6.10 (154)	3.00 (76)	2.50 (63)	1.20 (30)	5.00 (127)	2.10 (53)	2.10 (53)	1.10 (27)
	200	—	—	—	—	6.20 (157)	3.10 (78)	2.80 (71)	1.70 (43)	5.20 (132)	2.10 (53)	2.30 (58)	1.60 (40)	—	—	—	—
Stainless Steel or Karbate	100	7.20 (182)	3.20 (81)	2.50 (63)	1.50 (38)	5.50 (139)	1.90 (48)	1.80 (45)	1.30 (33)	6.40 (162)	3.20 (81)	2.50 (63)	1.30 (33)	5.20 (132)	2.20 (55)	1.90 (48)	1.20 (30)
	200	7.60 (193)	3.60 (91)	1.70 (43)	2.00 (50)	5.90 (149)	2.30 (58)	1.10 (27)	1.80 (45)	—	—	—	—	—	—	—	—
	300	7.00 (177)	3.00 (76)	2.40 (60)	2.70 (68)	5.40 (137)	1.80 (45)	1.70 (43)	2.40 (60)	—	—	—	—	—	—	—	—

Note: All levels ±0.25" (6).



Model C10 Displacer Arrangement E



Model C10 Displacer Arrangement G

C10 STANDARD ACTUATING LEVELS AND LIQUID SPECIFIC GRAVITY WITH DISPLACER ARRANGEMENTS E AND G

Displacer Type	Liquid Temp. ° F	0.58				0.60				0.70				0.80			
		G	H	J	K	G	H	J	K	G	H	J	K	G	H	J	K
Porcelain	100	—	—	—	—	—	—	—	—	2.50 (63)	2.20 (55)	5.80 (147)	1.90 (48)	2.30 (58)	2.00 (50)	5.50 (139)	2.10 (53)
Stainless Steel or Karbate	100	4.50 (114)	3.70 (93)	7.70 (195)	2.80 (71)	3.80 (96)	3.20 (81)	7.50 (190)	2.70 (68)	4.20 (106)	3.80 (96)	6.60 (167)	2.50 (63)	1.80 (45)	2.20 (55)	5.80 (147)	2.20 (55)
	200	—	—	—	—	—	—	—	—	—	—	—	—	3.20 (81)	2.90 (73)	7.00 (177)	3.40 (86)

Displacer Type	Liquid Temp. ° F	0.90				1.00				1.10				1.20			
		G	H	J	K	G	H	J	K	G	H	J	K	G	H	J	K
Porcelain	100	3.00 (76)	2.40 (60)	6.30 (160)	3.20 (81)	1.40 (35)	1.40 (35)	5.70 (144)	1.90 (48)	3.00 (76)	2.60 (66)	6.10 (154)	3.60 (91)	1.70 (43)	1.70 (43)	5.70 (144)	3.40 (86)
	200	—	—	—	—	3.20 (81)	2.70 (68)	6.40 (162)	3.60 (91)	1.70 (43)	1.70 (43)	5.90 (149)	3.40 (86)	—	—	—	—
Stainless Steel or Karbate	100	3.10 (78)	3.20 (81)	7.00 (177)	3.80 (96)	1.30 (33)	1.90 (48)	6.30 (160)	3.40 (86)	3.10 (78)	3.20 (81)	7.00 (177)	4.40 (111)	1.60 (40)	2.20 (55)	6.40 (162)	4.00 (101)
	200	3.60 (91)	3.60 (91)	6.20 (157)	3.00 (76)	1.70 (43)	2.30 (58)	5.60 (142)	2.70 (68)	—	—	—	—	—	—	—	—
	300	3.40 (86)	3.00 (76)	6.90 (175)	3.70 (93)	1.60 (40)	1.80 (45)	6.20 (157)	3.30 (83)	—	—	—	—	—	—	—	—

Note: All levels ±0.25" (6).

SPECIFICATIONS

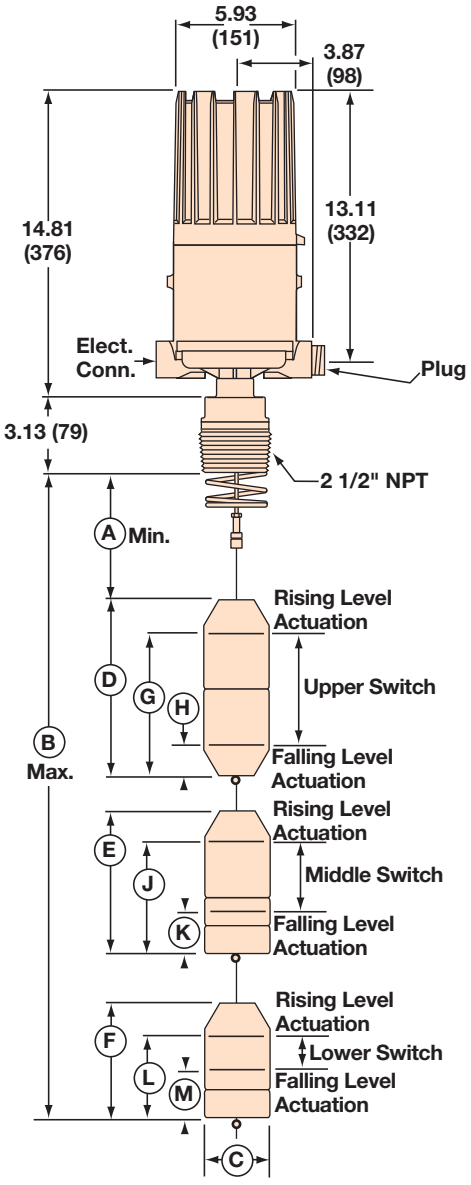
MODEL C15 DIMENSIONAL DATA AND ACTUATION LEVELS

INCHES (MM)

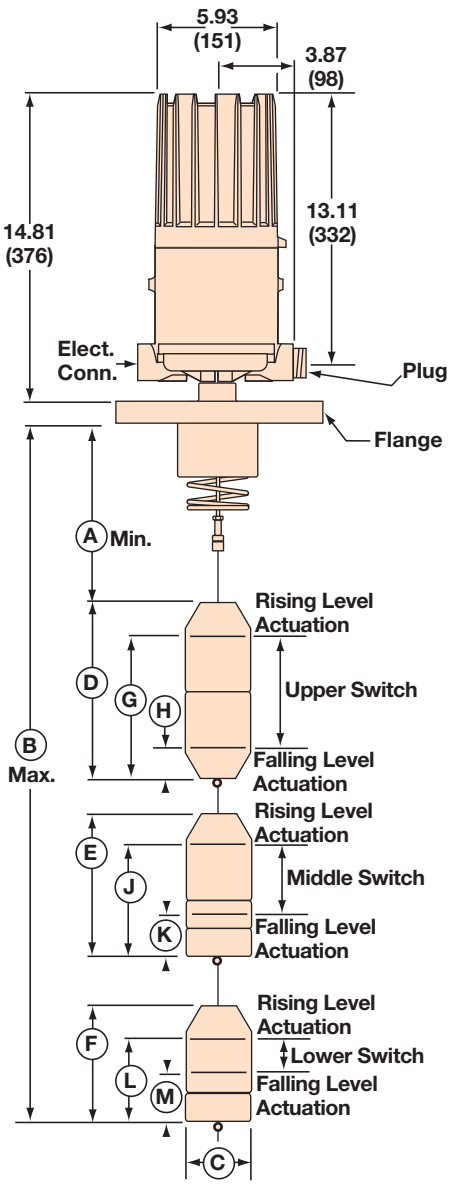
OUTLINE DIMENSIONS				
Displacer Type	Threaded Mounting		Flanged Mounting	
	A	B	A	B
Porcelain	7.75 (196)	125.00 (3175)	9.75 (247)	127.00 (3225)
Stainless Steel or Karbate	7.25 (184)	124.00 (3149)	9.25 (234)	126.00 (3200)

Displacer Type	C	D	E	F
Porcelain	2.56 (65)	7.25 (184)	6.42 (163)	5.02 (127)
Stainless Steel or Karbate	2.50 (63)	9.00 (228)	7.50 (190)	6.00 (152)

Electrical Connections	
NEMA 4X/7/9, Group B:	1" NPT



Model C15
with Threaded Mounting



Model C15
with Flanged Mounting

SPECIFICATIONS

MODEL C15 ACTUATION LEVELS

INCHES (MM)

C15 STANDARD ACTUATING LEVELS AND LIQUID SPECIFIC GRAVITY — INCHES

Displacer Type	Liquid Temp. ° F	0.65						0.70						0.80					
		G	H	J	K	L	M	G	H	J	K	L	M	G	H	J	K	L	M
Porcelain	0 to +130	—	—	—	—	—	—	—	—	—	—	—	—	6.20 (157)	1.40 (35)	5.30 (134)	1.00 (25)	3.80 (96)	0.90 (22)
Stainless Steel or Karbate	0 to +130	7.70 (195)	2.20 (55)	6.10 (154)	2.00 (50)	4.90 (124)	1.40 (35)	6.70 (170)	1.60 (40)	5.50 (139)	1.60 (40)	4.60 (116)	1.30 (33)	6.50 (165)	2.00 (50)	5.20 (132)	1.60 (40)	4.30 (109)	1.10 (27)

Displacer Type	Liquid Temp. ° F	0.90						1.00						1.10					
		G	H	J	K	L	M	G	H	J	K	L	M	G	H	J	K	L	M
Porcelain	0 to +130	6.20 (157)	1.90 (48)	5.00 (127)	1.40 (35)	3.60 (91)	1.00 (25)	4.60 (116)	0.70 (17)	4.00 (101)	0.80 (20)	3.30 (83)	0.90 (22)	4.20 (106)	1.10 (27)	3.80 (96)	1.00 (25)	3.10 (78)	0.90 (22)
Stainless Steel or Karbate	0 to +130	6.60 (167)	2.60 (66)	5.20 (132)	1.80 (45)	4.00 (101)	1.20 (30)	4.60 (116)	1.00 (25)	4.00 (101)	1.00 (25)	3.60 (91)	1.10 (27)	—	—	—	—	—	—

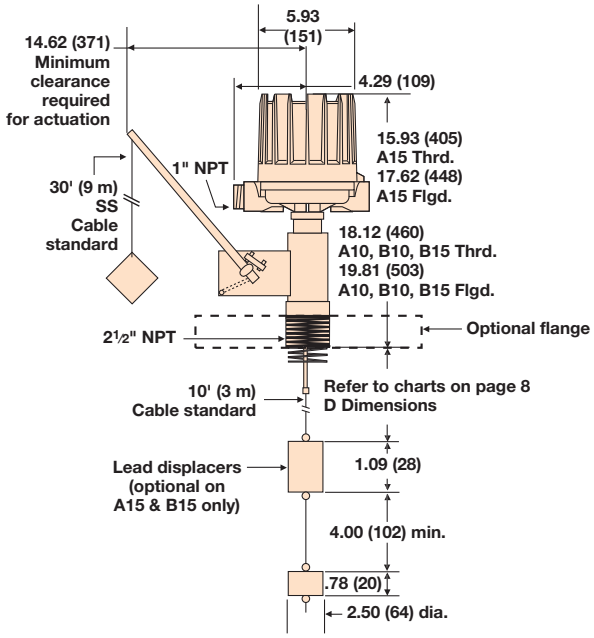
Displacer Type	Liquid Temp. ° F	1.20						1.25					
		G	H	J	K	L	M	G	H	J	K	L	M
Porcelain	0 to +130	4.50 (114)	1.60 (40)	3.70 (93)	1.10 (27)	2.90 (73)	0.90 (22)	3.90 (99)	1.10 (27)	3.30 (83)	0.90 (22)	2.80 (71)	0.80 (20)

Note: All levels ±0.25" (6).

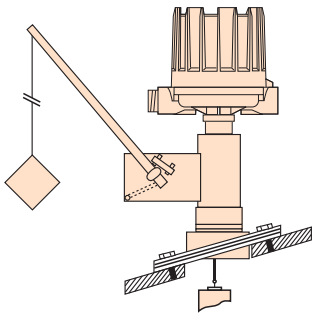
SPECIFICATIONS

PROOF-ER DIMENSIONAL DATA

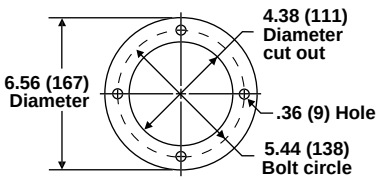
INCHES (MM)



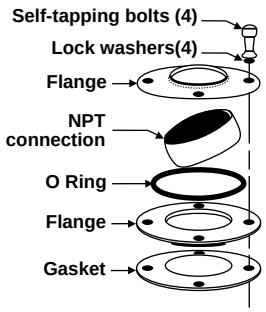
TYPICAL PROOF-ER INSTALLATION WITH VERSA FLANGE



VERSA FLANGE BOLT CIRCLE



VERSA FLANGE ASSEMBLY PART NUMBER 089-5207-001



SINGLE SWITCH MODELS

SERIES A10 AND SERIES A15

SERIES A10
PUMP OR VALVE CONTROL
WIDE DIFFERENTIAL TYPE

These wide differential units are factory calibrated to actuate as a liquid level reaches a given displacer and to deactuate when the level reaches a second displacer.

The minimum differential band is approximately 6 in. (152 mm) in water and varies somewhat with liquid specific gravity. The maximum differential is determined by the length of the displacer suspension cable.

SERIES A15
LEVEL ALARM APPLICATIONS
NARROW DIFFERENTIAL TYPE

These instruments are factory calibrated to operate over a narrow level differential band and are ideally suited for liquid level alarm applications on either high or low level.

The operating level is fully adjustable simply by repositioning the displacer along its suspension cable. The differential band varies slightly with liquid specific gravity.

DUAL SWITCH MODELS

SERIES B10 AND SERIES B15

SERIES B10
WIDE DIFFERENTIAL TYPE

These wide differential tandem units are factory calibrated with a choice of several operating sequences designed to meet virtually any application.

OPERATING SEQUENCES

Model B10 units are available with a choice of switch operating sequence. Five of the most popular sequences are described on page 8. When ordering, specify operating sequence number and specific gravity of the liquid.

SERIES B15
NARROW DIFFERENTIAL TYPE

These instruments utilize two switches — each actuated at a different level and each calibrated with a narrow differential band.

TRI-SWITCH MODELS

SERIES C10 AND SERIES C15

SERIES C10
WIDE DIFFERENTIAL TYPE

These wide differential type switches are designed to provide three electrically separate control signals in a selected sequence as liquid level varies.

These units come factory calibrated with a choice of several operating sequences combining wide and narrow level differential.

SERIES C15
NARROW DIFFERENTIAL TYPE

These instruments are factory calibrated to operate over a narrow level band while providing three electrically separate control signals as liquid level varies.

MODEL NUMBER

SERIES A10 AND A15 SINGLE SWITCH MODELS

Models available for quick shipment, usually within one week after factory receipt of a purchase order, through the Expedite Ship Plan (ESP)

PART NUMBER CODE AND SPECIFIC GRAVITY LIMITS ⑤

Part Number Code	Liquid Description	Temp.		Displacer Type		
		° F	° C	Porcelain	Stainless Steel	Karbate
A10①	Wide Differential, Single Stage	100	38	0.60 to 1.20	0.60 to 1.20	0.60 to 1.20
		200	93	0.70 to 1.20	0.70 to 1.20	0.70 to 1.20
		300	149	0.80 to 1.20	0.80 to 1.20	0.80 to 1.20
		400	204	1.00 to 1.20	0.90 to 1.20	—
		500	260	1.10 to 1.20	1.00 to 1.20	—
A15	Narrow Differential, Single Stage	100	38	0.60 to 2.40	0.40 to 1.65	0.40 to 1.65
		200	93	0.62 to 2.40	0.40 to 1.65	0.45 to 1.65
		300	149	0.65 to 2.40	0.50 to 1.65	0.50 to 1.65
		400	204	0.70 to 2.40	0.55 to 1.65	—
		500	260	0.75 to 2.40	0.60 to 1.65	—

MATERIALS OF CONSTRUCTION

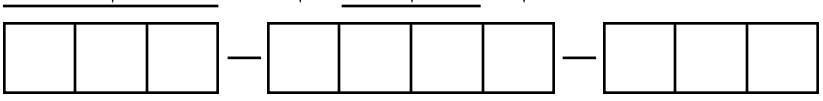
Code	Support Spring	Trim	E-Tube Mtg. Nut	Displacer Clamps/ Susp. Cable	Magnetic Sleeve	Process Connection
1	Inconel 600	300 Series SS	Carbon Steel	316 SS	400 Series SS	Carbon Steel ⑥
2①	Inconel 600	316 SS	316 SS	316 SS	316 SS	Carbon Steel ⑥
4①						316 SS
5①	Inconel 600	300 Series SS	Carbon Steel	Monel	400 Series SS	Carbon Steel ⑥
6①				Hastelloy		
M①② NACE Const.	Inconel X750	316 SS	316 SS	316 SS	316 SS	316 SS
N①② NACE Const.	Inconel X750	300 Series SS	316 SS	316 SS	316 SS	Carbon Steel

TANK CONNECTION

Tank Connection ③	Code
2½" NPT Threaded	E2
3" 125 lb. Cast Iron FF Flange ①④⑬	G2
3" 150 lb. Steel RF Flange ①	G3
4" 125 lb. Cast Iron FF Flange ④⑬	H2
4" 150 lb. Steel RF Flange	H3
4" 300 lb. Steel RF Flange ⑮	H4
6" 125 lb. Cast Iron FF Flange ④⑬	K2
6" 150 lb. Steel RF Flange	K3
6" 300 lb. Steel RF Flange	K4

DISPLACER MATERIAL AND PROOF-ER OPTION

Proof-er Type ⑭	Displacer Material			Floating Roof Weight Mat'l
	Porcelain	316 SS	Karbate	Lead
Without Proof-er	A	B	C	K ④
Low Pressure	D ④	E ④	F ④	L ④
Medium Pressure	G ④	H ④	J ④	—



ELECTRIC SWITCH MECHANISM AND ENCLOSURE ⑪

Switch Description	Max.⑩ Process Temp. ° F (°C)	One Set Point	A10 Codes			A15 Codes		
			NEMA 4X/7/9 Aluminum Polymer Coated⑦					
			Class I, Div. 1, Groups C & D	Class I, Div. 1, Group B	ATEX Ex II 2G EEx d IIC	Class I, Div. 1, Groups C & D	Class I, Div. 1, Group B	ATEX Ex II 2G EEx d IIC
Series A Mercury Switch	500 (260)	SPDT	AKB	AKK	AC9	AKQ	AKS	AA9
		DPDT	ANB	ANK	AF9	ANQ	ANS	AB9
Series B Snap Switch	250 (121)	SPDT	BKB	BKK	BC9	BKQ	BKS	BA9
		DPDT	BNB	BNK	BF9	BNQ	BNS	BB9
Series C Snap Switch	450 (232)	SPDT	CKB	CKK	CC9	CKQ	CKS	CA9
		DPDT	CNB	CNK	CF9	CNQ	CNS	CB9
Series D Snap Switch For DC Current Applications	250 (121)	SPDT	DKB	DKK	DC9	DKQ	DKS	DA9
		DPDT	DNB	DNK	DF9	DNQ	DNS	DB9
Series E Vibration Resistant Mercury Switch	500 (260)	SPDT	EKB	EKK	EC9	EKQ	EKS	EA9
		DPDT	ENB	ENK	EF9	ENQ	ENS	EB9
Series HS Hermetically Sealed Snap Switch w/Wiring Leads	500⑫ (260)	SPDT	HMJ	HMK	n/a	HMC	HEK ⑨	n/a
		DPDT	HMS	HMT		HMF	HET ⑨	
Series HS Hermetically Sealed Snap Switch w/Terminal Block	500⑫ (260)	SPDT	HM3	HM4	HA9	HM3 ⑧	HM4 ⑧	HA9 ⑧
		DPDT	HM7	HM8	HB9	HM7 ⑧	HM8 ⑧	HB9 ⑧

PNEUMATIC SWITCH MECHANISM AND ENCLOSURE

Switch Description	Maximum Supply Pressure		Maximum Process Temperature		Bleed Orifice Diameter		A10 Codes	A15 Codes
	PSIG	Bar	° F	° C	Inches	mm	NEMA 1	NEMA 1
Series J Bleed Type Pneumatic Switch	100	7	400	204	.063	1	JGF	JDE
	60	4	400	204	.094	2	JHF	JEE
Series K Non-Bleed Pneumatic Switch	100	7	400	204	—	—	KOF	KOE

① Not available with displacer material and Proof-er option codes K, L.

② Not available with displacer material and Proof-er option codes D, E, F, G, H, and J.

③ Pressure/temperature ratings on page 3. Flanges are ANSI type.

④ Not available with material of construction codes M and N.

⑤ Specific gravity limits do not apply to floating roof top units, not to be used in liquid.

⑥ #125 flanges will be cast iron.

⑦ Uncontrolled housing heater or drain available in NEMA 4X/7/9 enclosures. Consult factory for standard part numbers.

⑧ Available with a 6" tall cover only.

⑨ CSA approval does not apply to Series HE switches.

⑩ Process temperature based on +100° F (+38° C) ambient.

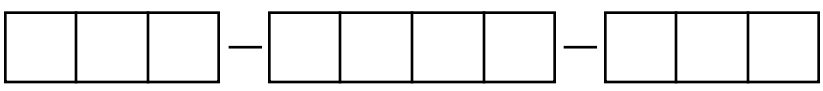
⑪ Consult factory for NEMA 4X/7/9 cast iron housings.

⑫ On steam applications, temperature down rated to +400° F (+204° C) process at +100° F (+38° C) ambient.

⑬ Not available with material of construction code -4.

⑭ Proofer in carbon steel only with all materials of construction codes.

⑮ Available only in carbon steel. Consult factory for 4" 300 lb. 316 SS flanged connection.



MODEL NUMBER

SERIES B10 AND B15 DUAL SWITCH MODELS

Models available for quick shipment, usually within one week after factory receipt of a purchase order, through the Expedite Ship Plan (ESP)

Note: Each B10 instrument is factory calibrated to operate on a given specific gravity within the minimum and maximum values listed.

PART NUMBER CODE AND SPECIFIC GRAVITY LIMITS ⑤

Part Number Code	Liquid Description	Temp.		Displacer Type		
		° F	° C	Porcelain	Stainless Steel	Karbate
B10†	Wide Differential, Dual Stage	100	38	0.60 to 1.20	0.50 to 1.00	0.50 to 1.00
		200	93	0.64 to 1.50	0.50 to 1.00	0.50 to 1.00
		300	149	0.80 to 1.50	0.60 to 1.00	0.60 to 1.00
		400	204	1.00 to 1.50	0.72 to 1.00	—
		500	260	1.10 to 1.50	0.84 to 1.00	—
B15	Narrow Differential, Dual Stage	100	38	0.95 to 1.20	0.70 to 1.20	0.70 to 1.20
		200	93	1.10 to 1.20	0.80 to 1.20	0.80 to 1.20
		300	149	—	0.90 to 1.20	0.90 to 1.20
		400	204	—	1.00 to 1.20	—
		500	260	—	1.04 to 1.20	—

† When ordering B10 units, an operating sequence and operating specific gravity must be provided.

MATERIALS OF CONSTRUCTION

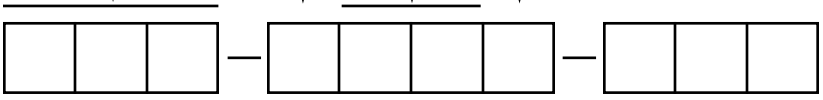
Code	Support Spring	Trim	E-Tube Mtg. Nut	Displacer Clamps/ Susp. Cable	Magnetic Sleeve	Process Connection
1	Inconel 600	300 Series SS	Carbon Steel	316 SS	400 Series SS	Carbon Steel ⑥
2①	Inconel 600	316 SS	316 SS	316 SS	316 SS	Carbon Steel ⑥
4①						316 SS
5①	Inconel 600	300 Series SS	Carbon Steel	Monel	400 Series SS	Carbon Steel ⑥
6①				Hastelloy		
M①② NACE Const.	Inconel X750	316 SS	316 SS	316 SS	316 SS	316 SS
N①② NACE Const.	Inconel X750	300 Series SS	316 SS	316 SS	316 SS	Carbon Steel

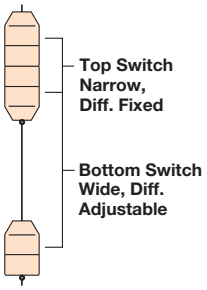
TANK CONSTRUCTION

Tank Connection ③	Code
2½" NPT Threaded	E2
3" 125 lb. Cast Iron FF Flange ① ④ ⑫	G2
3" 150 lb. Steel RF Flange ①	G3
4" 125 lb. Cast Iron FF Flang ④ ⑫	H2
4" 150 lb. Steel RF Flange	H3
4" 300 lb. Steel RF Flange ⑭	H4
6" 125 lb. Cast Iron FF Flang ④ ⑫	K2
6" 150 lb. Steel RF Flange	K3
6" 300 lb. Steel RF Flange	K4

DISPLACER MATERIAL AND PROOF-ER OPTION

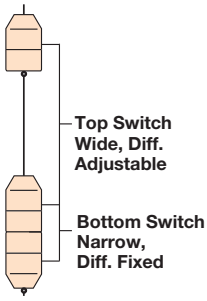
Proof-er Type ⑬	Displacer Material			Floating Roof Weight Mat'l Model B15 only
	Porcelain	316 SS	Karbate	Lead
Without Proof-er	A	B	C	K ④
Low Pressure	D ④	E ④	F ④	L ④





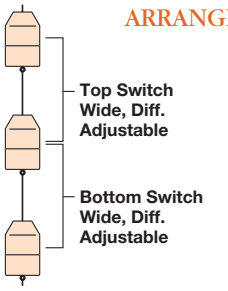
PLUS ALARM ARRANGEMENT NO. 1 – FILL WITH HIGH LEVEL ALARM

The bottom switch starts the fill cycle when the level reaches the bottom displacer. The fill cycle stops when the level rises to the top displacer. If level continues to rise, the top switch will activate an alarm.



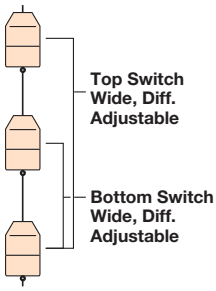
PLUS ALARM ARRANGEMENT NO. 2 – DRAIN WITH LOW LEVEL ALARM

The top switch starts the drain cycle when level rises to the top displacer. The drain cycle stops when level falls below the top of the lower displacer. If level continues to fall, the bottom switch will activate an alarm.



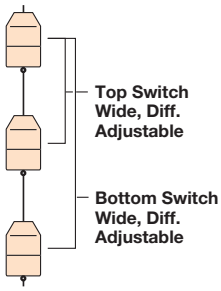
CONTROL OF TWO PUMPS OF DIFFERENT CAPACITY ARRANGEMENT NO. 3 – TWO SWITCH, WIDE DIFFERENTIAL OR DRAIN

The top switch cycles with level between the top and middle displacer. The bottom switch cycles with level between the middle and bottom displacer.



CONTROL OF TWO PUMPS ARRANGEMENT NO. 4

The top switch cycles with level between the top and bottom displacer. The bottom switch cycles with level between the middle and bottom displacer.



CONTROL OF TWO PUMPS ARRANGEMENT NO. 5

The top switch cycles with level between the top and middle displacer. The bottom switch cycles with level between the top and bottom displacer.

ELECTRIC SWITCH MECHANISM AND ENCLOSURE ⑩⑧

Switch Description	Max. ⑨ Process Temp. ° F (°C)	Two Set Points	Switch Enclosure		
			NEMA 4X/7/9 Alum Polymer Coated ⑦		
			Class I, Div. 1, Groups C & D	Class I, Div. 1, Group B	ATEX Ex II 2G EEx d IIC T6
Series A Mercury Switch	500 (260)	SPDT	ALB	ALK	AD9
		DPDT	AOB	AOK	AG9
Series B Snap Switch	250 (121)	SPDT	BLB	BLK	BD9
		DPDT	BOB	BOK	BG9
Series C Snap Switch	450 (232)	SPDT	CLB	CLK	CD9
		DPDT	COB	COK	CG9
Series D Snap Switch For DC Current Applications	250 (121)	SPDT	DLB	DLK	DD9
		DPDT	DOB	DOK	DG9
Series E Vibration Resistant Mercury Switch	500 (260)	SPDT	ELB	ELK	ED9
		DPDT	EOB	EOK	EG9
Series HS Hermetically Sealed Snap Switch w/Wiring Leads	500 (260) ⑪	SPDT	HMN	HMP	n/a
		DPDT	HMY	HMZ	

① Not available with displacer material and Proof-er option codes K and L.
② Not available with displacer material and Proof-er option codes D, E, and F.
③ Pressure/temperature ratings on page 3. Flanges are ANSI type.
④ Not available with material of construction codes M and N.
⑤ Specific gravity limits do not apply to floating roof top units, not to be used in liquid.
⑥ #125 flanges will be cast iron.
⑦ Uncontrolled housing heater or drain available in NEMA 4X/7/9 enclosures. Consult factory for standard part numbers.
⑧ Pneumatic switch mechanisms and enclosures are unavailable for Series B10 and B15 switches.
⑨ Process temperature based on +100° F (+38° C) ambient.
⑩ Consult factory for NEMA 4X/7/9 cast iron housings.
⑪ On steam applications, temperature down rated to +400° F (+204° C) process at +100° F (+38° C) ambient.
⑫ Not available with material of construction code -4.
⑬ Proofer in carbon steel only with all materials of construction codes.
⑭ Available only in carbon steel. Consult factory for 4" 300 lb. 316 SS flanged connection.

MODEL NUMBER

SERIES C10 AND C15 TRI-SWITCH MODELS

Note: Each C10 and C15 instrument is factory calibrated to operate for a given specific gravity within the minimum and maximum values listed.

PART NUMBER CODE AND SPECIFIC GRAVITY LIMITS

Part Number Code	Liquid Description	Temp.		Displacer Type		
		° F	° C	Porcelain	Stainless Steel	Karbate
C10†	Wide Differential, 3 switches	100	38	0.65 to 1.20	0.58 to 1.20	0.58 to 1.20
		200	93	0.95 to 1.10	0.76 to 1.00	0.76 to 1.00
		300	149	—	0.820 to 1.00	0.82 to 1.00
C15††	Narrow Differential, 3 switches	130	54	0.80 to 1.25	0.65 to 1.00	0.65 to 1.00

† When ordering C10 units, an operating sequence and operating specific gravity must be provided.
†† When ordering C15 units, an operating specific gravity must be provided.

MATERIALS OF CONSTRUCTION

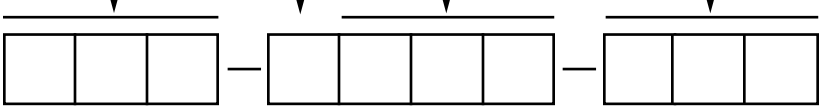
Code	Support Spring	Trim	E-Tube Mtg. Nut	Displacer Clamps/ Susp. Cable	Magnetic Sleeve	Process Connection
1	Inconel 600	300 Series SS	Carbon Steel	316 SS	400 Series SS	Carbon Steel ⑥
2	Inconel 600	316 SS	316 SS	316 SS	316 SS	Carbon Steel ⑥
4						316 SS
5	Inconel 600	300 Series SS	Carbon Steel	Monel	400 Series SS	Carbon Steel ⑥
6				Hastelloy		
M NACE Const.	Inconel X750	316 SS	316 SS	316 SS	316 SS	316 SS
N NACE Const.	Inconel X750	300 Series SS	316 SS	316 SS	316 SS	Carbon Steel

TANK CONNECTION AND DISPLACERS

Tank Connection ①	Displacer Material		
	Porcelain	316 SS	Karbate
2½" NPT Threaded	E2A	E2B	E2C
3" 125 lb. Cast Iron FF Flange ②	G2A	G2B	G2C
3" 150 lb. Steel RF Flange ③	G3A	G3B	G3C
4" 125 lb. Cast Iron FF Flange ②	H2A	H2B	H2C
4" 150 lb. Steel RF Flange ③	H3A	H3B	H3C
4" 300 lb. Steel RF Flange ③	H4A	H4B	H4C
6" 125 lb. Cast Iron FF Flange ②	K2A	K2B	K2C
6" 150 lb. Steel RF Flange ③	K3A	K3B	K3C
6" 300 lb. Steel RF Flange ③	K4A	K4B	K4C

ELECTRIC SWITCH MECHANISM AND ENCLOSURE ④

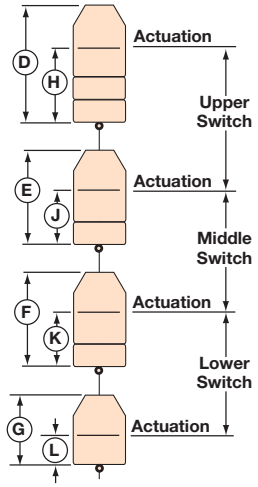
Switch Description	Max.⑤ Process Temp. ° F (°C)	Three Set Points	Switch Enclosure	
			NEMA 4X/7/9 Aluminum Enclosure ⑦	
			Class I, Div. 1, Groups C & D	Class I, Div. 1, Group B
Series N Mercury Switch	300 (149)	SPDT	NMB	NMN
		DPDT	NKB	NKN
Series O Snap Switch	300 (149)	SPDT	OMB	OMN
		DPDT	OKB	OKN
Series Q Snap Switch	250 (121)	SPDT	QMB	QMN
		DPDT	QKB	QKN
Series T Vib. Res. Mercury Switch	300 (149)	SPDT	TMB	TMN
		DPDT	TKB	TKN



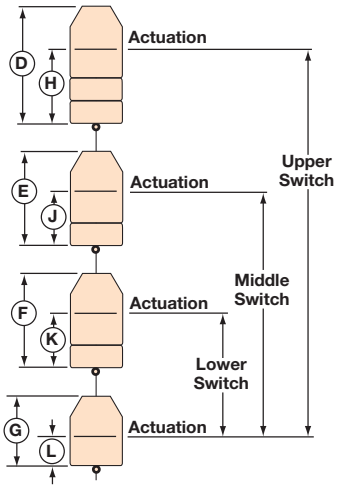
① Pressure/temperature ratings on page 3. Flanges are ANSI type.
② Not available with material of construction codes M, N and 4.
③ 316 SS flange is provided with material of construction code 4 and M.
④ Pneumatic switch mechanisms and enclosures are unavailable for Series C10 and C15 switches.
⑤ Process temperature based on +100° F (+38° C) ambient.
⑥ #125 flanges will be cast iron.
⑦ Consult factory for NEMA 4X/7/9 cast iron housings.

MODEL C10 DISPLACER ARRANGEMENTS

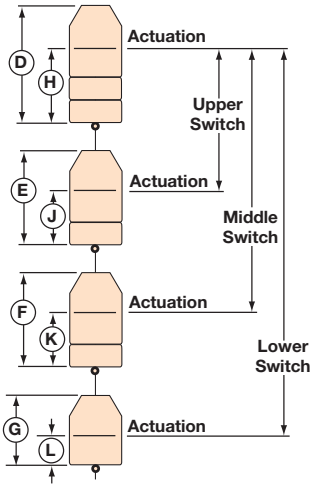
INCHES (MM)



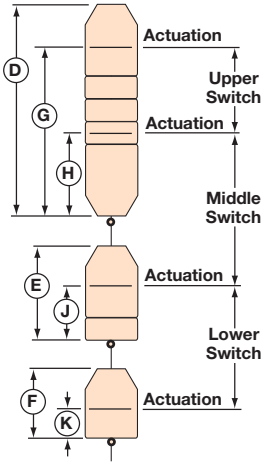
Model C10
Displacer Arrangement A



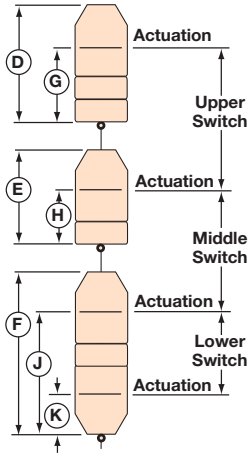
Model C10
Displacer Arrangement B



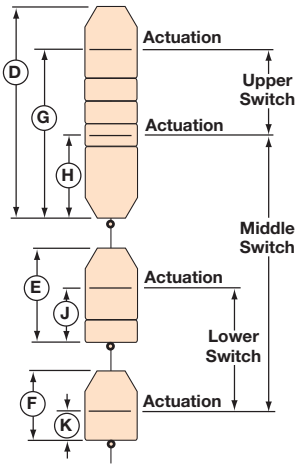
Model C10
Displacer Arrangement C



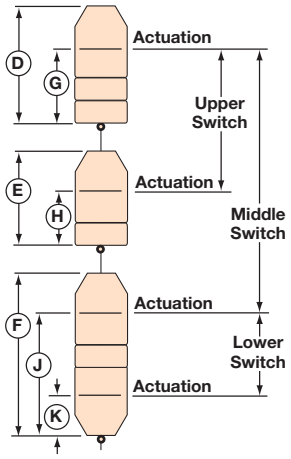
Model C10
Displacer Arrangement D



Model C10
Displacer Arrangement E



Model C10
Displacer Arrangement F



Model C10
Displacer Arrangement G

QUALITY

MAGNETROL REGISTERED TO ISO 9001 Your Assurance of Quality and Service

The quality assurance system in place at Magnetrol guarantees the highest level of quality throughout the company. Magnetrol is committed to providing full customer satisfaction both in quality products and quality service.

Magnetrol's quality assurance system is registered to ISO 9001 affirming its commitment to known international quality standards providing the strongest assurance of product/service quality available.

ESP

Expedite
Ship
Plan

Several Displacer Type Liquid Level Switches are available for quick shipment, usually within one week after factory receipt of a purchase order, through the Expedite Ship Plan (ESP).

Models covered by ESP service are conveniently color coded in the selection data charts.

To take advantage of ESP, simply match the color coded model number codes (standard dimensions apply).

ESP service may not apply to orders of ten units or more. Contact your local representative for lead times on larger volume orders, as well as other products and options.

WARRANTY

All Magnetrol mechanical level and flow controls are warranted free of defects in materials or workmanship for five full years from the date of original factory shipment.

If returned within the warranty period; and, upon factory inspection of the control, the cause of the claim is determined to be covered under the warranty; then, Magnetrol will repair or replace the control at no cost to the purchaser (or owner) other than transportation.

Magnetrol shall not be liable for misapplication, labor claims, direct or consequential damage or expense arising from the installation or use of equipment. There are no other warranties expressed or implied, except special written warranties covering some Magnetrol products.

For additional information, see Instruction Manual, 45-610.

Magnetrol®

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BULLETIN: 45-115.17
EFFECTIVE: March 2007
SUPERSEDES: December 2005

Series 3Y – Corrosion Resistant Probes

- Metallic Bars
- Corrosion Resistant
- Available in Many Materials for Various Requirements
- Adaptable for Various Fittings

Series 3Y wire suspended probes consist of metallic bars within a protective plastic shield, designed to be suspended in liquid. Series 3Y suspension wires are PVC or Teflon® insulated for use in corrosive liquid applications. 7/8˝ (2.22 cm) diameter x 3-1/2˝ (8.90 cm) length.

Series 3Y

Specifications

Style	Wire suspended
Tip Material	Carp. 20, Hastelloy C, 316 stainless steel
Shield Material	PVC (150°F), Teflon®

How to Order

Use the **Bold** characters from the chart below to construct a product code.

3Y X X X

Series
3Y

Shield Material
1 – PVC
3 – Teflon®

Probe Tip Material
C – 316 Stainless Steel
D – Carp. 20
F – Hastelloy C

Length of Wire
1 – 10 feet
2 – 20 feet
3 – 30 feet
etc.

Note: 3Z1B Connector is used to connect suspension wire with 3B, 3E, 3F, 3G or 3N fitting.

Applications

- General Purpose
- Wire Suspended Probes
- Corrosive Liquids, Chemicals

Rosemount 1151 Pressure Transmitter

- *Proven field performance and reliability*
- *Commitment to continuous improvement*
- *Reference accuracy of 0.075%*
- *Two-year stability of 0.1%*
- *Rangeability of 50:1*

HART CE

Contents

Specifications . . . . . page Pressure-3
Product Certifications . . . . . page Pressure-8
Dimensional Drawings. . . . . page Pressure-10
Ordering Information . . . . . page Pressure-16

Leading a tradition of excellence

With over five million transmitters installed worldwide, the Rosemount 1151 continues to offer industry leading value. Changing customer needs and new technologies have driven product improvements, while advanced manufacturing and testing processes have guaranteed product quality. Even today, the Rosemount 1151 is world-reowned for proven field reliability and longevity.

Proven field performance and reliability

For over 35 years, the 1151 has provided the process control industry with unsurpassed service and reliability in even the harshest of environments. The lasting customer preference results from a combination of advanced technology, and a tradition of field proven performance.

Commitment to continuous improvement

Through ongoing focus on continuous improvement, ±0.075% reference accuracy has been accomplished as a result of manufacturing and engineering enhancements. In addition, Smart electronics offer rangeability to 50:1, reducing the number of transmitters to specify, procure, and carry in inventory. A modular design allows interchangeable mechanical and electrical components, providing backward and forward compatibility.

Application flexibility

The 1151 offers a variety of configurations for differential, gage, absolute and liquid- level measurements including integrated solutions for pressure, level, and flow. High pressure models allow static line pressures up to 4500 psi (310 bar). Multiple wetted materials, as well as alternative fill fluids ensure process compatibility. Smart, analog and low-power electronics are available to meet specific application requirements.

Rosemount Pressure Solutions

Rosemount 3051S Series of Instrumentation
Scalable pressure, flow and level measurement solutions improve installation and maintenance practices.

Rosemount 3095 Mass Flow Transmitter
Accurately measures differential pressure, static pressure and process temperature to dynamically calculate fully compensated mass flow.

Rosemount 305, 306 and 304 Manifolds
Factory-assembled, calibrated and seal-tested transmitter-to-manifold assemblies reduce installation costs.

Rosemount 1199 Diaphragm Seals
Provides reliable, remote measurements of process pressure and protects the transmitter from hot, corrosive, or viscous fluids.

Orifice Plate Primary Element Systems: Rosemount 1495 and 1595 Orifice Plates, 1496 Flange Unions and 1497 Meter Sections
A comprehensive offering of orifice plates, flange unions and meter sections that are easy to specify and order. The 1595 Conditioning Orifice provides superior performance in tight fit applications.

***Annubar*® Flowmeter Series: Rosemount 3051SFA *ProBar*®, 3095MFA Mass *ProBar*®, and 485**
The state-of-the-art, fifth generation Rosemount 485 *Annubar* combined with the 3051S or 3095 *MultiVariable* transmitter creates an accurate, repeatable and dependable insertion-type flowmeter.

Compact Orifice Flowmeter Series: Rosemount 3051SFC, 3095MFC, and 405
Compact Orifice Flowmeters can be installed between existing flanges, up to a Class 600 (PN100) rating. In tight fit applications, a conditioning orifice plate version is available, requiring only two diameters of straight run upstream and two downstream.

***ProPlate*® Flowmeter Series: Rosemount 3051SFP *ProPlate*, 3095MFP Mass *ProPlate*, and 1195**
These integral orifice flowmeters eliminate the inaccuracies that become more pronounced in small orifice line installations. The completely assembled, ready to install flowmeters reduce cost and simplify installation.

Specifications

PERFORMANCE SPECIFICATIONS

(Zero-based calibrated ranges, reference conditions, silicone oil fill, 316 SST isolating diaphragms.)

Accuracy

Output Code S

Ranges 3 through 8, DP and GP transmitters;
Ranges 4 through 7, HP transmitters

±0.075% of calibrated span for spans from 1:1 to 10:1 of URL. Between 10:1 and 50:1 of URL.

$$\text{accuracy} = \pm\left[0.02\left(\frac{\text{URL}}{span}\right) - 0.1\right]\% \text{ of calibrated span}$$

All other ranges and transmitters

±0.25% of calibrated span(1)

Output Code S, square root mode

$$\pm\left[0.2 + 0.05x\left(\frac{\text{URL}}{\text{span}}\right)\right]\% \text{ of calibrated flow span}$$

Output Codes E, G, L, and M

±0.2% of calibrated span for 1151DP Ranges 3 through 5. All other ranges and transmitters, ±0.25% of calibrated span.

Stability

Output Code S

±0.1% of URL for 2 years for DP and GP Ranges 3 through 8. (±0.25% for all other ranges and transmitters.)

Output Codes E and G

±0.2% of URL for six months for Ranges 3 through 5. (±0.25 for all other ranges.)

Output Codes L and M

±0.25% of URL for six months

Temperature Effect

Output Code S [–20 to 185 °F (–29 to 85 °C)]

For DP and GP transmitter Range 4 through 8;
HP transmitter Range 4 through 7:

Zero Error = ±0.2% URL per 100 °F (56 °C)
Total Error = ±(0.2% URL + 0.18% of calibrated span) per 100 °F; For Range 3, double the stated effects. For other ranges and transmitters follow analog temperature specifications (Output Code E).

Output Code E, G, L, and M

[–20 to 200 °F (–29 to 93 °C)]
For Ranges 4 through 0

Zero Error = ±0.5% URL per 100 °F.
Total Error = ±(0.5% URL + 0.5% of calibrated span) per 100 °F; double the effect for Range 3.

Static Pressure Effect – DP Transmitters

DP Transmitters

Zero Error

±0.25% of URL for 2,000 psi (13790 kPa) for Range 4 and 5 or ±0.5% for other ranges, correctable through rezeroing at line pressure.

Span Error

Correctable to ±0.25% of input reading per 1,000 psi (6895 kPa), or to ±0.5% for Range 3.

HP Transmitters

Zero Error

±2.0% of URL for 4,500 psi (31027 kPa), correctable through rezeroing at line pressure.

Span Error

Correctable to ±0.25% of input reading per 1,000 psi (6895 kPa).

Vibration Effect

0.05% of URL per g to 200 Hz in any axis

Power Supply Effect

Output Codes S, E, and G

Less than 0.005% of output span per volt

Output Codes L, M

Output shift of less than 0.05% of URL for a 1 V power supply shift

Load Effect

Output Codes S, E, and G

No load effect other than the change in power supplied to the transmitter.

Output Codes L, M

Less than 0.05% of URL effect for a change in load from 100kΩ to infinite ohms.

Short Circuit Condition (Low Power Only)

No damage to the transmitter will result when the output is shorted to common or to power supply positive (limit 12 V).

EMI/RFI Effect

Output shift of less than 0.1% of span when tested to SAMA PMC 33.1 from 20 to 1000 MHz and for field strengths up to 30 V/m.

(1) Accuracy for Range 9, GP transmitter at 40:1 is ±0.7% of calibrated span.

Mounting Position Effect

Zero shift of up to 1 inH_2O (0.25 kPa).

With liquid level diaphragm in vertical plane, zero shift of up to 1 inH_2O (0.25 kPa). With liquid level diaphragm in horizontal plane, zero shift of up to 5 inH_2O (1.25 kPa) plus extension length on extended units. All zero shifts can be calibrated out. No effect on span.

FUNCTIONAL SPECIFICATIONS

Service

Liquid, gas, and vapor applications

Ranges

See Table 2 for ranges. Minimum span equals the upper range limit (URL) divided by rangedown. Rangedown varies with the output code See Table 1.

Outputs

Code S, Smart

4–20 mA dc, user selectable for linear or square root output. Digital process variable superimposed on 4–20 mA signal, available to any host that conforms to the HART® protocol.

Code E, Analog

4–20 mA dc, linear with process pressure

Code G, Analog

10–50 mA dc, linear with process pressure

Code L, Low Power

0.8 to 3.2 V dc, linear with process pressure

Code M, Low Power

1 to 5 V dc, linear with process pressure

Current Consumption Under Normal Operating Conditions (Low Power Only)

Output Code L

1.5 mA dc

Output Code M

2.0 mA dc

Zero Elevation and Suppression

Output Codes S, E, and G

Zero elevation and suppression must be such that the lower range value is greater than or equal to the (–URL) and the upper range value is less than or equal to the (+URL). The calibrated span must be greater than or equal to the minimum span and less than or equal to the maximum span.

Output Code L

Zero is adjustable ±10% of URL and span is adjustable from 90 to 100% of URL.

Output Code M

Zero is adjustable ±50% of URL and span is adjustable from 50 to 100% of URL.

Span and Zero

Output Code S

Span and zero may be accessed with local adjustments or remotely through a HART-compatible Interface.

Output Codes E, G, L, and M

Span and zero are continuously adjustable.

Power Supply

External power supply required. Transmitter operates according to the following requirements:

Output Codes S, E

12 to 45 V dc with no load

Output Code G

30 to 85 V dc with no load

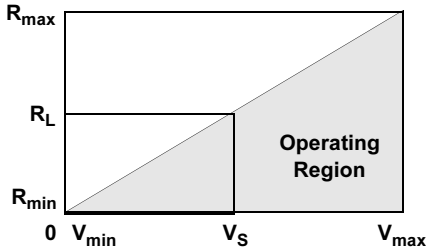
Output Code L

5 to 12 V dc

Output Code M

8 to 14 V dc

Where:



Code	V_{min}	V_{max}	R_{min}	R_{max}	R_L at Supply Voltage (V_S)
S(1)	12	45	0	1650	$R_L = 43.5 (V_S – 12)$
E(2)	12	45	0	1650	$R_L = 50 (V_S – 12)$
G	30	85	0	1100	$R_L = 20 (V_S – 30)$
L	5	12	Low Power Minimum Load Impedance: 100 kΩ		
M	8	14			

(1) A minimum of 250 ohms is required for communication.

(2) For CSA approvals V_{max} = 42.4 V dc.

Temperature Limits

Electronics Operating

Code S: –40 to 185 °F (–40 to 85 °C)

Code E: –40 to 200 °F (–40 to 93 °C)

Code G, L, M: –20 to 200 °F (–29 to 93 °C)

Sensing Element Operating

Silicone fill: –40 to 220 °F (–40 to 104 °C)

Inert fill: 0 to 160 °F (–18 to 71 °C)

Storage

Code S: –60 to 185 °F (–51 to 85 °C)

Codes E, G, L, M: –60 to 250 °F (–51 to 121 °C)

TABLE 1. Rangeability

Output Code	Minimum Span	Maximum Span
S (DP and GP, SST, Range 3–8; HP SST, Range 4–7)	URL/50	2 × URL(1)
S (All Others)	URL/50(2)	2 × URL(1)
E, G	URL/6	URL
L	URL/1.1	URL
M	URL/2	URL

(1) Transmitter is capable of measuring from –URL to URL.

(2) Accuracy specification for calibrated spans from 1:1 to 6:1 of URL only.

TABLE 2. Transmitter Range Availability by Model (URL = Upper Range Limit)

Range Code	1151 Ranges (URL)	DP	HP	GP	DP/GP/Seals	AP	LT
3	30 inH_2O (7.46 kPa)	•	NA	•	NA	NA	NA
4	150 inH_2O(37.3 kPa)	•	•	•	•	•	•
5	750 inH_2O (186.4 kPa)	•	•	•	•	•	•
6	100 psi (689.5 kPa)	•	•	•	•	•	•
7	300 psi (2,068 kPa)	•	•	•	•	•	NA
8	1,000 psi (6,895 kPa)	•	NA	•	NA	•	NA
9	3,000 psi (20,684 kPa)	NA	NA	•	NA	NA	NA
0	6,000 psi (41,369 kPa)	NA	NA	•	NA	NA	NA

TABLE 3. Upper Range Limits (URL)

Range Code	bar	mbar	kg/cm^2	psi	kPa	inH_2O @20 °C	mmH_2O @20 °C	inHg @0 °C
3	0.075	75	0.076	1.082	7.461	30	762	2.203
4	0.373	373	0.380	5.409	37.305	150	3810	11.013
5	1.865	1865	1.901	27.045	186.505	750	19050	55.065
6	6.90	6895	7.031	100	690	2773	70434	204
7	21	20685	21	300	2069	8319	211302	611
8	69	68950	70	1000	6895	27730	704340	2036
9	207	206850	211	3000	20685	83190	2113020	6108
0	413.686	413686	421.842	6000	41369	166378	4225992	12216.12

TABLE 4. Output Code Availability

Code	1151 Output Options/Damping	DP	HP	GP	DP/GP/Seals	AP	LT
S	4–20 mA, Digital, Smart/Variable	•	•	•	•	•	•
E	4–20 mA, Linear, Analog/Variable	•	•	•	•	•	•
G	10–50 mA, Linear, Analog/Variable	•	•	•	•	•	•
L	0.8 to 3.2 V, Linear, Low Power/Fixed	•	•	•	•	•	NA
M	1 to 5 V, Linear, Low Power/Fixed	•	•	•	•	•	NA

TABLE 5. Fill Fluid Specifications

Fill Fluid	Temperature Limits(1)	Specific Gravity	Coeff. of Therm. Exp. cc/cc/°F (cc/cc/°C)	Viscosity at 25 °C centistokes
D.C.® 200 Silicone	–40 to 400 °F (–40 to 205 °C)	0.934	0.00060 (0.00108)	9.5
D.C. 704 Silicone	60 to 400 °F (15 to 204 °C)	1.07	0.00053 (0.00095)	44
Inert Fill	–50 to 350 °F (–45 to 177 °C)	1.85	0.0004 (0.000864)	6.5
Syltherm®XLT, Silicone	–100 to 300 °F (–73 to 149 °C)	0.85	0.000666 (0.001199)	1.6
Glycerin and Water(2)	0 to 200 °F (–17 to 93 °C)	1.13	0.00019 (0.00034)	12.5
Propylene Glycol and Water(3)	0 to 200 °F (–17 to 93 °C)	1.02	0.00019 (0.00034)	2.85
Neobee M-20®(3)	0 to 400 °F (–17 to 205 °C)	0.900	0.00056 (0.001008)	9.8

(1) Temperature limits are reduced in vacuum service. Contact an Emerson Process Management representative for assistance.

(2) Glycerin and Water and Propylene Glycol and Water are not suitable for vacuum service.

(3) Not compatible with Buna-N or Ethylene-Propylene O-ring material.

Static Pressure and Overpressure Limits

1151DP

0 psia to 2,000 psig (0 to 13.79 MPa) on either side without damage to transmitter. Operates within specifications from static line pressures of 0.5 psia (3.45 kPa) to 2,000 psig (13.79 MPa).

1151HP

0 psia to 4,500 psig (0 to 31.02 MPa) on either side without damage to transmitter. Operates within specifications from 0.5 psia (3.45 kPa) to 4,500 psig (31.02 MPa). Consult an Emerson Process Management representative for higher Static Pressure options up to 6000 psi.

1151AP

0 psia to 2,000 psia (0 to 13.79 MPa) without damage to transmitter. Operates within specifications from 0 psia to the upper range limit of the transmitter.

1151GP

0 psia to 2,000 psig (0 to 13.79 MPa) for ranges to 1,000 psig (6.90 MPa), 4,500 psig (31.02 MPa) for the 3,000 psig (20.68 MPa) range, and 7,500 psig (51.71 MPa) for the 6,000 psig (41.37 MPa) range, without damage to the transmitter. Operates within specifications from 0.5 psia (3.45 kPa) to the upper range limit of the transmitter.

1151LT

TABLE 6. Flange Pressure Rating

Standard	Class/Rating	Carbon Steel	Stainless Steel
ANSI	150	285 psig(1)	275 psig(1)
ANSI	300	740 psig(1)	720 psig(1)
ANSI	600	1,480 psig(1)	1,440 psig(1)
DIN	PN 10–40	40 bar(2)	40 bar(2)
DIN	PN 10/16	16 bar(2)	16 bar(2)
DIN	PN 25/40	40 bar(2)	40 bar(2)

(1) At 100 °F (38 °C); the rating decreases with increasing temperature.

(2) At 248 °F (120 °C); the rating decreases with increasing temperature.

Burst Pressure All Models

10,000 psig (68.95 MPa) proof pressure on the flanges.

Humidity Limits

0 to 100% relative humidity

Volumetric Displacement

Less than 0.01 in^3 (0.16 cm^3)

Failure Mode Alarm (Output Code S)

If self-diagnosis detects a gross transmitter failure, the analog signal will be driven below 3.9 mA or above 21 mA to alert the user. High or low alarm signal is user selectable.

Level	4–20 mA Saturation Value	4–20 mA Alarm Value
Low	3.9 mA	3.75 mA
High	20.8 mA	21.75 mA

Transmitter Security (Output Code S)

Activating the transmitter security function prevents changes to the transmitter configuration, including local zero and span adjustments. Security is activated by an internal switch.

Overpressure Saturation Value (Output Code S)

If the sensor detects a negative overpressure value, the analog signal will be driven to 3.9 mA. If the sensor detects a positive overpressure value, the analog signal is driven to 20.8 mA.

Damping

Numbers given are for silicone fill fluid at room temperature. The minimum time constant is 0.2 seconds (0.4 seconds for Range 3). Inert-filled sensor values would be slightly higher.

Output Code S

Time constant is adjustable in 0.1 second increments from minimum to 16.0 seconds.

Output Codes E and G

Time constant continuously adjustable between minimum and 1.67 seconds.

Output Codes L, M

Damping is fixed at minimum time constant.

1151LT

Time constant continuously adjustable between 0.4 and 2.2 seconds with silicone oil fill, or 1.1 and 2.7 seconds with inert fill for flush models and electronics codes E or G.

Turn-on Time

Maximum of 2.0 seconds with minimum damping. Low power output is within 0.2% of steady state value within 200 ms after application of power.

Physical Specifications, Standard Configuration

Electrical Connections

1/2–14 NPT conduit with screw terminals and integral test jacks compatible with miniature banana plugs (Pomona 2944, 3690, or equivalent). The HART Hand-Held Interface connections are fixed to the terminal block on smart transmitters.

Wetted Materials

Isolating Diaphragms

316L SST, Hastelloy C-276, or Tantalum. See ordering table for availability per model type.

Drain/Vent Valves

316 SST or Hastelloy C-276, see ordering table for availability per model type.

Process Flanges and Adapters

Plated carbon steel, 316 SST or Hastelloy C-276, see ordering table for availability per model type.

Wetted O-rings

Viton® (other materials also available)

Non-wetted Materials

Fill Fluid

Silicone oil or inert fill

Nuts and Bolts

Plated carbon steel

Blank flange (GP and AP only)

Plated carbon steel

Electronics Housing

Low-copper aluminum. NEMA 4X

Cover O-rings

Buna-N

Paint

Polyurethane

Process Connections

Rosemount 1151DP, HP, GP, AP

1/4–18 NPT on 2.125-in. (54-mm) centers on flanges for Ranges 3, 4, and 5.

1/4–18 NPT on 2.188-in. (56-mm) centers on flanges for Ranges 6 and 7.

1/4–18 NPT on 2.250-in. (57-mm) centers on flanges for Range 8.

1/2–14 NPT on adapters.

For Ranges 3, 4, and 5, flange adapters can be rotated to give centers of 2.0 in. (51 mm), 2.125 in. (54 mm), or 2.250 in. (57 mm).

Rosemount 1151LT

High pressure side: 2-, 3-, or 4-in., Class 150, 300 or 600 flange; 50, 80, or 100 mm, PN 40 or 10/16 flange.

Low pressure side: 1/4–18 NPT on flange. 1/2–14 NPT on adapter.

Weight

12 lb (5.4 kg) for AP, DP, GP, and HP transmitters, excluding options. Meter option: Add 2 lb (1 kg)

TABLE 7. 1151LT Weight with Flange

Flange[(1)]	Flush lb. (kg)	2-in (50mm) Ext. lb. (kg)	4-in. (100mm) Ext. lb. (kg)	6-in. (150mm) Ext. lb. (kg)
2-in., Class 150	18 (8.2)	N/A	N/A	N/A
3-in., Class 150	23 (10.4)	25 (11.3)	26 (11.8)	27 (12.3)
4-in., Class 150	29 (13.2)	32 (14.5)	34 (15.4)	36 (16.3)
2-in., Class 300	20 (9.1)	N/A	N/A	N/A
3-in., Class 300	28 (12.7)	30 (13.6)	31 (14.1)	32 (14.5)
4-in., Class 300	38 (17.2)	41 (18.6)	43 (19.5)	45 (20.4)
2-in., Class 600	22 (10.0)	N/A	N/A	N/A
3-in., Class 600	31 (14.1)	33 (15.0)	34 (15.4)	35 (15.9)
DN 50, PN10-40	20 (9.1)	N/A	N/A	N/A
DN 80, PN 25/40	25 (11.3)	27 (12.3)	28 (12.7)	29 (13.2)
DN 100, PN 10/16	25 (11.3)	28 (12.7)	30 (13.6)	32 (14.5)
DN 100, PN 25/40	29 (13.2)	32 (14.5)	34 (15.4)	36 (16.3)

(1) Stainless steel flange weights are listed.

Product Certifications

Approved Manufacturing Locations

Rosemount Inc. — Chanhassen, Minnesota, USA

Emerson Process Management GmbH & Co. — Wessling, Germany

Emerson Process Management Asia Pacific Private Limited — Singapore

Beijing Rosemount Far East Instrument Co., Limited – Beijing, China

European Directive Information

The EC declaration of conformity for all applicable European directives for this product can be found on the Rosemount website at www.rosemount.com. A hard copy may be obtained by contacting our local sales office.

ATEX Directive (94/9/EC)

Emerson Process Management complies with the ATEX Directive.

European Pressure Equipment Directive (PED) (97/23/EC)

1151GP9, 0; 1151HP4, 5, 6, 7, 8 Pressure Transmitters
— QS Certificate of Assessment - EC No. PED-H-100 Module H Conformity Assessment

All other 1151 Pressure Transmitters
— Sound Engineering Practice

Transmitter Attachments: Diaphragm Seal - Process Flange - Manifold
— Sound Engineering Practice

Electro Magnetic Compatibility (EMC) (2004/108/EC)

All models
— EN 61326: 1997 with Amendments A1, A2, and A3

Hazardous Locations Certifications

North American Certifications

Ordinary Location Certification for Factory Mutual

As standard, the transmitter has been examined and tested to determine that the design meets basic electrical, mechanical, and fire protection requirements by FM, a nationally recognized testing laboratory (NRTL) as accredited by the Federal Occupational Safety and Health Administration (OSHA).

Factory Mutual (FM) Approvals

FM Explosion-Proof tag is standard. Appropriate tag will be substituted if optional certification is selected.

Explosion-Proof: Class I, Division 1, Groups B, C, and D. Dust-Ignition Proof: Class II, Division 1, Groups E, F, and G; Class III, Division 1. Indoor and outdoor use. NEMA 4X. Factory Sealed.

I5 Intrinsically safe for Class I, II, and III Division 1, Groups A, B, C, D, E, F, and G hazardous locations in accordance with entity requirements and Control drawing 01151-0214 and 00268-0031. Non- incendive for Class I, Division 2, Groups A, B, C and D hazardous locations.

For entity parameters see control drawing 01151-0214.

Canadian Standards Association (CSA) Approvals

E6 Explosion-Proof for Class I, Division 1, Groups C and D; Class II, Division 1, Groups E, F, and G; Class III, Division 1 Hazardous Locations. Suitable for Class I, Division 2, Groups A, B, C, and D; CSA enclosure type 4X. Factory Sealed.

I6 Intrinsically safe for Class I, Division 1, Groups A, B, C, and D hazardous locations when connected per Drawing 01151-2575. For entity parameters see control drawing 01151-2575. Temperature Code T2D.

European Certifications

I1 ATEX Intrinsically Safe and Combustible Dust
(1151 Smart only)
Certificate No.: BAS99ATEX1294X
ATEX Marking Ex II 1 GD
EEx ia IIC T5 (-60°C ≤ Ta ≤ 40°C)
EEx ia IIC T4 (-60°C ≤ Ta ≤ 80°C)
CE 1180
IP66

TABLE 8. IS Entity Parameters

Ui = 30 V
Ii = 125 mA
Pi = 1.0 W (T4) or 0.67 W (T5)
Ci = 0.034 µF
Li = 20 µH

Special Conditions for Safe Use (X)

The apparatus, is not capable of withstanding the 500V test as required by EN 50020: 1994. This must be taken into account when installing the apparatus.

N1 ATEX Type n and Combustible Dust
(1151 Smart only)
Certificate No.: BAS 99ATEX3293X
ATEX marking: ⟨Ex⟩ II 3 GD
EEx nL IIC T5 (-40°C ≤ Ta ≤ 40°C)
EEx nL IIC T4 (-40°C ≤ Ta ≤ 80°C)
Dust Rating: T90 °C (Ta = -20°C to 40°C)
U_i = 45 Vdc Max
CE
IP66

Special Conditions for Safe Use (x)
The apparatus is not capable of withstanding the 500V insulation test required by EN 50021: 1999. This must be taken into account when installing the apparatus.

E8 ATEX Flame-Proof
Certification Number CESI03ATEX037
ATEX Marking ⟨Ex⟩ II 1/2 G
EEx d IIC T6 (–40 ≤ Ta ≤ 40 °C)
EEx d IIC T4 (–40 ≤ Ta ≤ 80 °C)
CE 1180
V = 60 Vdc maximum

Australian Certifications

Standards Association of Australia (SAA) Certification

E7 SAA Flame-proof
Certificate Number Ex 494X
Ex d IIB + H_2 T6
DIP T6
IP65

Special Conditions for safe use (x):
For transmitters having NPT, PG or G cable entry threads, an appropriate flame-proof thread adaptor shall be used to facilitate application of certified flame-proof cable glands or conduit system.

I7 SAA Intrinsically Safe
Certificate Number: Ex 122X
Ex ia IIC T5 (T_{amb} = 40 °C)
Ex ia IIC T4 (T_{amb} = 60 °C)

Special Conditions for Safe Use (x):
The equipment has been assessed to the entity concept and accordingly the following electrical parameters must be taken into account during installation.

TABLE 9. Entity Parameters

U_i = 30V
I_i = 125 mA
P_i = 1.0 W (T4) or 0.67W (T5)
C_i = 14.8 nF
L_i = 20 μH

N7 SAA Type n
Certificate Number: Ex 887X
Ex n IIC T6 (T_{amb} = 40 °C)
Ex n IIC T5 (T_{amb} = 80 °C)
IP66

Special Conditions for safe use (x):
The equipment must be connected to a supply voltage which does not exceed the rated voltage. The enclosure end caps must be correctly fitted whilst the equipment is energized.

Combination Certifications

Stainless steel certification tag is provided when optional approval is specified. Once a device labeled with multiple approval types is installed, it should not be reinstalled using any other approval types. Permanently mark the approval label to distinguish it from unused approval types.

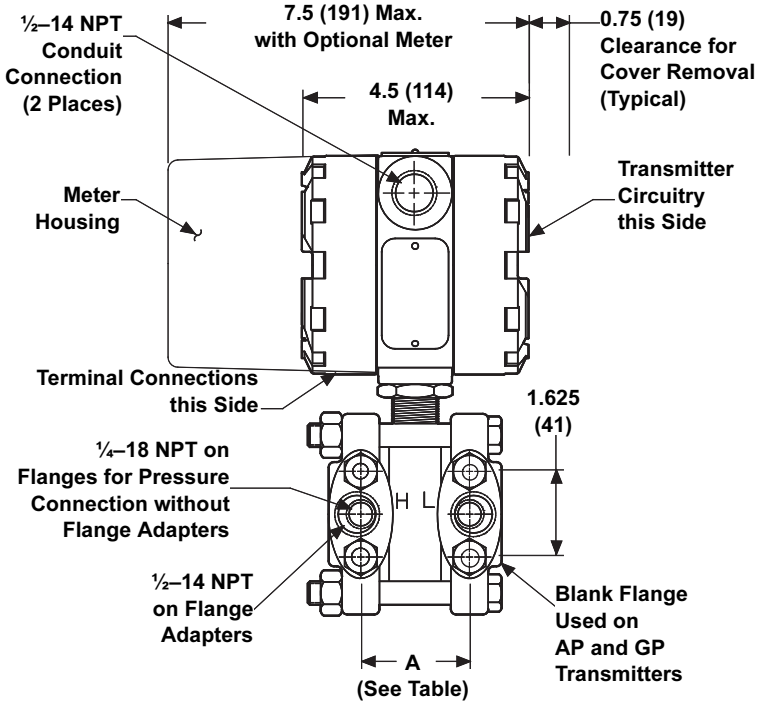
C6 Combination of I6 and E6,

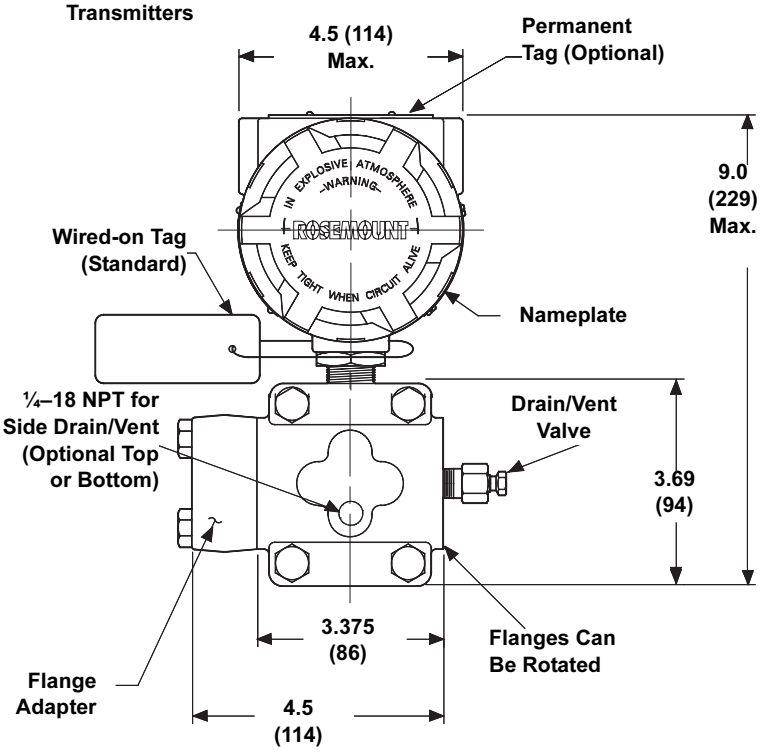
K5 Combination of FM Approvals Explosion-Proof and I5.

K6 Combination of E6, I6, I1, and E8

Dimensional Drawings

1151 Transmitter

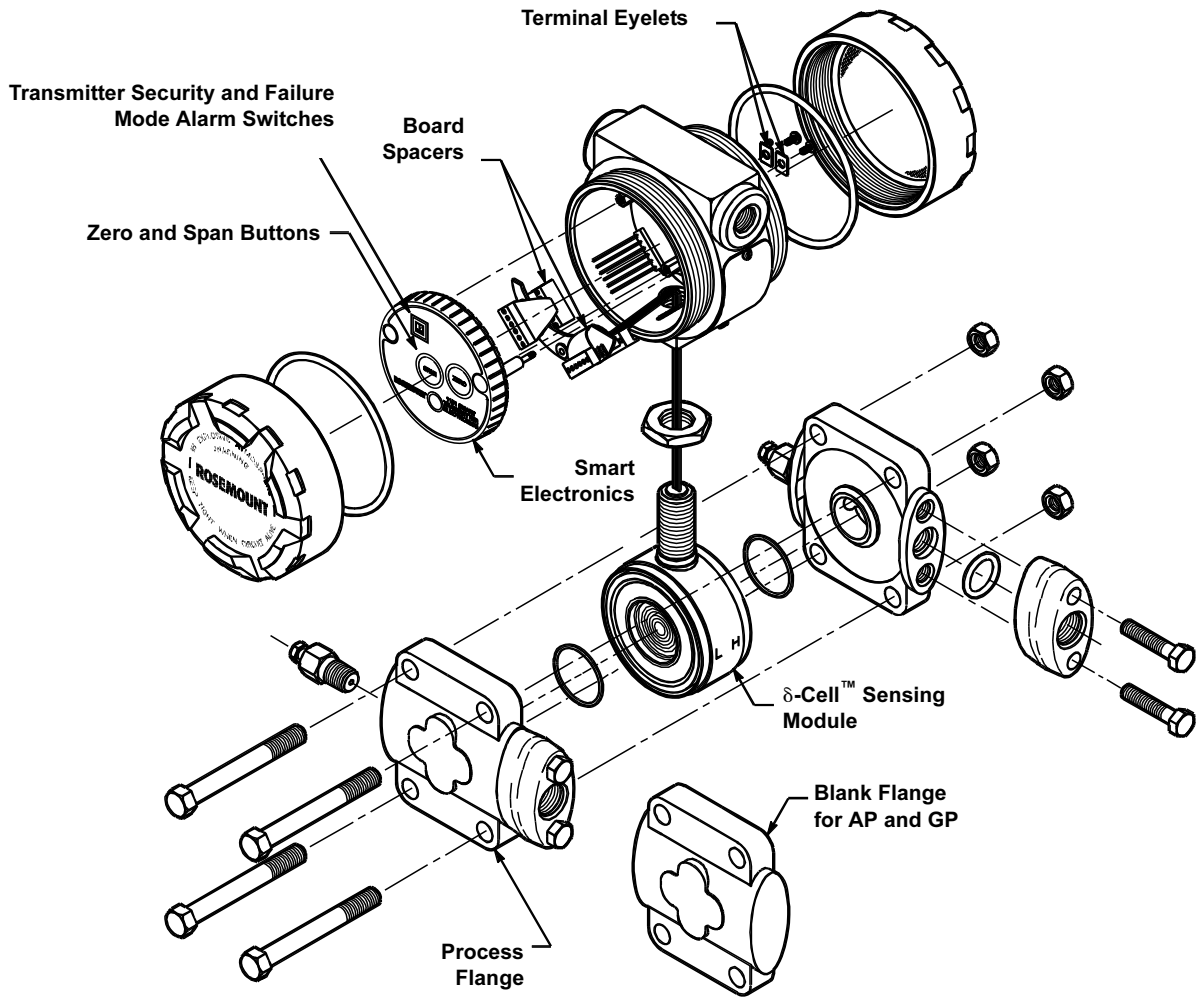




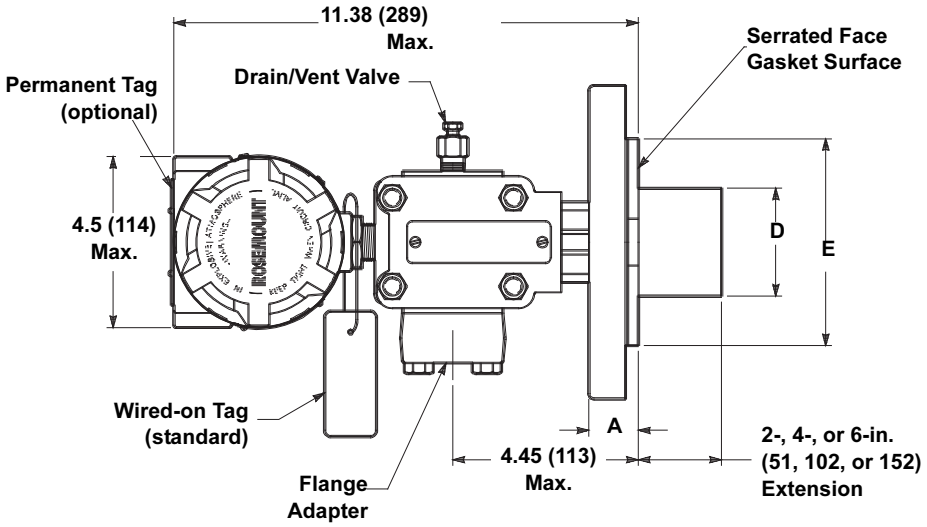
Flange Distance "A" Center to Center		
Range	inches	mm
3, 4, 5	2.125	54
6, 7	2.188	56
8	2.250	57
9	2.281	58
0	2.328	59

NOTE
Dimensions are in inches (millimeters).

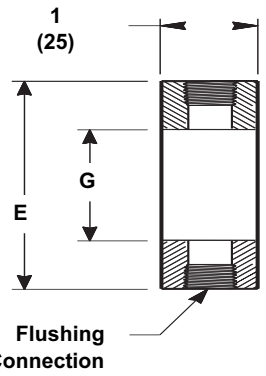
Typical Transmitter Exploded View with Smart Electronics

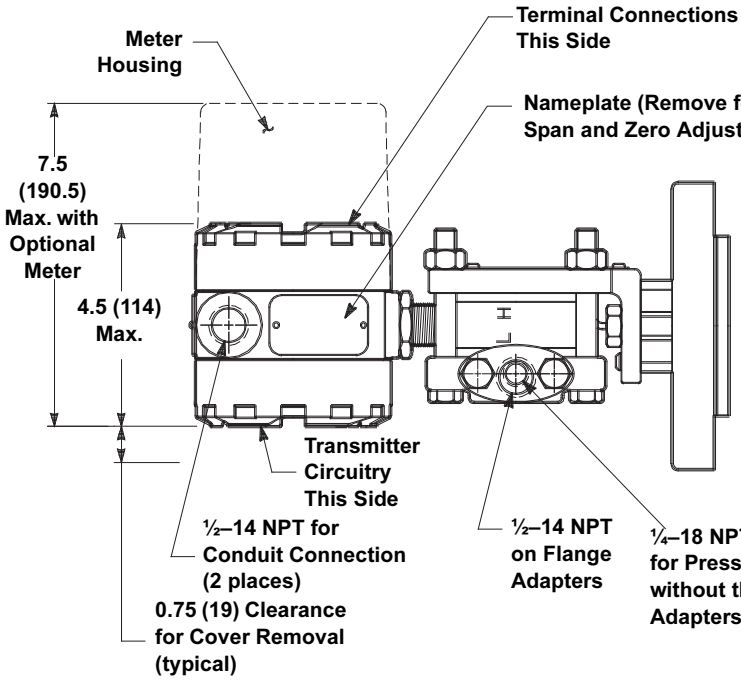


1151LT

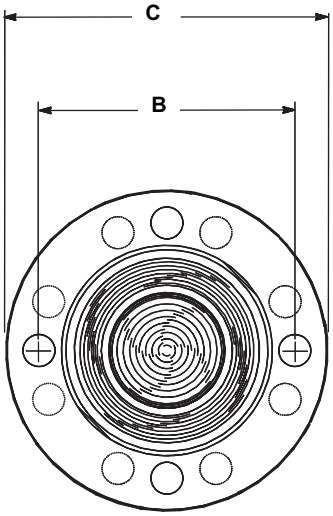


OPTIONAL FLUSHING CONNECTION RING (LOWER HOUSING)





DIAPHRAGM ASSEMBLY AND MOUNTING FLANGE



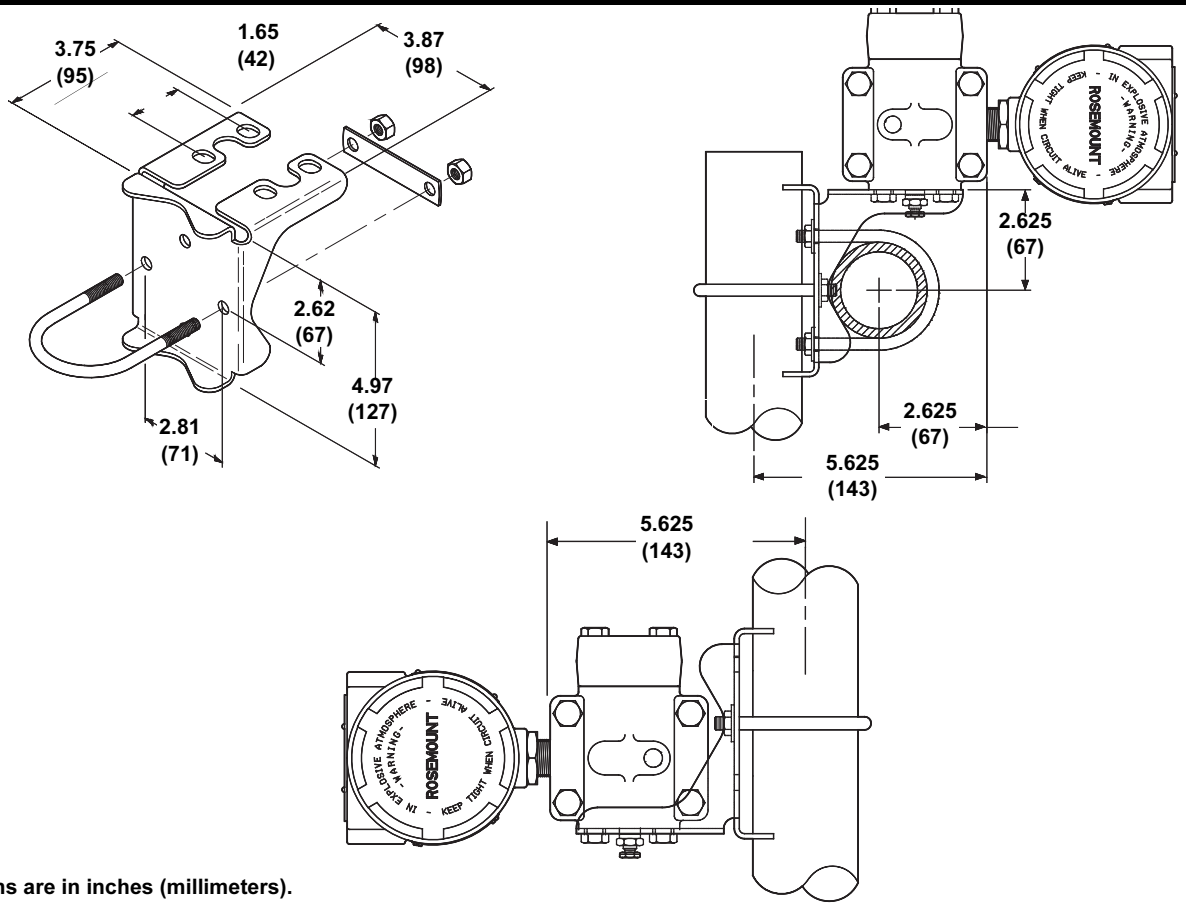
NOTE
Dimensions are in inches (millimeters).

TABLE 10. 1151LT Dimensional Specifications

Class	Pipe Size	Flange Thickness A	Bolt Circle Diameter B	Outside Diameter C	No. of Bolts	Bolt Hole Diameter	Exten. Diam. D (1)	O.D. Gask. Surf. E	Proc. Side G
ANSI 150	2 (51)	1.12 (28)	4.75 (121)	6.0 (152)	4	0.75 (19)	NA	3.6(92)	2.12 (54)
	3 (76)	1.31 (33)	6.0 (152)	7.5 (191)	4	0.75 (19)	2.58 (66)	5.0 (127)	3.5 (89)
	4 (102)	1.31 (33)	7.5 (191)	9.0 (229)	8	0.75 (19)	3.5 (89)	6.2 (158)	4.5 (114)
ANSI 300	2 (51)	1.25 (32)	5.0 (127)	6.5 (165)	8	0.75 (19)	NA	3.6(92)	2.12 (54)
	3 (76)	1.50 (38)	6.62 (168)	8.25 (210)	8	0.88 (22)	2.58 (66)	5.0 (127)	3.5 (89)
	4 (102)	1.62 (41)	7.88 (200)	10.0 (254)	8	0.88 (22)	3.5 (89)	6.2 (158)	4.5 (114)
ANSI 600	2 (51)	1.12 (28)	5.0 (127)	6.5 (165)	8	0.75 (19)	NA	3.6(92)	2.12 (54)
	3 (76)	1.37 (35)	6.62 (168)	6.62 (168)	8	0.88 (22)	2.58 (66)	5.0 (127)	3.5 (89)
DIN PN10-40	DN 50	26 mm	125 mm	165 mm	4	18 mm	NA	4.0 (102)	2.5 (63)
DIN PN 25/40	DN 80	30 mm	160 mm	200 mm	8	18 mm	65 mm	5.4 (138)	3.7 (94)
	DN 100	30 mm	190 mm	235 mm	8	22 mm	89 mm	6.2 (158)	4.5 (114)
DIN PN 10/16	DN 100	26 mm	180 mm	220 mm	8	18 mm	89 mm	6.2 (158)	4.5 (114)

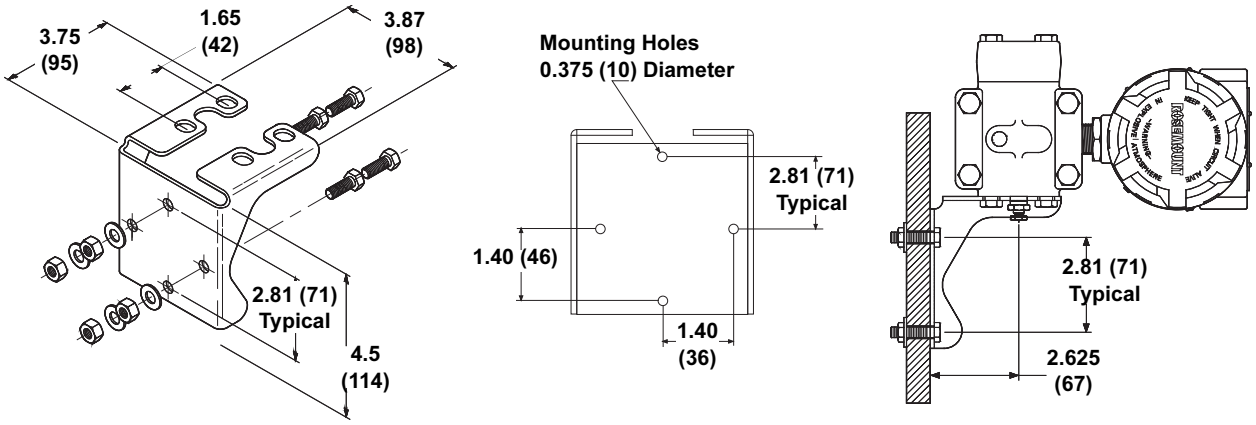
(1) Tolerances are 0.040 (1.02), –0.020 (0.51).

Mounting Bracket Option Codes B1, B4, and B7



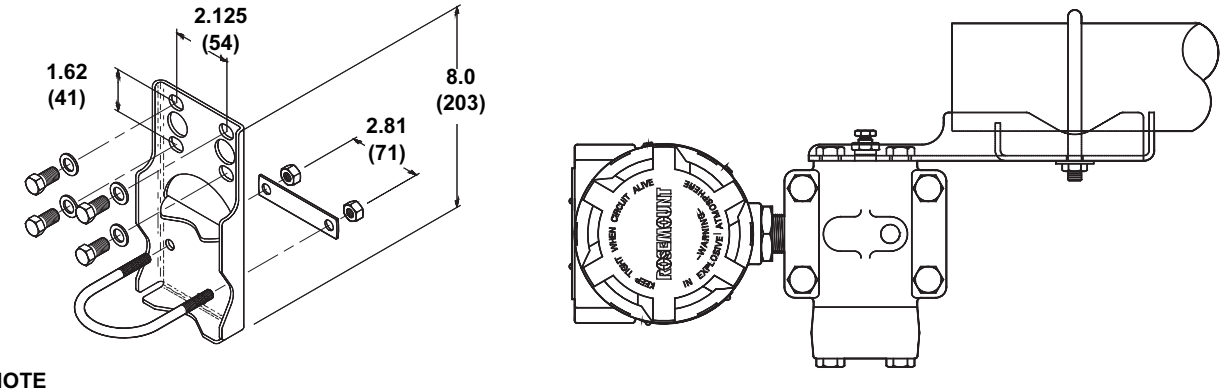
NOTE
Dimensions are in inches (millimeters).

Panel Mounting Bracket Option Codes B2 and B5



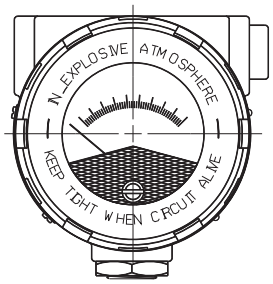
NOTE
Dimensions are in inches

Flat Mounting Bracket Option Codes B3, B6, and B9

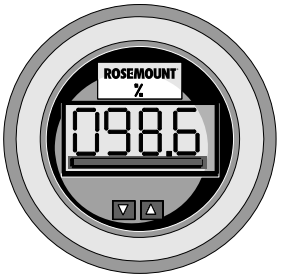


NOTE
Dimensions are in inches (millimeters).

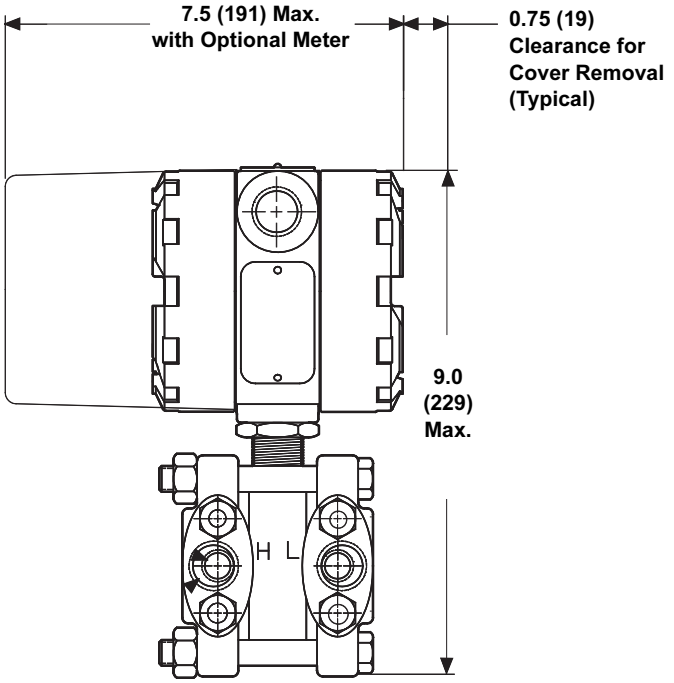
Meter Options



OPTION CODE M1
LINEAR SCALE

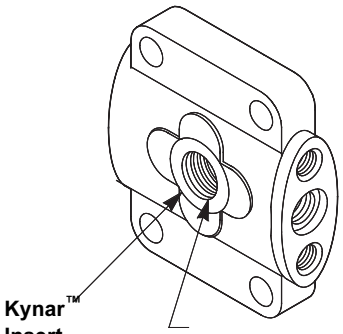


OPTION CODE M4
LINEAR SCALE

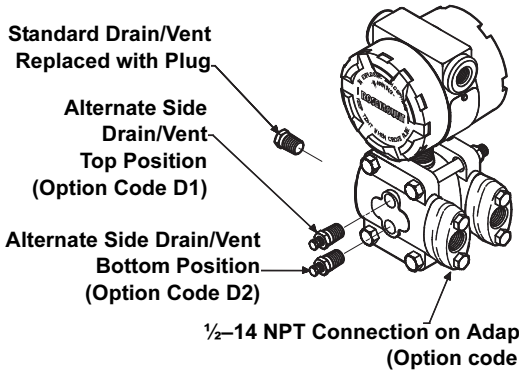


NOTE
DImensions are in inches

Flange Insert



1151 Process Connections



Ordering Information

• = Applicable — = Not Applicable

Model	Transmitter Type	DP	HP	GP	AP
1151DP	Differential Pressure Transmitter	•	—	—	—
1151HP	Differential Pressure Transmitter for High Line Pressures	—	•	—	—
1151GP	Gage Pressure Transmitter	—	—	•	—
1151AP	Absolute Pressure Transmitter	—	—	—	•

Code	Pressure Ranges (URL) (select one)	DP	HP	GP	AP
3	30 inH2O (7.46 kPa)	•	—	•	—
4	150 inH2O (37.3 kPa)	•	•	•	•
5	750 inH2O (186.4 kPa)	•	•	•	•
6	100 psi (689.5 kPa)	•	•	•	•
7	300 psi (2068 kPa)	•	•	•	•
8	1,000 psi (6895 kPa)	•	—	•	•
9	3,000 psi (20684 kPa)	—	—	•	—
0	6,000 psi (41369 kPa)	—	—	•	—

Code	Transmitter Output (select one)	DP	HP	GP	AP
S	4–20 mA with Digital Signal based on HART Protocol (Smart)	•	•	•	•
E	4–20 mA, Linear with Input	•	•	•	•
G[1]	10–50 mA, Linear with Input	•	•	•	•
L	Low Power 0.8 to 3.2 Vdc	•	•	•	•
M[2]	Low Power 1 to 5 Vdc	•	•	•	•

		MATERIALS OF CONSTRUCTION[3]						
Code	Flanges/Adapters	Drains/Vents	Diaphragms	Fill Fluid	DP	HP	GP[4]	AP
52	Nickel-plated Carbon Steel	316 SST	316L SST	Silicone	•	•	•	•
53	Nickel-plated Carbon Steel	316 SST	Hastelloy C-276	Silicone	•	•	•	•
55	Nickel-plated Carbon Steel	316 SST	Tantalum	Silicone	•	—	•	—
22	316 SST	316 SST	316L SST	Silicone	•	•	•	•
23	316 SST	316 SST	Hastelloy C-276	Silicone	•	•	•	•
25	316 SST	316 SST	Tantalum	Silicone	•	—	•	—
33[5]	Hastelloy C-276	Hastelloy C-276	Hastelloy C-276	Silicone	•	•	•	•
35	Hastelloy C-276	Hastelloy C-276	Tantalum	Silicone	•	—	•	—
73[5]	316 SST	Hastelloy C-276	Hastelloy C-276	Silicone	•	•	•	•
83[5]	Nickel-plated Carbon Steel	Hastelloy C-276	Hastelloy C-276	Silicone	•	•	•	•
5A	Nickel-plated Carbon Steel	316 SST	316L SST	Inert	•	—	•	—
5B	Nickel-plated Carbon Steel	316 SST	Hastelloy C-276	Inert	•	—	•	—
5D	Nickel-plated Carbon Steel	316 SST	Tantalum	Inert	•	—	•	—
2A	316 SST	316 SST	316L SST	Inert	•	—	•	—
2B	316 SST	316 SST	Hastelloy C-276	Inert	•	—	•	—
2D	316 SST	316 SST	Tantalum	Inert	•	—	•	—
3B	Hastelloy C-276	Hastelloy C-276	Hastelloy C-276	Inert	•	—	•	—
3D	Hastelloy C-276	Hastelloy C-276	Tantalum	Inert	•	—	•	—
7B[5]	316 SST	Hastelloy C-276	Hastelloy C-276	Inert	•	—	•	—
8B[5]	Nickel-plated Carbon Steel	Hastelloy C-276	Hastelloy C-276	Inert	•	—	•	—

Code	Mounting Brackets (optional - select one)	DP	HP	GP	AP
B1	Bracket, 2-in. Pipe Mount	•	•	•	•
B2	Bracket, Panel Mount	•	•	•	•
B3	Bracket, Flat, 2-in. Pipe Mount	•	•	•	•
B4	B1 Bracket w/Series 316 SST Bolts	•	•	•	•
B5	B2 Bracket w/Series 316 SST Bolts	•	•	•	•
B6	B3 Bracket w/Series 316 SST Bolts	•	•	•	•
B7	316 SST B1 Bracket with 316 SST Bolts	•	•	•	•
B9	316 SST B3 Bracket with 316 SST Bolts	•	•	•	•

Code	Meters[6] (optional - select one)	DP	HP	GP	AP
M1	Analog Scale, Linear Meter, 0–100%	•	•	•	•
M2	Analog Scale, Square Root Meter, 0–100% Flow	•	•	—	—
M3[7]	Analog Scale, Linear Meter, Special Scale	•	•	•	•
M4[9][8]	LCD Display, Linear Meter, 0–100%, User Selectable	•	•	•	•
M6	*Analog Scale, Square Root Meter, 1–10√*	•	•	—	—
M7[9]	LCD Display, Linear Meter, Special Configuration	•	•	•	•
M8[9]	LCD Display Square Root Meter, 0–100% Flow	•	•	—	—
M9[9]	LCD Display, Square Root Meter, 0–10√	•	•	—	—

Code	Product Certifications		DP	HP	GP	AP
E8	ATEX Flameproof		•	•	•	•
I1[10]	ATEX Intrinsic Safety	**NOTE**	•	•	•	•
N1[10]	ATEX Type n	FM explosion-proof approval is standard.	•	•	•	•
I5[10]	FM Intrinsically Safe, Division 2		•	•	•	•
K5[10]	FM Explosion-Proof, Dust Ignition-proof, Intrinsically Safe, Division 2		•	•	•	•
C6[10]	CSA Explosion-Proof, Intrinsically Safe		•	•	•	•
I6[10]	CSA Intrinsically Safe		•	•	•	•
K6[10]	CSA Explosion-Proof, Dust Ignition-proof, Intrinsically Safe, Division 2		•	•	•	•
E6	CSA Explosion-Proof, Dust Ignition-proof, Division 2		•	•	•	•
E7	SAA Flameproof, Dust Ignition-proof		•	•	•	•
I7[10]	SAA Intrinsic Safety		•	•	•	•
N7[10]	SAA Type n		•	•	•	•
C5[11]	Measurement Canada Accuracy Approval		•	•	•	•

Code	Housing (optional - select one)	DP	HP	GP	AP
H1[12]	SST Non-wetted Parts on Transmitter without Meter	•	•	•	•
H2[12]	SST Non-wetted Parts on Transmitter with Meter	•	•	•	•
H3	SST Housing, Covers, Conduit Plug, Lock-nut, without Meter	•	•	•	•
H4	SST Housing, Covers, Conduit Plug, Lock-nut, with Meter	•	•	•	•
C2[13]	M20 Conduit Threads	•	•	•	•
J1	G½ Conduit Threads	•	•	•	•

Code	Terminal Blocks (optional - select one)	DP	HP	GP	AP
R1	Integral Transient Protection (Only available with Option Code S and E electronics				

Code	Bolts for Flanges and Adapters (optional - select one)	DP	HP	GP	AP
L3	ASTM A193-B7 Flange and Adapter Bolts	•	•	•	•
L4	316 SST Flange and Adapter Bolts	•	•	•	•
L5	ASTM A193-B7M Flange and Adapter Bolts	•	•	•	•

Code	Process Connections (optional[14])	Materials	DP	HP	GP	AP
D1	Side Drain/ Vent, Top	316 SST	•	•	•	•
		Hastelloy C-276	•	•	•	•
D2	Side Drain/ Vent, Bottom	316 SST	•	•	•	•
		Hastelloy C-276	•	•	•	•
DF	½–14 NPT Flange adapter(s)- Material determined by flange material	Carbon Steel	•	•	•	•
		316 SST	•	•	•	•
		Hastelloy C-276	•	•	•	•
D4[15]	Conformance to DIN EN61518 Ranges 3, 4, 5 with ¼ NPT Process Connections Thread (Available in Germany Only)		•	•	—	—
D5[15]	Conformance to DIN EN61518 Ranges 6, 7, 8, without ¼ NPT Process Connections Thread (Available in Germany Only)		•	•	—	—
D6	316 SST Low Side Blank Flange		—	—	•	•
D9	JIS Process Connection–RC ¼ Flange with RC ½ Flange Adapter	Carbon Steel	•	•	•	•
		316 SST	•	•	•	•
		Hastelloy C-276	•	•	•	•
G1	DIN Spacing (Single Entry Port, No Side V/D Hole Flange)		•	•	•	•
G2	DIN Spacing (Single Entry Port, Two Side V/D Hole Flange)		•	•	•	•
G3	DIN Spacing (Dual Entry Port, No Side V/D Hole Flange)		•	•	•	•
G4	DIN Spacing (Dual Entry Port, One Top Side V/D Hole Flange)		•	•	•	•
G5	DIN Spacing (Dual Entry Port, One Bottom Side V/D Hole Flange)		•	•	•	•
G6	DIN Spacing (Dual Entry Port, Two Side V/D Hole Flange)		•	•	•	•

K1[16]	Kynar insert, ¼–18 NPT	•	—	•	•
K2[16]	Kynar insert, ½–14 NPT	•	—	•	•
S1[17][18]	Assemble to one Rosemount diaphragm seal	•	—	•	—
S2[17][18]	Assemble to two Rosemount diaphragm seals	•	—	—	—
S4[18][19]	Assemble to Rosemount 1195 Integral Orifice	•	—	—	—
S6[18]	Assemble to Rosemount 304 Manifold or Connection System	•	•	•	•
Code	**Wetted O-ring Material (optional - select one)**	**DP**	**HP**	**GP**	**AP**
W2	Buna-N	•	•	•	•
W3	Ethylene-Propylene	•	•	•	•
W4	Aflas	•	•	•	•
W6[20][21]	Spring-loaded PTFE	•	—	•	•
W7[21][22]	PTFE	•	—	•	•
Code	**Special Configuration (Software)**	**DP**	**HP**	**GP**	**AP**
CN[23][24]	Analog Output Levels Compliant with NAMUR Recommendation NE43: 27-June-1996 and Low Alarm Level	•	•	•	•
C4[23][24]	Analog Output Levels Compliant with NAMUR Recommendation NE43: 27-June-1996 and High Alarm Level	•	•	•	•
C9[24]	Software Configuration (Requires completed Configuration Data Sheet)	•	•	•	•
Code	**Special Certifications**	**DP**	**HP**	**GP**	**AP**
Q4	Calibration Certificate	•	•	•	•
Q8[25]	Material Traceability per EN 10204 3.1	•	•	•	•
Q16	Surface Finish Certification for Sanitary Remote Seals	•	•	•	•
Code	**Toolkit Total System Performance Reports**	**DP**	**HP**	**GP**	**AP**
QZ	Remote Seal System Performance Calculation Report	•	•	•	•
Code	**Procedures (optional - select one)**	**DP**	**HP**	**GP**	**AP**
P1[26]	Hydrostatic Testing, 150% Maximum Working Pressure	•	•	•	•
P2[27]	Cleaning for Special Service	•	•	•	•
P3	Cleaning for <1 PPM Chlorine/Fluorine	•	•	•	•
Code	**Outputs (optional - select one)**	**DP**	**HP**	**GP**	**AP**
V1[28]	Reverse Output	—	—	•	—
V2[29]	4–20 mV Test Signal	•	•	•	•
V3[29]	20–100 mV Test Signal	•	•	•	•
Typical Model Number: 1151DP 4 S 52 B3 M4					

(1) Output Code G is not available with CE Mark.
(2) Meter or SST housing not valid with this option.
(3) Bolts and conduit plugs are plated carbon steel.
(4) On GP and AP transmitters, the low-side flange is plated carbon steel. For a stainless-steel low-side flange, order process connection Option Code D6.
(5) These selections meet NACE material recommendations per MR 01-75.
(6) Not available with Output Codes L or M, or Option Codes V2 or V3.
(7) Limited availability. Contact your Emerson Process Management representative.
(8) Specify the range, mode, and engineering units. Also, the 20 mA value must be greater than the 4 mA value.
(9) Not available with Output Codes G.
(10) Not available with Output Codes E, G, L, or M.
(11) Limited availability depending on transmitter type and range. Contact an Emerson Process Management representative.
(12) Option includes SST housing, covers, conduit plug, locknut, L4 bolting, and D6 low side blank flange for GP and AP transmitters. Option Codes L4 and D6 parts are included with housing Option Codes H1 and H2.
(13) Not available with Output Codes L or M.
(14) Allowable combinations are: D1, D3, D6; D2, D3, D6; and D6, S1.
(15) Material Traceability Certificate Option Q8 available.
(16) The maximum working pressure on this option is 300 psig. Available only with materials of construction Option Code 2x.
(17) This option may only be used on Ranges 4–8.
(18) "Assemble-to" items are specified separately and require a completed model number.
(19) This option has a maximum static pressure rating of 3,000 psi, and is available for factory assembly only without associated piping and is available only for Ranges 2, 3, 4, and 5.
(20) Contains a Hastelloy spring that is wetted by the process; consult factory for PTFE *O-ring without a spring.*
(21) Available for all the ranges of DP (3-8), HP (4-7), and AP (4-8), but it is only available for GP ranges 3-8.
(22) PTFE O-ring has seal property limitations; Consult an Emerson Process Management representative for more information.
(23) NAMUR-Compliant operation is pre-set at the factory and cannot be changed to standard operation in the field.
(24) Available with Output Code S only.
(25) This option is available for the transmitter flange and adapters.
(26) Hydrostatic testing for Range 0, 125% maximum working pressure.
(27) Fluorolube® grease on wetted O-rings.
(28) Reverse output option is not needed with smart electronics; configured via HART-based communicator.
(29) Not available with Output Codes L or M.

Model	Product Description
1151LT	Flange-Mounted Liquid Level Transmitter

Code	Pressure Range
4	150 inH2O (0–635 to 0–3,810 mmH2O)
5	750 inH2O (0–3,175 to 0–19,050 mmH2O)
6	2,770 inH2O (0–11.96 to 0–70.36 mmH2O)

Code	Output
S	4–20 mA with Digital Signal based on HART Protocol (Smart)
E	4–20 mA, Linear with Input
G[1] [2]	10–50 mA, Linear with Input

Code	Size	Material	Extension Length	
G0	2 in./DN 50	316L SST	Flush Mount Only	When specifying these option codes, a lower housing must be selected from the flushing connection options.
H0	2 in./DN 50	Hastelloy C-276	Flush Mount Only	
J0	2 in./DN 50	Tantalum	Flush Mount Only	
A0	3 in./DN 80	316L SST	Flush Mount	
A2	3 in./DN 80	316L SST	2 in./50 mm	
A4	3 in./DN 80	316L SST	4 in./100 mm	
A6	3 in./DN 80	316L SST	6 in./150 mm	
B0	4 in./DN 100	316L SST	Flush Mount	**NOTE** Extension diameters are sized to fit Schedule 80 pipe. Consult factory for Schedule 40 pipe.
B2	4 in./DN 100	316L SST	2 in./50 mm	
B4	4 in./DN 100	316L SST	4 in./100 mm	
B6	4 in./DN 100	316L SST	6 in./150 mm	
C0	3 in./DN 80	Hastelloy C-276	Flush Mount	
C2	3 in./DN 80	Hastelloy C-276	2 in./50 mm	
C4	3 in./DN 80	Hastelloy C-276	4 in./100 mm	
C6	3 in./DN 80	Hastelloy C-276	6 in./150 mm	
D0	4 in./DN 100	Hastelloy C-276	Flush Mount	
D2	4 in./DN 100	Hastelloy C-276	2 in./50 mm	
D4	4 in./DN 100	Hastelloy C-276	4 in./100 mm	
D6	4 in./DN 100	Hastelloy C-276	6 in./150 mm	
E0	3 in./DN 80	Tantalum	Flush Mount Only	
F0	4 in./DN 100	Tantalum	Flush Mount Only	

MOUNTING FLANGE				
Code	Size	Rating	Material	Applicable with these High Pressure Side Diaphragm Sizes
M	2-in.	Class 150	CS	2 in./DN 50
A	3-in.	Class 150	CS	3 in./DN 80
B	4-in.	Class 150	CS	4 in./DN 100
N	2-in.	Class 300	CS	2 in./DN 50
C	3-in.	Class 300	CS	3 in./DN 80
D	4-in.	Class 300	CS	4 in./DN 100
P	2-in.	Class 600	CS	2 in./DN 50
E	3-in.	Class 600	CS	3 in./DN 80
X	2-in.	Class 150	SST	2 in./DN 50
F	3-in.	Class 150	SST	3 in./DN 80
G	4-in.	Class 150	SST	4 in./DN 100
Y	2-in.	Class 300	SST	2 in./DN 50
H	3-in.	Class 300	SST	3 in./DN 80
J	4-in.	Class 300	SST	4 in./DN 100
Z	2-in.	Class 600	SST	2 in./DN 50
L	3-in.	Class 600	SST	3 in./DN 80
Q	DN 50	PN 10-40	CS	2 in./DN 50
R	DN 80	PN 40	CS	3 in./DN 80
S	DN 100	PN 40	CS	4 in./DN 100
V	DN 100	PN 10/16	CS	4 in./DN 100
K	DN 50	PN 10-40	SST	2 in./DN 50

T	DN 80	PN 40	SST	3 in./DN 80
U	DN 100	PN 40	SST	4 in./DN 100
W	DN 100	PN 10/16	SST	4 in./DN 100

SENSOR MODULE AND LOW-SIDE MATERIALS OF CONSTRUCTION

Code	Low-Side Flange and Adapter	Drain/ Vent Valves	Low-Side Isolator Diaphragm	Low-Side Fluid Fill
52	Nickel-plated CS	316 SST	316L SST	Silicone
55	Nickel-plated CS	316 SST	Tantalum	Silicone
22	316 SST	316 SST	316L SST	Silicone
23	316 SST	316 SST	Hastelloy C-276	Silicone
25	316 SST	316 SST	Tantalum	Silicone
33	Hastelloy C-276	Hastelloy C-276	Hastelloy C-276	Silicone
35	Hastelloy C-276	Hastelloy C-276	Tantalum	Silicone
5D	Nickel-plated CS	316 SST	Tantalum	Inert
2A	316 SST	316 SST	316L SST	Inert
2B	316 SST	316 SST	Hastelloy C-276	Inert
2D	316 SST	316 SST	Tantalum	Inert
3B	Hastelloy C-276	Hastelloy C-276	Hastelloy C-276	Inert
3D	Hastelloy C-276	Hastelloy C-276	Tantalum	Inert

Code	Process Fill - High Pressure Side	Temperature Limits
A	Syltherm XLT	–100 to 300 °F (–73 to 135 °C)
C	D. C. Silicone 704	60 to 400 °F (15 to 205 °C)
D	D. C. Silicone 200	–40 to 400 °F (–40 to 205 °C)
H	Inert	–50 to 350 °F (–45 to 177 °C)
G	Glycerin and Water	0 to 200 °F (–17 to 93 °C)
N	Neobee M-20	0 to 400 °F (–17 to 205 °C)
P	Propylene Glycol and Water	0 to 200 °F (–17 to 93 °C)

Code	Options
S1[3][4]	Assemble to one Rosemount diaphragm seal
	METERS
M1[5]	Linear Meter, 0–100% Scale
M3[5]	Special Scale Meter, Specify Range
M4[5][6]	LCD Display, 0–100%
M7[5][7]	LCD Display, Linear, Special Configuration
	TERMINAL BLOCKS
R1	Integral Transient Protection (Available with output codes S and E only)
	HARZARDOUS LOCATIONS CERTIFICATIONS
E8	ATEX Flameproof
I1[8]	ATEX Intrinsic Safety
N1[8]	ATEX Type n
I5[8]	FM Intrinsically Safe, Division 2
K5[8]	FM Explosion-Proof, Dust Ignition-proof, Intrinsically Safe, Division 2
C6[8]	CSA Explosion-Proof, Intrinsically Safe
I6[8]	CSA Intrinsically Safe
K6[8]	CSA Explosion-Proof, Dust Ignition-proof, Intrinsically Safe, Division 2
E6	CSA Explosion-Proof, Dust Ignition-proof, Division 2
E7	SAA Flameproof, Dust Ignition-proof
I7[8]	SAA Intrinsic Safety
N7[8]	SAA Type n
C5[9]	Measurement Canada Accuracy Approval

NOTE
FM explosion-proof approval is standard.

	OTHER OPTIONS
W5	Copper O-ring for Vacuum Service (Nonwetted)
C2	M20 Conduit Threads
Q4	Calibration Data Sheet
Q8(10)	Material Traceability per EN 10204 3.1B
Q16	Surface Finish Certification for Sanitary Remote Seals (all options)
QZ	Remote Seal System Performance Calculation Report
V1	Reverse Output
V2	4–20 mV Test Signal
V3	20–100 mV Test Signal
F_	Select One Code from Flushing Connections Lower Housing Option. See Table 11.

Typical Model Number: 1151LT 4 S A0 A 52 D F1

(1) Not available with Output Codes E and G.
(2) Output Code G is not available with CE Mark.
(3) For welded capillary assemblies, order sensor module and low-side materials of construction Option Code 22 (refer to 00813-0100-4016 for more information).
(4) "Assemble-to" items are specified separately and require a completed model number.
(5) Not available with Option Codes Zx, V2, or V3.
(6) Limited availability. Contact an Emerson Process Management representative.
(7) Specify the Range, Mode, and Engineering Units. Also, the 20 mA value must be greater than the 4 mA value.
(8) Not available with Output Codes E and G.
(9) Limited availability depending on transmitter type and range. Contact an Emerson Process Management representative.
(10) Available for the diaphragm, upper housing, flange, adapter, extension, and lower housing.

TABLE 11. Flushing Connections Lower Housing Options

• = Applicable — = Not Applicable

Code	Flushing Connection Ring Material (Lower Housing)	Flushing Connections	Size	Diaphragm Size 2-in.	3-in.	4-in.
F1	SST	1	1/4 - 18 NPT	•	•	•
F2	SST	2	1/4 - 18 NPT	•	•	•
F3(1)	Hastelloy C-276	1	1/4 - 18 NPT	•	•	•
F4(1)	Hastelloy C-276	2	1/4 - 18 NPT	•	•	•
F7	SST	1	1/2 - 14 NPT	•	•	•
F8	SST	2	1/2 - 14 NPT	•	•	•
F9	Hastelloy C-276	1	1/2 - 14 NPT	•	•	•
F0	Hastelloy C-276	2	1/2 - 14 NPT	•	•	•

(1) Not available with high pressure side Option Codes A0, B0, and G0.

Standard Accessories

All models are shipped with drain/vent valves, and one instruction manual per shipment.

Tagging

The transmitter will be tagged, at no charge, in accordance with customer requirements. All tags are stainless steel. The standard tag is wired to the transmitter, however a permanently attached tag is available upon request. Tag character height is 0.125 in. (0.318 cm).

Calibration

Transmitters are factory calibrated to the customer's specified range. If calibration is not specified, the transmitters are calibrated at maximum range. Calibration is performed at ambient temperature and pressure.

Options

The following sections describe a variety of available options for the 1151 Transmitter. These options permit greater application flexibility.

Optional Manifolds

Refer to Manifold Product Data Sheet (document number 00813-0100-4839).

Optional Diaphragm and Sanitary Seals

Refer to Product Data Sheet (document numbers 00813-0100-4016 or 00813-0201-4016)

Mounting Brackets

B1 Bracket for 2-in. Pipe Mounting
- Bracket for mounting transmitter on 2-in. pipe
- Constructed of carbon steel with carbon steel U-bolt
- Coated with polyurethane paint

B4 Bracket for 2-in. Pipe with 316 SST Bolts
- Same bracket as Option Code B1 with 316 SST bolts

B7 304 SST Bracket and 316 SST Bolts for 2-in. Pipe Mounting
- Same bracket as Option Code B1 with all SST materials

B2 Bracket for Panel Mounting
- Bracket for mounting transmitter on panel or wall
- Constructed of carbon steel with carbon steel bolts
- Coated with polyurethane paint

B5 Bracket for Panel with 316 SST Bolts
- Same bracket as Option Code B2 with 316 SST bolts

B3 Flat Bracket for 2-in. Pipe Mounting
- Bracket for vertical mounting of transmitter on 2-in. pipe
- Constructed of carbon steel with carbon steel U-bolt
- Coated with polyurethane paint

Process Connections

D1 Side Drain/Vent-Top
- Drain/vent valve mounted in side of flange.
- Top position used to vent gas buildup in liquid process applications with transmitter mounted vertically.

B6 Flat Bracket for 2-in. Pipe with 316 SST Bolts
- Same bracket as Option Code B3 with 316 SST bolts

B9 304 SST Flat Bracket and 316 SST Bolts for 2-in. Pipe Mounting
- Same bracket as Option Code B3 with all 316 SST materials

Bolts and Nuts for Flanges and Adapters

Options permit bolts and nuts for flanges and adapters in the specified material.
- L3 ANSI/ASTM A - 193-B7
- L4 Austenitic 316 SST
- L5 ANSI/ASTM A193-B7M

Meters

Analog
- Meters have 2-in. (50.8 mm) scale
- Plug-in mounting configuration
- Indication accuracy ±2%
- Operating temperature limit: –40 to 150 °F (–40 to 65 °C)
- Meters are enclosed in a housing certified by Factory Mutual as Explosion-Proof for Class I, Division 1, Groups B, C, and D; Class II, Division 1, Groups E, F, and G and Class III, Division 1
- For optional CSA explosion-proof approval, see certification Option Code E6
- M1 Linear Analog Meter, 0–100% Scale
- M2 Square Root Analog Meter, 0–100% Flow Scale
- M3 Special Scaling Analog Meter (Specify Range)
- M6 Square Root Analog Meter, 0– 10$\sqrt{}$ Scale

LCD
- 4-digit display
- Indication accuracy ±0.25% of calibrated span ±1 digit
- Display resolution at ±0.5% of calibrated span ±1 digit
- Operating temperature limit: –4 to 158 °F (–20 to 70 °C)
- Plug-in mounting configuration
- Meters are enclosed in a housing certified by FM as Explosion-Proof for Class I, Division 1, Groups B, C, and D; Class II, Division 1, Groups E, F, and G and Class III, Division 1
- For Optional CSA explosion-proof approval, see certification Option Code E6
- Reverse output not available with LCD Display
- M4 Linear LCD Meter, 0 to 100%
- M7 Special Scale LCD Display (Specify Range, Mode, and Engineering Units)
- M8 Square Root LCD Display, 0 to 100%
- M9 Square Root LCD Display, 0–10$\sqrt{}$ Scale

NOTES
Meter Options are not available with Output Codes L or M, or Option Codes V2 or V3. Meter Options M4, M7, M8, and M9 are not available with Output Code G.

- Plug of same material as requested flange inserted in end of flange opposite adapter.

D2 Side Drain/Vent-Bottom

- Drain/vent valve mounted in side of flange.
- Bottom position used to drain liquid buildup in gas process applications with transmitter mounted vertically.
- Plug of same material as requested flange inserted in end of flange opposite adapter.

D6 316 SST Low Side Flange (1151GP and 1151AP Only)

DF 1/2–14 NPT flange adapters

- Options provide 1/2–14 NPT process connection on flanges rather than 1/4–18 NPT

K1 1/4–18 NPT Kynar™ Process Flange Insert

K2 1/2–14 NPT Kynar Process Flange Insert

- Options provide Kynar plastic process flange insert that prevents process from coming in contact with the metal of the flange. One process insert for the 1151GP and LT; two inserts for the 1151DP.
- Process connections are from the side.
- Available with carbon steel and stainless steel process flanges only.
- Pressure Maximum: 200 psi at 200 °F with Kynar impulse piping; 300 psi at 200 °F with metal impulse piping.

S1 Assembled with One Remote Diaphragm Seal

S2 Assembled with Two Remote Diaphragm Seals

- Options provide for the assembly of one or two remote diaphragm seals.

S4 Assembled with 1195 Integral Orifice

- Designed for highly accurate, small-bore flow measurement of any clean gas, liquid, or vapor.
- Reduce the costs associated with traditional orifice plate installations.
- Several configurations are available factory assembled to Rosemount differential pressure transmitters.(1)
- Wide orifice bore/flow range capability.
- Wide choice of process connections, including threaded, socket weld, and ANSI flanges.
- Static pressure maximum limit is 3,000 psig.
- Wetted materials are available that comply with NACE MR 01-75(90).
- Available only with Ranges 2, 3, 4, and 5.

(1) Applicable only to orifice assemblies without piping.

Wetted O-rings

- Standard: Viton®
- W2 Buna N
- W3 Ethylene-Propylene
- W4 Aflas®
- W5 Copper O-ring for Vacuum Service (Nonwetted - 1151LT only)
- W6 Spring-Loaded PTFE
  - Contains a Hastelloy spring that is in contact with the process fluid. Consult factory if Hastelloy is unacceptable.
- W7 PTFE

Procedures

Standard Configuration

Unless otherwise specified, transmitter will be shipped as follows:

Engineering Units:	inH_2O
4 mA:	0
20 mA:	Upper Range Limit
Output:	Linear
Software Tag:	Blank

Customer may specify the above items at no charge. Software tag (8 characters) is left blank unless specified.

C9 Custom Configuration (Option Code C9)

If Option Code C9 is ordered, the customer may specify the following data in addition to the standard configuration parameters.

Descriptor:	16 characters
Message:	32 characters
Date:	Day, Month, Year
Damping:	Seconds
Burst Mode:	Select Output Choice
Failure Mode:	High or Low
Transmitter Security:	Off or On

TABLE 12. Hydrostatic Test Pressure

Model	Test Pressure
1151DP	3,000 psi
1151HP	6,750 psi
1151AP	2,000 psi
1151GP	
Ranges 3–8	2,000 psi
Range 9	4,500 psi
Range 0	7,500 psi
1151LT	
Class 150 Flange	450 psi
Class 300 Flange	1,100 psi

P1 Hydrostatic Testing

- Each transmitter is hydrostatic tested according to Table 12.
- Test medium is water.
- This option provided for transmitters with remote diaphragm seal on application only.
- Rosemount Procedure 1746 outlines the testing procedure.

P2 Cleaning for Special Service

- This option minimizes contaminants to the process system by cleaning wetted surfaces with a suitable detergent.
- Rosemount Procedure 97412 outlines the cleaning procedure.

P3 Cleaning for <1 PPM Chlorine/Fluorine

Outputs

V1 Reverse Output

- This option permits reversing of pressure input so that electrical output will increase as pressure input decreases.
- This option applies only to 1151GP and 1151LT. When this option is selected, the process flange, adapter, drain/vent valve, appropriate O-rings, and bolting are installed on low side of transmitter. Not available for Ranges 9 and 0.
- Not available with 1151AP. Reverse output on 1151DP and 1151HP can be obtained by connecting high-pressure input to low side of transmitter and vice versa.
- This option should not be ordered with smart transmitters (Output Code S). The 1151 Smart transmitter can be configured for reverse output through a HART-Compatible Interface.

V2 1 Ω Test Resistor

- A 1 Ω precision resistor is mounted across the test terminals to provide 4–20 mV output or a 10–50 mV output if 10–50 mA output is used.
- This option cannot be used with any meter options or Option Codes I5 or I6.

V3 5 Ω Test Resistor

- A 5 Ω precision resistor is mounted across test terminals to provide 20–100 mV output or a 50–250 mV output if 10–50 mA output is used.
- This option cannot be used with any meter options or Option Codes I5 or I6.

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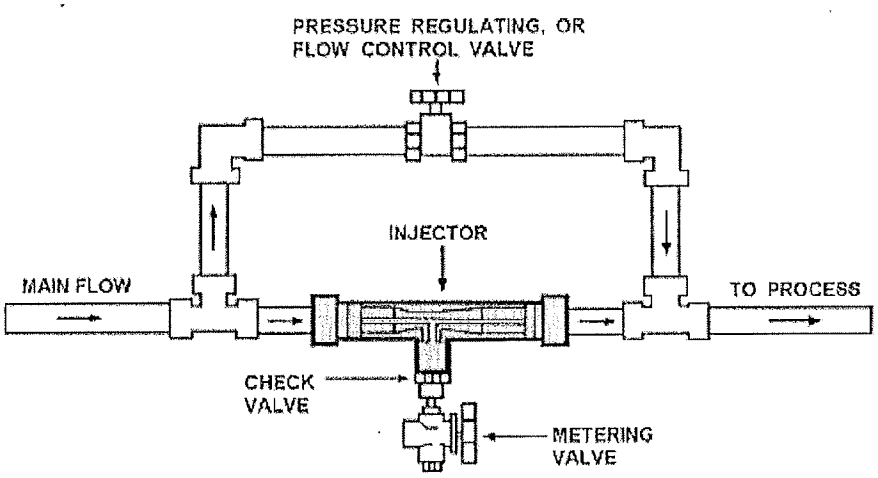
TECHNICAL BULLETIN No. 7

INSTALLATION OF MAZZEI® INJECTORS IN A BYPASS ASSEMBLY

Bypass assemblies are used with Mazzei Injectors for two purposes. These are:

1. To create a pressure differential across the injector to induce suction
2. To enable use of an injector whose flow rate is less than the total flow rate

A typical Bypass Assembly is shown below. When used for liquid suction, the injector may be mounted in either the "straight" run or in the bypass portion. When used for gas suction, the injector should be mounted in the "straight" run of piping. This will optimize gas mass transfer.



Bypass Assemblies should be installed so that the injector outlet is at, or above, the horizontal. "Full Flow" valves and pipe fittings should be used so that water flow through the injector is not restricted. Bypass Assemblies are available from Mazzei Injector Corporation in standard pipe sizes from ½ to 2". Custom manifolds are available in sizes to 8".

mazzei injector corporation

Setting the standard for efficiency

Injector Performance Table

Air Suction Capacity • Injector Inlet Pressure 5-50 PSIG

Operating Pressure PSIG		Model 1584 1.5" Threads		Model 1585X 1.5" Threads		Model 1587 1.5" Threads		Model 2081 2" Threads		Model 3090 3" Threads		Model 4091 4" Threads	
Injector Inlet	Injector Outlet	Motive Flow GPM	Air Suction SCFH	Motive Flow GPM	Air Suction SCFH	Motive Flow GPM	Air Suction SCFH	Motive Flow GPM	Air Suction SCFH	Motive Flow GPM	Air Suction SCFH	Motive Flow GPM	Air Suction SCFH
5	0	18.0	47.0	10.3	56.4	17.0	65.9	33	178.7	73		131	1200
	1		40.0		12.0		21.9		183.1				1151
	2		31.8		6.9		15.7		122.3				1046
	3		20.6				8.7		119.9				941
	4	(4.0)	10.7	(3.5)		(4.1)		(4.5)		(4.0)		(4.5)	618
10	0	25.5	98.0	14.5	65.0	24.0	127.8	46	432.0	103	717	186	1830
	2		72.4		20.1		61.1		352.0		635		1305
	5		37.1		11.7		21.7		185.5		379		945
	7		20.6				9.8		119.9		293		868
	8	(8.5)	12.7	(6.5)		(8.7)	5.1	(9.0)		(8.5)	30	(8.8)	724
15	0	31.3	144.0	17.8	117.3	29.4	153.8	57	503.7	127	985	227	2355
	5		71.7		18.7		42.7		393.5		670		1300
	7		45.7		11.7		26.8		182.3		422		1118
	10		23.9		0.2		13.7		156.7		262		638
	12	(13.0)	9.4	(9.4)		(13.5)	9.1	(13.3)		(13.5)	120	(13.1)	389
20	0	36.1	170.0	20.6	130.8	33.9	173.1	66	813.0	146	1139	263	2273
	5		102.1		31.1		64.3		457.4		851		1574
	10		41.1		12.7		25.5		257.5		391		806
	12		31.2		6.4		18.8		191.9		296		701
	15	(17.0)	12.7	(12.7)		(17.0)	12.0	(17.5)	137.3	(17.0)	214	(17.5)	533
25	0	40.3	185.0	23.0	145.4	37.9	195.6	73	820.2	164	1241	294	2389
	5		128.9		48.6		91.1		630.4		1002		1691
	10		65.7		20.3		43.5		303.9		541		1166
	15		33.1		8.1		19.1		266.3		314		634
	20	(21.5)	12.0	(15.4)		(22.1)	9.8	(22.3)	147.1	(21.5)	60	(21.7)	475
30	0	44.2	194.0	25.2	169.3	41.5	230.5	80	844.2	179	1375	322	2564
	5		152.8		60.8		114.6		664.8		1139		1784
	10		99.4		25.7		54.8		379.0		680		1267
	15		54.4		14.8		30.0		346.2		386		921
	20		28.5		0.2		17.5		161.5		253		629
	25	(26.0)	10.0	(19.3)		(25.6)	10.2	(26.0)		(25.5)		(26.0)	437
35	0	47.7	206.0	27.2	175.6	44.9	230.7	87	959.4	194	1449	347	2746
	5		173.5		78.2		143.6		840.0		1244		2254
	10		123.4		34.2		70.9		511.8		747		1795
	15		72.4		20.6		41.6		423.5		451		1204
	20		39.8		10.5		27.0		268.7		299		787
	25	(30.5)	22.6	(22.4)		(29.0)	18.7	(30.5)	195.1	(29.5)	197	(30.5)	619
40	0	51.0	212.0	29.1	177.0	48.0	255.0	93	993.0	207	1359	371	2858
	5		188.7		87.4		189.7		935.4		1242		2423
	10		147.8		45.3		86.8		551.8		794		1895
	15		98.7		24.9		52.4		465.4		532		1310
	20		59.7		16.7		36.2		340.6		352		931
	25		38.4		2.7		26.7		263.9		246		677
	30	(35.0)	21.9	(25.5)		(33.2)	17.2	(33.5)	110.3	(32.5)	158	(35.0)	542
45	0	54.1	222.0	30.9	229.9	50.9	267.3	98	1021.8	219	1487	394	3114
	5		197.5		105.4		207.9		988.2		1401		2620
	10		157.7		51.2		91.2		652.8		1017		2226
	15		111.0		32.6		58.9		475.0		750		1612
	20		73.7		21.6		39.9		350.2		475		1190
	25		49.7		12.2		28.2		215.9		345		854
	30		32.5				18.9		148.7		234		701
	35	(39.5)	21.2	(28.7)		(38.3)	15.1	(38.0)		(36.0)	30	(38.9)	600
50	0	57.1	226.0	32.5	203.7	53.6	269.3	104	1036.2	231	1548	415	3140
	5		207.9		129.6		222.0		1020.0		1416		2940
	10		175.6		56.7		111.5		849.0		1167		2610
	15		133.1		38.1		70.7		696.0		787		1852
	20		96.7		27.4		51.7		432.0		548		1334
	25		68.4		17.6		37.4		263.9		426		1070
	30		47.1		6.4		22.8		206.3		306		825
	35		31.8				19.6		139.1		226		605
	40	(42.5)	18.6	(32.4)		(41.0)	14.4	(41.5)	100.7	(40.5)		(43.1)	450

** Numbers in parenthesis indicate the injector outlet pressure when suction stops (Zero Suction Point). **

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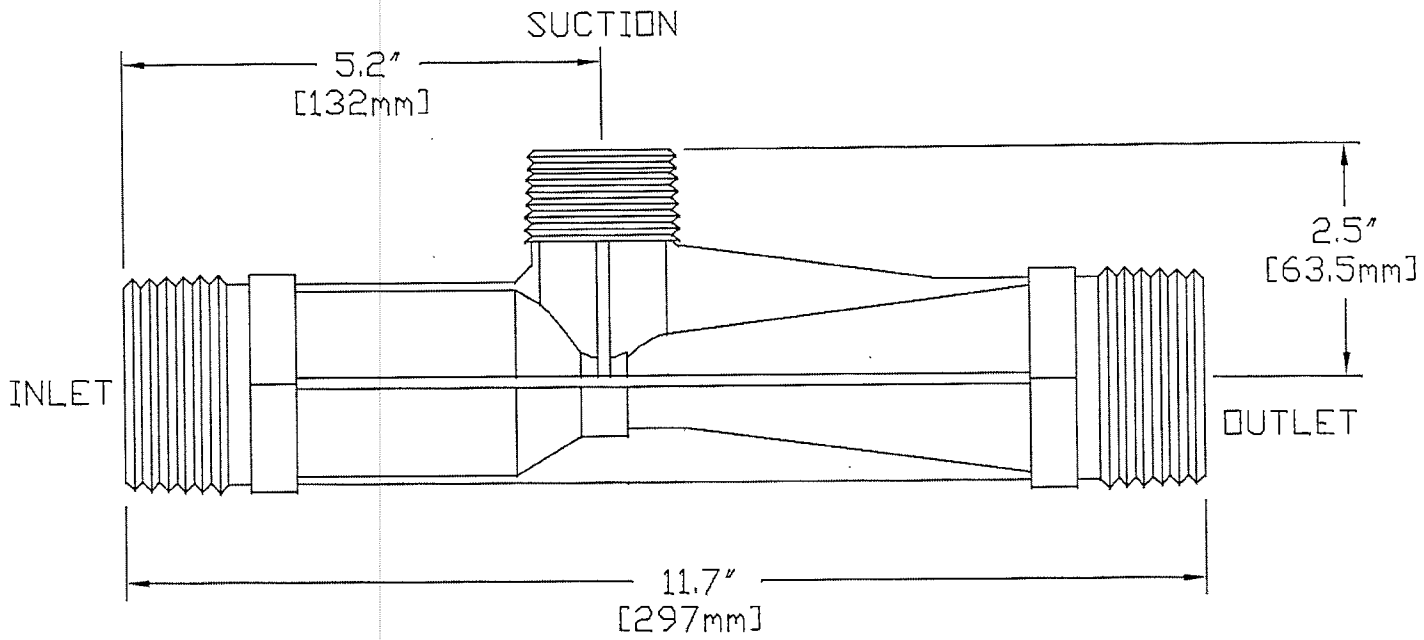
NOTES:

1. INLET AND OUTLET: 2" MNPT OR BSPT (ISO-R)
2. SUCTION PORT: 1.25" MNPT OR BSPT (ISO-R)
3. MATERIAL: GLASS REINFORCED POLYPROPYLENE OR PVDF (KYNAR)
4. MAXIMUM TEMPERATURE RATING:
   POLYPROPYLENE: 150 F. (65.5 C.)
   PVDF (KYNAR): 200 F. (93.3 C.)
5. MAXIMUM PRESSURE RATING AT 68 F. (20 C.)
   POLYPROPYLENE: 150 PSIG (10.3 BAR)
   PVDF (KYNAR): 200 PSIG (13.8 BAR)



Covered By United States Patent No. 5,863,128
International Patents Pending

mazzei injector corporation
Bakersfield, California, USA

DATE	12-19-00	TITLE	MODEL 2081-A INJECTOR
DRAWN BY	JRM		
REVIEWED BY	RST	NUMBER	JRM-22
SCALE	NONE	SIZE	REV.
MATERIALS: SEE NOTES		PAGE (1) OF (1)	

EJM Series Reversing Electric Actuators

Overview

Cost effective, rugged, quarter-turn actuator designed for use with all ball and butterfly valves up to 24″ in size. Ideal for a wide range of applications without costly options. Positioners are available for special throttling or modulating requirements.

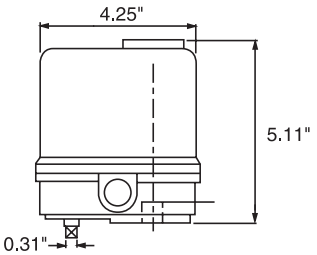
Features

- Two Auxiliary Limit Switches
- Heater with Thermostat
- NEMA 4/4X Enclosure
- Position Indicator
- Manual Override
- Self-Locking Gear Train
- Permanently Lubricated
- Thermal Overload Protection
- CE and CSA Approved
- ISO 5211 Mounting Base

Options

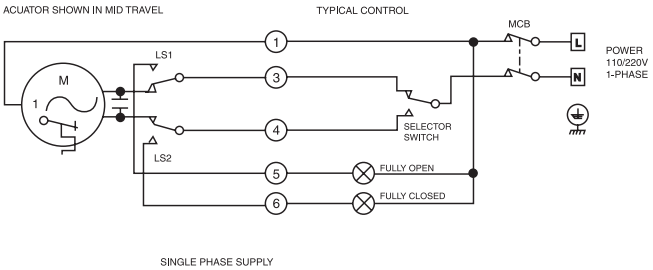
- Positioners
- Voltage Options: 12 VDC, 24 VDC, 12 VAC, 24 VAC and 220 VAC Motors
- Feedback Potentiometer
- Control Stations

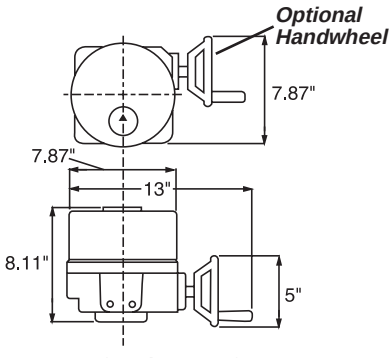
EJM Series Dimensions–Inches



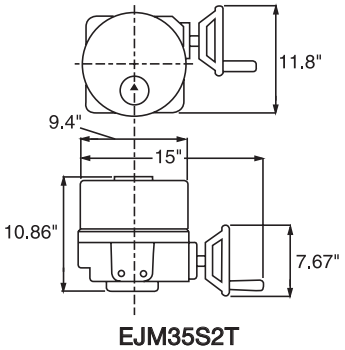
EJM2S2T/EJM3S2T

Wiring Diagram

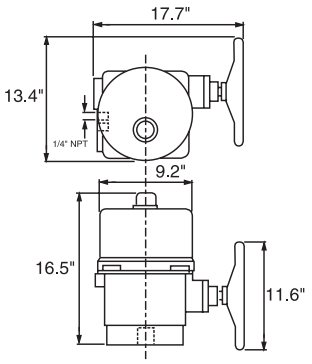




EJM8S2T/EJM13S2T



EJM35S2T



EJM130S2T

Technical Information

Actuator Specifications

Model	EJM2S2T	EJM3S2T	EJM8S2T	EJM13S2T	EJM35S2T	EJM130S2T
Torque Output (in-lbs)	150	300	800	1300	3500	13300
Standard Voltage	50/60 Hz, 115 VAC, 1 Phase, PSC					
Duty Cycle	25%					
Thermal Overload	Standard					
Cycle Time (secs @ 90°)	8	12	15	22	22	46
Auxiliary Limit Switch Rating	5 amps @ 125 V		1/2 hp, 15 amps @ 125/250 V			
Conduit Entry	1/2″ NPT					
Enclosure	NEMA 4/4X					
Enclosure Material	Aluminum Alloy, Dry Powder Coated					
Max Current Amps @ 115 VAC	.60	1.8	3.6	10.0		
Weight (lbs/kg)	5/2.3	20/9.1	40/18.2	52/23.6		

Ball Valve Selection Chart*

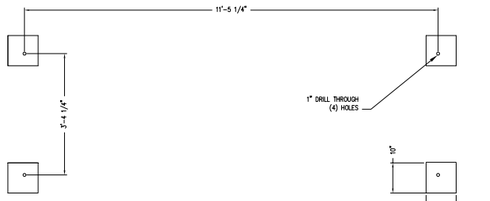
Size	True Union Ball Valve	Three-Way Ball Valve
1/2″ – 2″	EJM2S2T	EJM2S2T
2 1/2″ – 6″	EJM3S2T	EJM8S2T

*Actuator size selections based on clean water at 70°F.

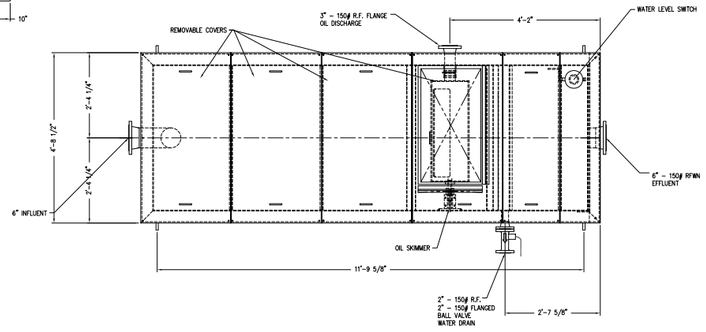
Butterfly Valve Selection Chart*

Size	Butterfly Valve
1 1/2″, 2″, 3″	EJM3S2T
4″, 6″	EJM8S2T
8″	EJM13S2T
10″, 12″	EJM35S2T
14″ – 24″	EJM130S2T

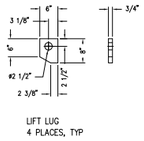
*Actuator size selections based on clean water at 70°F.



FUNDATION LAYOUT



PLAN VIEW

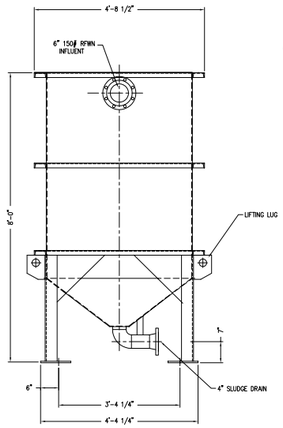


LIFT LUG
4 PLACES, TYP

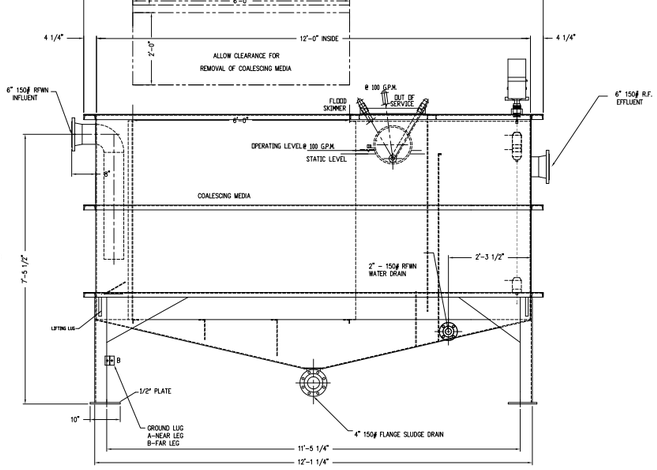
NOTES:

1) FLANGES TO BE ANSI B31.1 WITH 150# RAISED FACE FLANGES.
2) SEPARATOR BODY TO BE CONSTRUCTED OF 1/4" THICK ASTM A-36 CARBON STEEL.
3) SEPARATOR PLATE PACK MADE OF PVC.
4) SKIMMING DEVICE MADE OF ASTM A53.
5) INTERIOR OF SEPARATOR TO BE COATED USING SHERWIN WILLIAMS HIGH PERFORMANCE PHENOLIC EPOXY (8-10 MILS DFT).
6) EXTERIOR OF SEPARATOR TO BE COATED USING SHERWIN HEAVY DUTY EPOXY (8-10 MILS DFT) GRAY.
7) SURFACE PREPARATION FOR COATINGS TO BE NEAR WHITE BLAST, SSPC-SP10.
8) STRUCTURAL WELDING TO BE PERFORMED ACCORDING TO AWS D1.1.
9) TANK IS TO BE WATER FILL LEAK TESTED FOR 1 HOUR.
10) FLANGE BOLT HOLE CENTERLINES TO STRADDLE HORIZONTAL AND VERTICAL SEPARATOR AXES.

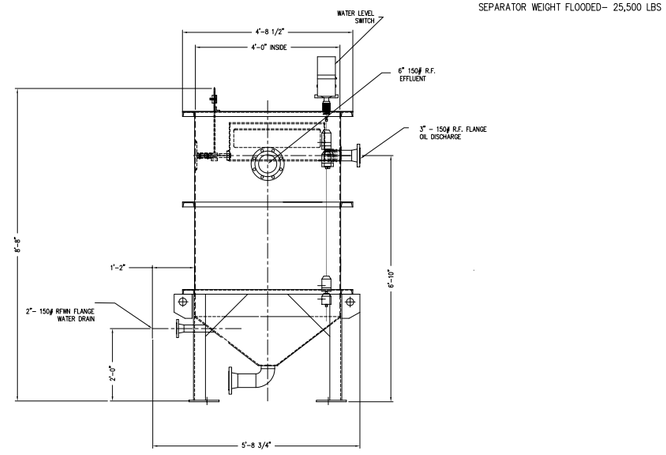
SEPARATOR WEIGHT EMPTY- 7,500 LBS
SEPARATOR WEIGHT FLOODED- 25,500 LBS



INFLUENT VIEW



ELEVATION VIEW



EFFLUENT END VIEW

DRAWING ISSUED ☐ PRELIMINARY ☐ FOR CONSTRUCTION ☐ FOR ENGINEERING ☐ FOR APPROVAL ☐ FOR DESIGN ☐ FOR INFORMATION ☐ REVISED DESTROY ALL PREVIOUS COPIES OF DWG. REVIEW THIS ISSUE FOR CHANGES. DATE: BY:	NOTES: TOLERANCE: FRACTIONAL ±1/16"(1.6mm) DECIMAL ±.063"(1.6mm) ANGLE ±0.5°				DR. BY DATE TR. BY DATE CH. BY DATE APP. BY DATE SCALE FULL	HUDSON INDUSTRIES CLAIMS PROPRIETARY RIGHTS IN THE MATERIAL DISCLOSED HEREIN. THIS DRAWING IS ISSUED IN CONFIDENCE FOR ENGINEERING INFORMATION ONLY AND MAY NOT BE REPRODUCED OR USED TO MANUFACTURE ANYTHING SHOWN HEREON WITHOUT THE DIRECT WRITTEN PERMISSION OF HUDSON INDUSTRIES.
		1	05/26/04	NT	REVISED THE Q-TY OF OIL STORAGE TANK	
		REV.	DATE	INIT.	DESC.	
		REPRO. FROM			COMPUTER FILE *	

HUDSON™ INDUSTRIES
439 NEILSER STREET
SHELBY, NC 28020
Ph: 704-480-0014
Fax: 704-482-9881

CS100H_OIL_WATER_SEPARATOR
P/N_00_198

SHEET 1 OF 5
INITIAL ISSUE
3/7/07
DWG. NO. 00_198 REV. 00

MODEL CS-100 COALESCING OIL/WATER SEPARATOR SPECIFICATIONS

CAPACITY: 100 GPM

DIMENSIONS: 12'L X 4'W X 6'H

EFFLUENT: As Low As 10 Mg/L

TEMPERATURE RANGE: 35°F - 140°F

PH RANGE: 2 - 12

TANK MATERIAL: 3/16" A36 Carbon Steel, All Welded Construction
Structural Angle and Channel Reinforced

TANK COATINGS: **INTERIOR -** High Performance Phenolic Epoxy to to 6-7 Mils DFT
EXTERIOR - Industrial Enamel to 6-7 Mils DFT, Gray in color

COALESCING MATERIAL: Preformed Modules of Corrugated PVC w/9600 FT/2, of Surface Area

OIL SKIMMER: Manually Adjustable Slotted Pipe Skimmer

HARDWARE: Stainless Steel

ELECTRICAL REQUIREMENTS: 230/460 V, 3 Ph, 60 Hz,

INLET PIPE SIZE: 6", 150# Flange

OUTLET PIPE SIZE: 8", 150# Flange

OIL OUTLET: 2" NPT

TANK DRAIN: 2" NPT

WEIGHT: **EMPTY -** 3,800 LBS
OPERATING - 16,000 LBS

P-02 5AIM5B0

with high eff motor

3656/3756 S-Group Numbering System For All Units Built After June 1, 1998

Sistema de numeración del Grupo S, modelos 3656/3756, para todas las unidades fabricadas luego del 1° de junio de 1998

The various versions of the 3656 and 3756 S-Group are identified by a product code number on the pump label. This number is also the catalog number for the pump. The meaning of each digit in the product code number is shown below.

Not all combinations of motor, impeller and seal options are available for every pump model. Please check with Goulds on non-cataloged numbers.

Not recommended for operation beyond printed H-Q curve. For critical application conditions consult factory.

Las diferentes versiones de los modelos 3656 y 3756 del Grupo S se identifican con un número de código de producto en la etiqueta de la bomba. Este número es también el número de catálogo de la bomba. A continuación se ilustra el significado de cada dígito en el código del producto.

No todas las combinaciones de motor, impulsor y sellos están disponibles para cada modelo. Consulte a Goulds sobre números que no aparecen en el catálogo.

No se recomienda la operación más allá de la curva impresa de H-Q (carga-capacidad). Para aplicaciones bajo condiciones críticas, consulte con la fábrica.

Example Product Code, *Ejemplo del código de producto*

9 BF 1 H 2 G 0 H

High Head Impeller (1½ x 2 – 6H Only), *Impulsor de carga alta (1½ x 2 – 6H únicamente)*

Mechanical Seal and O-ring, *Sello mecánico y anillo en O*

Type 21 Mechanical Seal, *Tipo 21 sello mecánico*					
Seal Code, *Código del Sello*	**Rotary, *Rotativo***	**Stationary, *Estacionario***	**Elastomers, *Elastómeros***	**Metal Parts, *Partes Metálicas***	**Part No., *Pieza Número***
0	Carbon, *Carbón*	Ceramic, *Cerámica*	BUNA-N	316 SS, *316 Acero inoxidable*	10K13
1		Sil-Carbide, *Carburo de silicona*	EPR		10K19
3			Viton		10K27
5	Sil-Carbide				10K64
9	Packed Box Design with BUNA O-Ring, *Diseño de prensaestopas empacado con anillo en O de BUNA*				15K16

Note: 10K27 replaces obsolete 10K25, ***Nota:** La 10K27 reemplace la obsoleta 10K25.*

Impeller Option Code, *Código de opción de impulsor*

Impeller Code, *Código del impulsor*	22BF	9BF	3BF		5BF	4BF	6BF
	1 x 2 – 7	1 x 2 – 8	1½ x 2 – 6	1½ x 2 – 6H	1½ x 2 – 8	2½ x 3 – 7	3 x 4 – 7
	Dia.	Dia.	Dia.	Dia.	Dia.	Dia.	Dia.
A	6¾"	8 1/16"	5 15/16"	5 15/16"	8 1/16"	7 1/16"	7 1/16"
B	6 7/16	7⅜	5⅝	5⅝	7⅛	6⅞	6⅞
C	6	7 5/16	5⅛		6¾	6 5/16	5½
D	5¾	7	4¾		5¾	6	4 11/16
E	5½	6½			7¾	5 11/16	5⅛
F	5 1/16	6 3/16			7	5 5/16	6
G	4 13/16	5⅜			6¼	5 3/16	
H	4 9/16	5⅛			6⅛	4¾	
J	4⅜					4½	
K	4 1/16					4 1/16	
L	3 13/16						

Driver, *Elemento motor*

1 = 1 PH, *fase*, ODP 4 = 1PH, *fase*, TEFC 7 = 3 PH, *fases*, XP 0 = 1 PH, *fase*, XP
2 = 3 PH, *fases*, ODP 5 = 3 PH, TEFC 8 = 575 V, XP
3 = 575 V, ODP 6 = 575 V, TEFC 9 = 3 PH, *fases*, TEFC, PREFF
1 PH, fase = Monofásico; 3 PH, fases = Trifásico

HP Rating, *Potencia nominal, HP*

C = ½ HP F = 1½ HP J = 5 HP M = 15 HP
D = ¾ HP G = 2 HP K = 7½ HP N = 20 HP
E = 1 HP H = 3 HP L = 10 HP

Driver: Hertz/Pole/RPM, *Elemento motor: Hertz/Polos/RPM*

1 = 60 Hz, 2 pole, 3500 RPM 4 = 50 Hz, 2 pole, 2900 RPM
2 = 60 Hz, 4 pole, 1750 RPM 5 = 50 Hz, 4 pole, 1450 RPM
3 = 60 Hz, 6 pole, 1150 RPM

For frame mounted version, substitute the letters "FRM" in these positions.

Para las versiones de montaje en bastidor, reemplazar las letras en esta ubicación con "FRM".

Material, *Material*

BF = Bronze fitted, *Accesorios de bronce* AI = All iron, *Todo hierro* AB = All bronze, *Todo bronce*

Pump Size, *Tamaño de bomba*

3 = 1½ x 2 – 6(H) 5 = 1½ x 2 – 8 9 = 1 x 2 – 8
4 = 2½ x 3 – 7 6 = 3 x 4 – 7 22 = 1 x 2 – 7

The 1 x 2 – 8 and 1 x 2 – 7 are only available in Bronze Fitted.
Los tamaños 1 x 2 – 8 y 1 x 2 – 7 están disponibles con accesorios de bronce únicamente.

GOULDS PUMPS

Performance Data

3656 S All Iron

End Suction Cast Iron Pumps

MODEL : 5AI1M5B0(7.3125)

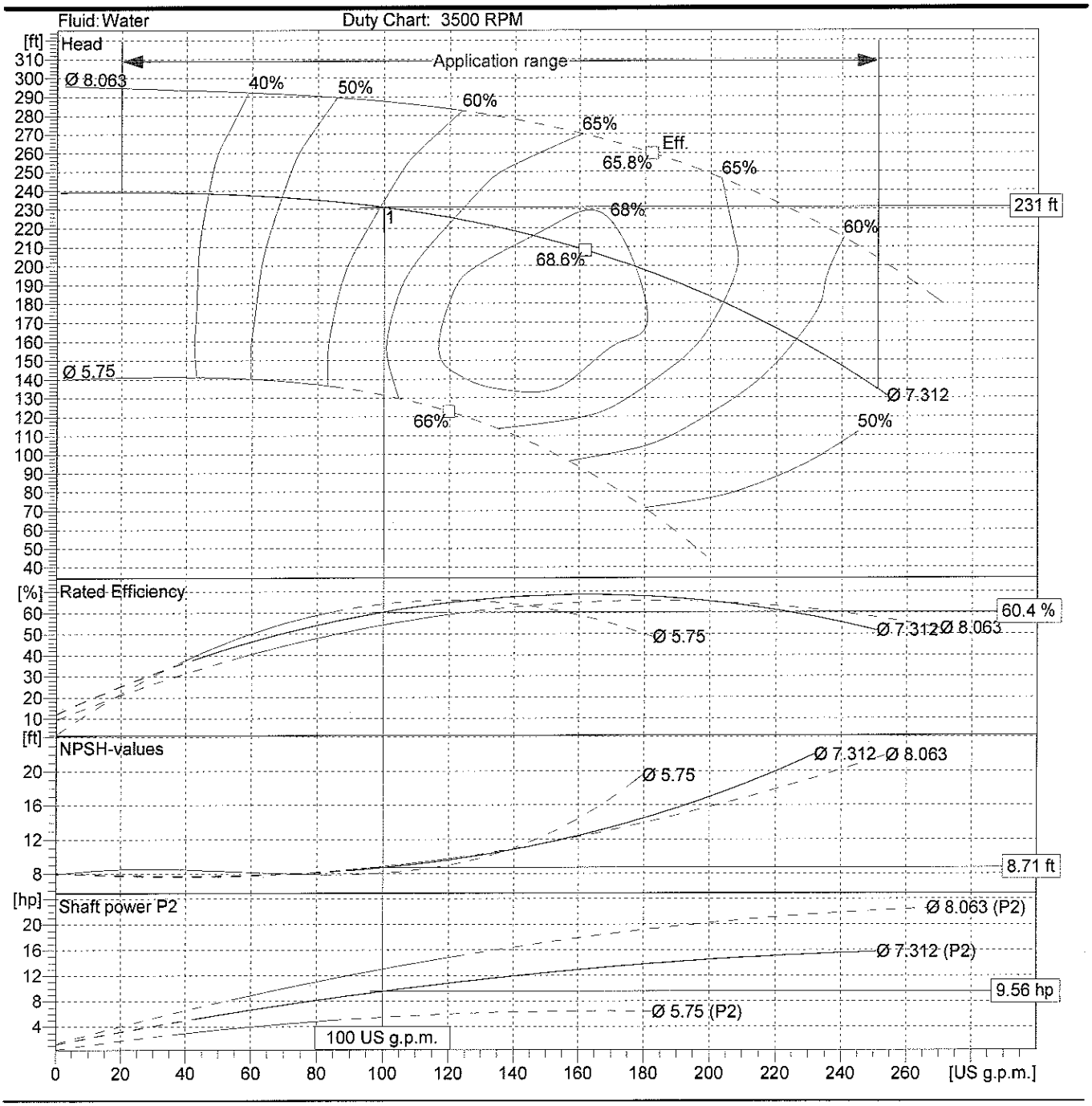
Hydraulic Data					Motor Data	3656/3756 S Group	Qty.
Maximum Flow	Flow at Duty Point	Maximum TDH	TDH at Duty Point	$NPSH_R$	Voltage / Phase / Enclosure	Model	
254 US g.p.m.	100 US g.p.m.	239 ft	231 ft	9 ft	460V 3PH TEFC	5AI1M5B0(7.3125)	1

Submittal Prepared for: _____ Job: _____

Engineer: _____ Contractor: _____

Submittal Prepared by: _____ Company: _____

Submittal Date: 2008-08-26 Approved by: _____ Date: _____



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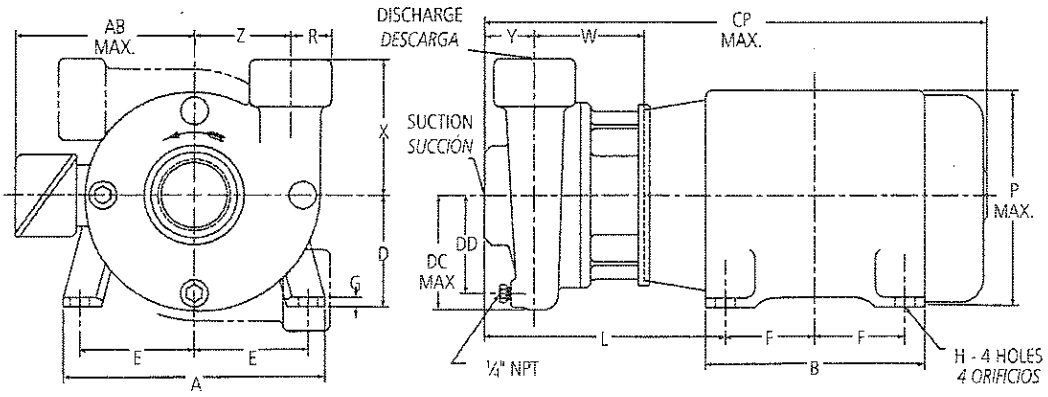


Pump Dimensions and Weights (Dimension "L" determined by Pump and Motor)
Peso y dimensiones de la bomba *(la dimensión "L" está determinada por la bomba y el motor)*

Pump *Bomba*	Suction *Succión*	Discharge *Descarga*	CP Max.	DC Max.	DD	R	W	X	Y	Z	Wt. (lbs.) *Pesos (libras)*	Motor Frame Size, *Bastidor*			
												140	180	210	250
												L			
1 x 2 – 7	2	1	27	4¼	3½	1 1/16	4⅛	5½	3	4	52	10	10¾	—	—
1 x 2 – 8					4		3 15/16	5¾	3 5/16	4¼	52			—	—
1½ x 2 – 6		1½	23¾		3½	1¼	4¼	4½	2⅝	3½	34	9¾	10½	—	—
1½ x 2 – 8			27⅛	5⅜	4⅝			5		4¼	54			11⅜	11⅜
2½ x 3 – 7	3	2½	25⅝	5⅛	4½	1 13/16		6	3	4	49	10⅛	10¾	11¾	—
3 x 4 – 7	4*	3*	25¼	5¾	5⅛	3¾	4⅜		2½	4½	82	9¾	10⅜	11⅜	—

*For use with ANSI class 150 mating flange. All others are NPT connections.
** Para uso con brida de contacto ANSI clase 150. Todas las demás son conexiones NTP.*

Motor Dimensions and Weights (may vary with manufacturer)*
Peso y dimensiones del motor *(pueden variar de acuerdo al fabricante) **

Frame Size JM *Tamaño del bastidor JM*	A	AB (Max.)	B	D	E	F	G	H	P (Max.)	Weight (lbs.) *Pesos (libras)*
143	6½	5¼	6	3½	2¾	2	⅛	11/32	6⅜	41
145						2½				57
182	8½	5⅞	6½	4½	3¾	2¼	3/16	13/32	7⅛	77
184						2¾				97
213	9½	7⅜	8	5¼	4¼	2¾	1/32	13/32	9⅝	122
215						3½				155
254 TCZ	11¼	9	9½	6¼	5	4⅛	¼	17/32	11½	265
256 TCZ			11¾			5				320

NOTE:
All pumps shipped in vertical discharge position. May be rotated in 90° increments. Tighten casing bolts to 25 ft./lbs. torque.

NOTA:
Todas las bombas se embarcan con la descarga en posición vertical. Esta posición puede rotarse en incrementos de 90°. Ajustar los pernos de la carcasa a una torsión de 25 pies/libras.

Motor Frames and Horsepower
Bastidores del motor y potencia en HP

Motor Frame *Bastidor del motor*	3500 RPM				1750 RPM			
	1 Phase		3 Phase		1 Phase		3 Phase	
	ODP	TEFC	ODP	TEFC	ODP	TEFC	ODP	TEFC
143	—	¾, 1, 1½	¾, 1, 1½	¾, 1, 1½	—	½, ¾	½, ¾, 1	½, ¾, 1
145	—	2	2, 3	2, 3	—	1, 1½	1½, 2	1½, 2
182	3	3	5	3	3	2, 3	3	3
184	5	3, 5	7½	5	—	—	5	5
213	7½	—	10	7½	5	—	7½	7½
215	10	—	15	10, 15	—	—	—	—
254TCZ	—	—	20	—	—	—	—	—
256TCZ	—	—	25	20, 25	—	—	—	—

All dimensions in inches and weights in lbs. Do not use for construction purposes.
Todas las dimensiones están en pulgadas, el peso en libras. No utilizar para fines de construcción.

P-03 1GAI2J5C Ø
w/ m high eff. motor

3656/3756 M & L-Group Numbering System
Sistema de numeración del Grupo M y L, modelos 3656/3756

The various versions of the 3656 and 3756 M & L-Group are identified by a product code number on the pump label. This number is also the catalog number for the pump. The meaning of each digit in the product code number is shown below. Not all combinations are possible; consult your Goulds Pumps distributor for specific requirements.

Las diferentes versiones de los modelos 3656 y 3756 del Grupo M Y L se identifican con un número de código de producto en la etiqueta de la bomba. Este número es también el número de catálogo de la bomba. A continuación se ilustra el significado de cada dígito en el código del producto. No todas las combinaciones son posibles, consulte a su distribuidor Goulds Pumps para requisitos específicos.

Example Product Code, *Ejemplo del código de producto*

11 BF 2 L 5 A 0

Mechanical Seal/Packed Box and O-ring Material, *Materiales del sello mecánico/empaque y anillo en O*

For Optional Mechanical Seal modify catalog order no. with Seal code listed below.
Para sellos mecánicos optativos, modificar el número de pedido del catálogo con los códigos de sello que se indican a continuación.

Seal Code, *Código del Sello*	Rotary, *Rotativo*	Stationary, *Estacionario*	Elastomers, *Elastómeros*	Metal Parts, *Partes Metálicas*	Part No., *Pieza Número*		
					M-Group, *Grupo-M*		L-Group, *Grupo-L*
					1.25" Shaft	1.625" Shaft	
0	Carbon, *Carbone*	Ceramic, *Cerámica*	BUNA-N	316 SS, *316 Acero inoxidable*	10K13	10K16	10K84
1		Sil-Carbide, *Carburo de silicona*	EPR		10K19	10K20	NA
3			Viton		10K27	10K45	10K112
5	Sil-Carbide				10K64	10K65	10K144
8A*					NA	NA	
8B**					10K64	10K65	
9***	Packed Box Design with BUNA O-Ring, *Diseño de prensaestopas empacado con anillo en O de BUNA*				15K17	15K3	15K4

* Prime-Safe option with oiler, *Opción Primero-Segura con el engrasador* ** Prime-Safe option with grease, *Opción Primero-Segura con la grasa*
*** All Packed Box Units use JP style motors, *Todas las unidades de prensaestopas empacado utilizan motores estilo JP*

Impeller Option Code, *Código de opción de impulsor*

■ Indicates L-Group pump (1780 RPM, 60 to 150 HP) • For 1180 RPM Close-Coupled applications only.
■ *Indica una bomba Grupo "L". (1780 RPM, de 60 a 150 HP)* • *Para aplicaciones de acople cerrado de 1180 RPM únicamente.*

Impeller Code, *Código del impulsor*	M-Group Pump Size, *Tamaño de la bomba*										
	8	7	11	13	16	12	14	10	17	15	21
	Dia.	Dia.	Dia.	Dia.	Dia.	Dia.	Dia.	Dia.	Dia.	Dia.	Dia.
A	10 1/16"	7 13/16"	10 1/16"	13 1/16"	8 1/16"	10 1/16"	13 1/16"	7 1/8"	10 1/16"	12 7/8"	10 1/16"
B	9 1/16	7 7/16	9 1/8	12 3/4	7 1/16	9 1/2	12 9/16	7 3/8	9 9/16	12 1/2	9 1/8
C	8 1/8	7 3/16	9 1/16	11 7/8	7 1/16	9	12 1/16	7 1/2	9 1/8	12 1/8	9 1/2
D	7 3/4	6 13/16	9	11 3/8	6 7/8	8 3/8	12	7 1/4	8 11/16	11 7/8	9 1/4
E	7 1/4	6 3/8	8 3/8	9 7/8	6 1/8	8 1/8	11 3/4	7	8 1/8	11 3/8	8 15/16
F	7	6 1/16	8 1/4	9 1/2	5 15/16	7 7/8	11 5/16	6 1/4	7 3/4	11 1/16	8 1/8
G			8		5 1/2	*9 1/8	10 1/4	6 1/8		10 7/8	8 1/16
H			7 7/8		5 1/8	*8 3/4	10 1/8	6 1/16		10 1/2	8
J			7 7/8		4 7/8	*8 9/16	9 1/8	5 3/4		10 1/16	7 11/16
K						*8 1/2	8 11/16			9 7/8	
L						*7 7/8	8			9 3/4	
M						*7 7/8	7 7/8			13 1/16	
N						*7 1/4					
P						*7 1/16					
Q											
R						*6 1/4					

L-Group Pump Size, *Tamaño de la bomba*		
18	19	20
Dia.	Dia.	Dia.
■13"	■13"	■16"
■12 1/2	■12 3/4	■15 5/8
■12 7/16	■12 5/8	■15 5/16
■11 7/8	■11 15/16	■14 1/2
11 5/8	■11 11/16	■13 3/4
11 1/4	■11 1/4	
10 7/8	■10 7/8	
10 1/2	■9 13/16	
10	•13	
9 1/2	•12 3/4	
•13	•12 5/8	
•12 1/2	•11 15/16	
•12 5/16	•11 11/16	
•11 7/8	•11 1/4	
	•10 7/8	
	•9 13/16	

Driver, *Elemento motor*
1 = 1 PH, ODP 3 = 575 V, ODP 5 = 3 PH, TEFC 7 = 3 PH, XP 9 = 3 PH, TEFC, Premium efficiency
2 = 3 PH, ODP 4 = 1PH, TEFC 6 = 575 V, TEFC 8 = 575 V, XP
1PH = monofásico, 3PH = trifásico 0 = 1 PH, XP *Eficiencia superior*

HP Rating, *Potencia nominal, HP*
G = 2 J = 5 L = 10 N = 20 Q = 30 S = 50 U = 75 W = 125
H = 3 K = 7½ M = 15 P = 25 R = 40 T = 60 V = 100 X = 150

Driver: Hertz/Pole/RPM, *Elemento motor: Hertz/Polos/RPM*
1 = 60 Hz, 2 pole, 3500 RPM 3 = 60 Hz, 6 pole, 1180 RPM 5 = 50 Hz, 4 pole, 1450 RPM
2 = 60 Hz, 4 pole, 1750 RPM 4 = 50 Hz, 2 pole, 2900 RPM

Material (Packed Box in AI or BF), ***Material*** *(Caja prensaestopas en AI o BF)*
AI = All iron BF = Bronze fitted *AI = Todo hierro BF = con accesorios de bronce*

Pump Size, *Tamaño de bomba*
8 = 1½ x 2 – 10 11 = 2½ x 3 – 10 12 = 3 x 4 – 10 10 = 4 x 5 – 8 16 = 3 x 4 – 8
18 = 6 x 8 – 13 19 = 8 x 10 – 13 20 = 4 x 6 – 16 21 = 2½ x 3 – 9
7 = 2½ x 3 – 8 13 = 2½ x 3 – 13 14 = 3 x 4 – 13 15 = 4 x 6 – 13 **17 = 4 x 6 – 10 (BF Only)** ***(Accesorios de bronce únicamente)***

* Indicates 3500 RPM impeller for the 3 x 4 – 10, all others are 1750 RPM.
** Indica un impulsor de 3500 RPM para el 3 x 4 – 10, todos los demás son de 1750 RPM.*

Drive Options, *Opciones de mando*

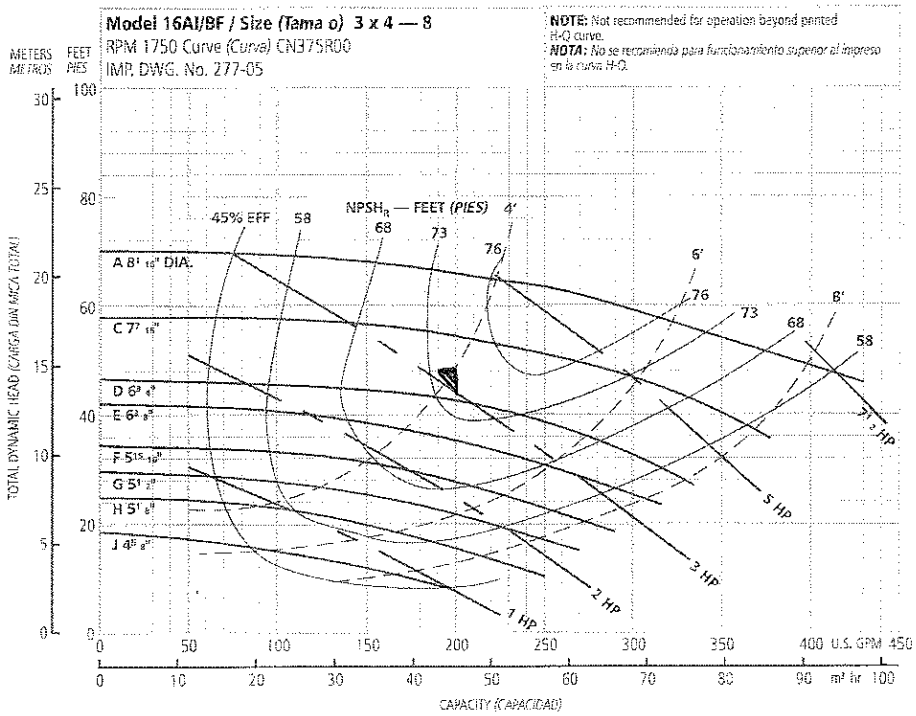
Substitute, *Substituto*	Description, *Descripción*
FRM	Bearing frame mount, Montaje del bastidor del cojinete
SAE1	SAE #1 mount, Montura SAE #1
SAE2	SAE #2 mount, Montura SAE #2
	SAE #3 mount, Montura SAE #3
SAE4	SAE #4 mount, Montura SAE #4
	SAE #5 mount, Montura SAE #5

SAE drive number is determined by the engine flywheel housing size.
El número del mando SAE se determina por el tamaño de la caja del volante del motor.

P-03

16AI2J5C∅

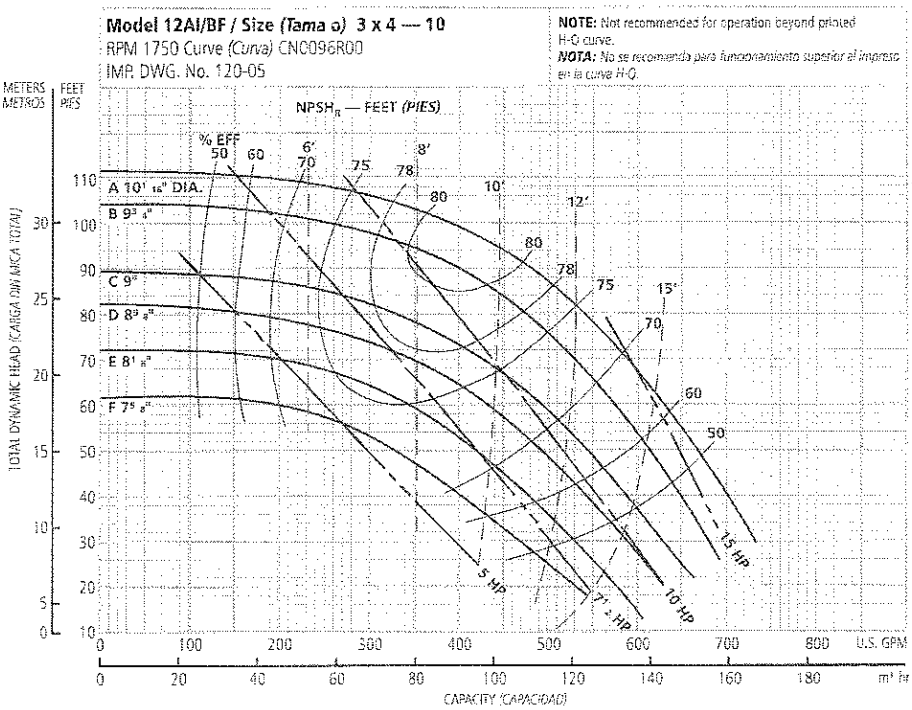
Performance Curves – 60 Hz, 1750 RPM
Curvas de desempeño – 60 Hz, 1750 RPM



Optional Impeller *Impulsor optativo*	
Ordering Code *Código de pedido*	**Dia.** *Diá.*
A	8 1⁄16"
C	7 7⁄16
D	6¾
E	6⅜
F	5 15⁄16
G	5½
H	5⅛
J	4⅞

NOTE: Pump will pass a sphere to ⅜" diameter.

NOTA: *La bomba dejará pasar una esfera de hasta ⅜ de pulgada de diámetro.*

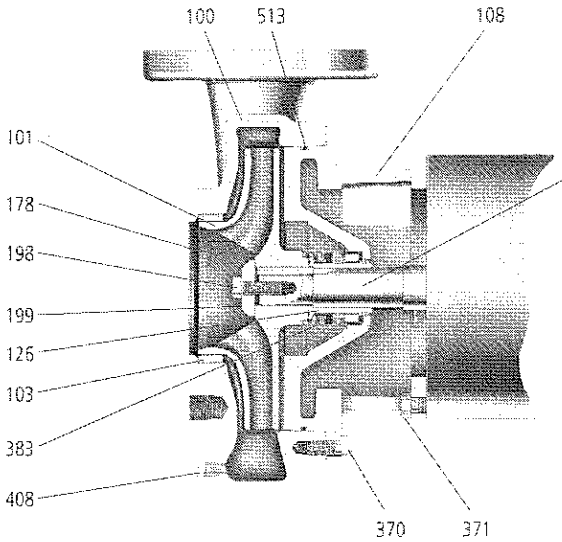


Optional Impeller *Impulsor optativo*	
Ordering Code *Código de pedido*	**Dia.** *Diá.*
A	10 1⁄16"
B	9 ¼
C	9
D	8⅝
E	8⅛
F	7⅝

NOTE: Pump will pass a sphere to ⅜" diameter.

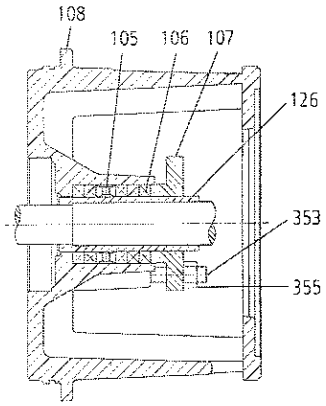
NOTA: *La bomba dejará pasar una esfera de hasta ⅜ de pulgada de diámetro.*

3656 M & L-Group Materials of Construction
Materiales de construcción - Grupo M y L, modelo 3656



ANSI 1045 steel motor shaft extension (typical)

ANSI 1045 Extensi n del eje del motor de acero t pica)



Packed Box Arrangement
Caja prensaestopas

Item No. *No. Ítem*	Description *Descripción*	Materials, *Materiales* All Iron *Todo hierro*	Bronze Fitted *Accesorios de bronce*
100	Casing, *Carcasa*	1001	1003
101	Impeller, *Impulsor*		1101
103	Casing wear ring, *Anillo de desgaste de la carcasa*		1618
108	Adapter/seal housing, *Adaptador/Cubierta del sello*		1001
126	Shaft sleeve, *Camisa del eje*	AISI Type 300 Series SS *Acero inoxidable serie AISI tipo 300*	
178	Impeller key, *Chaveta del impulsor*		
198	Impeller bolt, *Tornillo del impulsor*		
199	Impeller washer, *Arandela del impulsor*		
370	Hex head cap screw (adapter to case), *Tornillo de cabeza hexagonal (del adaptador a la cubierta)*	Steel Zinc Platted Grade 5 *Acero SAE 1200 grado 5*	
371	Hex head cap screw (adapter to motor), *Tornillo de cabeza hexagonal (del adaptador al motor)*		
383	Mechanical seal, *Sello mecánico*	See seal chart, *Ver tabla del sello*	
408	Pipe plug ¼" or ⅜", *Tapón de tubos de ¼ de pulgada ó ⅜ de pulgada*	Zinc Platted Steel *Zinc Platted Steel*	
513	O-ring, *Anillo en O*	BUNA-N – Standard, EPR – Optional Viton – Optional	

Material Code *Código de material*	Engineering Standard *Norma de ingeniería*
1003	Cast iron ASTM A48 CL30 *Hierro fundido ASTM A48 CL20*
1618	Bismuth Bronze – Lead Free, *Bismuth Bronze – Lead Free*
1001	Cast iron ASTM A48 CL20 *Hierro fundido ASTM A48 CL20*
1101	ASTM B584, Modified C87500 – Lead Free *ASTM B584, modified C87500 – Lead Free*

Packed Box Arrangement, *Caja prensaestopas*

Item No. *No. Ítem*	Description *Descripción*	Materials *Materiales*
105	Lantern ring *Aro de linterna*	Teflon®
106	Packing, 5 rings *Empaquetadura, 5 aros*	Teflon Impregnated *Impregnado de Teflon*
107	Gland, *Casquillo*	AISI 316SS
126	Shaft sleeve *Camisa del eje*	AISI Type 300 Series Stainless Steel *Acero inoxidable serie AISI tipo 300*
353	Gland stud *Perno del casquillo*	
355	Gland nut *Tuerca del casquillo*	

NOTE:
Seal housing wear ring (item number 203) not shown. See repair parts page for detail. (Required for all models except 3 x 4 – 10.)

NOTA:
El anillo de desgaste del compartimiento de sello (ítem número 203) no se muestra. Consulte la página de piezas de repuesto para mayor detalle. (Se requiere para todos los modelos con excepción del 3 x 4 – 10).

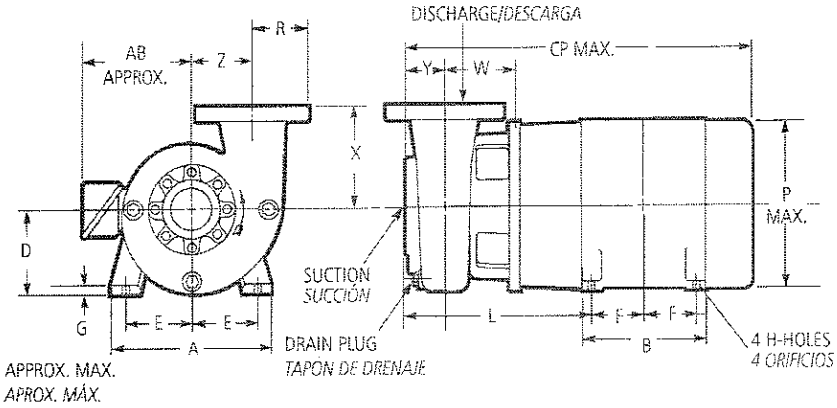
Mechanical Seal Chart, Type 21, *Tabla para sello mecánico, tipo 21*

Item No., *No. Ítem*	Part No., *Pieza Número* M-Group, *Grupo-M* 180JM-210JM 180JP-210CZ*	250JM-360TCZ 210JP-360TCZ* M Bearing Frame, *Bastidor de cojinetes M*	L-Group, Grupo-L All motors, *Todos los motores* L Bearing Frame, *Bastidor de cojinetes L*	Rotary, *Rotativo*	Stationary, *Estacionario*	Elastomers, *Elastómeros*	Metal Parts, *Partes Metálicas*	Intended Duty, *Servicio previsto*
383	10K13	10K16	10K84	Carbon, *Carbone*	Ceramic, *Cerámica*	BUNA-N	316 SS, *316 Acero inoxidable*	Standard, *Estándar*
	10K19	10K20	Consult Factory, *Consultar con la fábrica*		Sil-Carbide, *Carburo de silicona*	EPR		High Temp, Caustic, *Alta temp/Caustic*
	10K27	10K45	10K112			Viton		Abrasive, *Abrasivo*
	10K64	10K65	10K144	Sil-Carbide				
	15K17	15K3	15K4	Packed Box Design with BUNA O-Ring, *Diseño de prensaestopas empacado con anillo en O de BUNA*				

* All Packed Box units use JP style motors. *Todas las unidades de prensaestopas empacado utilizan motores estilo JP.*

3656 M & L-Group Dimensions and Weights
Grupo M y L, modelo 3656 - Peso y dimensiones

Mechanical Seal
Sello mecánico



NOTE:
1. All pumps shipped in vertical discharge position. For other orientations, remove casing bolts, rotate to desired position, and tighten ⅜- 16 casing bolts to 37 ft./lbs. torque., ½- 13 casing bolts to 90 ft./lbs. torque.
2. Dimensions in inches, weight in pounds.
3. Not to be used for construction purposes.

NOTA:
1. Todas las bombas se embarcan con la descarga en posición vertical. Para otras orientaciones, retire los pernos de la carcasa, haga rotar la descarga hasta la posición deseada y ajuste los 16 pernos de ⅜ de pulgada a una torsión de 37 pies/libra, y los 13 pernos de ½ pulgada a 90 pies/libra.
2. Dimensiones en pulgadas, peso en libras.
3. No utilizar con fines de construcción.

Pump Dimensions and Weights (Dimension "L" determined by Pump and Motor)
Peso y dimensiones de la bomba *(la dimension "L" esta determinada por la bomba y el motor)*

Pump *Bomba*	Suction *Succión*	Discharge *Descarga*	CP *Max.*	DC *Max.*	DD	R	NPT Drain *Drenaje NPT*	W	X	Y	Z	Weight (lbs) *Pesos (libras)*	L — Motor Frame, *Bastidor del motor*					
													140	180	210	250/280	320	360
1½ x 2 –10	2*	1½*	30¼	6¾	5⅞	1¼	1¼	5	6	3	5½	93	10⅞	11½	12½	12¾	–	–
2½ x 3 – 8	3*	2½*	30¼	6¼	5¼	1 15/16		5⅛		3⅜	5	78	11⅜	12	13	13¼	–	–
2½ x 3 – 9	3	2½	33½	7⅛	6	3½	⅜	5	7½	2¼	5½	85	10⅝	11¼	12¼	12½	13	13⅝
2½ x 3 – 10																		
2½ x 3 – 13			30¼	8⅛	7⅝				9	3	7½	139	–	–	12½	12¾	–	–
3 x 4 – 8	4	3	30 15/16	6¼	5⅜		¼	5 5/16	7	3	5¾	82	11 5/16	11 13/16	12 13/16	13 1/16	13⅜	–
3 x 4 – 10			30⅜	7⅜	6½	3¾		5⅛	7½		5½	99	11	11⅝	12⅝	12⅞	–	–
3 x 4 – 13			33¼	9¼	8⅛			5	9		7½	155	–	–	12½	12¾	–	–
4 x 5 – 8	5	4	34¼	6¼	5¾	4½	⅜	5½	8	3	5	99	11⅜	12	13	13¼	13¾	14⅜
4 x 6 – 10	6		30⅛	8⅝	7½			5½	8½	3⅛	7	135	–	–	13⅛	13⅜	–	–
4 x 6 – 13			32	9¾	8⅛			5¼	9	3	7½	171	–	–	12½	12¾	13¼	–
6 x 8 – 13 8 x 10 – 13 4 x 6 – 16	See Packed Box Dimension Page. (pumps utilize JP motors), *Ver la página de dimensiones de la caja empacada. (JP motors)*																	

*Denotes NPT connection. All other connections are for use with ANSI class 150 mating flanges.
Dimensions in inches, weights in lbs. Do not use for construction purposes.
** Indica conexión NPT Las demás conexiones deben usarse con bridas de contacto ANSI clase 150.*
Dimensiones en pulgadas, peso en libras. No utilizar para fines de construcción.

Motor Dimensions and Weights (may vary with manufacturer)*
Pesos y dimensiones del motor *(pueden variar de acuerdo al fabricante)**

Motor Frame *Bastidor del motor*	A	AB (Max.)	B	D	E	F	G	H	P* (Max.)	Weight (lbs.) *Pesos (libras)*
143JM	6½	5¼	6	3½	2¾	2	⅛	5/16	6⅝	41
145JM										57
182JM	8⅛	5⅞	6⅛	4½	3¾	2¼	3/16	⅜	7⅞	77
184JM						2¾				97
213JM	9½	7¾	8	5¼	4⅛	2¾	¼	½	9¾	122
215JM						3½				155
213TCZ						2¾	3/16	⅜	9⅝	122
215TCZ						3½				155
254JM	11¼	9	9⅛	6¼	5	4⅛	¼	⅛	11½	265
256JM						5				320
284JM	12¼	12¼	10¾	7	5½	4¾	¼	½	13¼	419
286JM						5½				422
324JM	13¼	13¼	12	8	6¼	5½	5/16	⅝	15⅛	562
326JM						6				588
364TCZ	17½	15⅛	14½	9	7	5⅝	1	⅝	18⅜	775
365TCZ						6⅛				1005

Motor Frames and Horsepower
Bastidores del motor y potencia en HP

Frame Size JM *Tamaño del bastidor JM*	ODP	TEFC	RPM
143 JM	1	1	1750
145 JM	1½, 2	1½, 2	
182 JM	3	3	
184 JM	5	5	
213 JM	7½	7½	
215 JM, 215 TCZ	10	10	
254 JM	15	15	
256 JM	20	20	
284 JM	25	25	
286 JM	30	30	
324 JM	40	40	
326 JM	50	50	
143 JM	1½	1½	3500
145 JM	2, 3	2	
182 JM	5	3	
184 JM	7½	5	
213 JM	10	7½	
215 JM	15	10	
215 TCZ	15	–	
254 JM	20	15	
256 JM	25	20	
284 JM	30	25	
286 JM	40	30	
324 JM	50	40	
326 JM	60	50	
364 TCZ	75	60	
365 TCZ	–	75	

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GOULDS PUMPS
Residential Water Systems

GB NUMBERING SYSTEM

For optional motor enclosures, seals and three phase configurations use the following product code system.

Example Code

5 GB C 05 1 5 J 0

MECHANICAL SEAL AND O-RING
0 = Standard on Cast Iron and 4 = Standard on Stainless Steel.
For Optional Mechanical Seal modify catalog order no. with Seal Code listed below.

Mechanical Seal (⅝" seal)						
Seal Code	Rotary	Stationary	Elastomers	Metal Parts	Part No.	Casing O-Ring
0	Carbon	Ceramic	BUNA	18-8SS	10K10	BUNA
3		Sil-Carbide	EPR	316SS	10K18	EPR
4			Viton		10K55	Viton

NUMBER OF STAGES

A = 1	D = 4	G = 7	K = 10	N = 13	R = 16	U = 19	X = 22
B = 2	E = 5	H = 8	L = 11	P = 14	S = 17	V = 20	Y = 23
C = 3	F = 6	J = 9	M = 12	Q = 15	T = 18	W = 21	Z = 24

DRIVER
1 = 1 PH, ODP
2 = 3 PH, ODP
3 = 3 PH, 575V ODP
4 = 1 PH, TEFC
5 = 3 PH, TEFC

DRIVER: HERTZ/POLE/RPM
1 = 60 Hz, 2 pole, 3500 RPM
2 = 50 Hz, 2 pole, 2900 RPM

HP RATING
03 = ⅓ HP
05 = ½ HP
07 = ¾ HP
10 = 1 HP
20 = 2 HP
30 = 3 HP
50 = 5 HP

Note: ⅓ HP Single Phase unit is supplied with ½ HP mootr.

MATERIAL – DISCHARGE, HEAD AND SUCTION HOUSING
C = Cast Iron
S = Stainless Steel

PUMP MODEL
GB

GALLONS PER MINUTE
5 7 10 18 25 33

Note: Not recommended for operation beyond recommended range specified on H-Q curve.

For critical application conditions consult factory.

Note: Not all combinations of motor, impeller and seal options are available for every pump model. Please check with Goulds Pumps on non-cataloged numbers.

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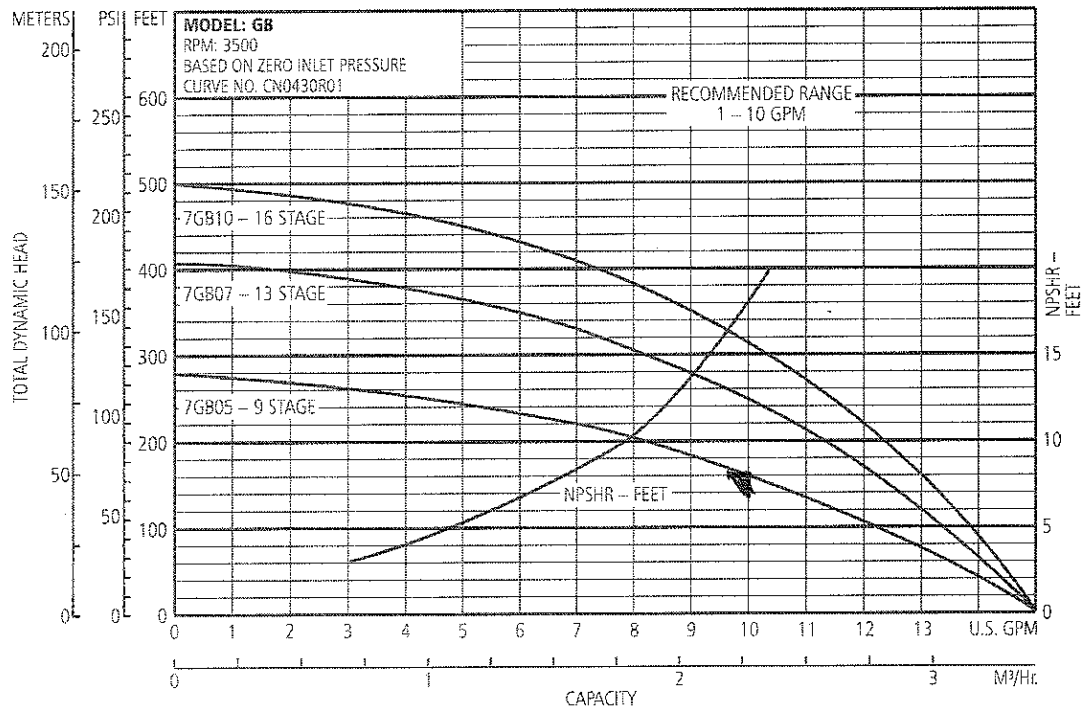
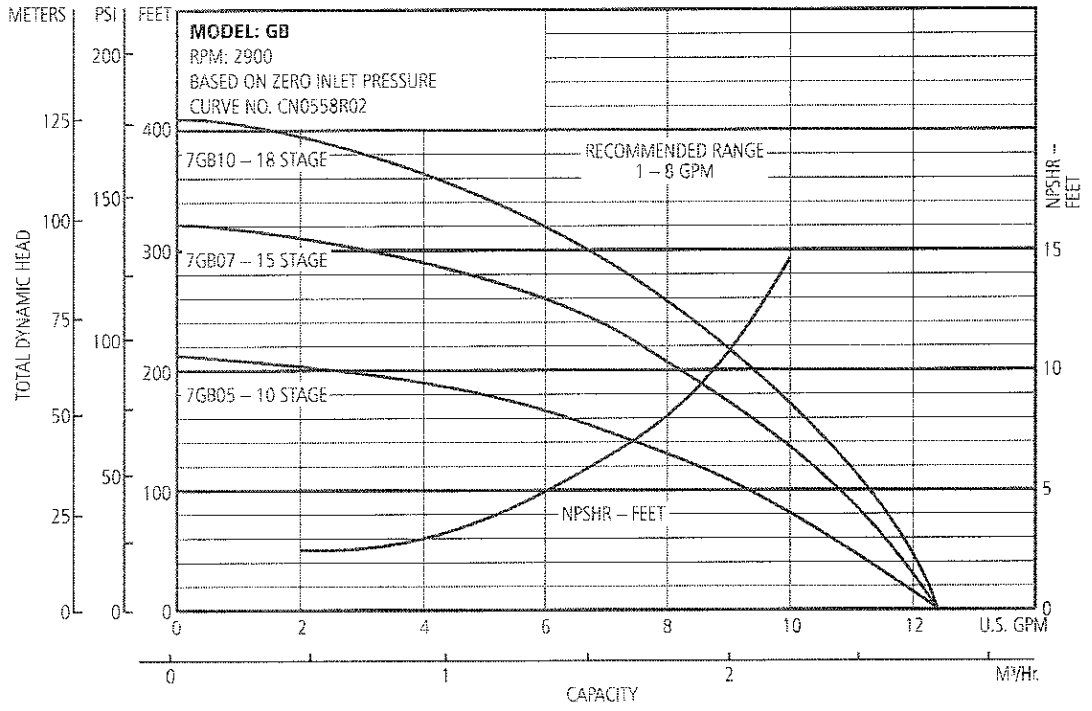
GOULDS PUMPS
Residential Water Systems

7GB PERFORMANCE CURVES





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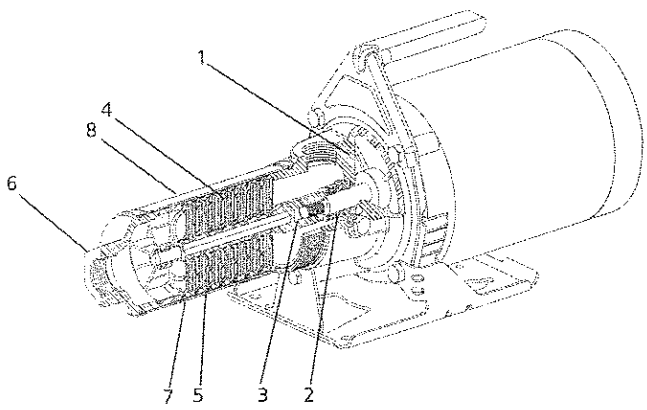
GOULDS PUMPS
Residential Water Systems

MATERIALS OF CONSTRUCTION

Item	Description	Material
1	Motor Adapter	Cast Iron or Cast 304 Stainless Steel
2	Mechanical Seal	0=Carbon/Ceramic/BUNA 3=Carbon/Silcar/EPR 4=Carbon/Silcar/Viton
3	Shaft Coupling	Stainless Steel
4	Impeller/Diffuser	Engineered Composite
5	Bowl	304 Stainless Steel
6	Discharge Head	Cast Iron or Cast 304 Stainless Steel
7	Hex Shaft	Stainless Steel
8	Casing	304 Stainless Steel



7GB SPECIFICATIONS

- Capacities: to 10 GPM.
- Maximum Flow: 10 GPM.
- Minimum Flow: 1 GPM.
- Heads: to 500 ft. (216 PSI).
- Pipe Connections: 1" NPT Suction and Discharge.

WARNINGS

- Pumps used on open spray applications must be plugged into electrical service which is protected by a Ground Fault Service Interruptor. Failure to do so may result in serious personal injury or death and property damage.
- Do not run pump dry.
- Do not run pump below minimum flow.
- If positive suction pressure is not available, be sure pump and suction line (with foot valve) are primed before starting pump.

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GOULDS PUMPS
Residential Water Systems

DIMENSIONS AND WEIGHTS FOR 60 HZ PUMPS

Size	Stages	L1 Approx.	L2 Approx.	HP	L3 Max.	Max. Wt. lbs.
5GB	7	9.19	11.19	⅓	10.5	41
	9	10.62	12.62	½	10.5	41
	14	15.12	17.12	¾	10.62	46
	17	17.12	19.12	1	11.25	50
7GB	9	11.88	13.88	½	10.5	41
	13	14.44	16.44	¾	10.62	46
	16	16.88	18.88	1	11.25	50
10GB	8	10.94	12.94	¾	10.62	46
	10	12.31	14.31	1	11.25	50
	15	15.81	17.81	1½	11.31	47
	17	17.19	19.19	2	12.06	67
18GB	5	9.69	11.69	¾	10.62	46
	7	11.38	13.38	1	11.25	50
	9	13.12	15.12	1½	11.31	47
	13	16.50	18.50	2	12.06	67
	15	18.25	20.25	3	13.03	69
25GB	5	10.12	12.12	¾	10.62	46
	7	12.00	14.00	1	11.25	50
	9	13.88	15.88	1½	11.31	47
	10	14.81	16.81	2	13.03	67
	14	18.56	20.56	3	13.03	69
33GB	5	11.77	13.77	1	11.25	51
	7	14.25	16.25	1½	11.31	55
	9	16.66	18.66	2	13.03	69
	13	21.47	23.47	3	13.03	70
	19	29.03	31.03	5	14.25	78

DIMENSIONS AND WEIGHTS FOR 50 HZ PUMPS

Size	Stages	L1 Approx.	L2 Approx.	HP	L3 Max.	Max. Wt. lbs.
5GB	7	9.19	11.19	⅓	10.5	41
	10	11.31	13.31	½	10.5	42
	16	16.50	18.50	¾	10.62	47
	19	18.50	20.50	1	11.25	51
7GB	10	12.60	14.60	½	10.5	42
	15	15.87	17.87	¾	10.62	47
	18	18.31	20.31	1	11.25	51
10GB	9	11.63	13.63	¾	10.62	47
	11	13.00	15.00	1	11.25	51
	17	17.19	19.19	1½	11.31	48
	23	21.32	23.32	2	12.06	68
18GB	8	12.23	14.23	1	11.25	51
	12	15.68	17.68	1½	11.31	48
	16	19.06	21.06	2	12.06	68
	23	25.07	27.07	3	13.03	70
25GB	5	10.12	12.12	¾	10.62	46
	7	12.00	14.00	1	11.25	50
	10	14.82	16.82	1½	11.31	48
	14	18.56	20.56	2	13.03	68
	21	25.13	27.13	3	13.03	70
33GB	6	13.00	15.00	1	11.25	52
	10	17.88	19.88	2	13.03	70
	14	22.69	24.69	3	13.03	71

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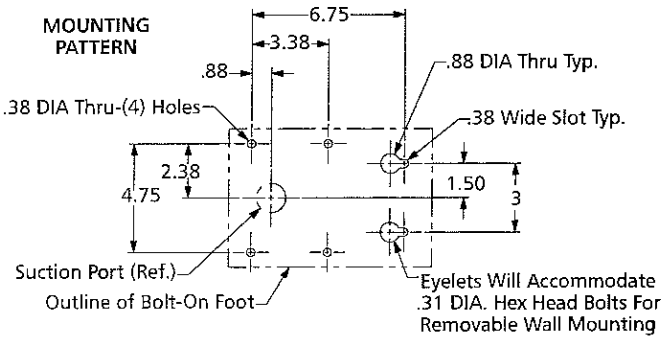
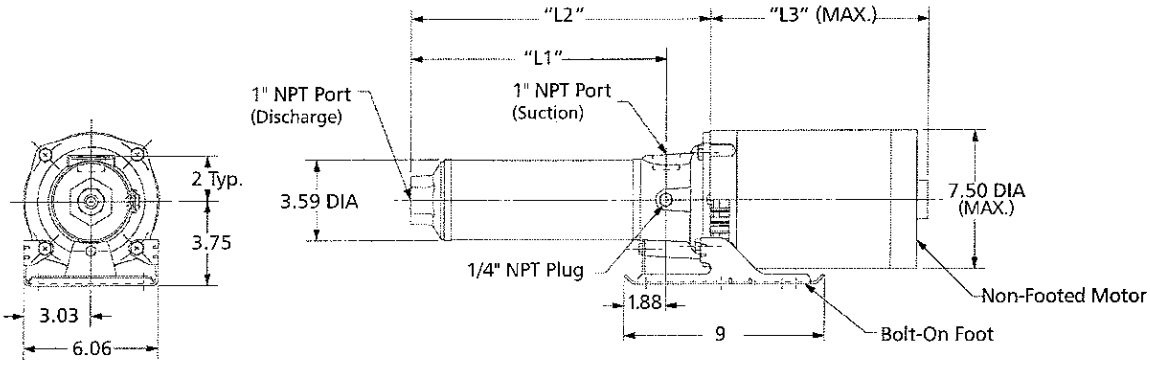
GOULDS PUMPS
Residential Water Systems

DIMENSIONS AND WEIGHTS FOR 60 HZ AND 50 HZ PUMPS





P-05 4AIL500

3656/3756 S-Group Numbering System For All Units Built After June 1, 1998

Sistema de numeración del Grupo S, modelos 3656/3756, para todas las unidades fabricadas luego del 1° de junio de 1998

The various versions of the 3656 and 3756 S-Group are identified by a product code number on the pump label. This number is also the catalog number for the pump. The meaning of each digit in the product code number is shown below.

Not all combinations of motor, impeller and seal options are available for every pump model. Please check with Goulds on non-cataloged numbers.

Not recommended for operation beyond printed H-Q curve. For critical application conditions consult factory.

Las diferentes versiones de los modelos 3656 y 3756 del Grupo S se identifican con un número de código de producto en la etiqueta de la bomba. Este número es también el número de catálogo de la bomba. A continuación se ilustra el significado de cada dígito en el código del producto.

No todas las combinaciones de motor, impulsor y sellos están disponibles para cada modelo. Consulte a Goulds sobre números que no aparecen en el catálogo.

No se recomienda la operación más allá de la curva impresa de H-Q (carga-capacidad). Para aplicaciones bajo condiciones críticas, consulte con la fábrica.

Example Product Code, *Ejemplo del código de producto*

9 BF 1 H 2 G 0 H

High Head Impeller (1½ x 2 – 6H Only), *Impulsor de carga alta (1½ x 2 – 6H únicamente)*

Mechanical Seal and O-ring, *Sello mecánico y anillo en O*

Type 21 Mechanical Seal, *Tipo 21 sello mecánico*					
Seal Code, *Código del Sello*	**Rotary, *Rotativo***	**Stationary, *Estacionario***	**Elastomers, *Elastómeros***	**Metal Parts, *Partes Metálicas***	**Part No., *Pieza Número***
0	Carbon, *Carbón*	Ceramic, *Cerámica*	BUNA-N	316 SS, *316 Acero inoxidable*	10K13
		Sil-Carbide, *Carburo de silicona*	EPR		10K19
3			Viton		10K27
5	Sil-Carbide				10K64
9	Packed Box Design with BUNA O-Ring. *Diseño de prensaestopas empacado con anillo en O de BUNA*				15K16

Note: 10K27 replaces obsolete 10K25, ***Nota:*** *La 10K27 reemplace la obsoleta 10K25.*

Impeller Option Code, *Código de opción de impulsor*

Impeller Code, *Código del Impulsor*	22BF	9BF	3BF		5BF	4BF	6BF
	1 x 2 – 7	1 x 2 – 8	1½ x 2 – 6	1½ x 2 – 6H	1½ x 2 – 8	2½ x 3 – 7	3 x 4 – 7
	Dia.	Dia.	Dia.	Dia.	Dia.	Dia.	Dia.
A	6¾"	8 1/16"	5 15/16"	5 15/16"	8 1/16"	7 1/16"	7 1/16"
B	6 1/16	7⅛	5⅛	5⅛	7⅛	6⅞	6⅞
C	6	7 5/16	5⅛		6¾	6¾	5½
D	5¾	7	4¾		5¾	6	4 11/16
E	5½	6½			7⅛	5 5/16	5⅛
F	5 1/16	6 3/16			7	5 7/16	6
G	4 13/16	5⅜			6¼	5 3/16	
H	4 3/16	5⅛			6⅛	4¾	
J	4⅜					4½	
K	4 1/16					4 1/16	
L	3 13/16						

Driver, *Elemento motor*

1 = 1 PH, *fase*, ODP 4 = 1PH, *fase*, TEFC 7 = 3 PH, *fases*, XP 0 = 1 PH, *fase*, XP
2 = 3 PH, *fases*, ODP 5 = 3 PH, TEFC 8 = 575 V, XP
3 = 575 V, ODP 6 = 575 V, TEFC 9 = 3 PH, *fases*, TEFC, PREFF
1 PH, fase = Monofásico; 3 PH, fases = Trifásico

HP Rating, *Potencia nominal, HP*

C = ½ HP F = 1½ HP J = 5 HP M = 15 HP
D = ¾ HP G = 2 HP K = 7½ HP N = 20 HP
E = 1 HP H = 3 HP L = 10 HP

For frame mounted version, substitute the letters "FRM" in these positions.

Para las versiones de montaje en bastidor, reemplazar las letras en esta ubicación con "FRM".

Driver: Hertz/Pole/RPM, *Elemento motor: Hertz/Polos/RPM*

1 = 60 Hz, 2 pole, 3500 RPM 4 = 50 Hz, 2 pole, 2900 RPM
2 = 60 Hz, 4 pole, 1750 RPM 5 = 50 Hz, 4 pole, 1450 RPM
3 = 60 Hz, 6 pole, 1150 RPM

Material, *Material*

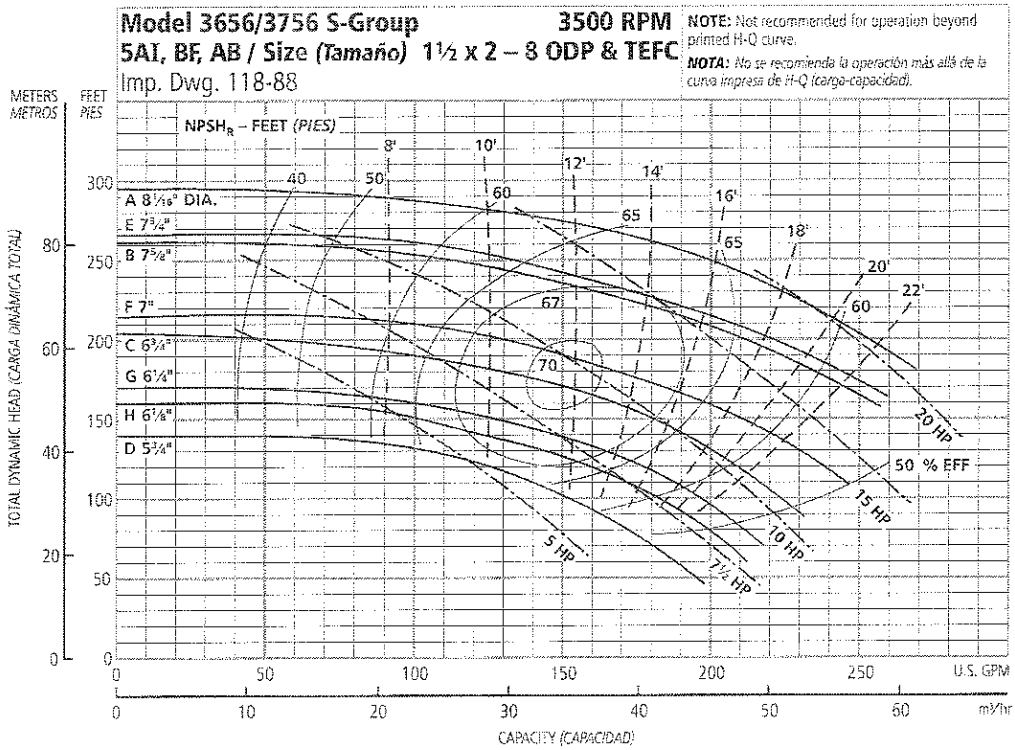
BF = Bronze fitted, *Accesorios de bronce* AI = All iron, *Todo hierro* AB = All bronze, *Todo bronce*

Pump Size, *Tamaño de bomba*

3 = 1½ x 2 – 6(H) 5 = 1½ x 2 – 8 9 = 1 x 2 – 8
4 = 2½ x 3 – 7 6 = 3 x 4 – 7 22 = 1 x 2 – 7

The 1 x 2 – 8 and 1 x 2 – 7 are only available in Bronze Fitted.
Los tamaños 1 x 2 – 8 y 1 x 2 – 7 están disponibles con accesorios de bronce únicamente.

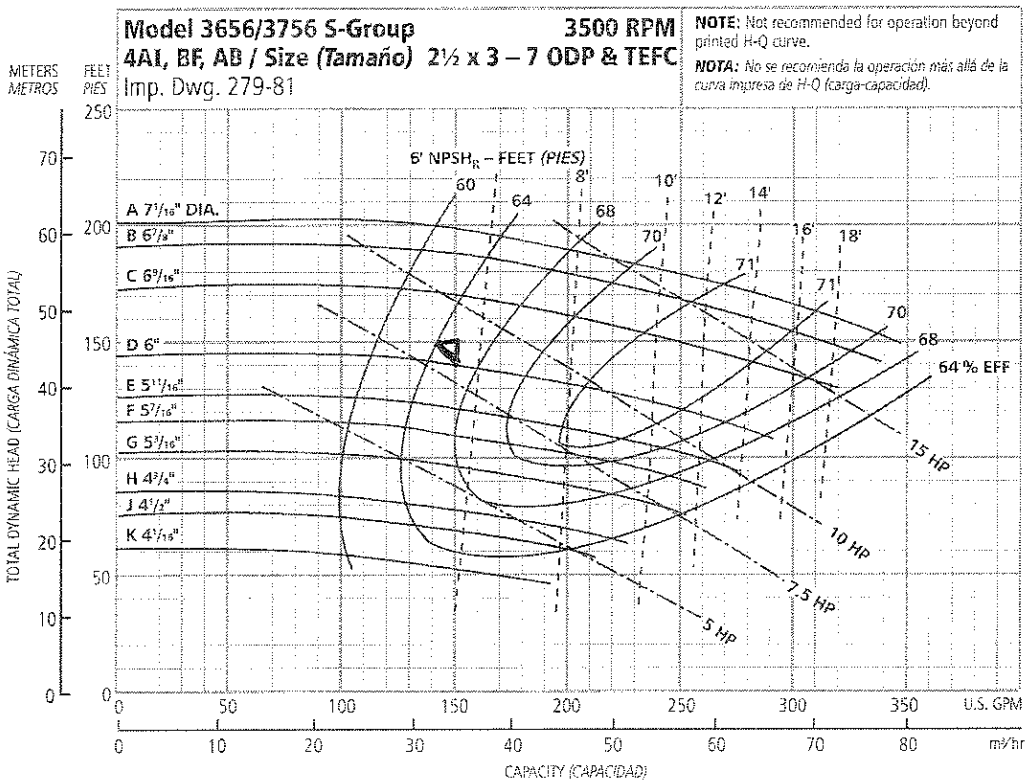
Performance Curves – 60 Hz, 3500 RPM
Curvas de desempeño – 60 Hz, 3500 RPM



Optional Impeller *Impulsor optativo*	
Ordering Code *Código de pedido*	**Dia.** *Diá.*
A	8 1/16"
E	7 3/4"
B	7 5/8
F	7
C	6 3/4
G	6 1/4
H	6 1/8
D	5 3/4

NOTE: Pump will pass a sphere to 5/16" diameter.

NOTA: La bomba dejará pasar una esfera de hasta 5/16 de pulgada de diámetro.

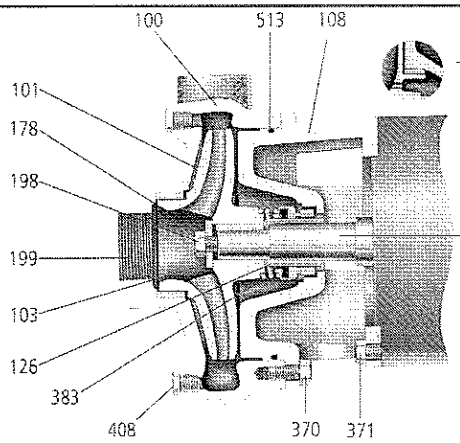


Optional Impeller *Impulsor optativo*	
Ordering Code *Código de pedido*	**Dia.** *Diá.*
A	7 1/16"
B	6 7/8
C	6 9/16
D	6
E	5 11/16
F	5 7/16
G	5 3/16
H	4 3/4
J	4 1/2
K	4 1/16

NOTE: Pump will pass a sphere to 7/16" diameter.

NOTA: La bomba dejará pasar una esfera de hasta 7/16 de pulgada de diámetro.

3656 S-Group Materials of Construction
Materiales de construcción - Grupo S, modelo 3756



Back wearing ring on S-Group (2½ x 3 – 7) only
Anillo de desgaste posterior en el Grupo S (2½ x 3 – 7) únicamente.

AISI 1045 steel motor shaft extension (typical)
Extensión del eje del motor de acero AISI 1045 (típico)

Item No. *No. Ítem*	Description *Descripción*	Materials, *Materiales*		
		All Iron *Todo hierro*	Bronze Fitted *Accesorios de bronce*	All Bronze *Todo bronce*
100	Casing, *Carcasa*	1001	1001	1101
101	Impeller, *Impulsor*		1101	
103	Casing wear ring, *Anillo de desgaste de la carcasa*		1618	1618
108	Adapter, *Adaptador*		1001	1001
184	Seal housing, *Cubierta del sello* ①	One piece with adapter, *Una pieza con adaptador*		1101
126	Shaft sleeve, *Camisa del eje*	AISI Type 300 series stainless steel *Acero inoxidable serie AISI tipo 300*		
198	Impeller bolt, *Perno del impulsor*			
199	Impeller washer, *Arandela del impulsor*			
178	Impeller key, *Chaveta del impulsor*	Carbon Steel, *Acero al carbono*		
370	Hex head cap screw (adapter to case), *Tornillo de cabeza hexagonal (del adaptador a la cubierta)*	Steel SAE 1200 Grade 5 *Acero SAE 1200 grado 5*		
371	Hex head cap screw (adapter to motor), *Tornillo de cabeza hexagonal (del adaptador al motor)*			
383	Mechanical seal, *Sello mecánico*	See seal chart. *Ver tabla del sello*		
408	Pipe plug ¼" or ⅜", *Tapón de tubos de ¼ de pulgada ó ⅜ de pulgada*	Steel, *Acero*	Bronze, *Bronce*	
513	O-ring, *Anillo en O*	BUNA-N, *BUNA-N*		

Material Code, *Código de material*	Engineering Standard, *Norma de ingeniería*
1001	Cast Iron ASTM A48 CL20, *Hierro fundido ASTM A48 CL20*
1101	Silicon bronze ASTM B584, C87500, *Silicuro de bronce ASTM B584, C87500*
1618	Bizmuth brass, *Latón al bismuto*

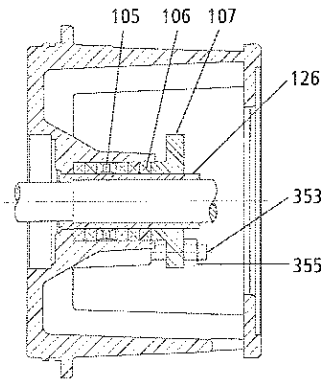
Packed Box Arrangement, *Caja prensaestopas*

Item No., *No. Ítem*	Description, *Descripción*	Materials, *Materiales*
105	Lantern ring, *Aro de linterna*	Teflon™
106	Packing, 5 rings; *Empaquetadura, 5 aros*	Teflon Impregnated, *Impregnado de Teflon*
107	Gland, *Casquillo*	AISI 316SS
126	Shaft sleeve, *Camisa del eje*	AISI Type 300 Series Stainless Steel *Acero inoxidable serie AISI tipo 300*
353	Gland stud, *Perno del casquillo*	
355	Gland nut, *Tuerca del casquillo*	

Type 21 Mechanical Seal, *Tipo 21 sello mecánico*

Seal Code, *Código del Sello*	Rotary, *Rotativo*	Stationary, *Estacionario*	Elastomers, *Elastómeros*	Metal Parts, *Partes Metálicas*	Part No., *Pieza Número*
0	Carbon, *Carbón*	Ceramic, *Cerámica*	BUNA-N	316 SS, *316 Acero inoxidable*	10K13
1		Sil-Carbide, *Carburo de silicona*	EPR		10K19
3			Viton		10K27
5	Sil-Carbide				10K64
9	Packed Box Design with BUNA O-Ring, *Diseño de prensaestopas empacado con anillo en O de BUNA*				15K16

Note: 10K27 replaces obsolete 10K25, ***Nota:*** *La 10K27 reemplace la obsoleta 10K25.*



Packed Box Arrangement
Caja prensaestopas

① For separate seal housing and adapter construction, all bronze material only, see repair parts page.

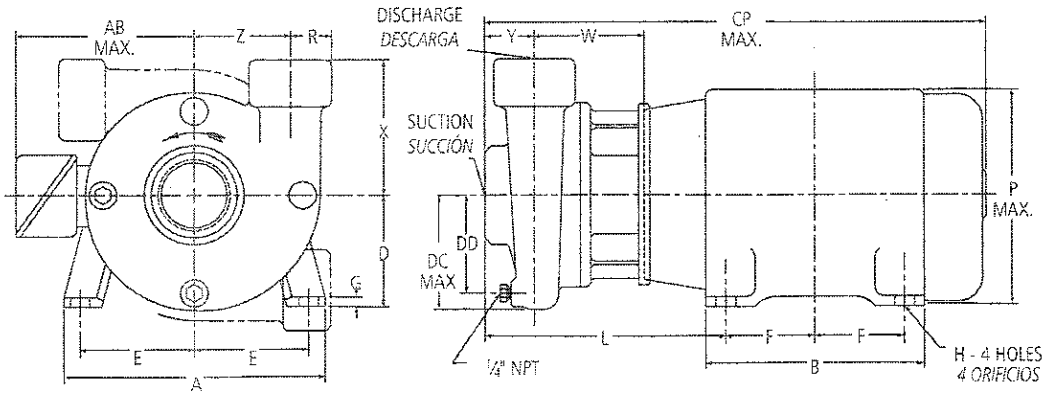
Para la construcción separada del compartimiento del sello y el adaptador, materiales de bronce únicamente, consulte la página de piezas de repuesto.

NOTE:
Pumps will be shipped with top-vertical discharge position as standard. For other orientations, remove casing bolts – rotate discharge to desired position – replace and tighten bolts to 25 ft./lbs. Note that discharge may extend below motor mounting surface in bottom-horizontal position; adequate clearance must be provided.

NOTA:
Las bombas salen de la fábrica con la descarga orientada en posición vertical superior de manera estándar. Para modificar la orientación, retirar los pernos de la carcasa, hacer girar la descarga hasta la posición deseada y volver a colocar los pernos, ajustándolos a una torsión de 25 pies/libras. Se ha de notar que la descarga se puede extender por debajo de la superficie de montaje del motor en la posición horizontal inferior; por lo tanto, debe proveerse suficiente espacio.

3656 S-Group Dimensions and Weights
Grupo S, modelo 3656 - Peso y dimensiones

Mechanical Seal
Sello mecánico



Pump Dimensions and Weights (Dimension "L" determined by Pump and Motor)
Peso y dimensiones de la bomba (la dimensión "L" está determinada por la bomba y el motor)

Pump *Bomba*	Suction *Succión*	Discharge *Descarga*	CP Max.	DC Max.	DD	R	W	X	Y	Z	Wt. (lbs.) *Pesos (libras)*	Motor Frame Size, *Bastidor*			
												140	180	210	250
												L			
1 x 2 – 7	2	1	27	4¼	3½	1 1/16	4⅛	5½	3	4	52	10	10¾	—	—
1 x 2 – 8					4		3 5/16	5¾	3 5/16	4⅛	52			—	—
1½ x 2 – 6		1½	23¾		3½	1¼	4¼	4½	2⅝	3½	34	9¾	10½	—	—
1½ x 2 – 8			27⅛	5⅜	4⅝			5		4¼	54			11⅜	11⅜
2½ x 3 – 7	3	2½	25⅝	5⅓	4½	1 13/16		6	3	4	49	10⅛	10¾	11¾	—
3 x 4 – 7	4*	3*	25¼	5¾	5⅛	3¾	4⅜		2½	4½	82	9¾	10⅜	11⅜	—

*For use with ANSI class 150 mating flange. All others are NPT connections.
** Para uso con brida de contacto ANSI clase 150. Todas las demás son conexiones NTP.*

Motor Dimensions and Weights (may vary with manufacturer)*
*Peso y dimensiones del motor (pueden variar de acuerdo al fabricante) **

Frame Size JM *Tamaño del bastidor JM*	A	AB (Max.)	B	D	E	F	G	H	P (Max.)	Weight (lbs.) *Pesos (libras)*
143	6½	5¼	6	3½	2¾	2	1/16	11/32	6⅝	41
145						2½				57
182	8½	5⅞	6½	4½	3¾	2¼	3/16	13/32	7⅞	77
184						2¾				97
213	9½	7⅜	8	5¼	4¼	2¾	1/32	13/32	9⅝	122
215						3½				155
254 TCZ	11¼	9	9½	6¼	5	4⅛	¼	17/32	11½	265
256 TCZ			11¾			5				320

NOTE:
All pumps shipped in vertical discharge position. May be rotated in 90° increments. Tighten casing bolts to 25 ft./lbs. torque.

NOTA:
Todas las bombas se embarcan con la descarga en posición vertical. Esta posición puede rotarse en incrementos de 90°. Ajustar los pernos de la carcasa a una torsión de 25 pies/libras.

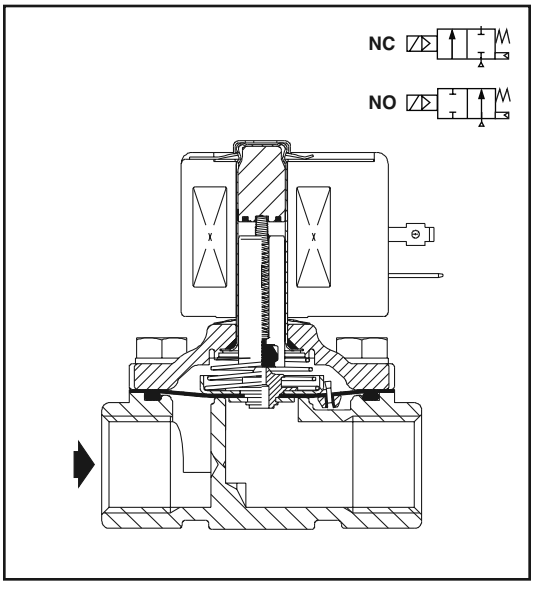
Motor Frames and Horsepower
Bastidores del motor y potencia en HP

Motor Frame *Bastidor del motor*	3500 RPM				1750 RPM			
	1 Phase		3 Phase		1 Phase		3 Phase	
	ODP	TEFC	ODP	TEFC	ODP	TEFC	ODP	TEFC
143	—	¾, 1, 1½	¾, 1, 1½	¾, 1, 1½	—	½, ¾	½, ¾, 1	½, ¾, 1
145	—	2	2, 3	2, 3	—	1, 1½	1½, 2	1½, 2
182	3	3	5	3	3	2, 3	3	3
184	5	3, 5	7½	5	—	—	5	5
213	7½	—	10	7½	5	—	7½	7½
215	10	—	15	10, 15	—	—	—	—
254TCZ	—	—	20		—	—	—	—
256TCZ	—	—	25	20, 25	—	—	—	—

All dimensions in inches and weights in lbs. Do not use for construction purposes.
Todas las dimensiones están en pulgadas, el peso en libras. No utilizar para fines de construcción.

Features

- Wide range of pressure ratings, sizes, and resilient materials provide long service life and low internal leakage
- High Flow Valves for liquid, corrosive, and air/inert gas service
- Industrial applications include:
  - Car wash
  - Laundry equipment
  - Air compressors
  - Industrial water control
  - Pumps



Construction

Valve Parts in Contact with Fluids		
Body	Brass	304 Stainless Steel
Seals and Discs	NBR or PTFE	
Disc-Holder	PA	
Core Tube	305 Stainless Steel	
Core and Plugnut	430F Stainless Steel	
Springs	302 Stainless Steel	
Shading Coil	Copper	Silver

Electrical

Standard Coil and Class of Insulation	Watt Rating and Power Consumption				Spare Coil Part Number			
		AC			General Purpose		Explosionproof	
	DC Watts	Watts	VA Holding	VA Inrush	AC	DC	AC	DC
F	-	6.1	16	40	238210	-	238214	-
F	11.6	10.1	25	70	238610	238710	238614	238714
F	16.8	16.1	35	180	272610	97617	272614	97617
F	-	17.1	40	93	238610	-	238614	-
F	-	20	43	240	99257	-	99257	-
F	-	20.1	48	240	272610	-	272614	-
H	30.6	-	-	-	-	74073	-	74073
H	40.6	-	-	-	-	238910	-	238914

Standard Voltages: 24, 120, 240, 480 volts AC, 60 Hz (or 110, 220 volts AC, 50 Hz). 6, 12, 24, 120, 240 volts DC. Must be specified when ordering.
Other voltages available when required.

Solenoid Enclosures

Standard: RedHat II - Watertight, Types 1, 2, 3, 3S, 4, and 4X; RedHat - Type I.

Optional: RedHat II - Explosionproof and Watertight, Types 3, 3S, 4, 4X, 6, 6P, 7, and 9; Red-Hat - Explosionproof and Watertight, Types 3, 4, 4X, 7, and 9.

(To order, add prefix "EF" to catalog number, except Catalog Numbers 8210B057, 8210B058, and 8210B059, which are not available with Explosionproof enclosures.)
See Optional Features Section for other available options.

Nominal Ambient Temp. Ranges

RedHat II/
RedHat AC: 32˚F to 125˚F (0˚C to 52˚C)

RedHat II DC: 32˚F to 104˚F (0˚C to 40˚C)
RedHat DC: 32˚F to 77˚F (0˚C to 25˚C)
(104˚F/40˚C occasionally)

Refer to Engineering Section for details.

Approvals

CSA certified. RedHat II meets applicable CE directives.
Refer to Engineering Section for details.

2/2 SERIES 8210

ASCO®

Specifications (English units)

Pipe Size (ins.)	Orifice Size (ins.)	Cv Flow Factor	Operating Pressure Differential (psi)							Max. Fluid Temp. ˚F		Brass Body			Stainless Steel Body			Watt Rating/ Class of Coil Insulation ⑦	
				Max. AC			Max. DC												
			Min.	Air-Inert Gas	Water	Light Oil @ 300 SSU	Air-Inert Gas	Water	Light Oil @ 300 SSU	AC	DC	Catalog Number	Const. Ref. ④	UL ⑤ Listing	Catalog Number	Const. Ref. ④	UL ⑤ Listing	AC	DC
NORMALLY CLOSED (Closed when de-energized), NBR or PTFE ② Seating																			
3/8	3/8	1.5	①	150	125	-	40	40	-	180	150	8210G073 ③	1P	●	8210G036 ③	1P	●	6.1/F	11.6/F
3/8	5/8	3	0	150	150	-	40	40	-	180	150	8210G093	5D	❍	-	-	-	10.1/F	11.6/F
3/8	5/8	3	5	200	150	135	125	100	100	180	150	8210G001	6D	❍	-	-	-	6.1/F	11.6/F
3/8	5/8	3	5	300	300	300	-	-	-	175	-	8210G006	5D	❍	-	-	-	17.1/F	-
1/2	7/16	2.2	①	150	125	-	40	40	-	180	150	8210G015 ③	2P	●	8210G037 ③	2P	●	6.1/F	11.6/F
1/2	5/8	4	0	150	150	-	40	40	-	180	150	8210G094	5D	❍	-	-	-	10.1/F	11.6/F
1/2	5/8	4	0	150	150	125	40	40	-	175	150	-	-	-	8210G087	7D	●	17.1/F	11.6/F
1/2	5/8	4	5	200	150	135	125	100	100	180	150	8210G002	6D	❍	-	-	-	6.1/F	11.6/F
1/2	5/8	4	5	300	300	300	-	-	-	175	-	8210G007	5D	❍	-	-	-	17.1/F	-
1/2	3/4	4	5	-	300	-	-	300	-	180	125	8210G227	5D	❍	-	-	-	17.1/F	40.6/H
3/4	5/8	4.5	0	150	150	125	40	40	-	175	150	-	-	-	8210G088	7D	●	17.1/F	11.6/F
3/4	3/4	5	5	125	125	125	100	90	75	180	150	8210G009	9D	❍	-	-	-	6.1/F	11.6/F
3/4	3/4	5	0	150	150	-	40	40	-	180	150	8210G095	8D	❍	-	-	-	10.1/F	11.6/F
3/4	3/4	6.5	5	250	150	100	125	125	125	180	150	8210G003	11D	❍	-	-	-	6.1/F	11.6/F
3/4	3/4	6	0	-	-	-	200	180	180	-	77	8210B026 ② ‡	10P	-	-	-	-	-	30.6/H
3/4	3/4	6	0	350	300	200	-	-	-	200	-	8210G026 ② ‡	40P	●	-	-	-	16.1F	-
1	1	13	0	-	-	-	100	100	80	-	77	8210B054 ‡	31D	-	8210D089	15D	-	-	30.6/H
1	1	13	0	150	125	125	-	-	-	180	-	8210G054	41D	●	8210G089	45D	●	16.1/F	-
1	1	13	5	150	150	100	125	125	125	180	150	8210G004	12D	❍	-	-	-	6.1/F	11.6/F
1	1	13.5	0	300	225	115	-	-	-	200	-	8210G027 ‡	42P	●	-	-	-	20.1/F	-
1	1	13.5	10	300	300	300	-	-	-	175	-	8210G078 ②	13P	-	-	-	-	17.1/F	-
1 1/4	1 1/8	15	0	-	-	-	100	100	80	-	77	8210B055 ‡	32D	-	-	-	-	-	30.6/H
1 1/4	1 1/8	15	0	150	125	125	-	-	-	180	-	8210G055	43D	●	-	-	-	16.1/F	-
1 1/4	1 1/8	15	5	150	150	100	125	125	125	180	150	8210G008	16D	❍	-	-	-	6.1/F	11.6/F
1 1/2	1 1/4	22.5	0	-	-	-	100	100	80	-	77	8210B056 ‡	33D	-	-	-	-	-	30.6/H
1 1/2	1 1/4	22.5	0	150	125	125	-	-	-	180	-	8210G056	44D	●	-	-	-	16.1/F	-
1 1/2	1 1/4	22.5	5	150	150	100	125	125	125	180	150	8210G022	18D	●	-	-	-	6.1/F	11.6/F
2	1 3/4	43	5	150	125	90	50	50	50	180	150	8210G100	20P	●	-	-	-	6.1/F	11.6/F
2 1/2	1 3/4	45	5	150	125	90	50	50	50	180	150	8210G101	21P	●	-	-	-	6.1/F	11.6/F
NORMALLY OPEN (Open when de-energized), NBR Seating (PA Disc-Holder, except as noted)																			
3/8	5/8	3	0	150	150	125	125	125	80	180	150	8210G033	23D	●	-	-	-	10.1/F	11.6/F
3/8	5/8	3	5	250	200	200	250	200	200	180	180	8210G011 ⑧ ⑨	39D	●	-	-	-	10.1/F	11.6/F
1/2	5/8	4	0	150	150	125	125	125	80	180	150	8210G034	23D	●	-	-	-	10.1/F	11.6/F
1/2	5/8	3	0	150	150	100	125	125	80	180	150	-	-	-	8210G030	37D	●	10.1/F	11.6/F
1/2	5/8	4	5	250	200	200	250	200	200	180	180	8210G012 ⑧ ⑨	39D	●	-	-	-	10.1/F	11.6/F
3/4	3/4	5.5	0	150	150	125	125	125	80	180	150	8210G035	25D	●	-	-	-	10.1/F	11.6/F
3/4	5/8	3	0	150	150	100	125	125	80	180	150	-	-	-	8210G038	38D	●	10.1/F	11.6/F
3/4	3/4	6.5	5	-	-	-	250	200	200	-	180	8210C013	24D	●	-	-	-	-	16.8/F
3/4	3/4	6.5	5	250	200	200	-	-	-	180	-	8210G013	46D	●	-	-	-	16.1/F	-
1	1	13	0	125	125	125	-	-	-	180	-	8210B057 ⑥ ⑩	34D	●	-	-	-	20/F	-
1	1	13	5	-	-	-	125	125	125	-	180	8210D014	26D	●	-	-	-	-	16.8/F
1	1	13	5	150	150	125	-	-	-	180	-	8210G014	47D	●	-	-	-	16.1/F	-
1 1/4	1 1/8	15	0	125	125	125	-	-	-	180	-	8210B058 ⑥ ⑩	35D	●	-	-	-	20/F	-
1 1/4	1 1/8	15	5	-	-	-	125	125	125	-	180	8210D018	28D	●	-	-	-	-	16.8/F
1 1/4	1 1/8	15	5	150	150	125	-	-	-	180	-	8210G018	48D	●	-	-	-	16.1/F	-
1 1/2	1 1/4	22.5	0	125	125	125	-	-	-	180	-	8210B059 ⑥ ⑩	36D	●	-	-	-	20/F	-
1 1/2	1 1/4	22.5	5	-	-	-	125	125	125	-	180	8210D032	29D	●	-	-	-	-	16.8/F
1 1/2	1 1/4	22.5	5	150	150	125	-	-	-	180	-	8210G032	49D	●	-	-	-	16.1/F	-
2	1 3/4	43	5	-	-	-	125	125	125	-	150	8210 103	30P	●	-	-	-	-	16.8/F
2	1 3/4	43	5	125	125	125	-	-	-	180	-	8210G103	50P	●	-	-	-	16.1/F	-
2 1/2	1 3/4	45	5	-	-	-	125	125	125	-	150	8210 104	27P	●	-	-	-	-	16.8/F
2 1/2	1 3/4	45	5	125	125	125	-	-	-	180	-	8210G104	51P	●	-			16.1/F	-

① 5 psi on Air; 1 psi on Water.
② Valve provided with PTFE main disc.
③ Valve includes Ultem (G.E. trademark) piston.
④ Letter "D" denotes diaphragm construction; "P" denotes piston construction.
⑤ ❍ Safety Shutoff Valve; ● General Purpose Valve.
Refer to Engineering Section (Approvals) for details.
⑥ Valves not available with Explosionproof enclosures.
⑦ On 50 hertz service, the watt rating for the 6.1/F solenoid is 8.1 watts.
⑧ AC construction also has PA seating.
⑨ No disc-holder.
⑩ Stainless steel disc-holder.
‡ Must have solenoid mounted vertical and upright.

Specifications (Metric units)

Pipe Size (ins.)	Orifice Size (mm)	Kv Flow Factor (m3/h)	Operating Pressure Differential (bar)							Max. Fluid Temp. ˚C		Brass Body			Stainless Steel Body			Watt Rating/ Class of Coil Insulation ⑦	
				Max. AC			Max. DC												
			Min.	Air-Inert Gas	Water	Light Oil @ 300 SSU	Air-Inert Gas	Water	Light Oil @ 300 SSU	AC	DC	Catalog Number	Const. Ref. ④	UL ⑤ Listing	Catalog Number	Const. Ref. ④	UL ⑤ Listing	AC	DC
NORMALLY CLOSED (Closed when de-energized), NBR or PTFE ② Seating																			
3/8	10	1.29	①	10	9	-	3	3	-	82	65	8210G073 ③	1P	●	8210G036 ③	1P	●	6.1/F	11.6/F
3/8	16	2.57	0	10	10	-	3	3	-	82	65	8210G093	5D	❍	-	-	-	10.1/F	11.6/F
3/8	16	2.57	0.3	14	10	9	9	7	7	82	65	8210G001	6D	❍	-	-	-	6.1/F	11.6/F
3/8	16	2.57	0.3	21	21	21	-	-	-	79	-	8210G006	5D	❍	-	-	-	17.1/F	-
1/2	11	1.89	①	10	9	-	3	3	-	82	65	8210G015 ③	2P	●	8210G037 ③	2P	●	6.1/F	11.6/F
1/2	16	3.43	0	10	10	-	3	3	-	82	65	8210G094	5D	❍	-	-	-	10.1/F	11.6/F
1/2	16	3.43	0	10	10	9	3	3	-	79	65	-	-	-	8210G087	7D	●	17.1/F	11.6/F
1/2	16	3.43	0.3	14	10	9	9	7	7	82	65	8210G002	6D	❍	-	-	-	6.1/F	11.6/F
1/2	16	3.43	0.3	21	21	21	-	-	-	79	-	8210G007	5D	❍	-	-	-	17.1/F	-
1/2	19	3.43	0.3	-	21	-	-	21	-	82	52	8210G227	5D	❍	-	-	-	17.1/F	40.6H
3/4	16	3.86	0	10	10	9	3	3	-	79	65	-	-	-	8210G088	7D	●	17.1/F	11.6/F
3/4	19	4.29	0.3	9	9	9	7	6	5	82	65	8210G009	9D	❍	-	-	-	6.1/F	11.6/F
3/4	19	4.29	0	10	10	-	3	3	-	82	65	8210G095	8D	❍	-	-	-	10.1/F	11.6/F
3/4	19	5.57	0.3	17	10	7	9	9	9	82	65	8210G003	11D	❍	-	-	-	6.1/F	11.6/F
3/4	19	5.14	0	-	-	-	14	12	12	-	25	8210B026 ② ‡	10P	-	-	-	-	-	30.6/H
3/4	19	5.14	0	24	21	14	-	-	-	93	-	8210G026 ② ‡	40P	●	-	-	-	16.1F	-
1	25	11.14	0	-	-	-	7	7	6	-	25	8210B054 ‡	31D	-	8210D089	15D	-	-	30.6/H
1	25	11.14	0	10	9	9	-	-	-	82	-	8210G054	41D	●	8210G089	45D	●	16.1/F	-
1	25	11.14	0.3	10	10	7	9	9	9	82	65	8210G004	12D	❍	-	-	-	6.1/F	11.6/F
1	25	11.57	0	21	16	8	-	-	-	93	-	8210G027 ‡	42P	●	-	-	-	20.1/F	-
1	25	11.57	0.7	21	21	21	-	-	-	79	-	8210G078 ②	13P	-	-	-	-	17.1/F	-
1 1/4	29	12.86	0	-	-	-	7	7	6	-	25	8210B055 ‡	32D	-	-	-	-	-	30.6/H
1 1/4	29	12.86	0	10	9	9	-	-	-	82	-	8210G055	43D	●	-	-	-	16.1/F	-
1 1/4	29	12.86	0.3	10	10	7	9	9	9	82	65	8210G008	16D	❍	-	-	-	6.1/F	11.6/F
1 1/2	32	19.29	0	-	-	-	7	7	6	-	25	8210B056 ‡	33D	-	-	-	-	-	30.6/H
1 1/2	32	19.29	0	10	9	9	-	-	-	82	-	8210G056	44D	●	-	-	-	16.1/F	-
1 1/2	32	19.29	0.3	10	10	7	9	9	9	82	65	8210G022	18D	●	-	-	-	6.1/F	11.6/F
2	44	36.86	0.3	10	9	6	3	3	3	82	65	8210G100	20P	●	-	-	-	6.1/F	11.6/F
2 1/2	44	38.57	0.3	10	9	6	3	3	3	82	65	8210G101	21P	●	-	-	-	6.1/F	11.6/F
NORMALLY OPEN (Open when de-energized), NBR Seating (PA Disc-Holder, except as noted)																			
3/8	16	2.57	0.0	10	10	9	9	9	6	82	65	8210G033	23D	●	-	-	-	10.1/F	11.6/F
3/8	16	2.57	0.3	17	14	14	17	14	14	82	82	8210G011 ⑧ ⑨	39D	●	-	-	-	10.1/F	11.6/F
1/2	16	3.43	0	10	10	9	9	9	6	82	65	8210G034	23D	●	-	-	-	10.1/F	11.6/F
1/2	16	2.57	0	10	10	7	9	9	6	82	65	-	-	-	8210G030	37D	●	10.1/F	11.6/F
1/2	16	3.43	0.3	17	14	14	17	14	14	82	82	8210G012 ⑧ ⑨	39D	●	-	-	-	10.1/F	11.6/F
3/4	19	4.71	0	10	10	9	9	9	6	82	65	8210G035	25D	●	-	-	-	10.1/F	11.6/F
3/4	16	2.57	0	10	10	7	9	9	6	82	65	-	-	-	8210G038	38D	●	10.1/F	11.6/F
3/4	19	5.57	0.3	-	-	-	17	14	14	-	82	8210C013	24D	●	-	-	-	-	16.8/F
3/4	19	5.57	0.3	17	14	14	-	-	-	82	-	8210G013	46D	●	-	-	-	16.1/F	-
1	25	11.14	0	9	9	9	-	-	-	82	-	8210B057 ⑥ ⑩	34D	●	-	-	-	20/F	-
1	25	11.14	0.3	-	-	-	9	9	9	-	82	8210D014	26D	●	-	-	-	-	16.8/F
1	25	11.14	0.3	10	10	9	-	-	-	82	-	8210G014	47D	●	-	-	-	16.1/F	-
1 1/4	29	12.86	0	9	9	9	-	-	-	82	-	8210B058 ⑥ ⑩	35D	●	-	-	-	20/F	-
1 1/4	29	12.86	0.3	-	-	-	9	9	9	-	82	8210D018	28D	●	-	-	-	-	16.8/F
1 1/4	29	12.86	0.3	10	10	9	-	-	-	82	-	8210G018	48D	●	-	-	-	16.1/F	-
1 1/2	32	19.29	0	9	9	9	-	-	-	82	-	8210B059 ⑥ ⑩	36D	●	-	-	-	20/F	-
1 1/2	32	19.29	0.3	-	-	-	9	9	9	-	82	8210D032	29D	●	-	-	-	-	16.8/F
1 1/2	32	19.29	0.3	10	10	9	-	-	-	82	-	8210G032	49D	●	-	-	-	16.1/F	-
2	44	36.86	0.3	-	-	-	9	9	9	-	65	8210 103	30P	●	-	-	-	-	16.8/F
2	44	36.86	0.3	9	9	9	-	-	-	82	-	8210G103	50P	●	-	-	-	16.1/F	-
2 1/2	44	38.57	0.3	-	-	-	9	9	9	-	65	8210 104	27P	●	-	-	-	-	16.8/F
2 1/2	44	38.57	0.3	9	9	9	-	-	-	82	-	8210G104	51P	●	-	-	-	16.1/F	-

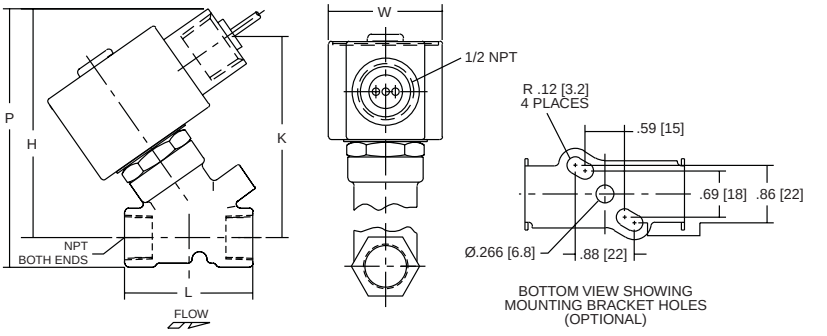
① 0.3 bar on Air; 0.0 bar on Water.
② Valve provided with PTFE main disc.
③ Valve includes Ultem (G.E. trademark) piston.
④ Letter "D" denotes diaphragm construction; "P" denotes piston construction.
⑤ ❍ Safety Shutoff Valve; ● General Purpose Valve.
Refer to Engineering Section (Approvals) for details.
⑥ Valves not available with Explosionproof enclosures.
⑦ On 50 hertz service, the watt rating for the 6.1/F solenoid is 8.1 watts.
⑧ AC construction also has PA seating.
⑨ No disc-holder.
⑩ Stainless steel disc-holder.
‡ Must have solenoid mounted vertical and upright.

Dimensions: inches (mm)

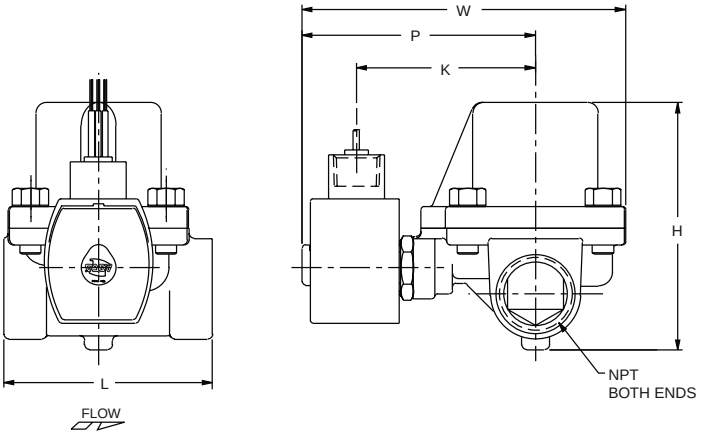
Const. Ref.		H	K	L	P	W
1*	ins.	3.85	3.00	1.91	3.41	1.69
	mm	98	76	49	87	43
2*	ins.	4.17	3.25	2.28	3.63	1.69
	mm	106	83	58	92	43
5	ins.	3.84	2.31	2.75	3.28	2.28
	mm	98	59	70	83	58
6*	ins.	3.38	1.94	2.75	2.80	2.28
	mm	86	49	70	71	58
7	ins.	4.19	2.50	2.81	3.47	2.39
	mm	106	64	71	88	61
8	ins.	4.13	2.47	2.81	3.44	2.29
	mm	105	63	71	87	58
9*	ins.	3.66	2.10	2.81	2.96	2.28
	mm	93	53	71	75	58
10*	ins.	5.25	X	2.81	4.59	2.31
	mm	133	X	71	117	59
11*	ins.	4.16	2.66	3.84	3.52	2.75
	mm	106	68	98	89	70
12	ins.	5.64	3.15	3.75	4.01	3.36
	mm	143	80	95	102	85
13	ins.	4.44	3.22	3.75	4.19	5.81
	mm	113	82	95	106	147
15*	ins.	5.34	X	3.75	4.47	3.84
	mm	136	X	95	114	98
16	ins.	5.64	3.15	3.66	4.01	3.56
	mm	143	80	93	102	90
18	ins.	6.11	3.30	4.38	4.16	3.92
	mm	155	84	111	106	100
20*	ins.	7.33	3.71	5.06	4.57	4.87
	mm	186	94	129	116	124
21*	ins.	7.33	3.71	5.50	4.57	4.87
	mm	186	94	140	116	124
23	ins.	4.35	2.65	2.75	3.79	2.28
	mm	110	67	70	96	58
24	ins.	5.06	X	3.78	4.44	2.75
	mm	129	X	96	113	70
25	ins.	4.64	2.81	2.81	3.94	2.28
	mm	118	71	71	100	58
26	ins.	6.53	X	3.75	4.91	3.19
	mm	166	X	95	125	81
27	ins.	8.22	X	5.50	5.47	4.87
	mm	209	X	140	139	124
28	ins.	6.53	X	3.66	4.91	3.19
	mm	166	X	93	125	81
29	ins.	7.03	X	4.38	5.06	4.40
	mm	179	X	111	129	112

* DC dimensions slightly larger.
IMPORTANT: Valves may be mounted in any position, except as noted in specifications table.

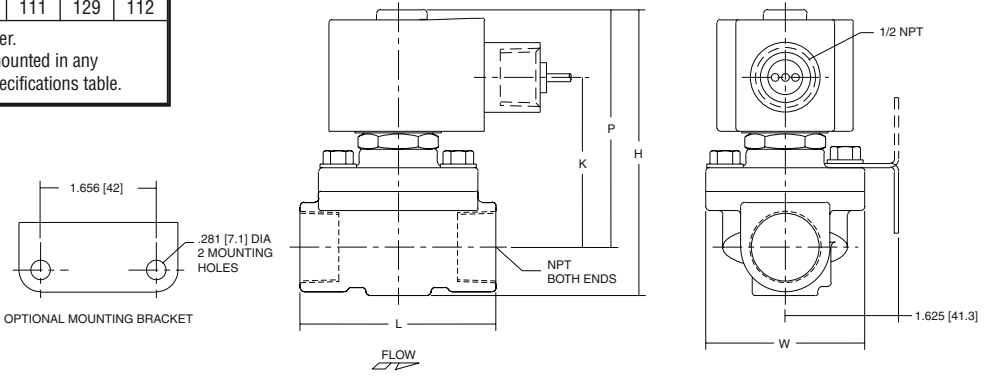
Const. Ref. 1, 2



Const. Ref. 13



Const. Ref. 5-9, 11, 20, 21, 23 , 25, 37,38

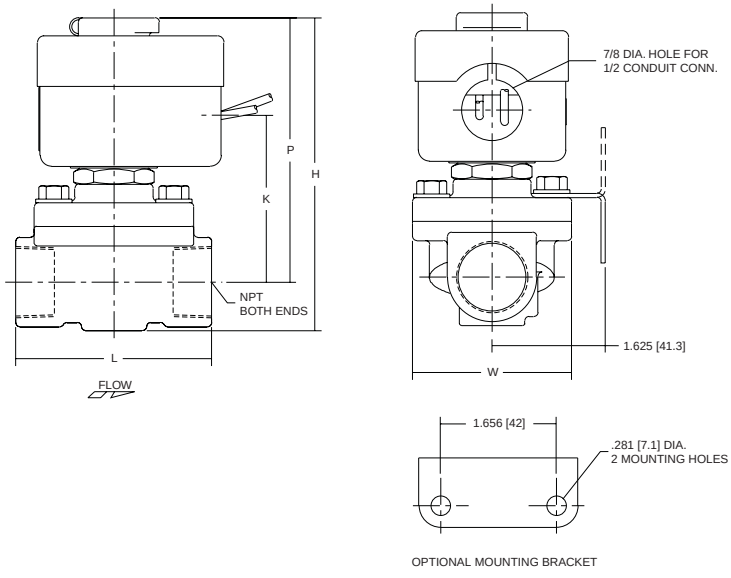


Dimensions: inches (mm)

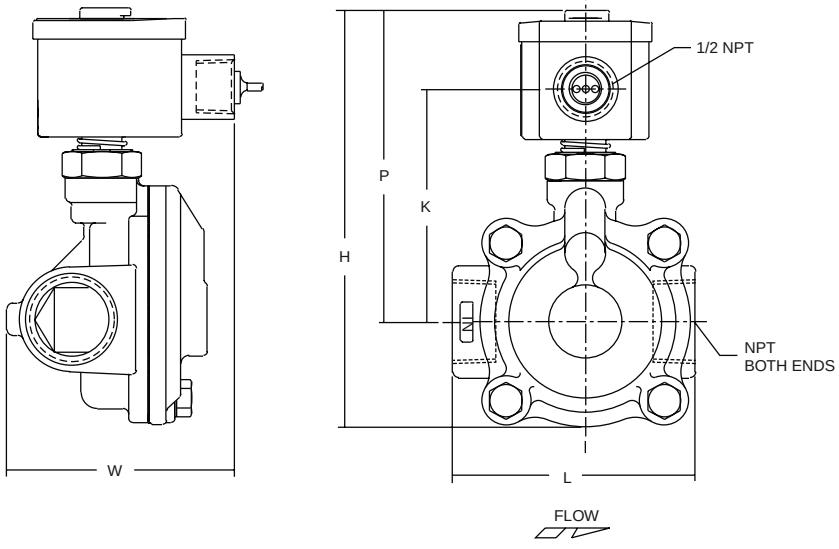
Const. Ref.		H	K	L	P	W
30	ins.	8.22	X	5.06	5.47	4.87
	mm	209	X	129	139	124
31	ins.	5.25	X	3.75	4.44	3.25
	mm	133	X	95	113	83
32	ins.	5.69	X	3.66	4.69	3.25
	mm	145	X	93	119	83
33	ins.	6.06	X	4.38	4.94	3.91
	mm	154	X	111	125	99
34	ins.	6.91	X	3.75	6.09	3.25
	mm	176	X	95	155	83
35	ins.	7.34	X	3.66	6.34	3.25
	mm	186	X	93	161	83
36	ins.	7.66	X	4.38	6.56	3.91
	mm	1.95	X	111	167	99
37	ins.	4.61	2.75	2.81	3.89	2.39
	mm	117	70	71	99	61
38	ins.	4.61	2.75	2.81	3.89	2.39
	mm	117	70	71	99	61
39	ins.	5.42	2.31	2.75	4.86	3.80
	mm	138	59	70	123	97
40	ins.	5.20	3.29	2.81	4.50	2.28
	mm	132	83	71	114	58
41	ins.	5.13	3.10	3.75	4.32	3.25
	mm	130	79	95	110	83
42	ins.	6.43	4.40	3.93	5.62	3.25
	mm	163	112	100	143	83
43	ins.	5.57	3.35	3.66	4.57	3.25
	mm	142	85	93	116	83
44	ins.	5.90	3.57	4.38	4.79	3.91
	mm	150	91	111	122	99
45	ins.	5.26	3.17	3.75	4.38	3.84
	mm	134	81	95	111	98
46	ins.	4.95	3.10	3.84	4.31	2.75
	mm	126	79	98	110	70
47	ins.	6.43	3.59	3.75	4.81	3.52
	mm	163	91	95	122	90
48	ins.	6.43	3.59	3.66	4.81	3.73
	mm	163	91	93	122	95
49	ins.	6.91	3.75	4.38	4.96	4.40
	mm	176	95	111	126	112
50	ins.	8.13	4.15	5.06	5.37	4.87
	mm	207	105	129	136	124
51	ins.	8.13	4.15	5.50	5.37	5.18
	mm	207	105	140	136	132

IMPORTANT: Valves may be mounted in any position, except as noted in specifications table.

Const. Ref. 10, 15, 24, 26-36

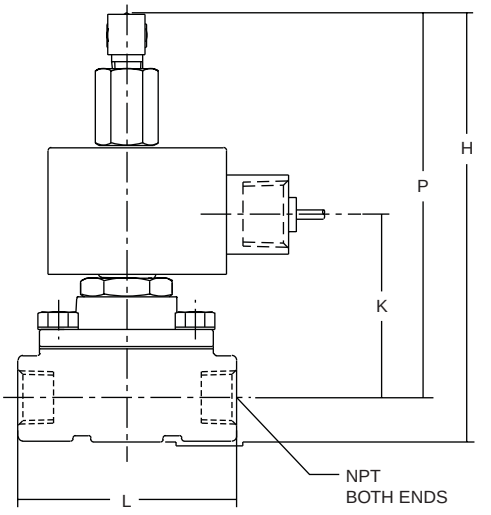


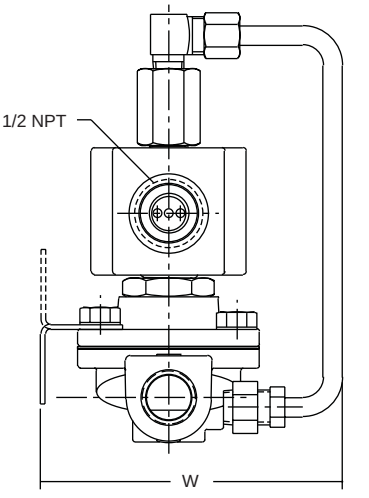
Const. Ref. 12, 16, 18

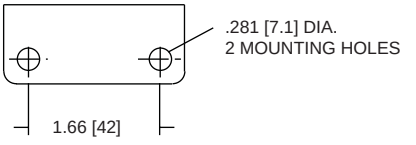


Dimensions: inches (mm)

Const. Ref. 39

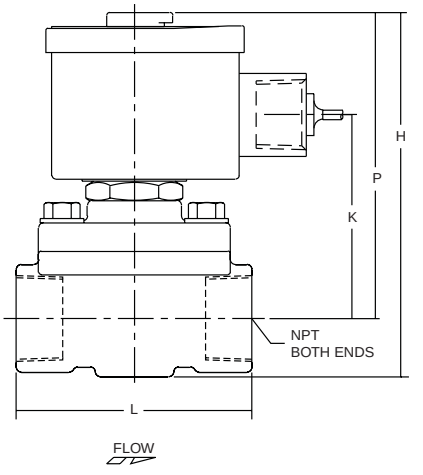


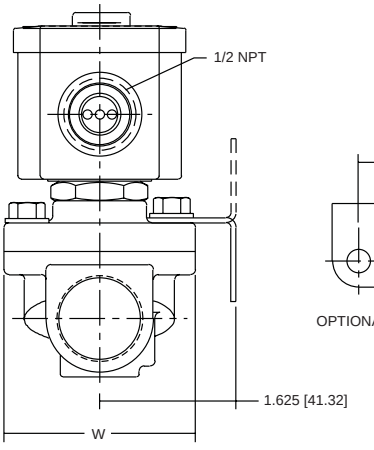


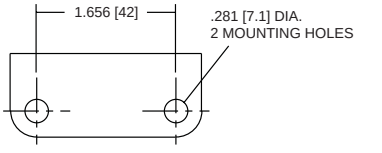


SHOWING MOUNTING
BRACKET ONLY

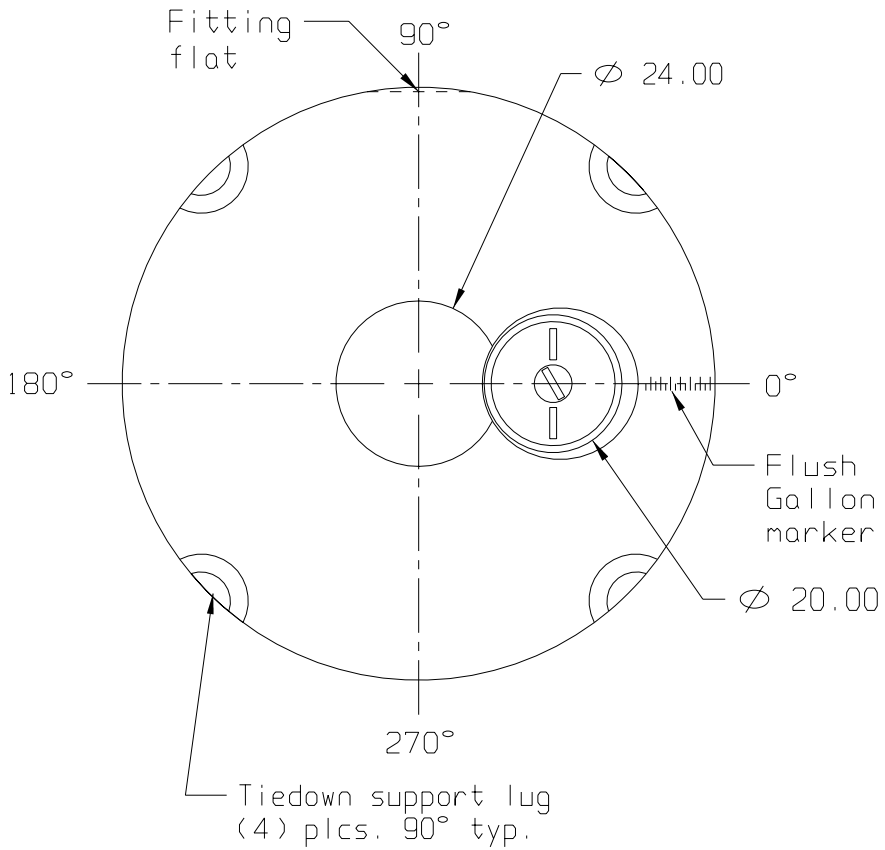
Const. Ref. 40-51

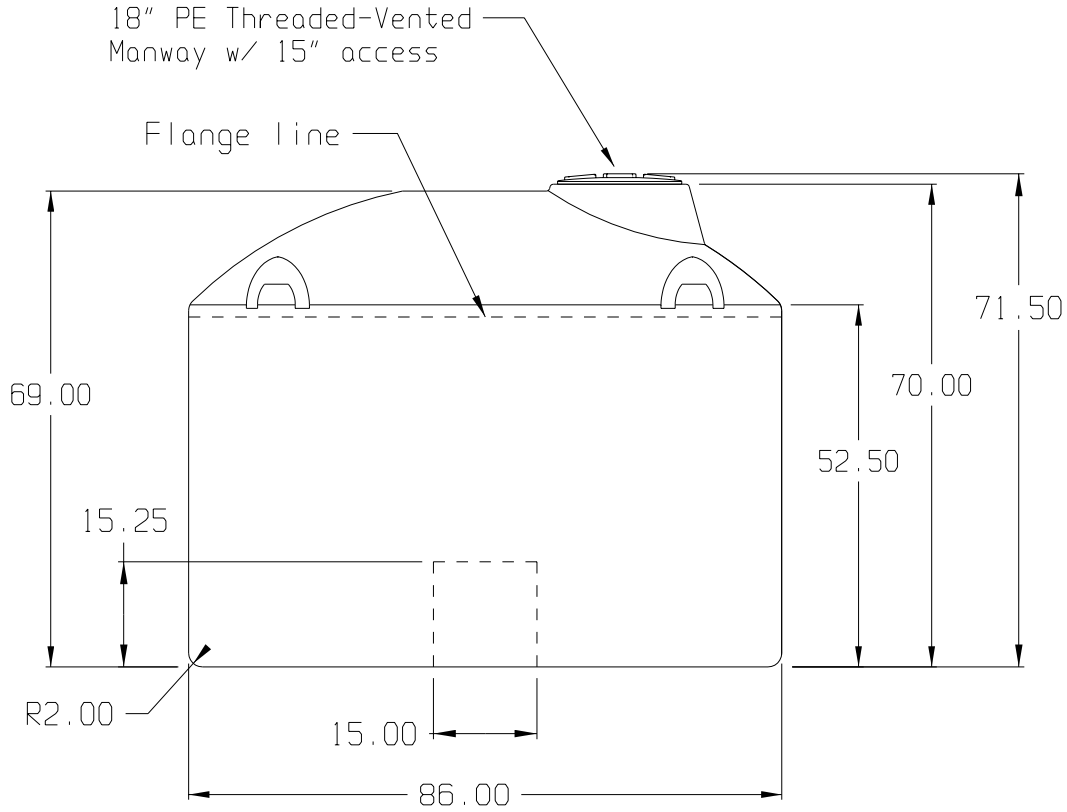






OPTIONAL MOUNTING BRACKET





NOTE:
SOME GALLONAGE MARKS MAY BE REMOVED FOR FITTING PLACEMENT.

(all dimensions in inches)

BASE FITTINGS TO BE LEFT INSTALLED AT TIME OF SHIPMENT PER SII PROCEDURE

1,500 GALLON FLAT BOTTOM TANK

PART # TANK: 177--L

REF#: 0000 02/12/03

SNYDER INDUSTRIES INC.

PROPRIETARY DATA

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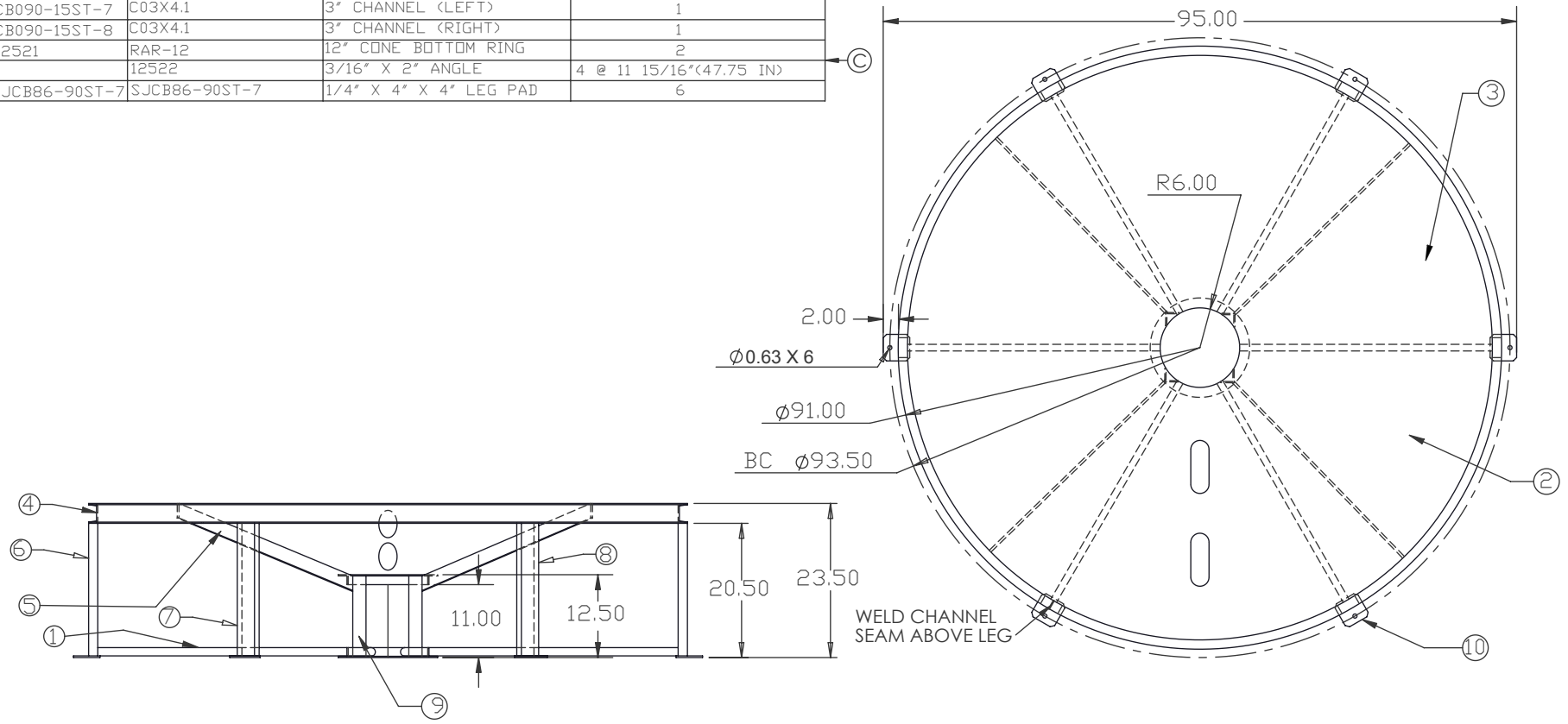
KEY	PART NUMBER	MATERIAL	DESCRIPTION	QTY.
1	CB090-15ST-1	P10000	1" PIPE	6 @ 37.75 IN (226.5 IN)
2	CB090-15ST-2	S-14GA	14 GA SHEET STEEL(HOLES)	1
3	CB090-15ST-3	S-14GA	14 GA SHEET STEEL	2 @48" X 96" (9216 SI)
4	CB090-15ST-4	C03X4.1	3" CHANNEL	298 IN
5	CB090-15ST-5	B03750X20000	3/8" X 2"MILD STEEL FLAT	4 @ 38 IN (152 IN)
6	CB090-15ST-6	C03X4.1	3" CHANNEL	6 @ 20.50 IN (123 IN LEFT AND RIGHT LEGS INCLUDED)
7	CB090-15ST-7	C03X4.1	3" CHANNEL (LEFT)	1
8	CB090-15ST-8	C03X4.1	3" CHANNEL (RIGHT)	1
9	12521	RAR-12	12" CONE BOTTOM RING	2
		12522	3/16" X 2" ANGLE	4 @ 11 15/16"(47.75 IN)
10	SJCB86-90ST-7	SJCB86-90ST-7	1/4" X 4" X 4" LEG PAD	6



REV	DESCRIPTION	BY / DATE	CCN
C	12521 WAS SJCB85/90ST-2	ADH 12/7/07	1542
B	TOLERANCE WAS 1%@68°F	GWC 3/8/07	
A	ADDED COMPONANT MATERIALS	NVE 4/11/06	

DRAWN / DATE: ADH 6/29/07

APPRD. / DATE: REH 7/18/07

MATERIAL

ALL DIMENSIONS ARE IN DECIMAL INCHES
TOLERANCES UNLESS OTHERWISE SPECIFIED

DECIMAL ± .125"
FRACTION ± 1/4"
ANGLE ± 1°

THIRD ANGLE PROJECTION
ANSI 14.5M

NOTES:

Den Hartog INDUSTRIES, INC.

Ace Roto-Mold Injection Molding Blow Molding Sowjoy

4010 HOSPERS DRIVE S. BOX 425, HOSPERS, IOWA 51238-0421

DESCRIPTION: CONE BOTTOM STAND FOR Ø90 15° TANKS

SCALE: N.S.

PART NO.: CB090-15ST

PROPRIETARY DATA

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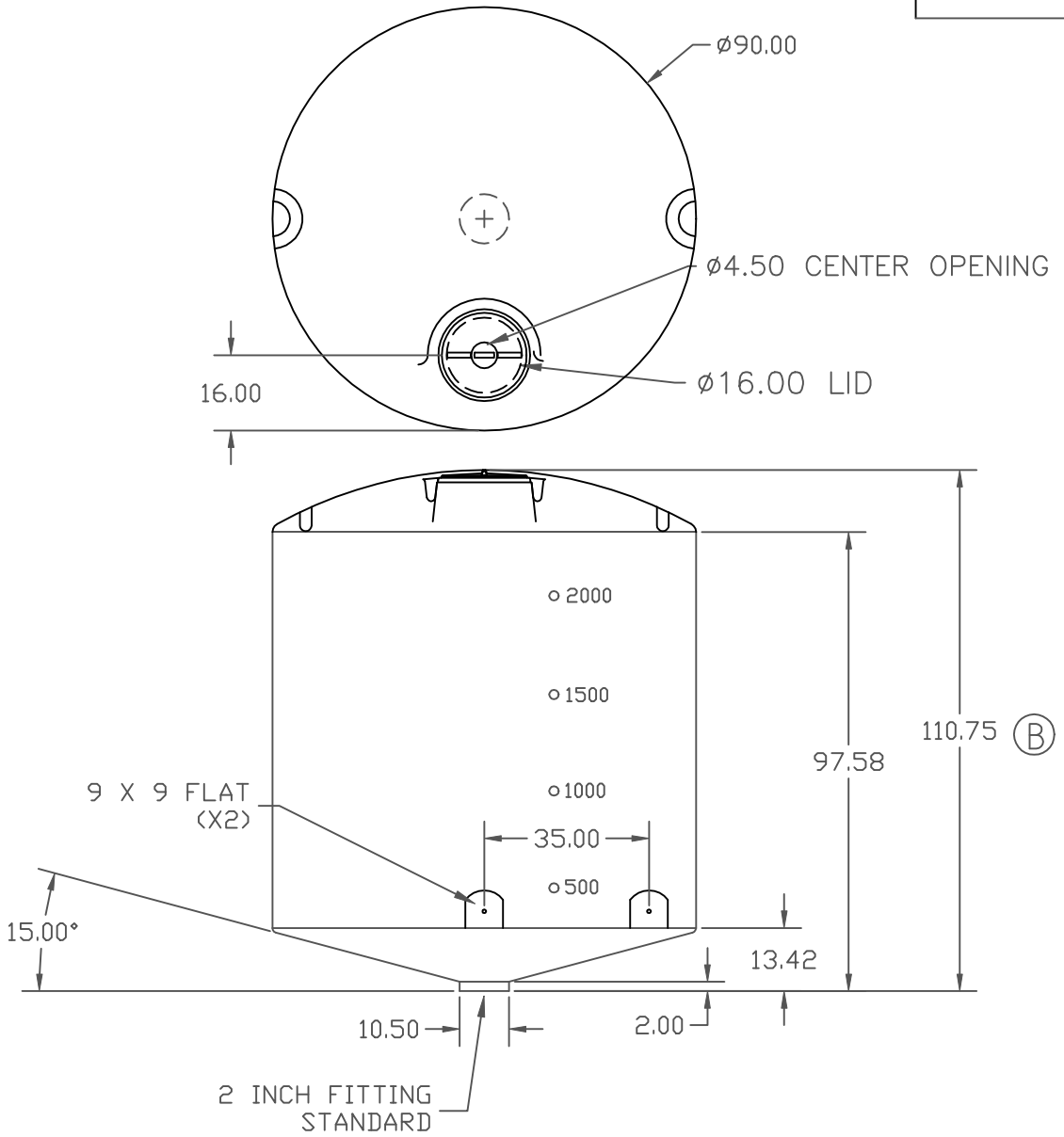


REV	DESCRIPTION	DATE	APPRD
B	HEIGHT WAS 108.75	6/28/06	NVE
A	ISOLATED TANK FROM STAND	6/13/06	NVE

DRAWN / DATE
DHJ 10/7/04

APPRD. / DATE
REH 4/18/07

MATERIAL

HDPE OR EQUIVALENT
REFERENCE MATERIAL DATA SHEET
FOR SPECIFIC PROPERTIES.

ALL DIMENSIONS ARE IN DECIMAL INCHES
TOLERANCES UNLESS OTHERWISE SPECIFIED
± 1% @ 68° F

THIRD ANGLE PROJECTION
ANSI 14.5M

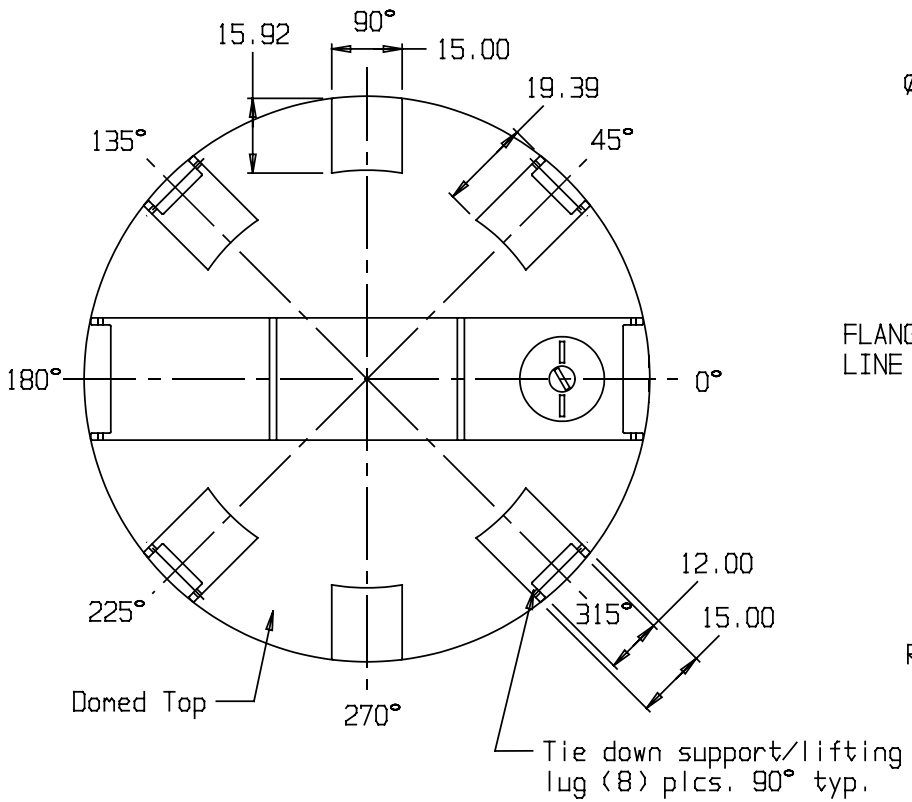
NOTES:
1. SHOT WEIGHT 435 LBS.

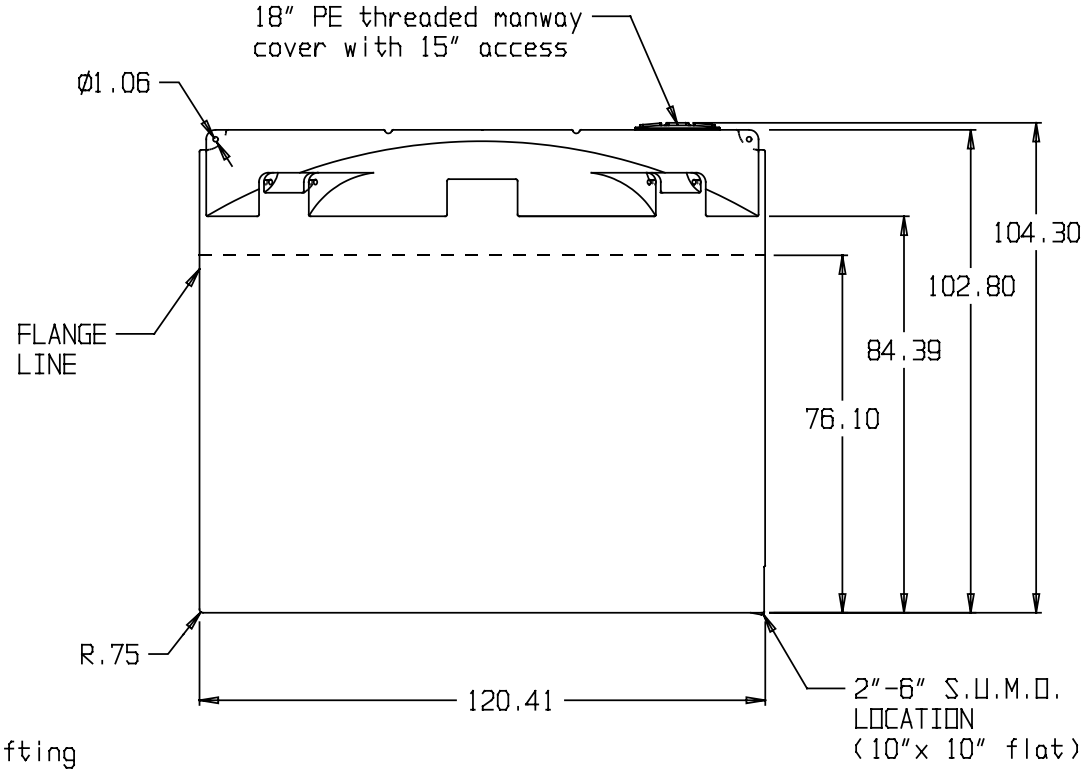
ACE ROTO-MOLD
A DIVISION OF DEN HARTOG INDUSTRIES, INC.
4010 HWY. 60 BLVD., BOX 425, HOSPERS, IOWA 51238

CLIENT / DESCRIPTION
2500 GALLON ø90" 15° CONE BOTTOM TANK

SCALE
N.S.

PART NO.
CB2500-90





SNYDER INDUSTRIES INC.

* BASE FITTINGS TO BE LEFT INSTALLED AT TIME OF SHIPMENT PER SII PROCEDURE
* Consult Snyder's Guidelines for Use and Installation prior to delivery. Available on-line at www.snydernet.com

(all dimensions in inches)

4,000 GALLON FLAT BOTTOM TANK

PART # TANK: H742010000--

REF#: 00000 04/01/04

Warnings and Cautions

Warning	Dangerous Voltage Warning: warns of situations in which a high voltage can cause physical injury and/or equipment damage. The text next to this symbol describes ways to avoid the danger.
Warning	General Warning: warns of situations that can cause physical injury and/or equipment damage by means other than electrical. The text next to this symbol describes ways to avoid the danger.

General Safety Instructions

Warning	Be sure to read, understand, and follow all safety instructions.
Warning	Only qualified electricians should carry out all electrical installation and maintenance work on the V1k drive output filter.
Warning	All wiring must be in accordance with the National Electrical Code (NEC) and/or any other codes that apply to the installation site.
Warning	Disconnect all power before working on the equipment. Do not attempt any work on a powered V1k output filter.
Warning	The V1k, VFD, motor, and other connected equipment must be properly grounded.
Warning	The VFD terminals and connected cables are at a dangerously high voltage when power is applied to the VFD, regardless of motor operation.

Field Wiring

Field Wiring Connection Terminals
Compression type terminals are provided for all line wiring connections. The wire size capacity ranges and tightening torque for the power terminals are listed in the table.

V1k Model Numbers	Input and Output Motor Power	
	Wire Size	Torque (in. - lb.)
V1k2A to V1k12A	12 -18	10
V1k16A to V1k80A	4 - 18	20
V1k110A to V1k130A	2/0 - 6	120
V1k160A	250 MCM - 6	275
V1k200A to V1k250A	Two: 2/0 - 14	120
V1k305A	600 MCM - 4 Two: 250 MCM - 1/0	500
V1k362A	Two: 350 MCM - 4	275
V1k420A to V1k600A	Two: 600 MCM - 2	500
V1k750A	350 MCM - 6	275

For V1k Products with the Short-Circuit Rating Option. Required fusing for SCCR.

V1k Series Device	Withstand Rating	Branch Protective Device
2-45A	5,000A; 600 VAC	Class J fuse rated 225% of FLA
55-160A	10,000A; 600 VAC	Class J fuse rated 225% of FLA
200-305A	18,000A; 600 VAC	Class J fuse rated 450A max
362A	100,000A; 600 VAC	Class L fuse rated 300% of FLA
420-750A	100,000A; 600 VAC	Class L fuse rated 1200A max

See www.transcoil.com for dimensions tables. Please contact TCI Technical Support or your TCI distributor for application information regarding the use of V1k output filters on the output side of the VFD.

TCI, LLC
7878 North 86th Street
Milwaukee, Wisconsin 53224
Ph: 800-TCI-8282
www.transcoil.com

Performance and Protection for Drives

V1k Installation Guide

TCI, LLC
7878 North 86th Street
Milwaukee, Wisconsin 53224
Ph: 800-TCI-8282
www.transcoil.com

Revision 3.3 Part # 25316 May 1, 2010

V1k KLC-Series
Motor Protection Filter
Installation Instructions

Installation Checklist

- Make sure that the installation location will not be exposed to direct sunlight, rain or dripping liquids, corrosive liquids or gases, explosive or combustible gases or dust, excessive airborne dirt and dust, or excessive vibration.
- Select a mounting area that will allow adequate cooling air and maintenance access.
- Make sure that all wiring conforms to the requirements of the National Electric Code (NEC) and/or other applicable electrical codes.
- Ground the V1k Output Filter to a dedicated system ground to ensure safety and filter performance. Use a properly sized grounding conductor.
- Wire the output power terminals of the VFD, T1(U), T2(V), & T3(W) to the input terminals of the V1k filters A1, B1, and C1.
- Wire the output power terminals, of the V1k, A2, B2, & C2 to the motor power connections.
- Make sure the VFD is set for operating modes and ranges that are compatible with the V1k Output Filter.
- Check the entire system thoroughly before energizing and operating any equipment.

When you receive the unit, you should immediately inspect the shipping container and report any damage to the shipping carrier who delivered the unit.

Verify the Application

Make sure the V1k drive output filter is correct for the application. The current ratings of the V1k should be sized to handle the FLA rating of the motor but not to exceed 110% of the drive output current rating. This output filter is best applied matched closely to the load. The V1k drive output filter is not selected by the drive input current rating. Properly sized and applied, TCI guarantees that the V1k will limit motor terminal peak input voltage to 150% of the bus voltage with a wire lead lenth of 1000 feet and a carrier frequency of 4 kHz. Maximum lead length and carrier frequency can vary depending on wire lead type.

Variable Frequency Drive Settings

Make sure that the variable frequency drive will be set for operation modes and ranges that are compatible with the V1k output filter:

- Maximum output frequency: 60 Hz
- PWM switching frequency best between 2kHz and 4kHz
- Mode of operation: Do not use with DC braking unless the drive application has been confirmed by TCI Technical Support.
- Do not use on overhauling loads without bus voltage control.

Mounting an open panel unit

If you are mounting an open panel unit in your own enclosure, you must provide an enclosure that is adequately sized and ventilated sufficiently to prevent overheating. The filter is designed with an maximum ambient temperature of 40°C (104°F). If the ambient temperature exceeds this value it is the responsibility of the customer to provide auxiliary cooling to reduce the ambient operating temperature around the V1k filter. TCI strongly recommends using auxiliary cooling devices such as cooling fans, heat exchangers, or possibly air conditioning units when required to maintain the proper operating temperature.

The V1k must be mounted vertically on a smooth, solid surface, free from heat, dampness, and condensation. Mounting it vertically is important for natural convection cooling. A metal plate is provided to mount the V1k on a composite surface.

Power Wiring

The conduit and wiring from the output of the variable frequency drive to the motor must be routed to the V1k and then to the motor. TCI recommends a separate dedicated conduit run for each drive/filter/motor run unless properly shielded and segregated wiring procedures are practiced. Parasitic and induced capacitance can greatly reduce the effectiveness of the filter performance. Under no circumstances should you wire both control and power wire in the same conduit unless the wire way is specifically designed for this practice. The line reactor temperature is sensitive to lead wire oversizing. Avoid lead wires more than five times oversized by copper cross sectional area regardless of the material used. Use 75°C copper conductors only or the equivalent, unless the wire connector is marked for AI/Cu, then the use of aluminum wire is permitted. Use only copper conductor on units rated above 80 amps.

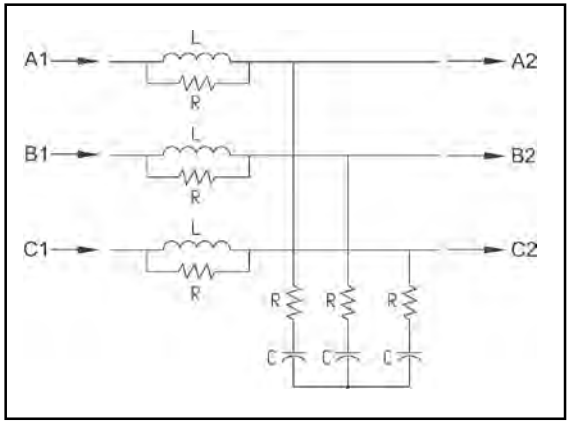
Wiring Cable Entry Locations

TCI has provided enclosure knock-outs on the two smaller enclosures for incoming and outgoing power cables. These are located in a typical wiring location for customer convenience. On the two larger size enclosures, TCI has not provided knock-outs due to the wide variety of application requirements. TCI allows installing electricians the option of locating the cable openings at a point of their choosing.

Grounding

The V1k filter must be connected to the ground of the premises wiring system. This can be conducted by identifying a known premises ground near by the filter or running a special ground dedicated for this application. The ground connection must be made using a wire conductor. Metallic conduit is not a suitable grounding conductor. The integrity of all ground connections should be periodically checked.

Wiring Diagram



Product Specifications

- Current Rating: 2 - 750 Amps
- UL and CUL Listed
- Open, UL Type 1 and 3R Enclosures
- Efficiency > 98%
- Insulation Rating: 600V Class
- Insulation Class: Class H (180°C or Better)
- Altitude (Maximum): 1000 m
- Lead Length: 3000 ft (Specific Applications)
- Operating Temp: 40°C Ambient

V1000 KLC-Series Motor Protection Filters

Performance and Protection for Drives

The V1000 KLC-Series output filters provide exceptional motor and cable protection in a compact design

The next installment of the KLC-Series Filter provides excellent protection in a user-friendly package. This compact design has been developed with space sensitive applications in mind. The V1000 greatly reduces motor failures on VFD applications by limiting the magnitude of voltage spikes to levels below 1000 volts and slows down the rate of change of PWM switching by a factor of three. The V1000 has demonstrated success in protecting the cable and motor insulation by reducing the damaging effects of reflected wave.

Common Mode currents, which can lead to bearing pitting and fluting, are typically reduced by 30%. Extensive testing has demonstrated that TCI's V1000 filter is effective at reducing Common Mode currents, without costly machine modifications.

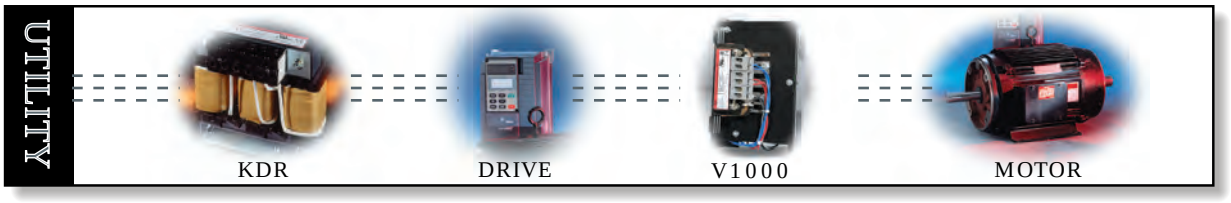
Designed to be installed within ten feet of the drive output terminals, V1000 Filters are easily accessible for both installation and maintenance. The superior performance increases process uptime and motor life. The V1000 provides the outstanding performance that our customers have come to expect from the KLC-Series Output Filters.

Manufacturer's Warranty

V1000 KLC-Series Output Filters are warranted against Manufacturer's defect for one year from the date of original purchase.

Drawings/Specifications

Autocad compatible *.dxf drawings and Acrobat Reader compatible *.pdf drawings of all V1000 Series KLC Output Filters are available at www.transcoil.com or by contacting TCI at (800) 824-8282.



Typical Problems, Superior Solutions with KLC-Series Products

The Reflective Wave Phenomenon

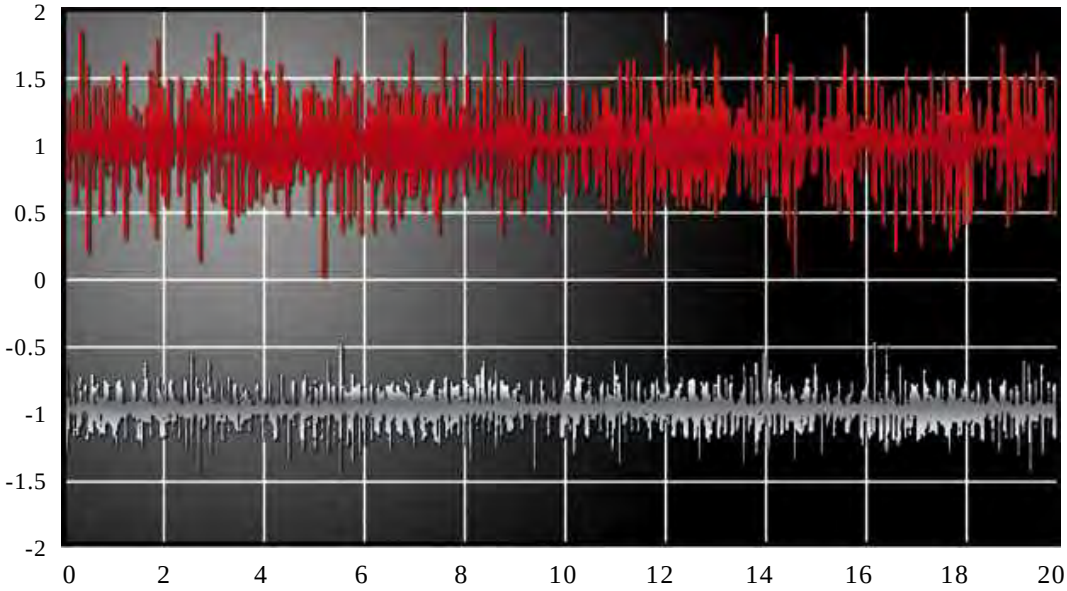
Variable Frequency Drives generate useful "fundamental" voltage and frequency using Pulse Width Modulation (PWM) for adjusting the speed of an AC motor. The Drive's inverter circuit "switches" (transitions from the off state to the on state) rapidly, producing a carrier containing the fundamental voltage and frequency. Voltage wave reflection is a function of the voltage rise time (dV/dT) and the length of the motor cables. The impedance on either end of the cable run does not match, causing voltage pulses to be reflected back in the direction from which it arrived. As these reflected waves encounter incoming waves, their values add, causing higher peak voltage. As wire length or carrier frequency increases, the overshoot peak voltage also increases. The KLC-Series Output Filters have been designed to limit peak voltage and increase voltage rise time. In specific applications, the V1000 has performed with cable runs of up to 3,000 feet.

The Resonant Circuit Phenomenon

Electrical systems of every nature have a natural frequency at which they operate. The natural frequency is determined by the equation: $Fr = \frac{1}{2\Pi * \sqrt{L * C}}$. Individual components within a system also operate at frequencies specific unto themselves. When system components have a resonant frequency that matches the natural resonant frequency of the entire system, peak voltages can quickly exceed standard reflective wave overshoots. The insertion of a V1000 ensures that the system resonance frequency remains sufficiently high in order to avoid matching the resonant frequency of any single component.

Common Mode Motor Bearing Current

Common mode voltage occurs when the voltages on the three output lines of a drive do not sum “instantaneously” to zero. The V1000 substantially slows down the rate of change of PWM switching as seen by the load. This reduction in the rate of change results in increased capacitive coupling impedance between bearings and bearing races. This increase in impedance, in turn, reduces the damaging Common Mode currents and increases motor up-time.



30% Reduction in rms Common Mode Current with V1000 Applied

dV/dT and Reflective Wave unsuppressed causes Motor failures

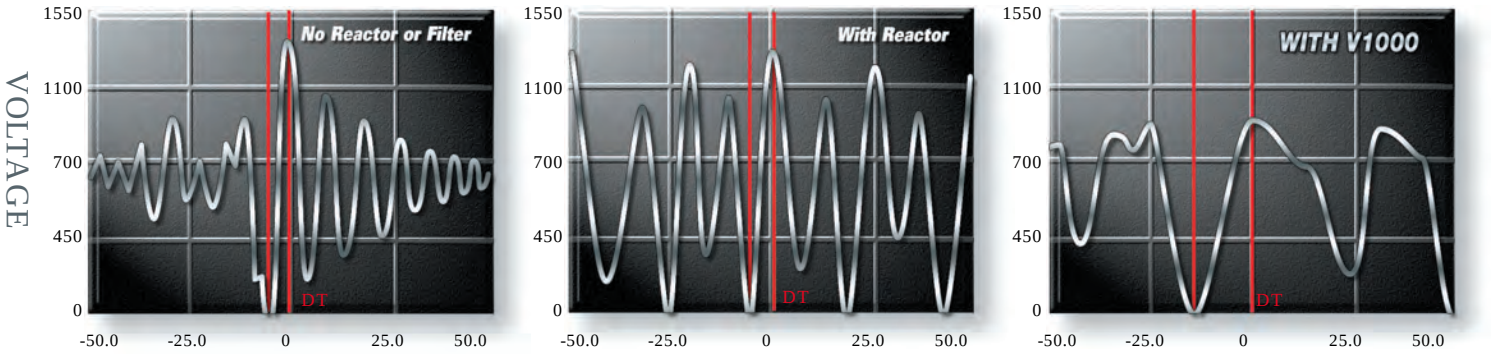
- Peak Voltages on a 460V system can commonly exceed 1500V, causing rapid breakdown of motor insulation, leading to motor failure. On 575 V systems, the peak voltages can easily reach 2100 V. If this is left uncontrolled, insulation failure may occur.
- The same peak voltages that damage the motor can also damage the cable. Since the V1000 filters are designed to be placed at the output of the Drive, these units will also protect the cable runs.

  The added inductance of a V1000 filter will also help reduce motor heating, motor noise, and motor vibration by reducing the current harmonics in the system.

Voltage Rise Time

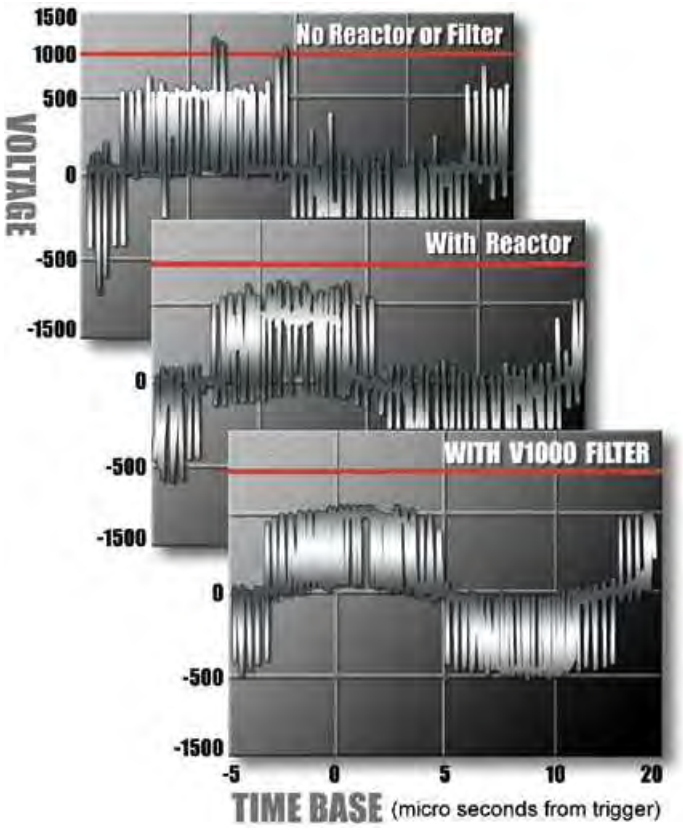
While peak voltages can commonly exceed 1500V, it is important to note that these same spikes can have a rise time, dV/dT, in excess of 7500V/µs. Such high rise times can cause significant damage to the motor windings and the insulation system, resulting in premature motor failure. The life of the motor can be greatly extended by limiting both the magnitude of the voltage spikes to levels below 1000V and the dV/dT at the motor terminals to levels less than 1000V/µs on 480V systems.

Carrier Frequency 8KHZ; 500 Feet of Cable Rate of voltage rise at motor terminals

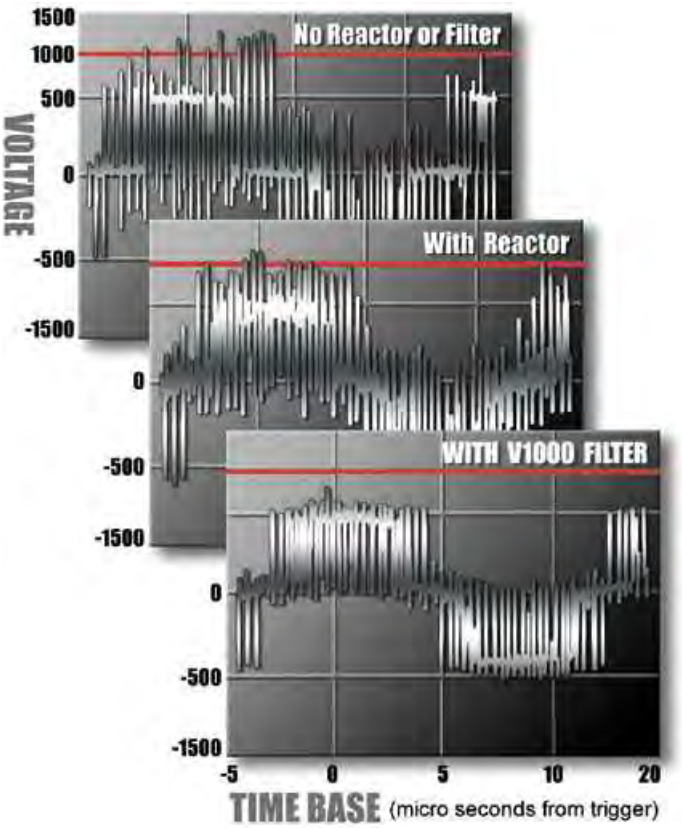


Carrier Frequency 2.5KHZ

70 Feet of Cable

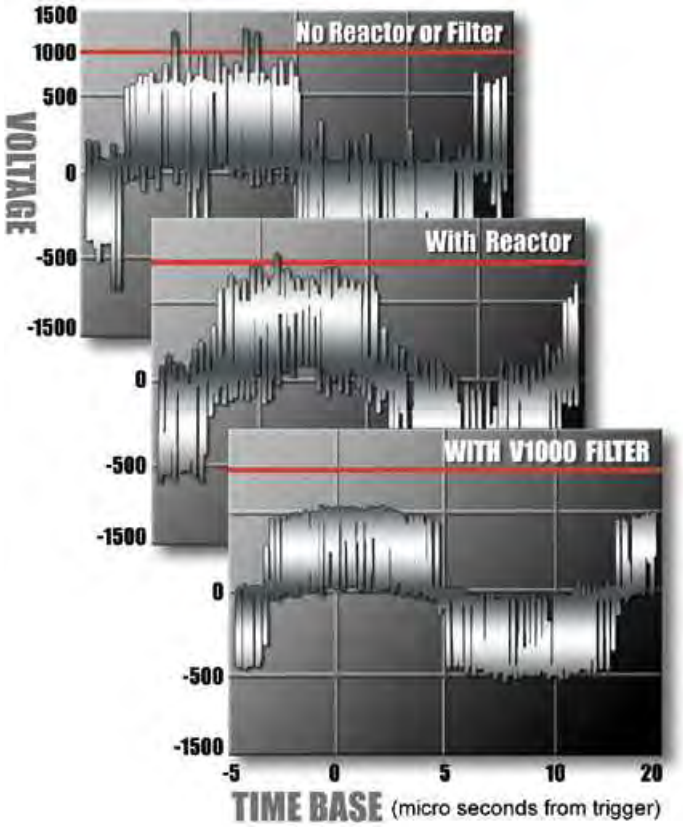


500 Feet of Cable

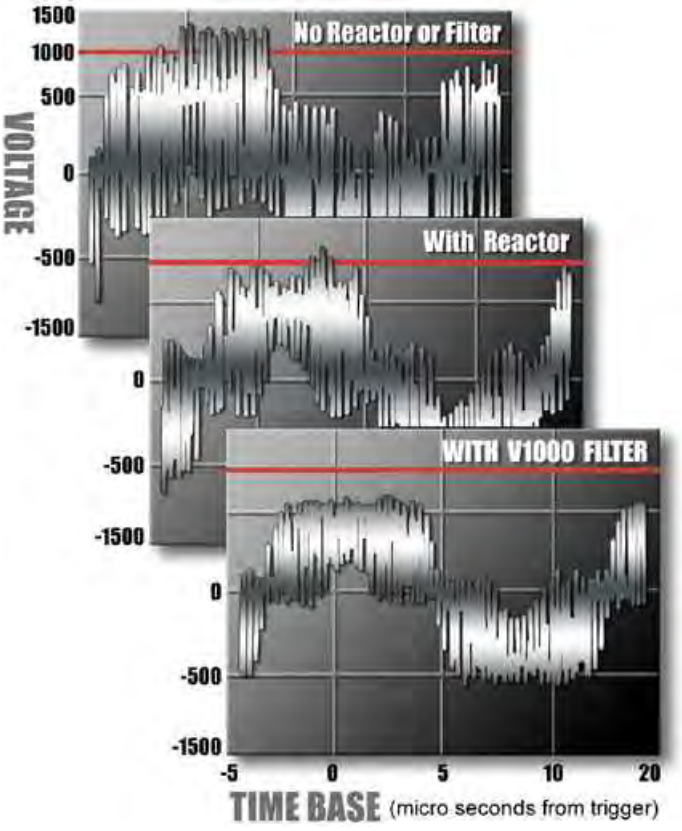


Carrier Frequency 8KHZ

70 Feet of Cable



500 Feet of Cable



V1000 OPEN FILTER

PART NUMBER	NEC MOTOR HP			RATED CURRENT	WATTS LOSS	DIMENSIONS (inches)			WEIGHT	PART NUMBER HEAVY DUTY
	480V	600V	240V			HEIGHT	WIDTH	DEPTH		
V1K2A00	0.75	1	-	2	75	9.00	5.50	7.25	8	V1K2A00EX
V1K3A00	1 - 1.5	2	0.5	3	75	9.00	5.50	7.25	8	V1K3A00EX
V1K4A00	2	3	0.75	4	75	9.00	5.50	7.25	8	V1K4A00EX
V1K6A00	3	-	1 - 1.5	6	80	9.00	5.50	7.25	8	V1K6A00EX
V1K8A00	5	5	2	8	90	9.00	5.50	8.25	8	V1K8A00EX
V1K12A00	7.5	10	3	12	95	9.00	5.50	8.25	8	V1K12A00EX
V1K16A00	10	-	5	16	95	9.00	5.50	8.25	12	V1K16A00EX
VIK18A00	10	15	-	18	110	9.00	5.50	8.25	12	V1K18A00EX
V1K21A00	15	-	-	21	110	9.00	5.50	8.25	12	V1K21A00EX
V1K25A00	15	20	7.5	25	110	9.00	5.50	8.25	12	V1K25A00EX
V1K27A00	20	25	-	27	110	9.00	5.50	8.25	14	V1K27A00EX
V1K35A00	25	30	10	35	130	12.00	8.00	9.00	17	V1K35A00EX
V1K45A00	30	40	15	45	135	12.00	8.00	9.00	17	V1K45A00EX
V1K55A00	40	50	20	55	145	12.00	8.00	9.00	23	V1K55A00EX
V1K80A00	50 - 60	75	25 - 30	80	255	12.00	8.00	9.00	23	V1K80A00EX
V1K110A00	75	100	40	110	245	12.00	8.00	10.25	40	V1K110A00EX
V1K130A00	100	125	50	130	270	8.50	11.75	9.50	55	V1K130A00EX
V1K160A00	125	150	60	160	260	8.50	11.75	10.50	60	V1K160A00EX
V1K200A00	150	200	75	200	265	8.50	11.75	9.25	60	V1K200A00EX
V1K250A00	200	250	100	250	290	8.50	11.75	9.25	65	V1K250A00EX
V1K305A00	250	300	-	300	325	8.75	11.75	12.25	80	V1K302A00EX
V1K362A00	300	350	150	360	300	8.75	11.75	12.00	80	V1K361A00EX
V1K420A00	350	450	-	420	450	10.00	11.75	13.75	95	V1K420A00EX
V1K480A00	400	500	200	480	475	10.00	11.75	13.75	100	V1K480A00EX
V1K600A00	500	600	-	600	515	12.75	15.00	13.75	130	V1K600A00EX
V1K750A00	600	700	-	750	770	12.75	15.00	14.50	135	V1K750A00EX

The watts loss information provided within the selection charts are based on the effects of a sine-triangle modulated waveform at full load current, 60Hz fundamental, with a carrier frequency setting of 4 kHz and a lead length of 500 (wire) feet using THHN cable. It is important to note that as system specifics vary, so shall the watts loss. Typical testing results have indicated that the V1000 has an efficiency rating of 98% or better.

V1000 ENCLOSED FILTER

PART NUMBER (ENCLOSED)	NEC MOTOR HP			RATED CURRENT	WATTS LOSS	DIMENSIONS (inches)			WEIGHT	PART NUMBER HEAVY DUTY
	480V	600V	240V			HEIGHT	WIDTH	DEPTH		
V1K2A01	0.75	1	-	2	75	9.00	5.50	10.00	11	V1K2A01EX
V1K3A01	1 - 1.5	2	0.5	3	75	9.00	5.50	10.00	11	V1K3A01EX
V1K4A01	2	3	0.75	4	75	9.00	5.50	10.00	11	V1K4A01EX
V1K6A01	3	-	1 - 1.5	6	80	9.00	5.50	10.00	11	V1K6A01EX
V1K8A01	5	5	2	8	90	9.00	5.50	10.00	11	V1K8A01EX
V1K12A01	7.5	10	3	12	95	9.00	5.50	10.00	11	V1K12A01EX
V1K16A01	10	-	5	16	95	9.00	5.50	10.00	15	V1K16A01EX
VIK18A01	10	15	-	18	110	9.00	5.50	10.00	15	V1K18A01EX
V1K21A01	15	-	-	21	110	9.00	5.50	10.00	15	V1K21A01EX
V1K25A01	15	20	7.5	25	110	9.00	5.50	10.00	15	V1K25A01EX
V1K27A01	20	25	-	27	110	9.00	5.50	10.00	15	V1K27A01EX
V1K35A01	25	30	10	35	130	12.00	8.00	11.50	23	V1K35A01EX
V1K45A01	30	40	15	45	135	12.00	8.00	11.50	23	V1K45A01EX
V1K55A01	40	50	20	55	145	12.00	8.00	11.50	23	V1K55A01EX
V1K80A01	50 - 60	75	25 - 30	80	255	12.00	8.00	11.50	29	V1K80A01EX
V1K110A01	75	100	40	110	245	16.50	18.00	15.00	68	V1K110A01EX
V1K130A01	100	125	50	130	270	16.50	18.00	15.00	83	V1K130A01EX
V1K160A01	125	150	60	160	260	16.50	18.00	15.00	83	V1K160A01EX
V1K200A01	150	200	75	200	265	16.50	18.00	15.00	93	V1K200A01EX
V1K250A01	200	250	100	250	290	16.50	18.00	15.00	93	V1K250A01EX
V1K305A01	250	300	-	300	325	16.50	18.00	30.00	117	V1K302A01EX
V1K362A01	300	350	150	360	300	16.50	18.00	30.00	117	V1K361A01EX
V1K420A01	350	450	-	420	450	16.50	18.00	30.00	132	V1K420A01EX
V1K480A01	400	500	200	480	475	16.50	18.00	30.00	138	V1K480A01EX
V1K600A01	500	600	-	600	515	16.50	18.00	30.00	168	V1K600A01EX
V1K750A01	600	700	-	750	770	16.50	18.00	30.00	180	V1K750A01EX

The dv/dt Guarantee

Properly sized and applied, TCI guarantees that the V1000 will limit motor terminal peak input voltage to 150% of the bus voltage with a wire lead length of 1000 feet and a carrier frequency of 4 kHz. Maximum lead length and carrier frequency can vary depending on wire lead type. If a properly selected, installed, and loaded V1000 filter fails to meet the guaranteed performance levels, TCI will provide the necessary components or replacement filter at no additional charge. TCI does not take responsibility for additional installation or removal costs, to include, but not limited to, replacement of third party equipment.

Minimum System Requirements

In order to achieve the performance levels as stated in this guarantee, the electrical system must adhere to the following: The V1K must be sized at no more than 110% of the drive output current rating. The V1K must be sized to have regular line current loading of no less than 25% of its current rating. If the load has a potential for overhauling, the drive must be equipped with braking resistors or other features limiting bus voltage to no more than the level of the peak line voltage. The V1K must be wired no more than 12 feet from the drive.

Part Numbering System

V1K 80 A01 EX

Series

Current Rating (amps)

Enclosure:

A00 - Open

A01 - UL Type 1

Option A:

EX - Heavy Duty Model

Flexible Armored THHN Cable

Units 35 Amps and Below

Frequency (kHz)	Cable Leads (feet)			
	100’	101’ - 500’	501’ - 1000’	> 1000’
2	V1000 - STD	V1000 - STD	V1000 - STD	V1000 - EX
4	V1000 - STD	V1000 - STD	V1000 - STD	V1000 - EX
6	V1000 - STD	V1000 - STD	V1000 - EX	MotorGuard
8	V1000 - STD	V1000 - EX	MotorGuard	MotorGuard

Units 45 Amps to 750 Amps

Frequency (kHz)	Cable Leads (feet)			
	100’	101’ - 500’	501’ - 1000’	> 1000’
2	V1000 - STD	V1000 - STD	V1000 - STD	V1000 - EX
4	V1000 - STD	V1000 - STD	V1000 - STD	V1000 - EX
6	V1000 - STD	V1000 - STD	V1000 - STD	V1000 - EX
8	V1000 - STD	V1000 - EX	V1000 - EX	V1000 - EX

Flat Cable or VFD Cable

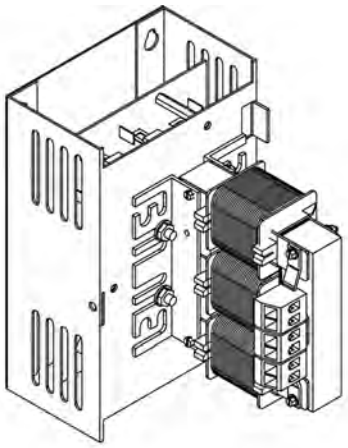
Units 35 Amps and Below

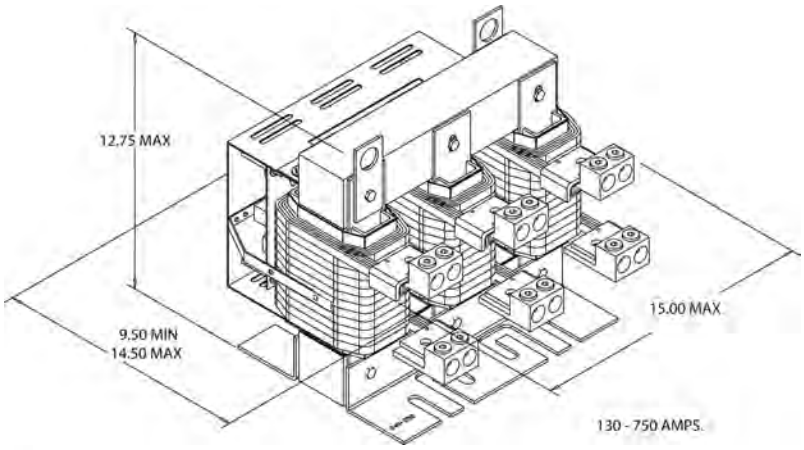
Frequency (kHz)	Cable Leads (feet)			
	100’	101’ - 500’	501’ - 1000’	> 1000’
2	V1000 - STD	V1000 - STD	V1000 - STD	V1000 - EX
4	V1000 - STD	V1000 - STD	V1000 - EX	MotorGuard
6	V1000 - STD	V1000 - STD	MotorGuard	MotorGuard
8	MotorGuard	MotorGuard	MotorGuard	MotorGuard

Units 45 Amps to 750 Amps

Frequency (kHz)	Cable Leads (feet)			
	100’	101’ - 500’	501’ - 1000’	> 1000’
2	V1000 - STD	V1000 - STD	V1000 - STD	V1000 - EX
4	V1000 - STD	V1000 - STD	V1000 - EX	MotorGuard
6	V1000 - STD	V1000 - EX	MotorGuard	MotorGuard
8	MotorGuard	MotorGuard	MotorGuard	MotorGuard

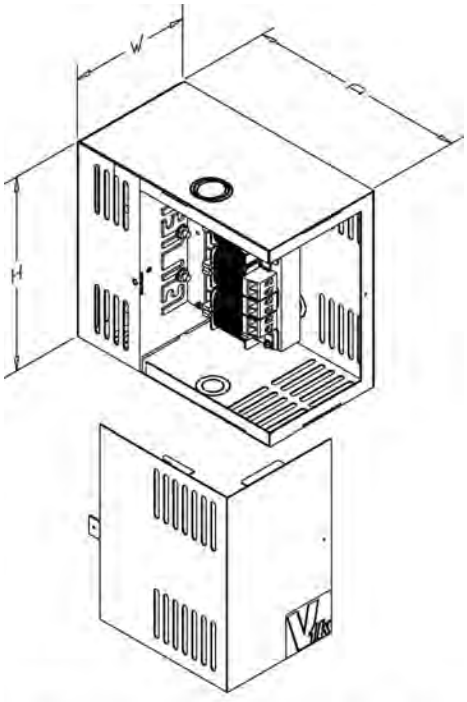
V1000 Open

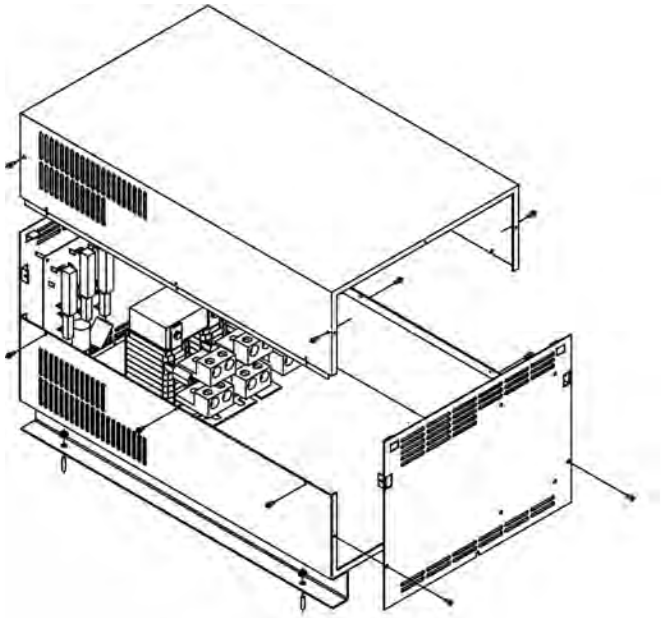




AMPS.	H	W	D_{MAX}	MH	MW	MS
2-27	9.0	5.5	8.25	8.0	4.5	.25
35-110	12.0	8.0	10.25	11.25	7.0	.25

V1000 Enclosed





AMPS.	H	W	D	MH	MW	MS
2-27	9.0	5.5	10.0	8.0	4.5	.25
35-80	12.0	8.0	11.5	11.25	7.0	.25

AMPS.	D	MD	MD1	MW	MS
110-250	15.0	11.0	2.0	16.5	.38
305-750	30.0	23.00	3.50	16.5	.38

SPECS

V1000 Product Specifications

- 3 Phase, 600V Class
- UL Listed
- Manufacturer's Warranty
- Performance Guarantee
- High Performance
- NEMA 1 enclosures available
- Inductor uses Distributed Gap Technology
- 40 degrees C ambient temperature
- 180 degrees C or 220 degrees C Inductor insulation rating
- Designed to mitigate the negative effects of very long motor leads and has reached lengths of up to 3000 feet
- Single motor or multiple motor capable

TCI

Performance and Protection For Drives

TRANS-COIL, INC.
7878 North 86th Street, Milwaukee, WI 53224
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WEB www.transcoil.com

Part No. 25383 Rev No. 10.28.05

MOORE INDUSTRIES

RTI1

Ready-to-Install TRY, TRX & THZ
Temperature Transmitter Assemblies

April 2000 | Data Sheet 3.05

We're Your One Stop Temp Shop

Why waste valuable time searching around for temperature assembly pieces and parts? Our ready-to-install temperature transmitter assemblies feature:

- Universal TRY & TRX PC-Programmable and THZ Smart HART® Temperature Transmitters
- General location, hazardous area, and explosion-proof connection heads
- Wide variety of RTD and thermocouple sensors
- Spring-loaded fittings allow you to easily separate the sensor and transmitter from the thermowell.
- Industrial-strength stainless steel thermowells, flanges, and fittings in the sizes and configurations you need most.
- Factory Mutual (FM) approved explosion-proof temperature transmitter and connection head combinations.
- Complete NIST-traceable calibration records available from our state-of-the-art "Calibration Suite".

One Ordering Number

Specify your complete temperature transmitter assembly using one simple table and ordering number.

Certifications

TRY & TRX PC-Programmable Temperature Transmitters:

FM APPROVED **Factory Mutual Research Corporation (FMRC) Global Explosion-Proof‡** – [LH2] (M/N only) Class I, Division 1, Groups A,B,C,D; [LH1]–**NEMA 4X, IP66**
Non-Incendive – [HPP] Class I, Div. 2, Groups A,B,C,D
Dust Ignition-Proof‡ – [LH2] Class II and III, Division 1, Groups E,F,G; T6;

CSA **CSA General (Ordinary) Location**
Non-Incendive – [HPP] Class I, Div. 2, Groups A,B,C,D

CE **CE Conformant,** EMC Directive 89/336/EEC
EN 50081-2, 1993 and EN 50082-2, 1995

THZ Smart HART Temperature Transmitter:

FM APPROVED **Factory Mutual Research Corporation (FMRC) Global Explosion-Proof‡** – [HPP in LH2 M/N]
Class I, Division 1, Groups A,B,C,D; Class II and III, Division 1, Groups E,F,G; **NEMA 4X, IP66**
Non-Incendive – [HPP]:
Class I, Division 2, Groups A,B,C,D;
Suitable for: Class II and III, Division 2, Groups F,G;
T4A @ 40°C$_{Max. Amb.}$ and T3C @ 60°C$_{Max. Amb.}$

CE **CE Conformant,** EMC Directive 89/336/EEC
EN 50081-2, 1993 and EN 50082-2, 1995

Optional Approvals: FMRC, CSA, SAA, NEPSI, and KEMA (CENELEC) Intrinsically Safe approvals are also available. Consult factory for details.

‡ Factory Mutual certifications apply to the temperature transmitter (TRY, TRX, and THZ) and Connection Head combination. Sensor, Thermowell and Fixed Immersion Sensor assembly components are not included in the certifications. For Group A, seal all conduits within 18".

Selection Guide

Temperature Transmitter Assemblies with Sensors and Thermowells	Pages 2-5
Temperature Transmitter Assemblies with Fixed Immersion Sensors	Pages 6-7
Temperature Transmitter Specifications	Page 8
Sensor Specifications	Page 8

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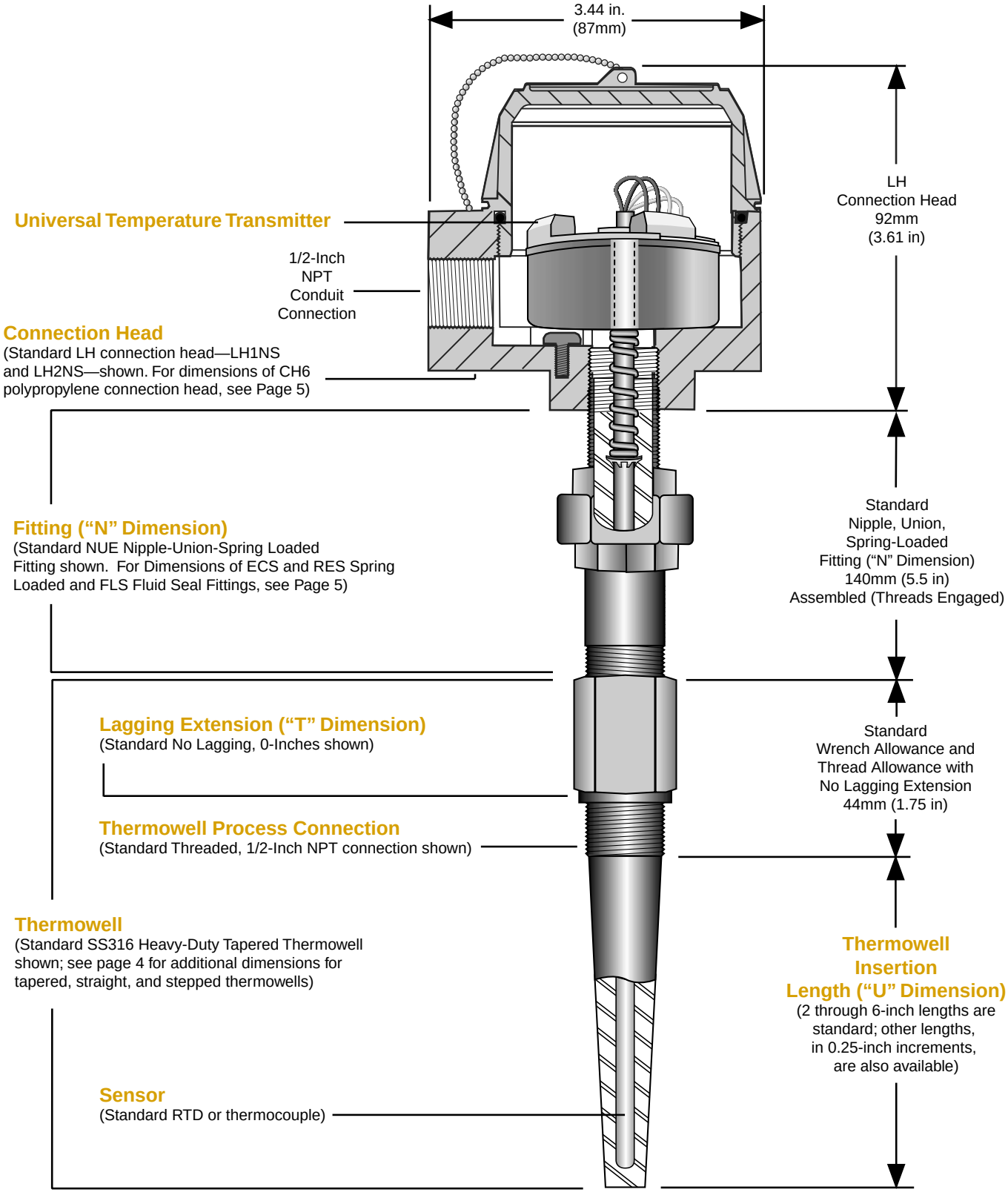
HART is a registered trademark of the HART Communication Foundation.

Standard Temperature Assemblies **with Sensor and Thermowell**



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Select one from each category to order a **Temperature Assembly with Sensor and Thermowell:**

Universal Temperature Transmitter (See Page 8, and the TRY/TRX and THZ Data Sheets for Specifications)

- **TRY** Isolated, PC-Programmable Temperature Transmitter **(standard)**
- **TRX** Non-Isolated, PC-Programmable Temperature Transmitter **(standard)**
- **THZ** Isolated, Smart HART® Temperature Transmitter **(standard)**
- **WEL** 6-position Terminal Block: No Transmitter **(standard)**

Thermowell Type (See Page 4 for Descriptions and Dimensions)

- **A** Heavy-Duty Threaded, Tapered Well **(standard)**
- **B** Standard-Duty Threaded, Straight Well **(standard)**
- **C** Standard-Duty Threaded, Stepped Well **(standard)**
- **S** Sanitary Well

Thermowell Process Connection Size (See Page 2)

- **P2** Threaded, ½-Inch NPT **(standard)**
- **P3** Threaded, ¾-Inch NPT **(standard)**
- P1 Threaded, 1-Inch NPT
- F? Flanged Well, replace "?" with ordering code from Table 1 on Page 5
- SW? Welded, replace "?" with size: SW1= 1-inch, SW2 = ½-inch, SW3 = ¾-inch, SW4 = 1¼-inch
- D? Sanitary well, replace "?" with cap diameter, 1-Inch, 2-Inch, etc. (consult factory for dimensions)

Thermowell Insertion Length ("U" Dimension) (See Page 2)

- **U?** Replace "?" with any Insertion Length in 0.25-Inch increments **(2 through 6-inch lengths are standard)**

Lagging Extension Length ("T" Dimension) (See Page 2)

- **T0** No Lagging, 0 Inches **(standard)**
- T? Replace "?" with length in 0.25-Inch increments

Thermowell Material

- **S304** SS304 **(standard)**
- **S316** SS316 **(standard)**
- **CS** Carbon Steel **(standard)**
- **BR** Brass **(standard)**

Fitting Type ("N" Dimension) (See Pages 2 and 5 for Descriptions and Dimensions)

- **26 – NUE** Nipple-Union Spring-Loaded Fitting **(standard)**
- 26 – ECS Spring Loaded Fitting
- 26 – RES Spring Loaded Fitting (specify when ordering –VTB option)
- 26 – FLS Fluid Seal Fitting

Sensor Type (See Pages 7 & 8 for Specifications)

- **PT14** Platinum RTD; 3- and 4-Wire; 100 ohm; α=0.00385 **(standard)**
- **PT104** Platinum RTD; 3- and 4-Wire; 1000 ohm; α=0.00385 **(standard)**
- CU4 Copper RTD; 3- and 4-Wire; 10 ohm
- N4 Nickel RTD; 3- and 4-Wire; 120 ohm
- **TCJU** J-Type Thermocouple; Ungrounded **(standard)**
- **TCKU** K-Type Thermocouple; Ungrounded **(standard)**
- TC?U Replace "?" with other T/C type E, T, R, S, N, B, or C; Ungrounded

Note: Other RTD types and grounded T/Cs are also available. Consult factory for details.

Options (See Page 7 for Descriptions)

- **–VTB** High accuracy temp. system calibration with NIST test data report
- **–VTD** Standard factory calibration with NIST test data report
- **–RM?** Remote-Mounted terminal block; replace "?" with connection head type for the terminal block, i.e. **–RMLH1NS**. See Page 7 for details.

Connection Head (See Pages 2 and 5 for Dimensions)

- **LH1NS** Aluminum Body with Valox (357U) Cap, NEMA 4X, IP66
- **LH2NS** Aluminum Body with Aluminum Cap, Explosion-Proof
- **CH6** Polypropylene Body and Cap, NEMA 4

Don't See What You Need?
This bulletin features just a sample of the wide range of temperature assembly choices we offer. Whatever your temperature assembly needs are, our interface solution experts are ready to help!

TRY / C – P2 / U4 – T0 / S304 / – 26 – NUE – PT14 –VTB [LH1NS] (Ordering Number Example)

Thermowell Selection

Figure 1. Heavy-Duty Threaded, Tapered Thermowells (Standard) *are convenient to install and replace. Being heavy-duty, they will withstand a high force and high velocity factor from process fluid flow. They are easy to weld or braze for applications which require sealing.*

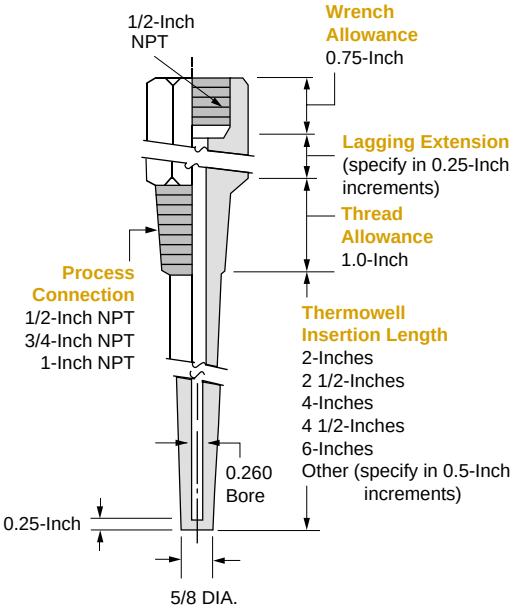


Figure 2. Standard-Duty Threaded, Straight Thermowells (Standard), *convenient to install and replace, will withstand a high force and high velocity factor from the process fluid flow, but less than that of the heavy duty well because of lower natural frequency. They are easy to weld or braze for applications which require sealing.*

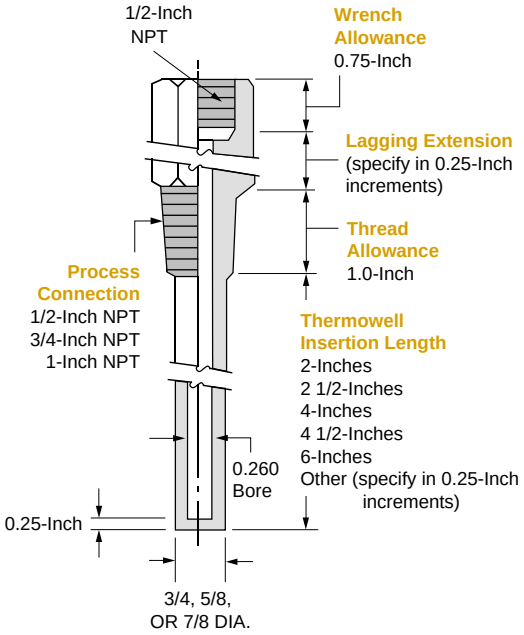


Figure 3. Standard-Duty Threaded, Stepped Thermowells (Standard), *also convenient to install and replace, deliver a faster response time than tapered or straight wells, but less stength and capability to withstand high force and high velocity from the process fluid flow. They are easy to weld or braze for applications which require sealing.*

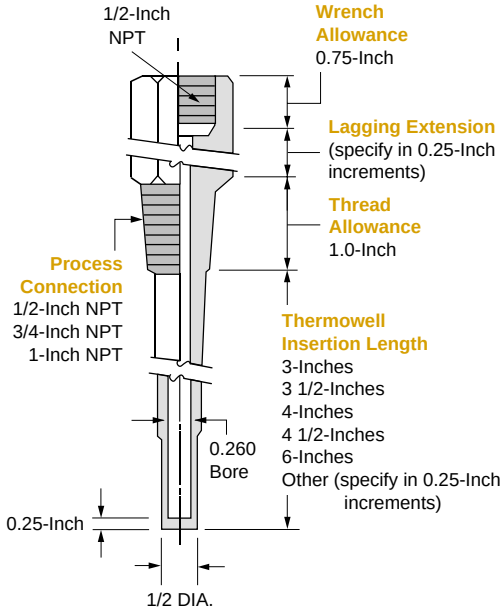
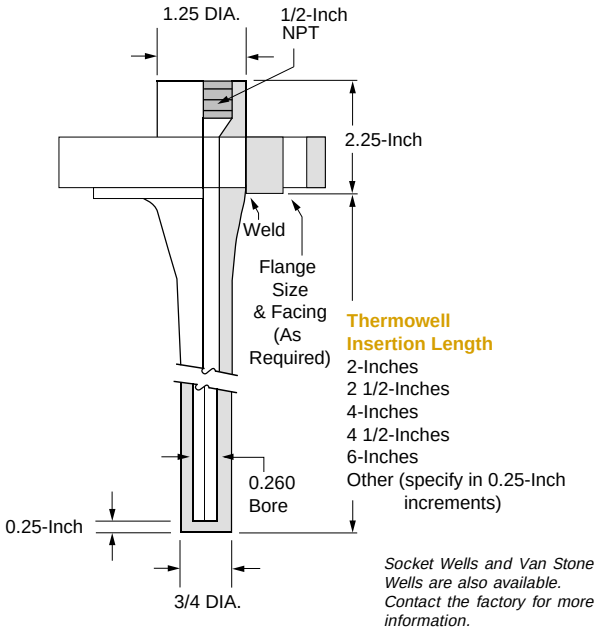


Figure 4. Flanged Thermowells *provide easy removal and high pressure resistance (shown with a Straight Thermowell). Tapered and Stepped Thermowell can also be ordered as Flanged Wells. See Table 1 for available process connection flange sizes.*



Socket Wells and Van Stone Wells are also available. Contact the factory for more information.

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***Figure 5. Dimensions for CH6** Polypropylene, NEMA 4 Connection Head.*

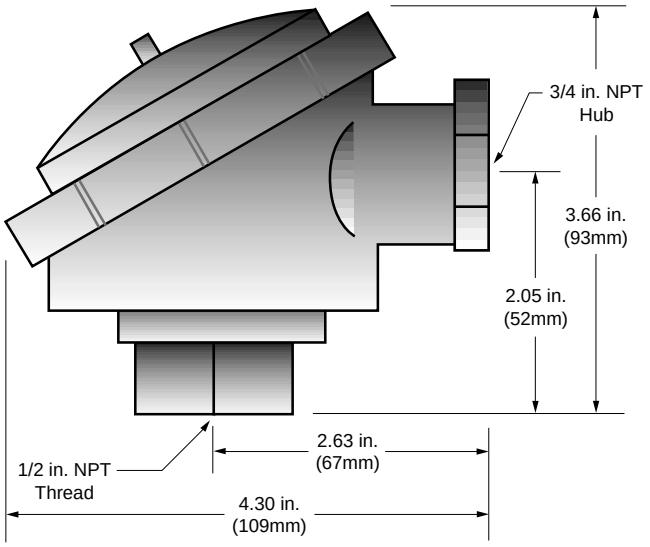


***Table 1.** Process Connection Flange Sizes.*

Ordering Code	Flange Size
F1	1-Inch, 150#, Flat Facing
F2	1-Inch, 150#, Raised Facing
F3	1-Inch, 150#, Ring Type Joint
F4	1 1/2-Inch, 150#, Flat Facing
F5	1 1/2-Inch, 150#, Raised Facing
F6	1 1/2-Inch, 150#, Ring Type Joint
F7	2-Inch, 150#, Flat Facing
F8	2-Inch, 150#, Raised Facing
F9	2-Inch, 150#, Ring Type Joint
F10	1-Inch, 300#, Flat Facing
F11	1-Inch, 300#, Raised Facing
F12	1-Inch, 300#, Ring Type Joint
F13	1 1/2-Inch, 300#, Flat Facing
F14	1 1/2-Inch, 300#, Raised Facing
F15	1 1/2-Inch, 300#, Ring Type Joint
F16	2-Inch, 300#, Flat Facing
F17	2-Inch, 300#, Raised Facing
F18	2-Inch, 300#, Ring Type Joint
F19	1-Inch, 400-600#, Flat Facing
F20	1-Inch, 400-600#, Raised Facing
F21	1-Inch, 400-600#, Ring Type Joint
F22	1 1/2-Inch, 400-600#, Flat Facing
F23	1 1/2-Inch, 400-600#, Raised Facing
F24	1 1/2-Inch, 400-600#, Ring Type Joint
F25	2-Inch, 400-600#, Flat Facing
F26	2-Inch, 400-600#, Raised Facing
F27	2-Inch, 400-600#, Ring Type Joint
F28	1-Inch, 900-1500#, Flat Facing
F29	1-Inch, 900-1500#, Raised Facing
F30	1-Inch, 900-1500#, Ring Type Joint
F31	1 1/2-Inch, 900-1500#, Flat Facing
F32	1 1/2-Inch, 900-1500#, Raised Facing
F33	1 1/2-Inch, 900-1500#, Ring Type Joint
F34	2-Inch, 900-1500#, Flat Facing
F35	2-Inch, 900-1500#, Raised Facing
F36	2-Inch, 900-1500#, Ring Type Joint

Fitting Selection

***Figure 6. NUE Nipple, Union, Spring-Loaded Fitting (Standard)** combination fitting uses a union to allow easy assembly of the entire system. It can be adjusted as many times as required.*

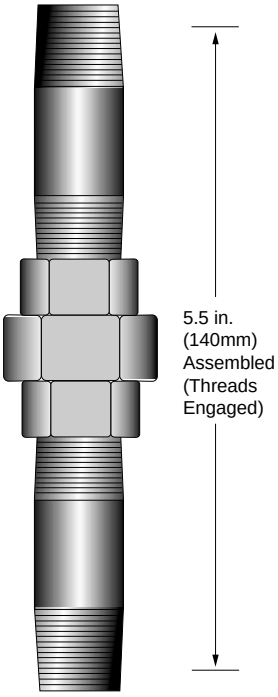


***Figure 7. FLS Fluid Seal Fitting** is used for transmitter assemblies with thermowells and assemblies with fixed immersion sensors. It prevents fluid leak along the sensor sheath so it's ideal for using heat transfer fluid in the thermowell and for air duct applications. Although the FLS provides adjustment precision, it crimps the sensor sheath, and can therefore be adjusted only once (up to 0.5 inch).*

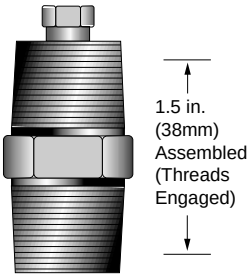
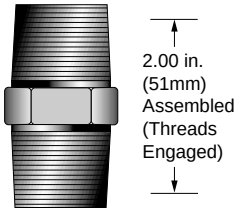
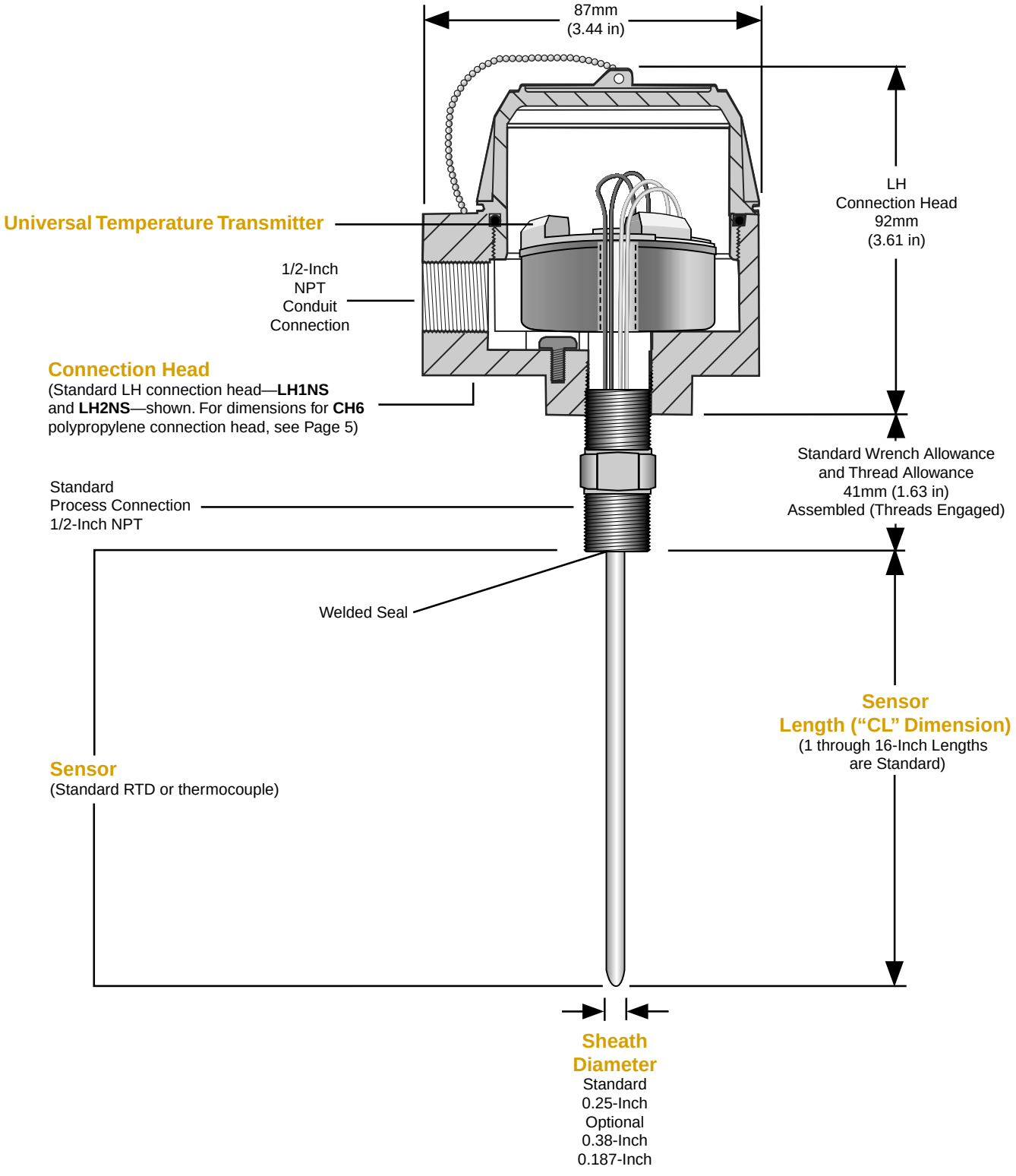


***Figure 8. ECS Spring-Loaded Fittings** assure a good thermal connection between the sensor and thermowell offering a quick response time.*



Standard Temperature Assemblies **with Fixed Immersion Sensor**



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Select one from each category to order a **Temperature Assembly with Fixed Immersion Sensor:**

Universal Temperature Transmitter (See Page 8 and TRY/TRX and THZ Data Sheets for Specifications)

- **TRY** Isolated, PC-Programmable Temperature Transmitter **(standard)**
- **TRX** Non-Isolated, PC-Programmable Temperature Transmitter **(standard)**
- **THZ** Smart HART® Temperature Transmitter **(standard)**

Sensor Length ("CL" Dimension) (See Page 6)

- **CL?** Replace "?" with any Sensor Length (e.g., CL2.75, CL6) in 0.25-inch increments **(2 through 16-inch lengths are standard)**

Sensor Sheath Diameter

- **D18** 0.187-Inch Diameter **(standard)**
- **D25** 0.25-Inch Diameter **(standard)**
- D38 0.38-Inch Diameter

Sensor Sheath Material

- **S304** SS304 **(standard)**
- **S316** SS316 **(standard)**

Sensor Type (See Page 8 for Specifications)

- **PT1C4** Platinum RTD; for 3- and 4-Wire; 100 ohm; α=0.00385 **(standard)**
- **PT10C4** Platinum RTD; for 3- and 4-Wire; 1000 ohm ; α=0.00385 **(standard)**
- CUC4 Copper RTD; 2-, 3-, 4-Wire; 10 ohm
- NC4 Nickel RTD; 2-, 3-, 4-Wire; 120 ohm
- **TCCJU** J-Type Thermocouple; Ungrounded **(standard)**
- **TCCKU** K-Type Thermocouple; Ungrounded **(standard)**
- TCC?U Replace "?" with other T/C type E, T, R, S, N, B, or C

Note: Other RTD types and grounded T/Cs are also available consult the factory for details.

Options (See Page 7 for Descriptions)

- **–VTB** High accuracy temperature system calibration with NIST test data report
- **–VTD** Standard factory calibration with NIST test data report
- **–RM?** Remote-Mounted terminal block; replace "?" with connection head type for the terminal block, i.e. **–RMLH1NS**. See *Remote-Mounted Terminal Block* below for details.

Connection Head (See Pages 5 and 6 for Dimensions)

- **LH1NS** Aluminum Body with Valox (357U) Cap, NEMA 4X, IP66 locations **(standard)**
- **LH2NS** Aluminum Body with Aluminum Cap, Explosion-Proof locations **(standard)**
- **CH6** Polypropylene Body and Cap, NEMA 4 **(standard)**

THZ / CL6 / D25 / S316 / -TCCJU –VTB [LH2NS] **(Ordering Number Example)**

Don't See What You Need?
This bulletin features just a sample of the wide range of temperature assembly choices we offer. Whatever your temperature assembly needs are, our temperature interface solution experts are ready to help!

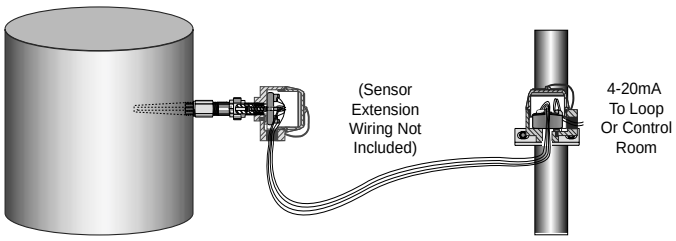
Factory Calibration Available

Sensor-to-Transmitter Trimming—Our state-of-the-art **Calibration Suite** provides exceptional accuracy by immersing the system's sensor in a precision calibration bath, then using the transmitter to "capture" the sensor's true readings. This method effectively compensates for errors caused by inherent sensor inaccuracies. The system is delivered configured, calibrated, and ready for installation. NIST traceable test data is supplied with each system. To order, specify option **–VTB** in the model number.

NIST Traceable Test Report—Moore Industries will configure the temperature transmitter and calibrate zero and span points with customer-supplied values using a precision simulated sensor input. NIST traceable test data indicating actual recorded values is supplied with each instrument. To order, specify option **–VTD** in the model number.

Remote-Mounted Terminal Block

Remove the Display From the Process—Position your sensor in the heart of your process while keeping your transmitter in an easily accessible area with our *Remote Terminal Block* option. Add the **–RM?** option to your temperature assembly and receive two housings: a transmitter in the specified connection head, and a terminal block enclosed in an additional connection head with your selected sensor and fittings attached. Sensor extension wiring (not included) connects the terminal block to the transmitter.



RTI1

Ready-to-Install TRY, TRX & THZ
Temperature Transmitter Assemblies

Temperature Transmitter Specifications

TRY & TRX PC-Programmable Temperature Transmitters

In one minute, from one software window, you can configure our TRY (isolated) and TRX (non-isolated) 2-wire (loop-powered) transmitters to handle nearly every temperature application in your plant. Everything you need for set up (Intelligent Configuration Software and RS-232 cable) are supplied **FREE** with your order.

Programmable parameters include: Input type and range; output range; output damping; sensor trim offset; RJC or no RJC; linearization or no linearization; temperature readout in °C or °F; and upscale or downscale drive on sensor burnout

Basic TRY & TRX Specifications:

Temperature Assemblies Come with Transmitter Model Number:
TRY / PRG / 4-20MA / 10-42DC / [HOUSING CHOICE]
TRX / PRG / 4-20MA / 8-42DC / [HOUSING CHOICE]
Input: See Table 2
Output: 4-20mA output is accurate to within ±0.03% of input span
Power: TRY: 10-42Vdc (loop-powered on output side)
TRX: 8-42Vdc (loop-powered on output side)
RJC Accuracy (T/C inputs only): ±0.45°C
Linearity: 0.1% of span, within rated ranges
Isolation (TRY Only): 1500Vrms input to output to case
RFI/EMI Protection: 20V/m @20-1000MHz
Operating and Storage Range: –40°C to +85°C (–40°F to +185°F)
Ambient Temperature Effect on Accuracy: ±0.015% of span per °C change, maximum (+0.001% of ohm reading for RTD inputs
Ambient Temperature Effect on RJC (T/C only): ±0.015°C/°C change

For detailed specifications, *see the TRY/TRX Data Sheet (#3.95)*

Sensor Specifications

Number of Lead Wires (RTDs): All temperature assemblies are supplied with 4-wire RTDs that inherently avoid lead wire resistance imbalances caused by wire corrosion and aging.
Lead Wires: Teflon insulated, hermetically sealed
Sheath Material: Stainless steel 316 (other materials available)
Accuracy: RTD: ±0.12% at 0°C (high accuracy RTDs also available); Consult factory for thermocouple tolerances
Pressure: 12,000 psig (-20 to 100°C, -29 to 37°C) for 0.25" dia.
Response Time: RTD, <5 seconds to 63.2% temperature change; Thermocouple, 4.5 sec. for ungrounded, typical; 2.0 sec. for grounded to 63.2% temperature change
Vibration Limit: 10 G over a frequency range of 10–500Hz
Stability: RTD, 0.2°C after 10,000 hrs. at maximum temperature (1 year, 51 days, 16 hours continuous)

THZ Smart HART® Temperature Transmitter

The THZ programs over the 4-20mA wire pair from anywhere on the loop using a standard hand held HART Communicator or our Intelligent Configuration Software (HART to RS-232 Smart Interface cable required).

Programmable parameters include: Input type and range; output range; output damping; sensor trim offset; temperature readout in °C or °F; and upscale or downscale drive on sensor burnout

Basic THZ Specifications:

Temperature Assemblies Come with Transmitter Model Number:
THZ / PRG / 4-20MA / 12-42DC / [HOUSING CHOICE]
Input: See Table 2
Output: 4-20mA output is accurate to within ±0.015% of input span
Power: 12-42Vdc (loop-powered on output side)
RJC Accuracy (T/C inputs only): ±0.45°C
Isolation: 500Vrms input to output continuous
RFI/EMI Protection: 10V/m @80-1000MHz
Operating and Storage Range: –40°C to +85°C (–40°F to +185°F)
Ambient Temperature Effect on Accuracy: 0.01% of span per °C change, maximum; 0.003% of span per °C change typical
Ambient Temperature Effect on RJC: ±0.005°C/°C change of ambient temperature

For detailed specifications, *see the THZ Data Sheet (#3.80)*

Table 2. *TRY, TRX, & THZ Input Specifications*

Input Type	Range	Accuracy
TRY & TRX PC-Programmable Temperature Transmitters		
PT14 Platinum RTD; 3- and 4-Wire; 100 ohm, α = 0.00385 (standard)	–200 to +850°C (–328 to +1562°F)	±0.21°C ±0.38°F
PT104 Platinum RTD; 3- and 4-Wire; 1000 ohm, α = 0.00385 (standard)	–50 to +500°C (–58 to +932°F)	±0.21°C ±0.38°F
CU4 Copper RTD; 3- and 4-Wire; 10 ohm, α = 0.00427 @ 0°C	–50 to +250°C (–58 to +482°F)	±1.2°C ±2.16°F
N4 Nickel RTD; 3- and 4-Wire; 120 ohm, α = 0.00672 @ 0°C	–80 to +320°C (–112 to +608°F)	±0.16°C ±0.29°F
TCJU J-Type T/C; Ungrounded (standard)	–180 to +770°C (–292 to +1418°F)	±0.28°C ±0.5°F
TCKU K-Type T/C; Ungrounded (standard)	–150 to +1372°C (–238 to +2502°F)	±0.3°C ±0.54°F
THZ Smart HART® Temperature Transmitter		
PT14 Platinum RTD; 3- and 4-Wire; 100 ohm, α = 0.00385 (standard)	–200 to +850°C (–328 to +1562°F)	±0.1°C ±0.18°F
PT104 Platinum RTD; 3- and 4-Wire; 1000 ohm, α = 0.00385 (standard)	–200 to +320°C (–328 to +608°F)	±0.1°C ±0.18°F
N4 Nickel RTD; 3- and 4-Wire; 120 ohm, α = 0.00618 @ 0°C	–50 to +250°C (–58 to +482°F)	±0.1°C ±0.18°F
TCJU J-Type T/C; Ungrounded (standard)	–200 to +1000°C (–328 to +1832°F)	±0.25°C ±0.45°F
TCKU K-Type T/C; Ungrounded (standard)	–230 to +1370°C (–382 to +2498°F)	±0.3°C ±0.54°F

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YASKAWA

P7 Drive
User Manual

This Manual
also available on
www.drives.com

Model: P7U **Document Number: TM.P7.01**

Quick Reference for P7 Parameters

Parameter Number	Factory Setting	User Setting
A1-00	0	
A1-01	2	
A1-03	0	
A1-04	0	
A1-05	0	
A2-01		
A2-02		
A2-03		
A2-04		
A2-05		
A2-06		
A2-07		
A2-08		
A2-09		
A2-10		
A2-11		
A2-12		
A2-13		
A2-14		
A2-15		
A2-16		
A2-17		
A2-18		
A2-19		
A2-20		
A2-21		
A2-22		
A2-23		
A2-24		
A2-25		
A2-26		
A2-27		
A2-28		
A2-29		
A2-30		
A2-31		
A2-32		
b1-01	1	
b1-02	1	
b1-03	0	
b1-04	1	
b1-07	0	
b1-08	0	
b1-11	0	
b1-12	0	
b2-01	0.5	
b2-02	50	
b2-03	0	
b2-04	0	
b2-09	0	
b3-01	2	
b3-02	120	
b3-03	2	
b3-05	0.2	
b3-14	1	
b4-01	0	
b4-02	0	
b5-01	0	
b5-02	2	
b5-03	5	
b5-04	100	
b5-06	100	

Parameter Number	Factory Setting	User Setting
b5-07	0	
b5-08	0	
b5-09	0	
b5-10	1	
b5-11	0	
b5-12	0	
b5-13	0	
b5-14	1	
b5-15	0	
b5-16	0	
b5-17	0	
b5-18	0	
b5-19	0	
b5-20	1	
b5-21	1	
b5-22	0	
b5-23	0	
b5-24	0	
b5-25	0	
b5-26	0	
b5-27	60	
b5-28	0	
b5-29	1	
b5-30	0	
b8-01	0	
b8-04	kVA Dep.	
b8-05	20	
b8-06	0	
C1-01	30	
C1-02	30	
C1-03	30	
C1-04	30	
C1-09	10	
C1-11	0	
C2-01	0.2	
C2-02	0.2	
C4-01	1	
C4-02	200	
C6-01	2	
C6-02	kVA Dep.	
C6-03	kVA Dep.	
C6-04	kVA Dep.	
C6-05	0	
d1-01	0	
d1-02	0	
d1-03	0	
d1-04	0	
d1-17	6	
d2-01	100	
d2-02	0	
d2-03	0	
d3-01	0	
d3-02	0	
d3-03	0	
d3-04	1	
d4-01	0	
d4-02	10	
E1-01	240V or 480V	
E1-03	F	
E1-04	60	
E1-05	240V or 480V	
E1-06	60	

Parameter Number	Factory Setting	User Setting
E1-07	3	
E1-08	18	
E1-09	1.5	
E1-10	10.8	
E1-11	0	
E1-12	0	
E1-13	0	
E2-01	kVA Dep.	
E2-03	kVA Dep.	
E2-05	kVA Dep.	
F6-01	1	
F6-02	0	
F6-03	1	
F6-05	0	
H1-01	24	
H1-02	14	
H1-03	3	
H1-04	4	
H1-05	6	
H2-01	0	
H2-02	A	
H3-02	100	
H3-03	0	
H3-08	2	
H3-09	2	
H3-10	100	
H3-11	0	
H3-12	0.3	
H3-13	0	
H4-01	2	
H4-02	100	
H4-03	0	
H4-04	8	
H4-05	50	
H4-06	0	
H4-07	0	
H4-08	0	
H5-01	1F	
H5-02	3	
H5-03	0	
H5-04	3	
H5-05	1	
H5-06	5	
H5-07	1	
H5-08	0	
H5-09	2	
L1-01	1	
L1-02	8	
L1-03	3	
L1-04	1	
L1-05	0.2	
L2-01	2	
L2-02	kVA Dep.	
L2-03	kVA Dep.	
L2-04	kVA Dep.	
L2-05	Voltage Dep.	
L3-01	1	
L3-02	120	
L3-04	1	
L3-05	1	
L3-06	120	
L4-01	0	

Parameter Number	Factory Setting	User Setting
L4-02	2	
L4-05	1	
L4-06	80	
L5-01	0	
L5-02	0	
L5-03	180	
L6-01	6	
L6-02	15	
L6-03	10	
L8-01	0	
L8-02	kVA Dep.	
L8-03	4	
L8-06	kVA Dep.	
L8-09	1	
L8-10	0	
L8-11	300	
L8-12	45	
L8-15	1	
L8-18	1	
L8-19	20	
n1-01	1	
n1-02	1	
n3-01	5	
n3-02	150	
n3-03	1	
n3-04	40	
o1-01	6	
o1-02	1	
o1-03	0	
o1-05	3	
o1-06	0	
o1-07	2	
o1-08	3	
o2-01	1	
o2-02	1	
o2-03	0	
o2-04	kVA Dep.	
o2-05	1	
o2-06	1	
o2-07	0	
o2-08	1	
o2-10	0	
o2-12	0	
o2-14	0	
o2-15	1	
o3-01	0	
o3-02	0	
T1-02	kVA Dep.	
T1-04	kVA Dep.	

Warnings and Cautions

This Section provides warnings and cautions pertinent to this product, that if not heeded, may result in personal injury, fatality, or equipment damage. Yaskawa is not responsible for consequences of ignoring these instructions.

⚠ WARNING

YASKAWA manufactures component parts that can be used in a wide variety of industrial applications. The selection and application of YASKAWA products remain the responsibility of the equipment designer or end user. YASKAWA accepts no responsibility for the way its products are incorporated into the final system design. Under no circumstances should any YASKAWA product be incorporated into any product or design as the exclusive or sole safety control. Without exception, all controls should be designed to detect faults dynamically and fail safely under all circumstances. All products designed to incorporate a component part manufactured by YASKAWA must be supplied to the end user with appropriate warnings and instructions as to that part's safe use and operation. Any warnings provided by YASKAWA must be promptly provided to the end user. YASKAWA offers an express warranty only as to the quality of its products in conforming to standards and specifications published in the YASKAWA manual. NO OTHER WARRANTY, EXPRESS OR IMPLIED, IS OFFERED. YASKAWA assumes no liability for any personal injury, property damage, losses, or claims arising from misapplication of its products.

⚠ WARNING

- Read and understand this manual before installing, operating, or servicing this Drive. All warnings, cautions, and instructions must be followed. All activity must be performed by qualified personnel. The Drive must be installed according to this manual and local codes.
- Do not connect or disconnect wiring while the power is on. Do not remove covers or touch circuit boards while the power is on. Do not remove or insert the digital operator while power is on.
- Before servicing, disconnect all power to the equipment. The internal capacitor remains charged even after the power supply is turned off. Status indicator LEDs and Digital Operator display will be extinguished when the DC bus voltage is below 50 VDC. To prevent electric shock, wait at least five minutes after all indicators are OFF and measure DC bus voltage level to confirm safe level.
- Do not perform a withstand voltage test on any part of the unit. This equipment uses sensitive devices and may be damaged by high voltage.
- The Drive is not suitable for circuits capable of delivering more than the specified RMS symmetrical amperes. Install adequate branch short circuit protection per applicable codes. Refer to the specification. Failure to do so may result in equipment damage and/or personal injury.
- Do not connect unapproved LC or RC interference suppression filters, capacitors, or overvoltage protection devices to the output of the Drive. These devices may generate peak currents that exceed Drive specifications.
- To avoid unnecessary fault displays caused by contactors or output switches placed between Drive and motor, auxiliary contacts must be properly integrated into the control logic circuit.
- YASKAWA is not responsible for any modification of the product made by the user; doing so will void the warranty. This product must not be modified.
- Verify that the rated voltage of the Drive matches the voltage of the incoming power supply before applying power.
- To meet CE directives, proper line filters and proper installation are required.

⚠ WARNING

- Some drawings in this manual may be shown with protective covers or shields removed, to describe details. These must be replaced before operation.
- Observe electrostatic discharge procedures when handling circuit cards to prevent ESD damage.
- The equipment may start unexpectedly upon application of power. Clear all personnel from the drive, motor, and machine area before applying power. Secure covers, couplings, shaft keys, and machine loads before energizing the Drive.
- Please do not connect or operate any equipment with visible damage or missing parts. The operating company is responsible for any injuries or equipment damage resulting from failure to heed the warnings in this manual.

■ Intended Use

Drives are intended for installation in electrical systems or machinery.

For use in the European Union, the installation in machinery and systems must conform to the following product standards of the Low Voltage Directive:
EN 50178, 1997-10, Equipping of Power Systems with Electronic Devices
EN 60201-1, 1997-12 Machine Safety and Equipping with Electrical Devices
Part 1: General Requirements (IEC 60204-1:1997)/
EN 61010, 1997-11Safety Requirements for Information Technology Equipment
(IEC 950:1991 + A1:1992 + A2:1993 + A3:1995 + A4:1996, modified)

CE certification per EN 50178 can be achieved using the line filters specified in this manual and following the appropriate installation instructions.

■Other

The Drive is suitable for use on a circuit capable of delivering not more than 100,000 RMS symmetrical amperes, 240Vac maximum (240V Class) and 480Vac maximum (480V Class).

Introduction

This Section describes the applicability of the Manual

The P7 Drive is a Pulse Width Modulated Drive for 3-Phase AC induction motors. This type of Drive is also known as an Adjustable Frequency Drive, Variable Frequency Drive, AC Drive, AFD, ASD, VFD, and Inverter. In this manual, the P7 Drive will be referred to as the “Drive”.

The Drive is a variable torque AC drive, designed specifically for HVAC applications in building automation, including fans, blowers and pumps. A new benchmark for size, cost, performance, benefits, and quality, the Drive includes numerous built-in features such as network communications, PI, parameter storage and copy functions.

The Drive has embedded communications for Modbus®protocol. An optional LONWORKS® interface card is also available.

The LCD keypad/operator is equipped with local/remote functions, copy feature, 7 language choices, and 5 lines of display with 16 characters per line. User parameter settings can be recovered at any time via “user initialization”. Optional software allows upload/download, as well as graphing and monitoring of drive parameters from a PC for ease of drive management.

Built-in PI control eliminates the need for closed loop output signals from a building automation system. It includes feedback display, inverse, square root and differential control functions, and maintains setpoint for closed loop control of fans and pumps for pressure, flow, or temperature regulation.

This manual is applicable to Drives defined by model numbers CIMR-P7U_ _ _ _ . This manual reflects the Software Version 1020.

This manual is subject to change as product improvements occur. The latest version of the manual can be obtained from the Yaskawa website www.drives.com . The date shown on the rear cover is changed when revisions are made.

This manual may describe trademarked equipment, which is the property of other companies. These trademarks are the property of the registered owner companies and may include the following:

Modbus®, trademark of Schneider Automation, Inc.
LONWORKS®, trademark of Echelon Corporation

Other Documents and Manuals are available to support special use or installation of this product. These documents may be provided with the product or upon request. Contact Yaskawa Electric America, Inc. as required. Documents may include the following:

TM.P7.02.Programming… Manual included on CD ROM with product
TM.AFD.11.Modbus… Manual included on CD ROM with product
TM.AFD.20.LONWORKS… Manual included on CD ROM with product
TM.P7B.01. Bypass… This manual should be used when the Drive is packaged with Bypass Control
DriveWizard ... Software and Manual…Included on CD ROM with product
Option Instructions… Included on CD ROM with product

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Physical Installation

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Model Number and Enclosure Style

Table 1.1 Model Numbers and Enclosure Style

Input Voltage 3-Phase	Model Number	EnclosureStyle	Rated Output Current	Nominal Hp
208-240Vac	CIMR-P7U20P4	NEMA Type 1 (IP20)	3.6	0.5/0.75
	CIMR-P7U20P7	NEMA Type 1 (IP20)	4.6	1
	CIMR-P7U21P5	NEMA Type 1 (IP20)	7.8	1.5/2
	CIMR-P7U22P2	NEMA Type 1 (IP20)	10.8	3
	CIMR-P7U23P7	NEMA Type 1 (IP20)	16.8	5
	CIMR-P7U25P5	NEMA Type 1 (IP20)	23.0	7.5
	CIMR-P7U27P5	NEMA Type 1 (IP20)	31.0	7.5/10
	CIMR-P7U2011	NEMA Type 1 (IP20)	46.2	15
	CIMR-P7U2015	NEMA Type 1 (IP20)	59.4	20
	CIMR-P7U2018	NEMA Type 1 (IP20)	74.8	25
	CIMR-P7U2022	NEMA Type 1 (IP20)	88.0	30
	CIMR-P7U2030	NEMA Type 1 (IP20)	115.0	40
208-230Vac	CIMR-P7U2037	Open Chassis (IP00)	162.0	50/60
	CIMR-P7U2045	Open Chassis (IP00)	192.0	60/75
	CIMR-P7U2055	Open Chassis (IP00)	215.0	75
	CIMR-P7U2075	Open Chassis (IP00)	312.0	100/125
	CIMR-P7U2090	Open Chassis (IP00)	360.0	125/150
	CIMR-P7U2110	Open Chassis (IP00)	415.0	150
480Vac	CIMR-P7U40P4	NEMA Type 1 (IP20)	1.8	0.5/0.75
	CIMR-P7U40P7	NEMA Type 1 (IP20)	2.1	1
	CIMR-P7U41P5	NEMA Type 1 (IP20)	3.7	1.5/2
	CIMR-P7U42P2	NEMA Type 1 (IP20)	5.3	3
	CIMR-P7U43P7	NEMA Type 1 (IP20)	7.6	5
	CIMR-P7U45P5	NEMA Type 1 (IP20)	12.5	7.5
	CIMR-P7U47P5	NEMA Type 1 (IP20)	17.0	10
	CIMR-P7U49P0	NEMA Type 1 (IP20)	21.0	15
	CIMR-P7U4011	NEMA Type 1 (IP20)	27.0	20
	CIMR-P7U4015	NEMA Type 1 (IP20)	34.0	25
	CIMR-P7U4018	NEMA Type 1 (IP20)	40.0	30
	CIMR-P7U4024	NEMA Type 1 (IP20)	52.0	40
	CIMR-P7U4030	NEMA Type 1 (IP20)	67.2	50
	CIMR-P7U4037	NEMA Type 1 (IP20)	77.0	60
	CIMR-P7U4045	NEMA Type 1 (IP20)	96.0	75
	CIMR-P7U4055	NEMA Type 1 (IP20)	125.0	100
	CIMR-P7U4075	Open Chassis (IP00)	156.0	125
	CIMR-P7U4090	Open Chassis (IP00)	180.0	150
	CIMR-P7U4110	Open Chassis (IP00)	240.0	200
	CIMR-P7U4160	Open Chassis (IP00)	304.0	250
	CIMR-P7U4185	Open Chassis (IP00)	414.0	300/350
	CIMR-P7U4220	Open Chassis (IP00)	515.0	400/450
	CIMR-P7U4300	Open Chassis (IP00)	675.0	500+

Confirmations upon Delivery

◆ Receiving Checks

Check the following items as soon as the Drive is received.

Table 1.2 Receiving Checks

Item	Method
Has the correct model of Drive been delivered?	Check the model number on the nameplate on the right side of the Drive. Reconcile with packing slip and/or order information.
Is the Drive damaged in any way?	Inspect the entire exterior of the Drive to see if there are any dents, scratches or other damage resulting from shipping.
Are any screws or other components loose?	Use a screwdriver or other tool to check for tightness.

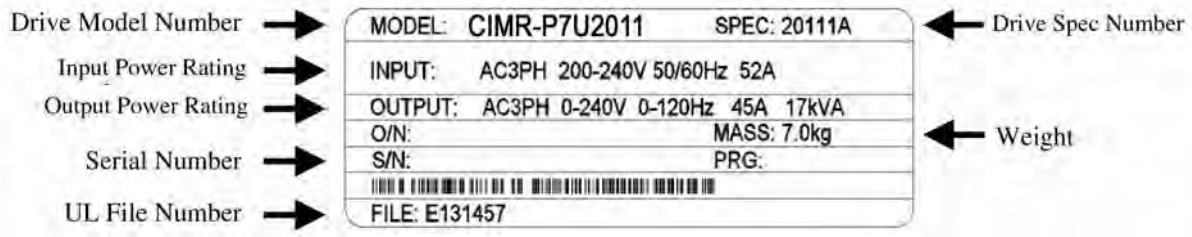
If there are any irregularities in the above items, contact the shipping company, the distributor or representative who sold the Drive, or a Yaskawa office immediately.

The P7 is thoroughly tested at the factory. Any damages or shortages evident when the equipment is received must be reported immediately to the commercial carrier that transported the material. Shipping damage is not covered by the Yaskawa warranty. After unpacking and inspecting for damage, verify that internal wire connections have not come loose during shipment by spot checking wire terminations with a screwdriver or the appropriate tool.

P7 Drive storage must be in a clean and dry location. Maintain the factory packaging and provide covering as needed to protect the P7 from construction site dirt, water, debris and traffic prior to and during construction.

◆ Nameplate Information

A nameplate is attached to the right side of each Drive. The following nameplate is an example for a standard Drive.



Note: The Drive Model Number and Drive Spec Number are required to completely identify a Drive.

Fig 1.1 Drive Nameplate

◆ Drive Model Numbers

The model number on the nameplate indicates the design specification, voltage, and rating of the Drive in alphanumeric codes.

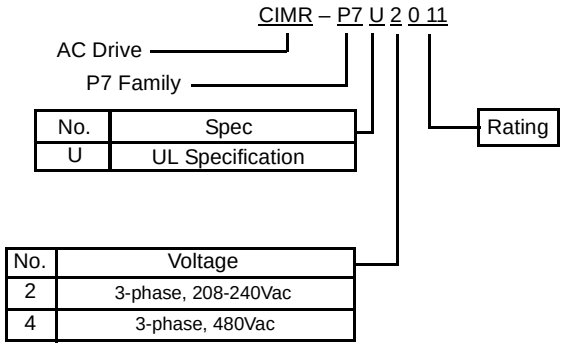


Fig 1.2 Drive Model Number Structure

◆ Drive Enclosure and Revision Code

The Drive SPEC number on the nameplate indicates the voltage, Drive rating, enclosure type, and the revision code of the Drive in alphanumeric codes.

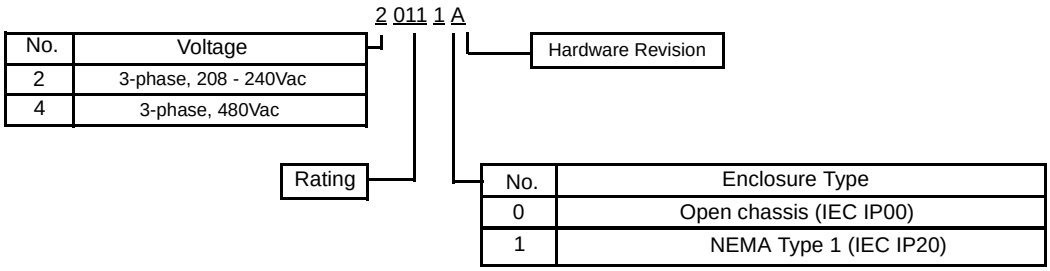


Fig 1.3 SPEC Number Structure

TERMS

Open Chassis Type (IEC IP00)
Protected so that parts of the human body cannot reach electrically charged parts from the front when the Drive is mounted in a control panel, also called (protected chassis).

NEMA Type 1 (IEC IP20)
The Drive is shielded from the exterior, and can thus be mounted to the interior wall of a building (not necessarily enclosed in a control panel). The protective structure conforms to the standards of NEMA Type 1 in the USA. All protective covers (Fig 1.4) must be installed to conform with IEC IP20 and NEMA Type 1 requirements.

Component Names

◆ Models CIMR-P7U20P4 thru 2018 (25HP @ 208V/240V) and 40P4 thru 4018 (30HP @ 480V)

The external appearance, component names, and terminal arrangement of the Drive are shown in Fig 1.4. and 1.5.

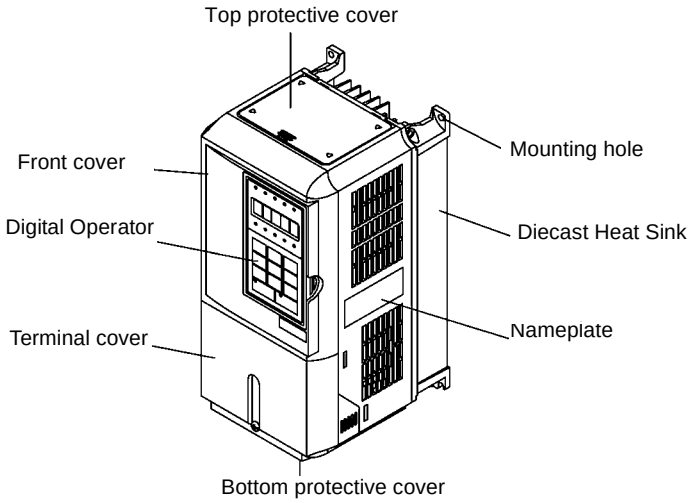


Fig 1.4 Drive Appearance

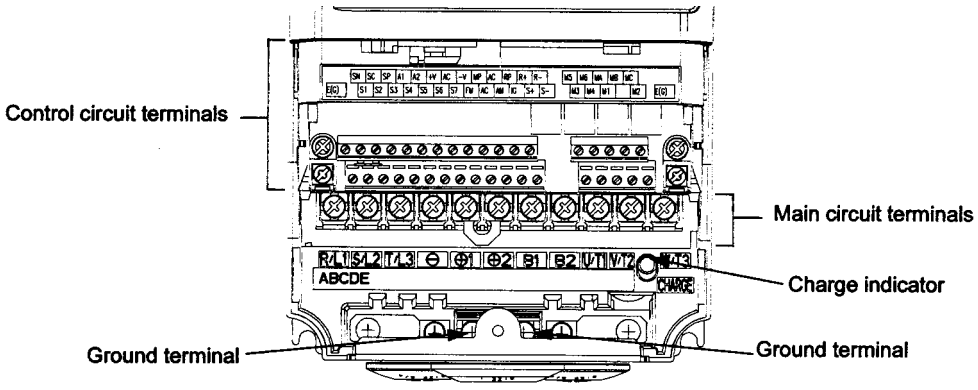


Fig 1.5 Terminal Arrangement (Terminal Cover Removed)

◆ Models CIMR-P7U2022 thru 2110 (30HP and above @ 208V/240V) and 4030 thru 4300 (40HP and above @ 480V)

The external appearance, component names, and terminal arrangement of the Drive are shown in Fig 1.6 and 1.7.

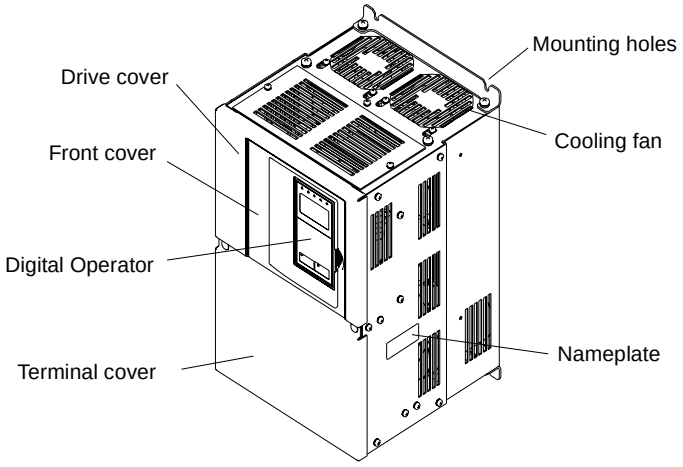


Fig 1.6 Drive Appearance

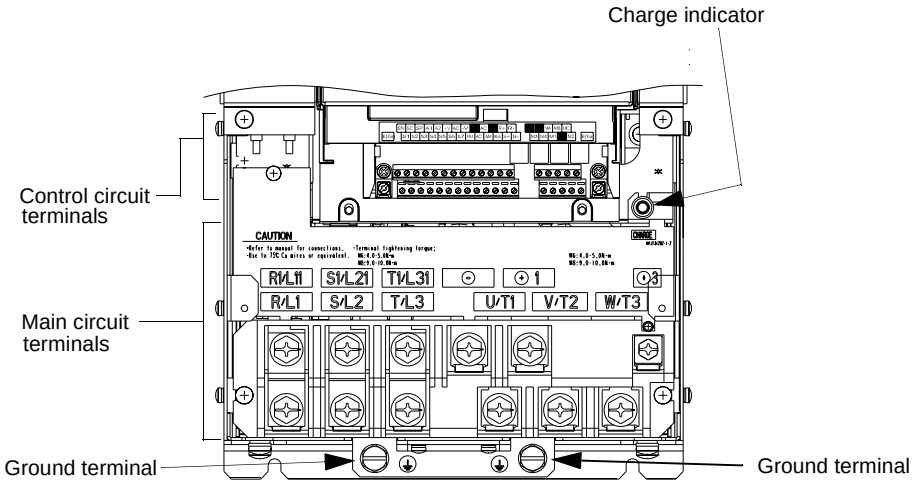
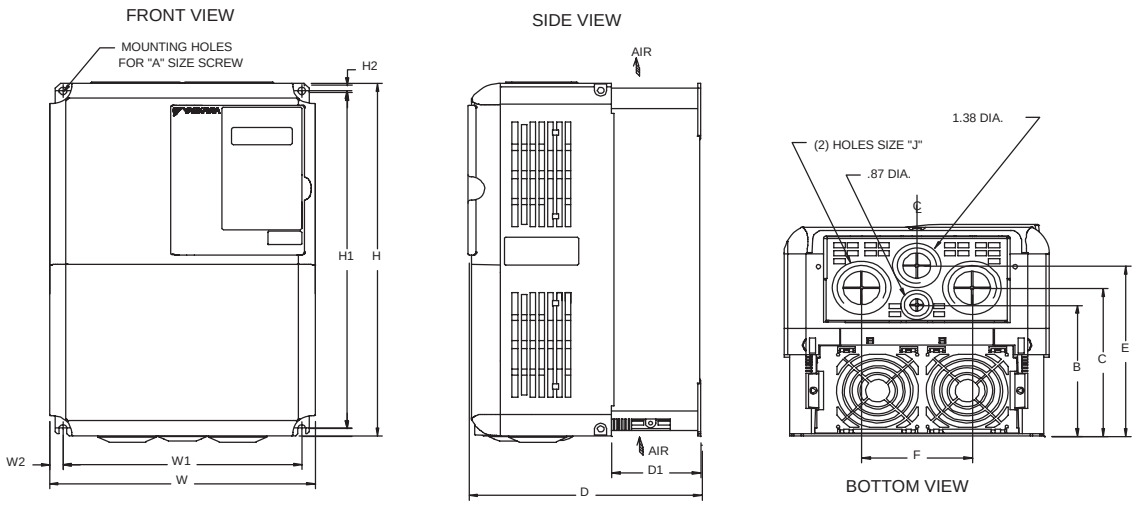


Fig 1.7 Terminal Arrangement (Terminal Cover Removed)

Exterior and Mounting Dimensions

DIMENSIONS: P7 (NEMA 1) **208/240V (3.6-74.8 AMPS) 480V (1.8- 40.0 AMPS)**



RATED INPUT	MODEL CIMR-P7U	RATED OUTPUT CURRENT (AMPS)	NOMINAL HP	DIMENSIONS IN INCHES														APPROX. WEIGHT (LBS.)
				MOUNTING		H	W	H2	W2	D	D1	A	B	C	E	F	J	
				H1	W1													
208V	20P41	3.6	1/2 3/4	10.47	4.96	11.02	5.51	.28	.28	6.30	1.54	#10	---	3.35	4.73	1.97	1.10	6.6
	20P71	4.6	1	10.47	4.96	11.02	5.51	.28	.28	6.30	1.54	#10	---	3.35	4.73	1.97	1.10	6.6
	21P51	7.8	2	10.47	4.96	11.02	5.51	.28	.28	6.30	1.54	#10	---	3.35	4.73	1.97	1.10	6.6
	22P21	10.8	3	10.47	4.96	11.02	5.51	.28	.28	6.30	1.54	#10	---	3.35	4.73	1.97	1.10	6.6
	23P71	16.8	5	10.47	4.96	11.02	5.51	.28	.28	7.09	2.32	#10	---	4.14	5.52	1.97	1.10	8.8
	27P51	31.0	7.5-10	11.22	7.32	11.81	7.87	.28	.28	7.87	2.58	1/4	4.63	5.11	6.21	3.07	1.38	13.2
	20111	46.2	15	11.22	7.32	12.20	7.87	.28	.28	7.87	2.58	1/4	4.63	5.11	6.21	3.07	1.38	15.4
	20151	59.4	20	13.19	8.50	13.78	9.45	.30	.47	8.27	3.07	1/4	5.12	5.79	6.65	3.94	1.73	24.2
	20181	74.8	25	13.19	8.50	14.96	9.45	.30	.47	8.27	3.07	1/4	5.12	5.79	6.65	3.94	1.73	24.2
240V	20P41	3.6	1/2 3/4	10.47	4.96	11.02	5.51	.28	.28	6.30	1.54	#10	---	3.35	4.73	1.97	1.10	6.6
	20P71	4.6	1	10.47	4.96	11.02	5.51	.28	.28	6.30	1.54	#10	---	3.35	4.73	1.97	1.10	6.6
	21P51	7.8	2	10.47	4.96	11.02	5.51	.28	.28	6.30	1.54	#10	---	3.35	4.73	1.97	1.10	6.6
	22P21	10.8	3	10.47	4.96	11.02	5.51	.28	.28	6.30	1.54	#10	---	3.35	4.73	1.97	1.10	6.6
	23P71	16.8	5	10.47	4.96	11.02	5.51	.28	.28	7.09	2.32	#10	---	4.14	5.52	1.97	1.10	8.8
	25P51	23.0	7.5	10.47	4.96	11.02	5.51	.28	.28	7.09	2.32	#10	---	4.14	5.52	1.97	1.10	8.8
	27P51	31.0	10	11.22	7.32	11.81	7.87	.28	.28	7.87	2.58	1/4	4.63	5.11	6.21	3.07	1.38	13.2
	20111	46.2	15	11.22	7.32	12.20	7.87	.28	.28	7.87	2.58	1/4	4.63	5.11	6.21	3.07	1.38	15.4
	20151	59.4	20	13.19	8.50	13.78	9.45	.30	.47	8.27	3.07	1/4	5.12	5.79	6.65	3.94	1.73	24.2
	20181	74.8	25	13.19	8.50	14.96	9.45	.30	.47	8.27	3.07	1/4	5.12	5.79	6.65	3.94	1.73	24.2
480V	40P41	1.8	1/2 3/4	10.47	4.96	11.02	5.51	.28	.28	6.30	1.54	#10	---	3.35	4.73	1.97	1.10	6.6
	40P71	2.1	1	10.47	4.96	11.02	5.51	.28	.28	6.30	1.54	#10	---	3.35	4.73	1.97	1.10	6.6
	41P51	3.7	2	10.47	4.96	11.02	5.51	.28	.28	6.30	1.54	#10	---	3.35	4.73	1.97	1.10	6.6
	42P21	5.3	3	10.47	4.96	11.02	5.51	.28	.28	7.09	2.32	#10	---	4.14	5.52	1.97	1.10	8.8
	43P71	7.6	5	10.47	4.96	11.02	5.51	.28	.28	7.09	2.32	#10	---	4.14	5.52	1.97	1.10	8.8
	45P51	12.5	7.5	10.47	4.96	11.02	5.51	.28	.28	7.09	2.32	#10	---	4.14	5.52	1.97	1.10	8.8
	47P51	17.0	10	11.22	7.32	11.81	7.87	.28	.28	7.87	2.58	1/4	4.63	5.11	6.21	3.07	1.38	13.2
	49P01	21.0	15	11.22	7.32	11.81	7.87	.28	.28	7.87	2.58	1/4	4.63	5.11	6.21	3.07	1.38	13.2
	40111	27.0	20	11.22	7.32	11.81	7.87	.28	.28	7.87	2.58	1/4	4.63	5.11	6.21	3.07	1.38	13.2
	40151	34.0	25	13.19	8.50	13.78	9.45	.30	.47	8.27	3.07	1/4	5.12	5.79	6.65	3.94	1.73	22
	40181	40.0	30	13.19	8.50	13.78	9.45	.30	.47	8.27	3.07	1/4	5.12	5.79	6.65	3.94	1.73	22

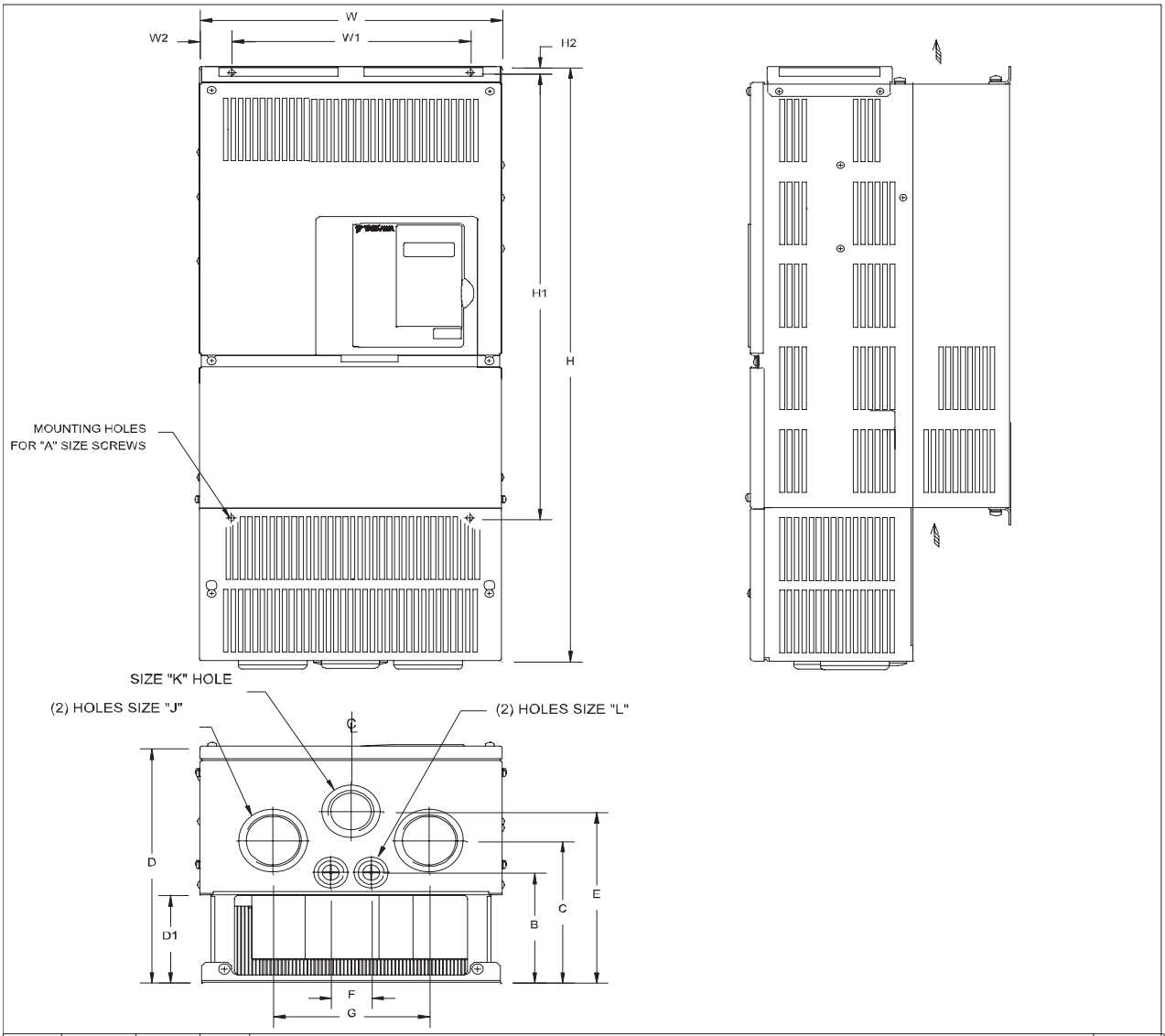
FOR REFERENCE ONLY UNLESS PROPERLY ENDORSED.

IN ORDER TO ACHIEVE ADEQUATE COOLING
THE DRIVE MUST BE POSITIONED TO ALLOW A MINIMUM
OF FREE AIR SPACE OF 1.2 INCHES ON SIDES AND
5 INCHES TOP AND BOTTOM

YASKAWA

DR BY RIP 9.29.04
APPVL. TA 9.29.04

DIMENSIONS: P7 (NEMA 1) 208/240V (88.0-115 AMPS) 480V (52.0-125 AMPS)



RATED INPUT	MODEL CIMR-P7U	RATED OUTPUT CURRENT (AMPS)	NOM. HP	DIMENSIONS IN INCHES																	APPROX. WEIGHT (LBS.)
				MOUNTING		H	W	H2	W2	D	D1	A	B	C	E	F	G	J	K	L	
				H1	W1																
208V	20221	88.0	30	15.16	7.68	21.06	10.00	.30	1.16	10.24	3.94	1/4	4.98	6.50	7.87	1.73	5.91	2.44	1.97	1.10	53
	20301	115	40	17.13	8.66	24.21	10.98	.30	1.16	10.24	3.94	1/4	4.98	6.50	7.87	1.73	5.91	2.44	1.97	1.10	59
240V	20221	88.0	30	15.16	7.68	21.06	10.00	.30	1.16	10.24	3.94	1/4	4.98	6.50	7.87	1.73	5.91	2.44	1.97	1.10	53
	20301	115	40	17.13	8.66	24.21	10.98	.30	1.16	10.24	3.94	1/4	4.98	6.50	7.87	1.73	5.91	2.44	1.97	1.10	59
480V	40241	52.0	40	17.13	8.66	21.06	10.98	.30	1.16	10.24	3.94	1/4	4.98	6.50	7.87	1.73	5.91	1.97	1.97	1.10	53
	40301	67.2	50	17.13	8.66	21.06	10.98	.30	1.16	10.24	3.94	1/4	4.98	6.50	7.87	1.73	5.91	1.97	1.97	1.10	53
	40371	77.0	60	21.06	10.24	25.00	12.95	.30	1.36	11.22	4.13	1/4	5.18	6.69	8.07	1.73	6.69	1.97	1.97	1.10	88
	40451	96.0	75	21.06	10.24	28.15	12.95	.30	1.36	11.22	4.13	1/4	5.18	6.69	8.07	1.73	6.69	2.44	1.97	1.10	88
	40551	125	100	21.06	10.24	28.15	12.95	.30	1.36	11.22	4.13	1/4	5.18	6.69	8.07	1.73	6.69	2.44	1.97	1.10	88

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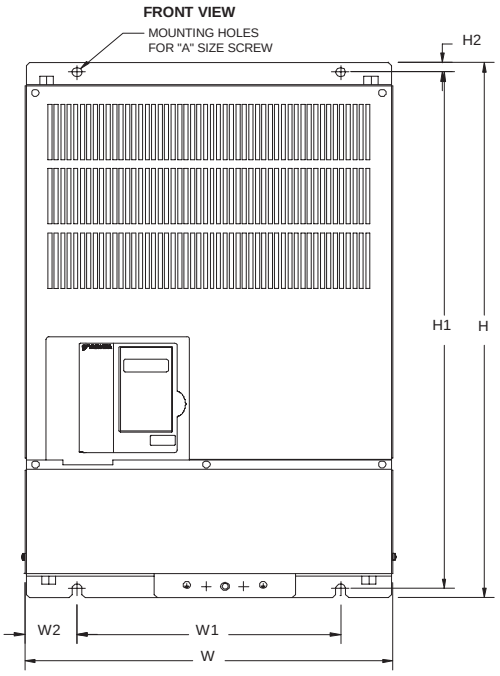
5 INCHES TOP AND BOTTOM

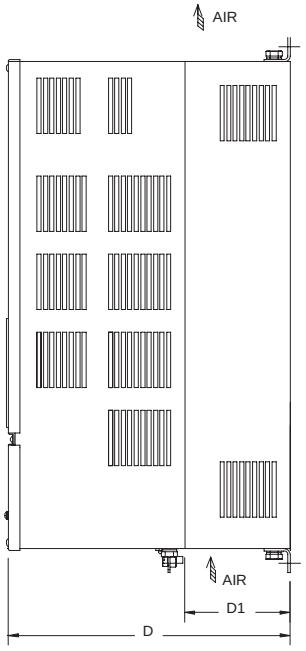
YASKAWA

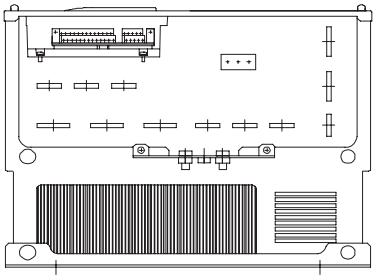
DR BY RIP 10-04
APPVL. TA 10-04

DIMENSIONS: P7 (PROTECTED CHASSIS)

208-230V (162-415 AMPS)
480V (156-304 AMPS)







RATED INPUT	MODEL CIMR-P7U	RATED OUTPUT CURRENT (AMPS)	NOM. HP	DIMENSIONS IN INCHES									APPROX. WEIGHT (LBS.)
				MOUNTING		H	W	H2	W2	D	D1	A	
				H1	W1								
208V	20370	162	50	22.64	9.84	23.62	14.76	.49	2.46	11.81	3.94	3/8	125
	20450	192	60	22.64	9.84	23.62	14.76	.49	2.46	12.99	5.12	3/8	139
	20550	215	75	27.56	12.80	28.54	17.72	.49	2.46	13.78	5.12	3/8	189
	20750	312	100	27.56	12.80	28.54	17.72	.49	2.46	13.78	5.12	3/8	191
	20900	360	125	32.28	14.57	33.46	19.69	.59	2.56	14.17	5.12	3/8	238
	21100	415	150	33.66	17.52	34.84	22.64	.59	2.56	14.96	5.51	3/8	330
230V	20370	162	50-60	22.64	9.84	23.62	14.76	.49	2.46	11.81	3.94	3/8	125
	20450	192	75	22.64	9.84	23.62	14.76	.49	2.46	12.99	5.12	3/8	139
	20750	312	100-125	27.56	12.80	28.54	17.72	.49	2.46	13.78	5.12	3/8	191
	20900	360	150	32.28	14.57	33.46	19.69	.59	2.56	14.17	5.12	3/8	238
480V	40750	156	125	27.56	12.80	28.54	17.72	.49	2.46	13.78	5.12	3/8	194
	40900	180	150	27.56	12.80	28.54	17.72	.49	2.46	13.78	5.12	3/8	196
	41100	240	200	32.28	14.57	33.46	19.69	.59	2.56	14.17	5.12	3/8	224
	41600	304	250	33.66	17.52	36.06	22.64	.59	2.56	14.96	5.51	3/8	352

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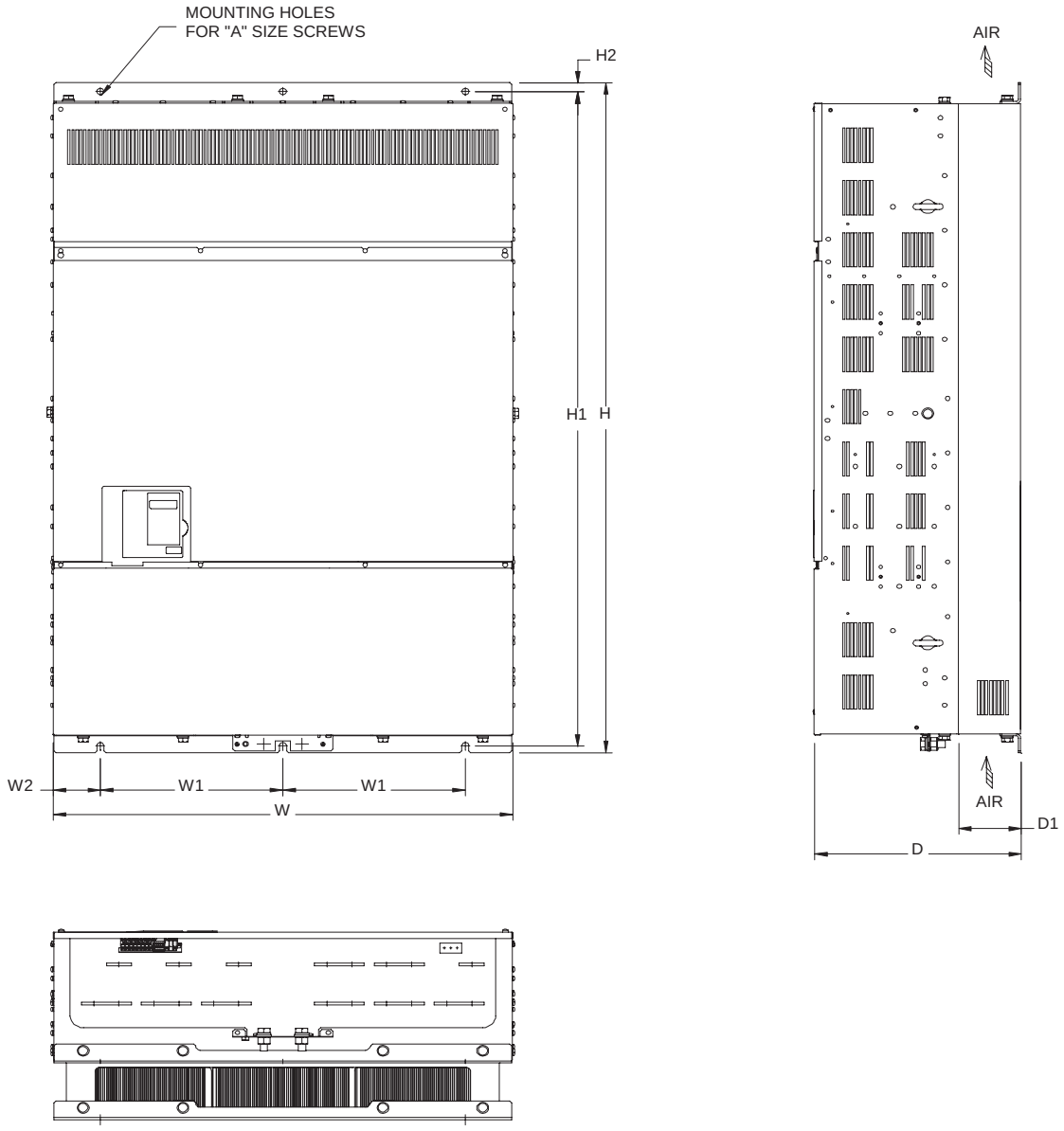
OF FREE AIR SPACE OF 1.2 INCHES ON SIDES AND
5 INCHES TOP AND BOTTOM

YASKAWA

DR BY RIP 9.29.04
APPVL. TA 9.29.04

DIMENSIONS: P7 (PROTECTED CHASSIS)



RATED INPUT	MODEL CIMR-P7U	RATED OUTPUT CURRENT (AMPS)	NOM. HP	DIMENSIONS IN INCHES									APPROX. WEIGHT (LBS.)
				MOUNTING		H	W	H2	W2	D	D1	A	
				H1	W1								
480V	41850	414	300-350	50.00	10.63	51.38	27.95	.79	3.35	16.34	4.94	3/8	572
	42200	515	400-450	50.00	10.63	51.38	27.95	.79	3.35	16.34	4.94	3/8	616
	43000	675	500	56.70	14.37	58.07	36.06	.79	3.66	16.34	4.94	3/8	891

FOR REFERENCE ONLY UNLESS PROPERLY ENDORSED.

IN ORDER TO ACHIEVE ADEQUATE COOLING
THE DRIVE MUST BE POSITIONED TO ALLOW A MINIMUM
OF FREE AIR OF 1.2 INCHES ON SIDES AND
5 INCHES TOP AND BOTTOM

YASKAWA

DR BY RIP 8-02
APPVL. TBS 9.5.02

Heat Loss Data

Table 1.3 200V Class Heat Loss Data						
TYPE CIMR-P7U□	Drive (Inverter) Capacity (kVA)	Rated Output Current (A)	Cooling Fin Side (W)	Internal Unit Side (W)	Total Watt Loss (W)	Cooling Method
20P4	1.4	3.6	19	39	58	Self
20P7	1.8	4.6	26	42	68	Self
21P5	3.0	7.8	48	50	98	Self
22P2	4.1	10.8	68	59	127	Self
23P7	6.4	16.8	110	74	184	Fan
25P5	8.8	23	164	84	248	Fan
27P5	12	31	219	113	332	Fan
2011	18	46.2	357	168	524	Fan
2015	23	59.4	416	182	597	Fan
2018	29	74.8	472	208	680	Fan
2022	34	88	583	252	835	Fan
2030	44	115	883	333	1217	Fan
2037	62	162	1010	421	1430	Fan
2045	73	192	1228	499	1727	Fan
2055	82	215	1588	619	2206	Fan
2075	120	312	1956	844	2800	Fan
2090	140	360	2194	964	3157	Fan
2110	160	415	2733	1234	3967	Fan

Table 1.4 400V Class Heat Loss Data						
TYPE CIMR-P7U□	Drive (Inverter) Capacity (kVA)	Rated Output Current (A)	Cooling Fin Side (W)	Internal Unit Side (W)	Total Watt Loss (W)	Cooling Method
40P4	1.4	1.8	14	39	53	Self
40P7	1.6	2.1	17	41	58	Self
41P5	2.8	3.7	36	48	84	Self
42P2	4.0	5.3	59	56	115	Fan
43P7	5.8	7.6	80	68	140	Fan
44P0	6.6	8.7	90	70	160	Fan
45P5	9.5	12.5	127	81	209	Fan
47P5	13	17	193	114	307	Fan
49P0	16	21	232	158	390	Fan
4011	21	27	232	158	390	Fan
4015	26	34	296	169	465	Fan
4018	30	40	389	201	590	Fan
4022	38	50.4	420	233	653	Fan
4024	40	52	691	297	989	Fan
4030	51	67.2	691	297	989	Fan
4037	59	77	801	332	1133	Fan
4045	73	96	901	386	1287	Fan
4055	95	125	1204	478	1682	Fan
4075	120	156	1285	562	1847	Fan
4090	140	180	1614	673	2287	Fan
4110	180	240	1889	847	2736	Fan
4132	200	260	2388	1005	3393	Fan
4160	230	304	2636	1144	3936	Fan
4185	315	414	2791	1328	3964	Fan
4220	390	515	3797	1712	5509	Fan
4300	510	675	5838	2482	8319	Fan

Checking and Controlling the Installation Site

Install the Drive as described below and maintain optimum conditions.

WARNING The Drive heatsink temperature may exceed 158°F (70°C). Therefore, mount the Drive to a surface suitable for high temperature.

◆ Installation Site

Locate the P7 Drive as close as possible to the motor.

Install the Drive under the following conditions in UL Pollution Degree 1 & 2 environments. This excludes wet locations where surfaces may become conductive due to moisture and contaminant loading.

Table 1.5 Installation Site Specifications

Type	Ambient Operating Temperature	Humidity	Plenum Rated
NEMA Type 1	14°F to 104°F (-10 to +40°C)	95% RH or less (no condensation)	Yes
Open Chassis	14°F to 113°F (-10 to +45°C)	95% RH or less (no condensation)	No

Protective covers are attached to the top and bottom of the Drive. It is recommended to remove the protective covers before operating a CIMR-P7U2030/4055 Drive and smaller in a panel to obtain the 113°F (45°C) ambient operating temperature.

Observe the following precautions when installing the Drive:

- in a clean location which is free from oil mist and dust.
- in an environment where metal shavings, oil, water, or other foreign materials will not get into the Drive enclosure.
- in a location free from radioactive materials.
- in a location free from harmful gasses and liquids.
- in a location free from excessive vibration.
- in a location free from chlorides.
- in a location away from direct sunlight.
- on a non-combustible surface.

◆Controlling the Ambient Temperature

To enhance the reliability of operation, the Drive should be installed in an environment free from extreme temperature variations. If the Drive is installed in an enclosure, use a cooling fan or air conditioner to maintain the internal air temperature below 113°F (45°C).

◆ Protecting the Drive from Foreign Matter

During Drive installation and project construction it is possible to have foreign matter, such as metal shavings or wire clippings, fall inside the Drive. To prevent foreign matter from falling into the Drive, place a temporary cover over the Drive.

Always remove the temporary cover from the Drive before Start-Up. Otherwise, ventilation will be reduced, causing the Drive to overheat.

Installation Orientation and Clearances

Install the Drive vertically so as not to reduce the cooling efficiency. When installing the Drive, always provide the following installation clearances to allow normal heat dissipation. Ensure that the heatsink is against a closed surface to avoid diverting cooling air around the heatsink.

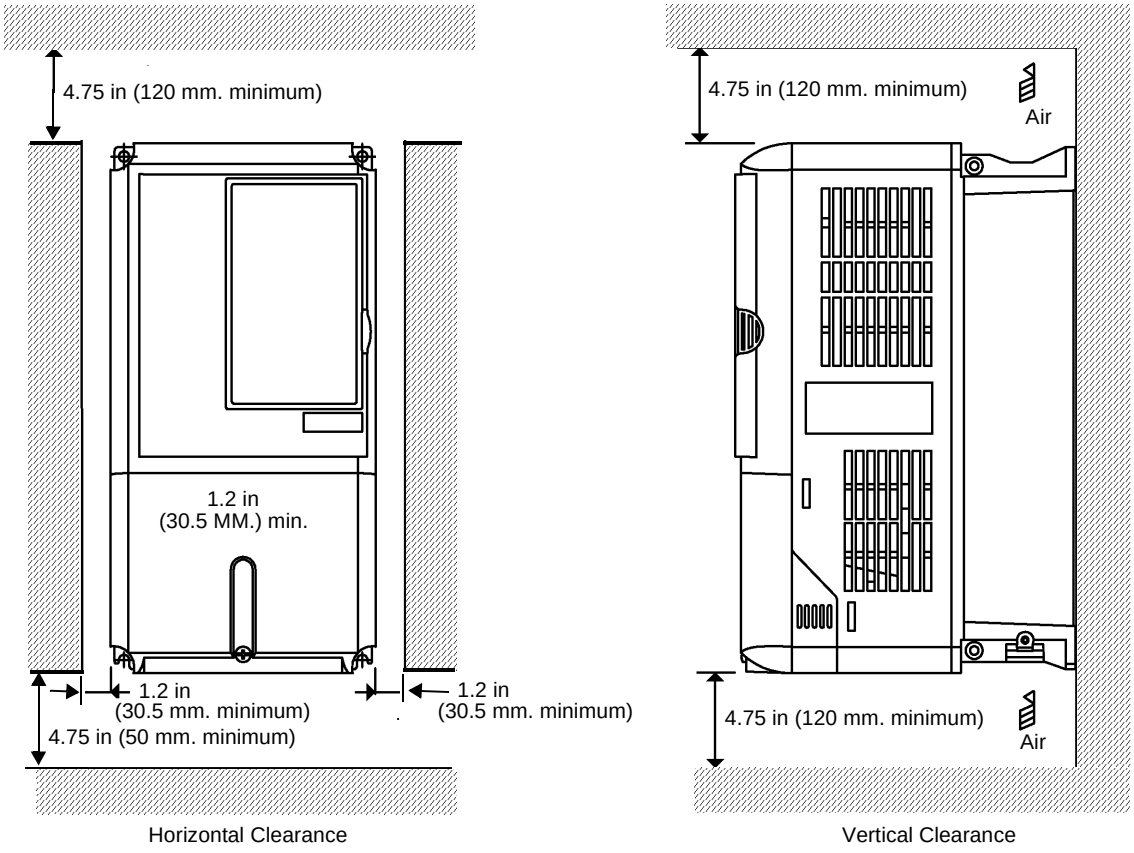


Fig 1.8 Drive Installation Orientation and Clearance

IMPORTANT

1. The same clearance is required horizontally and vertically for both Open Chassis (IP00) and NEMA Type 1 Drives.
2. Always remove the top and bottom protection covers before installing a CIMR-P7U2018/4018 and smaller Drive in a panel.
   Always provide enough clearance for lifting eye bolts and the main circuit wiring when installing a CIMR-P7U2022/4030 and larger Drive in a panel.

Removing and Attaching the Terminal Cover

Remove the terminal cover to connect cables to the control circuit and main circuit terminals.

WARNING Prior to removing any protective cover or wiring any part of the Drive, remove all power sources, including main input power and control circuit power. Wait a minimum of 5 minutes after power removal, before removing any cover. The charge lamp located within the Drive should be off prior to working inside. Even if the charge lamp is off, one must measure the AC input, output, and DC Bus potential to insure safe levels prior to resuming work. Failure to adhere to this warning may result in personal injury or death.

◆ Removing the Terminal Cover

■ Models CIMR-P7U20P4 thru 2018 (0.5HP to 25HP @ 208V/240V) and 40P4 thru 4018 (0.5HP to 30HP @ 480V)

Loosen the screw at the bottom of the terminal cover, press in on the sides of the terminal cover in the directions of arrow 1, and then lift up on the terminal in the direction of arrow 2. Refer to Figure 1.9

■ Models CIMR-P7U2022 thru 2110 (30HP to 150HP @ 208V/240V) and 4030 thru 4300 (40HP to 500HP @ 480V)

Loosen the screws on the left and right at the top of the terminal cover, pull down the terminal cover in the direction of arrow 1 and then lift up on the terminal cover in the direction of arrow 2. Refer to Figure 1.10

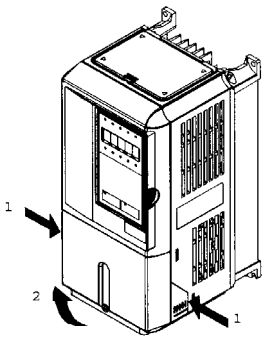


Fig 1.9 Removing the Terminal Cover

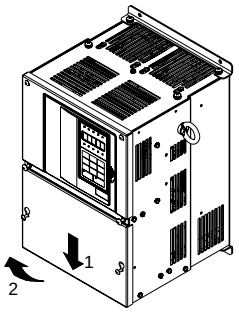


Fig 1.10 Removing the Terminal Cover

◆ Attaching the Terminal Cover

After wiring the terminal block, attach the terminal cover by reversing the removal procedure.

For Models CIMR-P7U2018/4018 and smaller, insert the tab on the top of the terminal cover into the groove on the Drive and press in on the bottom of the terminal cover until it snaps into place.

For Drives CIMR-P7U2022/4030 and larger, insert the tab on the top of the terminal cover into the groove on the Drive, and secure the terminal cover by lifting it up toward the top of the Drive.

Removing/Attaching the Digital Operator and Front Cover

◆ Models CIMR-P7U20P4 thru 2018 (0.5HP to 25HP @ 208V/240V) and 40P4 thru 4018 (0.5HP to 30HP @ 480V)

For Models CIMR-P7U2018/4018 and smaller, remove the terminal cover and then use the following procedures to remove the Digital Operator and front cover.

■Removing the Digital Operator

Press on the side of the Digital Operator in the direction of arrow 1 to unlock, then lift the Digital Operator in the direction of arrow 2 to remove it as shown in Fig 1.11.

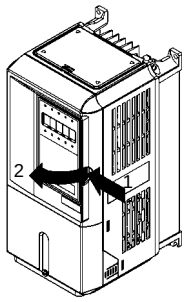


Fig 1.11 Removing the Digital Operator

■Removing the Front Cover

Press the left and right sides of the front cover in the direction of arrows 1 and lift the bottom of cover in the direction of arrow 2 to remove it as shown in Fig 1.12.

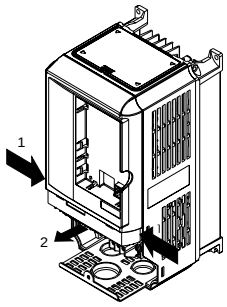


Fig 1.12 Removing the Front Cover

■Attaching the Front Cover

Mount the front cover to the Drive by performing the steps to remove the front cover in reverse order.

1. Do not mount the front cover with the Digital Operator attached to the front cover; this may cause the Digital Operator to malfunction due to imperfect contact.
2. Insert the tab of the upper part of the front cover into the groove of the Drive and press the lower part of the front cover onto the Drive until the front cover snaps into place.

◆ Models CIMR-P7U2022 thru 2110 (30HP to 150HP @ 208V/240V) and 4030 thru 4300 (40HP to 500HP @ 480V)

For Models CIMR-P7U2022/4030 and larger, remove the terminal cover and then use the following procedures to remove the Digital Operator and front cover.

■Removing the Digital Operator

Use the same procedure for Models CIMR-P7U2018/4018 and smaller.

■Removing the Front Cover

Loosen all screws on the front cover. Lift up at the location labeled 1 at the top of the control circuit terminal card and move in the direction of arrow 2.

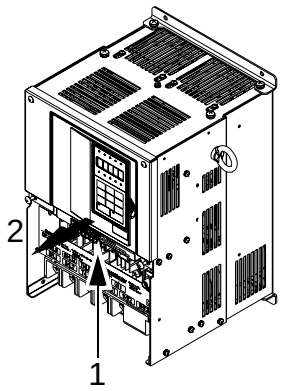


Fig 1.13 Removing the Front Cover

■ Attaching the Front Cover

Attach the front cover by reversing the procedure to remove it.

1. Confirm that the Digital Operator is not mounted on the front cover. Contact faults can occur if the cover is attached while the Digital Operator is mounted to it.
2. Insert the tab on the top of the front cover into the slot on the Drive and press in on the cover until it snaps into place on the Drive.

■ Attaching the Digital Operator

After attaching the front cover, mount the Digital Operator onto the Drive using the following procedure.

1. Hook the Digital Operator at A (two locations) on the front cover by moving in the direction of arrow 1 as shown in the following illustration.
2. Press the Digital Operator in the direction of arrow 2 until it snaps in place at B (two locations).

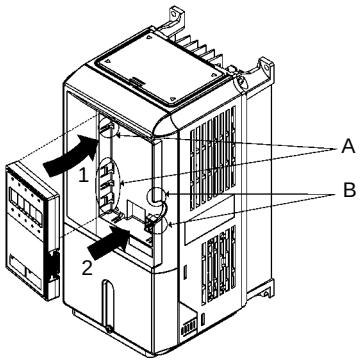


Fig 1.14 Mounting the Digital Operator

IMPORTANT

1. Do not remove or attach the Digital Operator or mount or remove the front cover using methods other than those described above, damage to the Digital Operator or Drive may occur.
2. Never attach the front cover to the Drive with the Digital Operator attached to the front cover. Damage to the Digital Operator may occur. Always attach the front cover to the Drive first, and then attach the Digital Operator to the front cover.

Chapter 2
Electrical Installation

This chapter describes wiring terminals, main circuit terminal connections, main circuit terminal wiring specifications, control circuit terminals, and control circuit wiring specifications.

Terminal Block Configuration 2-2
Wiring Main Circuit Terminals..... 2-3
Control Wiring 2-21

Terminal Block Configuration

The wiring terminals are shown in Fig 2.1.

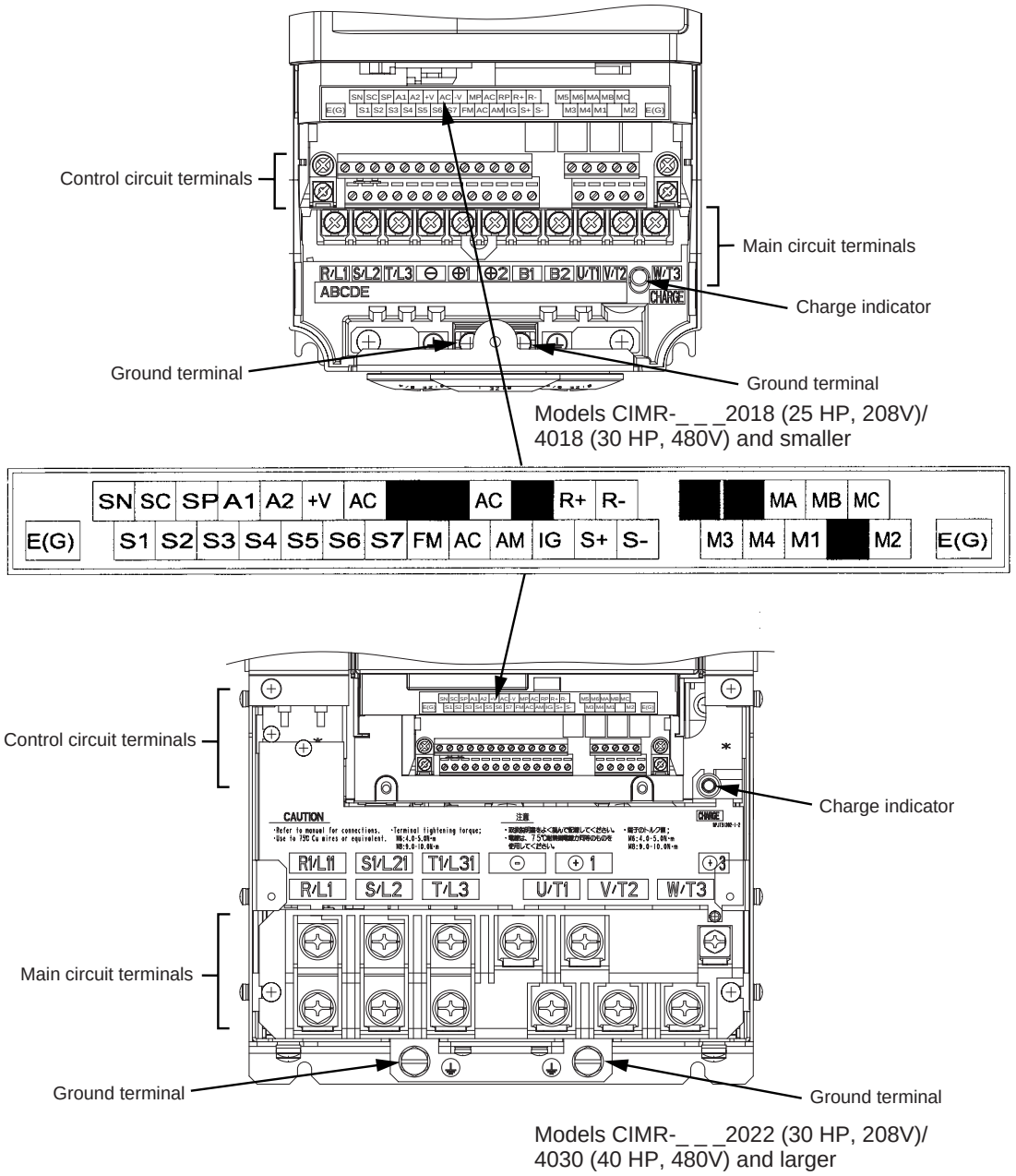


Fig 2.1 Control Circuit Terminal Layout

Wiring Main Circuit Terminals

◆ Applicable Wire Sizes and Closed-loop Connectors

Select the appropriate wires and crimp terminals from Table 2.1 to Table 2.2.

Table 2.1 208-240Vac Wire Sizes and Connector Specifications

Drive Model CIMR-P7U	Nominal Hp	Terminal Symbol	Terminal Screws	Clamping Torque lb. in. (N•m)	Recommended Wire Size AWG (mm^2)	Wire Type
20P4	0.5/0.75	R/L1, S/L2, T/L3, ⊖, ⊕1, ⊕2, B1, B2,U/T1, V/T2, W/T3	M4	13.3 (1.5)	14 (2.1)	600Vac UL Approved vinyl-sheathed or equivalent
		⏚				
20P7	2	R/L1, S/L2, T/L3, ⊖, ⊕1, ⊕2, B1, B2, U/T1, V/T2, W/T3	M4	13.3 (1.5)	14 (2.1)	
		⏚				
21P5	1.5/2	R/L1, S/L2, T/L3, ⊖, ⊕1, ⊕2, B1, B2, U/T1, V/T2, W/T3	M4	13.3 (1.5)	14 (2.1)	
		⏚				
22P2	3	R/L1, S/L2, T/L3, ⊖, ⊕1, ⊕2, B1, B2, U/T1, V/T2, W/T3	M4	13.3 (1.5)	12 (3.3)	
		⏚				
23P7	5	R/L1, S/L2, T/L3, ⊖, ⊕1, ⊕2, B1, B2, U/T1, V/T2, W/T3	M4	13.3 (1.5)	10 (5.3)	
		⏚				
25P5	7.5	R/L1, S/L2, T/L3, ⊖, ⊕1, ⊕2, B1, B2, U/T1, V/T2, W/T3	M4	13.3 (1.5)	10 (5.3)	
		⏚				
27P5	10	R/L1, S/L2, T/L3, ⊖, ⊕1, ⊕2, B1, B2, U/T1, V/T2, W/T3	M5	22.1 (2.5)	8 (8)	
		⏚				
2011	15	R/L1, S/L2, T/L3, ⊖, ⊕1, ⊕2, B1, B2, U/T1, V/T2, W/T3	M5	22.1 (2.5)	6 (13.3)	
		⏚				
2015	20	R/L1, S/L2, T/L3, ⊖, ⊕1, ⊕2, U/T1, V/T2, W/T3	M6	44.3 (5.0)	4 (21.2)	
		B1, B2	M5	22.1 (2.5)	6 (13.3)	
		⏚	M6	44.3 (5.0)	6 (13.3)	
2018	25	R/L1, S/L2, T/L3, ⊖, ⊕1, ⊕2, U/T1, V/T2, W/T3	M8	88.5 (10.0)	2 (33.6)	
		B1, B2	M5	22.1 (2.5)	6 (13.3)	
		⏚	M6	44.3 (5.0)	4 (21.2)	
2022	30	R/L1, S/L2, T/L3, ⊖, ⊕1, U/T1, V/T2, W/T3, R1/L11, S1/L21, T1/L31	M8	88.5 (10.0)	1 (42.4)	
		⊕3	M6	45.1 (5.1)	4 (21.2)	
		⏚	M8	88.5 (10.0)	4 (21.2)	
2030	40	R/L1, S/L2, T/L3, ⊖, ⊕1 U/T1, V/T2, W/T3, R1/L11, S1/L21, T1/L31	M8	88.5 (10.0)	1/0 (53.5)	
		⊕3	M6	45.1 (5.1)	4 (21.2)	
		⏚	M8	88.5 (10.0)	2 (38)	

Table 2.1 208-240Vac Wire Sizes and Connector Specifications

Drive Model CIMR-P7U	Nominal Hp	Terminal Symbol	Terminal Screws	Clamping Torque lb. in. (N•m)	Recommended Wire Size AWG (mm^2)	Wire Type
2037	50	R/L1, S/L2, T/L3, ⊖, ⊕1 U/T1, V/T2, W/T3, R1/L11, S1/L21, T1/L31	M10	199 (22.5)	4/0 (100)	600Vac UL Approved vinyl-sheathed or equivalent
		⊕3	M8	88.5 (10.0)	4 (22)	
		⏚	M10	203.6 (23)	2/0 (67.4)	
		r/ℓ1, ø/ℓ2	M4	12.4 (1.4)	14 (2.1)	
2045	60	R/L1, S/L2, T/L3, ⊖, ⊕1 U/T1, V/T2, W/T3, R1/L11, S1/L21, T1/L31	M10	199 (22.5)	300 (152)	
		⊕3	M8	88.5 (10.0)	4 (21.2)	
		⏚	M10	199 (22.5)	3/0 (85)	
		r/ℓ1, ø/ℓ2	M4	12.4 (1.4)	14 (2.1)	
2055	75	R/L1, S/L2, T/L3, ⊖, ⊕1	M12	347 (39.2)	1/0 X 2P (53.5 X 2P)	
		U/T1, V/T2, W/T3, R1/L11, S1/L21, T1/L31	M10	199 (22.5)	1/0 X 2P (53.5 X 2P)	
		⊕3	M8	88.5 (10.0)	2/0 (67.4)	
		⏚	M10	199 (22.5)	4/0 (107.2)	
		r/ℓ1, ø/ℓ2	M4	12.4 (1.4)	14 (2.1)	
2075	75/100	R/L1, S/L2, T/L3, ⊖, ⊕1	M12	347 (39.2)	4/0 X 2P (80 X 2P)	
		U/T1, V/T2, W/T3, R1/L11, S1/L21, T1/L31	M10	199 (22.5)	3/0 X 2P (85 X 2P)	
		⊕3	M8	88.5 (10.0)	2/0 (67.4)	
		⏚	M10	199 (22.5)	2/0 X 2P (67.4 X 2P)	
		r/ℓ1, ø/ℓ2	M4	12.4 (1.4)	14 (2.1)	
2090	125	R/L1, S/L2, T/L3, ⊖, ⊕1	M12	347 (39.2)	250 x2P (127 x2P)	
		U/T1, V/T2, W/T3, R1/L11, S1/L21, T1/L31	M12	347 (39.2)	4/0 X 2P (107.2 X 2P)	
		⊕3	M8	88.5 (10.0)	2/0 (67.4)	
		⏚	M12	347 (39.2)	2/0 X 2P (67.4 X 2P)	
		r/ℓ1, ø/ℓ2	M4	12.4 (1.4)	14 (2.1)	
2110	150	R/L1, S/L2, T/L3, ⊖, ⊕1	M12	347 (39.2)	300 X 2P (152 X 2P)	
		U/T1, V/T2, W/T3, R1/L11, S1/L21, T1/L31	M12	347 (39.2)	300 X 2P 152 X 2P	
		⊕3	M8	88.5 (10.0)	2/0 (67.4)	
		⏚	M12	347 (39.2)	4/0 X 2P (107.2 X 2P)	
		r/ℓ1, ø/ℓ2	M4	12.4 (1.4)	16 (1.25)	

* Use 75°C copper wire or equivalent

Table 2.2 480Vac Wire Sizes and Connector Specifications

Drive Model CIMR-P7U	Nominal Hp	Terminal Symbol	Terminal Screws	Clamping Torque lb. in. (N•m)	Recommended Wire Size AWG (mm^2)	Wire Type
40P4	0.5/0.75	R/L1, S/L2, T/L3, ⊖, ⊕1, ⊕2, B1, B2, U/T1, V/T2, W/T3	M4	13.3 (1.5)	14 (2.1)	600Vac UL Approved vinyl-sheathed or equivalent
		⏚				
40P7	1	R/L1, S/L2, T/L3, ⊖, ⊕1, ⊕2, B1, B2, U/T1, V/T2, W/T3	M4	13.3 (1.5)	14 (2.1)	
		⏚				
41P5	1.5/2	R/L1, S/L2, T/L3, ⊖, ⊕1, ⊕2, B1, B2, U/T1, V/T2, W/T3	M4	13.3 (1.5)	14 (2.1)	
		⏚				
42P2	3	R/L1, S/L2, T/L3, ⊖, ⊕1, ⊕2, B1, B2, U/T1, V/T2, W/T3	M4	13.3 (1.5)	14 (2)	
		⏚				
43P7	5	R/L1, S/L2, T/L3, ⊖, ⊕1, ⊕2, B1, B2, U/T1, V/T2, W/T3	M4	13.3 (1.5)	14 (2.1)	
		⏚			14 (2.1)	
45P5	7.5	R/L1, S/L2, T/L3, ⊖, ⊕1, ⊕2, B1, B2, U/T1, V/T2, W/T3	M4	13.3 (1.5)	12 (3.5)	
		⏚			14 (2)	
47P5	10	R/L1, S/L2, T/L3, ⊖, ⊕1, ⊕2, B1, B2, U/T1, V/T2, W/T3	M4	15.6 (1.8)	10 (5.5)	
		⏚			12 (3.5)	
49P0/4011	15/20	R/L1, S/L2, T/L3, ⊖, ⊕1, ⊕2, B1, B2, U/T1, V/T2, W/T3	M5	22.1 (2.5)	8 (8)	
		⏚			10 (5.5)	
4015	25	R/L1, S/L2, T/L3, ⊖, ⊕1, ⊕2, B1, B2, U/T1, V/T2, W/T3	M5	22.1 (2.5)	8 (8)	
		⏚				
4018	30	R/L1, S/L2, T/L3, ⊖, ⊕1, ⊕3, U/T1, V/T2, W/T3,	M6	44.3 (5.0)	6 (13.3)	
		B1, B2	M5	21.1 (2.5)	8 (8)	
		⏚	M6	44.3 (5.0)	6 (13.3)	
4024/4030	40/50	R/L1, S/L2, T/L3, ⊖, ⊕1, ⊕3, U/T1, V/T2, W/T3, R1/L11, S1/L21, T1/L31	M6	44.3 (5.0)	3 (26.7)	
		⏚	M8	88.5 (10.0)	6 (13.3)	
4037	60	R/L1, S/L2, T/L3, ⊖, ⊕1, U/T1, V/T2, W/T3, R1/L11, S1/L21, T1/L31	M8	88.5 (10.0)	2 (33.6)	
		⊕3	M6	44.3 (5.0)	4 (21.2)	
		⏚	M8	88.5 (10.0)	4 (21.2)	
4045	75	R/L1, S/L2, T/L3, ⊖, ⊕1, U/T1, V/T2, W/T3, R1/L11, S1/L21, T1/L31	M8	88.5 (10.0)	2 (33.6)	
		⊕3	M6	44.3 (5.0)	4 (21.2)	
		⏚	M8	88.5 (10.0)	4 (21.2)	

Table 2.2 480Vac Wire Sizes and Connector Specifications						
Drive Model CIMR-P7U	Nominal Hp	Terminal Symbol	Terminal Screws	Clamping Torque lb. in. (N•m)	Recommended Wire Size AWG (mm^2)	Wire Type
4055	100	R/L1, S/L2, T/L3, ⊖, ⊕1, U/T1, V/T2, W/T3, R1/L11, S1/L21, T1/L31	M8	88.5 (10.0)	2/0 (33.6)	600Vac UL Approved vinyl-sheathed or equivalent
		⊕3	M6	44.3 (5.0)	4 (21.2)	
		⏚	M8	88.5 (10.0)	1 (42.4)	
4075	125	R/L1, S/L2, T/L3, ⊖, ⊕1	M12	347 (39.2)	4/0 (107.2)	
		U/T1, V/T2, W/T3, R1/L11, S1/L21, T1/L31	M10	199 (22.5)	3/0 (85)	
		⊕3	M8	88.5 (10.0)	4/0 (107.2)	
		⏚	M12	347 (39.2)	1/0 (53.5)	
		r/ℓ1, ø200/ℓ2200, ø400/ℓ2400	M4	12.4 (1.4)	14 (2.1)	
4090	150	R/L1, S/L2, T/L3, ⊖, ⊕1	M12	347 (39.2)	250 (127)	
		U/T1, V/T2, W/T3, R1/L11, S1/L21, T1/L31	M10	199 (22.5)	4/0 (107.2)	
		⊕3	M8	88.5 (10.0)	4/0 (107.2)	
		⏚	M12	347 (39.2)	2/0 (67.4)	
		r/ℓ1, ø200/ℓ2200, ø400/ℓ2400	M4	12.4 (1.4)	14 (2.1)	
4110	200	R/L1, S/L2, T/L3, ⊖, ⊕1	M12	347 (39.2)	2/0 X 2P (67.4 X 2P)	
		U/T1, V/T2, W/T3, R1/L11, S1/L21, T1/L31	M12	347 (39.2)	1/0 X 2P (53.5 X 2P)	
		⊕3	M8	88.5 (10.0)	2/0 (67.4)	
		⏚	M12	347 (39.2)	4/0 (107.2)	
		r/ℓ1, ø200/ℓ2200, ø400/ℓ2400	M4	12.4 (1.4)	14 (2.1)	
4160	250	R/L1, S/L2, T/L3, ⊖, ⊕1	M12	347 (39.2)	4/0 X 2P (107.2 X 2P)	
		U/T1, V/T2, W/T3, R1/L11, S1/L21, T1/L31	M12	347 (39.2)	3/0 X 2P (85 X 2P)	
		⊕3	M8	88.5 (10.0)	2/0 (67.4)	
		⏚	M12	347 (39.2)	1/0 X 2P (53.5 X 2P)	
		r/ℓ1, ø200/ℓ2200, ø400/ℓ2400	M4	12.4 (1.4)	14 (2.1)	

Table 2.2 480Vac Wire Sizes and Connector Specifications

Drive Model CIMR-P7U	Nominal Hp	Terminal Symbol	Terminal Screws	Clamping Torque lb. in. (N•m)	Recommended Wire Size AWG (mm^2)	Wire Type
4185	300/350	R/L1, S/L2, T/L3, ⊖, ⊕1	M8	88.5 (10.0)	300 X 2P (152 X 2P)	600Vac UL Approved vinyl-sheathed or equivalent
		U/T1, V/T2, W/T3, R1/L11, S1/L21, T1/L33	M8	88.5 (10.0)	300 X 2P (152 X 2P)	
		⊕3	M8	88.5 (10.0)	2/0 (67.4)	
		⏚	M16	867.4 (98.0)	3/0 X 2P (85 X 2P)	
		r/ℓ1, ø200/ℓ2200, ø400/ℓ2400	M4	12.4 (1.4)	14 (2.1)	
4220	400/450	R/L1, S/L2, T/L3, ⊖, ⊕1	M8	88.5 (10.0)	500 X 2P (253 X 2P)	
		U/T1, V/T2, W/T3, R1/L11, S1/L21, T1/L33	M8	88.5 (10.0)	400 X 2P (203 X 2P)	
		⊕3	M8	88.5 (10.0)	2/0 (67.4)	
		⏚	M16	867.4 (98.0)	250 X 2P (127 X 2P)	
		r/ℓ1, ø200/ℓ2200, ø400/ℓ2400	M4	12.4 (1.4)	14 (2.1)	
4300	500+	R/L1, S/L2, T/L3, ⊖, ⊕1	M8	88.5 (10.0)	700 X 2P (355 X 2P)	
		U/T1, V/T2, W/T3, R1/L11, S1/L21, T1/L33	M8	88.5 (10.0)	600 X 2P (304 X 2P)	
		⊕3	M8	88.5 (10.0)	2/0 (67.4)	
		⏚	M8	867.4 (98.0)	400 X 2P (203 X 2P)	
		r/ℓ1, ø200/ℓ2200, ø400/ℓ2400	M16	12.4 (1.4)	14 (2.1)	

* Use 75°C copper wire or equivalent.

IMPORTANT

Determine the wire size for the main circuit so that line voltage drop is within 2% of the rated voltage. Line voltage drop is calculated as follows:

Line voltage drop (V) = $\sqrt{3}$ x wire resistance (Ω/km) x wire length (m) x current (A) x 10^{-3}

WARNING

Prior to removing any protective cover or wiring any part of the Drive, remove all power sources, including main input power and control circuit power. Wait a minimum of 5 minutes after power removal, before removing any cover. The charge lamp located within the Drive should be off prior to working inside. Even if the charge lamp is off, one must measure the AC input, output, and DC Bus potential to insure safe levels prior to resuming work. Failure to adhere to this warning may result in personal injury or death.

◆ Main Circuit Terminal Functions

Main circuit terminal functions are summarized according to terminal symbols in Table 2.3. Wire the terminals correctly for the desired purpose.

Table 2.3 Main Circuit Terminal Functions (208-240Vac and 480Vac)

Purpose	Terminal Designation	Model: CIMR-P7U_ _ _ _	
		208-240Vac	480Vac
Main circuit power input	R/L1, S/L2, T/L3	20P4 to 2110	40P4 to 4300
	R1/L11, S1/L21, T1/L31	2022 to 2110	4030 to 4300
Drive outputs	U/T1, V/T2, W/T3	20P4 to 2110	40P4 to 4300
DC power input	⊕1, ⊖	20P4 to 2110	40P4 to 4300
Braking Transistor Unit Connection	⊕3, ⊖	2022 to 2110	4030 to 4300
Braking Resistor Unit Connection	B1, B2	20P4 to 2018	40P4 to 4018
DC reactor connection	⊕1, ⊕2	20P4 to 2018	40P4 to 4018
Ground	⏚	20P4 to 2110	40P4 to 4300

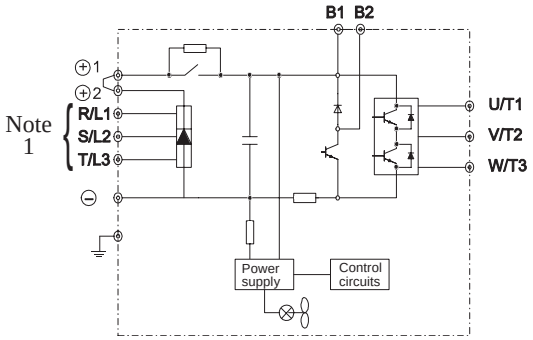
◆ Main Circuit Configurations 208-240Vac

The 208-240Vac main circuit configurations of the Drive are shown in Table 2.4.

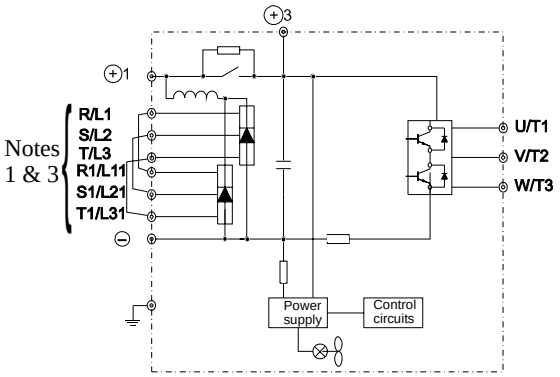
Table 2.4 Drive Main Circuit Configurations

208-240Vac

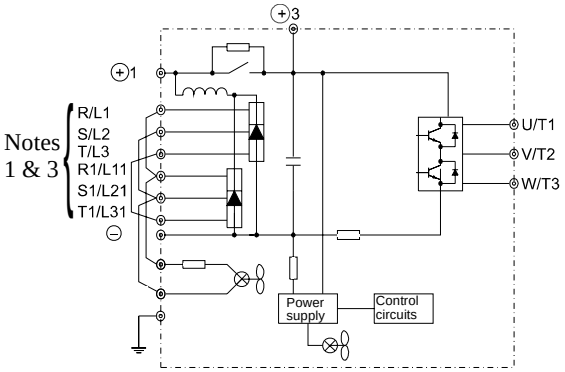
CIMR-_ _ _ 20P4 to 2018
(1/2 Hp to 25 Hp)



CIMR-_ _ _ 2022 and 2030
(30 Hp to 40 Hp)



CIMR-_ _ _ 2037 to 2110
(50 Hp to 150 Hp)



Note 1. Input fuses or molded case circuit breakers are required for proper branch circuit protection for all Drives. Failure to use recommended fuses/circuit breakers (See Appendix E) may result in damage to the wiring, Drive and/or personal injury.

2. Control power is supplied internally from the main circuit DC power supply for all Drives.
3. Consult your Yaskawa representative before using 12-pulse rectification.

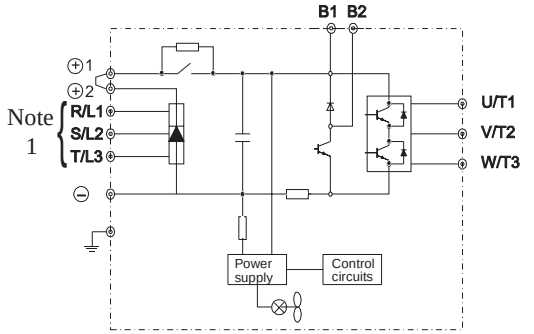
◆ Main Circuit Configurations 480Vac

The 480Vac main circuit configurations of the Drive are shown in Table 2.5.

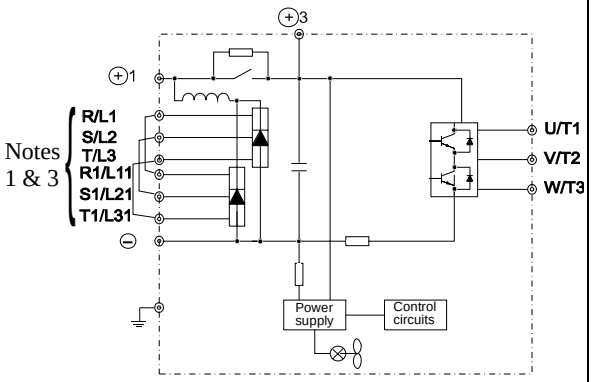
Table 2.5 Drive Main Circuit Configurations

480Vac

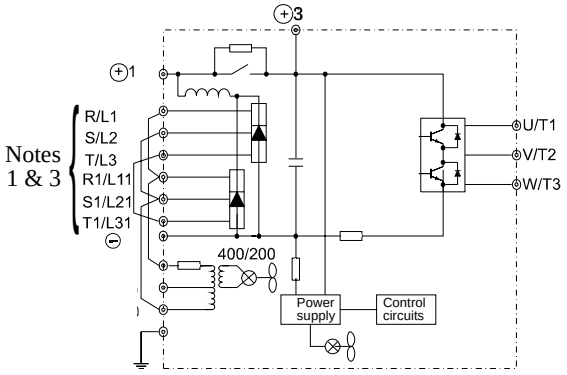
CIMR-_ _ _ 40P4 to 4018
(1/2 Hp to 30 Hp)



CIMR-_ _ _ 4024 to 4055
(40 Hp to 100 Hp)



CIMR-_ _ _ 4075 to 4160 and CIMR-_ _ _ 4185 to 4300
(125 Hp to 500 Hp)



Note 1. Input fuses or molded case circuit breakers are required for proper branch circuit protection for all Drives. Failure to use recommended fuses/circuit breakers (See Appendix E) may result in damage to the wiring, Drive and/or personal injury.

2. Control power is supplied internally from the main circuit DC power supply for all Drives.
3. Consult your Yaskawa representative before using 12-pulse rectification.

Cable Length between Drive and Motor

The P7 should be installed as close as possible to the motor to minimize the length of load side power cable. If the cable between the Drive and the motor is long, the high-frequency leakage current will increase, causing the Drive output current to increase as well. This may affect peripheral devices. To prevent this, reduce the cable length whenever possible, or if necessary, adjust the carrier frequency (set in C6-02) as shown in Table 2.6.

Table 2.6 Motor Cable Length vs. Carrier Frequency (C6-02)

Motor Cable Length	164 ft. (50m) maximum	328 ft. (100m) maximum	More than 328 ft.(100m)
Carrier Frequency	15kHz maximum	10kHz maximum	5kHz maximum

■Ground Wiring

Observe the following precautions when connecting the ground wire:

1. 208-240Vac Drives should have a ground connection with resistance of less than 100Ω.
2. 480Vac Drives should have a ground connection with resistance of less than 10Ω.
3. Do not share the ground wire with other devices, such as motors or large-current electrical equipment.
4. Always use a ground wire that complies with technical standards on electrical equipment and minimize the length of the ground wire. Leakage current flows through the Drive. Therefore, if the distance between the ground rod and the ground terminal is too long, potential on the ground terminal of the Drive will become unstable.
5. When using more than one Drive, be careful not to loop the ground wire. See Fig 2.2.

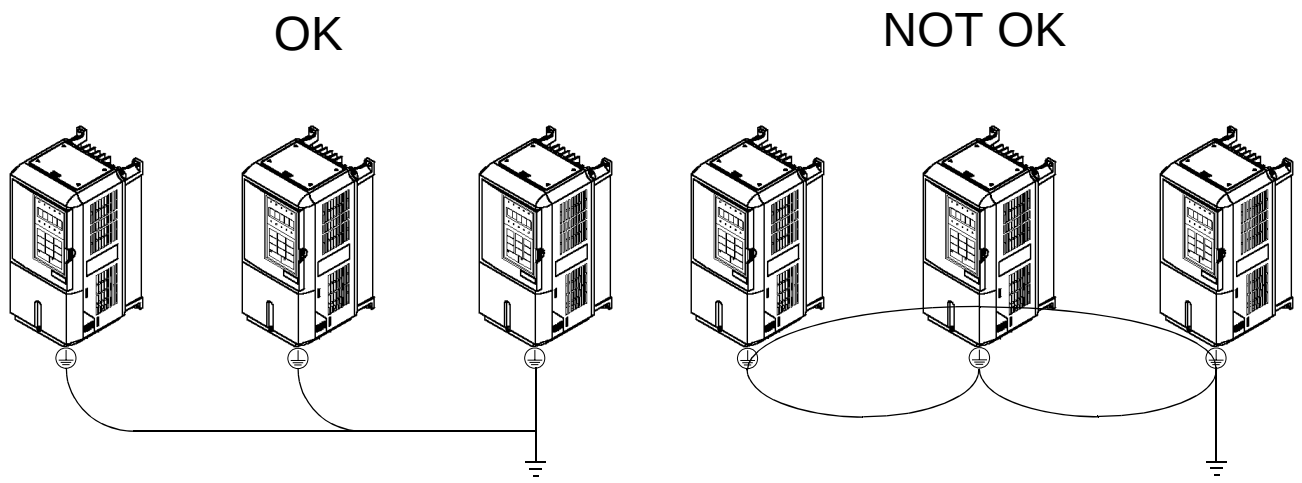


Fig 2.2 Ground Wiring Examples

■ Control Circuit Ground Terminals

The removable Drive control terminal card provides two ground terminals (marked TB3 and TB4) to accept the control wire shield connection. The control wire shield should be connected on this end only, the opposite end should be isolated with electrical tape.

IMPORTANT | Grounding of the P7 enclosure and motor is required for proper system operation.

◆ Dynamic Braking Connections

■General

Dynamic braking (DB) enables the motor to be brought to a smooth and rapid stop. This is achieved by dissipating the regenerative energy of the AC motor across the resistive components of the Dynamic Braking option. For further details on dynamic braking operation, see the instruction sheet shipped with dynamic braking components.

Drives P7U20P4 thru P7U2018 and P7U40P4 thru P7U4018 have an integral braking transistor and require the addition of a Remote Mounted Resistor Unit or a Heat Sink Mount Resistor (ERF). All higher rated Drives require the use of a Braking Transistor Unit (CDBR) and a Remote Mount Resistor Unit.

Remote Mount Resistor Units typically mount outside of the electrical enclosure. Braking Transistor Units mount inside of the electrical enclosure. Heat Sink Mount Resistors mount to the back of the Drive, attaching directly to the heat sink.

Table 2.7 Heat Sink Mount Dynamic Braking Resistor - 3% Duty Cycle

Drive		Heat Sink Mount Resistor							
Rated Input Vac	Drive Model No. P7U	Part No.	Qty. Reqd.	Resistance (Ohms)	Power (Watts)	Approx. Braking Torque (%)	Dimensions (Inches)		
							Height	Width	Depth
208-240	20P4	R7505	1	200	150	220	7.16	1.73	0.51
	20P7	R7505	1	200	150	125	7.16	1.73	0.51
	21P5	R7504	1	100	150	125	7.16	1.73	0.51
	22P2	R7503	1	70	150	120	7.16	1.73	0.51
	23P7	R7510	1	62	150	100	7.16	1.73	0.51
480	40P4	R7508	1	750	150	230	7.16	1.73	0.51
	40P7	R7508	1	750	150	130	7.16	1.73	0.51
	41P5	R7507	1	400	150	125	7.16	1.73	0.51
	42P2	R7506	1	115	150	115	7.16	1.73	0.51
	43P7	R7505	1	200	150	110	7.16	1.73	0.51

■Installation

This option should only be installed by a technically qualified individual who is familiar with this type of equipment and the hazards involved.

⚠WARNING

Hazardous voltages can cause severe injury or death. Lock all power sources feeding the Drive in the "OFF" position. Failure to follow these installation steps may cause equipment damage or personal injury.

Preliminary Procedures

1. Disconnect all electrical power to the Drive.

2. Remove Drive front cover.

3. Use a voltmeter to verify that voltage is disconnected from incoming power terminals and that the DC bus has dissipated.

Duty and HP			Required Dynamic Braking Units and Resistors				Typical Performance	
Braking Duty	Motor Voltage and Power Rating		Required Dynamic Braking Units:	Resistance and rms Current Rating	Additional Required Dynamic Braking Units:	Resistance and rms Current Rating	Peak Braking Power	Average Braking Power
Standard Duty: 150% Peak Braking Power 12% Average Braking Power	230VAC	15HP	1 of CDBR-2022B	9.00 ohm 12.0A			154% of 15HP	12.5% of 15HP
		20HP	1 of CDBR-2022B	6.80 ohm 16.0A			152% of 20HP	12.5% of 20HP
		25HP	2 of CDBR-2022B	9.00 ohm 12.0A			183% of 25HP	14.8% of 25HP
		30HP	2 of CDBR-2022B	9.00 ohm 12.0A			152% of 30HP	12.3% of 30HP
		40HP	2 of CDBR-2022B	6.80 ohm 16.0A			151% of 40HP	12.4% of 40HP
		50HP	1 of CDBR-2110B	2.10 ohm 50.0A			194% of 50HP	14.8% of 50HP
		60HP	1 of CDBR-2110B	2.10 ohm 50.0A			162% of 60HP	12.3% of 60HP
		75HP	1 of CDBR-2110B	1.60 ohm 64.0A			169% of 75HP	12.3% of 75HP
		100HP	1 of CDBR-2110B	1.60 ohm 64.0A	and 1 of CDBR-2022B	6.80 ohm 16.0A	156% of 100HP	11.6% of 100HP
		125HP	1 of CDBR-2110B	1.60 ohm 64.0A	and 2 of CDBR-2022B	6.80 ohm 16.0A	148% of 125HP	11.2% of 125HP
		150HP	2 of CDBR-2110B	1.60 ohm 64.0A			167% of 150HP	12.1% of 150HP
Heavy Duty: 150% Peak Braking Power 50% Average Braking Power	230VAC	15HP	2 of CDBR-2022B	18.0 ohm 12.0A			154% of 15HP	49.8% of 15HP
		20HP	2 of CDBR-2022B	13.6 ohm 16.0A			152% of 20HP	49.9% of 20HP
		25HP	1 of CDBR-2110B	4.20 ohm 50.0A			197% of 25HP	60.0% of 25HP
		30HP	1 of CDBR-2110B	4.20 ohm 50.0A			163% of 30HP	49.9% of 30HP
		40HP	1 of CDBR-2110B	3.20 ohm 64.0A			160% of 40HP	46.5% of 40HP
		50HP	2 of CDBR-2110B	4.20 ohm 50.0A			194% of 50HP	59.4% of 50HP
		60HP	2 of CDBR-2110B	4.20 ohm 50.0A			162% of 60HP	49.4% of 60HP
		75HP	2 of CDBR-2110B	3.20 ohm 64.0A			169% of 75HP	49.1% of 75HP
		100HP	3 of CDBR-2110B	3.20 ohm 64.0A			189% of 100HP	55.0% of 100HP
		125HP	4 of CDBR-2110B	4.20 ohm 50.0A			153% of 125HP	46.8% of 125HP
		150HP	4 of CDBR-2110B	3.20 ohm 64.0A			167% of 150HP	48.6% of 150HP
'Decel' Duty: 150% Peak Braking Power 6% Average Braking Power	230VAC	15HP	1 of CDBR-2022B	9.00 ohm 09.2A			154% of 15HP	7.3% of 15HP
		20HP	1 of CDBR-2022B	6.80 ohm 11.6A			152% of 20HP	6.6% of 20HP
		25HP	2 of CDBR-2022B	9.00 ohm 09.2A			183% of 25HP	8.7% of 25HP
		30HP	2 of CDBR-2022B	9.00 ohm 09.2A			152% of 30HP	7.2% of 30HP
		40HP	2 of CDBR-2022B	6.80 ohm 11.6A			151% of 40HP	6.5% of 40HP
		50HP	1 of CDBR-2110B	2.10 ohm 36.0A			194% of 50HP	7.7% of 50HP
		60HP	1 of CDBR-2110B	2.10 ohm 36.0A			162% of 60HP	6.4% of 60HP
		75HP	1 of CDBR-2110B	1.60 ohm 46.0A			169% of 75HP	6.3% of 75HP
		100HP	1 of CDBR-2110B	1.60 ohm 46.0A	and 1 of CDBR-2022B	6.80 ohm 11.6A	156% of 100HP	6.0% of 100HP
		125HP	1 of CDBR-2110B	1.60 ohm 46.0A	and 2 of CDBR-2022B	6.80 ohm 11.6A	148% of 125HP	5.8% of 125HP
		150HP	2 of CDBR-2110B	1.60 ohm 46.0A			167% of 150HP	6.3% of 150HP

Fig 2.3 230V Rated Braking Transistor and Resistor Units

Duty and HP			Required Dynamic Braking Units and Resistors				Typical Performance	
Braking Duty	Motor Voltage and Power Rating		Required Dynamic Braking Units:	Resistance and rms Current Rating	Additional Required Dynamic Braking Units:	Resistance and rms Current Rating	Peak Braking Power	Average Braking Power
Standard Duty:	480VAC	30HP	1 of CDBR-4045B	18.0 ohm 12.1A			152% of 30HP	12.5% of 30HP
		40HP	1 of CDBR-4045B	13.6 ohm 16.0A			151% of 40HP	12.4% of 40HP
		50HP	2 of CDBR-4045B	18.0 ohm 12.1A			182% of 50HP	14.9% of 50HP
		60HP	2 of CDBR-4045B	18.0 ohm 12.1A			151% of 60HP	12.4% of 60HP
150% Peak Braking Power		75HP	2 of CDBR-4045B	13.6 ohm 16.0A			159% of 75HP	13.0% of 75HP
		100HP	1 of CDBR-4220B	4.20 ohm 50.0A			192% of 100HP	14.7% of 100HP
		125HP	1 of CDBR-4220B	4.20 ohm 50.0A			153% of 125HP	11.7% of 125HP
		150HP	1 of CDBR-4220B	3.20 ohm 64.0A			167% of 150HP	12.1% of 150HP
		200HP	1 of CDBR-4220B	3.20 ohm 64.0A	and 1 of CDBR-4045B	13.6 ohm 16.0A	154% of 200HP	11.5% of 200HP
12% Average Braking Power		250HP	1 of CDBR-4220B	3.20 ohm 64.0A	and 2 of CDBR-4045B	13.6 ohm 16.0A	146% of 250HP	11.1% of 250HP
		300HP	2 of CDBR-4220B	3.20 ohm 64.0A			166% of 300HP	12.0% of 300HP
		400HP	2 of CDBR-4220B	4.20 ohm 50.0A	and 1 of CDBR-4220B	3.20 ohm 64.0A	156% of 400HP	11.7% of 400HP
		500HP	3 of CDBR-4220B	3.20 ohm 64.0A			148% of 500HP	10.7% of 500HP
Heavy Duty:	480VAC	30HP	2 of CDBR-4045B	36.0 ohm 12.1A			152% of 30HP	50.1% of 30HP
		40HP	2 of CDBR-4045B	27.2 ohm 16.0A			151% of 40HP	49.4% of 40HP
		50HP	1 of CDBR-4220B	8.40 ohm 50.0A			194% of 50HP	59.4% of 50HP
		60HP	1 of CDBR-4220B	8.40 ohm 50.0A			162% of 60HP	49.4% of 60HP
150% Peak Braking Power		75HP	1 of CDBR-4220B	6.40 ohm 64.0A			169% of 75HP	49.1% of 75HP
		100HP	2 of CDBR-4220B	8.40 ohm 50.0A			192% of 100HP	58.8% of 100HP
		125HP	2 of CDBR-4220B	8.40 ohm 50.0A			153% of 125HP	46.8% of 125HP
		150HP	2 of CDBR-4220B	6.40 ohm 64.0A			167% of 150HP	48.6% of 150HP
		200HP	3 of CDBR-4220B	6.40 ohm 64.0A			187% of 200HP	54.4% of 200HP
50% Average Braking Power		250HP	4 of CDBR-4220B	8.40 ohm 50.0A			152% of 250HP	46.3% of 250HP
		300HP	4 of CDBR-4220B	8.40 ohm 50.0A			126% of 300HP	38.5% of 300HP
		400HP	5 of CDBR-4220B	8.40 ohm 50.0A			118% of 400HP	36.0% of 400HP
		500HP	6 of CDBR-4220B	6.40 ohm 64.0A			148% of 500HP	42.9% of 500HP
'Decel' Duty:	480VAC	30HP	1 of CDBR-4045B	18.0 ohm 08.5A			152% of 30HP	6.2% of 30HP
		40HP	1 of CDBR-4045B	13.6 ohm 11.6A			151% of 40HP	6.5% of 40HP
		50HP	2 of CDBR-4045B	18.0 ohm 08.5A			182% of 50HP	7.4% of 50HP
		60HP	2 of CDBR-4045B	18.0 ohm 08.5A			151% of 60HP	6.1% of 60HP
150% Peak Braking Power		75HP	2 of CDBR-4045B	13.6 ohm 11.0A			159% of 75HP	6.2% of 75HP
		100HP	1 of CDBR-4220B	4.20 ohm 36.0A			192% of 100HP	7.6% of 100HP
		125HP	1 of CDBR-4220B	4.20 ohm 36.0A			153% of 125HP	6.1% of 125HP
		150HP	1 of CDBR-4220B	3.20 ohm 46.0A			167% of 150HP	6.3% of 150HP
		200HP	1 of CDBR-4220B	3.20 ohm 46.0A	and 1 of CDBR-4045B	13.6 ohm 11.6A	154% of 200HP	6.0% of 200HP
6% Average Braking Power		250HP	1 of CDBR-4220B	3.20 ohm 46.0A	and 2 of CDBR-4045B	13.6 ohm 11.0A	146% of 250HP	5.6% of 250HP
		300HP	2 of CDBR-4220B	3.20 ohm 46.0A			166% of 300HP	6.2% of 300HP
		400HP	2 of CDBR-4220B	4.20 ohm 50.0A	and 1 of CDBR-4220B	3.20 ohm 46.0A	156% of 400HP	9.5% of 400HP
		500HP	3 of CDBR-4220B	3.20 ohm 46.0A			148% of 500HP	5.5% of 500HP

Fig 2.4 480V Rated Braking Transistor and Resistor Units

Heat Sink Mount Resistor Installation

1. Remove the Drive from its mounting for access to the rear of the heat sink.
2. Attach the Heat Sink Mount Resistor on the back of the Drive's heat sink with screws M4 x 10mm (0.7mm pitch), as shown in figure below.
3. Remove the rubber plug and run the braking resistor wires into the hole that leads to the terminal block.
4. Reinstall the Drive in its mounting position.
5. Connect the leads from the Heat Sink Mount Resistor to the Drive terminals B1 and B2.
6. Proceed to "Adjustments" section on page 2-20.

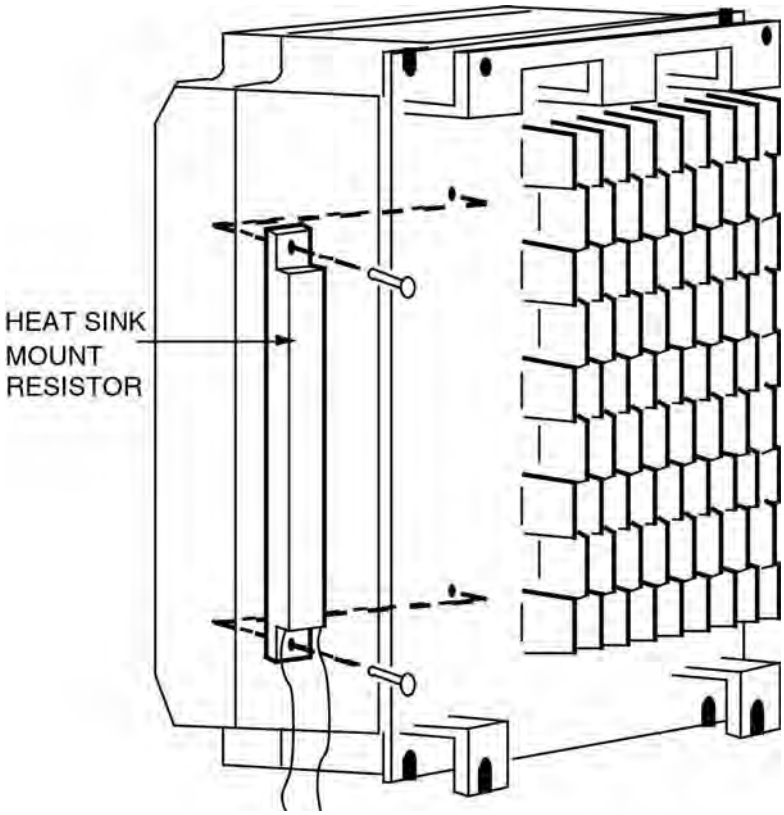


Fig 2.5 Attaching Heat Sink Mount Resistor on Heat Sink

Remote Mount Resistor Unit Installation Using Internal Braking Transistor (for P7U20P4 thru P7U2018 and P7U40P4 thru P7U4018)

Since the Remote Mount Resistor Unit generates heat during dynamic braking operation, install it in a location away from other equipment.

1. Install the Remote Mount Resistor Unit to a non-combustible surface, maintaining a minimum 1.97 inches (50mm) clearance on each side and a minimum 7.87 inches (200mm) clearance on top.
2. Remove the Remote Mount Resistor Unit cover to access its terminal block. Connect the Remote Mount Resistor Unit to the Drive and to external control circuitry according to Fig 2.6 below.

Table 2.8 Wire Size for Remote Mount Resistor Unit		
Terminals	B, P, R1, R2	1, 2*
Wire Size (AWG)	12-10	18-14*
Wire Type	600V Ethylene propylene rubber insulated, or equivalent	
Terminal Screw	M4	
* Power Leads for the Remote Mount Resistor Unit generate high levels of electrical noise - these signal leads must be grouped separately.		

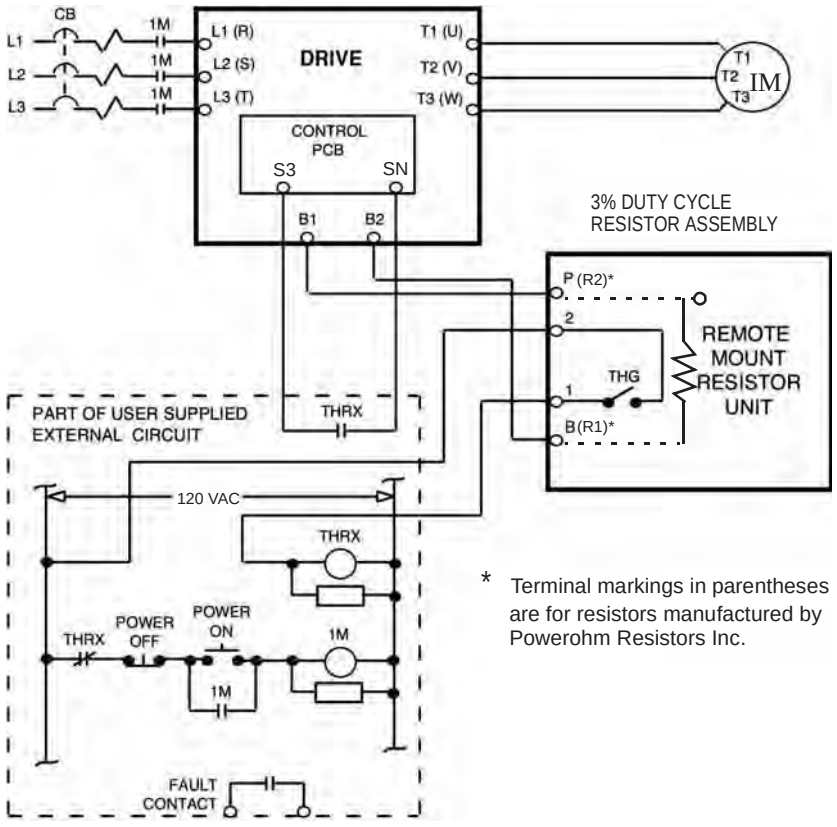


Fig 2.6 Wiring Remote Mount Resistor Unit (for P7U20P4 thru P7U2018 and P7U40P4 thru P7U4018)

3. Reinstall and secure Remote Mount Resistor Unit cover and Drive front cover.
4. Proceed to “Adjustments” section on page 2-20.

Braking Transistor Unit(s) and Remote Mount Resistor Unit(s) Installation (for P7U2022 thru P7U2110 and P7U4022 thru P7U4300)

Since the Remote Mount Resistor Unit generates heat during dynamic braking operation, install it in a location away from other equipment.

Select Mounting locations for Braking Transistor Unit(s) and Remote Mount Resistor Unit(s) so that wiring between the Drive and the (Master) Braking Transistor Unit, and between each Braking Transistor Unit and its associated Remote Mount Resistor Unit, is less than 33 feet (10m).

1. Mount the Braking Transistor Unit(s) on a vertical surface. The Braking Transistor Unit requires a minimum of 1.18 inches (30mm) clearance on each side and a minimum 3.94 inches (100mm) clearance top and bottom. Attach the Remote Mount Resistor Unit maintaining a minimum 1.97 inches (50mm) clearance on each side and a minimum 7.87 inches (200mm) clearance on top.
2. In each Braking Transistor Unit, set the nominal line voltage jumper plug to the correct setting for the installation; this is factory set at the 230V/460V position. To access jumper plugs, remove the Plexiglas cover.
3. If multiple Braking Transistor Units are being installed, the unit closest to the Drive should have the Slave/Master jumper plug set to the "Master" position (factory setting); all others must have this jumper plug set to the "Slave" position.
4. If a single Braking Transistor Unit and Remote Mount Resistor Unit are being installed, connect them to the Drive and external control circuitry according to the chart and figure below.
5. Power leads for the Remote Mount Resistor Unit generate high levels of electrical noise - these power leads must be grouped separately.

Table 2.9 Wire Size for Remote Mount Resistor Unit and Braking Transistor Unit

Name	Circuit	Terminals	Wire Size AWG (mm^2)	Wire Type	Terminal Screw
Braking Transistor Unit (Models CDBR-2015B, -2022B, -4030B, -4045B)	Main	⊕ ⊕0 ⊖ ⊖0	12-10 (3.5-5.5)	600V vinyl sheathed wire or equivalent	M4
	Control	1 2 3 4 5 6	18-14 (0.75-2)		
Braking Transistor Unit (Model CDBR-2045, -4090)	Main	P, Po, N, B	12-10 (3.5-5.5)	600V vinyl sheathed wire or equivalent	M5
	Control	1 2 3 4 5 6	18-14 (0.75-2)		M4
Braking Transistor Unit (Model CDBR-2110)	Main	P, Po, N, B	4 (22) 8-6 (8-14) *1	600V vinyl sheathed wire or equivalent	M6
		r ℯ	12-10 (3.5-5.5)		M4
	Control	1 2 3 4 5 6	18-14 (0.75-2)		
Braking Transistor Unit (Model CDBR-4220)	Main	P, Po, N, B	4 (22) 8-6 (8-14) *1	600V vinyl sheathed wire or equivalent	M6
		r ℯ	12-10 (3.5-5.5)		M4
	Control	1 2 3 4 5 6	18-14 (0.75-2)		
Braking Resistor Unit (Model LKEB-□)	Main	B P	12-10 (3.5-5.5)	600V vinyl sheathed wire or equivalent	M4 (M5) *2
	Control	1 2	18-14 (0.75-2)		M4

*1 For wire size of 8-6 (8-14), use UL1283 heat-resistant vinyl-insulated wire or equivalent.
*2 M4 for Models LKEB-20P7 to -27P5 or -40P7 to -4015.
M5 for Models LKEB-2011 to -2022 or -4018 to -4045.

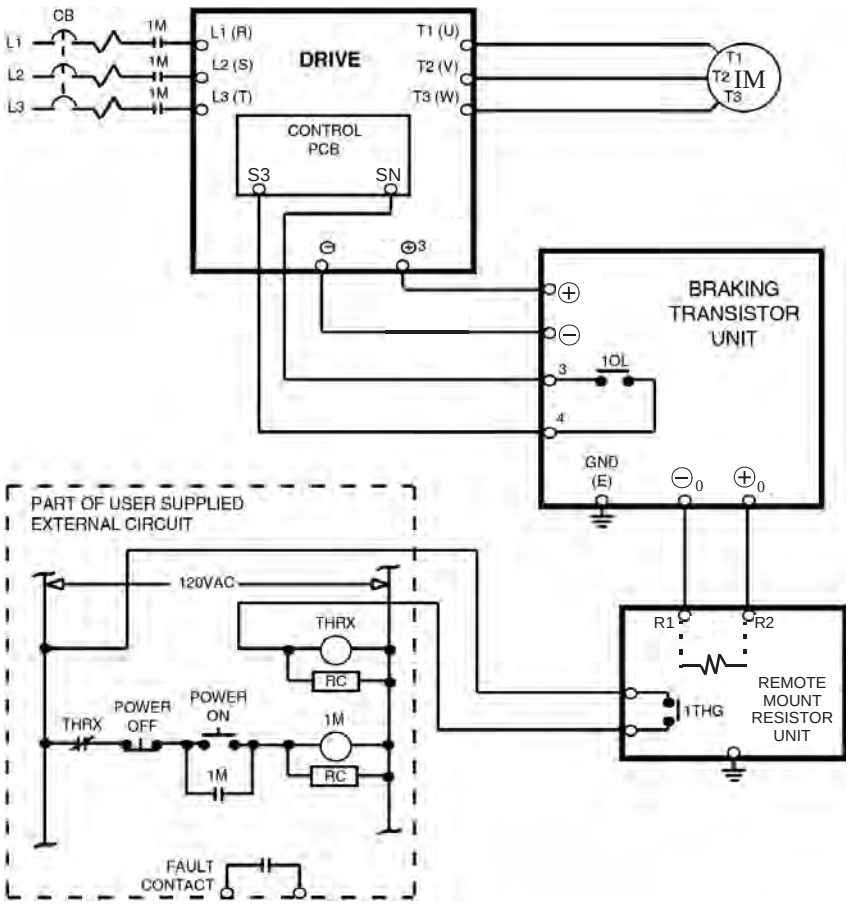
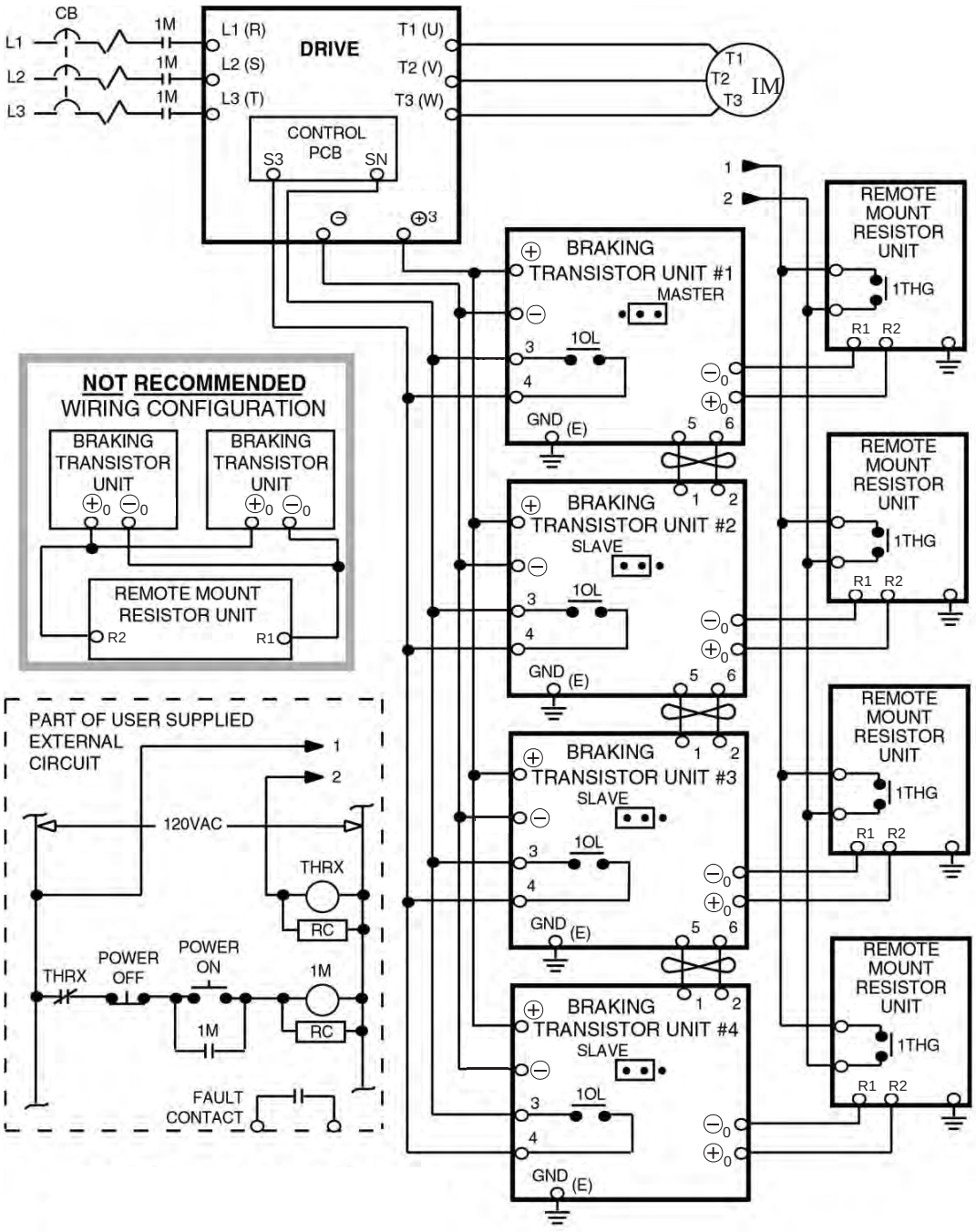


Fig 2.7 Wiring Single Braking Transistor Unit and Remote Mount Resistor Unit to Drive (P7U2022 thru P7U2110 and P7U4022 thru P7U4300)

6. If two or more Braking Transistor Units and Remote Mount Resistor Units are being installed, connect them to the Drive and to external circuitry according to Fig 2.8.



Note: Connect only the number of braking transistor units and remote mount resistor units required for the application.

Fig 2.8 Wiring Multiple Braking Transistor Units and Remote Mount Resistor Units to Drive (P7U2022 thru P7U2110 and P7U4022 thru P7U4300)

Adjustments

7. All Drives: Program Parameter L3-04 to “0” or “3” to disable stall prevention during deceleration.
8. Heat Sink Mount Resistor Only: Program L8-01 to “1” to enable overheat protection for heat sink mount braking resistor.

Operation Check

9. During dynamic braking, verify that the “BRAKE” lamp inside the Braking Unit is lit. This lamp illuminates only when dynamic braking is activating (during quick deceleration).
10. During dynamic braking, ensure that the required deceleration characteristic is obtained. If not, contact Yaskawa for assistance.
11. Reinstall and secure covers on the Braking Transistor Units, Remote Mount Resistor Units, and the Drive.

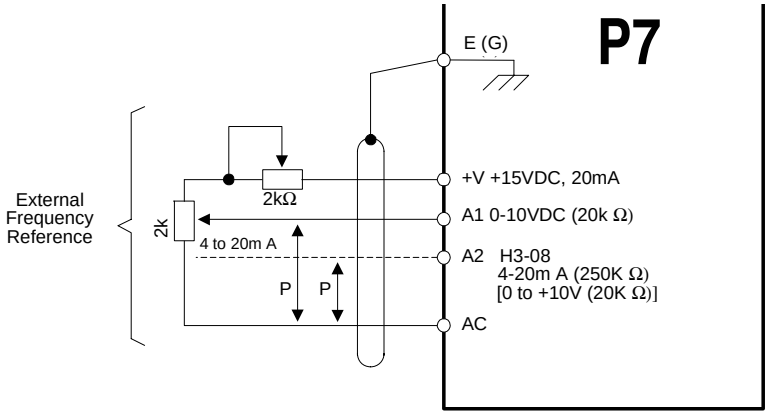
Control Wiring

◆ Control Circuit Wire Sizes

The auto mode speed reference (speed command) field wiring connection is made to P7 Drive terminals A1 or A2 (signal positive), AC (signal common) and G (shield). Keep this lead length as short as possible to maintain signal quality. Insulated twisted shielded pair wire (2 conductor # 18 ga, Belden 8760 or equivalent) is required. Do not run these wires in the same conduits as other AC power or control wires. The shield must be connected on this end only, stub and isolate the other end. The A2 signal employed is 4 to 20 mA with parameter H3-08 set for "2: 4 - 20 mA". For 0 to 10 VDC, parameter H3-08 is set for "0: 0 - 10 VDC" and the P7 control board DIP switch S1-2 must be in the OFF position. (See Figure 2.9)

For remote operation, keep the length of the control wiring to 50m or less. Separate the control wiring from high-power lines (input power, motor leads or relay sequence circuits) to reduce noise induction from peripheral devices.

When setting speed commands (frequency references) from an external speed potentiometer (and not from the Digital Operator), use shielded twisted-pair wires and ground the shield to terminal E(G), as shown in Fig 2.9. Terminal numbers and wire sizes are shown in Table 2.10.



Signal	Terminal Connections
0-10Vdc	A1 to AC
4-20mA or 0-10Vdc	A2 to AC

Fig 2.9 Analog Input Terminal Configuration

Table 2.10 Terminal Numbers and Wire Sizes (Same for all Drives)

Terminals	Terminal Screws	Tightening Torque lb-in (N•m)	Possible Wire Sizes AWG (mm^2)	Recommended Wire Size AWG (mm^2)	Wire Type
S1, S2, S3, S4, S5, S6, S7 SN, SC, SP, +V, A1, A2, AC, MI, M2, M3, M4, MA, MB, MC, FM, AC, AM, R+, R-, S+, S-, IG	Phoenix type *3	4.2 to 5.3 (0.5 to 0.6)	Stranded wire: 26 to 16 (0.14 to 1.5)	18 (0.75)	• Shielded, twisted-pair wire*1 • Shielded, polyethylene-covered, vinyl sheath cable
E(G)	M3.5	7.0 to 8.8 (0.8 to 1.0)	20 to 14 (0.5 to 2*2)	12 (1.25)	

*1. Use shielded twisted-pair cables to input an external speed command.
*2. Yaskawa recommends using straight solderless terminals on digital inputs to simplify wiring and improve reliability.
*3. Yaskawa recommends using a thin-slot screwdriver with a 3.5 mm blade width.

◆ Wiring Checks

After all wiring is completed, perform the following checks:

1. Is all wiring correct?
2. Have all wire clippings, screws or other foreign material been removed from the Drive enclosure?
3. Are all terminal screws tight?

◆ Control Circuit Terminal Functions

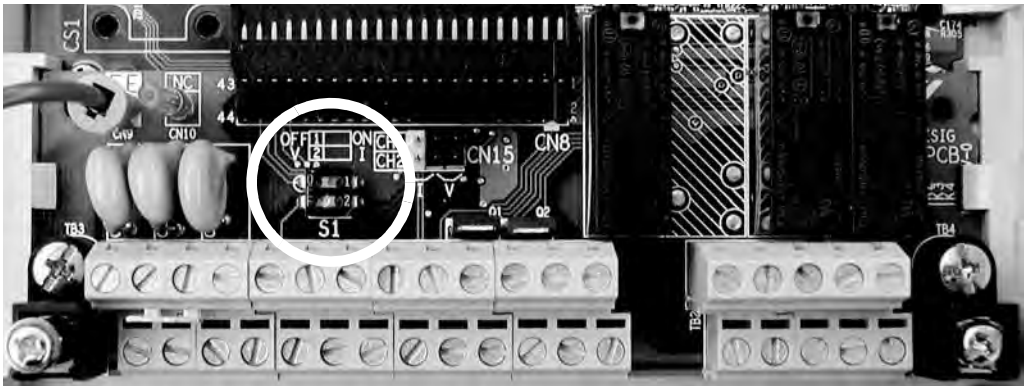
The factory default functions of the control circuit terminals for 2-wire control are shown in Table below.

Table 2.11 Control Circuit Terminals

Type	No.	Signal Name	Description		Signal Level
Digital input signals	S1	Forward run/stop command	Forward run when CLOSED; stopped when OPEN.		24 Vdc, 8 mA Photocoupler isolation
	S2	Reverse run/stop command	Reverse run when CLOSED; stopped when OPEN.		
	S3	External fault input	Fault when CLOSED.	Multi-function digital inputs Functions set by H1-01 to H1-05.	
	S4	Fault reset	Reset when CLOSED		
	S5	Multi-step speed reference 1 (Master/auxiliary switch)	Auxiliary frequency reference when CLOSED.		
	S6	Multi-step speed reference 2	Multi-step setting 2 when CLOSED.		
	S7	Jog frequency reference	Jog frequency when CLOSED.		
	SN	Digital input supply common	Refer to Table 2.14 for connection details.		
	SC	Digital input photocoupler			
	SP	Digital input supply +24Vdc			
Analog input signals	+V	+15Vdc power output	+15Vdc power supply for analog inputs or transmitters		+15Vdc (Max. current: 20 mA)
	A1	Analog input or Speed Command	0 to +10Vdc/100%		0 to +10 V(20 kΩ)
	A2	Multi-function analog input	4 to 20 mA/100% 0 to +10Vdc/100% (H3-0	Function set by H3-09.	4 to 20 mA(250Ω) 0 to +10 V(20kΩ)
	AC	Analog common	–		–
	E(G)	Shield wire, optional ground line connection point	–		–
Digital output signals	M1	During Run (N.O. contact)	CLOSED during operation	Multi-function digital output Function set by H2-01.	Dry contacts Contact capacity: 1 A max. at 250Vac 1 A max. at 30Vdc
	M2				
	M3	Remote/Auto Operation (N.O. contact)	CLOSED when local control	Multi-function digital output Function set by H2-02.	
	M4				
	MA	Fault output signal (SPDT)	MA/MC: CLOSED during fault condition MB/MC: OPEN during fault condition		Dry contacts Contact capacity: 1 A max. at 250Vac 1 A max. at 30Vdc
	MB				
	MC				
Analog output signals	FM	Multi-function analog output	(output frequency) 0 to +10Vdc/100% frequency	Multi-function analog monitor 1 Function set by H4-01	0 to +10Vdc max. ±5% 2 mA max.
	AC	Analog common	–		
	AM	Multi-function analog output	(output current) 0 to +10Vdc/100% Drive's rated output current	Multi-function analog monitor 2 Function set by H4-04	
RS-485/ 422	R+	Modbus communication input	For 2-wire RS-485, jumper R+ and S+ and jumper R- and S-.		Differential input, PHC isolation
	R-				
	S+	Modbus communication output			Differential input, PHC isolation
	S-				
	IG	Signal common	-		-

◆ DIP Switch S1

DIP Switch S1 is described in this section. The functions of DIP switch S1 are shown in Table 2.12.



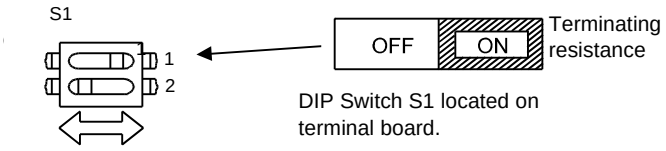


Fig 2.10 DIP Switch S1 Location

Table 2.12 DIP Switch S1

Name	Function	Setting
S1-1	RS-485 and RS-422 terminating resistance	OFF: No terminating resistance ON: Terminating resistance of 110Ω Factory Default = OFF
S1-2	Input method for analog input A2	OFF: 0-10 Vdc (internal resistance: 20KΩ) ON: 4-20mA (internal resistance: 250Ω) Factory Default = ON

◆ Shunt Connector CN15

The shunt connector CN15 is described in this section. Shunt connector along with parameters H4-07 and H4-08 select the signal range of the analog output terminals FM and AM.

Shunt connector CN15 is only available when the optional Terminal Card with the 4-20mA Analog Output Monitor is installed (Model No. ETC61812_). See Chapter 7, Maintenance, for installation of the optional Terminal Card.

The function of various shunt connector CN15 configurations is shown in Table 2.13.

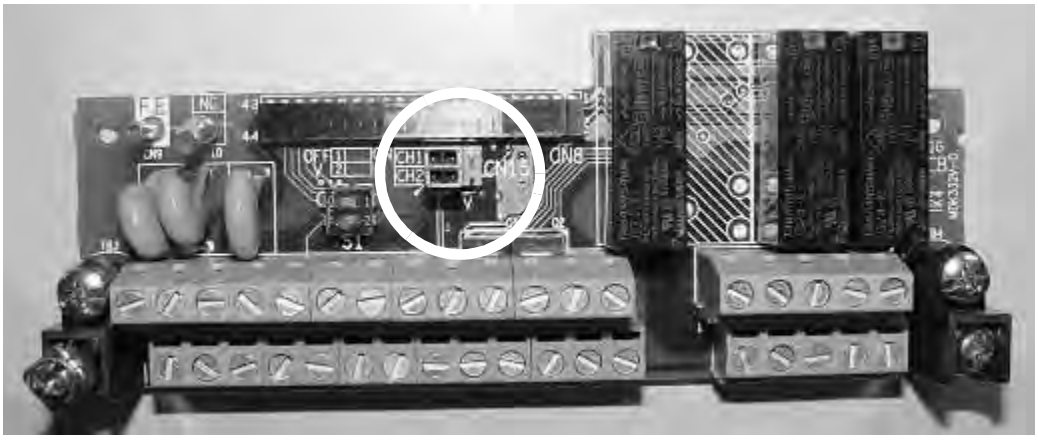


Fig 2.11 Shunt Connector CN15 Location

Table 2.13 Shunt Connector CN15 Configuration Options	
CN15	Analog Output Monitor Configurations
	Voltage Output (0-10Vdc) for terminals FM-AC (CH1) and AM-AC (CH2)
	Current Output (4-20mA) for terminals FM-AC (CH1) and AM-AC (CH2)
	Voltage Output (0-10Vdc) for terminals FM-AC (CH1) Current Output (4-20mA) for terminals AM-AC (CH2)
	Current Output (4-20mA) for terminals FM-AC (CH1) Voltage Output (0-10Vdc) for terminals AM-AC (CH2)

The software configuration for the analog output monitor signal type is listed below:

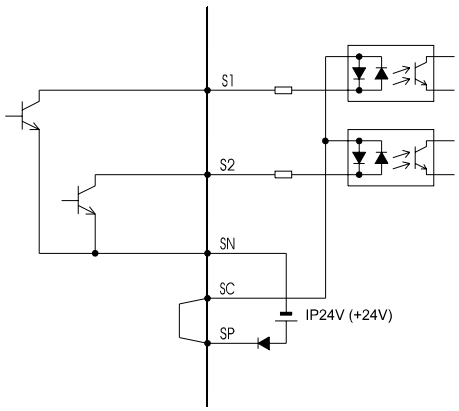
Parameter No.	Parameter Name **Digital Operator Display**	Description	Setting Range	Factory Setting	Menu Location
H4-07	Terminal FM Signal Level Selection **AO Level Select1**	0: 0 - 10 V 2: 4-20 mA	0 or 2	0	Programming
H4-08	Terminal AM Signal Level Selection **AO Level Select2**	0: 0 - 10 V 2: 4-20 mA	0 or 2	0	Programming

◆ Sinking/Sourcing Mode

The input terminal logic can be switched between sinking mode (0V common) and sourcing mode (+24V common) by using the terminals SN, SC, and SP. An external power supply can also be connected, providing more freedom in signal input methods.

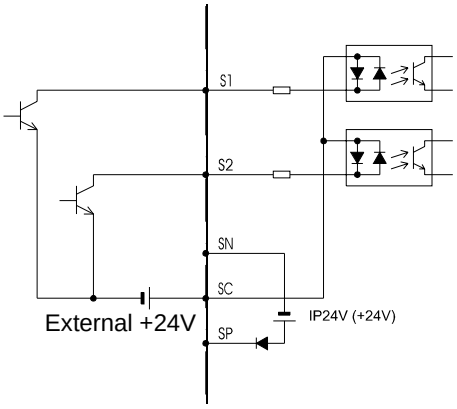
Table 2.14 Sinking/Sourcing Mode and Input Signals

Internal Power Supply – Sinking Mode

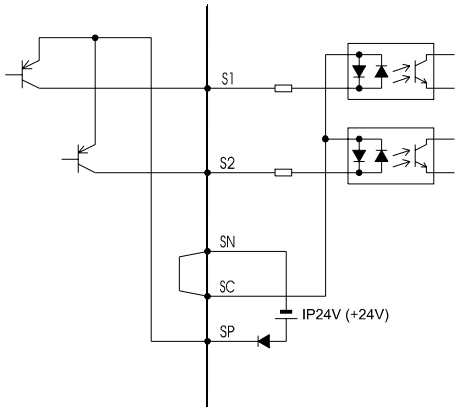


(Factory Default)

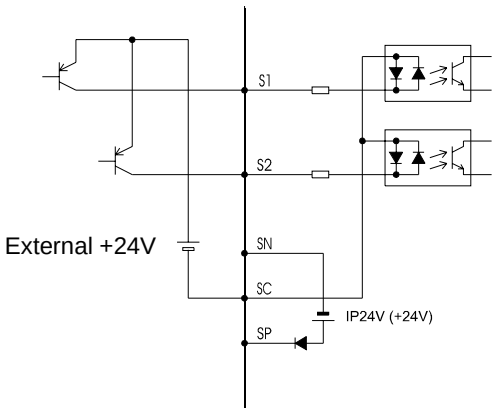
External Power Supply – Sinking Mode



Internal Power Supply – Sourcing Mode



External Power Supply – Sourcing Mode



◆ Terminal Connections

Connections to Drive terminals are shown.

o Drive terminals are shown.

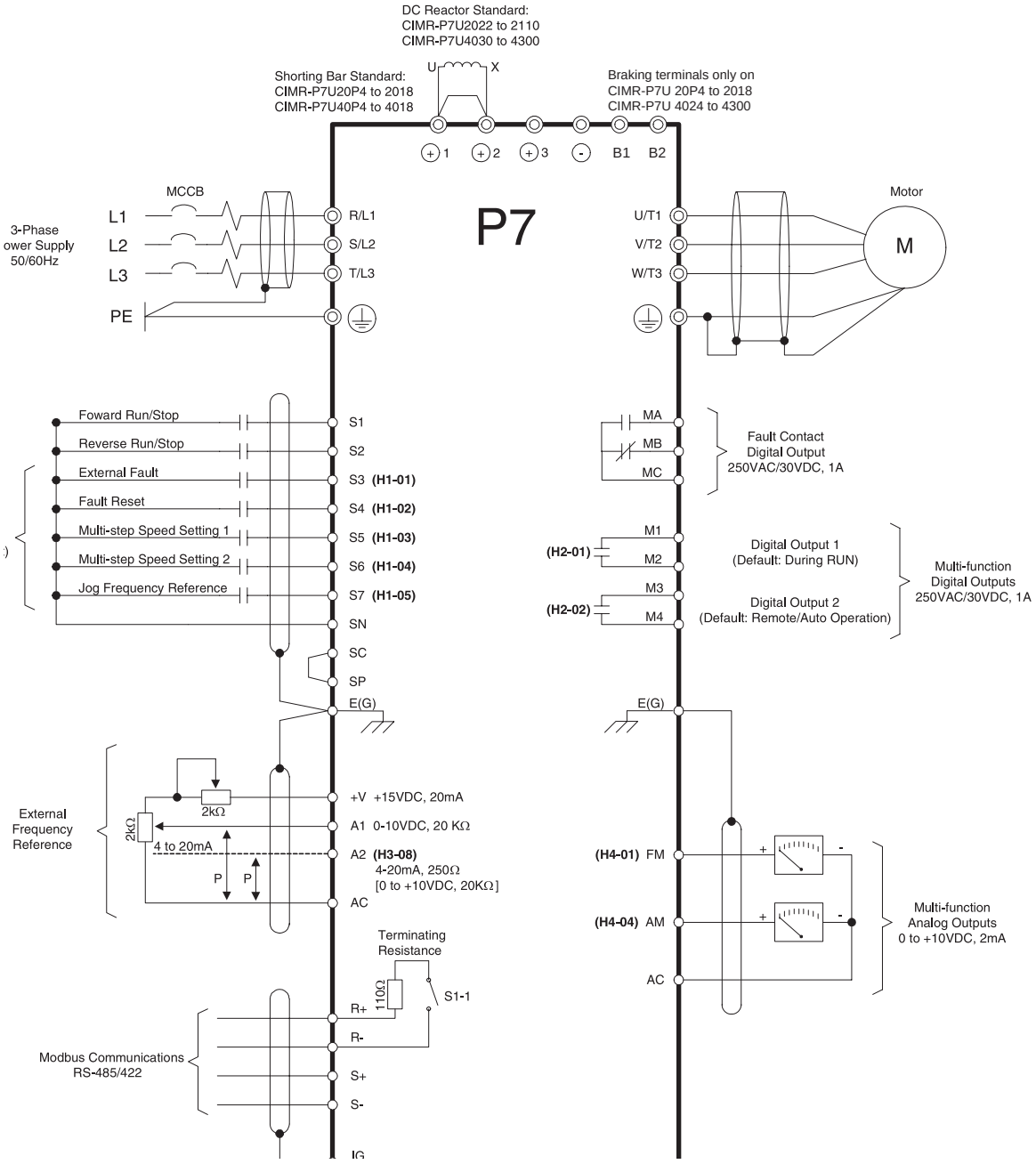


Fig 2.12 Terminal Connections

◆ Control Circuit Wiring Precautions

Observe the following precautions when wiring control circuits:

1. Separate control wiring from power/motor wiring (terminals R/L1, S/L2, T/L3, U/T1, V/T2, W/T3, ⊖, ⊕1, ⊕2, and ⊕3) and other high-power lines.
2. Separate wiring for control circuit terminals MA, MB, MC, M1, M2, M3, and M4 (digital outputs) from wiring to other control circuit terminals.
3. If using an optional external power supply, ensure it is a UL Listed Class 2 power supply source.
4. Use twisted-pair or shielded twisted-pair cables for control circuits to prevent operating faults. Prepare cable ends as shown in Figure below.
5. Connect the shield wire to terminal E(G).
6. Insulate the shield with tape to prevent contact with other signal lines and equipment.

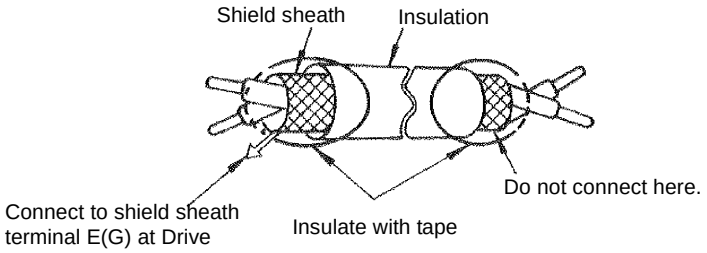


Fig 2.13 Preparing the Termination of Shielded Twisted-pair Cables

◆ Field Wiring Diagram

Use this diagram to document field wiring. It may be helpful to copy this page.

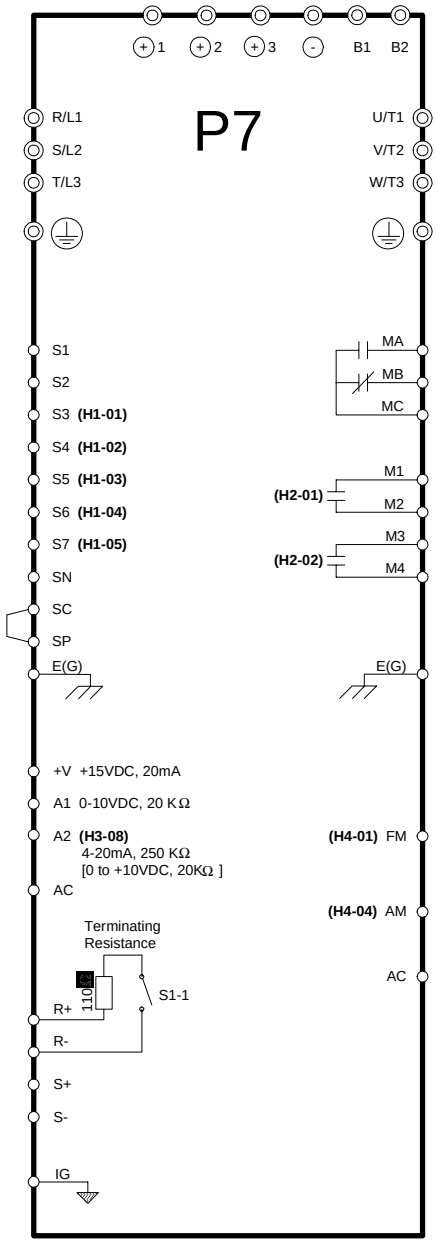


Fig 2.14 Field Wiring Diagram

Chapter 3
Digital Operator

This chapter describes the displays and functions of the Digital Operator.

Digital Operator Display.....3-2
Digital Operator Keys 3-3
Drive Mode Indicators.....3-4
Drive Main Menu 3-6
Quick Setting Menu (-QUICK-) 3-11
Programming Menu (-ADV-) 3-12
Example of Changing a Parameter 3-14

Digital Operator Display

The Digital Operator is used for programming, operating, monitoring, and copying the Drive's parameters. To copy parameters, both Drives must have the same software version, model, and control method. The various items included on the Digital Operator are described below.

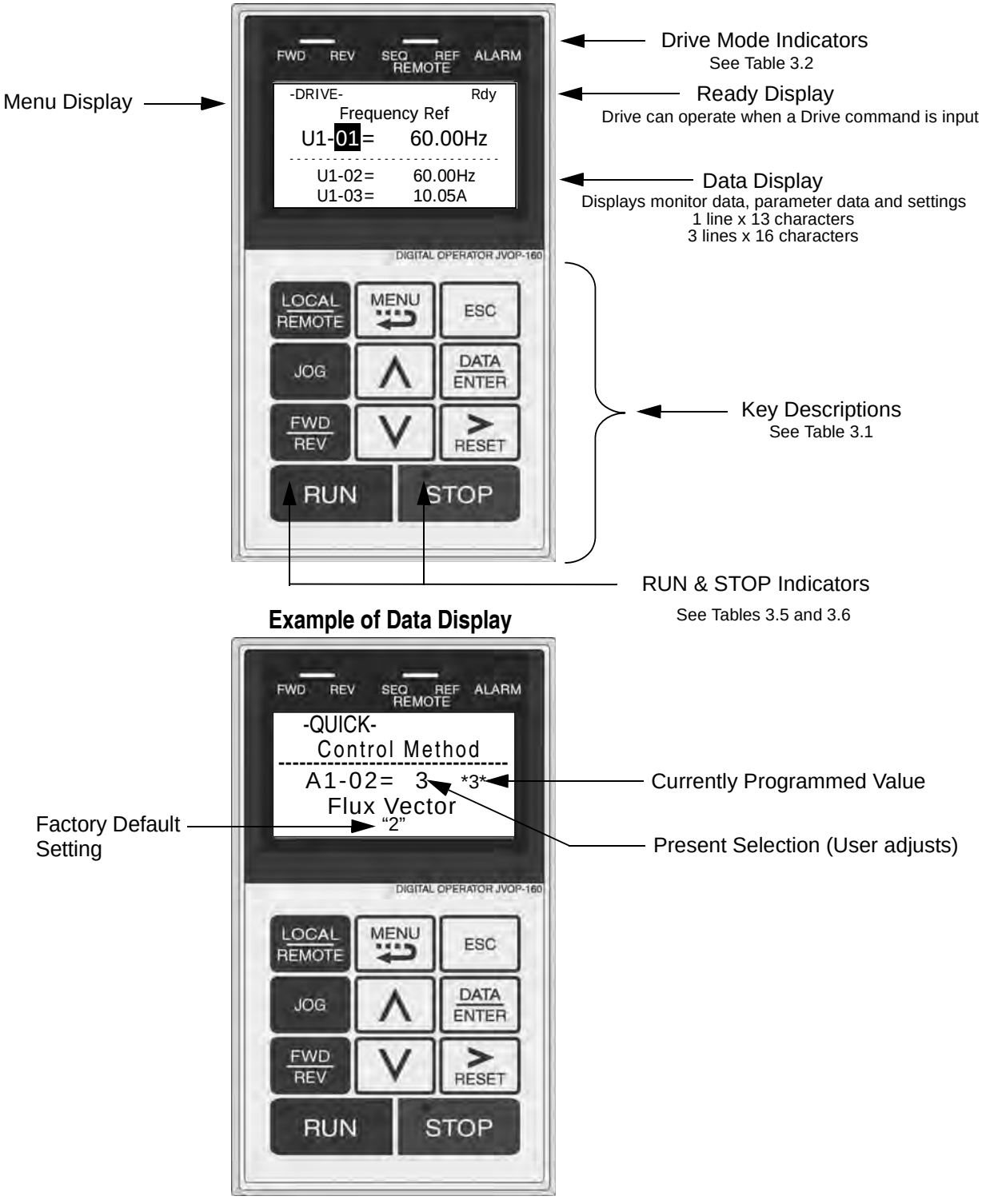


Fig 3.1 Digital Operator Component Names and Functions

Digital Operator Keys

The names and functions of the Digital Operator Keys are described in Table 3.1.

Table 3.1 Digital Operator Keys

Key	Name	Function
	LOCAL / REMOTE	• Switches between operation via the Digital Operator (LOCAL) and the settings in parameter b1-01 (Frequency Reference Selection) and b1-02 (Run Command Selection) (REMOTE). • This key can be enabled or disabled by the setting in parameter o2-01. • The Drive must be in a stopped condition before it can be transferred to “LOCAL” or “REMOTE” mode.
	MENU	• Scrolls through the five main menus: • Operation (-DRIVE-), Quick Setting (-QUICK-), Programming (-ADV-), Modified Constants (-VERIFY-), and Auto-Tuning (-A.TUNE-).
	ESCAPE	• Returns to the previous display, before the DATA/ENTER key was pressed.
	JOG	• Enables jog operation when the Drive is being operated from the Digital Operator (LOCAL).
	FWD / REV	• Selects the rotation direction of the motor when the Drive is being operated from the Digital Operator (LOCAL).
	INCREASE	• Increases parameter numbers and set values. • Used to move to the next item or data value.
	DECREASE	• Decreases parameter numbers and set values. • Used to move to the previous item or data value.
	SHIFT/RESET	• Selects the digit to be changed. The selected digit will blink. • Also resets the Drive when a fault has occurred. The run command must be removed before the reset command will be accepted.
	DATA/ENTER	• Enter menus and parameters as well as to set values.
	RUN	• Starts Drive operation when the Drive is being controlled by the Digital Operator (LOCAL).
	STOP Key	• Stops Drive operation. • This key can be enabled or disabled when operating from the external terminal or communications by setting user parameter o2-02.

Drive Mode Indicators

The definition of the Drive mode indicators are shown in Table 3.2.

Table 3.2 Drive Mode Indicators	
Indicator	Definition
FWD	Lit when a forward run command is input.
REV	Lit when a reverse run command is input.
REMOTE SEQ	See Table 3.3.
REMOTE REF	See Table 3.4.
ALARM	Lit when a fault has occurred. Flashes when an Alarm has occurred.

◆ REMOTE Sequence (SEQ) Indicator

The status of the “REMOTE” Sequence (SEQ) indicator is shown in Table 3.3. This indicator is always “Off” when the Drive is in the “LOCAL” mode. When the Drive is in the “REMOTE” mode, the SEQ indicator status is dependent on the setting of parameter b1-02 (Run Command Selection). See Table 3.3.

Table 3.3 REMOTE Sequence (SEQ) Indicator	
Indicator Status	Condition
On	Parameter b1-02 (Run Command Selection) is set to terminal strip, communications, or an option board as indicated below: b1-02 =1 (Terminals) =2 (Communications) =3 (Option PCB)
Off	Parameter b1-02 (Run Command Selection) is set to Digital Operator as indicated below: b1-02=0 (Operator)

◆ REMOTE Reference (REF) Indicator

The status of the “REMOTE” Reference (REF) indicator is shown in Table 3.4. This indicator is always “Off” when the Drive is in the “LOCAL” mode. When the Drive is in the “REMOTE” mode, the REF indicator status is dependent on the setting of parameter b1-01 (Frequency Reference Selection). See Table 3.4.

Table 3.4 REMOTE Reference (REF) Indicator

Indicator Status	Condition
On	Parameter b1-01 (Frequency Reference Selection) is set to terminal strip, communications, option board, or pulse train as indicated below: b1-01 =1 (Terminals) =2 (Communications) =3 (Option PCB) =4 (Pulse Train)
Off	Parameter b1-01 (Frequency Reference Selection) is set to digital operator as indicated below: b1-01=0 (Operator)

◆ Run Indicator

The status of the “RUN” indicator is shown in Table 3.5 when the Drive is in either the “LOCAL” or “REMOTE” mode.

Table 3.5 RUN Indicator

Indicator Status	Condition
On	Drive is running.
Blinking	Drive is decelerating to a stop.
Off	Drive is stopped.

◆ Stop Indicator

The status of the “STOP” indicator is shown in Table 3.6 when the Drive is in either the “LOCAL” or “REMOTE” mode.

Table 3.6 STOP Indicator

Indicator Status	Condition
On	Drive is decelerating to a stop or stopped.
Blinking	Drive is in a run condition but the frequency reference is less than the minimum output frequency E1-09, or the Drive is running in “REMOTE” mode and the “STOP” key on has been pressed.
Off	Drive is running.

Drive Main Menu

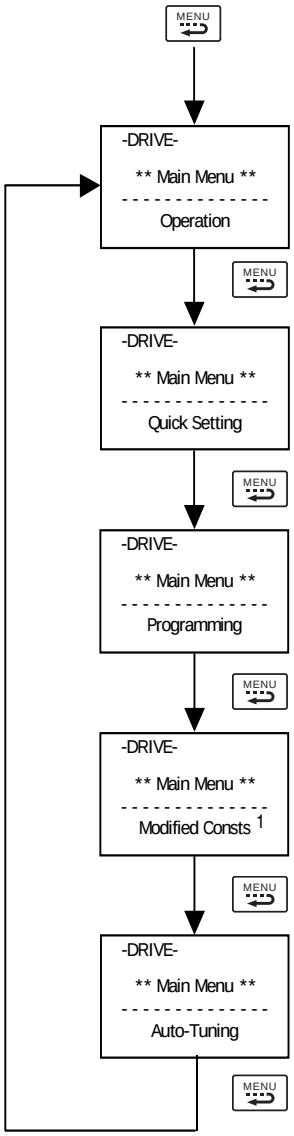
The Drive's parameters and monitoring functions are organized into menu groups that make it easier to read and set parameters. The Drive is equipped with five menu selections. The five selections and their primary functions are shown in Table 3.7 and are directly available by pressing the menu key.

Table 3.7 Drive Main Menu

Main Menu	Primary Function(s)
Operation - DRIVE -	The Drive can be run in this menu. Use this menu for monitoring values such as frequency reference or output current, displaying fault history or displaying the fault traces.
Quick Setting - QUICK -	The Drive can be programmed in this menu. Use this menu to set/read the most commonly used parameters.
Programming - ADV -	The Drive can be programmed in this menu. Use this menu to set/read every parameter.
Modified Constants - VERIFY -	The Drive can be programmed in this menu. Use this menu to set/read the parameters that have been modified from their factory default settings.
Auto-Tuning - A.TUNE -	The Drive can be programmed in this menu. Use this menu to auto-tune the Drive in order to optimize motor control as well as utilize the bi-directional speed search feature.

◆ Main Menu Structure

The menu selection display will appear when the MENU key is pressed from a monitor or setting display. While viewing the menu selection display, press the MENU key repeatedly to scroll between the menu selections. Press the DATA/ENTER key to enter the desired menu selection.



[1] Modified Consts = Modified Parameters

Fig 3.2 Main Menu Structure

◆ Operation Menu (-DRIVE-)

This menu is used for setting a speed command or monitoring values such as output frequency and output current. It is also used for displaying the fault history and the fault traces. The Drive must be in this menu in order to run, see parameter b1-08.

IMPORTANT Leaving the Drive in a menu other than the Operation Menu, will prohibit the Drive from running. While running, if the Drive is in a menu other than "Operation" and the run command is removed and re-applied, the Drive will stop and will not start until the Operation Menu is selected.

U1 Monitor List

Follow the key operations below (Fig.3.3) to access the Operation Menu:

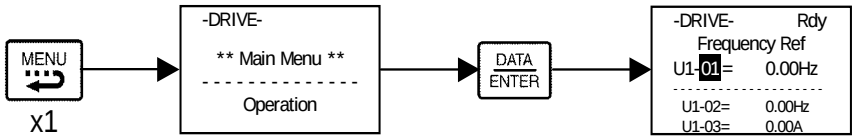


Fig 3.3 U1 Monitor List Access Procedure

Use [∧] and [∨] keys to scroll through the U1 "Monitor" parameter list. See Appendix A for functional description.

Table 3.8 U1 Monitor List

Monitor		Monitor	
U1-01	Frequency Ref	U1-20	SFS Output (Soft Starter Signal)
U1-02	Output Freq	U1-24	PI Feedback
U1-03	Output Current	U1-28	CPU ID
U1-06	Output Voltage	U1-29	kWh
U1-07	DC Bus Voltage	U1-30	MWh
U1-08	Output kWatts	U1-34	OPE Detected
U1-10	Input Term Sts	U1-36	PI Input
U1-11	Output Term Sts	U1-37	PI Output
U1-12	Int Ctl Sts 1	U1-38	PI Setpoint
U1-13	Elapsed Time	U1-39	Transmit Err
U1-14	FLASH ID	U1-40	FAN Elapsed Time
U1-15	Term A1 Level	U1-51	Auto Mode Fref
U1-16	Term A2 Level	U1-52	Hand Mode Fref
U1-18	Mot SEC Current (Secondary Current)	U1-53	PI Feedback 2

■U2 Fault Trace List

After viewing the “Monitor” parameter list, in order to view the “Fault Trace” parameter list, follow the key operations below (Fig.3.4).

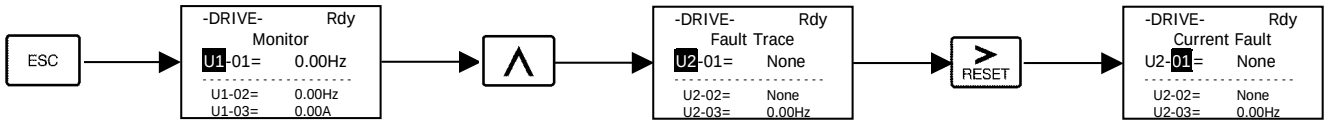


Fig 3.4 U2 Fault Trace List Access Procedure

Use ∧ and ∨ keys to scroll through the U2 “Fault Trace” parameter list.

Table 3.9 U2 Fault Trace List

Fault Trace Parameters	
U2-01	Current Fault
U2-02	Last Fault
U2-03	Frequency Ref
U2-04	Output Freq
U2-05	Output Current
U2-07	Output Voltage
U2-08	DC Bus Voltage
U2-09	Output kWatts
U2-11	Input Term Sts
U2-12	Output Term Sts
U2-13	AC Drive Status
U2-14	Elapsed Time

■ U3 Fault History List

After viewing the “Fault Trace” parameter list, in order to view the “Fault History” parameter list, follow the key operations below Fig. 3.5).

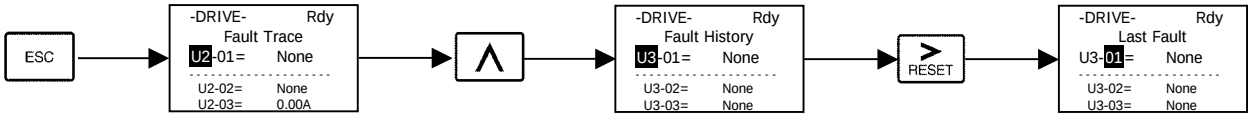


Fig 3.5 U3 Fault History Access Procedure

Use ∧ and ∨ keys to scroll through the U3 “Fault History” parameter list.

Table 3.10 Fault History List

Fault History Parameters	
U3-01	Last Fault
U3-02	Fault Message 2
U3-03	Fault Message 3
U3-04	Fault Message 4
U3-05	Elapsed Time 1
U3-06	Elapsed Time 2
U3-07	Elapsed Time 3
U3-08	Elapsed Time 4
U3-09	Fault Message 5
U3-10	Fault Message 6
U3-11	Fault Message 7
U3-12	Fault Message 8
U3-13	Fault Message 9
U3-14	Fault Message 10
U3-15	Elapsed Time 5
U3-16	Elapsed Time 6
U3-17	Elapsed Time 7
U3-18	Elapsed Time 8
U3-19	Elapsed Time 9
U3-20	Elapsed Time 10

Quick Setting Menu (-QUICK-)

This menu is used to set/read the most commonly used parameters in the Drive. Follow the key operations below (Fig. 3.6) to access the Quick Setting Menu:

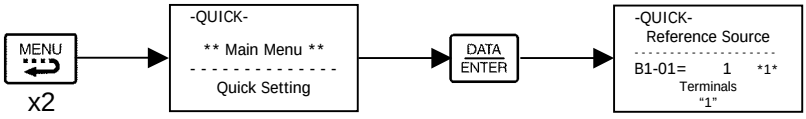


Fig 3.6 Quick Setting Parameter Access Procedure

Use [∧] and [∨] keys to scroll through the "Quick Setting" parameter list.

Table 3.11 Quick Setting Parameter List

Parameter Number	Parameter Name	Parameter Number	Parameter Name
A1-00	Language Selection	b5-29	PI Square Root Gain
b1-01	Frequency Reference Selection	b5-30	Output Square Root Monitor Selection
b1-02	Run command Selection	b8-01	Energy Savings Control Selection
b1-03	Stopping Method Selection	C1-01	Acceleration Time 1
b1-04	Reverse Operation Selection	C1-02	Deceleration Time 1
b4-01	Delay-On Timer		
b5-01	PI Mode Selection	d2-01	Frequency Reference Upper Limit
b5-02	Proportional Gain Setting	d2-02	Frequency Reference Lower Limit
b5-03	Integral Time Setting	E1-01	Input Voltage Setting
b5-04	Integral Limit Setting	E2-01	Motor Rated Current
b5-06	PI Output Limit	F6-01	Operation Selection After Communication Error
b5-07	PI Offset Adjustment	H3-02	Terminal A1 Gain Setting
b5-08	PI Primary Delay Time	H3-03	Terminal A1 Bias Setting
b5-09	PI Output Level Selection	H3-10	Terminal A2 Gain Setting
b5-10	PI Output Gain Setting	H3-11	Terminal A2 Bias Setting
b5-11	PI Output Reverse Selection	L2-01	Momentary Power Loss Detection Selection
b5-12	PI Feedback Reference Missing Detection Selection	L2-02	Momentary Power Loss Ride-thru Time
b5-13	PI Feedback Loss Detection Level	L4-05	Frequency Reference Loss Detection Selection
b5-14	PI Feedback Loss Detection Time	L4-06	Frequency Reference Level at Loss Frequency
b5-15	PI Sleep Function Start Level	L5-01	Number of Auto Restarts Attempts
b5-16	PI Sleep Delay Time	L5-03	Maximum Restart Time After Fault
b5-17	PI Accel/Decel Time	L6-01	Torque Detection Selection 1
b5-18	PI Setpoint Selection	L6-02	Torque Detection Level 1
b5-19	PI Setpoint Value	L6-03	Torque Detection Time 1
b5-20	PI Setpoint Display Setting	L8-11	Heatsink Cooling Fan Operation Delay Time
b5-21	PI Sleep Input Source	o1-01	User Monitor Selection
b5-22	PI Snooze Level	o1-05	LCD Brightness Adjustment
b5-23	PI Snooze Delay Time	o1-07	Second Line User Monitor Selection
b5-24	PI Snooze Deactivation Level	o1-08	Third Line User Monitor Selection
b5-25	PI Setpoint Boost Setting	o2-03	User Parameter Default Value
b5-26	PI Maximum Boost Time	o2-05	Frequency Operation Time Selection
b5-27	PI Snooze Feedback Level	o2-08	Cumulative Operation Time Selection
b5-28	PI Feedback Square Root Ac Function Selection	o3-02	Read Allowed Selection

Programming Menu (-ADV-)

This menu is used to set/read every parameter in the Drive. Follow the key operations below (Fig. 3.7) to access the Programming Menu.

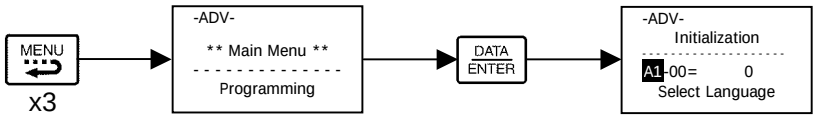


Fig 3.7 Programming Menu Access Procedure

Use [∧], [∨], and [RESET] keys to scroll through the "Programming" parameter group list. For complete parameter listing see appendix A.

Table 3.12 Programming Parameter Group List

Parameter Group Functions	
A1	Initialization
A2	User Parameters
b1	Sequence
b2	DC Braking
b3	Speed Search
b4	Delay Timers
b5	PI Control
b8	Energy Saving
C1	Accel/Decel
C2	S-Curve Acc/Dec
C4	Torque Comp
C6	Carrier Freq
d1	Preset Reference
d2	Reference Limits
d3	Jump Frequencies
d4	Sequence
E1	V/F Pattern
E2	Motor Setup
F6	Com OPT Setup
H1	Digital Inputs
H2	Digital Outputs
H3	Analog Inputs
H4	Analog Outputs
H5	Serial Com Setup
L1	Motor Overload
L2	PwrLoss Ridethru
L3	Stall Prevention
L4	Ref Detection
L5	Fault Restart
L6	Torque Detection
L8	Hdwe Protection
n1	Hunting Prev
n3	High Slip
o1	Monitor Select
o2	Key Selections
o3	COPY Function

◆ Modified Constants Menu (-VERIFY-)

This menu is used to set/read the parameters that have been modified from their original factory default settings. Follow the key operations below (Fig. 3.8) to access the Modified Constants Parameter Menu.

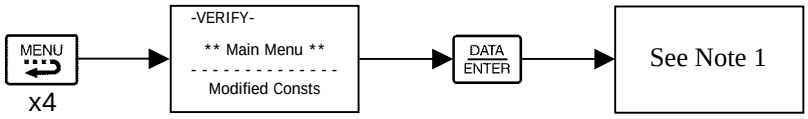


Fig 3.8 Modified Constants Menu Access Procedure

Note 1: If there are not any parameters that have been modified from their original factory default settings, then the display will state “None Modified”. Otherwise, use the “increase” and “decrease” keys to scroll through the “Modified Constants” list.

◆ Auto-Tuning Menu (-A.TUNE-)

This menu is used to auto-tune the Drive in order to optimize motor control as well as utilize the bi-directional speed search feature. Follow the key operations below (Fig. 3.9) to access the Auto-Tuning Menu.

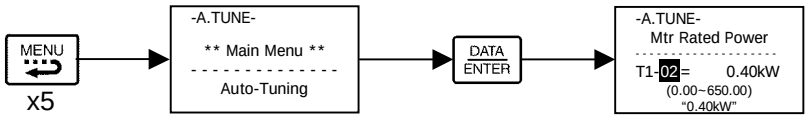


Fig 3.9 Auto-Tuning Menu Access Procedure

Use ∧ and ∨ keys to scroll through the “Auto-Tuning” parameter list.

Table 3.13 Auto-Tuning Parameter List

Auto-Tuning Parameters	
T1-02	Mtr Rated Power
T1-04	Rated Current

Example of Changing a Parameter

Table 3.14 provides an example of how to change parameter “C1-02” (Deceleration Time 1) from 30 seconds to 40 seconds.

Table 3.14 Changing a Parameter in the Programming Menu

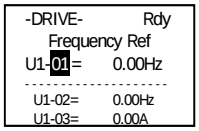
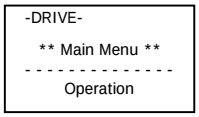
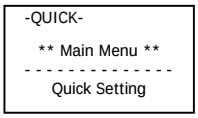
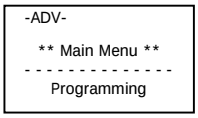
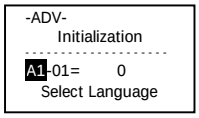
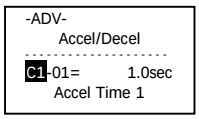
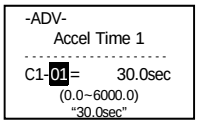
Step Number	Digital Operator Display	Description
1		The Drive is first powered up.
2		Press the MENU key to scroll to “Operation” menu.
3		Press the MENU key to scroll to “Quick Setting” menu.
4		Press the MENU key to scroll to “Programming” menu.
5		Press the DATA/ENTER key to enter “Programming” menu.
6		Press the INCREASE key until C1-01 (Accel/Decel) is displayed.
7		Press the SHIFT/RESET key to move flashing digit to the right.

Table 3.14 Changing a Parameter in the Programming Menu

Step Number	Digital Operator Display	Description
8	-ADV- Decel Time 1 C1-02= 30.0sec (0.0~6000.0) "30.0sec"	Press the INCREASE key to display C1-02 (Decel Time 1).
9	-ADV- Decel Time 1 C1-02= 0030.0sec (0.0~6000.0) "30.0sec"	Press the DATA/ENTER key to access setting display.
10	-ADV- Decel Time 1 C1-02= 0030.0sec (0.0~6000.0) "30.0sec"	Press the SHIFT/RESET key to move the flashing digit to the right.
11	-ADV- Decel Time 1 C1-02= 0030.0sec (0.0~6000.0) "30.0sec"	Press the SHIFT/RESET key to move the flashing digit to the right.
12	-ADV- Decel Time 1 C1-02= 0040.0sec (0.0~6000.0) "30.0sec"	Press the INCREASE key to increase the set data.
13	-ADV- Entry Accepted	Press the DATA/ENTER key to enter the set data. "Entry Accepted" is displayed for 1.0 sec after the data setting has been confirmed.
14	-ADV- Decel Time 1 C1-02= 40.0sec (0.0~6000.0) "30.0sec"	The monitor display for C1-02 returns.
15	-DRIVE- ** Main Menu ** Operation	Press the MENU key to scroll to "Operation" menu.
16	-DRIVE- Rdy Frequency Ref U1-01= 0.00Hz U1-02= 0.00Hz U1-03= 0.00A	Press the DATA/ENTER key to enter "Operation" menu.

Chapter 4
Start Up

This chapter describes the procedures to prepare the Drive for start up and the procedures to conduct a Drive start up.

Drive Start Up Preparation 4-2
Drive Start Up Procedures 4-5

Start Up

In order to provide the most reliable Drive available and to avoid any extra costs related to loss or reduction of warranty coverage, an authorized Yaskawa service representative should complete this start up procedure. Please complete the following checklist and maintain it in a secure location as technical service personnel may request information from this checklist.

◆ DRIVE START UP PREPARATION

Date: _____

Start Up Person:

Company Name: _____ Start Up Location: _____
Sales Order #: _____ Serial #: _____

Printed Name: _____ Drive Location: _____

Phone #: _____ Signature: _____

Owners Representative:

Printed Name: _____ Phone #: _____

Company: _____ Signature: _____

Step

☐ 1. The Drive is thoroughly tested at the factory. The start up person should verify that the drive is free of shipping and installation damage. Shipping damage is not covered by the Yaskawa warranty. Claims must be filed with the shipping company as soon as possible for any potential recovery via insurance.

☐ 2. Review the User Manual shipped with the Drive.

☐ 3. Verify that the model number and voltage ratings in the purchase order match the nameplate data for each unit.

☐ 4. Location of the Drive is important to achieve proper performance and normal operating life. The unit should be installed in an area where it is protected from:
- ▪Direct sunlight, rain or moisture
- ▪Corrosive gases or liquids
- ▪Vibration, airborne dust or metallic particles

☐ 5. Ensure the Drive is on a vertical surface with adequate space for air circulation (4.75” above and below, 1.2” on each side). Refer to Fig 1.8.

☐ 6. Verify that the proper branch circuit protection is installed in front of the Drive. Refer to Appendix E - Peripheral Devices for proper input fuse or circuit breaker sizing.

☐ 7. Avoid running input and output wiring in the same conduit.

☐ 8. Avoid routing power wiring near equipment sensitive to electrical noise.

☐ 9. Never allow wire leads to touch metal surfaces. Short-circuit may result.

☐ 10. Never connect AC main power to output terminals U/T1, V/T2 and W/T3.

☐ 11. Never connect power factor correction capacitors or noise filters to the Drive output.

☐ 12. Use 600Vac vinyl-sheathed wire or equivalent. Wire size should be determined considering voltage drop of leads.

Line voltage drop (V) = $\sqrt{3}$ x wire resistance (Ω/km) x wire length (m) x current (A) x 10^{-3}

☐ 13. It is recommended that the motor lead length not exceed 164 feet (50 meters) and motor wiring be run in a separate conduit from the power wiring. If lead length must exceed this distance, reduce the carrier frequency (See Table 2.6) and consult Yaskawa toll free at 1-800-YASKAWA (927-5292) for other motor protection measures.

☐ 14. Signal and control leads must be separated from main circuit leads (R/L1, S/L2, T/L3, U/T1, V/T2, W/T3).

☐ 15. Determine proper wire size for power and motor leads. Refer to Tables 2.1 and 2.2 for details.

☐ 16. Review proper ground connections for the Drive. Refer to Chapter 2 – Electrical Installation for details. The Drive must be solidly grounded using the main circuit ground terminal. Ground resistance should be less than 100Ω for a 208-240Vac Drive. Ground resistance should be less than 10Ω for a 480Vac Drive. Select wire size suitable for the size of terminal screw. Make the length as short as possible.

Never ground the drive in common with welding machines, motors or other large-current electrical equipment.

Where several Drives are used, ground each Drive directly or daisy-chain to the ground pole(s).
DO NOT FORM A LOOP WITH THE GROUND LEADS. See Figure 2.4.

☐ 17. Review terminal functions of signal and control circuits. Refer to Table 2.8.

☐ 18. Verify if any customer safety devices are required (e.g. firestat, freezestat, high static pressure).

☐ 19. Record the following motor nameplate information:

Voltage: _____Full Load Amps: _____

☐ 20. Verify that the commercial power supply is within the rated Drive input voltage:

Power Supply: _____VAC Drive Input Voltage: _____VAC

☐ 21. Verify that the leads in the 3-Phase electric motor conduit box are configured for the proper voltage.

☐ 22. Ensure Motor Rated Current is less than or equal to Drive Output Amps. If multiple motors are being used, make sure that the Motor Rated Current sum is less than or equal to Drive Output Amp rating. Please note that if multiple motors are being operated from one Drive, each motor must have its own overload and short circuit protection.

☐ 23. Wire all necessary power leads to the Drive. ***DO NOT CONNECT MOTOR TO DRIVE YET.***

☐ 24. Wire all necessary ground wires to the Drive.

☐ 25. Wire all necessary control wires to the Drive.

☐ 26. Ensure that the power leads are connected to the R/L1, S/L2 and T/L3 terminals in the Drive.

☐ 27. Tighten all of the three-phase power and ground connections. Please check that all control and signal terminations are tight.

☐ 28. Inspect the control circuit connections (including the shield) and determine if a motor "safety circuit" is connected.

If normally closed, these contacts may be wired in series with the **RUN** command contacts, which are between terminals **S1** and **SN** of the Drive. No special programming is required. Refer to Chapter 2 – Electrical Installation (Fig. 2.7).

Alternately, these contacts could be wired between terminals **S3** and **SN** as **External Fault Inputs**, and may be either normally closed or normally open contacts.

☐ 29. Record any other connections to the Drive using the blank terminal connection drawing in Chapter 2 – Electrical Installation (Fig. 2.9) to determine if special programming is required for the following:

•Multi-function Inputs – refer to Appendix A – Parameter List
•Multi-function Outputs – refer to Appendix A – Parameter List
•Multi-function Digital Inputs – refer to Appendix A – Parameter List
•Multi-function Analog Outputs – refer to Appendix A – Parameter List
•Serial Communications – refer to Appendix A – Parameter List

THIS COMPLETES THE DRIVE START UP PREPARATION.

DRIVE START UP PROCEDURES

☐ 1. Confirm that all three phases are present and that the input voltage is correct for the Drive being set up. Measure the voltage on the line side of the Drives Molded Case Circuit Breaker/disconnect and record below.

Table 4.1 Input Voltage Check	
Measurement Location	Voltage (Vac)
L1 – L2	
L2 – L3	
L1 – L3	

WARNING Use extreme caution when performing measurements as contact with live parts may result in personal injury or death.

☐ 2. If voltage level is within Drive Specification (See Appendix C - Specification), **APPLY POWER** to energize the Drive. The **STOP**, **AUTO SEQ** and **AUTO REF** indicators should be on.

☐ 3. **REMOVE POWER** from the Drive. Wait for the Red CHARGE LED (near the power terminals) to go out.

☐ 4. Connect the motor leads to the Drive at terminals U/T1, V/T2 and W/T3.

WARNING The internal capacitor remains charged even after the power supply is turned off. The status indicator LED's and the digital operator display will be extinguished when the DC bus voltage is below 50VDC. To prevent electric shock, wait at least 5 minutes after all indicators are off and measure the DC Bus voltage level to confirm a safe level prior to working on the Drive.

☐ 5. APPLY POWER to the Drive.

☐ 6. Set the Drive to Local control. Press the **MENU** key once to display the **Operation** menu. Then, press **DATA/ ENTER** to display "Frequency Reference". Press the **LOCAL/REMOTE** key once. This puts the Drive in the Local Mode, allowing run/stop and speed commands by the Digital Operator. The **AUTO SEQ** and **AUTO REF** indicators turn off, and the **FWD** light turns on.

☐ 7. Press the **OFF** key.

☐ 8. Press the **MENU** key two times. Press the **DATA/ENTER** key once to enter the Quick Setting Menu. Press the ▼ key 25 times to display parameter E1-01 "Input Voltage". This parameter selects the nominal input voltage the Drive will receive. To set this parameter for the application. Press the **DATA/ENTER** key once. Use the ▲, ▼, and ▶ keys and the **DATA/ENTER** key to set this parameter per the application.

Table 4.2 Input Voltage Setting				
Parameter No.	Parameter Name Digital Operator Display	Setting Range	Factory Setting	Menu Location
E1-01	Input Voltage Setting **Input Voltage**	155.0 to 255.0 (208-240Vac)	240.0 (208-240Vac)	Quick Setting or Programming
		310.0 to 510.0 (480Vac)	480.0 (480Vac)	

Ensure the **DATA/ENTER** key is pressed to enter the selection in the Drive. "Entry Accepted" briefly appears and the display is now no longer flashing.

☐ 9. Press the ▲ key once to display E2-01 “Motor Rated FLA”.

This parameter is the foundation of motor protection. It can be entered when auto-tuning is performed. Set this parameter according to the motor rated current (FLA). Press the **DATA/ENTER** key once. Use the ▲, ▼ , and ▶ keys to adjust E2-01 to the motor rated full load amps.

Table 4.3 Motor Rated Current

Parameter No.	Parameter Name Digital Operator Display	Setting Range	Factory Setting	Menu Location
E2-01	Motor Rated Current **Motor Rated FLA**	kVA Dependent	kVA Dependent	Quick Setting or Programming

Ensure the **DATA/ENTER** key is pressed to enter the value in the Drive. “Entry Accepted” briefly appears and your display is now flashing.

☐ 10. Press the ESC once. Press DATA/ENTER once. Press ▲ key twice to display b1-02 “Run Source”. This parameter selects where the Drive will receive the run command. Press the **DATA/ENTER** key once. Use the ▲ or ▼ keys and the **DATA/ENTER** key to set this parameter for the application.

Table 4.4 Run Command Selection

Parameter No.	Parameter Name Digital Operator Display	Setting Choices	Setting Range	Factory Setting	Menu Location
b1-02	Run Command Selection **Run Source**	0: Operator 1: Terminals 2: Serial Com 3: Option PCB	0 - 3	1	Quick Setting or Programming

Ensure the **DATA/ENTER** key is pressed to enter the selection in the Drive. “Entry Accepted” briefly appears and the display is now not flashing.

☐ 11. Press the ▼ key once to display b1-01 “Reference Source”. This parameter selects where the Drive will receive the speed command. Press the **DATA/ENTER** key once. Use the ▲ or ▼ keys and the **DATA/ENTER** key to set this parameter for the application.

Table 4.5 Speed Command Selection

Parameter No.	Parameter Name Digital Operator Display	Setting Choices	Setting Range	Factory Setting	Menu Location
b1-01	Frequency Reference Selection **Reference Source**	0: Operator 1: Terminals 2: Serial Com 3: Option PCB	0 - 3	1	Quick Setting or Programming

Ensure the **DATA/ENTER** key is pressed to enter the selection in the Drive. “Entry Accepted” briefly appears and the display is now not flashing.

☐ 12. Press the ▲ key twice to display b1-03 “Stopping Method”.

This parameter selects the stopping method used when a stop command is given to the Drive.

Table 4.6 Stopping Method Selection					
Parameter No.	Parameter Name Digital Operator Display	Setting Choices	Setting Range	Factory Setting	Menu Location
b1-03	Stopping Method Selection **Stopping Method**	0: Ramp to Stop 1: Coast to Stop 2: DCInj to Stop 3: Coast w/Timer	0 - 3	0	Quick Setting or Programming

Press the **DATA/ENTER** key once. Use the ▲ or ▼ keys to select the stopping method. Ensure the **DATA/ENTER** key is pressed to enter the selection in the Drive. "Entry Accepted" briefly appears and the display is not flashing.

☐ 13. Press the **MENU** key once to display "Operation".

☐ 14. Press the **DATA/ENTER** key once to display "Frequency Ref".

☐ 15. The **STOP** and **FWD** lights are on.

☐ 16. Press the **DATA/ENTER** key once to enable entering of a speed command in U1-01. Use the ▲ and ▼ keys to set a speed command of 6.00Hz.

☐ 17. Press the **RUN** key once to start the motor and verify correct motor rotation for the application. The **RUN** light turns on and the **STOP** light turns off.

If the direction of motor rotation is wrong, press the **STOP** key. The **RUN** light turns off and the **STOP** light turns on. **REMOVE POWER** from the Drive. Wait for the Red CHARGE LED (near the power terminals) to go out. When it does, swap the motor wires connected to terminals **U/T1** & **V/T2** in the Drive. Be sure to re-tighten the terminal lugs. **APPLY POWER**.

To verify the motor rotation is now correct for the application, press the **RUN** key once to start the motor. The **FWD** light turns on and the motor will rotate at the speed entered in step 16.

☐ 18. Press the **MONITOR** key to display the U1 monitors. Use the ▲ and ▼ keys to view Output Current (U1-03), Output Voltage (U1-06), and DC Bus Voltage (U1-07) while running the Drive throughout its entire speed range. Record the following information at each speed:

Frequency (Hz) Monitor U1-01	Output Current (A) Monitor U1-03	Output Voltage (VAC) Monitor U1-06	DC Bus Voltage (VDC) Monitor U1-07
6.0			
10.0			
15.0			
20.0			
25.0			
30.0			
35.0			
40.0			
45.0			
50.0			
55.0			
60.0			

When this table is complete, press the **STOP** key. The Drive will stop and the **FWD** light remains on. This step provides benchmark data for the application from the initial start up.

☐ 19. Press the **MENU** key once to display "Operation". Press the **DATA/ENTER** key to display "Frequency Ref". If using a remote speed command, press the **LOCAL/REMOTE** key so the **REMOTE SEQ** and **REMOTE REF** indicators are on. This puts the Drive in Remote mode.

☐ 20. If using an external speed command, determine whether the speed command is a 0-10Vdc or a 4-20mA signal. Connect the positive side of a 0-10Vdc signal to terminal **A1**. Connect the positive side of a 4-20mA signal to terminal **A2**. Connect the COMMON of the speed command to terminal **AC**.

Note: Connect only one input. The factory default is 0-10Vdc. To change to 4-20mA adjust parameter H3-08 to "2:4 – 20mA" and ensure DIP Switch S1-2 (located on the terminal board) is in the ON position.

☐ 21. Check the signal for proper polarity. Observe if the speed command can achieve the minimum and maximum speeds desired. If not, perform the following:

For 0-10Vdc input (Terminal **A1**)

1. With no input, adjust Bias (**H3-03** setting) until an output of “0.0 Hz” is obtained.

2. With full-scale input, adjust Gain (**H3-02** setting) until an output of “60.0 Hz” (or other desired maximum frequency) is obtained.

For 4-20mA input (Terminal **A2**)

1. With 4mA input, adjust Bias (**H3-11** setting) until an output of “0.0 Hz” is obtained.

2. With 20 mA input, adjust Gain (**H3-10** setting) until an output of “60.0 Hz” (or other desired maximum frequency) is obtained.

THIS COMPLETES THE DRIVE START UP PROCEDURE.

Notes:

Chapter 5
Basic Programming

This Manual contains descriptions of all user accessible parameters contained in the Drive. Parameters are listed in alpha-numerical order. Parameter number and name, along with a detailed description and its settings are described on the following pages.

A1 Initialization 5-2
b1 Sequence 5-4
b2 DC Braking 5-9
b3 Speed Search 5-11
b5 PI Function 5-15
b8 Energy Savings 5-24
C1 Accel/Decel 5-25
d2 Reference (Speed Command) Limits 5-26
d3 Jump Frequencies 5-27
E1 V/f Pattern 5-28
E2 Motor Setup 5-31
F6 Com OPT Selection 5-32
H3 Analog Inputs 5-33
L2 Momentary Power Loss Ride-thru Function 5-39
L3 Stall Prevention 5-40
L4 Speed Command Loss Detection 5-43
L5 Fault Restart 5-44
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o1 Monitor Configuration 5-50
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Basic Programming Parameters

The initialization group contains parameters associated with initial set-up of the Drive. Parameters involving the display language, access levels, initialization and password are located in this group.

◆ A1 Initialization

■ A1-00 Select Language

Setting	Description
0	English (*factory default*)
1	Japanese
2	Deutsch
3	Francais
4	Italiano
5	Espanol
6	Portuguese

The setting of parameter A1-00 determines which international language the Drive will use to display non-numerical text. The A1-00 parameter will not be changed by an Initialization of the drive (A1-03= “1110: User Initialize”, “2220: 2-Wire Initial”, or “3330: 3-Wire Initial”).

If the Drive is accidentally set to a language unfamiliar to the operator, locating the parameter to change the operator language can be done by performing the following:

1. Press the MENU key until the “-ADV-” MENU is shown in the upper left corner of the digital operator.
2. Press the DATA/ENTER key to enter the programming menu. The first parameter shown is A1-00 (Select Language).
3. Press the DATA/ENTER key again and use the INCREASE and DECREASE arrow keys to choose the preferred language from the list below:

0 : English
1 : Japanese
2 : Deutsch (German)
3 : Francais (French)
4 : Italiano (Italian)
5 : Español (Spanish)
6 : Portugu s (Portuguese)

■ A1-01 Access Level Selection

Setting	Description
0	Operation Only
1	User Level
2	Advanced Level (*factory default*)

A1-01 can be used to allow access to and permission to change all Drive parameters. If the Drive is programmed for Operation Only (A1-01= “0: Operation Only”), then only the OPERATION and the PROGRAMMING menus are accessible. Within the PROGRAMMING menu only parameters A1-01 and A1-04 are adjustable.

If A1-01 is configured for Advanced Access (A1-01= “2: Advanced Level”), then all menus and all parameters are shown. If the Access Level Selection is set to Advanced, all parameters should be adjustable unless:

1. The Drive parameters are password protected (A1-04) which will prevent access to A1-00 through A1-03 and all A2 parameters.

2. A digital input has been configured as a Program Lockout (H1-0X= 1B) is active.

3. During serial communication writing, if a parameter change is also attempted via the digital operator, a “BUSY - WRITE PROTECTED” message will display. Parameter change will not be possible from the digital operator until an Enter command is received via the serial communication to finish the serial writing process.

■ A1-03 Initialize Parameters

Setting	Description
0	No Initialize (*factory default*)
1110	User Initialize
2220	2-Wire Initialize
3330	3-Wire Initialize

The Drive can be set back to one of three default states via the A1-03 parameter.

1. User Initialization – 1110: The modified Drive parameters are returned to the values selected as user settings. User settings are stored when parameter o2-03= “1: Set Defaults”.

2. 2-Wire Initialization – 2220: The Drive parameters are returned to factory default values with digital inputs S1 and S2 configured as Forward Run and Reverse Run, respectively.

3. 3-Wire Initialization – 3330: The Drive parameters are returned to factory default values with digital inputs S1, S2, and S5 configured as Run, Stop, and Forward/Reverse respectively.

After an initialization is performed, parameter A1-03 will automatically be set back to 0.

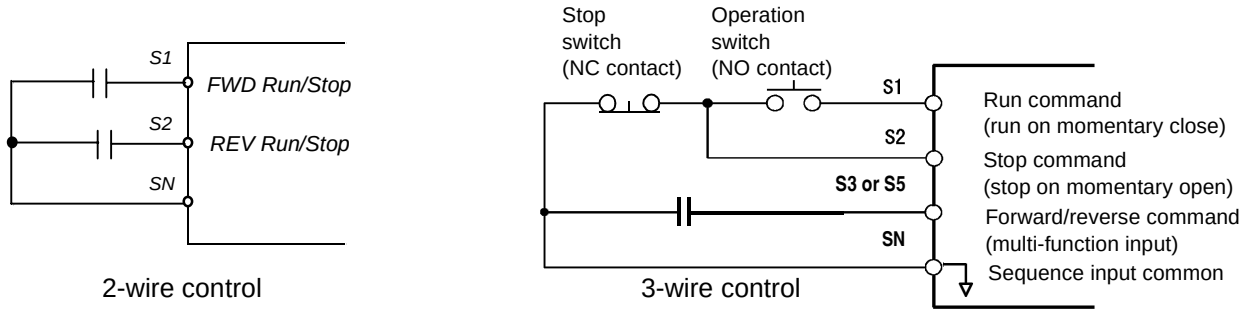


Fig. 1, 2 & 3-Wire Control Wiring Examples

IMPORTANT Some parameters are unaffected by either the 2-Wire or 3-Wire initialization. The following parameters will not be reset when parameter A1-03=2220 or 3330:

A1-00	Language Selection
E1-03	V/f Pattern Selection
o2-04	kVA Selection

◆ b1 Sequence

The Sequence Group contains parameters associated with starting and stopping the Drive. Parameters involving the Run Command, Speed Reference location, Stopping Method and Hand/Auto changeover are located in this group.

■ b1-01 Reference (Speed Command) Source Selection

Setting	Description
0	Operator - Digital Preset Speed d1-01
1	Terminals - Analog Input Terminal A1 (or Terminal A2, see Parameter H3-13)
2	Serial Com - RS-485 Terminals R+, R-, S+ and S-
3	Option PCB - Option Board connected at 2CN

In order to run the Drive and motor, the Drive must receive a Run command and a speed command. Parameter b1-01 specifies from where the speed command is received when in the "Auto mode. Switching into the "Auto" mode can be done by pressing the AUTO button on the digital operator while the Drive is stopped.

IMPORTANT If a Run command is input to the Drive but no corresponding speed command is input, the Run indicator on the digital operator will turn on and the STOP indicator on the digital operator will blink.

If you want the Drive to follow the speed command set by the digital operator: Use the "Hand" mode by pressing the hand key or set b1-01= "0: Operator". The speed command can then be entered into the U1-01 monitor parameter in the "-DRIVE-" Menu.

If you want the Drive to follow an "Auto" analog speed command: Set b1-01= "1: Terminals", and connect a 0 – 10 Vdc speed command signal between terminals A1 and AC or a 4 – 20 mA speed command signal to terminals A2 and AC.

If you want the Drive to receive the speed command from serial communication: Set b1-01= "2: Serial Com", and connect the RS-485/422 serial communications cable to terminals R+, R-, S+, and S- on the control I/O terminal block.

If you want to use LONWORKS® **to input a speed command:** Set b1-01= "3: Option PCB", and plug a LONWORKS® option board (p/n SI-J) into the 2CN port on the Drive Control PCB. Consult the manual supplied with the option board for instructions on integrating the Drive into the LONWORKS® System.

IMPORTANT If b1-01= "3: Option PCB" but a LONWORKS® card is not installed in 2CN, an OPE05 Operator Programming Error will be displayed on the digital operator and the Drive will not run.

■ b1-02 Run Source

Setting	Description
0	Operator
1	Terminals (*factory default*)
2	Serial Com
3	Option PCB

To successfully operate the Drive remotely, an external run command must be received by the Drive. Parameter b1-02 specifies from where the run command will be accepted.

Although the Run Source and the Reference Source (b1-01) are normally taken from the same source (e.g. digital operator, terminals or serial communication), this is not always the case.

To issue a run command from the digital operator: Set b1-02= "0: Operator", and use the HAND and OFF buttons to start and stop the Drive.

To issue the run command from the terminals: Set b1-02= "1: Terminals", and select between 2-wire and 3-wire control operation by doing the following:

2-Wire Control The factory default setting is for 2-wire operation. In the 2-wire configuration a closure between S1 and SN will be interpreted as a Forward Run command by the Drive. A closure between S2 and SN will be interpreted as a Reverse Run command. If both S1 and S2 are closed, the Drive will stop (decelerate to zero speed) and the digital operator will display an EF (external fault) alarm (Flashing).

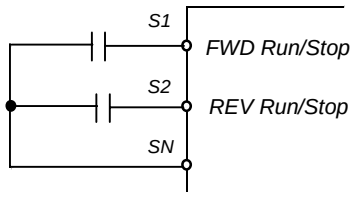


Fig. 2 2-Wire Control

3-Wire Control When any of the multi-function digital input parameters, H1-01 through H1-05, is set to 0, terminals S1 and S2 become Run and Stop, respectively. The multi-function digital input that was set to 0 will function as a Forward/Reverse input for the Drive. When the Forward/Reverse input is open the Drive will run in the Forward direction and when the input is closed, the Drive will run in the Reverse direction.

In 3-wire operation a momentary closure (> 50mS) of S1 will cause the Drive to run provided that S2 is held closed. The Drive will stop anytime the S2-SN connection is broken. If the 3-wire configuration is implemented via a 3-wire Initialization (A1-03= "3330: 3-Wire Initial"), then terminal S3 becomes the Forward/Reverse input.

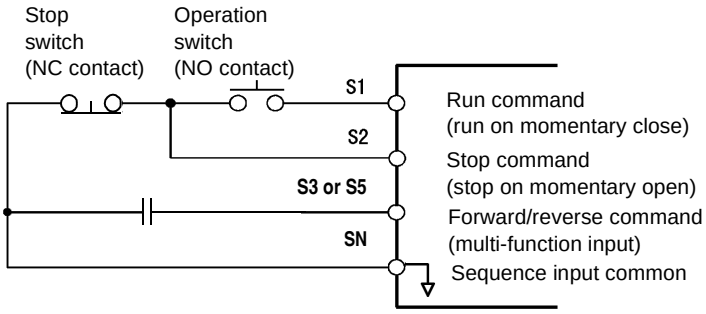


Fig. 3 3-Wire Control

To issue a run command via serial communication: Set b1-02= "2: Serial Com" and connect the RS-485/422 serial communication cable to R+, R-, S+, and S- on the removable terminal block.

To issue the Run command via the LONWORKS® **option card:** Set b1-02= "3: Option PCB", and plug a LONWORKS® option board (p/n SI/J) into the 2CN port on the Control PCB. Consult the manual supplied with the option board for instructions on integrating the Drive into your LONWORKS® System.

IMPORTANT If b1-01= "3: Option PCB" but a LONWORKS® card is not installed in 2CN, an "OPE05" operator programming error will be displayed on the digital operator and the Drive will not run.

■ b1-03 Stopping Method

There are four methods of stopping the Drive when the Run command is removed.

Setting	Description
0	Ramp to Stop (*factory default*)
1	Coast to Stop
2	DC Injection to Stop
3	Coast w/Timer

"0:Ramp to stop": When the Run command is removed, the Drive will decelerate the motor to 0 rpm. The rate of deceleration is determined by the active deceleration time. The factory default Decel Time is in parameter C1-02. When the output frequency has dropped below the DC Injection Start Frequency in b2-01 (Default = 0.5HZ) DC current will be injected in the motor at a level determined by b2-02 (50% Default). The DC Injection condition will occur for the time specified by b2-04 (0.0 Default), to establish the end point of the ramp. DC injection can be used to insure the motor is at zero rpm prior to the Drive shutting off.

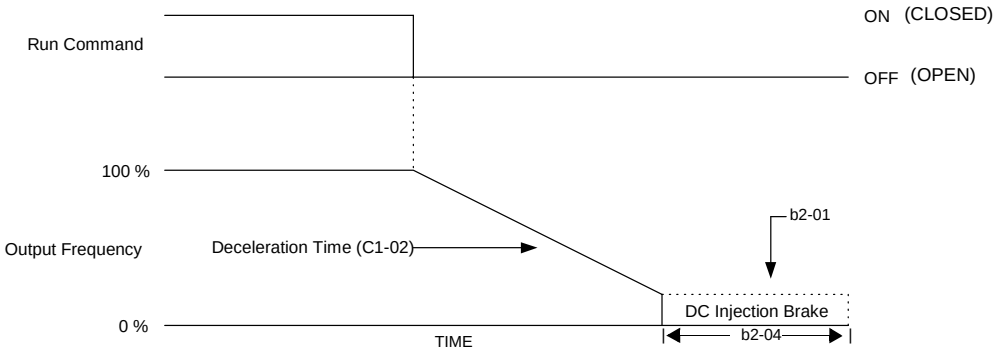


Fig. 4 Deceleration to Stop

The actual deceleration time can be determined by the following formula

$$\text{Time to Stop} = \frac{\text{Output Freq. at time of stop command}}{\text{Maximum Frequency (E1 - 04)}} \times \text{Setting of active Decel Time (C1 - 02 or C1-04)}$$

If S-Curve characteristics are specified by the Drive programming, they will add to the total time to stop.

"1:Coast to stop": When the Run command is removed, the Drive will turn off its output and the motor will coast (uncontrolled deceleration). The friction of the driven equipment will eventually overcome any residual inertia of the system and the rotation will stop.

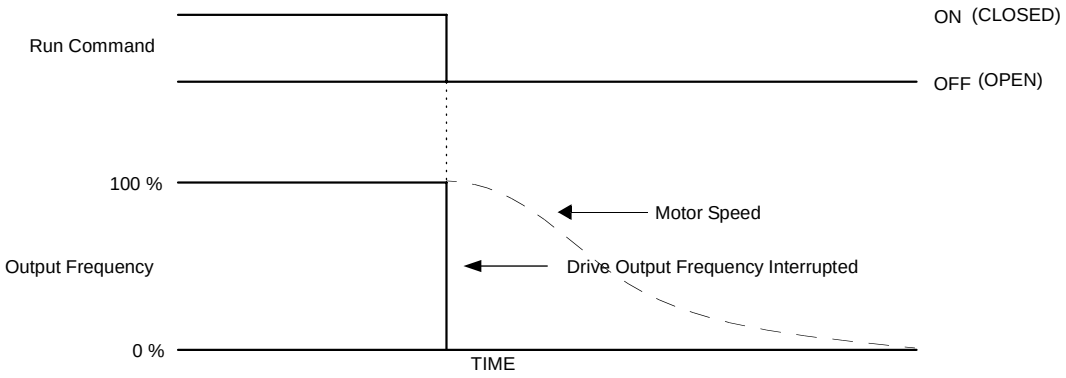


Fig. 5 Coast to Stop

IMPORTANT After a stop is initiated, a subsequent Run commands input before the Minimum Baseblock Time (L2-03) has expired, will be ignored.

2: DCInj to Stop: When the Run command is removed, the Drive will Baseblock (turn off its output) for the Minimum Baseblock Time (L2-03). Once the Minimum Baseblock Time has expired, the Drive will inject DC current into the motor windings to lock the motor shaft. The stopping time will be reduced as compared to Coast to Stop. The level of DC Injection current is set by parameter b2-02 (50% Default). The DC Injection brake time is determined by the set value in b2-04 and the output frequency at the time the Run command is removed.

$$\text{DC Injection Brake Time} = \frac{(\text{b2 - 04}) \times 10 \times \text{Output Frequency}}{\text{Maximum Frequency (E1 - 04)}}$$

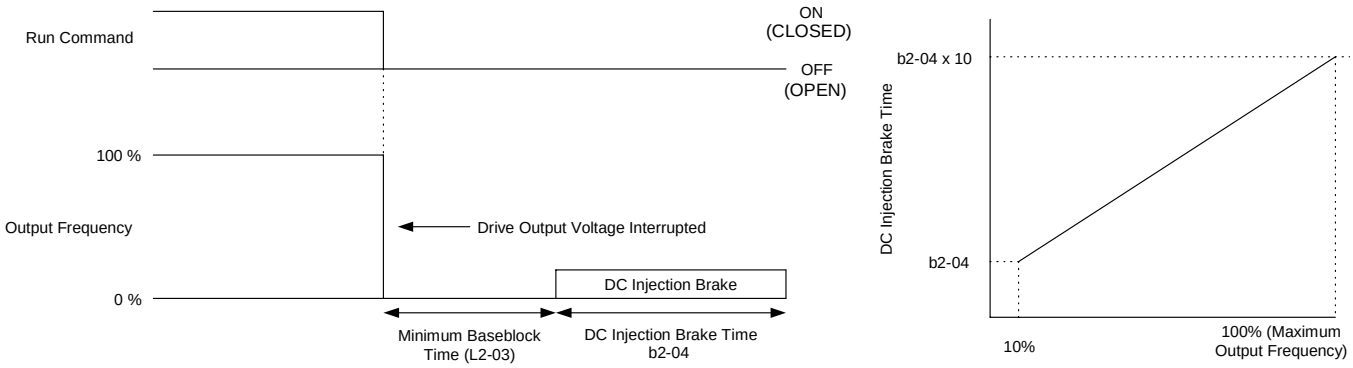


Fig. 6 DC Injection Braking to Stop

IMPORTANT If an overcurrent (OC) fault occurs during DCInj to Stop, lengthen the Minimum Baseblock Time (L2-03) until the fault no longer occurs.

3: Coast w/Timer: When the Run command is removed, the Drive will turn off its output and the motor will coast to a stop. If a Run command is input before time T (operation wait time) expires, the Drive will not run and the Run command will need to be cycled before operation can occur. The time T (operation wait time) is determined by the output frequency when the Run command is removed and the active deceleration time (C1-02).

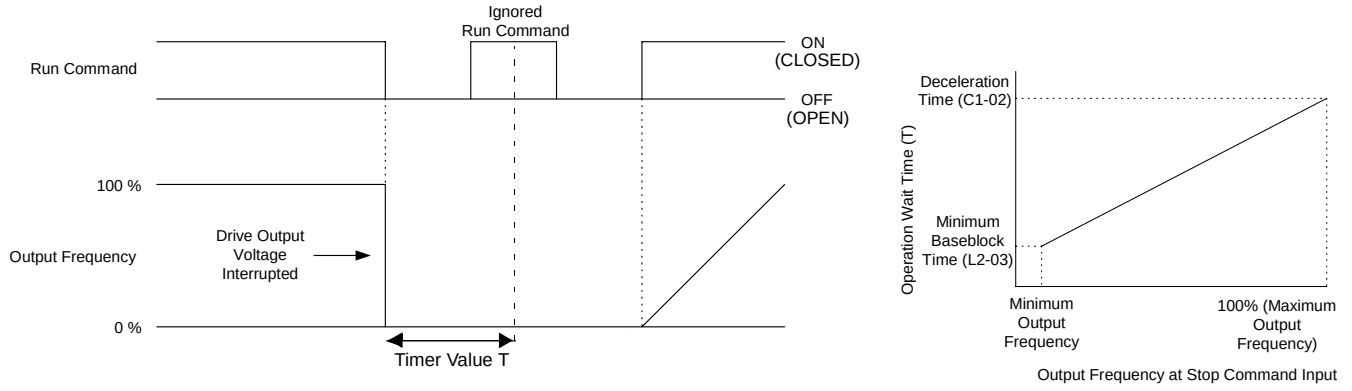


Fig. 7 Coast to Stop with Timer

■ b1-04 Reverse Operation

Setting	Description
0	Reverse Enabled
1	Reverse Disabled (*factory default*)
2	Exchange Phase
3	ExchgPhs, Rev Dsbl

For some applications reverse motor rotation is not applicable and may even cause problems (e.g., air handling units, pumps, etc.). Setting parameter b1-04 to 1 or 3 will cause the Drive to ignore any inputs for reverse operation. Setting parameter b1-04 to either 2 or 3 will change the motor shaft rotation when a Forward Run command is given by exchanging the order of the output phasing.

The factory default setting of parameter b1-04 is “1: Disabled”. When b1-04= “1: Disabled”, reverse operation is prohibited and no exchanging of output phasing occurs.

Drive terminal S2 is a dedicated input for reverse Run/Stop.

■ b1-07 Local/Remote Run Selection

Setting	Description
0	Cycle Extern Run (*factory default*)
1	Accept Extrn Run

When the Drive is switched between the Local (Hand) mode (the digital operator) to the Remote (Auto) mode (determined by b1-01 and b1-02), there is the possibility that a Run command is already present (i.e. a contact closure between S1 and SN when b1-02= “1: Terminals”). Parameter b1-07 determines whether the Drive will:

Ignore the external Run command until it is removed and re-instated (b1-07= “0: Cycle Extern Run”)

OR

Accept the already present Run command and immediately begin acceleration to the commanded speed (b1-07= “1: Accept Extrn Run”).

IMPORTANT

When switching from local mode to Auto mode when b1-07=“1: Accept Extrn Run” the Drive may start unexpectedly if the Run command is already applied. Be sure all personnel are clear of rotating machinery and electrical connections prior to switching between local mode and Auto mode.

■ b1-08 Run Command Selection During Programming

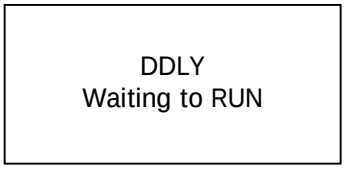
Setting	Description
0	Disabled (*factory default*)
1	Enabled

As a safety precaution, the Drive will not normally respond to a Run input when the digital operator is being used to adjust parameters. If it is necessary that external Run commands be recognized even while the Drive is being programmed, set b1-08= “1: Enabled”.

■ b1-11 Drive Delay Time Setting

Setting Range: 0 to 600 Seconds
Factory Default: 0 Seconds

If a time is set into parameter b1-11, the Drive will delay executing any run command until the b1-11 time has expired. During Drive delay time execution, the digital operator will display:



Both the ALARM and Run indicators will blink while the Drive waits to execute the Run command.

■ b1-12 Hand Frequency Reference Selection

Setting	Description
0	Operator (*factory default*)
1	Terminals

When the Drive is put into the HAND mode, by pressing the HAND key while in Operation, the Speed Command will be set via the digital operator by default. If it is desirable to have the Speed Command input from the terminals instead of the digital operator, set b1-12= “1: Terminals”.

IMPORTANT When the Speed Command is set via the terminals, parameter H3-13 will determine whether analog input terminal A1 or A2 is the Speed Command.

◆ b2 DC Braking

The DC Braking Group contains parameters associated with the DC injection braking feature. Parameters involving the starting frequency, current level, braking time, and motor pre heat current level are located here.

■ b2-01 DC Injection Braking Start Frequency

Setting Range: 0.0 to 10.0 Hz
Factory Default: 0.5 Hz

Parameter b2-01 sets the output frequency where the Drive begins DC Injection during Ramp to stop. in order to lock the rotor of the motor and established the end point of the ramp. If b2-01 < E1-09 (Minimum Frequency), then DC Injection begins at E1-09.

Parameter b2-01 also determines the output frequency that the Drive must be at or below before a Zero Speed condition is considered true. This affects any digital output configured as a Zero Speed signal (H2-0x= “1: Zero Speed”).

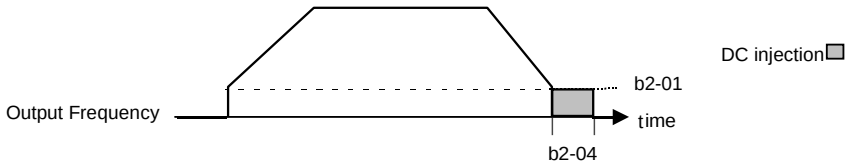


Fig. 8 DC Injection Braking During Stopping

■ b2-02 DC Injection Braking Current

Setting Range: 0 to 100%
Factory Default: 50%

The level of DC Injection Braking Current affects the strength of the magnetic field attempting to lock the motor shaft. Increasing the level of current will increase the amount of heat generated by the motor windings and should only be increased to the level necessary to hold the motor shaft. DC Injection current is set in percentage of Drive rated output current. Drive rated output current is stated on the Drive nameplate.

■ b2-03 DC Injection Braking Time at Start
b2-04 DC Injection Braking Time at Stop

Setting Range: 0.00 to 10.00 Seconds
Factory Default: 0.00 Seconds

The Drive can be programmed to automatically DC Inject for a predetermined amount of time prior to accelerating to speed (b2-03) and/or at the end of a Ramp to stop (b2-04). Parameter b2-03 can be used to stop a rotating motor prior to attempting acceleration (i.e. a wind milling fan). If DC Injection braking at start or Speed Search is not enabled, attempting to drive a spinning motor may cause nuisance tripping.

Parameter b2-04 can be used to resist any residual motion of the load after the deceleration has finished.

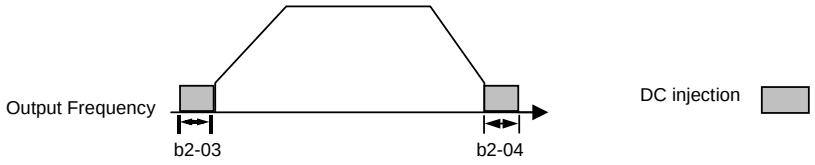


Fig. 9 DC Injection Braking During Starting and Stopping

Parameter b2-04 also serves the function of affecting the length of time DC Injection to stop (b1-03= “2: DC Injection to Stop”) will occur.

■ b2-09 Motor Pre-Heat Current

Setting Range: 0 to 100%
Factory Default: 0%

A DC current can be circulated within the motor windings while the motor is stopped. The current will produce heat within the motor and prevent condensation. Parameter b2-09 determines the percentage of Drive rated output current that will be used for the motor pre-heat function. This function can be useful in applications where the motor sits for extended periods of time in humid conditions. Motor pre-heating can only be initiated by closing a digital input programmed as a Motor Pre-heat Input（H1-0x= 60). Check with the motor manufacturer to determine the maximum acceptable current level the motor can withstand when stopped. Be sure not to exceed the motor manufacturers recommended level.

◆ b3 Speed Search

The Speed Search function allows the Drive to determine the speed of a motor shaft that is being driven by rotational inertia. Speed Search will allow the Drive to determine the speed of the already rotating motor and begin to ramp the motor to a set speed without first having to bring it to a complete stop. When a momentary loss of supply power is experienced, the Drive output is turned off. This results in a coasting motor. When power returns, the Drive can determine the speed of the coasting motor and start without requiring it to be brought to minimum speed. Speed Search can be programmed to always be active by setting b3-01 or it can be commanded by remote contact closure by setting a digital input.

There are two forms of Speed Search in the Drive, the speed estimation method and the current detection method.

IMPORTANT

When setting the Drive for remote Speed Search input, via a contact closure, the method of Speed Search is determined by the setting of b3-01. If b3-01= “0: SpdsrchF Disable” then the remote input will initiate speed estimation method, and if b3-01= “2: SpdsrchI Disable”, then the remote input will start the current detection method.

Parameters L2-03 and L2-04 also affect the current detection method of Speed Search operation.

■ b3-01 Speed Search Selection

This parameter is effective only when the Drive is given a new “RUN” command.

Setting	Description
0	SpdsrchF Disable
1	SpdsrchF Enable
2	SpdsrchI Disable (*factory default*)
3	SpdsrchI Enable

Speed Estimation: Method (b3-01= 0 or 1) The speed estimation method will calculate the speed using measurements of residual motor fields. The speed estimation version is bi-directional and will determine both the motor speed and direction. To enable speed estimation Speed Search at start, set b3-01= “1: SpdsrchF Enable”.

IMPORTANT

If the speed estimation method of Speed Search is to be used, then Auto-tuning must be performed prior to using Speed Search. If the length of cable between the Drive and motor is ever changed after Auto-tuning then Auto-tuning should be performed again.

IMPORTANT The speed estimation mode cannot be used when there are multiple motors operated by one Drive or the motor is two or more frames smaller than the standard size motor per the Drive capacity.

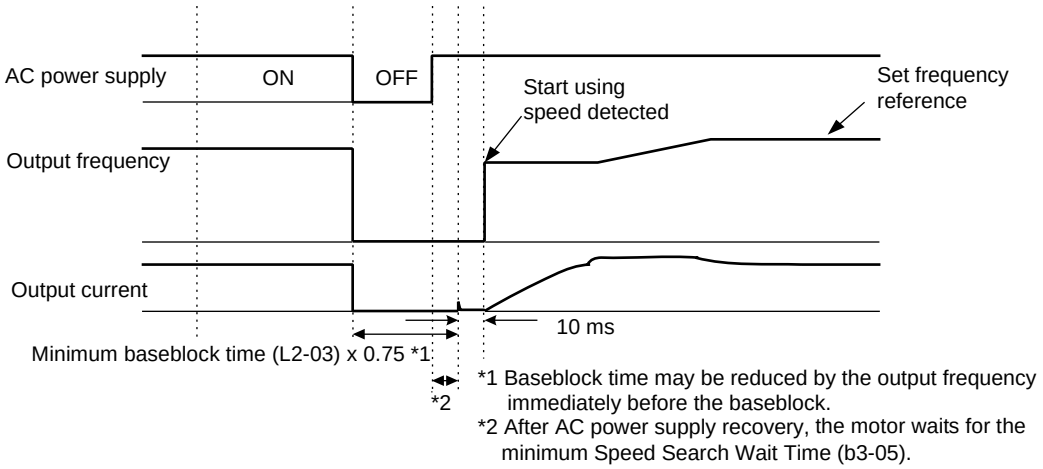
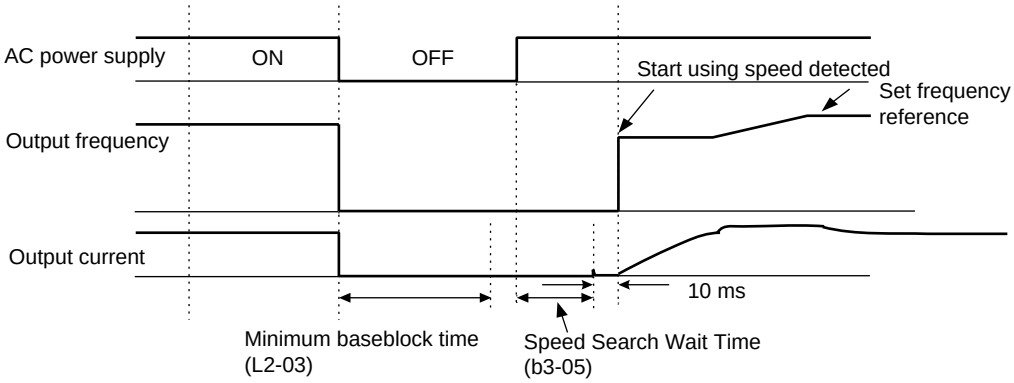


Fig. 10 Speed Search (Estimated Speed Method) after momentary power loss where the power loss time is less than the minimum baseblock time



Note: If the frequency immediately before the baseblock is low or the power supply off time is long, operation may be the same as the search in case 1.

Fig. 11 Speed Search (Estimated Speed Method) after momentary power loss where the power loss time exceeds the minimum baseblock time

Current Detection Method (b3-01=2 or 3): The current detection method starts searching from a predetermined frequency while monitoring the Drive output current to determine when the rotor speed and the Drive output speed (frequency) match. The current detection version is not bi-directional. To enable current detection Speed Search at start set b3-01= “3: SpdscrhI enable” and program any digital input equal to Speed Search 1 (H1-0x= 61) or Speed Search 2 (H1-0x= 62). Speed Search 1 will start searching from the max. frequency (E1-04) and ramp down to meet the rotor speed. Speed Search 2 will start searching from the set frequency and ramp down to meet the rotor speed.

IMPORTANT If a UV1 fault occurs when current detection Speed Search is attempted, increase the setting of L2-04

IMPORTANT If an OC fault occurs when Speed Search is attempted after power loss recovery, increase the setting of L2-03.

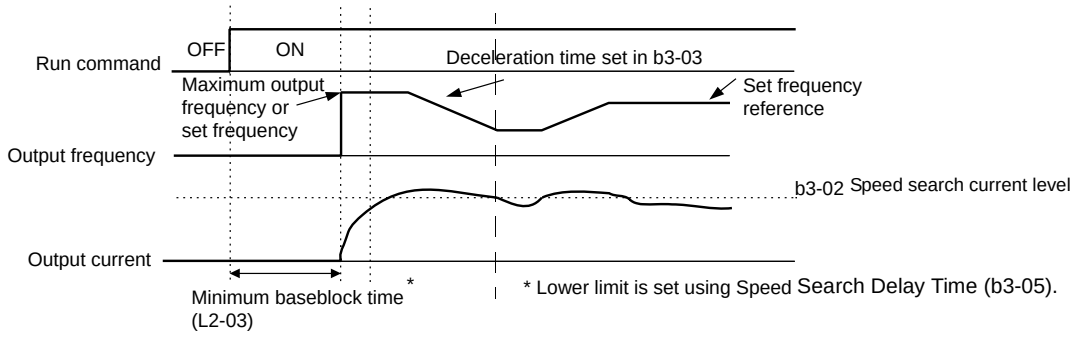


Fig. 12 Speed Search (Current Detection Method) at Startup

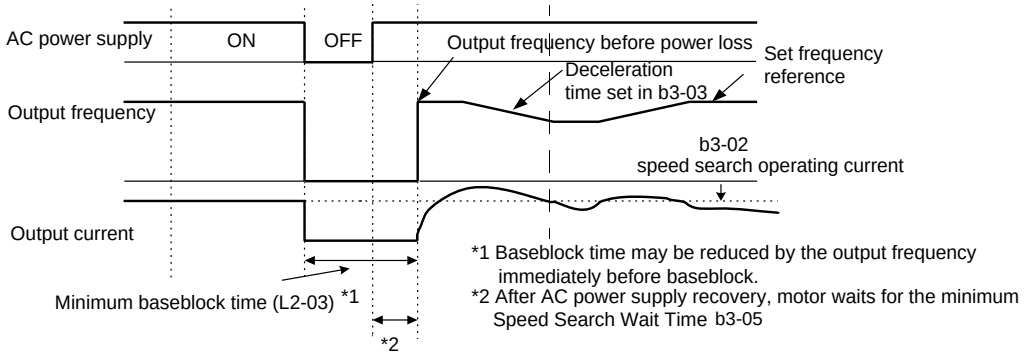


Fig. 13 Speed Search (Current Detection Method) after momentary power loss where the power loss time is less than the minimum baseblock time

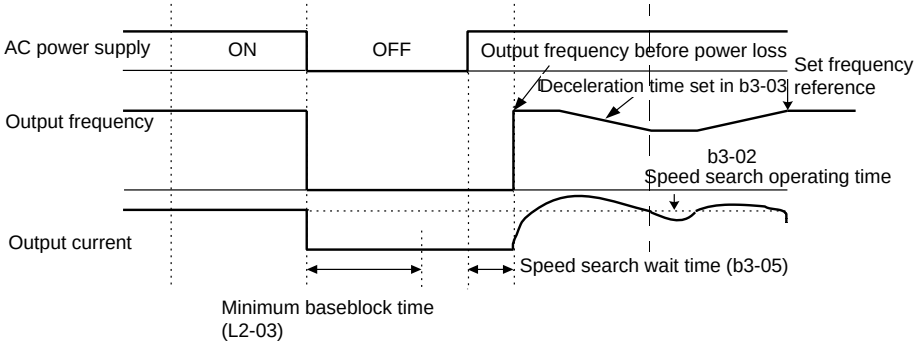


Fig. 14 Speed Search (Current Detection Method) after momentary power loss where the power loss time exceeds the minimum baseblock time

Speed Search Settings and Methods			
Setting of b3-01	Automatic Speed Search for all RUN commands	Automatic Speed Search after momentary power loss and baseblock	Speed Search Used for Run with programmed multi-function input
0	No	Yes - Speed Estimation	Yes - Speed Estimation
1	Yes - Speed Estimation	Yes - Speed Estimation	Yes - Speed Estimation
2	No	Yes - Current Detection	Yes - Current Detection
3	Yes - Current Detection	Yes - Current Detection	Yes - Current Detection

■ b3-02 Speed Search Deactivation Current

Setting Range: 0 to 200% of Drive rated output current
Factory Default: 120% of Drive rated output current

When using the current detection method of Speed Search, parameter b3-02 sets the current level that will determine when the search is complete and the rotor and output speeds match. When the output frequency is higher than the actual rotor speed the slip causes the current to be high. As the output frequency is lowered, the closer it comes to the rotor speed, the lower the current draw will be. When the output current drops below the level as set in b3-02 (100% = Drive Rated Current) the output frequency stops decreasing and normal operation resumes.

■ b3-03 Speed Search Deceleration Time

Setting Range: 0.1 to 10.0 Seconds
Factory Default: 2.0 Seconds

Parameter b3-03 sets the deceleration ramp used by the current detection method of Speed Search when searching for the motor's rotor speed. Even if Speed Search 2 is selected, for Speed Search at start, the time entered into b3-03 will be the time to decelerate from maximum frequency (E1-04) to minimum frequency (E1-09).

■ b3-05 Speed Search Delay Time

Setting Range: 0.0 to 20.0 Seconds
Factory Default: 0.2 Seconds

In cases where an output contactor is used between the Drive and the motor, extra waiting time is provided after power returns and before Speed Search is performed. This extra time allows for the contactor to operate. When Speed Search at start is used, b3-05 will serve as the lower limit of the Minimum Baseblock Time (L2-03).

■ b3-14 Bi-Directional Speed Search Selection

Setting	Description
0	Disabled
1	Enabled (*factory default*)

The b3-14 parameter can be used to turn off the bi-directional capabilities of the Speed Estimation form of Speed Search. By turning off the bi-directional capability, the speed search will only try to match the speed in the last known direction.

◆ b5 PI Function

The capability to accept an analog signal as feedback for a PI (Proportional + Integral) control function is built into the Drive.

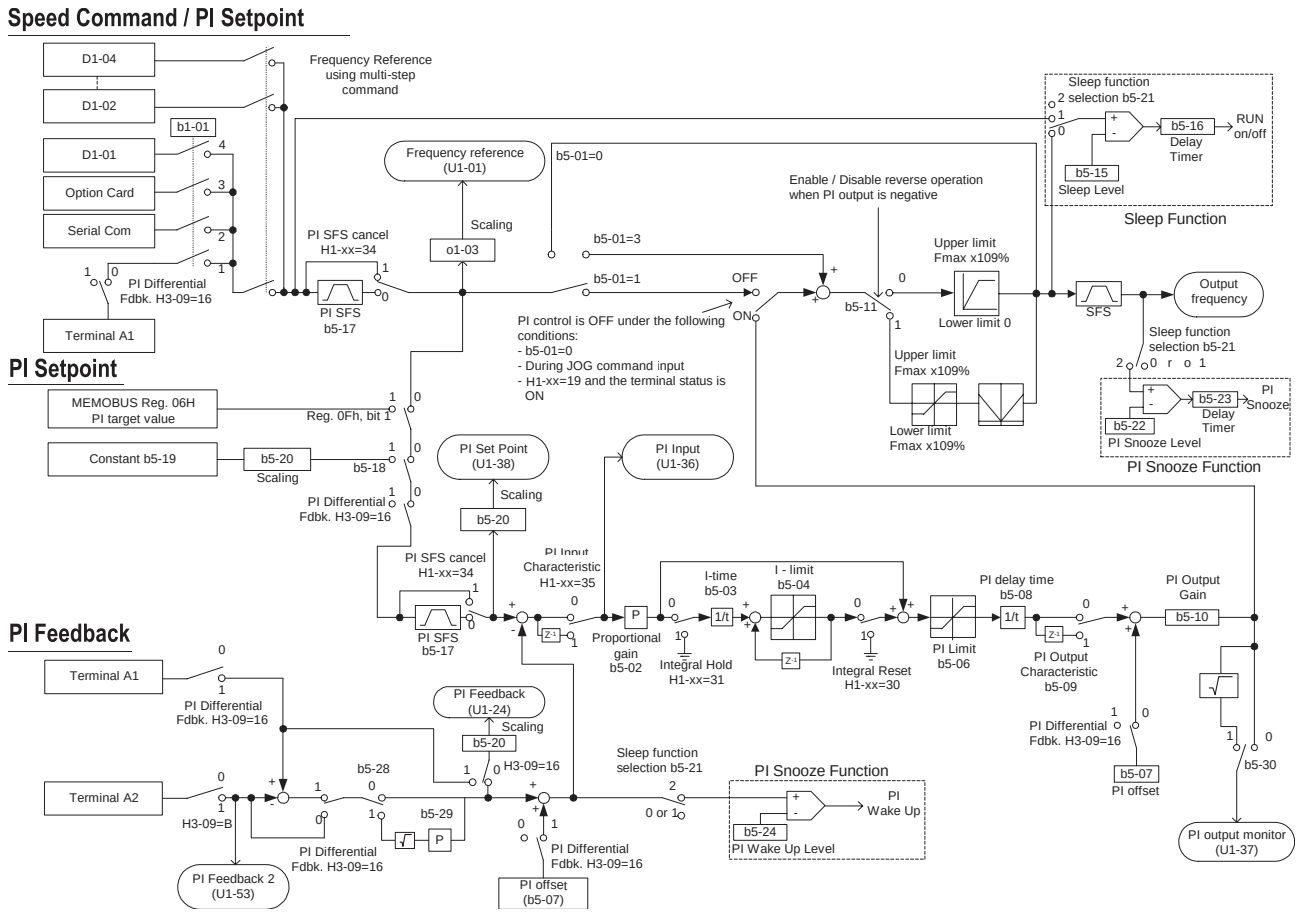


Fig. 15 PI Block Diagram

The analog feedback to the Drive for the PI control is via the A2 terminal. The Drive must be programmed (H3-09= “B: PI Feedback”) to use terminal A2 as feedback for the PI functionality of the Drive.

The PI setpoint can be configured to come from one of many different inputs or parameters. The table below describes the options for originating the PI setpoint.

Table 1 PI Setpoint Options

The PI Setpoint will be read from:	If these conditions are true		
	Status of b5-18	Status of Modbus Register 0Fh bit 1	Status of b1-01
Parameter b5-19	= 1	N/A	N/A
Modbus Register 06H	= 0	ON	N/A
D1-01	= 0	OFF	= 0
Terminal A1	= 0	OFF	= 1
Serial Comm.	= 0	OFF	= 2
Option PCB	= 0	OFF	= 3

In some situations there are two feedback inputs. The drive can be programmed to maintain a set differential between two analog signals. If input A2 is configured as a “PI Differential Mode” (H3-09= “16: PI Differential”), then the Drive will maintain a set difference between the measurements read on inputs A1 and A2. This differential setpoint is programmed by parameter (b5-07).

■ b5-01 PI Mode

Setting	Description
0	Disabled (*factory default*)
1	Enabled
3	Fref+PI

The Drive can be used as a stand-alone PI controller. If PI functionality is selected by parameter b5-01, the Drive will adjust its output to cause the feedback from a transmitter to match the PI setpoint (b5-19). The setting of b5-01 will determine whether PI functionality is disabled (b5-01= “0: Disabled”), enabled (b5-01= “1: Enabled”), or enable with the output of the PI function used to trim a Speed Command (b5-01= “3: Fref+PI”).

■ b5-02 Proportional Gain Setting

Setting Range: 0.00 to 25.00
Factory Default: 2.00

The proportional gain will apply a straight multiplier to the calculated difference (error) between the PI Setpoint and the measured transmitter feedback at terminal A2. A large value will tend to reduce the error but may cause instability (oscillations) if too high. A small value may allow to much offset between the setpoint and feedback (See Figure 16 below).

■ b5-03 Integral Time Setting

Setting Range: 0.0 to 360.0 Seconds
Factory Default: 5.0 Seconds

The Integral factor of PI functionality is a time-based gain that can be used to eliminate the error (difference between the setpoint and feedback at steady state). The smaller the Integral Time set into b5-03, the more aggressive the Integral factor will be. To turn off the Integral Time, set b5-03= 0.00.

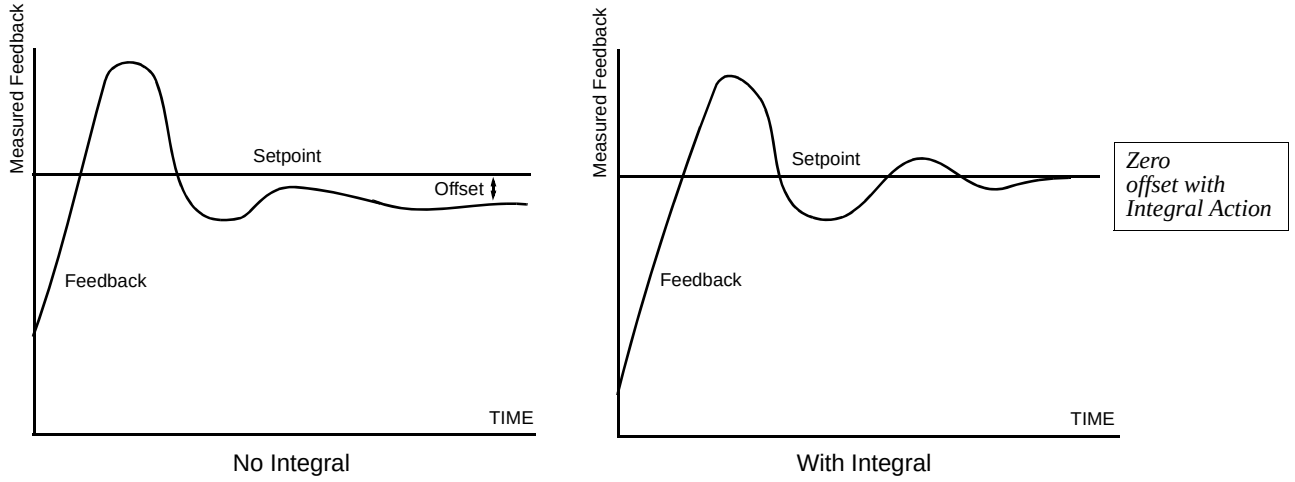


Fig. 16 PID Feedback Response Characteristics

■ b5-04 Integral Limit Setting

Setting Range: 0.0 to 100.0%
Factory Default: 100.0%

On some applications, especially those with rapidly varying loads, the output of the PI function may have large oscillations. To suppress these oscillations, a limit can be applied to the integral factor by programming b5-04.

■ b5-06 PI Output Limit

Setting Range: 0.0 to 100.0%
Factory Default: 100.0%

Places a cap on the output of the PI function. Limiting the PI function may help to prevent large overshoots in the Drive's response to error (the difference between the setpoint and the feedback).

■ b5-07 PI Offset Adjustment

Setting Range: -100.0% to +100.0%
Factory Default: 0.0%

The PI Offset Adjustment parameter has two different uses. Parameter b5-07 serves different functions depending on whether it is used on a standard PI loop or a Differential PI loop.

Parameter b5-07 causes an offset to be applied to the output of the PI function in a non-Differential PI loop. Every time the PI output is updated, the offset (b5-07) is summed with the PI output. This can be used to artificially kick-start a slow starting PI loop.

If the Drive is configured for Differential PI Regulation (H3-09= "16: PI differential"), then this parameter is the target setpoint for the differential to be maintained between the signal measured on analog input A1 and the signal measured on analog input A2.

■ b5-08 PI Primary Delay Time Constant

Setting Range: 0.00 to 10.00 Seconds
Factory Default: 0.00 Seconds

Acts as a time based filter that lowers the responsiveness of the PI function, but also makes the function more stable when the setpoint varies rapidly or when the feedback is noisy.

■ b5-09 PI Output Level Selection

Setting	Description
0	Normal Output (direct acting) (*factory default*)
1	Reverse Output (reverse acting)

Normally, the output of the PI function causes an increase in motor speed whenever the measured feedback is below the setpoint. This is referred to as direct acting response. However, if b5-09= "1: Reverse Output", the output of the PI function causes the motor to slow down when the feedback is below the setpoint. This is referred to as reverse acting response.

■ b5-10 PI Output Gain Setting

Setting Range: 0.0 to 25.0
Factory Default: 1.0

Applies a multiplier to the output of the PI function. Using the gain can be helpful when the PI function is used to trim the Speed Command. Increasing b5-10 causes the PI function to have a greater regulating affect on the speed command.

■ b5-11 PI Reverse Selection

Setting	Description
0	0 Limit (*factory default*)
1	Reverse

Parameter b5-11 determines whether reverse operation is allowed while using PI control (b5-01≠0). The factory default setting will not allow the Drive to run in reverse. This parameter does not need to be changed from factory default for a majority of HVAC applications. (Refer also to b5-09).

■ b5-12 PI Feedback Reference Missing Detection Selection

Setting	Description
0	Disabled (*factory default*)
1	Alarm
2	Fault

Loss of feedback can cause problems to a PI application. The Drive can be programmed to turn on a digital output whenever a loss of feedback occurs. Feedback Loss Detection is turned on by b5-12. When b5-12= "1: Alarm", the Drive acknowledges the loss of feedback without stopping or turning on the fault output (MA-MB). If b5-12= "2: Fault", the Drive coasts to a stop and turns on the fault output if the feedback is determined to be lost.

■ b5-13 PI Feedback Loss Detection Level

Setting Range: 0 to 100%
Factory Default: 0%

■ b5-14 PI Feedback Loss Detection Time

Setting Range: 0.0 to 25.0 Seconds
Factory Default: 1.0 Seconds

The Drive interprets feedback loss whenever the feedback signal drops below the value of b5-13 and stays below that level for at least the time set into b5-14. See Figure below for timing details.

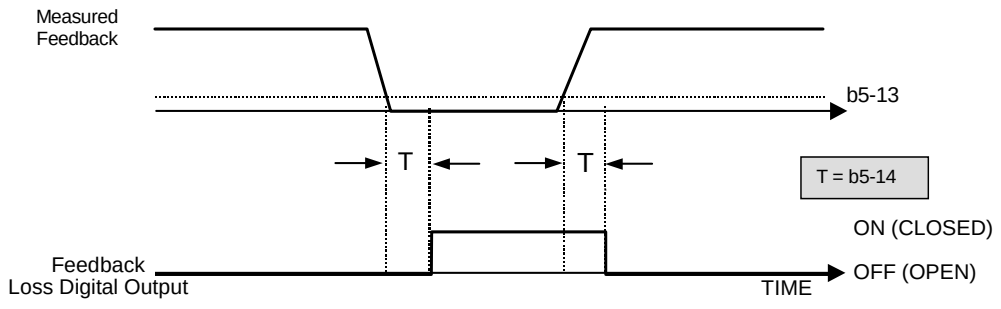


Fig. 17 Loss of PI Feedback Feature

■ b5-15 Sleep Function Start Level

Setting Range: 0.0 to 200.0 Hz
Factory Default: 0.0 Hz

■ b5-16 Sleep Delay Time

Setting Range: 0.0 to 25.5 Seconds
Factory Default: 0.0 Seconds

The Sleep Function can be programmed to prevent running the Drive when the PI loop output or the speed command is so low that no usable work is being done and/or equipment damage may result. The Sleep Function can be Enabled by entering a value in parameter b5-15. If the Drive's output drops below the level set by the Sleep Function Start Level (b5-15) and remains there at least as long as the delay time determined by the Sleep Delay Time (b5-16), then the Drive's internal Run command drops out and the Drive output ceases. Though the Drive's output has ceased, all other Drive functions continue. Once the Drive's theoretical output returns to a level above the Sleep Function Start Level (b5-15) and remains above that level for at least the Sleep Delay Time (b5-16), the internal Run command returns and the Drive output begins again. The b5-16 Delay Time prevents oscillation about the sleep level.

Note: The sleep function can be used even if the PI function is disabled (b5-01 = "0: Disabled").

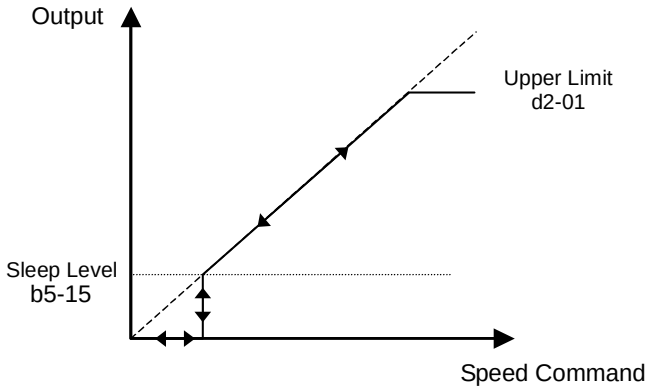


Fig. 18 Sleep Function Response

■ b5-17 PI Accel/Decel Time

Setting Range: 0.0 to 25.5 Seconds
Factory Default: 0.0 Seconds

This is a soft start function that is applied to the PI setpoint analog input. Instead of having nearly instantaneous changes in signal levels, there is a programmed ramp applied to level changes. When changing setpoints the error can be limited by gradually ramping the setpoint through the use of parameter b5-17.

■ b5-18 PI Setpoint Selection

Setting	Description
0	Disabled (*factory default*)
1	Enabled

In order to use parameter b5-19 as the PI Setpoint, set parameter b5-18= “1: Enabled”. If b5-18= “0: Disabled” the PI Setpoint will either be:

- Modbus Register 06H (If Register 0FH bit 1 is high)
- The active speed command (i.e. Determined by the setting of b1-01). See Table 1 “Setpoint Options”

■ b5-19 PI Setpoint Value

Setting Range: 0.00 to 100.00%
Factory Default: 0.00%

Parameter b5-19 is for a PI Setpoint value. When b5-18= “1: Enabled”, the value of b5-19 will take precedent over any other PI setpoint unless the Drive is set up for Differential Feedback, in which case, b5-18 and b5-19 have no affect on the PI function.

■ b5-20 PI Setpoint Display Scaling

Setting	Description
0	Hz (*factory default*)
1	%
3	RPM (Synchronous)
3	Engineering Units

The PI Setpoint Display Scaling value (b5-20) is a scaling factor that is applied to the monitor display for both the PI Setpoint (U1-38) and the PI Feedback (U1-24).

Table 2 PI Setpoint Display Scaling Options

If b5-20 is:	U1-24 and U1-38 Display Increments.
0	0.01 Hz
1	0.00%
2 through 39 (enter the # of motor poles)	0 RPM
40 through 39999	Engineering Units

If the monitors seem more natural in terms of percentage, set b5-20= 1. If the monitors are easier to work with when displaying the equivalent synchronous RPM, set b5-20= [the number of motor poles].
If another engineered unit, such a fpm or cfm, is desired, set b5-20= xxxxx where

X X X X X
Digit 5 Digit 4 Digit 3 Digit 2 Digit 1

Digits 1 through 4 set the desired number to be displayed at 100% speed.
Digit 5 determines the number of decimal places

If Digit 5 = 0 number format is XXXX
If Digit 5 = 1 number format is XXX.X
If Digit 5 = 2 number format is XX.XX
If Digit 5 = 3 number format is X.XXX

For example:

If b5-20= 10425 then at 100% output the digital operator would display 42.5 for monitor U1-38 or U1-24.

■ b5-21 Sleep Source

Setting	Description
0	SFS Input (Output of PI block)
1	PI Setpoint (*factory default*)
2	Snooze

Parameter b5-21 selects the sleep function characteristic action:
When b5-21= "0: SFS Input" the sleep function start level (b5-15) is compared to the Drive's output (Speed Command after PI block). This is the setting that should be used for open loop or closed loop control.

It is also possible to have the sleep function start level (b5-15) compared to the Drive input or setpoint. For this special application set b5-21= "1: PI Setpoint".

When b5-21= "2: Snooze" a variation of the sleep function called "Snooze" is enabled, see parameter b5-22 to b5-27.

IMPORTANT The sleep function can be used even if the PI function is disabled (b5-01= "0: Disabled").

■ b5-22 PI Snooze Level

Setting Range: 0 to 100%
Factory Default: 0%

■ b5-23 PI Snooze Delay Time

Setting Range: 0 to 3600 Seconds
Factory Default: 0 Seconds

■ b5-24 PI Snooze Deactivation Level

Setting Range: 0 to 100%
Factory Default: 0%

The Snooze Function is a variation on the Sleep Function. The Snooze function must be selected by setting parameter b5-21= "2: Snooze". Once the Snooze Function is selected, the Drive monitors the output frequency. If the output frequency drops below the PI Snooze Level (b5-22), and stays below that level for at least the PI Snooze Delay Time (b5-23), the Drive output shuts off. This is different from the Sleep Function because it is the feedback that must drop below the PI Snooze Deactivation Level (b5-24) before normal Drive output will begin again. See Figure 19 below.

■ b5-25 PI Setpoint Boost Setting

Setting Range: 0 to 100%
Factory Default: 0%

Just before the Snooze Function is activated, the PI Setpoint can be temporarily increased to create an overshoot of the intended PI Setpoint. The temporary boost is determined by the PI Setpoint Boost Setting (b5-25). Once the temporary boost level is reached (or the PI Maximum Boost Time (b5-26) is exceeded), the Drive output shuts off (snoozes) and the intended PI Setpoint returns. From this point on, the Snooze Function operates normally and the Drive output returns when the feedback level drops below b5-24. See Figure 20 below.

■ b5-26 PI Maximum Boost Time

Setting Range: 0 to 3600 Seconds
Factory Default: 0 Seconds

Associated with the Snooze Function. In cases where the temporary PI Setpoint (intended PI setpoint + PI Setpoint Boost) cannot be reached within the PI Maximum Boost Time (b5-26), the Setpoint Boost is interrupted and the Drive output is turned off.

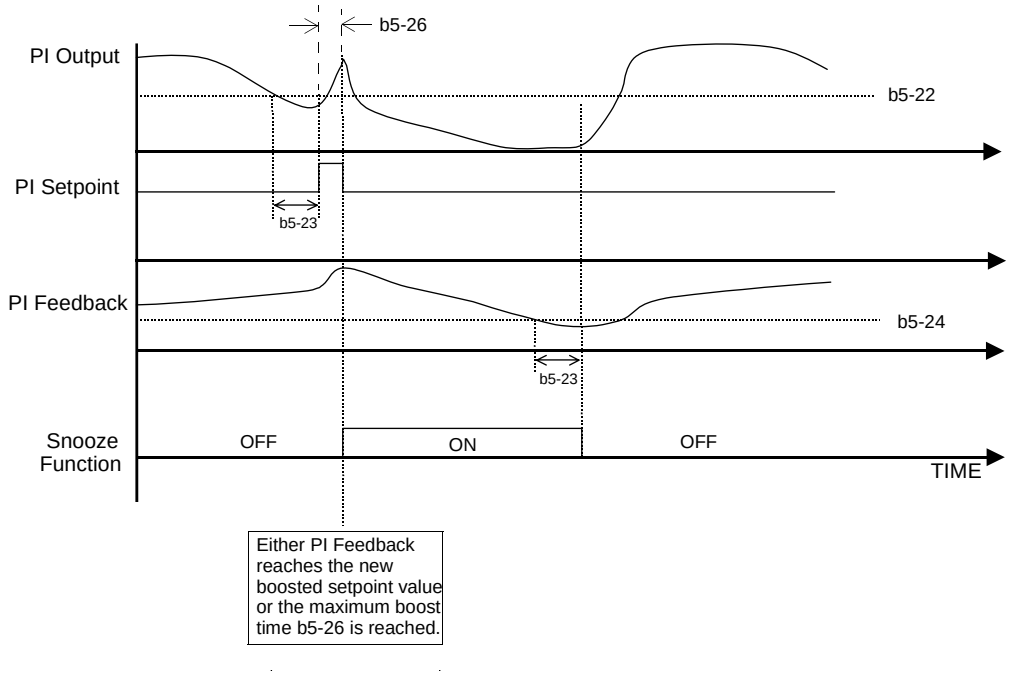


Fig. 19 Snooze Function Operation

■ b5-27 PI Snooze Feedback Level

Setting Range: 0 to 100%
Factory Default: 60%
This is a second method of initiating the Snooze Function. If the PI feedback level exceeds the PI Snooze Feedback Level (b5-27), then the Drive output shuts off. Once the PI feedback drops below the PI Snooze Deactivation Level (b5-24) then normal Drive and PI operation return. Snooze activates if both b5-22 and b5-27 conditions are met. There is no time delay for wake-up.

■ b5-28 PI Feedback Square Root Function Activation

Setting	Description
0	Disabled (*factory default*)
1	Enabled

If b5-28= “1: Enabled”, the square root of the PI feedback is compared to the PI Setpoint in order to determine appropriate Drive output to properly regulate the system. This is helpful in cases where the measured feedback is pressure but the PI loop needs to regulate flow.

■ b5-29 PI Square Root Gain

Setting Range: 0.00 to 2.00
Factory Default: 1.00

A multiplier applied to the square root of the feedback.

■ b5-30 PI Output Square Root Monitor Selection

Setting	Description
0	Disabled (*factory default*)
1	Enabled

If the PI Function is regulating the flow of a closed loop system by using a pressure feedback, it may be convenient to view the square root of the PI output using monitor U1-37.

◆ b8 Energy Savings

The energy savings function improves overall system operating efficiency by operating the motor at its highest efficiency. This is accomplished by continuously monitoring the motor load and adjusting the motor terminal voltage so that the motor always operates near its rated slip frequency. A motor is most efficient when operating near rated slip conditions.

■ b8-01 Energy Savings Selection

Setting	Description
0	Disabled (*factory default*)
1	Enabled

When the Energy Savings function is enabled (b8-01= "1: Enabled"), the Drive reduces the output voltage to the motor below the voltage value specified by the programmed V/f pattern whenever the motor load is light. Since torque is reduced during this voltage reduction, the voltage has to return to normal levels when the load returns. The energy savings is realized through improved motor efficiency. The reduced output voltage causes increased rotor slipping even with a light load. A motor is most efficient when operating fully loaded (i.e. operating at rated slip).

■ b8-04 Energy Saving Coefficient Value

Setting Range: 0.0 to 655.0
Factory Default: Model Dependent

Parameter b8-04 is used in maximizing motor efficiency. The factory setting will be Drive capacity dependant but can be adjusted in small amounts while viewing the kW monitor (U1-08) and running the Drive to minimize the output kW. A larger value typically results in less voltage to the motor and less energy consumption. Too large a value will cause the motor to stall.

■ b8-05 Power Detection Filter Time

Setting Range: 0 to 2000 mS
Factory Default: 20 mS

The Energy Saving function will search out the lowest output voltage in order to achieve minimum output power usage. Parameter b8-05 determines how often the output power (kW) is measured and the output voltage is adjusted.

■ b8-06 Search Operation Voltage Limit

Setting Range: 0 to 100%
Factory Default: 0%

Once Energy Savings is enabled and the optimal energy saving coefficient value has been set, the programmer can have the Drive further search out the proper voltage to achieve the lowest output power by making minute changes to the output voltage and measuring the output power every b8-05 ms. Parameter b8-06 sets limits to the range over which the voltage will be adjusted in order to minimize the power output. Settings too large a value may allow the motor to stall if the load is applied abruptly.

If b8-06= 0, then the optimum voltage search operation is disabled (but not Energy Savings itself).

◆ C1 Accel/Decel

■ C1-01 Acceleration Time 1
C1-02 Deceleration Time 1
C1-03 Acceleration Time 2
C1-04 Deceleration Time 2

Setting Range: 0.0 to 6000.0 Seconds
Factory Default: 30.0 Seconds

C1-01 (Acceleration Time 1) sets the time to accelerate from zero to maximum speed (E1-04). C1-02 (Deceleration Time 1) sets the time to decelerate from maximum speed to zero. C1-01 and C1-02 are the factory default active accel/decel "pair". Another accel/decel pair (C1-03 and C1-04) exists that can be activated by a multi-function digital input (H1-0x= 7), or specified by a switch over frequency as programmed in parameter C1-11.

Note: If fan applications employing duct high pressure safety limit switches, it may be necessary to further adjust the deceleration time to avoid high pressure limit trips due to damper closure as the system is shut down. (An alternate solution in this situation is to set parameter b1-03 to "Coast to Stop").

■ C1-09 Fast Stop Time

Setting Range: 0.0 to 6000.0 Seconds
Factory Default: 10.0 Seconds

A special deceleration parameter is available for use with emergency or fault operations. Parameter C1-09 will set a special deceleration that can be operated by closing a digital input configured as H1-0x= 15 or H1-0x= 17. A digital input configured as H1-0x= 15 will look for a switch closure before initiating the Fast Stop operation. A digital input configured as H1-0x= 17 will look for the switch opening before initiating the Fast Stop operation.

Unlike a standard deceleration time, once the Fast Stop operation is initiated even momentarily, the Drive cannot be re-operated until the deceleration is complete, the Fast Stop input is cleared, and the Run command is cycled.

◆ d2 Reference (Speed Command) Limits

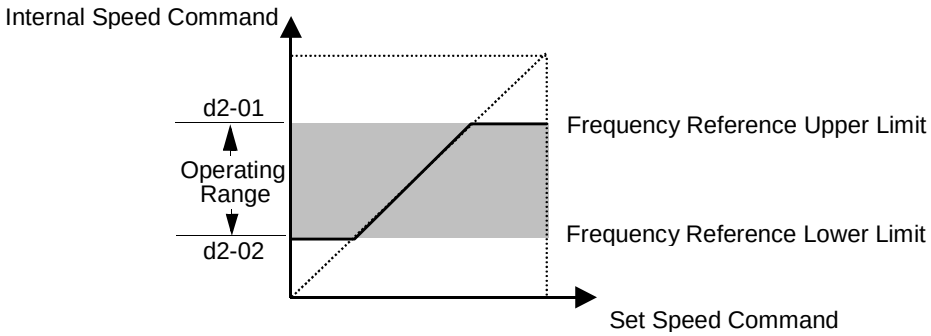
■ d2-01 Frequency Reference Upper Limit

Setting Range: 0.0 to 110.0%
Factory Default: 100.0%

■ d2-02 Frequency Reference Lower Limit

Setting Range: 0.0 to 110.0%
Factory Default: 0.0%

The use of parameters d2-01 and d2-02 places limitations on the speed command that the Drive will accept. The parameters are set in units of percentage of the maximum frequency (E1-04) and provide limits on any remote speed command input. By entering upper or lower frequency limits, the Drive programmer can prevent operation of the Drive above or below levels that may cause resonance, equipment damage or discomfort (see also parameter d3-0X). For example, limits may be needed to prevent low speed operation of: Cooling tower fans with gear boxes, pumps with pressure dependent seals, or AHUs with minimum delivery requirements.



Note: See also the “Sleep” function in Figure 19 for alternate “lower limit” implementation.

Fig. 20 Frequency Reference Upper and Lower Limit Effects on the Speed Command

■ d2-03 Master Speed Reference Lower Limit

Setting Range: 0.0 to 110.0%
Factory Default: 0.0%

Unlike Frequency Reference Lower Limit (d2-02) which will affect the speed command no matter where it is sourced from (i.e. analog input, preset speed, jog speed, etc.), the Master Speed Reference Lower Limit (d2-03) sets a low speed threshold that will only affect the analog input that is the active master speed frequency (as determined by parameter H3-13 and H3-09). This parameter allows a minimum speed to be programmed for the master reference while allowing a lower speed to be set as a jog reference. If the speed commanded by the active master speed frequency is below the setting of d2-03, then the Drive will operate at the speed specified by d2-03.

◆ d3 Jump Frequencies

■ d3-01 Jump Frequency 1
d3-02 Jump Frequency 2
d3-03 Jump Frequency 3

Setting Range: 0.0 to 200.0 Hz
Factory Default: 0.0 Hz

■ d3-04 Jump Frequency Width

Setting Range: 0.0 to 20.0 Hz
Factory Default: 1.0 Hz

In order to avoid continuous operation at a speed that causes resonance in driven machinery, the Drive can be programmed with jump frequencies that will not allow continued operation within specific frequency ranges. If a speed is commanded that falls within a dead band, or Jump Frequency, the Drive will clamp the frequency reference just below the dead band and only accept higher speed commands when the commanded speed rises above the upper end of the dead band, for increasing references. Similarly, the Drive will clamp the frequency reference just above the dead band and accept lower speed commands when the command speed falls below the lower end of the dead band, for decreasing references.

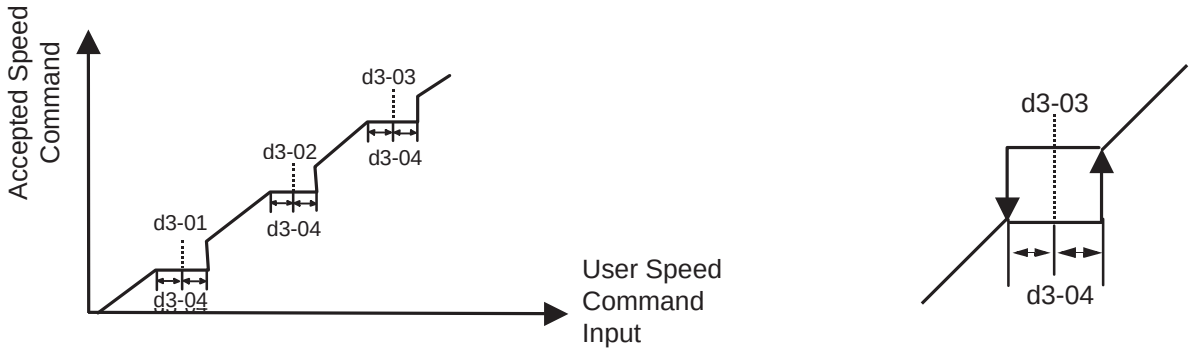


Fig. 21 Jump Frequency Characteristics

Setting the center point of the dead band with the d3-01 through d3-03 parameters and setting the width of the dead band with parameter d3-04 determines the dead band characteristics. The programmer can set up to three Jump Frequencies. If multiple Jump Frequencies are programmed the following rule applies:

$$d3\text{-}01 <= d3\text{-}02 <= d3\text{-}03$$

◆ E1 V/f Pattern

■ E1-01 Input Voltage Setting

Setting Range: 155.0V to 255.0V (208V/240V Models)
310.0V to 510.0V (480V Models)

Factory Defaults: 208.0V (208V Models)
240.0V (240V Models)
480.0V (480V Models)

Set the Input Voltage parameter (E1-01) to the nominal voltage of the connected AC power supply. This parameter adjusts the levels of some protective features of the Drive (i.e. Overvoltage, Stall Prevention, etc.). E1-01 also serves as the Maximum/ Base Voltage used by the Preset V/Hz curves (E1-03= 0 to D).

■ E1-03 V/f Pattern Selection

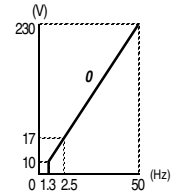
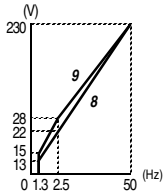
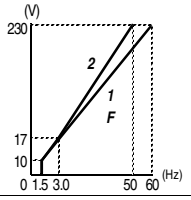
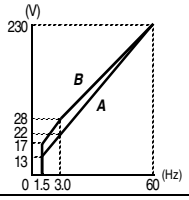
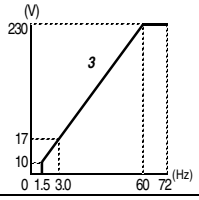
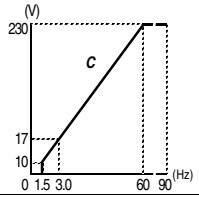
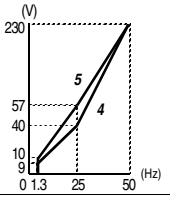
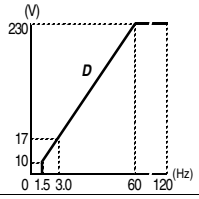
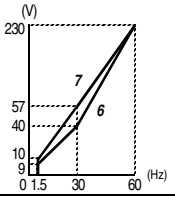
Setting	Description
0	50 Hz
1	60 Hz Saturation
2	50 Hz Saturation
3	72 Hz
4	50 Hz VT1
5	50 Hz VT2
6	60 Hz VT1
7	60 Hz VT2
8	50 Hz HST1
9	50 Hz HST2
A	60 Hz HST1
B	60 Hz HST2
C	90 Hz
D	120 Hz
F	Custom V/f (*factory default, with parameter values per setting 1*)
FF	Custom w/o limit

The Drive operates utilizing a set V/f pattern to determine the appropriate output voltage level for each commanded speed. There are 14 different preset V/f patterns to select from with varying voltage profiles, saturation levels (frequency at which maximum voltage is reached), and maximum frequencies.

There are also settings for Custom V/f patterns that will allow the programmer to manually set (“Customize”) the V/f pattern using parameters E1-04 through E1-13.

Using parameter E1-03, the programmer can select one of the preset V/f patterns or chose between a custom V/F pattern with an upper voltage limit (E1-03= “F: Custom V/F”) and a custom V/f pattern without a voltage limit (E1-03= “FF: Custom w/o limit”).

Table 3 Preset V/f Patterns

	Specifications		E1-03	V/f Pattern *1		Specifications		E1-03	V/f Pattern *1
General-purpose	50Hz		0		High Starting Torque *2	50Hz	High Starting Torque 1	8	
							High Starting Torque 2	9	
	60Hz Saturation		1 F			60Hz	High Starting Torque 1	A	
	50Hz Saturation		2				High Starting Torque 2	B	
	72Hz		3		High Speed Operation	90Hz		C	
Variable Torque	50Hz	Variable Torque 1	4			120Hz		D	
		Variable Torque 2	5						
	60Hz	Variable Torque 1	6						
		Variable Torque 2	7						

If one of the custom V/f patterns is selected, then parameters E1-04 through E1-13 will determine the V/F pattern.

Table 3 is for 240V class units only, for 480V class units multiply the voltage value by 2.

IMPORTANT When a factory Initialization is performed, the setting of E1-03 is unaffected but the settings of E1-04 through E1-13 are returned to their factory default settings.

■ E1-04 Maximum Output Frequency

Setting Range: 0.0 to 120.0 Hz
Factory Default: 60.0 Hz

■ E1-05 Maximum Output Voltage

Setting Range: 0.0 to 255.0V (240V Models)
0.0 to 510.0V (480V Models)

Factory Defaults: 240.0V (240V Models)
480.0V (480V Models)

■ E1-06 Base Frequency

Setting Range: 0.0 to 200.0 Hz (settings above 120.0 Hz are currently not supported)
Factory Default: 60.0 Hz

■ E1-07 Mid Output Frequency A

Setting Range: 0.0 to 200.0 Hz (settings above 120.0 Hz are currently not supported)
Factory Default: 3.0 Hz

■ E1-08 Mid Output Voltage A

Setting Range: 0.0 to 255.0V (240V Models)
0.0 to 510.0V (480V Models)

Factory Defaults: 18.0V (240V Models)
33.6V (480V Models)

■ E1-09 Minimum Output Frequency

Setting Range: 0.0 to 200.0 Hz (settings above 120.0 Hz are currently not supported)
Factory Default: 1.5 Hz

■ E1-10 Mid Output Voltage

Setting Range: 0.0 to 255.0V (240V Models)
0.0 to 510.0V (480V Models)

Factory Defaults: 10.8V (240V Models)
16.8V (480V Models)

■ E1-11 Mid Output Frequency B

Setting Range: 0.0 to 200.0 Hz (settings above 120.0 Hz are currently not supported)
Factory Default: 0.0 Hz

■ E1-12 Mid Output Voltage B
E1-13 Base Voltage

Setting Range: 0.0 to 255.0V (240V Models)
0.0 to 510.0V (480V Models)

Factory Defaults: 0.0V (240V Models)
0.0V (480V Models)

To set up a custom V/f pattern, program the points shown in the diagram below using parameters E1-04 through E1-13. Be sure that the following condition is true:

E1-09 ≤ E1-07 ≤ E1-06 ≤ E1-11 ≤ E1-04

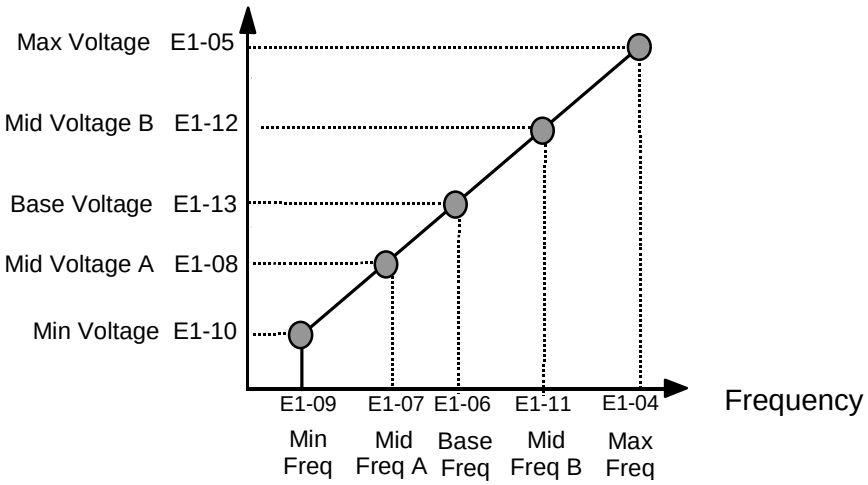


Fig. 22 Custom V/f Pattern Programming Curve

Increasing the voltage in the V/f pattern increases the available motor torque. However, when setting a custom V/f pattern, increase the voltage gradually while monitoring the motor current, to prevent:

- Drive faults as a result of motor over-excitation
- Motor overheating or excessive vibration

◆ E2 Motor Setup

■ E2-01 Motor Rated Current

Setting Range: Model Dependent (see Appendix B)
Factory Default: Model Dependent

The Motor Rated Current parameter (E2-01) is necessary information for the Drive motor protection function. The motor overload protection parameter L1-01 is enabled by default. In addition, motor rated current is used by the torque compensation function to insure optimum torque production. Set E2-01 to the full load amps (FLA) value stamped on the motor's nameplate. During Auto-tuning, it is required for the operator to enter the motor rated current in parameter T1-04 on the Auto-Tuning menu. If the Auto-tuning operation completes successfully, the value entered into T1-04 will be also written into E2-01.

For applications employing a Drive that is oversized for the motor, E2-01 may be set as low as 10% of the Drive output current rating. The AMP value in E2-01, however, must always be greater than the "No Load Current" value in parameter E2-03 or an OPE02 error will be displayed.

■ E2-03 No Load Current

Setting Range: Model Dependent (see Appendix B)
Factory Default: Model Dependent

Set E2-03 to the motor no-load current at rated voltage and rated frequency. Consult the motor manufacturer for the proper value if the no load current is not stated on the motor nameplate.

◆ F6 Com OPT Setup (applies only to the LonWorks option)

■ F6-01 Operation Selection After Communication Error

Setting	Description
0	Ramp to Stop
1	Coast to Stop (*factory default*)
2	Fast-Stop
3	Alarm Only

If a serial communication option board is attached to the Drive at the 2CN connector, the Drive will automatically monitor the card for any type of communication errors. F6-01 is applicable no matter whether a run command or speed command is coming via the option board, digital operator, or terminal input. The setting of F6-01 determines whether the communication error is seen as a fault or an alarm. If F6-01= "3: Alarm Only", then the fault output is not energized upon a communication error. All other settings of F6-01 cause the fault output to energize. The setting of F6-01 does not apply to any of the embedded communication protocols used at the RS-485/422 terminals on the removable terminal board. (See parameters H5-0X).

■ F6-02 Option PCB External Fault Detection Selection

Setting	Description
0	Always Detected (*factory default*)
1	Detected only during operation

■ F6-03 Option PCB External Fault Stopping Method

Setting	Description
0	Ramp to Stop
1	Coast to Stop (*factory default*)
2	Fast-Stop
3	Alarm Only

If an external fault is received from the LONWORKS®or other communication option card, the settings of F6-02 and F6-03 will determine the Drive operation in reaction to the fault signal. Parameter F6-02 will determine if the external fault is always recognized (F6-02= "0: Always Detected") or only recognized when the Run command is active (F6-02= "1: Detected only during operation").
Once the fault is recognized, parameter F6-03 will determine the operation of the Drive. If parameter F6-03 is set to anything other then "3", the Drive will fault and a stopping sequence is begun. If F6-03= "3: Alarm Only", then the external fault is treated like an alarm. Operation will continue and an EF0 fault will flash on the digital operator.

■ F6-05 Current Scaling via Communication Option PCB

Setting	Description
0	A Display (*factory default*)
1	100%/8192 (Drive Rated Current)

A communication option card can read the Drive's DPRAM to access the current monitor. The format of the current reading in the DPRAM will be determined by parameter F6-05.

F6-05= "0: A Display" → Current is a decimal number corresponding to actual Amperes
F6-05= "1: 100%/8192 (Drive Rated Current)" → Current reading is a number where
8192 = 100% of Drive rated output current

◆ H3 Analog Inputs

■ H3-02 Terminal A1 Gain Setting

Setting Range: 0.0 to 1000.0%
Factory Default: 100.0%

■ H3-03 Terminal A1 Bias Setting

Setting Range: -100.0% to +100.0%
Factory Default: 0.0%

In order to have the Drive properly interpret an analog input, it may be necessary to apply a gain and/or a bias to the signal. The analog inputs have a resolution of 10 bits (1024 steps). Using the factory default settings for the analog input's gain and bias, the 0-10Vdc or 4-20mA signal at the analog input will yield a 0-100% speed command span.

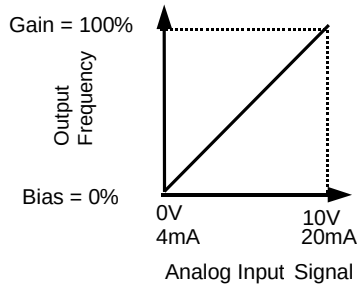


Fig. 23 Output Frequency as Commanded Via Analog Input

If a different span of analog input signal is desirable, it will be necessary to adjust the gain, the bias, or both to allow the analog input level to generate the desired frequency command. Adjustment of the gain setting will change the speed command that is equivalent to the maximum analog input (10Vdc or 20mA). If, for instance, the gain is increased to 200%, then 10Vdc or 20mA will be equivalent to a 200% speed command and 5 VAC or 12mA will be equivalent to a 100% Speed Command. Since the Drive output is limited by the maximum frequency parameter (E1-04), 0-5Vdc or 4-12mA will now be equivalent to 0-100% speed command span.

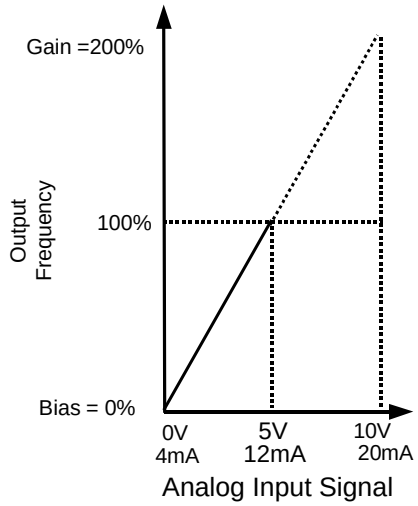


Fig. 24 Output Frequency as Commanded via Analog Input with Increased Gain Setting

Adjustment of the bias setting will likewise adjust the speed command that is equivalent to the minimum analog input level (0Vdc or 4mA). If, for instance, the bias is set to –25%, then 0Vdc or 4mA will be equivalent to a –25% speed command. Since the minimum speed command is 0% an analog input of 2.5 to10Vdc or 8 to 20mA will now be equivalent to 0-100% speed command span.

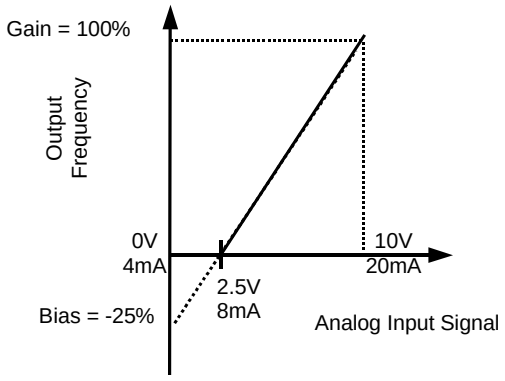


Fig. 25 Output Frequency with Reduced Bias Setting

As a further example, for an inverse-acting speed command, set the bias= 100% and the gain= 0%. The minimum analog input level (0Vdc or 4mA) will produce a 100% speed command and the maximum analog input level (10Vdc or 20mA) will produce a 0% speed command.

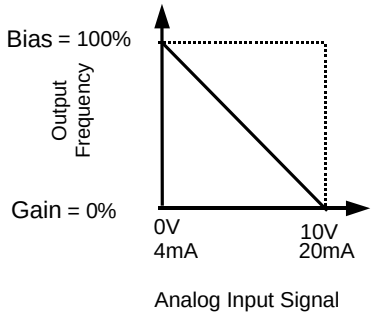
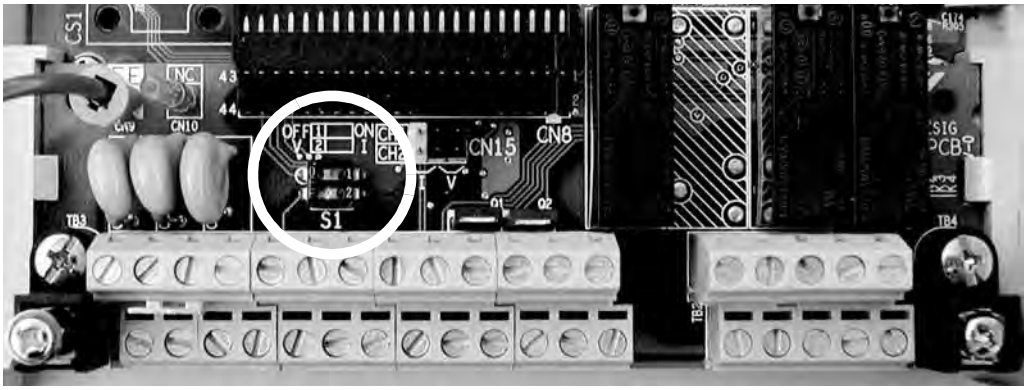


Fig. 26 Output Frequency with Inverted Gain and Bias Settings

■ H3-08 Terminal A2 Signal Level

Setting	Description
0	0 - 10VDC
2	4 - 20mA (Default)

The H3-08 parameter (Terminal A2 Signal Level) allows the programmer to specify the signal that will be applied to the A2 analog input. The A2 analog input can accept either a 0–10 Vdc or 4-20 mA signal as a reference. The Drive also has a DIP switch (S1) on the removable terminal board that must be set for the proper reference signal into the A2 analog input. The S1-2 dipswitch setting determines the internal resistance of the A2 input while parameter H3-08 determines how the Drive interprets the measured signal.



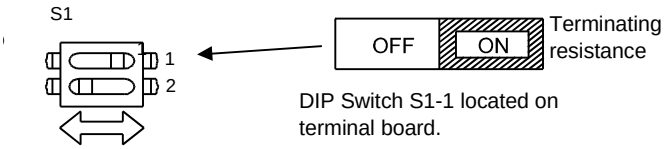


Fig. 27 DIP Switch S1

Table 4 DIP Switch S1		
Name	Function	Setting
S1-1	RS-485 and RS-422 terminating resistance	OFF: No terminating resistance ON: Terminating resistance of 110 Ω
S1-2	Input signal for analog input A2	OFF: 0 to 10 V (internal resistance: 20 kΩ) ON: 4 to 20 mA (internal resistance: 250 Ω) (Default)

■ H3-09 Terminal A2 Function Selection

Setting	Description
0	Frequency Bias
2	Aux Reference (*factory default*)
B	PI Feedback
D	Frequency Bias 2
E	Motor Temperature
16	PI Differential
1F	Not Used

The A2 analog input can be programmed to perform many different functions. The setting of parameter H3-09 determines which of the following functions the A2 analog input will perform.

Function: Frequency Bias
Setting: 0

By setting H3-09= "0: Frequency Bias", the A2 analog input will serve as a bias signal to the A1 Speed Command. The effect of using A2 for a frequency bias is that the level of the A2 analog input will be summed with the level of the Speed Command analog input (A1). For example, if H3-02= 100%, H3-03= 0%, and the A2 analog input level is 1 Vdc, the Speed Command profile will look like the figure below. If A1= 0 Vdc the Speed Command would be 10% of the programmed maximum frequency because A1 (0 Vdc) + A2 (1 Vdc) = 1 Vdc.

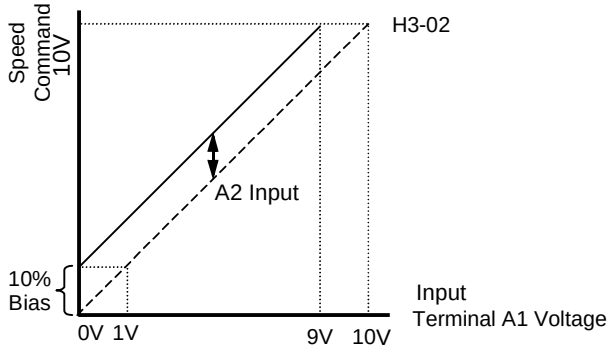


Fig. 28 Effect of Frequency Bias Function on Speed Command

It should be noted that the bias applied by the A2 analog input functions differently than the level set by the H3-03. If both biases are used simultaneously they will sum together.

The level of the A1 analog input, as a percentage of the maximum input (either 10 Vdc or 20 mA), can be viewed by the U1-15 monitor. The level of the A2 analog input, as a percentage of the maximum input, can be viewed by the U1-16 monitor.

The bias applied by setting H3-09= "0: Frequency Bias", can be used in conjunction with the parameter bias H3-03. In that case the H3-03 bias is applied first which changes the slope of the Speed Command vs. Terminal A1 Voltage graph. Then the level of the A2 analog input is summed with the A1 analog input level, which in effect shifts the Speed Command vs. Terminal A1 Voltage graph upwards or downwards but does not change the slope of the line.

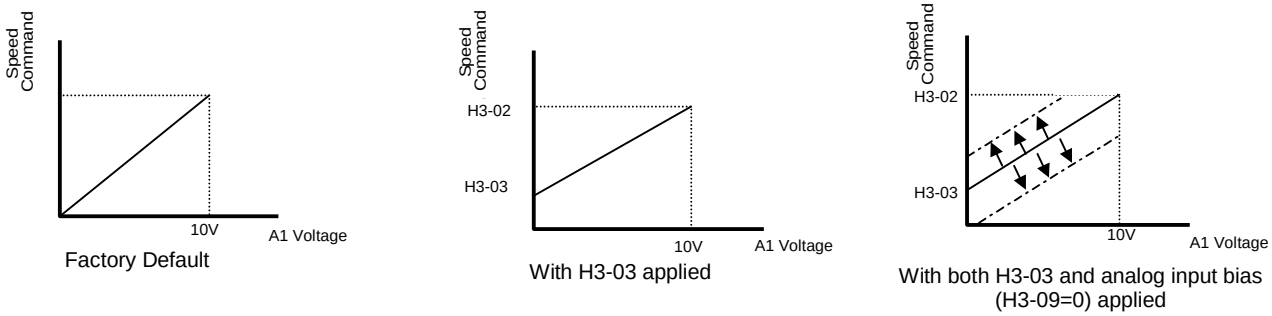


Fig. 29 Frequency Bias Applied to Analog Speed Command

Function: Aux Reference
Setting: 2

In order for the A2 analog input to be used as the master Speed Command, parameter H3-09 must be set for Aux Reference (H3-09= "2: Aux Reference"). Once A2 is configured as an auxiliary reference, it can be selected as the master Speed Command by setting H3-13= "1: Main Fref TA2". If H3-09= 2, terminal A2 analog input will become the speed command when a digital input programmed for Multi-Step Ref 1 (H1-0x= 3) is selected by a contact closure.

Function: PI Feedback
Setting: B

Configuring the A2 analog input as PI Feedback (H3-09= "B: PI Feedback") is a requirement of setting the Drive up for PI operation. The A2 analog input is the only source for feedback for PI operation though the setpoint can come from a number of different sources (refer to the section covering the PI parameters for more information regarding specifying the setpoint source. PI parameters are listed in section b5).

Parameters H3-10 (Terminal A2 Gain) and H3-11 (Terminal A2 Bias) can be used to configure the A2 analog input to match the signal from the Feedback Transmitter.

The U1-24 monitor (PI Feedback) can be used to check the PI Feedback level with the digital operator.

Function: Frequency Bias 2
Setting: D

By setting H3-09= "D: Frequency Bias 2", the A2 analog input will serve as a bias signal to the A1 Speed Command. This setting functions the same as a setting of H3-09=0: Frequency Bias.

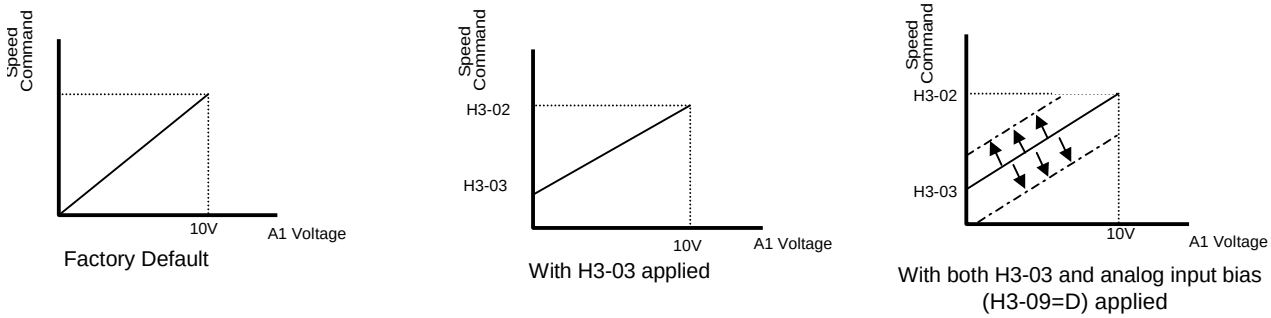


Fig. 30 Frequency Bias 2 Applied to Analog Speed Command

Function: PI Differential
Setting: 16

Normal PI operation will adjust the Drive output in order to match the measured feedback value to a desired setpoint. When PI is operated in the differential mode, however, the Drive output is adjusted in order to maintain a desired differential between two feedback signals.

When the A2 analog input is configured as a PI Differential (H3-09= “16: PI Differential”), the A1 analog input becomes the other PI Differential input. The desired differential is set by parameter b5-07 (PI Differential Setpoint) and can be set so that A2 is held less than A1 (b5-07 <0) or A2 is held greater than A1 (b5-07>0).

When PI Differential operation is chosen, the A1 feedback level can be monitored by U1-24 (PI Feedback) and the A2 feedback level can be monitored by U1-53 (PI Feedback2).

Function: Not Used
Setting: 1F

When H3-09= “1F: Not Used”, any signal applied to the A2 analog input will be ignored by the Drive.

■ H3-10 Terminal A2 Gain Setting

Setting Range: 0.0 to 1000.0%
Factory Default: 100.0%

■ H3-11 Terminal A2 Bias Setting

Setting Range: -100.0% to +100.0%
Factory Default: 0.0%

Parameters H3-10 and H3-11 perform the same function for the A2 analog input that parameters H3-02 and H3-03 perform for the A1 analog input. Please refer to the parameter description for H3-02 and H3-03 for information about H3-10 and H3-11.

These parameters could be used for final calibration of a factory or field installed pressure to electric transducer input connected to terminal A2 and AC. This field calibration may be needed if there is a job site variation from the typical 3 to 15 PSIG pneumatic signal input range.

■ H3-12 Analog Input Filter Time Constant

Setting Range: 0.0 to 2.00 Seconds
Factory Default: 0.30 Seconds

An analog input filter can be used to prevent erratic Drive control when a “noisy” analog reference is used. Parameter H3-12 sets the time constant for a first order filter that will be applied to both the A1 and A2 analog inputs. The Drive operation becomes more stable the longer the time programmed, but it becomes less responsive to rapidly changing analog signals.

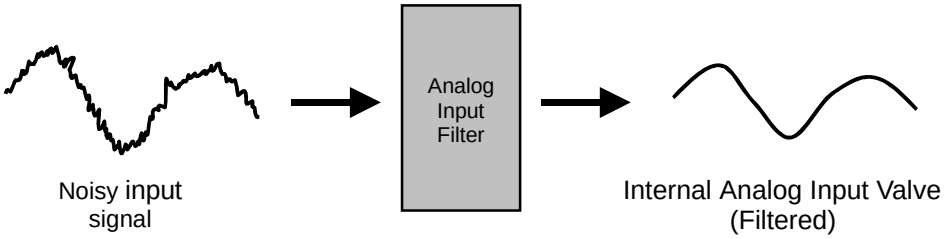


Fig. 31 Analog Input Filter Time Constant Effect on “Noisy” Signal

■ H3-13 Master Frequency Reference Terminal Selection

Setting	Description
0	Main Fref= A1(*factory default*)
1	Main Fref= A2

Parameter H3-13 allows the programmer to select which analog input will serve as the Speed Command input when "Terminals" are selected as the Auto Mode Speed source (b1-01= "1: Terminals"), or Terminal is selected as the reference source for the Hand mode (b1-12= "1: Terminals"). For the A2 analog input to be an effective selection for the H3-13 parameter, parameter H3-09 must be configured as Aux Reference (H3-09= "2: Aux Reference").

If H3-09≠2, then the A1 analog input will be used regardless of the setting of parameter b1-12.

◆ L2 Momentary Power Loss Ride-thru Function

When momentary power loss recovery is enabled (L2-01≠0), a speed search is executed to catch the potentially spinning motor shaft. This speed search will occur regardless of the setting of b3-01 "Speed Search Selection".

■ L2-01 Momentary Power Loss Detection Selection

Setting	Description
0	Disabled
1	PwrL Ride Thru t
2	CPU Power Active (*factory default*)

■ L2-02 Momentary Power Loss Ride-Thru Time

Setting Range: 0.0 to 25.5 Seconds
Factory Default: Model Dependent

The Drive allows different responses to momentary power losses. The setting of L2-01 determines whether the Drive attempts to restart after a short loss of incoming AC power and for what length of time this capability remains active.

If L2-01= "0: Disabled", the Drive detects a UV1 fault 15ms after power loss and automatic restarting is disabled. The Drive cannot restart until the external run command is removed and the UV1 fault is reset.

If L2-01= "1: PwrL Ride Thru t", the Drive restarts without the UV1 fault if power is returned within the time specified in L2-02, the Momentary Power Loss Ride-thru Time. During the power loss but before the fault trip, the digital operator will display a UV alarm. If L2-02 is set for a time longer than the control power supply can be sustained, a UV1 fault will not occur and the Drive restarts upon the return of AC power. The time that the control power supply can be maintained varies with Drive size. The larger the Drive, the greater the potential ride-thru time.

If L2-01= "2: CPU Power Active", the Drive ignores L2-02 and attempts a restart as long as the control power supply is still able to maintain a minimal voltage level. In effect, setting L2-01= "2: CPU Power Active" (factory default) is programming the Drive for maximum Power Loss Ride-thru. An equivalent setting is L2-01= "1: PwrL Ride Thru t", with L2-02 set to a time longer than the control power supply can be maintained after power is lost.

Note: The run command must be held during power loss for any power loss ride-thru capability to be possible. It is for this reason that 3-wire control is not recommended for use with the Momentary Power Loss function.

◆ L3 Stall Prevention

■ L3-01 Stall Prevention Selection During Accel

Setting	Description
0	Disabled
1	General Purpose (*factory default*)
2	Intelligent

■ L3-02 Stall Prevention Level During Accel

Setting Range: 0 to 200% of Drive rated output current
Factory Default: 120% of Drive rated output current

The stall prevention during acceleration function adjusts the acceleration time in order to prevent OC fault trips during acceleration. If L3-01= “0: Disabled”, stall prevention is disabled. If the load is large enough and the acceleration time short enough the Drive may fault and stop.

If L3-01= “1: General Purpose”, then the standard stall prevention function is enabled. When the output current exceeds the level set by the L3-02 parameter, the Drive will discontinue accelerating and maintain speed. If, during acceleration, the output current comes within 15% of the level set by parameter L3-02, the acceleration time is lengthened. Once the output current level has dropped below the L3-02 level, acceleration will begin again with the acceleration rate reaching the programmed rate once again 15% below the L3-02 level.

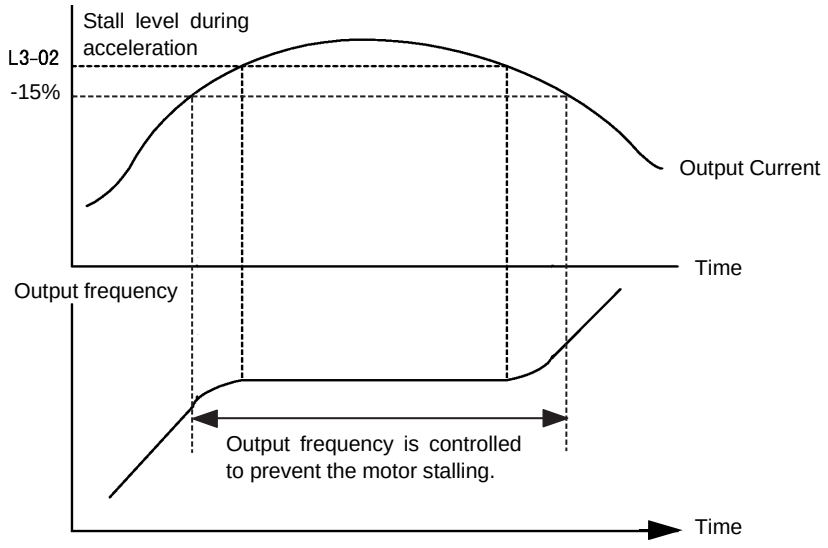


Fig. 32 Detailed Time Chart for Stall Prevention During Acceleration

If L3-01= “2: Intelligent”, the intelligent stall prevention is enabled. The active acceleration time is ignored and the Drive will attempt to accelerate as quickly as possible without exceeding the L3-02 output current level.

IMPORTANT | Stall Prevention during Acceleration is not effective when the output frequency is less than 6Hz.

The following figure demonstrates acceleration when L3-01= “1: General Purpose”.

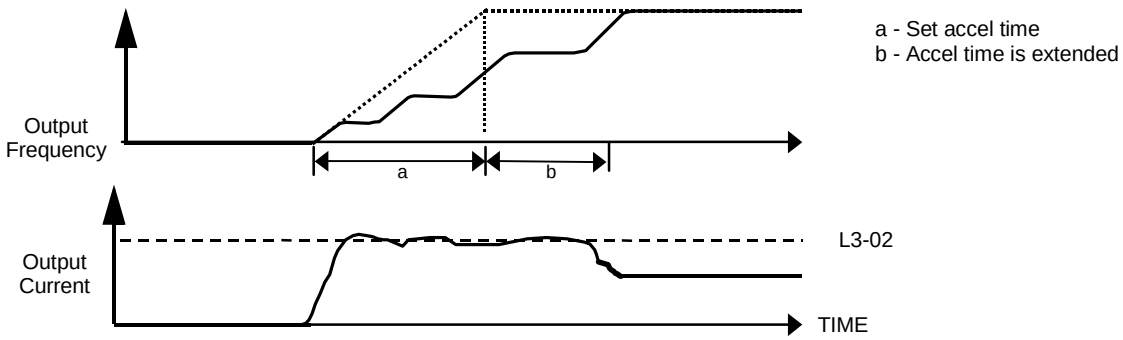


Fig. 33 Time Chart for Stall Prevention During Acceleration

The L3-02 parameter is set as a percentage of the Drive rated output current. If the motor capacity is small compared to the Drive’s capacity, or if the motor stalls during acceleration, lower the set value of L3-02.

■ L3-04 Stall Prevention Selection During Decel

Setting	Description
0	Disabled
1	General Purpose (*factory default*)
2	Intelligent
3	Stall prev w/R

The stall prevention during deceleration function adjusts the deceleration time in order to prevent OV fault trips during deceleration. If L3-04= “0: Disabled”, stall prevention is disabled and if the load is large and the deceleration time short enough the Drive may fault and stop.

If L3-04= “1: General Purpose”, then the standard stall prevention function is enabled. If, during deceleration, the DC Bus voltage exceeds the stall prevention level (see table below), the Drive will discontinue decelerating and maintain speed. Once the DC Bus voltage has dropped below the stall prevention level, the deceleration will continue down to the Speed Command level. See figure below.

Table 5 Stall Prevention During Decel

Drive Voltage		Stall Prevention Level during Deceleration (V)
240Vac		380
480Vac	E1-01 ≥ 400Vac	760
	E1-01 < 400Vac	660

If L3-01= “2: Intelligent”, the intelligent stall prevention is enabled. The active deceleration time is ignored and the Drive will attempt to decelerate as quickly as possible without causing the DC Bus voltage to exceed the stall prevention level.

The following figure demonstrates acceleration when L3-04= “1 General Purpose”.

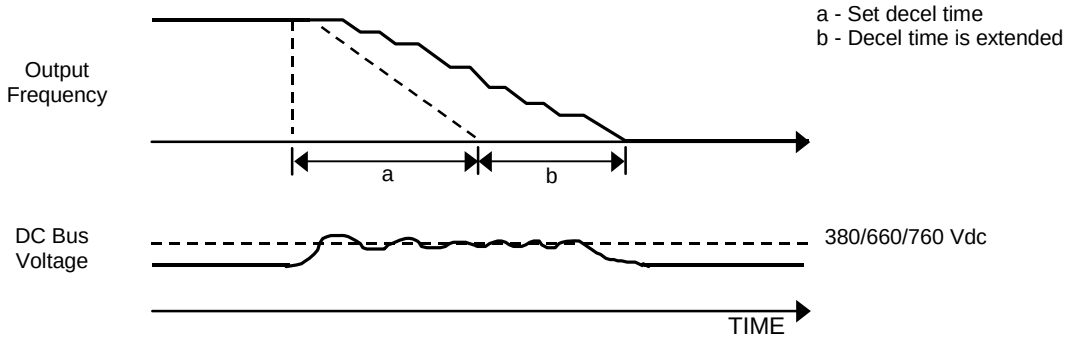


Fig. 34 Time Chart for Stall Prevention During Deceleration

■ L3-05 Stall Prevention Selection During Running

Setting	Description
0	Disabled
1	Decel Time 1 (*factory default*)
2	Decel Time 2

■ L3-06 Stall Prevention Level During Running

Setting Range: 30 to 200% of Drive rated output current
Factory Default: 120% of Drive rated output current

The Stall Prevention During Running function will attempt to avoid a Drive OC fault occurrence while the Drive is operating at a constant speed. If L3-05= “0: Disabled”, the Drive may fault if the load increases sufficiently to cause the output current to reach the OC fault level (180% of Drive rated output current).

If L3-05= “1: Decel Time 1”, the Drive is outputting a constant speed, and the Drive’s output current level exceeds the level set by parameter L3-06 for more than 100 ms the Drive will begin to decelerate at the rate specified by parameter C1-02. The Drive will continue to decelerate until the output current level drops below the L3-06 level (less a 2% hysteresis). Once the output current drops below the L3-06 – 2% level the Drive will begin to accelerate at the currently active acceleration rate (either C1-01 or C1-03).

If L3-05= “2: Decel Time 2”, the Drive will function as described above except C1-04 will be used instead of C1-02 as the deceleration rate used when the output current exceeds L3-06 for more than 100 ms.

The following figure demonstrates acceleration when L3-05≠0.

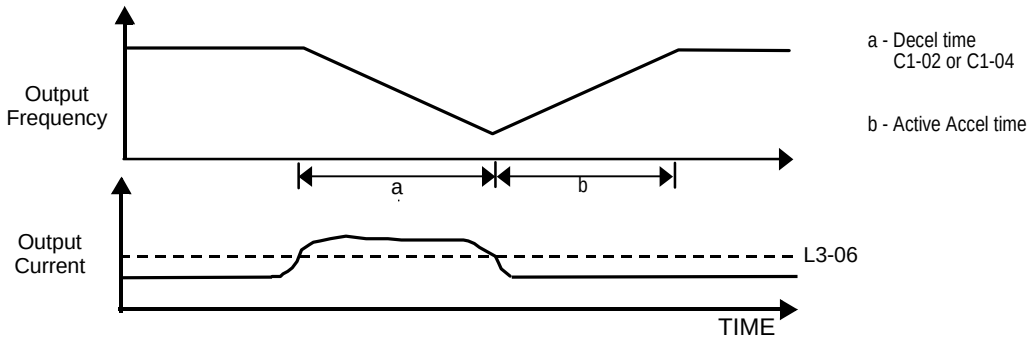


Fig. 35 Time Chart for Stall Prevention Level During Running

The L3-06 parameter is set as a percentage of the Drive rated output current. If the Drive still faults when L3-05≠0, then either lower the L3-06 or adjust the C1-02 or C1-04 settings for a quicker deceleration.

◆ L4 Speed Command Loss Detection

■ L4-01 Speed Agreement Detection Level

Setting Range: 0.0 to 200.0 Hz
Factory Default: 0.0 Hz

■ L4-02 Speed Agreement Detection Width

Setting Range: 0.0 to 20.0 Hz
Factory Default: 2.0 Hz

Parameters L4-01 and L4-02 are user specified levels for use with the Fref/Fout Agree 1, Fref/Set Agree 1, and Freq Detect 1 & 2 digital output functions. Please refer to the H2 Digital Output Parameters in the Programming Manual for more information.

■ L4-05 Frequency Reference Loss Detection Selection

Setting	Description
0	Disabled
1	Enabled @ % of PrevRef (*factory default*)

■ L4-06 Frequency Reference at Loss of Frequency Reference

Setting Range: 0.0 to 100.0% of previous speed command
Factory Default: 80.0% of previous speed command

The Drive can be configured to compensate for the loss of its external speed command. An external speed command is considered lost if it drops 90% of its value in 400mS or less.

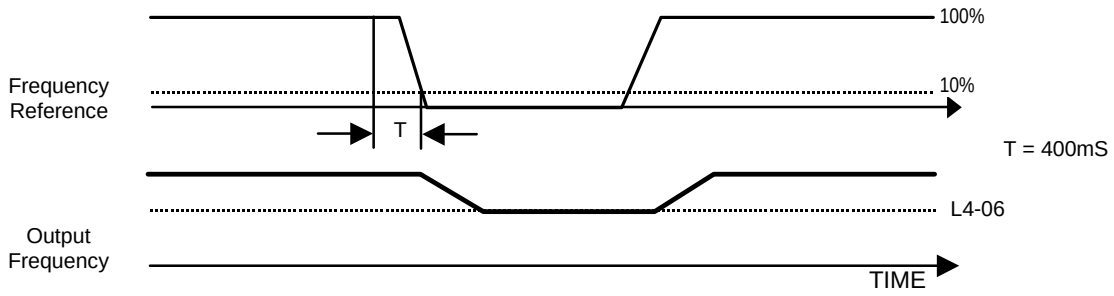


Fig. 36 Loss of Frequency Reference Timing Diagram

To enable Frequency loss detection, set L4-05= “1: Enabled @ % of PrevRef”. If Frequency Reference Loss Detection is enabled and the reference is lost, the Drive continues to operate at the speed commanded by parameter L4-06. When the speed command returns, the Drive again follows the speed command.

Setting H2-01/H2-02= “C: Loss of Ref”, configures a digital output as a Frequency Reference Loss indication only when L4-05= “1: Enabled @ % of PrevRef”.

◆ L5 Fault Restart

■ L5-01 Number of Auto Restart Attempts

Setting Range: 0 to 10
Factory Default: 0

■ L5-02 Auto Restart Operation Selection

Setting	Description
0	No Flt Relay (*factory default*)
1	Flt Relay Active

■ L5-03 Maximum Restart Time After Fault

Setting Range: 0.5 to 600.0 Seconds
Factory Default: 180.0 Seconds

All major faults will cause the Drive to stop. For some faults it is possible to configure the Drive to attempt a restart automatically. After the fault occurs, the Drive baseblocks for L2-03 seconds. After the baseblock is removed the Drive checks if a fault condition still exists. If no fault condition exists the Drive will attempt to restart the motor. If the restart is successful, the Drive performs a Speed Search (Regardless of the status of b3-01 “Speed Search Selection”) from the set speed command and the Auto Restart Attempts count is increased by one. Even if the restart fails the restart count is increased by one as long as the Drive attempted to rotate the motor. The restart count will not increment if the restart is not attempted due to a continuing fault condition, (i.e. an OV fault). The Drive waits L5-03 seconds before attempting another restart.

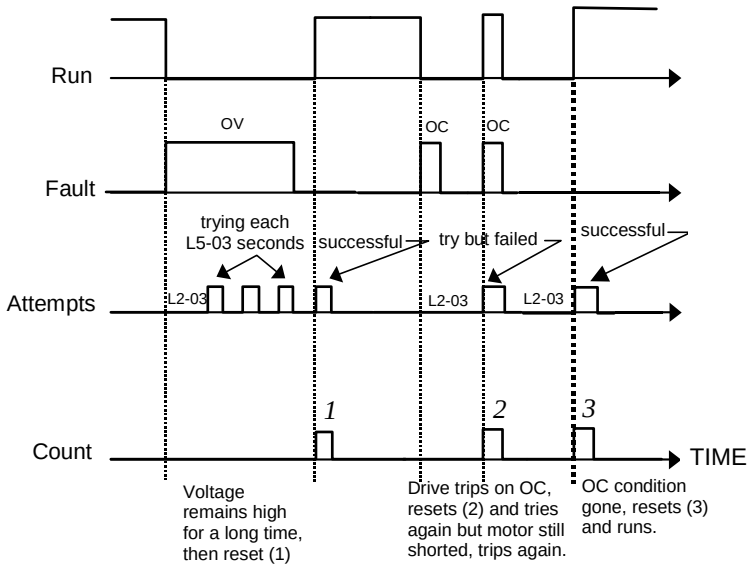


Fig. 37 Automatic Restart Timing Diagram

The auto restart count is reset back to 0 if any of the following occur:

- No further faults for ten minutes after the last retry.
- The Drives power is turned off (the Drive must be without power long enough to let control power dissipate).
- The SHIFT/RESET key is pushed after the last reset attempt.

The setting of parameter L5-02 determines whether the fault output (MA-MB) will be closed during an auto restart attempt. The setting of L5-02 can be important when interfacing the Drive with other equipment.

The following faults will allow the Auto Restart function to initiate:

- OC (Overcurrent)
- LF (Output Open Phase)
- PF (Input Phase Loss)
- PUF (DC Bus Fuse)
- OL1 (Motor Overload)
- OL3 (Overtorque)
- OL2 (Drive Overload)
- OV (DC Bus Overvoltage)
- GF (Ground Fault)
- UV1 (DC Bus Undervoltage)
- OH1 (Overheat)

In order for auto restart after a UV1 fault, Momentary Power Loss Ride-thru must be enabled (L2-01= “1: PwrL Ride Thru t”, or “2: CPU Power Active”). Setting H2-01 or H2-02 equal to “1E” configures a digital output as “Restart Enabled” to signal if an impending auto restart is possible.

◆ L6 Torque Detection

■ L6-01 Torque Detection Selection 1

Setting	Description
0	Disabled (*factory default*)
1	OL@SpdAgree - Alm
2	OL At Run -Alm
3	OL@SpdAgree - Flt
4	OL At Run - Flt
5	UL@SpdAgree - Alm
6	UL at Run - Alm
7	UL@SpdAgree - Flt
8	UL At Run - Flt

■ L6-02 Torque Detection Level 1

Setting Range: 0 to 300% of Drive rated output current
Factory Default: 15% of Drive rated output current

■ L6-03 Torque Detection Time 1

Setting Range: 0.0 to 10.0 Seconds
Factory Default: 10.0 Seconds

The Drive can be programmed to indicate when either an overtorque or an undertorque conditions exist. A digital output must be programmed for “Torque Detection”, (H2-01/H2-02= “B: Trq Det 1 N.O.” or “17: Trq Det 1 N.C.). A warning of an overtorque condition can indicate a jam and an undertorque condition can indicate a broken belt, no water in a pump, or other loss of load.
To configure Torque Detection requires the following decisions:
1. Do you wish to check for an overtorque condition or an undertorque condition?
2. Do you wish to check for the torque condition whenever the drive is running or only at speed agree? Nuisance detection during acceleration, when variable torques are normally required, can be avoided.
3. Do you want the drive to fault if the torque condition is detected or only alarm and continue operation?

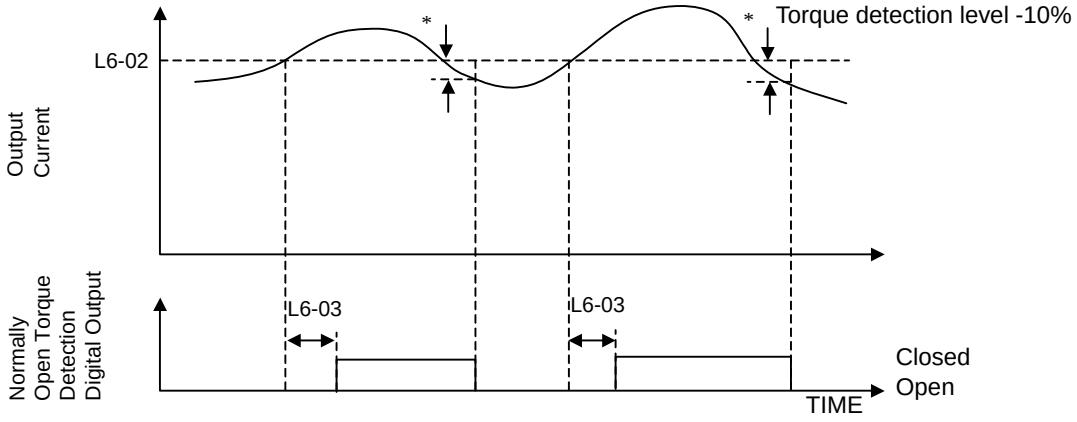
The following table can help choose the proper setting for Torque Detection Selection 1 to get the wanted results.

Table 6 L6-01 Setting Choices

L6-01 Setting	Overtorque	Undertorque	Fault	Alarm	Always Detected	Only Detected @ Spd Agree
0	Torque Detection Disabled					
1	X			X		X
2	X			X	X	
3	X		X			X
4	X		X		X	
5*		X		X		X
6		X		X	X	
7		X				X
8		X			X	

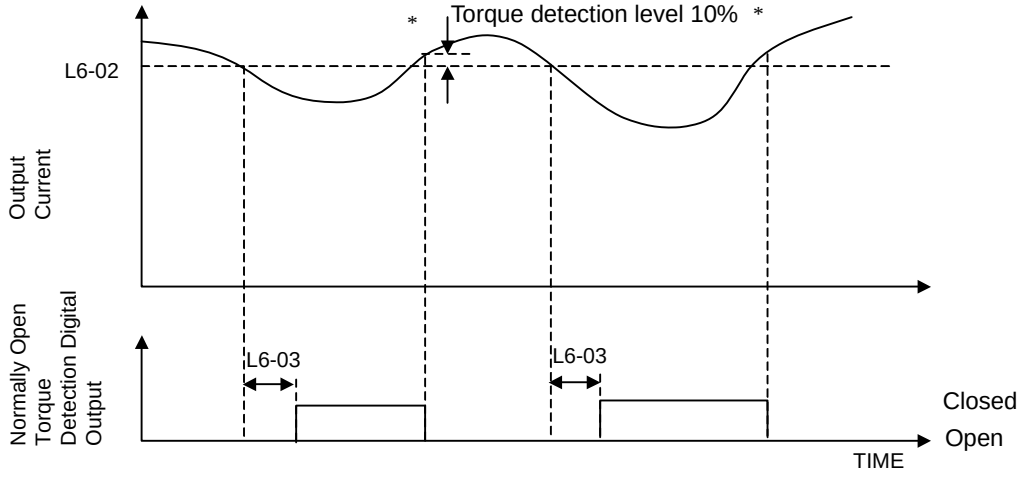
*Suggested settings for Loss of Load indication

After selecting the proper detection scheme the Torque Detection Level (L6-02) must be specified. If the current level read by the output current transformers rises above (overtorque) or drops below (undertorque) this level, and remains there for at least the Torque Detection Time (L6-03), then the Torque Detection Function will change the state of any digital output configured for Torque Detection (H2-01/H2-02= “B: Trq Det 1 N.O.”, or “17: Trq Det 1 N.C.”).



* When the output current drops below the Torque Detection Level by approximately 10% of the Drive’s rated output current the digital output is reset.

Fig. 38 Over Torque Detection



* When the output current rises above the Torque Detection Level by approximately 10% of the Drive’s rated output current the digital output is reset.

Fig. 39 Under Torque Detection

◆ L8 Hardware Protection

■ L8-02 Overheat Pre-Alarm Level

Setting Range: 50 to 130°C
Factory Default: 95°C

■ L8-03 Overheat Pre-Alarm Operation Selection

Setting	Description
0	Ramp to Stop (Decel Time C1-02)
1	Coast to Stop
2	Fast-Stop (Decel Time C1-09)
3	Alarm Only
4	OH Alarm and Reduce (*factory default*)

The Drive is capable of warning the operator of an impending heatsink over-temperature fault via an OH pre-alarm.The level at which the pre-alarm will activate is determined by the setting of parameter L8-02. Measurement of the heatsink temperature is done with several strategically mounted thermistors. If any of the heatsink thermistors measure a temperature in excess of the setting of L8-02, the Drive will fault (OH2) and either: ramp to stop using the C1-02 deceleration rate (L8-03= "0: Ramp to Stop"), coast to stop (L8-03= "1: Coast to Stop"), ramp to stop using the C1-09 fast stop deceleration rate (L8-03= "2: Fast-Stop"), alarm (OH) and continue running (L8-03 = "3: Alarm Only"), alarm (OH) and continue running but at a reduced speed (L8-03= "4: Alarm & Reduce"). If L8-03= 4: Alarm and Reduce, the Drive will continue to run but will reduce the speed to the level determined by parameter L8-19. Refer to the description for parameter L8-19.

If a digital output is configured for OH Prealarm (H2-01= "20: OH PreAlarm"), it will close whenever the heatsink temperature is greater than the L8-02 level no matter what the setting is of L8-03.

■ L8-06 Input Phase Loss Detection Level

Setting Range: 0.0 to 25.0% of Drives OV Trip point
Factory Default: KVA Dependent

⚠CAUTION: Changing this parameter from the factory default setting may cause Drive failure and void the product warranty. (Consult the factory for application assistance).

The Drive checks for a lost input phase by monitoring the DC Bus voltage ripple. After an initial delay of approximately 12 seconds, the Drive will sample the DC BUS voltage every 1.28 seconds to determine the minimum and maximum voltage readings. The difference between the minimum and maximum voltage is averaged over ten consecutive scans. If this "averaged" value is greater than the trip level as determined by L8-06 (L8-06 x 400 for 200 volt class Drives; L8-06 x 800 for 400 volt class Drives) the Drive shuts down and displays "PF", an input phase loss fault.

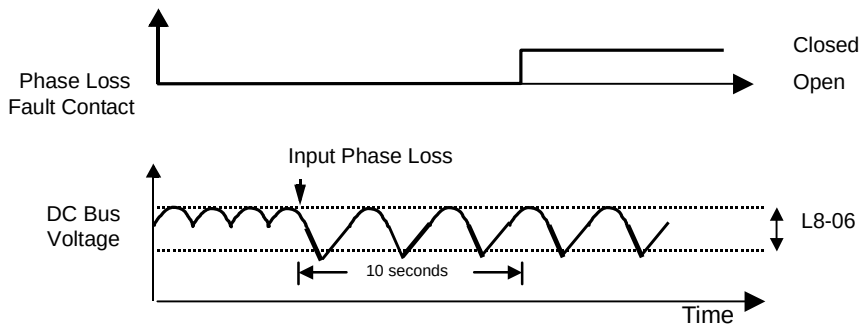


Fig. 40 Input Phase Loss Detection Diagram

■ L8-09 Output Ground Fault Detection Selection

Setting	Description
0	Disabled
1	Enabled (*factory default*)

The Drive has a ground fault detection circuit that activates when the current to ground exceeds 50% of the Drive's rated output current. The current to ground is determined by comparing the measured current on each of the output phases. If the current to ground is determined to be above 50% of the Drive's rated output current the digital operator will display a GF and the Drive will coast to stop.

■ L8-10 Heatsink Cooling Fan Operation Selection

Setting	Description
0	Fan On-Run Mode (*factory default*)
1	Fan Always On

■ L8-11 Heatsink Cooling Fan Operation Delay Time

Setting Range: 0 to 300 Seconds
Factory Default: 300 Seconds

Parameters L8-10 and L8-11 allow the Drive programmer to customize the heatsink cooling fan operation. Parameter L8-10 determines whether the cooling fans are always ON whenever the Drive is powered (L8-10= "1: Fan Always On") or if the cooling fans are only ON when the Drive is in a Run condition (L8-10= "0: Fan On-Run Mode").

Parameter L8-11 is a delayed OFF for the cooling fan if L8-10= "0: Fan On-Run Mode". When the cooling fans are set to turn OFF when the Run command is removed, parameter L8-11 will cause the fans to continue cooling the Drive for the amount of time programmed into L8-11 after the Run command is actually removed. The Drive can be programmed to allow the cooling fan to run for up to 5 minutes (factory default) after the run command is removed.

Both parameters are intended to extend fan life while still providing sufficient cooling for proper Drive operation.

■ L8-19 Overheat Frequency Reference Reduction Level

Setting Range: 0.0 to 100.0% of maximum frequency
Factory Default: 20.0% of maximum frequency

When the heatsink temperature reaches the OH Pre-alarm level (L8-02) and the Overheat Pre-Alarm Operation Selection parameter is set for Alarm and Reduce (L8-03= "4: OH Alarm & Reduce"), the L8-19 parameter sets the amount of speed decrease that will be applied to the Speed Command in order to lower the heatsink temperature. The decrease in speed will lower the current being switched and conducted by the heat producing output transistors of the Drive.

Parameter L8-19 is set in percentage of maximum frequency (E1-04).

◆ o1 Monitor Configuration

■ o1-01 User Monitor Selection

Setting Range: 6 to 53
Factory Default: 6

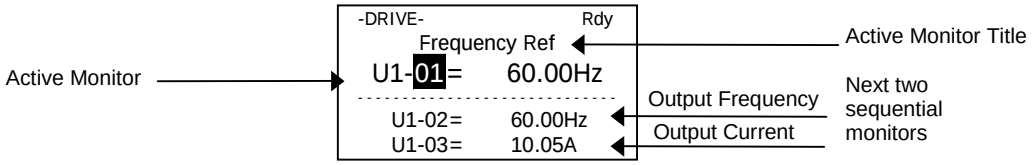
Setting	Description
6	Output Voltage (*factory default*)
7	DC Bus Voltage
8	Output Power
10	Input Terminal Status
11	Output Terminal Status
12	Drive Operation Status
13	Cumulative Operation Time
14	Software Number
15	Terminal A1 Input Voltage
16	Terminal A2 Input Voltage
18	Motor Secondary Current (I_q)
20	Output Frequency After Soft Start
24	PI Feedback Value
28	CPU Number
34	First Parameter Causing an OPE
36	PI Input
37	PI Output
38	PI Setpoint
39	Memobus Communication Error Code
40	Heatsink Cooling Fan Operation Time
51	Auto Mode Frequency Reference Value
52	Hand Mode Frequency Reference Value
53	PI Feedback 2 Value

■ o1-02 Power-On Monitor

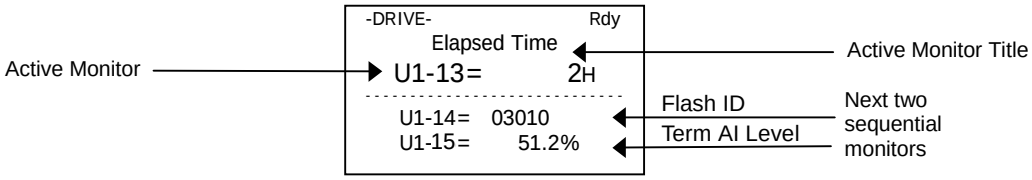
Setting	Description
1	Frequency Reference (*factory default*)
2	Output Frequency
3	Output Current
4	User Monitor (set by o1-01)

When the Drive is powered up, three monitors are displayed on the digital operator. The first and largest monitor is the "Power-On" monitor. The factory default "Power-On monitor" is Speed Command (U1-01). Below the Speed Command monitor are the next two sequential monitors, Output Frequency (U1-02) and Output Current (U1-03). Pressing the INCREASE key once scrolls the monitors to show the User Monitor as selected by o1-01. The factory default for o1-01 is the Output Voltage monitor (U1-06).

The active monitor displayed when the Drive is powered on can be changed to either be U1-01 (Speed Command), U1-02 (Output Frequency), U1-03 (Output Current), or the User Monitor. Whichever monitor is selected as the Power-On top monitor, the two monitors displayed below it are the next two sequential monitors. See example below.



For example, if the Drive needs to display the Elapsed Timer as the Power-On monitor, then o1-01 must be set to "13" and o1-02 must be set to "4". The next time Drive power is cycled, the digital operator displays U1-13 (Elapsed Time), U1-14 (Flash ID), and U1-15 (Term AI Level).



■ o1-03 Digital Operator Display Scaling

Setting	Description
0	Hz (*factory default*)
1	%
2 - 39	RPM (Enter the # of Motor Poles)
40 - 39999	User Display

Parameter o1-03 allows the programmer to change the units in which the speed monitors and some speed parameters are displayed. The o1-03 parameter will change the units of the following:

- U1-01 (Frequency Reference Monitor)
- U1-02 (Output Frequency Monitor)
- U1-20 (Output Frequency after Soft Start)
- d1-01 through d1-17 (Preset Frequency References and Jog Reference)

The table below details how the setting of o1-03 will affect the way the listed monitors and parameters will be displayed.

Table 7 Display Scaling

If o1-03 is:	The frequency format is
0	0.01 Hz
1	0.00%
2 through 39 (enter the # of motor poles)	0 RPM
40 through 39999	Engineering Units

The factory default setting (o1-03= “0”) sets the Drive up to display the affected monitors and parameters in terms of hertz (Hz).

If the speeds seem more natural in terms of percentage of maximum, set o1-03= “1”. If the speeds are easier to work with when displaying the equivalent synchronous motor RPM, set o1-03= [the number of motor poles]. If another engineered unit, such as fpm or gpm, is desired, set o1-03= xxxx where

X X X X X

Digit 5 Digit 4 Digit 3 Digit 2 Digit 1

Digits 1 through 4 set the desired number to be displayed at 100% speed.
Digit 5 determines the number of decimal places in the displayed number.

If Digit 5 = 0 number format is XXXX
If Digit 5 = 1 number format is XXX.X
If Digit 5 = 2 number format is XX.XX
If Digit 5 = 3 number format is X.XXX

For example:

If o1-03= 10425, then at full speed the digital operator will display “42.5”. Configuring parameter o1-03 for displaying in terms of an engineering unit is only appropriate if the actual display units have a linear relationship with the actual output speed.

■ o1-05 LCD Contrast Adjustment

Setting Range: 1, 3 or 5
Factory Default: 3

The contrast setting of the LCD display of the digital operator can be adjusted by the setting of parameter o1-05. The higher the number programmed into o1-05, the darker the background will become. Set o1-05 to the value that makes the LCD the easiest to view at the normal viewing distance and angle.

■ o1-06 User Monitor Selection Mode

Setting	Description
0	3 Mon Sequential (*factory default*)
1	3 Mon Selectable

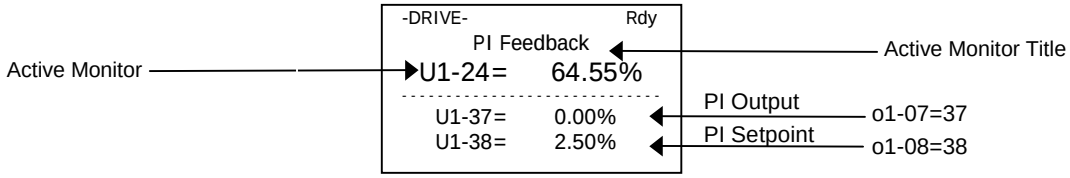
■ o1-07 Second Line User Monitor

Setting Range: 1 to 53
Factory Default: 2

■ o1-08 Third Line User Monitor

Setting Range: 1 to 53
Factory Default: 3

Normally the monitors shown directly below the active monitor are the next two sequential monitors. If o1-06 (User Monitor Selection Mode) is set to "1: 3 Mon Selectable", those two monitors are locked as specified by parameters o1-07 and o1-08 and will not change as the top parameter is scrolled with the INCREASE and DECREASE keys.



For Example:
The Display above showing PI Feedback, PI Output and PI Setpoint would be useful when setting up a PI Control Loop.

◆ o2 Key Selections

■ o2-03 User Parameter Default Value

Setting	Description
0	No Change
1	Set Defaults
2	Clear All

The Drive gives the option of configuring any and all of the programming parameters and then saving the parameters as “User Initialization Values”. After configuring the Drive, set parameter o2-03= “1: Set Defaults”, to save the parameters to a User Initialization memory location. Once this has been done, the “Initialize Parameters” parameter (A1-03) will offer the choice of “1110:User Initialize”. Choosing A1-03= “1110: User Initialized”, will reset all modified parameters back to what they were the last time they were saved using o2-03.

The choice of setting A1-03= “1110: User Initialized”, is unavailable until first setting the User Initialization parameters using o2-03. Once a User Initialization is set (saved), it can be cleared by setting o2-03= “2: Clear All”. After clearing the User Initialization parameters, the choice of “1110: User Initialize” is no longer a available in A1-03.

■ o2-05 Frequency Reference Setting Method Selection

Setting	Description
0	Disabled
1	Enabled (*factory default*)

The factory default setting of the Frequency Reference Setting Method parameter (o2-05= “1: Enabled”) dictates that when setting a Speed Command via the digital operator (“Hand” mode), it is not necessary to press the DATA/ENTER key before the Drive will begin to accelerate or decelerate to the new set speed. This is referred to as MOP (Motor Operated Potentiometer) type functionality. When o2-05= “1: Enabled”, the speed command is stored to memory 5 seconds after the INCREASE or DECREASE keys are released.

When o2-05= “0: Disabled”, the digital operator INCREASE and DECREASE keys will change the speed command but the Drive will not accelerate or decelerate to the new speed command until the DATA/ENTER key is pressed. In order to change the Speed Command in the HAND mode, U1-01 must be the top monitor and then the ENTER key must be pressed in order to access the Speed Command function. This in not to be confused with pressing the ENTER key in order to achieve a change in speed using the INCREASE and DECREASE keys, which is the subject of parameter o2-05.

■ o2-06 Operation Selection when Digital Operator is Disconnected

Setting	Description
0	Disabled
1	Enabled (*factory default*)

Leaving o2-06 enabled will cause the Drive to fault, when the digital operator is removed, even if it's not outputting to the motor. The reset key on the digital operator will need to be pressed after reconnecting the digital operator to reset the fault and continue normal operation.

If o2-06 = "0: Disabled" then the Drive will not fault if the digital operator is disconnected, but the Drive will discontinue motor operation. If full Drive operation is required while the digital operator is removed set o2-06 = "0: Disabled" and o2-15 = "0: Disabled" (Hand Key Function). If both o2-06 and o2-15 are disabled then the digital operator can be disconnected without disturbing Drive operation.

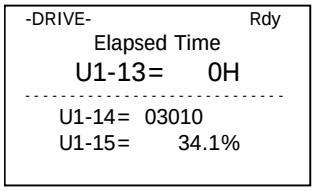
■ o2-07 Cumulative Operating Time Setting

Setting Range: 0 to 65535 Hours
Factory Default: 0 Hours

■ o2-08 Cumulative Operation Time Selection

Setting	Description
0	Power-On Time
1	Running Time (*factory default*)

The Drive features an Elapsed Timer monitor that records in units of hours. The Elapsed Timer monitor is U1-13. Parameter o2-08 programs this function to either accumulate elapsed hours based on time the Drive is powered (o2-08= "0: Power-On Time") or time the Drive is running (o2-08= "1: Running Time"). The Drive is considered "running" anytime there is an active run command or when the Drive is outputting voltage (i.e. including during deceleration).



Parameter o2-07 allows manual adjustment of the Elapsed Timer, primarily to accommodate maintenance or control board replacement in the event of damage. To reset the Elapsed Timer back to zero, set o2-07= 0.

◆ o3 Digital Operator Copy Function

■ o3-01 Copy Function Selection

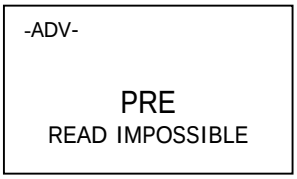
Setting	Description
0	COPY SELECT (*factory default*)
1	INV→OP READ
2	OP→INV WRITE
3	OP↔INV VERIFY

Note: The copy function is disabled when serial communication is active.

■ o3-02 Read Allowed Selection

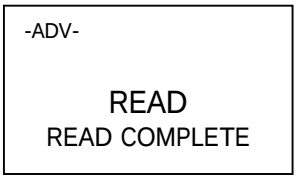
Setting	Description
0	Disabled (*factory default*)
1	Enabled

The digital operator has parameter COPY capabilities via built in non-volatile memory. The digital operator can READ all of the parameters in the Drive and store them for later WRITE back to the Drive or into a Drive with the same product code and software number. In order to read the parameter values and store them in the digital operator, select o3-02= “1: Enabled”. If you attempt to READ the data, which overwrites any previously stored data, without first setting o3-02= “1: Enabled”, you will get the following error:

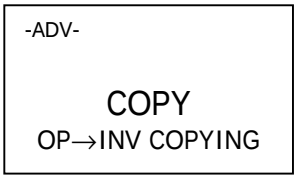


After setting o3-02= “1: Enabled”, it is possible to store parameter values in the digital operator by setting o3-01=1 (INV→OP READ).

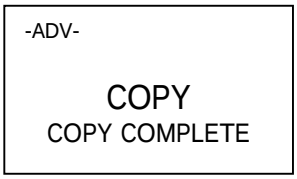
A successful READ of the parameter values will display:



An error may occur while saving the parameter values to the digital operator’s memory. If an error is displayed, press any key to cancel the error display and return to parameter o3-01. Error displays and their meanings are covered in *Chapter 6: Diagnostics and Troubleshooting* of the E7 Users Manual (TM.E7.01). To COPY parameter values into a Drive, set o3-01= “2: OP->INV WRITE”. During the writing of the parameter values into the Drive the digital operator will display:

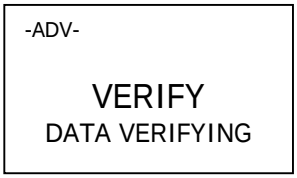


A successful COPY of the parameter values will display:

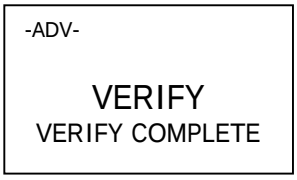


An error may occur while writing the parameter values to the Drive. If an error is displayed, press any key to cancel the error display and return to parameter o3-01. Error displays and their meanings are covered in *Chapter 6: Diagnostics and Troubleshooting* of the E7 Users Manual (TM.E7.01).

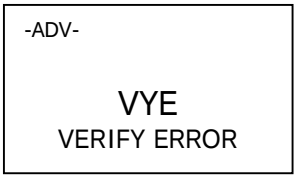
It is possible to compare the parameter values stored in the digital operator with the parameter values currently in the Drive by using the VERIFY function. This VERIFY function should not be confused with the "-VERIFY-"that is displayed on the digital operator when viewing the "Modified Constants" menu. To VERIFY the parameter values in the Drive as compared with those stored in the digital operator, set o3-01= "3: OP<-->INV VERIFY". During the comparing of the parameter values into the Drive the digital operator will display:



A successful VERIFY of the parameter values will display:



If all the parameter values stored in the digital operator do not match those programmed in the Drive, the digital operator displays the following:



The digital operator will not display which parameters did not match, only that the verification found discrepancies in some parameter values.

NOTE: In order to properly use the COPY or VERIFY functions, the following Drive specifications must be identical between the Drive that the parameters were read from and the Drive that the parameters are to be written to:

- Model Number (e.g. CIMR-E7U2015)
- Software Number (e.g. 03011 also known as FLASH ID)

Yaskawa offers DriveWizard™ software that can also READ, COPY, and VERIFY Drive parameter values. DriveWizard™ lists all discrepancies between the Drive and a pre-saved parameter file when verifying is performed.

To use DriveWizard first select o2-15= “0: Disabled” and select o2-06= “0: Disabled” then remove the digital operator/keypad and attach the DriveWizard cable in its place.

◆ T1 Auto-Tuning

■ T1-02 Motor Rated Power

Setting Range: 0.00 to 650.00 kW
Factory Default: Model Dependent

■ T1-04 Motor Rated Current

Setting Range: Model Dependent
Factory Default: Model Dependent

Auto tuning is recommended to achieve optimum performance. In addition, the Drive requires Line-To-Line Resistance auto-tuning before it can properly perform the Estimated Speed Search method. This method of speed search allows for bi-directional speed search. The T1 parameters are found under the Auto-Tuning menu.

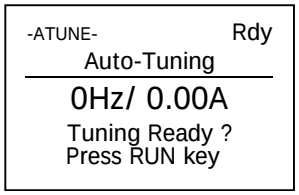
To perform auto-tuning follow these steps:

1. In T1-02, enter the rated power in kilowatts (kW) of the motor attached to the Drive. If the motor nameplate lists the rated power in terms of horsepower (HP), use the following formula to convert to kW before setting the value of T1-02:

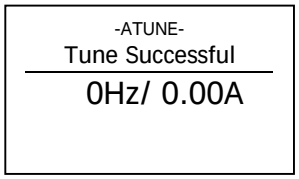
$$kW = HP \times 0.746$$

2. In T1-04, enter the Full Load Amps (FLA) as stamped on the motor's nameplate.

3. Press the INCREASE key once to display this:



4. If ready, press the RUN key once to start auto-tuning. This process will last for approximately 15 seconds. Once auto-tuning is finished, the digital operator will display this:



5. To exit the Auto-Tuning menu, press the MENU key once.

NOTE: It is possible to a get a "Data Invalid" error if the either T1-02 or T1-04 fall outside the range of what the Drive will accept as reasonable levels for the programmed size of drive (o2-04).

Notes:

Chapter 6
Diagnostics & Troubleshooting

This chapter describes diagnostics and troubleshooting for the Drive.

Fault Detection 6-2
Alarm Detection 6-8
Operator Programming Errors (OPE) 6-11
Auto-Tuning Faults 6-12
Digital Operator Copy Function Faults 6-13
Troubleshooting 6-14
Main Circuit Test Procedure 6-20
Drive Date Stamp Information 6-24

Fault Detection

When the Drive detects a fault, the fault information is displayed on the digital operator, the fault contact closes, and the motor coasts to stop. (However, a fault with selectable stopping method will operate according to the stopping method selected.)

- If a fault occurs, take appropriate action according to the table by investigating the cause.
- To restart, reset the fault with any of the following procedures:
  - Turn ON the fault reset signal.
  - Set “14: Fault Reset” to a multi-function digital input (H1-01 to H1-05).
  - Press the RESET key of the digital operator.
  - Shut off the Drive input power once, and then turn on again.

WARNING The Run Command (Start Command) needs to be removed prior to resetting a fault. Resetting a fault by removing and reapplying power to the Drive while the Run Command is applied, may cause the Drive to start unexpectedly. Therefore, make sure all personnel are clear from the Drive, motor, and machine prior to resetting the Drive.

Table 6.1 Fault Displays and Processing

Digital Operator Display	Description	Cause	Corrective Action
BUS Option Com Err	Option Communication Error After initial communication was established, the connection was lost.	Connection is broken, master has stopped communicating	Check all connections, verify all user-side software configurations.
CE Memobus Com Err	Modbus Communication Error Control data was not received correctly for two seconds	Connection is broken, master has stopped communicating	Check all connections, verify all user-side software configurations.
CPF00 COM-ERR(OP&INV)	Operator Communication Fault 1 Transmission between the Drive and the digital operator cannot be established within 5 seconds after supplying power	Digital operator cable not securely connected, digital operator defective, control board defective	Remove the digital operator once and then reinstall it
	External RAM of CPU is defective	Control circuit damage	Cycle power off and on to the Drive
			Replace the Drive
CPF01 COM-ERR(OP&INV)	Operator Communication Fault 2 After communication started with the digital operator, a communication fault occurred for 2 seconds or more	Digital operator cable not securely connected, digital operator defective, control board defective	Remove the digital operator once and then reinstall it
			Cycle power off and on to the Drive
			Replace the Drive
CPF02 BB Circuit Err	Baseblock Circuit Fault Baseblock circuit fault at power-up	Gate array hardware failure during power-up	Perform a factory initialization
			Cycle power off and on to the Drive
			Replace the control board
CPF03 EEPROM Error	EEPROM Fault EEPROM fault, check sum not valid	Noise or spike on the control circuit input terminals	Perform a factory initialization
			Cycle power off and on to the Drive
			Replace the control board

Table 6.1 Fault Displays and Processing			
Digital Operator Display	Description	Cause	Corrective Action
CPF04 Internal A/D Err	CPU Internal A/D Converter Fault	Noise or spike on the control circuit input terminals	Perform a factory initialization
			Cycle power off and on to the Drive
			Replace the control board
CPF05 External A/D Err	CPU External A/D Converter Fault	Noise or spike on the control circuit input terminals	Perform a factory initialization
			Cycle power off and on to the Drive
			Replace the control board
CPF07 RAM-Err	ASIC Internal RAM Fault (RAM)	- - -	Cycle power off and on to the Drive
		Control circuit damage	Replace the Drive
CPF08 WAT-Err	Watchdog Timer Fault (WAT)	- - -	Cycle power off and on to the Drive
		Control circuit damage	Replace the Drive
CPF09 CPU-Err	CPU-ASIC Mutual Diagnosis Fault (COY)	- - -	Cycle power off and on to the Drive
		Control circuit damage	Replace the Drive
CPF10 ASIC-Err	ASIC Version Fault (ASIC)	Control circuit damage	Replace the Drive
CPF20 Option A/D Error	Option Card Fault	Option card connector connection fault	Remove all inputs to the option board
		Option card A/D converter fault	Perform a factory initialization
			Cycle power off and on to the Drive
			Replace the option board
			Replace the Control board
CPF21 Option CPU Down	Self-diagnosis Fault of Communication Option Card	Noise or spike on the communication line, defective option board	Perform a factory initialization
			Cycle power off and on to the Drive
			Replace the option board
			Replace the control board
CPF22 Option Type Err	Communication Option Card Code Number Fault	Unrecognizable option board is connected to the control board	Remove any option boards
			Cycle power off and on to the Drive
			Perform a factory initialization
			Replace the option board
			Replace the control board
CPF23 Option DPRAM Err	Communication Option Card Interconnection Fault	An option board is not correctly connected to the control board or an option board that is not made for the Drive is attached to the control board	Remove power to the Drive
			Connect the option board once more
			Perform a factory initialization
			Cycle power off and on to the Drive
			Replace the option board
			Replace the control board

Table 6.1 Fault Displays and Processing			
Digital Operator Display	Description	Cause	Corrective Action
EF0 Opt External Flt	Communication Option Card External Fault	An external fault condition exists	Check for an external condition Verify the parameters Verify communication signal
EF3 Ext Fault S3	External Fault at Terminal S3	An external fault condition exists connected to a multi-function digital input	Eliminate the cause of an external fault condition
EF4 Ext Fault S4	External Fault at Terminal S4		
EF5 Ext Fault S5	External Fault at Terminal S5		
EF6 Ext Fault S6	External Fault at Terminal S6		
EF7 Ext Fault S7	External Fault at Terminal S7		Remove the fault from a multi-function digital input
FBL Feedback Loss	PI Feedback Loss This fault occurs when PI Feedback Loss Detection is programmed to fault (b5-12 = 2) and the PI Feedback < PI Feedback Loss Detection Level (b5-13) for the PI Feedback Loss Detection Time (b5-14)	PI Feedback source (e.g. transducer, sensor, building automation signal) is not installed correctly or is not working	Verify Drive is programmed to receive the PI Feedback source signal Check to ensure the PI Feedback source is installed and working properly
GF Ground Fault	Output Ground Fault Drive output grounding current has exceeded 50% of the Drive rated output current	Motor lead is shorted to ground, DCCT defective	Remove the motor and run the Drive without the motor Check the motor for a phase to ground short. Check the output current with a clamp on meter to verify the DCCT reading
LF Output Phase Loss	Output Open-phase An open-phase occurred at the Drive output This fault is detected when output current has exceeded 5% imbalance.	There is a broken wire in the output cable. There is a broken wire in the motor winding. The output terminals were loose.	Check the wiring to the motor. Check the motor for phase to ground short.
		The motor being used has a capacity less than 5% of the Drive's maximum motor capacity.	Check the motor and Drive capacity.
		Low impedance motor was used.	Add additional impedance.
		Parameter E2-03 set incorrectly	Adjust E2-03 to a lower value.
LL3 Loss of Load Det 1	Loss of Load Detection 1 Drive output current < L6-02 for more than the time set in L6-03	Motor is underloaded	Ensure the values in L6-02 and L6-03 are appropriate Check application/machine status to eliminate fault

Table 6.1 Fault Displays and Processing			
Digital Operator Display	Description	Cause	Corrective Action
OC Over Current	Overcurrent Drive output current exceeded the overcurrent detection level (approximately 180% of Drive rated output current)	Shorted Drive output phase to phase, shorted motor, locked rotor, load too heavy, accel/ decel time too short, contactor on the Drive output is opened and closed, a special motor or a motor with a FLA rating larger than Drive rated output current	Remove the motor and run the Drive without the motor
			Check the motor for a phase-to-phase short
			Check the Drive for a phase-to-phase short at the output
			Verify C1-01 and C1-02 are set correctly
			Check load conditions
OH1 Heatsnk MAX Temp	Cooling Fin/Cooling Fin Fan Overheat The temperature of the Drive cooling fin exceeded the temperature programmed in parameter L8-02	Cooling fan(s) are not working, high ambient temperature, a heat source is too close to the Drive	Check for dirt build-up on the fans and cooling fins
			Reduce the ambient temperature around the Drive
	Drive Internal Cooling Fan		Remove the heating unit
OH3 Motor Overheat 1	Motor Overheating Alarm The Drive stops or continues operation according to the setting of L1-03.	Overheating of motor as measured by motor thermistor	Recheck the cycle time and the size of the load
			Recheck the accel/decel time (C1-01 and C1-02)
			Recheck the V/F pattern (E1-01 thru E1-13)
			Recheck the motor rated current value (E2-01)
OH4 Motor Overheat 2	Motor Overheating Fault The Drive stops operation according to the setting of L1-04.	Overheating of motor as measured by motor thermistor	Recheck the cycle time and the size of the load
			Recheck the accel/decel time (C1-01 and C1-02)
			Recheck the V/F pattern (E1-01 thru E1-13)
			Recheck the motor rated current value (E2-01)
OL1 Motor Overloaded	Motor Overload Designed to protect the motor. Fully adjustable from parameter E2-01	The load is too large. The cycle time is too short at the accel/decel time	Recheck the cycle time and the size of the load as well as the times set in C1-01 and C1-02
		The voltage of the V/F pattern is high	Review the V/F pattern parameters, E1-01 thru E1-13
		Motor rated current setting is improper	Check the motor rated current value in E2-01
OL2 Inv Overloaded	Drive Overload Designed to protect the Drive	The load is too large. The cycle time is too short at the accel/decel time	Recheck the cycle time and the size of the load as well as the times set in C1-01 and C1-02
		The voltage of the V/F pattern is high	Review the V/F pattern parameters, E1-01 thru E1-13
		The size of the Drive is small	Change to a larger size Drive
OL3 Overtorque Det 1	Overtorque Detection 1 Drive output current > L6-02 for more than the time set in L6-03	Motor is overloaded	Ensure the values in L6-02 and L6-03 are appropriate
			Check application/machine status to eliminate fault

Table 6.1 Fault Displays and Processing

Digital Operator Display	Description	Cause	Corrective Action
OPR Oper Disconnect	Digital Operator Connection Fault The Drive will stop if the digital operator is removed when the Drive is commanded to run through the digital operator	The digital operator is not attached or the digital operator connector is broken	Attach the digital operator
			Check the digital operator connector
			Verify the setting of o2-06
OV DC Bus Overvolt	DC Bus Overvoltage 208-240Vac: Trip point is ≥ 400Vdc 480Vac: Trip point is ≥ 800Vdc	High input voltage at R/L1, S/L2 and T/L3	Check the input circuit and reduce the input power to within specifications
		The deceleration time is set too short	Extend the time in C1-02
		Power factor correction capacitors are being used on the input to the Drive	Remove the power factor correction capacitors
PF Input Pha Loss	Input Phase Loss Drive input power supply has an open phase or has a large imbalance of input voltage	Open phase on input of the Drive	Check the input voltage
		Loose terminal screws at R/L1, S/L2 or T/L3.	Tighten the terminal screws
		Momentary power loss occurred	Check the input voltage
		Input voltage fluctuation too large	Check the input voltage
		Parameter L8-06 value is set incorrectly	Verify parameter L8-06 is set correctly per the kVA tables on pages B-4 and B-5. Adjust L8-06 according to your application. The higher the value the less sensitive it becomes. **CAUTION: Changing this parameter from the factory default setting may cause Drive failure and void the product warranty. (Consult the factory for application assistance).**
PUF DC Bus Fuse Open	DC Bus Fuse Detects if the DC bus fuse has opened	Shorted output transistor(s) or terminals	Remove power from the Drive
			Disconnect the motor
			Perform the checks without power in Table 6.6
			Replace the shorted component(s)
			Replace the defective fuse
RH DynBrk Resistor	Dynamic Braking Resistor The protection of the dynamic braking resistor based on setting of L8-01	Overhauling load, extended dynamic braking duty cycle, defective dynamic braking resistor	Verify dynamic braking duty cycle
			Monitor DC bus voltage
			Replace dynamic braking resistor
RR DynBrk Transistr	Dynamic Braking Transistor The dynamic braking transistor failed	Shorted dynamic braking transistor, high DC bus voltage, defective dynamic braking resistor	Cycle power off and on to the Drive
			Replace defective dynamic braking transistor or resistor
			Monitor DC bus voltage

Table 6.1 Fault Displays and Processing			
Digital Operator Display	Description	Cause	Corrective Action
UV1 DC Bus Undervolt	DC Bus Undervoltage The DC bus voltage is ≤ L2-05 208-240Vac: Trip point is ≤ 190Vdc 480Vac: Trip point is ≤ 380Vdc	Low input voltage at R/L1, S/L2 and T/L3	Check the input circuit and increase the input power to within specifications
		The acceleration time is set too short	Extend the time in C1-01
		Voltage fluctuation of the input power is too large	Check the input voltage
UV2 CTL PS Undervolt	Control Power Supply Undervoltage Undervoltage of the control circuit when running	External load connected pulling down the Drive power supplies	Cycle power off and on to the Drive
			Repair or replace the Power PCB/ Gate Drive PCB
			Remove all control wiring and test Drive
UV3 MC Answerback	Soft Charge Circuit Fault The pre-charge contactor opened while the Drive was running	Contacts on the soft charge contactor are dirty and the soft charge contactor does not function mechanically	Cycle power off and on to the Drive
			Check the condition of the soft charge contactor
			Repair or replace the Power PCB/ Gate Drive PCB

WARNING Some features within the PI function group, cause the Drive to shut down momentarily (e.g. Sleep Function, Snooze Function, Feedback Loss feature etc.) Upon recovery from the conditions that activate these features, the Drive may start unexpectedly. Therefore, when enabling these features take appropriate measures to notify personnel working with this equipment that unexpected starting may occur.

Alarm Detection

Alarms are Drive protection functions that does not operate the fault contact. The Drive will automatically return to its original status once the cause of the alarm has been removed.

During an alarm condition, the Digital Operator display flashes and an alarm output is generated at the multi-function outputs (H2-01 to H2-02) if programmed.

When an alarm occurs, take appropriate corrective action according to the table below.

Table 6.2 Alarm Displays and Processing

Digital Operator Display	Description	Cause	Corrective Action
BUS Option Com Err	Option Communication Error After initial communication was established, the connection was lost.	Connection is broken, master has stopped communicating	Check all connections, verify all user side software configurations.
CALL SI-F/G ComCall	Serial communication transmission error. Communication has not yet been established	Connection not made properly, user software not configured to the proper baud rate or configuration	Check all connections, verify all user side software configurations
EF External Fault	Both the forward and the reverse run commands are input simultaneously for 500mS or more. This alarm stops the motor.	An external forward and reverse command are input simultaneously	Check external sequence logic
EF0 Opt External Flt (Flashing)	Communication Option Card External Fault	An external fault condition exists	Check for an external condition Verify the parameters Verify communication signal
EF3 Ext Fault S3 (Flashing)	External Fault at Terminal S3	An external fault condition exists connected to a multi-function digital input	Eliminate the cause of an external fault condition
EF4 Ext Fault S4 (Flashing)	External Fault at Terminal S4		
EF5 Ext Fault S5 (Flashing)	External Fault at Terminal S5		
EF6 Ext Fault S6 (Flashing)	External Fault at Terminal S6		
EF7 Ext Fault S7 (Flashing)	External Fault at Terminal S7		Remove the fault from a multi-function digital input
DNE Drive not Enable (Flashing)	The Drive does not have the enable command when the run command is applied	The Run command has been applied prior to the enable signal	Apply the enable command before applying the run command

Table 6.2 Alarm Displays and Processing			
Digital Operator Display	Description	Cause	Corrective Action
FAN Cooling Fan Error	Failure of the Drive internal cooling fan when L8-32=0	Drive cooling fan has stopped	Replace the cooling fan
FBL Feedback Loss	PI Feedback Loss This fault occurs when PI Feedback Loss Detection is programmed to fault (b5-12 = 2) and the PI Feedback < PI Feedback Loss Detection Level (b5-13) for the PI Feedback Loss Detection Time (b5-14)	PI Feedback source (e.g. transducer, sensor, building automation signal) is not installed correctly or is not working	Verify Drive is programmed to receive the PI Feedback source signal Check to ensure the PI Feedback source is installed and working properly Check the motor for a phase-to-phase short Check the Drive for a phase-to-phase short at the output Verify C1-01 and C1-02 are set correctly Check load conditions
LL3 Loss of Load Det 1 (Flashing)	Loss of Load Detection 1 Drive output current < L6-02 for more than the time set in L6-03	Motor is underloaded	Ensure the values in L6-02 and L6-03 are appropriate Check application/machine status to eliminate fault
OH Heatsnk Overtemp (Flashing)	Cooling Fin/Cooling Fin Fan Overheat The temperature of the Drive cooling fin exceeded the temperature programmed in parameter L8-02	Cooling fan(s) are not working, high ambient temperature, a heating unit in close proximity to Drive is present	Check for dirt build-up on the fans and cooling fins Reduce the ambient temperature around the Drive
	Drive Internal Cooling Fan		Remove the heating unit
OH2 Over Heat 2 (Flashing)	Drive overheat pre-alarm signal is input from a multi-function digital input terminal	An external overheat condition exists connected to one of the multi-function input terminals S3, S4, S5, S6 or S7	Check for an external condition Verify the program parameters H1-01 thru H1-05
OH3 Motor Overheat 1 (Flashing)	Motor Overheating Alarm The Drive stops or continues operation according to the setting of L1-03.	Overheating of motor	Recheck the cycle time and the size of the load Recheck the accel/decel time (C1-01 and C1-02) Recheck the V/F pattern (E1-01 thru E1-13) Recheck the motor rated current value (E2-01) Check the digital operator connector Verify the setting of o2-06

Table 6.2 Alarm Displays and Processing			
Digital Operator Display	Description	Cause	Corrective Action
OV DC Bus Overvolt (Flashing)	DC Bus Overvoltage 208-240Vac: Trip point is ≥ 400Vdc 480Vac: Trip point is ≥ 800Vdc	High input voltage at R/L1, S/L2 and T/L3	Check the input circuit and reduce the input power to within specifications
		The deceleration time is set too short	Extend the time in C1-02
		Power factor correction capacitors are being used on the input to the Drive	Remove the power factor correction capacitors
OVRD Emergcy Override	Emergency Override Emergency Override is active	Forward or Reverse Emergency Override input is closed	- - -
PRHT Motor Preheating	Motor Preheating Motor is preheating	Motor Preheat 2 input is closed	- - -
UL3 Undertorq Det 1 (Flashing)	Undertorque Detection 1 Drive output current < L6-02 for more than the time set in L6-03	Motor is underloaded	Ensure the values in L6-02 and L6-03 are appropriate
			Check application/machine status to eliminate fault
UV DC Bus Undervolt (Flashing)	DC Bus Undervoltage The DC bus voltage is ≤ L2-05 208-240Vac: Trip point is ≤ 190Vdc 480Vac: Trip point is ≤ 380Vdc	Low input voltage at R/L1, S/L2 and T/L3	Check the input circuit and increase the input power to within specifications
		The acceleration time is set too short	Extend the time in C1-01
		Voltage fluctuation of the input power is too large	Check the input voltage
UV2 CTL PS Undervolt	Control Power Supply Undervoltage of the control circuit when running	External load connected pulling down the Drive power supplies	Cycle power off and on to the Drive
			Repair or replace the Power PCB/ Gate Drive PCB
UV3 MC Answerback	Soft Charge Circuit Fault The pre-charge contactor opened while the Drive was running	Contacts on the soft charge contactor are dirty and the soft charge contactor does not function mechanically	Cycle power off and on to the Drive
			Check the condition of the soft charge contactor

Operator Programming Errors (OPE)

An Operator Programming Error (OPE) occurs when an inapplicable parameter is set or an individual parameter setting is inappropriate.

The Drive does not operate until the parameter is set correctly. (Alarm output and fault contact do not operate.)

If an OPE occurs, change the appropriate parameter by checking the cause shown in Table 6.3.

Table 6.3 OPE Error and Fault Displays

Digital Operator Display	Description	Cause	Corrective Action
OPE01 kVA Selection t	Drive kVA setting error.	The control board was replaced and the kVA parameter is set incorrectly	Enter the correct kVA setting (o2-04) by referring to the Drive model number in Appendix B
OPE02 Limit	Constant data out of range.	Parameter set above the allowable range.	Verify the program settings
OPE03 Terminal	Multi-function input selection fault.	Duplicate functions are selected, up/down commands or trim control increase/decrease are not set simultaneously. Speed search from maximum frequency and set frequency are set simultaneously. Emergency override FWD (H1-0X = 81) and Emergency Override REV (H1-0X = 82) are set simultaneously.	Verify program settings (H1-01~H1-05)
OPE05 Sequence Select	Run command is selected through serial communication at 2CN but option board is not installed.	Serial communication option board is not installed, option board is installed incorrectly. The run command selection parameter B1-02 is set to 3 and option board is not installed.	Verify that the board is installed. Remove power to the Drive and connect the option board once more.
OPE10 V/f Ptrn Setting	V/f data setting fault	V/f parameter settings are not set correctly.	Check parameters (E1-04 ~ E1-11). A minimum frequency/voltage value may be set higher than the maximum frequency/voltage.
OPE11 CarrFrq/On-Delay	Carrier frequency data setting fault. Carrier frequency proportional gain C6-05 > 6 and C6-04 > C6-03. Upper/lower limit error of C6-03 to 5.0kHz	Parameter setting incorrect.	Check the program settings and correct the errors.
ERR EEPROM R/W Err	It does not match at EEPROM write.	• Power supply is turned OFF. • Parameter is reset repeatedly.	• Cycle power off and on to Drive. • Do a factory initialization (A1-03).

Auto-Tuning Faults

Auto-tuning faults are shown below. When the following faults are detected, the fault is displayed on the digital operator and the motor coasts to a stop during operation. The fault contact is not activated.

Table 6.4 Auto-Tuning Displays and Processing

Digital Operator Display	Probable Cause	Corrective Action
Er - 01 Fault	•There is an error in the data input for autotuning. •There is an error in the relationship between the motor output and the motor rated current.	• Check input data. • Check Drive and motor capacity. • Check motor rated current.
Er - 02 Minor Fault	A minor fault is detected during auto-tuning.	• Check input data. • Check wirings and around the machine. • Check the load.
Er - 03 STOP key	The STOP key is pressed during auto-tuning, and the auto-tuning is interrupted.	–
Er - 04 Resistance	Auto-tuning is not completed within the specified time. The auto-tuning result became other than the parameter set range.	• Check input data. • Check motor wiring. • If a motor and a machine are connected, disconnect the motor from the machine.
Er - 12 I-det. Circuit	•Current flow exceeded the motor rated current. •Current detection value symbol was reversed. •Any of U/TI, V/T2, and W/T3 has open-phase.	• Check current detection circuit, wiring and mounting procedure.
Er - 13 Leakage Inductance Fault	Auto-tuning did not finish within the set time. Tuning result became other than the parameter setting range.	• Check motor wiring.
End - 3 Data Invalid	Rated current set value is set too high.	• Check input data (especially, motor output current and motor rated current value).

Digital Operator COPY Function Faults

These faults can occur occurred during the operator COPY function. Fault content is displayed on the operator. An error during the COPY function does not activate the fault contact output or alarm output.

Table 6.5 Digital Operator COPY Function Faults

Function	Digital Operator Display	Probable Causes	Corrective Action
READ Function	PRE READ IMPOSSIBLE	o3-01 was set to 1 to write a parameter when the Digital Operator was write-protected (o3-02 = 0).	Set o3-02 to 1 to enable writing parameters with the Digital Operator.
	IFE READ DATA ERROR	The read data length does not agree. The write data is incorrect.	• Repeat the Read. • Check the Digital Operator cable. • Replace digital operator.
	RDE DATA ERROR	An attempted write of a parameter to EEPROM on the Digital Operator failed.	• A low Inverter voltage has been detected. • Repeat the read • Replace Digital Operator.
COPY Function	CPE ID UNMATCHED	The Drive product code or software number is different.	Use COPY function for the same product code and software number.
	VAE INV. KVA UNMATCH	The capacity of the Drive being copied and the capacity in the Digital Operator are different.	Use COPY function for the same Drive capacity.
	CRE CONTROL UNMATCHED	The control method of the Drive being copied and the control method in the Digital Operator are different.	Use the COPY function for the same control method.
	CYE COPY ERROR	The parameter written to the Drive was compared with the parameter in the Digital Operator and they were different.	COPY retest
	CSE SUM CHECK ERROR	The checksum in the Drive parameter area was compared with the checksum in the Digital Operator parameter area and they were different.	Retry the copy.
Verify Function	VYE VERIFY ERROR	The set value of the digital operator and the Drive do not match.	Retry Verify function After COPY is retested, Verify is retested

Troubleshooting

Due to parameter setting errors, faulty wiring, etc., the Drive and motor may not operate as expected when the system is started up. If this occurs, use this section as a reference and apply the appropriate measures.

If a fault is displayed on the digital operator, refer to Fault Detection, Table 6.1.

◆ If Parameter Cannot Be Set

Use the following information if a Drive parameter cannot be set.

■The display does not change when the INCREASE and DECREASE keys are pressed.

The following causes are possible.

The Drive is operating (drive mode).

There are some parameters that cannot be set during operation. Remove the run command and then set the parameters.

Parameter write enable is input.

This occurs when “parameter write enable” (set value: 1B) is set for a multi-function digital input terminal (H1-01 to H1-05). If the parameter write enable input is OFF, the parameters cannot be changed. Turn it ON and then set the parameters.

Passwords do not match. (Only when a password is set.)

If the parameter A1-04 (Password) and A1-05 (Password Setting) numbers are different, the parameters for the initialize mode cannot be changed. Enter the correct password in A1-04.

If you cannot remember the password, display A1-05 (Password Setting) by pressing the Shift/Reset Key and the MENU Key simultaneously while in the A1-04 display. Reset the password and input the reset password in parameter A1-04.

■OPE01 through OPE11 is displayed.

The set value for the parameter is wrong. Refer to Operator Programming Errors in this chapter and correct the setting.

■CPF00 or CPF01 is displayed.

This is a Digital Operator communications error. The connection between the Digital Operator and the Drive may be faulty. Remove the Digital Operator and then re-install it.

◆ If the Motor Does Not Operate

Use the following information if the motor does not operate.

■Ensure the digital operator is securely connected to the Drive.

■The motor does not operate when the LOCAL/REMOTE key on the Digital Operator is pressed and the REMOTE SEQ and REF lights are out.

The following causes are possible:

The Speed Command (Frequency Reference) is too low.

If the Speed Command (frequency reference) is set below the frequency set in E1-09 (Minimum Output Frequency), the Drive will not operate.

Raise the Speed Command to at least the minimum output frequency.

■The motor does not operate when an external run command is input.

The following causes are possible.

The Drive is not in drive mode.

If the Drive is not in drive mode, it will remain in ready status and will not start. Press the MENU key once and press the DATA/ENTER key. The Drive is now in drive mode.

The Speed Command is too low.

If the Speed Command is set below the frequency set in E1-09 (Minimum Output Frequency), the Drive will not operate. Raise the Speed Command to at least the minimum output frequency.

■The motor stops during acceleration or when a load is connected.

The load may be too high. The Drive has a stall prevention function and an automatic torque boost function, but the motor responsiveness limit may be exceeded if acceleration is too rapid or if the load is too great. Lengthen the acceleration time (CI-01) or reduce the load. Also consider increasing the motor size.

■The motor only rotates in one direction.

“Reverse run prohibited” may be selected. If b1-04 (Prohibition of Reverse Operation) is set to 1 (reverse run prohibited), the Drive will not receive reverse run commands. This is the default to use both forward and reverse operation, set b1-04 to 0, and operate in Auto mode.

◆ The Direction of the Motor Rotation is Reversed

If the motor rotates in the wrong direction, the motor output wiring is incorrect. When the Drive U/T1, V/T2, and W/T3 terminals are properly connected to the motor, the motor operates in a forward direction when a forward run command is received. The forward direction depends on the manufacturer and the motor type, so be sure to check the specifications.

The direction of rotation can be reversed by switching any two wires among U/TI, V/T2, and W/T3.

◆ If the Motor Does Not Put Out Torque or If Acceleration is Slow

Use the following information if the motor does not output torque or if acceleration is too slow.

■The stall prevention level during acceleration is too low.

If the value set for L3-02 (Stall Prevention Acceleration Level) is too low, the acceleration time will be too long. Check to be sure that the set value is suitable.

■The stall prevention level during running is too low.

If the value set for L3-06 (Stall Prevention Level during Running) is too low, the motor speed and torque will be limited. Check to be sure that the set value is suitable.

◆ If the Motor Operates at a Higher Speed Than the Speed Command

Use the following information if the motor operates at a higher speed than the Speed Command.

■A signal is being input to the Speed Command (current) terminal A2.

If a preset frequency reference is selected, the preset reference takes priority over the normal reference.

If the PI mode of operation is enabled, the drive output frequency will change to regulate the process variable to the desired setpoint. Then, the Drive speed may go to maximum.

◆ If the Motor Overheats

Take the following steps if the motor overheats.

■The load is too high.

If the motor load is too high and the motor is used when the effective torque exceeds the motor's rated torque, the motor will overheat. Reduce the load amount by either reducing the load or increasing the acceleration/deceleration times. Also consider increasing the motor size.

■The ambient temperature is too high.

The motor rating is determined by a particular ambient operating temperature range. The motor will overheat if it is run continuously at the rated torque in an environment where the maximum ambient operating temperature rating is exceeded. Lower the motor's ambient temperature to within its acceptable range.

■The withstand voltage between the motor phases is insufficient.

When the motor is connected to the Drive output, Voltage surges are generated by standing waves that can occur with certain combinations of drive carrier frequency and motor cable length. Normally the maximum surge voltage is three times the Drive's input power supply voltage (i.e., 1200Vac for a 480Vac). Be sure to use a motor with a withstand voltage between the motor phases that is greater than the maximum surge voltage. In particular, when using a 480Vac Drive, use an inverter-duty (NEMA MG1, Parts 30 & 31) motor. Motor protection filter can also be an effective measure.

◆ If Peripheral Devices Like PLCs or Others are Influenced by Starting or Running Drive

If noise is generated by Drive switching, implement the following countermeasures:

1. Change the Drive's Carrier Frequency Selection (C6-02) to lower the carrier frequency. This will help to reduce the amount of internal switching.
2. Install an Input Noise Filter at the Drive's input power terminals.
3. Use metal conduit. Electric waves can be shielded by metal, so encase the Drive and power wires in metal.
4. Ground the Drive and motor.
5. Separate main circuit wiring from control wiring.

◆ If the Ground Fault Interrupter Operates When the Drive is Run

The Drive performs internal switching, so there is a certain amount of leakage current. This may cause an external ground fault interrupter to operate and cut off the power supply. Whenever possible, use a ground fault interrupter with a high leakage detection level (i.e., a sensitivity current of 200 mA or greater per Unit, with an operating time of 0.1 s or more), or one that incorporates high frequency countermeasures (i.e., one designed for use with Drives). It will also help to change the Drive's Carrier Frequency Selection (C6-02) to lower the carrier frequency. In addition, remember that the leakage current increases as the cable is lengthened.

◆ If There is Mechanical Vibration

Use the following information when there is mechanical vibration.

■The application is making unusual sounds.

The following causes are possible.

There may be resonance between the mechanical system's natural frequency and the carrier frequency.

This is characterized by the motor running with no noise generation, but the machinery vibrates with a high-pitched whine. To prevent this type of resonance, adjust the carrier frequency with parameters C6-02 to C6-05.

There may be resonance between an applications characteristic frequency and the output frequency of the Drive.

To prevent this from occurring, use the jump frequency functions in parameters d3-01 to d3-04, or have the driven motor and load balanced to reduce vibration.

■ Oscillation and hunting are occurring with V/f control.

The gain adjustment may be insufficient. Reset the gain to a more effective level by raising the value of C4-02 (Torque Compensation Primary Delay Time Parameter) and then lowering the setting of n1-02 (Hunting Prevention Gain).

■Oscillation and hunting are occurring with PI control.

If there is oscillation or hunting during PI control, check the oscillation cycle and individually adjust P and I parameters.

- •Disable integral (I) control
- •Reduce the proportional gain (P) until hunting stops
- •Reintroduce the integral function, starting with long integral time values, to eliminate the P offset

◆ If the Motor Rotates Even When Drive Output is Stopped

If the motor rotates even when the Drive is stopped, the DC injection braking may be insufficient. If the motor continues operating at low speed, without completely stopping after a stop has been executed, it means that the DC injection braking is not decelerating the motor enough. Adjust the DC injection braking as follows:

- Increase the parameter b2-04 (DC Injection Braking (initial excitation) Time at Stop) setting.
- Increase the parameter b2-02 (DC Injection Braking Current) setting.

◆ If Zero Volts is Detected When a Motor is Started, or Stalls

Generation of 0 V (main circuit voltage) and stalling can occur if a motor is turning when it is started and the DC injection braking is insufficient.

This can be prevented by slowing motor rotation by DC injection braking before starting. Increase parameter b2-03 (DC injection braking time at start) setting.

◆ If the Accepted Speed Command Does Not Rise to the User Speed Command Input

■The Speed Command is within the jump frequency range.

When the jump frequency function is used, the output frequency cannot be set within the jump frequency range. Check to be sure that the Jump Frequency (parameters d3-01 to d3-03) and Jump Frequency Width (parameter d3-04) settings are suitable.

■The frequency reference upper limit has been reached.

The output frequency upper limit is determined by the following formula:

Freq Ref Upper Limit = Maximum Output Frequency (E1-04) × Frequency Reference Upper Limit (d2-01) / 100

Check to be sure that the parameter E1-04 and d2-01 settings are suitable.

Main Circuit Test Procedure

WARNING

Prior to removing any protective cover or wiring any part of the Drive, remove all power sources, including main input power and control circuit power. Wait a minimum of 5 minutes after power removal, before removing any cover. The charge lamp located within the Drive should be off prior to working inside. Even if the charge lamp is off, one must measure the AC input, output, and DC Bus potential to insure safe levels prior to resuming work. Failure to adhere to this warning may result in personal injury or death.

Before attempting any troubleshooting checks, make sure that the three-phase power is disconnected and locked out. With power removed from the unit, the DC bus capacitors will stay charged for several minutes. The Charge LED in the Drive will glow red until the DC bus voltage is below 10Vdc. To ensure that the DC bus is completely discharged, measure between the positive and negative bus with a DC voltmeter set to the highest scale.

Table 6.6 Main Circuit Test Procedure

Check	Procedure
Measure DC Bus Voltage	1. Set the digital multi-meter to its highest VDC scale. 2. Measure between ⊕ 1 and (-) for the following check: Place the positive (red) meter lead on ⊕ 1. Place the negative (black) meter lead on (-). 3. If the measured voltage is < 10Vdc, it is safe to work inside the Drive. If not, wait until the DC Bus has completely discharged.
Input Diodes (D1-D12 or Q1)	The input diodes rectify or transform the three-phase input AC voltage into a DC voltage. 1. Set a digital multi-meter to the Diode Check setting. 2. Place the positive (red) meter lead on terminal R/L1. Place the negative (black) meter lead on terminal ⊕ 1. Expected reading is about 0.5 Volts. 3. Place the positive (red) meter lead on terminal S/L2. Place the negative (black) meter lead on terminal ⊕ 1. Expected reading is about 0.5 Volts. 4. Place the positive (red) meter lead on terminal T/L3. Place the negative (black) meter lead on terminal ⊕ 1. Expected reading is about 0.5 Volts. 5. Place the positive (red) meter lead on terminal R/L1. Place the negative (black) meter lead on terminal (-). Expected reading is OL displayed. 6. Place the positive (red) meter lead on terminal S/L2. Place the negative (black) meter lead on terminal (-). Expected reading is OL displayed. 7. Place the positive (red) meter lead on terminal T/L3. Place the negative (black) meter lead on terminal (-). Expected reading is OL displayed. 8. Place the positive (red) meter lead on terminal (-). Place the negative (black) meter lead on terminal R/L1. Expected reading is about 0.5 Volts. 9. Place the positive (red) meter lead on terminal (-). Place the negative (black) meter lead on terminal S/L2. Expected reading is about 0.5 Volts. 10. Place the positive (red) meter lead on terminal (-). Place the negative (black) meter lead on terminal T/L3. Expected reading is about 0.5 Volts. **(Continued on next page)**

Table 6.6 Main Circuit Test Procedure	
Check	Procedure
Input Diodes (D1-D12 or Q1)	**(Continued from previous page)** 11. Place the positive (red) meter lead on terminal ⊕ 1. Place the negative (black) meter lead on terminal R/L1. Expected reading is OL displayed. 12. Place the positive (red) meter lead on terminal ⊕ 1. Place the negative (black) meter lead on terminal S/L2. Expected reading is OL displayed. 13. Place the positive (red) meter lead on terminal ⊕ 1. Place the negative (black) meter lead on terminal T/L3. Expected reading is OL displayed.
Soft Charge Resistor Check (R1, R2, 6PCB)	The soft charge resistor works in conjunction with the soft charge contactor to slowly charge the DC bus capacitors to minimize the inrush current when power is applied to the Drive. 1. Conduct a visual inspection. Check for physical damage. 2. Set a digital multi-meter to the R x 1 scale. 3. If the resistor is damaged, the measured value will be infinite ohms.
Soft Charge Contactor (K1)	The purpose of the soft charge contactor is to bypass the soft charge resistor after the DC bus voltage has reached its normal operating level. 1. Conduct a visual inspection. Check for physical damage. 2. Set a digital multi-meter to the R x 1 scale. 3. On Drives with a board-mounted contactor, verify that each contact resistance measures infinite ohms. 4. On Drives without a board-mounted contactor, press the plunger in, and verify that each contact measures zero ohms. 5. On Drives without a board-mounted contactor, release the plunger, and verify that the resistance is the ohmic value of the soft charge resistor. 6. On Drives with a board-mounted contactor, verify that the contactor coil measures about 300 ohms. The coil can be tested by applying the appropriate voltage to verify the contacts change states. 7. On Drives without a board-mounted contactor, verify that the 230Vac contactor coil measures about 175 ohms. The coil can be tested by applying the appropriate voltage to verify the contacts change states. 8. On Drives without a board-mounted contactor, verify that the 24Vdc auxiliary coil measures about 2.2M ohms. The coil can be tested by applying the appropriate voltage to verify the contacts change states.
DC Bus Fuse (F1)	The DC bus fuse is located in the negative portion of the DC Bus. The DC bus fuse is used to protect the main circuit components if the output transistors short. If the DC bus fuse is open, at least one of the output transistors has failed. When a transistor fails, there is a short between the positive and negative portions of the DC Bus. The DC bus fuse does not protect the transistors, but protects the rest of the main circuit from the high current present during a short. ***Never replace the DC bus fuse without first checking all of the output transistors.*** 1. Set a digital multi-meter to the R x 1 scale. 2. Place one lead of the multi-meter on one side of the fuse and place the other lead of the multi-meter on the other side of the fuse. 3. If the fuse is good, the measured value will be zero ohms. If the fuse is bad, the measured value will be infinite ohms.

Table 6.6 Main Circuit Test Procedure	
Check	Procedure
Output Transistors (Q1-Q12)	The output transistors are used to switch the DC bus voltage to allow current to flow to the motor. 1. Set a digital multi-meter to the Diode Check setting. 2. Place the positive (red) meter lead on terminal U/T1. Place the negative (black) meter lead on terminal ⊕ 1. Expected reading is about 0.5 Volts. 3. Place the positive (red) meter lead on terminal V/T2. Place the negative (black) meter lead on terminal ⊕ 1. Expected reading is about 0.5 Volts. 4. Place the positive (red) meter lead on terminal W/T3. Place the negative (black) meter lead on terminal ⊕ 1. Expected reading is about 0.5 Volts. 5. Place the positive (red) meter lead on terminal U/T1. Place the negative (black) meter lead on terminal (-). Expected reading is OL displayed. 6. Place the positive (red) meter lead on terminal V/T2. Place the negative (black) meter lead on terminal (-). Expected reading is OL displayed. 7. Place the positive (red) meter lead on terminal W/T3. Place the negative (black) meter lead on terminal (-). Expected reading is OL displayed. 8. Place the positive (red) meter lead on terminal (-). Place the negative (black) meter lead on terminal U/T1. Expected reading is about 0.5 Volts. 9. Place the positive (red) meter lead on terminal (-). Place the negative (black) meter lead on terminal V/T2. Expected reading is about 0.5 Volts. 10. Place the positive (red) meter lead on terminal (-). Place the negative (black) meter lead on terminal W/T3. Expected reading is about 0.5 Volts. 11. Place the positive (red) meter lead on terminal ⊕ 1. Place the negative (black) meter lead on terminal U/T1. Expected reading is OL displayed. 12. Place the positive (red) meter lead on terminal ⊕ 1. Place the negative (black) meter lead on terminal V/T2. Expected reading is OL displayed. 13. Place the positive (red) meter lead on terminal ⊕1. Place the negative (black) meter lead on terminal W/T3. Expected reading is OL displayed.
Control Power Fuse	All Drives have a Control Power Fuse. The fuse is located on either the Power PCB (3PCB) or the Gate Drive PCB (3PCB). The Control Power Fuse protects the primary switching mode power supply. 1. Set a digital multi-meter to the R x 1 scale. 2. Place one lead of the multi-meter on one side of the fuse and place the other lead of the multi-meter on the other side of the fuse. 3. If the fuse is good, the measured value will be zero ohms. If the fuse is bad, the measured value will be infinite ohms.

Table 6.6 Main Circuit Test Procedure	
Check	Procedure
24Vdc Cooling Fans (Heat Sink & Internal)	The Heat Sink & Internal Cooling Fans cool the heat sink as well as the output transistor modules of the Drive. 1. Conduct a visual inspection to ensure the fan turns freely. 2. If there is no physical evidence that the fan is bad, the fan motor can be checked with a 3. digital multi-meter. 4. Set the digital multi-meter to the R x 1 scale. 5. Measure across the fan motor terminals. If zero ohms are measured, conclude that the fan motor is shorted. If infinite ohms are measured, conclude that the fan motor is burned open. 6. If the fan is not working, then disconnect the fan and apply 24Vdc to the fan to test the motor.
230/240Vac Cooling Fans (Heat Sink)	The Heat Sink Cooling Fans cool the heat sink to remove heat from the Drive. 1. Conduct a visual inspection to ensure the fan turns freely. 2. If there is no physical evidence that the fan is bad, the motor can be checked with a digital multi-meter. 3. Set a digital multi-meter to the R x 1 scale. 4. Measure across the fan motor terminals. If the fan motor is good, the measured value should be about 500 ohms. If zero ohms are measured, conclude that the fan motor is shorted. If infinite ohms are measured, conclude that the fan motor is burned open. If the fan is not working, then disconnect the fan and apply 230/240Vac to the fan to test the motor.
Cooling Fan Fuse	Large Drive units contain a Cooling Fan Fuse. It is located on either the Gate Drive Board (3PCB) or the Tap Change Board (8PCB). If the Cooling Fan Fuse is open, then the 230/240Vac cooling fans may be defective. 1. Set a digital multi-meter to the R x 1 scale. 2. Place one lead of the multi-meter on one side of the fuse and place the other lead of the multi-meter on the other side of the fuse. 3. If the fuse is good, the measured value will be zero ohms. If the fuse is bad, the measured value will be infinite ohms.

Drive Date Stamp Information

This information is used to determine when a Drive was built to see if it is within its warranty period. The date stamp is located on the lower right side of the Drive.

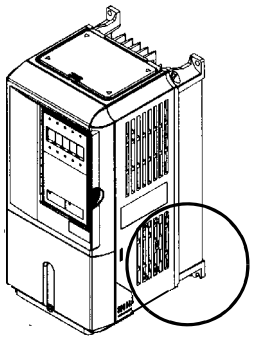
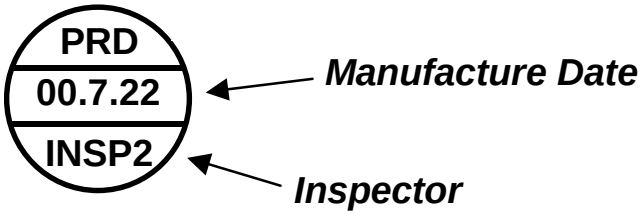


Fig 6.1 Date Stamp Location



Chapter 7
Maintenance

This chapter describes basic maintenance and inspection of the Drive. Please refer to these instructions to ensure that the Drive receives the proper maintenance to maintain overall performance.

Periodic Inspection 7-2
Preventive Maintenance 7-3
Heatsink Cooling Fan Replacement 7-4
Removing and Mounting the Terminal Card 7-6

Periodic Inspection

Check the following items during periodic maintenance.

- The motor should not be vibrating or making unusual noises.
- There should be no abnormal heat generation from the Drive or motor.
- The ambient temperature should be within the Drive specification of -10°C to 40°C (14°F to 104°F).
- The output current value shown in parameter U1-03 should not be higher than the motor rated current for an extended period of time.
- The cooling fan in the Drive should be operating normally.

Always turn OFF the input power before beginning inspection. Confirm that the digital operator indicators on the front cover have all turned OFF, and then wait an additional five minutes before beginning the inspection. Be sure not to touch terminals immediately after the power has been turned off. Doing so can result in electric shock. Please refer to Warnings on page i.

WARNING Prior to removing any protective cover or wiring any part of the Drive, remove all power sources, including main input power and control circuit power. Wait a minimum of 5 minutes after power removal, before removing any cover. The charge lamp located within the Drive should be off prior to working inside. Even if the charge lamp is off, one must measure the AC input, output, and DC Bus potential to insure safe levels prior to resuming work. Failure to adhere to this warning may result in personal injury or death.

Table 7.1 Periodic Inspections With no Power Applied

Item	Inspection	Corrective Action
External terminals, mounting bolts, connectors, etc.	Are all screws and bolts tight?	Tighten loose screws and bolts firmly.
	Are connectors tight?	Reconnect the loose connectors.
Cooling fins	Are the fins dirty or dusty?	Clean off any dirt and dust with an air gun using clean and dry air at a pressure between 55-85 psi.
Control PCB Terminal PCB Power PCB Gate Drive PCBs	Is there any conductive dirt or oil mist on the PCBs?	Clean off any dirt and dust with an air gun using clean and dry air at a pressure between 55-85 psi. Replace the boards if they cannot be made clean.
Input Diodes IPMs Output Transistors	Is there any conductive dirt or oil mist on the modules or components?	Clean off any dirt and dust with an air gun using clean and dry air at a pressure between 55-85 psi.
DC bus capacitors	Are there any irregularities, such as discoloration or odor?	Replace the capacitors or Drive.

Apply power to the Drive and conduct the following inspection.

Table 7.2 Periodic Inspections With Power Applied

Item	Inspection	Corrective Action
Cooling fan(s)	Is there any abnormal noise or vibration, or has the total operating time exceeded 20,000 hours.Check U1-40 for elapsed cooling fan operation time.	Replace Cooling Fan

Preventive Maintenance

Table 7.3 Preventive Maintenance				
Inspection Points	Item	Check Points	Every 3-6 Months	Yearly
General	Environment	Ambient Temperature Humidity Dust Harmful Gas Oil Mist	X X X X X	
	Equipment	Abnormal vibration or noise	X	
	AC Power Supply	Main circuit & control voltage	X	
AC Power Circuit & Devices	Conductors & Wire Connections	Loose lugs, screws & wires Hot spots on parts Corrosion Bent conductors Breakage, cracking or discoloration Check spacing		X X X X X X
	Transformers & Reactors	Discoloration or Noise	X	
	Terminal Blocks	Loose, damaged		X
	DC Bus Capacitors	Leakage Ruptures, broken, expansion Capacitance & insulation resistance		X X X
	Relays & Contactors	Noisy Contact discoloration		X X
	Soft Charge Resistors	Cracked Discoloration		X X
Control Circuits	Operation	Speed reference voltage/current I/O contact operation		X X
Cooling System	Cooling Fans/Fins & Heatsink	Abnormal fan noise Loose connectors Free of accumulation	X X	X
Keypad/Display	Digital Operator	LEDs Monitor display values Key functionality Clean	X X	 X X

If the Drive is used under the following conditions, it may be necessary to inspect more often:

- High ambient temperatures, humidity or altitudes above 3,300 feet
- Frequent starting and stopping
- Fluctuations of the AC power supply or load
- Excessive vibration and/or shock loading
- Poor environment, including dust, metal particles, salt, sulfuric acid, chlorine

Heatsink Cooling Fan Replacement

◆ Models CIMR-P7U20P4 thru 2018 and 40P4 thru 4018

A cooling fan is attached to the bottom of the Drive.

If the Drive is installed using the mounting holes on the back of the Drive heat sink, the cooling fan can be replaced without removing the Drive from the enclosure panel.

If the Drive is mounted with the heatsink external to the enclosure, the cooling fan can only be replaced by removing the Drive from the enclosure.

■Removing the Heatsink Cooling Fan

1. Always turn OFF the input power before removing and installing the heatsink cooling fan.
2. Press in on the right and left sides of the fan cover in the direction of arrows “1” and then pull the fan out in the direction of arrow “2”.
3. Pull out the cable connected to the fan from the fan cover and disconnect the power connector. See Figure 7.1
4. Open the fan cover on the left and right sides in the direction of arrows “3” and remove the fan cover from the fan.

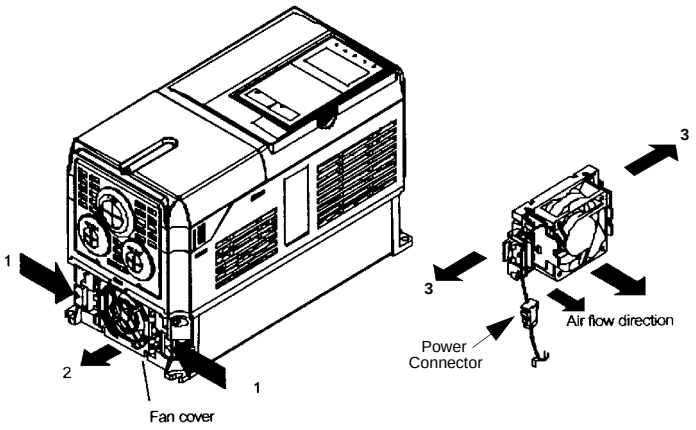


Fig 7.1 Cooling Fan Replacement Procedure

■Installing the Heatsink Cooling Fan

1. Attach the fan cover to the cooling fan. Be sure that the air flow direction indicated by the arrows above faces into the Drive.
2. Connect the power connector securely and place the power connector and cable into the fan cover.
3. Mount the fan cover on the Drive. Be sure that the tabs on the sides of the fan cover click into place on the Drive.

■Models CIMR-P7U2022 thru 2110 (30HP to 150HP @ 208V/240V) and 4024 thru 4300 (40HP to 500HP @ 480V)

A cooling fan assembly is attached to the top inside the Drive. The cooling fan assembly includes the heat sink cooling fans and the internal cooling fan. The cooling fan(s) can be replaced without removing the Drive from the enclosure panel.

Removing the Cooling Fan Assembly

1. Always turn OFF the input power before removing and installing the heatsink cooling fan assembly.
2. Remove the terminal cover, Drive cover, Digital Operator, and front cover from the front of the Drive.
3. Remove the Control PCB bracket (if necessary) to which the cards are mounted. Remove all cables connected to the Control PCB and remove the cooling fan power connector from the fan board (13 PCB) positioned near the top of the Drive.
4. Remove the cooling fan power connectors from the gate drive board (3PCB) positioned at the back of the Drive.
5. Remove the fan assembly screws and pull out the fan assembly from the Drive.
6. Remove the cooling fan(s) from the fan assembly.

Mounting the Cooling Fan Assembly

After attaching a new cooling fan, reverse the above procedure to attach all of the components.
When attaching the cooling fan to the mounting bracket, be sure that the air flow goes toward the top of the Drive.

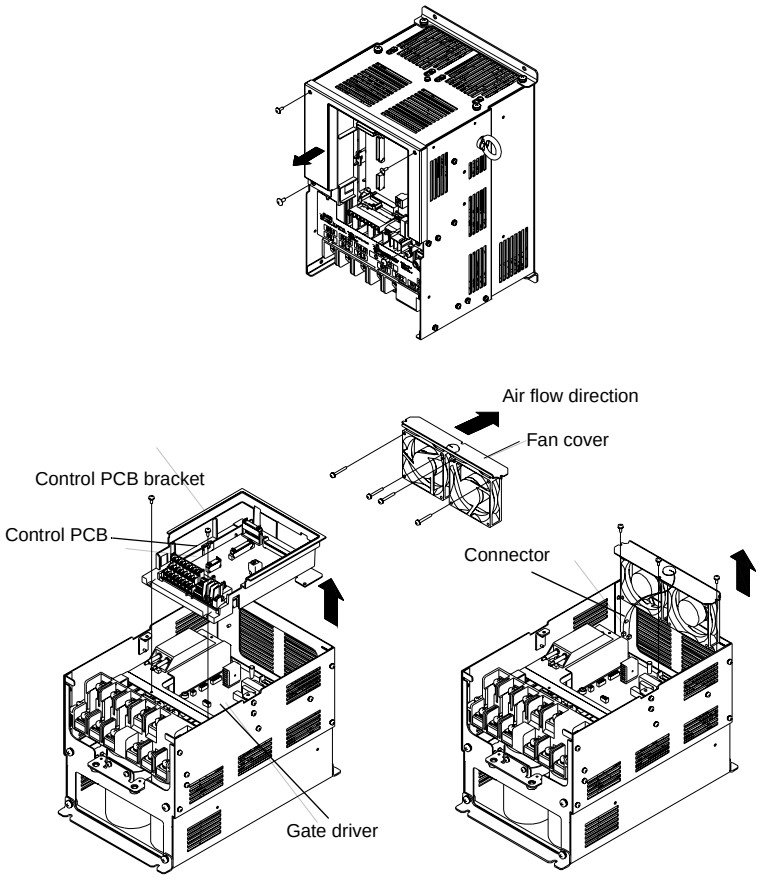


Fig 7.2 Cooling Fan Assembly Replacement Procedure

Removing and Mounting the Terminal Card

The terminal card can be removed and mounted without disconnecting the control wiring.

IMPORTANT | Always confirm that input power is removed and the Charge LED is not lit before removing or mounting the terminal card.

■Removing the Terminal Card

1. Remove the terminal cover on the Drive.
1. Remove the Digital Operator and front cover on the Drive.
2. Remove the wires connected to FE and NC on the terminal card.
3. Loosen the mounting screws on the left and right sides of the terminal card until they are free. It is not necessary to remove the mounting screws completely. They are captive and self-rising.
4. Pull the terminal card out in the direction of the block arrow.

■Mounting the Terminal Card

Reverse the removal procedure to mount the terminal card.

Confirm that the terminal card and the Control PCB properly meet at connector CN8 before insertion.

The connector pins may be bent if the terminal card is forced into place, possibly preventing correct Drive operation.

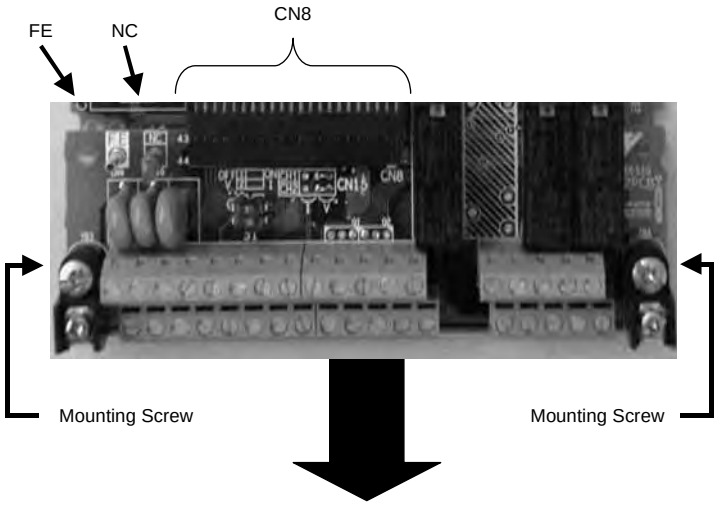


Fig 7.3 Terminal Card Removal Procedure

Appendix A
Parameters

This appendix lists all the parameter numbers and names, along with a description of each. Also, below the parameter name in bold type is the abbreviated name as it appears on the digital operator display/keypad.

Parameter List A-2

Monitor List A-26

Fault Trace List A-27

Fault History List A-28

Parameter List

Table 1: Parameter List

Parameter No.	Parameter Name **Digital Operator Display**	Description	Setting Range	Factory Setting	Menu Location
		Initialization			
A1-00 ♦	Language Selection **Select Language**	Language selection for digital operator display 0: English 2: Deutsch 3: Francais 4: Italiano 5: Espanol 6: Portuguese *Not returned to factory setting by initialization	0 to 6	0	Quick Setting
A1-01 ♦	Access Level Selection **Access Level**	This setting determines which parameters are accessible. 0: Operation Only 1: User Level 2: Advanced Level	0 to 2	2	Programming
A1-03	Initialize Parameters **Init Parameters**	Used to return all parameters to their factory or user setting. 0: No Initialize 1110: User Initialize (The user must set their own parameter default values and then parameter o2-03 must be set to "1" to save them. If the parameter values are changed after o2-03 is set to "1", the user default values can be restored by setting A1-03 to 1110.) 2220: 2-Wire Initial 3330: 3-Wire Initial	0 to 3330	0	Programming
A1-04	Password 1 **Enter Password**	When the value set into A1-04 does NOT match the value set into A1-05, parameters A1-01 thru A1-03 and A2-01 thru A2-32 cannot be changed. All other parameters as determined by A1-01 can be changed. Parameter A1-05 can be accessed by pressing the MENU key while holding the RESET key.	0 to 9999	0	Programming
A1-05	Password 2 **Select Password**		0 to 9999	0	Programming
		User Parameters			
A2-01	User Parameter 1 **User Param 1**	Selects the parameters to be available in the User Access Level (A1-01 = 1). These are the only parameters accessible for the user level. These parameters are not related to the User Initialize function.	b1-01 to o3-02	–	Programming
A2-02	User Parameter 2 **User Param 2**			–	Programming
A2-03	User Parameter 3 **User Param 3**			–	Programming
A2-04	User Parameter 4 **User Param 4**			–	Programming
A2-05	User Parameter 5 **User Param 5**			–	Programming
A2-06	User Parameter 6 **User Param 6**			–	Programming
♦Denotes that parameter can be changed when the drive is running.					

(Continued on following page)

Table 1: Parameter List (Continued)

Parameter No.	Parameter Name **Digital Operator Display**	Description	Setting Range	Factory Setting	Menu Location
A2-07	User Parameter 7 **User Param 7**	Selects the parameters to be available in the User Access Level (A1-01 = 1). These are the only parameters accessible for the user level. These parameters are not related to the User Initialize function.	b1-01 to o3-02	–	Programming
A2-08	User Parameter 8 **User Param 8**			–	Programming
A2-09	User Parameter 9 **User Param 9**			–	Programming
A2-10	User Parameter 10 **User Param 10**			–	Programming
A2-11	User Parameter 11 **User Param 11**			–	Programming
A2-12	User Parameter 12 **User Param 12**			–	Programming
A2-13	User Parameter 13 **User Param 13**			–	Programming
A2-14	User Parameter 14 **User Param 14**			–	Programming
A2-15	User Parameter 15 **User Param 15**			–	Programming
A2-16	User Parameter 16 **User Param 16**			–	Programming
A2-17	User Parameter 17 **User Param 17**			–	Programming
A2-18	User Parameter 18 **User Param 18**			–	Programming
A2-19	User Parameter 19 **User Param 19**			–	Programming
A2-20	User Parameter 20 **User Param 20**			–	Programming
A2-21	User Parameter 21 **User Param 21**			–	Programming
A2-22	User Parameter 22 **User Param 22**			–	Programming
A2-23	User Parameter 23 **User Param 23**			–	Programming
A2-24	User Parameter 24 **User Param 24**			–	Programming
A2-25	User Parameter 25 **User Param 25**			–	Programming
A2-26	User Parameter 26 **User Param 26**			–	Programming
A2-27	User Parameter 27 **User Param 27**			–	Programming
A2-28	User Parameter 28 **User Param 28**			–	Programming
A2-29	User Parameter 29 **User Param 29**			–	Programming
A2-30	User Parameter 30 **User Param 30**			–	Programming
A2-31	User Parameter 31 **User Param 31**			–	Programming
A2-32	User Parameter 32 **User Param 32**			–	Programming

Table 1: Parameter List (Continued)

Parameter No.	Parameter Name **Digital Operator Display**	Description	Setting Range	Factory Setting	Menu Location
		Sequence			
b1-01	Frequency Reference Selection **Reference Source**	Selects the speed command (frequency reference) input source. 0: Operator - Digital preset speed d1-01 1: Terminals - Analog Input Terminal A1 (or Terminal A2 see parameter H3-13) 2: Serial Com - RS-485 terminals R+, R-, S+ and S- 3: Option PCB - Option board connected at 2CN	0 to 3	1	Quick Setting
b1-02	Run Command Selection **Run Source**	Selects the run command input source. 0: Operator - "Run" and "Stop" keys on digital operator 1: Terminals - Contact Closure on Terminal S1 2: Serial Com - RS-485 terminals R+, R-, S+ and S- 3: Option PCB - Option board connected at 2CN	0 to 3	1	Quick Setting
b1-03	Stopping Method Selection **Stopping Method**	Selects the stopping method when the run command is removed. 0: Ramp to Stop 1: Coast to Stop 2: DC Injection to Stop 3: Coast w/Timer (A new run command is ignored if input before the time in C1-02 expires.)	0 to 3	0	Quick Setting
b1-04	Reverse Operation Selection **Reverse Oper**	Determines the forward rotation of the motor, and if reverse operation is disabled. 0: Reverse Enabled 1: Reverse Disabled 2: Exchange Phase - Change direction of forward motor rotation. 3: ExchgPhs, Rev Dsbl - Change direction of forward motor rotation and disable reverse operation.	0 to 3	1	Programming
b1-07	Local/Remote Run Selection **LOC/REM RUN Sel**	0: Cycle Extern RUN - If the run command is closed when switching from hand(local) mode to auto(remote) mode, the drive will not run. 1: Accept Extrn RUN - If the run command is closed when switching from hand(local) mode to auto(remote) mode, the drive WILL run.	0 or 1	0	Programming
b1-08	Run Command Selection During Program **RUN CMD at PRG**	0: Disabled - Run command accepted only in the operation menu. 1: Enabled - Run command accepted in all menus (except when b1-02 = 0).	0 or 1	0	Programming
b1-11	Drive Delay Time Setting **Wait to Run Time**	After a run command, drive output will start after this delay time.	0 to 600	0sec	Programming
b1-12	Hand Frequency Reference Selection **HAND Fref Source**	Selects the speed command input source in hand mode.* 0: Operator - Digital preset speed d1-01 1: Terminals - Analog Input Terminal A1 (or Terminal A2 see parameter H3-13)	0 or 1	0	Programming
b1-13	HAND/AUTO During Run Selection **HAND/AUTO @Run**	Selects if drive will permit switching between HAND and AUTO modes while running. 0: Disabled 1: Enabled	0 or 1	0	Programming
b1-14	Emergency Override Speed **E Override Speed**	Sets the speed command used in emergency override mode when b1-15=0.	0.00 to 120.00 Hz	0.00	Programming
b1-15	Emergency Override Reference Selection **E OverrideRefSel**	Selects the emergency override reverse source. 0: Use b1-14 Ref 1: Use AUTO Ref	0 or 1	0	Programming

Table 1: Parameter List (Continued)

Parameter No.	Parameter Name **Digital Operator Display**	Description	Setting Range	Factory Setting	Menu Location
		DC Braking			
b2-01	DC Injection Braking Start Frequency **DCInj Start Freq**	Sets the frequency at which DC injection braking starts when ramp to stop (b1-03 = 0) is selected. If b2-01< E1-09, DC Injection braking starts at E1-09.	0.0 to 10.0	0.5Hz	Programming
b2-02	DC Injection Braking Current **DCInj Current**	Selects the DC injection braking current as a percentage of the Drive rated current.	0 to 100	50%	Programming
b2-03	DC Injection Braking Time at Start **DCInj Time @Start**	Sets the time length of DC injection braking at start in units of 1 second.	0.00 to 10.00	0.00sec	Programming
b2-04	DC Injection Braking Time at Stop **DCInj Time @Stop**	When b1-03 = 2 actual DC Injection time is calculated as follows: b2-04 * 10 * Output Frequency / E1-04. When b1-03 = 0, this parameter determines the amount of time DC Injection is applied to the motor at the end of the decel ramp. This should be set to a minimum of 0.50 seconds when using HSB. This will activate DC injection during the final portion of HSB and help ensure that the motor stops completely.	0.00 to 10.00	0.00sec	Programming
b2-09	Motor Pre-Heat Current **Preheat Current**	Motor Pre-heat current in % of drive rated current. This is used to keep the motor warm to prevent condensation and is used in conjunction with a digital input (data = 60).	0 to100	0%	Programming
b2-10	Motor Pre-Heat Current 2 **Preheat Current2**	Sets the DC preheat current for multi-function output setting 80 (Motor Preheat 2) as a percentage of Motor Rated Current (E2-01).	0 to 10%	5	Programming
		Speed Search			
b3-01	Speed Search Selection **SpdSrch at Start**	Enables/disables and selects the speed search function at start. 0: SpdsrchF Disable - Speed search at start is disabled (estimated speed method is used at other times) 1: SpdsrchF Enable - Speed search is enabled (estimated speed method) 2: SpdsrchI Disable - Speed search at start is disabled (current detection method is used at other times) 3: SpdscrhI Enable - Speed search is enabled (current detection method) Estimated Speed Method: Actual motor speed and direction is estimated, then the motor is ramped from that speed to the commanded speed. Current Detection Method: Current level is monitored while output frequency is ramped down.	0 to 3	2	Programming
b3-02	Speed Search Deactivation Current **SpdSrch Current**	Used only when b3-01 = 3. Sets the speed search operation current as a percentage of drive rated current.	0 to 200	120%	Programming
b3-03	Speed Search Deceleration Time **SpdSrch Dec Time**	Used only when b3-01 = 3. Sets the deceleration time during speed search.	0.1 to 10.0	2.0sec	Programming
b3-05	Speed Search Delay Time **Search Delay**	Delays the speed search operation after a momentary power loss to allow time for an external output contactor to re-energize.	0.0 to 20.0sec	0.2sec	Programming
b3-14	Bidirectional Speed Search Selection **Bidir Search Sel**	0: Disabled 1: Enabled	0 or 1	1	Programming
		Delay Timers			
b4-01	Timer Function ON-Delay Time **Delay-ON Timer**	Used in conjunction with a multi-function digital input and a multi-function digital output. This sets the amount of time between when the digital input is closed, and the digital output is energized.	0.0 to 3000.0	0.0sec	Programming
b4-02	Timer Function OFF-Delay Time **Delay-OFF Timer**	Used in conjunction with a multi-function digital input and a multi-function digital output. This sets the amount of time the output stays energized after the digital input is opened.	0.0 to 3000.0	0.0sec	Programming

* If b1-13=1, this parameter instead selects whether the AUTO reference is retained as the new HAND reference (setting=0), or the drive will ramp from the AUTO reference to the existing HAND reference (setting=1).

Table 1: Parameter List (Continued)

Parameter No.	Parameter Name **Digital Operator Display**	Description	Setting Range	Factory Setting	Menu Location
		PI Control			
b5-01	PI Mode Setting **PI Mode**	This parameter enables / disables the closed loop (PI) controller. 0: Disabled 1: Enabled (commanded speed becomes PI setpoint) 3: Fref+PI	0, 1, 3	0	Quick Setting
b5-02 ♦	Proportional Gain Setting **P Gain**	Sets the proportional gain of the PI controller.	0.00 to 25.00	2.00	Quick Setting*
b5-03 ♦	Integral Time Setting **PI I Time**	Sets the integral time for the PI controller. A setting of zero disables integral control.	0.0 to 360.0	5.0sec	Quick Setting*
b5-04 ♦	Integral Limit Setting **PI I Limit**	Sets the maximum output possible from the integrator. Set as a % of fmax.	0.0 to 100.0	100%	Programming
b5-06 ♦	PI Output Limit **PI Limit**	Sets the maximum output possible from the entire PI controller. Set as a % of fmax.	0.00 to 100.0	100.0%	Programming
b5-07 ♦	PI Offset Adjustment **PI Offset**	Sets the amount of offset of the output of the PI controller. Set as a % of fmax. The PI Offset Adjustment parameter has two different uses. Parameter b5-07 serves different functions depending on whether it is used on a standard PI loop or a Differential PI loop. 1: Parameter b5-07 causes an offset to be applied to the output of the PI function in a non-Differential PI loop. Every time the PI output is updated, the offset is summed with the PI output. This can be used to artificially kick-start a slow starting PI loop. 2: If the Drive is configured for Differential PI Regulation (H3-09=16), then the PI Offset is the targeted maintained differential between the signal measured on analog input A1 and the signal measured on analog input A2.	–100.0 to +100.0	0.0%	Programming
b5-08 ♦	PI Primary Delay Time Constant **PI Delay Time**	Sets the amount of time for a filter on the output of the PI controller.	0.00 to 10.00	0.00sec	Programming
b5-09	PI Output Level Selection **Output Level Sel**	Determines whether the PI controller will be direct or reverse acting. 0: Normal Output (direct acting) 1: Reverse Output (reverse acting)	0 or 1	0	Programming
b5-10	PI Output Gain Setting **Output Gain**	Sets the output gain of the PI controller.	0.0 to 25.0	1.0	Programming
b5-11	PI Output Reverse Selection **Output Rev Sel**	0: 0 limit (when PI output goes negative Drive stops) 1: Reverse (when PI goes negative Drive reverses) 0 limit automatic when reverse prohibit is selected using b1-04	0 or 1	0	Programming
b5-12	PI Feedback Reference Missing Detection Selection **Fb los Det Sel**	0: Disabled 1: Alarm 2: Fault	0 to 2	0	Programming
b5-13	PI Feedback Loss Detection Level **Fb los Det Lvl**	Sets the PI feedback loss detection level as a percentage of maximum frequency (E1-04).	0 to 100	0%	Programming
b5-14	PI Feedback Loss Detection Time **Fb los Det Time**	Sets the PI feedback loss detection delay time in terms of seconds.	0.0 to 25.5	1.0sec	Programming
b5-15	Sleep Function Start Level **Sleep Level**	Sets the sleep function start frequency.	0.0 to 200.0	0.0Hz	Programming
b5-16	Sleep Delay Time **Sleep Time**	Sets the sleep function delay time in terms of seconds.	0.0 to 25.5	0.0sec	Programming
b5-17	PI Accel/Decel Time **PI Acc/Dec Time**	Applies an accel/decel time to the PI setpoint reference.	0.0 to 25.5	0.0sec	Programming
b5-18	PI Setpoint Selection **PI Setpoint Sel**	0: Disabled 1: Enabled	0 or 1	0	Programming
b5-19 ♦	PI Setpoint Value **PI Setpoint**	Depends on b5-20. (Continued on following page)	0.00 to 100.00	0.00%	Programming

♦Denotes that parameter can be changed when the drive is running. * Menu location is Quick Setting when b5-01=1, and Programming when b5-01=0.

Table 1: Parameter List (Continued)

Parameter No.	Parameter Name **Digital Operator Display**	Description	Setting Range	Factory Setting	Menu Location
b5-20	PI Setpoint Display Scaling **Setpoint Scaling**	Set display/setting Unit of b5-19.	0 to 39999	1	Programming
b5-21	PI Sleep Input Source **PI Sleep Source**	Input Source Selection for Sleep function Mode. 0: SFS Input (This is near the PI Output.) 1: PI Setpoint 2: Snooze	0 to 2	1	Programming
b5-22 ♦	PI Snooze Level **Snooze Level**	Sets the PI snooze function start level as a percentage of maximum frequency (E1-04).	0 to 100	0%	Programming
b5-23	PI Snooze Delay Time **Snooze Delay Time**	Sets the PI snooze function delay time in terms of seconds.	0 to 3600	0sec	Programming
b5-24	PI Snooze Deactivation Level **Wake-Up Level**	When the PI feedback drops below this level, normal PI operation starts again. Set as a percentage of maximum frequency (E1-04).	0 to 100	0%	Programming
b5-25	PI Setpoint Boost Setting **Setpoint Boost**	Temporary increase of PI setpoint to create an overshoot of the intended PI setpoint.	0 to 100	0%	Programming
b5-26	PI Maximum Boost Time **Max Boost Time**	Sets a time limitation for reaching temporarily boosted PI setpoint (intended PI setpoint + b5-25).	0 to 3600	0sec	Programming
b5-27	PI Snooze Feedback Level **Snooze Feedback**	PI snooze mode will be activated when PI feedback is above this level. Set as a percentage of maximum frequency (E1-04).	0 to 100	60%	Programming
b5-28	PI Feedback Square Root Function Selection **PI Feedback SqRt**	0: Disabled 1: Enabled	0 or 1	0	Programming
b5-29	PI Square Root Gain **PI Fb SqRt Gain**	A multiplier applied to the square root of the feedback.	0.00 to 2.00	1.00	Programming
b5-30	Output Square Root Monitor Selection **PI Out Moni SqRt**	0: Disabled 1: Enabled	0 or 1	0	Programming
b5-31	PI Unit Selection **PI Unit Sel**	Sets units for b5-19, U1-24, U1-38. 0: WC:InchOfWater 1: PSI:lb/SqrInch 2: GPM:Gallons/Min 3: F:DegFahrenheit 4: CFM:Cubic ft/Min 5: CMH:Cubic M/Hr 6: LPH:Liters/Hr 7: LPS:Liters/Sec 8: Bar:Bar 9: Pa:Pascals 10: C:DegCelsius 11: Mtr:Meters	0 to 11	0	Quick Setting*
		Energy Saving			
b8-01	Energy Saving Control Selection **Energy Save Sel**	Energy Savings function enable/disable selection 0: Disabled 1: Enabled	0 or 1	0	Quick Setting
b8-04	Energy Saving Coefficient Value **Energy Save COEF**	Used to fine-tune the energy savings function.	0.0 to 655.00	kVA Dependent	Programming
b8-05	Power Detection Filter Time **kW Filter Time**		0 to 2000	20ms	Programming
b8-06	Search Operation Voltage Limit **Search V Limit**		0 to 100	0%	Programming

♦Denotes that parameter can be changed when the drive is running. * Menu location is Programming when PI is disabled and Quick Setting when PI is enabled.

Table 1: Parameter List (Continued)

Parameter No.	Parameter Name **Digital Operator Display**	Description	Setting Range	Factory Setting	Menu Location
		Accel / Decel			
C1-01 ♦	Acceleration Time 1 **Accel Time 1**	Sets the time to accelerate from zero to maximum frequency.	0.0 to 6000.0	30.0sec	Quick Setting
C1-02 ♦	Deceleration Time 1 **Decel Time 1**	Sets the time to decelerate from maximum frequency to zero.		30.0sec	Quick Setting
C1-03 ♦	Acceleration Time 2 **Accel Time 2**	Sets the time to accelerate from zero to maximum frequency when selected via a multi-function input.		30.0sec	Programming
C1-04 ♦	Deceleration Time 2 **Decel Time 2**	Sets the time to decelerate from maximum frequency to zero when selected via a multi-function input.		30.0sec	Programming
C1-09	Fast Stop Time **Fast Stop Time**	Sets the time to decelerate from maximum frequency to zero for the "Fast Stop" function.	0.0 to 6000.0	10.0sec	Programming
C1-11	Accel/Decel Switch Frequency **Acc/Dec SW Freq**	Sets the frequency for automatic switching of accel / decel times. Fout < C1-11: Accel/Decel Time 2 Fout >= C1-11: Accel/Decel Time 1 Multi-function input "Multi-Acc/Dec 1" has priority over C1-11.	0.0 to 200.0	0.0Hz	Programming
		S-Curve Acc/Dec			
C2-01	S-Curve Characteristic at Accel Start **SCrv Acc @ Start**	S-curve is used to further soften the starting ramp. The longer the S-curve time, the softer the starting ramp. Run command ON OFF Output frequency C2-02 C2-01 Time	0.00 to 2.50	0.20sec	Programming
C2-02	S-Curve Characteristic at Accel End **SCrv Acc @ End**		0.00 to 2.50	0.20sec	Programming
		Torque Comp			
C4-01 ♦	Torque Compensation Gain **Torq Comp Gain**	This parameter helps to produce better starting torque. It determines the amount of torque or voltage boost based upon motor current and motor resistance.	0.00 to 2.50	1.00	Programming
C4-02	Torque Compensation Primary Delay Time **Torq Comp Time**	This parameter adjusts a filter on the output of the torque compensation function. Increase to add torque stability, decrease to improve torque response.	0 to 10000	200ms	Programming

♦Denotes that parameter can be changed when the drive is running. *Menu location is Programming when PI is disabled and Quick Setting when PI is enabled.

Table 1: Parameter List (Continued)

Parameter No.	Parameter Name **Digital Operator Display**	Description	Setting Range	Factory Setting	Menu Location
		Carrier Freq			
C6-01	Normal Duty Selection **Normal Duty Sel**	1: Normal Duty 1 2: Normal Duty 2	1 or 2	2	Programming
C6-02	Carrier Frequency Selection **CarrierFreq Sel**	Carrier frequency sets the number of pulses per second of the output voltage waveform. 0: Low Noise (Carrier frequency is randomly moduled for lower audible noise) 1: Fc = 2.0 kHz 2: Fc = 5.0 kHz 3: Fc = 8.0 kHz 4: Fc = 10.0 kHz 5: Fc = 12.5 kHz 6: Fc = 15.0 kHz F: Program (Determined by the settings of C6-03 thru C6-05)	0 to F	kVA Dependent	Programming
C6-03	Carrier Frequency Upper Limit **CarrierFreq Max**	Maximum carrier frequency allowed when C6-02 = F.	kVA Dependent	kVA Dependent	Programming
C6-04	Carrier Frequency Lower Limit **CarrierFreq Min**	Minimum carrier frequency allowed when C6-02 = F.	kVA Dependent	kVA Dependent	Programming
C6-05	Carrier Frequency Proportional Gain **CarrierFreq Gain**	Sets the relationship of output frequency to carrier frequency when C6-02 = F.	0 to 99	0	Programming
		Preset Reference (Speeds)			
d1-01 ♦	Frequency Reference 1 **Reference 1**	Digital preset speed command 1. Used when b1-01 = 0. Setting units are affected by o1-03.	0.00 to E1-04 Value	0.00Hz	Programming
d1-02 ♦	Frequency Reference 2 **Reference 2**	Digital preset speed command 2. Selected via multi-function input terminals. Setting units are affected by o1-03.		0.00Hz	Programming
d1-03 ♦	Frequency Reference 3 **Reference 3**	Digital preset speed command 3. Selected via multi-function input terminals. Setting units are affected by o1-03.		0.00Hz	Programming
d1-04 ♦	Frequency Reference 4 **Reference 4**	Digital preset speed command 4. Selected via multi-function input terminals. Setting units are affected by o1-03.		0.00Hz	Programming
d1-17 ♦	Jog Frequency Reference **Jog Reference**	Speed command used when a jog is selected via multi-function input terminals. Setting units are affected by o1-03.	0.00 to E1-04 Value	6.00Hz	Programming
		Reference Limits			
d2-01	Frequency Reference Upper Limit **Ref Upper Limit**	Determines maximum speed command, set as a percentage of parameter E1-04. If speed command is above this value, actual drive speed will be limited to this value. This parameter applies to all speed command sources.	0.0 to 110.0	100.0%	Quick Setting
d2-02	Frequency Reference Lower Limit **Ref Lower Limit**	Determines minimum speed command, set as a percentage of parameter E1-04. If speed command is below this value, actual drive speed will be set to this value. This parameter applies to all speed command sources.	0.0 to 110.0	0.0%	Quick Setting
d2-03	Master Speed Reference Lower Limit **Ref1 Lower Limit**	Determines the minimum speed command, set as a percentage of parameter E1-04. If speed command is below this value, actual drive speed will be set to this value. This parameter only applies to analog inputs A1 and A2.	0.0 to 110.0	0.0%	Programming
		Jump Frequencies			
d3-01	Jump Frequency 1 **Jump Freq 1**	These parameters allow programming of up to three prohibited frequency points for eliminating problems with resonant vibration of the motor / machine. This feature does not actually eliminate the selected frequency values, but will accelerate and decelerate the motor through the prohibited bandwidth.	0.0 to 200.0	0.0Hz	Programming
d3-02	Jump Frequency 2 **Jump Freq 2**			0.0Hz	Programming
d3-03	Jump Frequency 3 **Jump Freq 3**			0.0Hz	Programming
d3-04	Jump Frequency Width **Jump Bandwidth**	This parameter determines the width of the deadband around each selected prohibited frequency point. A setting of "1.0" will result in a deadband of +/- 1.0 Hz.	0.0 to 20.0	1.0Hz	Programming
♦Denotes that parameter can be changed when the drive is running.					

Table 1: Parameter List (Continued)

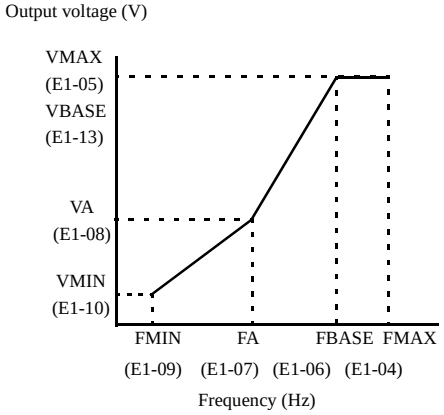
Parameter No.	Parameter Name **Digital Operator Display**	Description	Setting Range	Factory Setting	Menu Location
		Sequence (MOP and Trim Control)			
d4-01	**MOP Ref Memory**	0: Disabled 1: Enabled	0 or 1	0	Programming
d4-02	Trim Control Level **Trim Control Lvl**	Set the percentage of maximum speed to be added or subtracted via multi-function inputs.	0 to 100	10%	Programming
		V/F Pattern			
E1-01	Input Voltage Setting **Input Voltage**	Set to the nominal voltage of the incoming line.	155 to 255.0 (240V) 310 to 510.0 (480V)	240V 480V	Quick Setting
E1-03	V/F Pattern Selection **V/F Selection**	0: 50Hz 1: 60 Hz Saturation 2: 50 Hz Saturation 3: 72 Hz 4: 50 Hz VT1 5: 50 Hz VT2 6: 60 Hz VT1 7: 60 Hz VT2 8: 50 Hz HST1 9: 50 Hz HST2 A: 60 Hz HST1 B: 60 Hz HST2 C: 90 Hz D: 120 Hz F: Custom V/F FF: Custom w/o limit	0 to FF	F	Programming
E1-04	Maximum Output Frequency **Max Frequency**		0.0 to 120.0	60.0Hz	Programming
E1-05	Maximum Output Voltage **Max Voltage**		0 to 255.0 (240V) 0 to 510.0 (480V)	240V 480V	Programming
E1-06	Base Frequency **Base Frequency**		0.0 to 200.0	60.0Hz	Programming
E1-07	Mid Output Frequency A **Mid Frequency A**		0.0 to 200.0	3.0Hz	Programming
E1-08	Mid Output Voltage A **Mid Voltage A**		0 to 255.0 (240V) 0 to 510.0 (480V)	18.0VAC	Programming
E1-09	Minimum Output Frequency **Min Frequency**		0.0 to 200.0	1.5Hz	Programming
E1-10	Mid Output Voltage **Min Voltage**	To set V/f characteristics in a straight line, set the same values for E1-07 and E1-09. In this case, the setting for E1-08 will be disregarded. Always ensure that the four frequencies are set in the following manner: E1-04 (FMAX) ≥ E1-06 (FA) > E1-07 (FB) ≥ E1-09 (FMIN)	0 to 255.0 (240V) 0 to 510.0 (480V)	10.8VAC	Programming
E1-11	Mid Output Frequency B **Mid Frequency B**	Set only when V/f is finely adjusted at rated output range. Adjustment is not normally required.	0.0 to 200.0	0.0Hz	Programming
E1-12	Mid Output Voltage B **Mid Voltage B**		0 to 255.0 (240V) 0 to 510.0 (480V)	0.0VAC	Programming
E1-13	Base Voltage **Base Voltage**		0 to 255.0 (240V) 0 to 510.0 (480V)	0.0VAC	Programming

Table 1: Parameter List (Continued)

Parameter No.	Parameter Name **Digital Operator Display**	Description	Setting Range	Factory Setting	Menu Location
		Motor Setup			
E2-01	Motor Rated Current **Motor Rated FLA**	Set to the motor nameplate full load amps.	10% to 200% kVA Dependent	kVA Dependent	Quick Setting
E2-03	**No-Load Current**	Sets the magnetizing current of the motor.	kVA Dependent	kVA Dependent	Programming
E2-05	Motor Line-to-Line Resistance **Term Resistance**	Phase to phase motor resistance, normally set by the autotuning routine.	0.000 to 65.000	kVA Dependent	Programming
		Com OPT Setup			
F6-01	Operation Selection after Communication Error **Comm Bus Flt Sel**	Sets the stopping method for option PCB communications error (BUS fault). Active only when a communications option PCB is installed and when b1-01 or b1-02 = 3. 0: Ramp to Stop 1: Coast to Stop 2: Fast-Stop 3: Alarm Only	0 to 3	1	Programming
F6-02	Detection Selection of External Fault from Communication Option Card **EF0 Detection**	0: Always detected 1: Detected only during run	0 or 1	0	Programming
F6-03	Stopping Method for External Fault from Communication Option Card **EF0 Fault Action**	0: Ramp to Stop 1: Coast to Stop 2: Fast-Stop 3: Alarm Only	0 to 3	1	Programming
F6-05	Current Monitor Display Unit Selection **Current Unit Sel**	0: A Display (Amps) 1: 100%/8192 (Drive Rated Current)	0 or 1	0	Programming

Table 1: Parameter List (Continued)

Parameter No.	Parameter Name **Digital Operator Display**	Description	Setting Range	Factory Setting	Menu Location
		Digital Inputs			
H1-01	Terminal S3 Function Selection **Terminal S3 Sel**	0: 3-wire control FWD/REV selection for 3-wire sequence 1: Local/Remote Sel Local/Remote Selection - Closed = Local, Open = Remote 2: Option/Inv Sel Selects source of speed command and sequence Closed = b1-01 & b1-02, Open = Option Card 3: Multi-Step Ref 1 Closed = speed command from d1-02 or Aux Terminal Open = speed command determined by b1-01 4: Multi-Step Ref 2 Closed = speed command from d1-03 or d1-04 Open speed command determined by b1-01 6: Jog Freq Ref Closed = speed command from d1-17 Open = speed command determined by b1-01 7: Multi-Acc/Dec 1 Closed = Accel & Decel Ramps determined by C1-03 & C1-04, Open = Accel & Decel Ramps determined by C1-01 & C1-02 8: Ext BaseBlk N.O. Closed = Output transistors forced off, Open = Normal operation 9: Ext BaseBlk N.C. Closed = Normal Operation, Open = Output transistors forced off A: Acc/Dec RampHold Closed = Acceleration suspended and speed held, Open = Normal Operation C: Term A2 Enable Closed = Terminal A2 is active, Open = Terminal A2 is disabled F: Term Not Used Terminal has no effect 10: MOP Increase Closed = Speed Command Increases, Open = Speed Command Held. Must be set in conjunction with MOP Decrease and b1-02 must be set to 1. 11: MOP Decrease Closed = Speed Command Decreases, Open = Speed Command Held. Must be set in conjunction with MOP Increase and b1-02 must be set to 1. (Continued on following page)	0 to 6E	24	Programming
H1-02	Terminal S4 Function Selection **Terminal S4 Sel**		0 to 6E	14	Programming

Table 1: Parameter List (Continued)

Parameter No.	Parameter Name **Digital Operator Display**	Description	Setting Range	Factory Setting	Menu Location
H1-03	Terminal S5 Function Selection **Terminal S5 Sel**	12: Forward Jog Closed = drive runs forward at speed command entered into parameter d1-17. 13: Reverse Jog Closed = drive runs in reverse at speed command entered into parameter d1-17. 14: Fault Reset Closed = Resets the drive after the fault and the run command have been removed. 15: Fast-Stop N.O. Closed = Drive decelerates using C1-09, regardless of run command status. 17: Fast-Stop N.C. Closed = Normal operation Open = Drive decelerates using C1-09, regardless of run command status. 18: Timer Function Input for independent timer, controlled by b4-01 and b4-02. Used in conjunction with a multi-function digital output. 19: PI Disable Turns off the PI controller, and PI setpoint becomes speed command. 1B: Program Lockout Closed =All parameter settings can be changed. Open = Only speed command at U1-01 can be changed. 1C: TrimCtl Increase Closed = Increase motor speed by value in d4-02. Open = Return to normal speed command. Not effective when using d1-01 thru d1-04 as a speed command. Must be used in conjunction with Trim Ctrl Decrease. 1D: Trim Ctl Decrease Closed = Decrease motor speed by value in d4-02 Open = Return to normal speed command. Not effective when using d1-01 thru d1-04 as speed command. Must be used in conjunction with Trim Ctrl Increase. (Continued on following page)	0 to 6E	3: 2-wire 0: 3-wire	Programming

Table 1: Parameter List (Continued)

Parameter No.	Parameter Name **Digital Operator Display**	Description	Setting Range	Factory Setting	Menu Location
		Digital Inputs			
H1-04	Terminal S6 Function Selection **Terminal S6 Sel**	1E: Ref Sample Hold Analog speed command is sampled then held at time of input closure. 20: External fault, Normally Open, Always Detected, Ramp To Stop 21: External fault, Normally Closed, Always Detected, Ramp To Stop 22: External fault, Normally Open, During Run, Ramp To Stop 23: External fault, Normally Closed, During Run, Ramp To Stop 24: External fault, Normally Open, Always Detected, Coast To Stop 25: External fault, Normally Closed, Always Detected, Coast To Stop 26: External fault, Normally Open, During Run, Coast To Stop 27: External fault, Normally Closed, During Run, Coast To Stop 28: External fault, Normally Open, Always Detected, Fast-Stop 29: External fault, Normally Open, Always Detected, Fast-Stop 2A: External fault, Normally Open, During Run, Fast-Stop 2B: External fault, Normally Closed, During Run, Fast-Stop 2C: External fault, Normally Open, Always Detected, Alarm Only 2D: External fault, Normally Closed, Always Detected, Alarm Only 2E: External fault, Normally Open, During Run, Alarm Only 2F: External fault, Normally Closed, During Run, Alarm Only 30: PI Integral Reset Resets the PI Integral component to zero when closed 31: PI Integral Hold Holds the PI integral value when closed 34: PI SFS Cancel (SFS= SoftStart, also called Accel/Decel, See Parameter b5-17) 35: PI Input Level Sel Inverts the PI error signal when closed 36: Option/Inv Sel 2 Selects source of speed command and sequence Closed = Option Card, Open = b1-01 & b1-02 60: Motor Preheat Applies current to create heat to avoid condensation Closed = Apply amount of current as set in parameter b2-09 61: Speed Search 1 When closed as a run command is given, drive does a speed search starting at maximum frequency (E1-04). (current detection) 62: Speed Search 2 When closed as a run command is given, drive does a speed search starting at speed command. (current detection) 64: Speed Search 3 When opened, the Drive performs a baseblock (motor coasts). When closed, the Drive performs Speed Search from set frequency. 67: Com Test Mode - Used to test RS-485/422 interface. 68: High Slip Braking - Closed = Drive stops using High Slip Braking regardless of run command status. 69: Jog2 - Closed = Drive runs at speed command entered into parameter d1-17. Direction determined by fwd/rev input. 3-wire control Only. 6A: Drive Enable - Closed = Drive will accept run command. Open = Drive will not run. If running, drive will stop per b1-03. Run Command must be cycled 6B: Com/Inv Sel - Selects source of Speed Command and Sequence. Closed = Serial Communication (R+,R-,S+,S-), Open = b1-01 & b1-02 6C: Com/Inv Sel 2 - Selects source of Speed Command and Sequence. Closed = b1-01 & b1-02, Open = Serial Communication (R+,R-,S+,S-) 6D: Auto Mode Sel - Hand/Auto Selection - Closed = Auto, Open = Hand 6E: Hand Mode Sel - Hand/Auto Selection - Closed = Hand, Open = Auto 70: Bypass/Drv Enbl. Same as 6A except a run command is accepted 80: Motor Preheat 2 - Closed = Enable motor preheat with the current level as set by b2-10 81: EmergOverrideFWD - Closed = Forward Emergency Override Command 82: EmergOverrideREV - Closed = Reverse Emergency Override Command	0 to 6E	4: 2-wire 3: 3-wire	Programming
H1-05	Terminal S7 Function Selection **Terminal S7 Sel**		0 to 6E	6: 2-wire 4: 3-wire	Programming

Table 1: User Parameter List (Continued)

Parameter No.	Parameter Name **Digital Operator Display**	Description	Setting Range	Factory Setting	Menu Location
		Digital Outputs			
H2-01	Terminal M1-M2 Function Selection **Term M1-M2 Sel**	0: During RUN 1 = Closed when a run command is input or the drive is outputting voltage. 1: Zero Speed = Closed when drive output frequency is less than Fmin (E1-09) 2: Fref/Fout Agree 1 = Closed when drive output speed equals the speed command within the bandwidth of L4-02. 3: Fref/Set Agree 1 = Closed when the drive output speed and the speed command are equal to the value in L4-01 within the bandwidth of L4-02. 4: Freq Detect 1 = Closed when the drive output speed is less than or equal to the value in L4-01, with hysteresis determined by L4-02. 5: Freq Detect 2 = Closed when the drive output speed is greater than or equal to the value in L4-01, with hysteresis determined by L4-02. 6: Inverter Ready = Closed when the drive is not in a fault state, and not in program mode. 7: DC Bus Undervolt = Closed when the DC bus voltage falls below the UV trip level (L2-05) 8: Base Blk 1 = Closed when the drive is not outputting voltage. 9: Operator Reference = Closed when the speed command is coming from the digital operator. A: Remote/Auto Oper = Closed when the run command is coming from the digital operator. B: Trq Det 1 N.O. - Closes when the output current exceeds the value set in parameter L6-02 for more time than is set in parameter L6-03. C: Loss of Ref - Closes when the drive has detected a loss of analog speed command. Speed command is considered lost when it drops 90% in 0.4 seconds. Parameter L4-05 determines drive reaction to a loss of speed command. D: DB Overheat E: Fault - Closes when the drive experiences a major fault. F: Not Used 10: Minor Fault - Closes when drive experiences a minor fault or alarm. 11: Reset Cmd Active - Closes when the drive receives a reset command from terminals or serial comms. 12: Timer Output - Output for independent timer, controlled by b4-01 and b4-02. Used in conjunction with a multi-function digital input. 17: Trq. Det 1 N.C. - Opens when the output current exceeds the value set in parameter L6-02 for more time than is set in parameter L6-03. 1A: Reverse Dir - Closes when the drive is running in the reverse direction. 1E: Restart Enabled - Closes when the drive is performing an automatic restart. Automatic restart is configured by parameter L5-01. 1F: Overload (OL1) - Closes before a motor overload occurs. (90% of OL1 time) 20: OH Prealarm - Closes when the Drive's heatsink temperature exceeds the setting of parameter L8-02. 38: Drive Enable - Closes when the drive enable input is active. 39: Waiting to Run - Closes during the time after a run command is issued, but the Drive is not running due to the time set in parameter b1-10. 3A: OH Freq Reduce 3B: Run Src Com/Opt 3D: Cooling Fan Err = Closed during internal cooling fan failure	0 to 3B	0	Programming
H2-02	Terminal M3-M4 Function Selection **Term M3-M4 Sel**		0 to 3B	A	Programming

Table 1: Parameter List (Continued)

Parameter No.	Parameter Name **Digital Operator Display**	Description	Setting Range	Factory Setting	Menu Location
		Analog Inputs			
H3-02 ♦	Terminal A1 Gain Setting **Terminal A1 Gain**	Sets the speed command when 10V is input, as a percentage of the maximum output frequency (E1-04).	0.0 to 1000.0	100.0%	Programming
H3-03 ♦	Terminal A1 Bias Setting **Terminal A1 Bias**	Sets the speed command when 0V is input, as a percentage of the maximum output frequency (E1-04).	–100.0 to +100.0	0.0%	Programming
H3-08	Terminal A2 Signal Level Selection **Term A2 Signal**	Selects the signal level of terminal A2. 0: 0 - 10VDC (switch S1-2 must be in the off position) 2: 4 - 20 mA (switch S1-2 must be in the on position)	0 or 2	2	Programming*
H3-09	Aux Terminal Function Selection **Terminal A2 Sel**	Selects what effect the Aux terminal (A2) has on the drive. 0: Frequency Bias - 0 - 100% bias 2: Aux Reference B: PI Feedback D: Frequency Bias 2 - 0 - 100% bias E: Motor Temperature - See parameters L1-03 & L1-04 16: PI Differential 1F: Not Used	0 to 1F	2**	Programming*
H3-10 ♦	Terminal A2 Gain Setting **Terminal A2 Gain**	Sets the level of the A2 function corresponding to a 10V input (in%).	0.0 to 1000.0	100.0%	Programming
H3-11 ♦	Terminal A2 Bias Setting **Terminal A2 Bias**	Sets the level of the A2 function corresponding to a 0V input (in%).	–100.0 to +100.0	0.0%	Programming
H3-12	Analog Input Filter Time Constant **Filter Avg Time**	Used to “smooth” out erratic or noisy analog input signals.	0.00 to 2.00	0.30sec	Programming
H3-13	Master Frequency Reference Terminal Selection **TA1/A2 Select**	Determines which terminal will be the main reference source. 0: Main Fref TA1 - Terminal TA1 is the main speed command and Terminal TA2 is the Aux speed command. 1: Main Fref TA2 - Terminal TA2 is the main speed command and Terminal TA1 is the Aux speed command. Only effective when H3-09 is set to 2 “Aux Reference.”	0 or 1	0	Programming*

♦ Denotes that parameter can be changed when the drive is running.
* Menu location is Quick Setting when b5-01=1, and Programming when b5-01=0.
** Factory setting changes to “B” when b5-01=1.

Table 1: Parameter List (Continued)

Parameter No.	Parameter Name **Digital Operator Display**	Description	Setting Range	Factory Setting	Menu Location
		Analog Outputs			
H4-01	Terminal FM Monitor Selection **Terminal FM Sel**	Selects which monitor will be output on terminals FM and AC. 1: Frequency Ref (100% = max. output frequency) 2: Output Freq (100% = max. output frequency) 3: Output Current (100% = drive rated current) 6: Output Voltage (100% = 230V or 100% = 460V) 7: DC Bus Voltage (100% = 400V or 100% = 800V) 8: Output kWatts (100% = drive rated power) 15: Term A1 Level 16: Term A2 Level 18: Mot SEC Current (100% = Motor rated secondary current) 20: SFS Output (100% = max. output frequency) 24: PI Feedback 31: Not Used 36: PI Input 37: PI Output (100% = max. output frequency) 38: PI Setpoint 51: Auto Mode Fref (100% = max. output frequency) 52: Hand Mode Fref (100% = max. output frequency) 53: PI Feedback 2 NOTE: 100% = 10V DC output * FM gain setting (H4-02).	1 to 53	2	Programming
H4-02 ♦	Terminal FM Gain Setting **Terminal FM Gain**	Sets terminal FM output voltage (in percent of 10V) when selected monitor is at 100% output.	0.0 to 1000.0	100.0%	Programming
H4-03 ♦	Terminal FM Bias Setting **Terminal FM Bias**	Sets terminal FM output voltage (in percent of 10V) when selected monitor is at 0% output.	–110.0 to 110.0	0.0%	Programming
H4-04	Terminal AM Monitor Selection **Terminal AM Sel**	Selects which monitor will be output on terminals AM and AC. 1: Frequency Ref (100% = max. output frequency) 2: Output Freq (100% = max. output frequency) 3: Output Current (100% = drive rated current) 6: Output Voltage (100% = 230V or 100% = 460V) 7: DC Bus Voltage (100% = 400V or 100% = 800V) 8: Output kWatts (100% = drive rated power) 15: Term A1 Level 16: Term A2 Level 18: Mot SEC Current (100% = Motor rated secondary current) 20: SFS Output (100% = max. output frequency) 24: PI Feedback 31: Not Used 36: PI Input 37: PI Output (100% = max. output frequency) 38: PI Setpoint 51: Auto Mode Fref (100% = max. output frequency) 52: Hand Mode Fref (100% = max. output frequency) 53: PI Feedback 2 NOTE: 100% = 10V DC output * AM gain setting (H4-05).	1 to 53	8	Programming
H4-05 ♦	Terminal AM Gain Setting **Terminal AM Gain**	Sets terminal AM output voltage (in percent of 10V) when selected monitor is at 100% output.	0.0 to 1000.0	50.0%	Programming
H4-06 ♦	Terminal AM Bias Setting **Terminal AM Bias**	Sets terminal AM output voltage (in percent of 10V) when selected monitor is at 0% output.	–110.0 to 110.0	0.0%	Programming
H4-07	Terminal FM Signal Level Selection **AO Level Select1**	0: 0 - 10 VDC 2: 4-20 mA*	0 or 2	0	Programming
H4-08	Terminal AM Signal Level Selection **AO Level Select2**	0: 0 - 10 VDC 2: 4-20 mA* * An analog output of 4 - 20 mA can not be used with the standard terminal board. Therefore an optional terminal board (with shunt connector CN15) is needed.	0 or 2	0	Programming

♦Denotes that parameter can be changed when the drive is running.

Table 1: Parameter List (Continued)

Parameter No.	Parameter Name **Digital Operator Display**	Description	Setting Range	Factory Setting	Menu Location
		Serial Com Setup			
H5-01	Drive Node Address **Serial Comm Adr**	Selects drive station node number (address) for terminals R+, R-, S+, S-.* An address of "0" disables serial com.	0 to FF	1F #	Programming
H5-02	Communication Speed Selection **Serial Baud Rate**	Selects the baud rate for terminals R+, R-, S+ and S-.* 0: 1200 Baud 1: 2400 Baud 2: 4800 Baud (APOGEE FLN) 3: 9600 Baud (Metasys N2) 4: 19200 Baud	0 to 4	3	Programming
H5-03	Communication Parity Selection **Serial Com Sel**	Selects the communication parity for terminals R+, R-, S+ and S-.* 0: No Parity 1: Even Parity 2: Odd Parity	0 to 2	0	Programming
H5-04	Stopping Method after Communication Error **Serial Fault Sel**	Selects the stopping method when a communication error is detected. 0: Ramp to Stop 1: Coast to Stop 2: Fast-Stop 3: Alarm Only	0 to 3	3	Programming
H5-05	Communication Error Detection Selection **Serial Flt Dtct**	Enables or disables the communications timeout detection function. 0: Disabled - A communications loss will NOT cause a communications fault. 1: Enabled - If communications are lost for more than the time specified in parameter H5-09, a communications fault will occur.	0 or 1	1	Programming
H5-06	Drive Transmit Wait Time **Transmit WaitTIM**	Sets the time from when the drive receives data to when the drive sends data.	5 to 65	5ms	Programming
H5-07	RTS Control Selection **RTS Control Sel**	Enables or disables "request to send" (RTS) control: 0: Disabled (RTS is always on) 1: Enabled (RTS turns on only when sending)	0 or 1	1	Programming
H5-09	Communication Error Detection Time **CE Detect Time**	Determines how long communications must be lost before a fault is annunciated. Works in conjunction with parameters H5-05 and H5-04.	0 to 10.0 (H5-08=0) 0 to 10.0	2.0sec	Programming
		Motor Overload			
L1-01	Motor Overload Protection Selection **MOL Fault Select**	Enables or disables the motor thermal overload protection. 0: Disabled 1: Std Fan Cooled (Enabled) 2: Std Blower Cooled 3: Vector Motor	0 to 1	1	Programming
L1-02	Motor Overload Protection Time **MOL Time Const**	Determines how much time will elapse prior to a motor overload fault (OL1), when motor amps exceed the value set in parameter E2-01 by 10%. Actual (OL1) trip time will vary depending on severity of overload.	0.1 to 20.0	8.0min	Programming
L1-03	Motor Overheat Alarm Operation Selection **Mtr OH Alarm Sel**	Operation selection when the motor temperature analog input (H3-09=E) exceeds the OH3 alarm level (1.17V) 0: Ramp to Stop 1: Coast to Stop 2: Fast-Stop 3: Alarm Only	0 to 3	3	Programming
L1-04	Motor Overheat Fault Operation Selection **Mtr OH Fault Sel**	Stopping method when the motor temperature analog input (H3-09=E) exceeds the OH4 level (2.34V). 0: Ramp to Stop 1: Coast to Stop 2: Fast-Stop	0 to 2	1	Programming
L1-05	Motor Temperature Input Filter Time **Mtr Temp Filter**	Delay Time applied to motor temperature analog input (H3-09=E) for filtering purposes.	0.00 to 10.00	0.20sec	Programming

♦Denotes that parameter can be changed when the drive is running.

* After these parameters are changed, drive power must be cycled before the changes will take effect.

Hex, see page A-30.

Table 1: Parameter List (Continued)

Parameter No.	Parameter Name **Digital Operator Display**	Description	Setting Range	Factory Setting	Menu Location
		PwrLoss Ridethru			
L2-01	Momentary Power Loss Detection Selection **PwrL Selection**	Enables and disables the momentary power loss function. 0: Disabled - Drive trips on (UV1) fault when power is lost. 1: PwrL Ride Thru t - Drive will restart if power returns within the time set in L2-02.* 2: CPU Power Active - Drive will restart if power returns prior to internal power supply shut down.* * In order for a restart to occur, the run command must be maintained throughout the ride thru period.	0 to 2	2	Programming
L2-02	Momentary Power Loss Ride-thru Time **PwrL Ridethru t**	Determines the power loss ride-thru time. This value is dependent on the capacity of the drive. Only effective when L2-01 = 1.	0.0 to 25.5sec	kVA Dependent	Programming
L2-03	Momentary Power Loss Minimum Base Block Time **PwrL Baseblock t**	Used to allow the residual motor voltage to decay before the drive output turns back on. After a power loss, if L2-03 is greater than L2-02, operation resumes after the time set in L2-03.	0.1 to 5.0sec	kVA Dependent	Programming
L2-04	Momentary Power Loss Voltage Recovery Ramp Time **PwrL V/F Ramp t**	The time it takes the output voltage to return to the preset V/f pattern after speed search (current detection mode) is complete.	0.0 to 5.0sec	kVA Dependent	Programming
L2-05	Undervoltage Detection Level **PUV Det Level**	Sets the drive's DC Bus undervoltage trip level. If this is set lower than the factory setting, additional AC input reactance or DC bus reactance may be necessary.	Voltage Class Dependent	Voltage Class Dependent	Programming
		Stall Prevention			
L3-01	Stall Prevention Selection During Accel **StallP Accel Sel**	0: Disabled (Motor accelerates at active acceleration, C1-01 or C1-03. The motor may stall if load is too heavy or accel time is too short). 1: General Purpose (When output current exceeds L3-02 level, acceleration stops. It starts to accelerate at current value recovery). 2: Intelligent (The active acceleration rate, C1-01 or C1-02, is ignored. Acceleration is completed in the shortest amount of time w/o exceeding the current value set in L3-02).	0 to 2	1	Programming
L3-02	Stall Prevention Level During Accel **StallP Accel Lvl**	This function is enabled when L3-01 is “1” or “2”. Drive rated current is 100%. Decrease the set value if stalling occurs at factory setting.	0 to 200	120%	Programming
L3-04	Stall Prevention Selection During Decel **StallP Decel Sel**	0: Disabled (The drive decelerates at the active deceleration rate, C1-02 or C1-04. If the load is too large or the deceleration time is too short, an OV fault may occur). 1: General Purpose (The drive decelerates at the active deceleration rate, C1-02 or C1-04, but if the main circuit DC bus voltage reaches the stall prevention level the output frequency will clamp. Deceleration will continue once the DC bus level drops below the stall prevention level). 2: Intelligent (The active deceleration rate is ignored and the drive decelerates as fast as possible w/o hitting OV fault level).	0 to 3	1	Programming
L3-05	Stall Prevention Selection During Run **StallP Run Sel**	0: Disabled (Drive runs a set frequency). A heavy load may cause the drive to trip on an OC fault. 1: Decel Time 1 (In order to avoid stalling during heavy loading, the drive will start to decelerate at Decel time 1 (C1-02) if the output current exceeds the level set by L3-06. Once the current level drops below the L3-06 level the drive will accelerate back to its set frequency at the active acceleration rate). 2: Decel Time 2 (Same as setting 1 except the drive decelerates at Decel Time 2 (C1-04). For 6Hz or less frequency, stall prevention function during run is disabled regardless of L3-05 set.	0 to 2	1	Programming
L3-06	Stall Prevention Level During Running **StallP Run Level**	This function is enabled when L3-05 is “1” or “2”. Drive rated current is set as 100%. Normally, changing the setting is not required. Decrease the set value if stalling occurs at factory setting.	30 to 200	120%	Programming

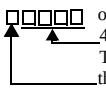
Table 1: Parameter List (Continued)

Parameter No.	Parameter Name **Digital Operator Display**	Description	Setting Range	Factory Setting	Menu Location
		Ref Detection			
L4-01	Speed Agreement Detection Level **Spd Agree Level**	L4-01 and L4-02 are used in conjunction with the multi-function outputs, (H2-01and H2-02) as a setpoint and hysteresis for a contact closure.	0.0 to 200.0	0.0Hz	Programming
L4-02	Speed Agreement Detection Width **Spd Agree Width**		0.0 to 20.0	2.0Hz	Programming
L4-05	Frequency Reference Loss Detection Selection **Ref Loss Sel**	Determines how the drive will react when the frequency reference is lost. 0: Stop (Disabled) - Drive will not run at the frequency reference 1: Enabled @ % of PrevRef - Drive will run at a percentage (L4-06) of the frequency reference level at the time frequency reference was lost.	0 or 1	1	Programming
L4-06	Frequency Reference Level at Loss Frequency **Fref at Floss**	If Frequency Reference loss function is enabled (L4-05=1) and Frequency Reference is lost, then the drive will run at reduced frequency reference determined by L4-06. New Fref =Fref at time of loss x L4-06.	0 to 100.0%	80.0%	Programming
		Fault Restart			
L5-01	Number of Auto Restart Attempts **Num of Restarts**	Determines the number of times the drive will perform an automatic restart.	0 to 10	0	Quick Setting
L5-02	Auto Restart Operation Selection **Restart Sel**	Determines if the fault contact activates during an automatic restart attempt. 0: No Flt Relay - fault contact will not activate during an automatic restart. 1: Flt Relay Active - fault contact will activate during an automatic restart.	0 or 1	0	Programming
L5-03	Maximum Restart Time After Fault **Max Restart Time**	If the restart fails (or is not attempted due to a continuing fault condition, e.g. an OV fault) the Drive waits L5-03 seconds before attempting another restart.	0.5 to 600.0	180.0sec	Quick Setting
		Torque Detection			
L6-01	Torque Detection Selection 1 **Load Detection**	Determines the drive's response to an overtorque / undertorque condition. Overtorque and Undertorque are determined by the settings in parameters L6-02 and L6-03. 0: Disabled 1: OL@SpdAgree - Alm (Overtorque Detection only active during Speed Agree and Operation continues after detection). 2: OL At RUN - Alm (Overtorque Detection is always active and operation continues after detection) 3: OL@SpdAgree - Flt (Overtorque Detection only active during Speed Agree and drive output will shut down on an OL3 fault). 4: OL At RUN - Flt (Overtorque Detection is always active and drive output will shut down on an OL3 fault.) 5: LL@SpdAgree - Alm (Undertorque Detection is only active during Speed Agree and operation continues after detection). 6: LL at RUN - Alm (Undertorque Detection is always active and operation continues after detection) 7: LL @ SpdAgree - Flt (Undertorque Detection only active during Speed Agree and drive output will shut down on an OL3 fault). 8: LL At RUN - Flt (Undertorque Detection is always active and drive output will shut down on an OL3 fault).	0 to 8	0	Programming
L6-02	Torque Detection Level 1 **Load Det Lvl**	Sets the overtorque/undertorque detection level as a percentage of Drive rated current.	0 to 300	15%	Programming
L6-03	Torque Detection Time 1 **Loss Det Time**	Sets the length of time an overtorque / undertorque condition must exist before being recognized by the drive. OL3 is then displayed.	0.0 to 10.0	10.0sec	Programming

Table 1: Parameter List (Continued)

Parameter No.	Parameter Name **Digital Operator Display**	Description	Setting Range	Factory Setting	Menu Location
		Hdwe Protection			
L8-01	Internal Dynamic Braking Resistor Protection Selection **DB Resistor Prot**	0: Not Provided 1: Provided	0 or 1	0	Programming
L8-02	Overheat Pre-Alarm Level **OH Pre-Alarm Lvl**	When the cooling fin temperature exceeds the value set in this parameter, an overheat pre-alarm (OH) will occur.	50 to 130	kVA Dependent	Programming
L8-03	Overheat Pre-Alarm Operation Selection **OH Pre-Alarm Sel**	Drive Operation upon OH Pre Alarm Detection. 0: Ramp to Stop (Decel Time C1-02). 1: Coast to Stop 2: Fast-Stop (Decel Time = C1-09). 3: Alarm Only *0 to 2 is recognized as fault detection, and 3 is recognized as alarm. (For the fault detection, the fault contact operates.) 4: OH Alarm & Reduce (Continue operation and reduce output frequency by L8-19).	0 to 4	4	Programming
L8-06	Input Phase Loss Detection Level **Ph Loss In Lvl**	Monitors the DC Bus current ripple and activates when one of the input phases is lost (PF).	0.0 to 25.0	kVA Dependent	Programming
L8-09	Output Ground Fault Detection Selection **Ground Fault Sel**	Enables and disables drive output ground fault detection. 0: Disabled 1: Enabled	0 or 1	1	Programming
L8-10	Heatsink Cooling Fan Operation Selection **Fan On/Off Sel**	Controls the Heatsink Cooling Fan Operation. 0: Fan On-Run Mode (Fan will operate only when drive is running and for L8-11 seconds after RUN is removed). 1: Fan Always On (Cooling fan operates whenever drive is powered up).	0 or 1	0	Programming
L8-11	Heatsink Cooling Fan Operation Delay Time **Fan Delay Time**	When L8-10=0 this parameter sets a delay time for Cooling Fan de-energization after the run command is removed.	0 to 300	300sec	Programming
L8-12	Ambient Temperature Setting **Ambient Temp**	When the drive is installed in an ambient temperature exceeding its rating, drive overload (OL2) protection level is reduced.	45 to 60°C	45°C	Programming
L8-15	OL2 Characteristic Selection at Low Speeds **OL2 Sel @ L-Spd**	This parameter assists in protecting the output transistor junctions from overheating when output current is high and output frequency is low. 0: Disabled 1: Enabled (L8-18 is active)	0 or 1	1	Programming
L8-18	Soft CLA Selection **Soft CLA Sel**	Enables and disables software Current Limit "A" (CLA) 0: Disabled 1: Enabled	0 or 1	1	Programming
L8-19	OH Frequency Reference Reduction Level **Fref During OH**	Sets the amount of frequency reference reduction when an Overheat Pre-alarm (OH) is detected.	0.0 to 100.0	20.0%	Programming
L8-32	OH1 Detection Selection for Fan Failure **OH1 Detect Sel**	Selects the drive response upon failure of the internal cooling fan. 0: Disabled FAN alarm is displayed 1: Enabled OH1 fault occurs	0 or 1	1	Programming
		Hunting Prev			
n1-01	Hunting Prevention Selection **Hunt Prev Select**	0: Disabled (Hunting prevention function disabled). 1: Enabled (Hunting prevention function enabled). If the motor vibrates while lightly loaded, hunting prevention may reduce the vibration. There is a loss of responsiveness if hunting prevention is enabled.	0 or 1	1	Programming
n1-02	Hunting Prevention Gain Setting **Hunt Prev Gain**	Gain setting for the Hunting Prevention Function. If the motor vibrates while lightly loaded and n1-01=1, increase the gain by 0.1 until vibration ceases. If the motor stalls while n1-01=1 decrease the gain by 0.1 until the stalling ceases.	0.00 to 2.50	1.00	Programming

Table 1: Parameter List (Continued)

Parameter No.	Parameter Name **Digital Operator Display**	Description	Setting Range	Factory Setting	Menu Location
		High Slip			
n3-01	High-Slip Braking Deceleration Frequency Width **HSB Decel Width**	Sets how aggressively the drive decreases the output frequency as it stops the motor. If overvoltage (OV) faults occur during HSB, this parameter may need to be increased.	1 to 20	5%	Programming
n3-02	High-Slip Braking Current Limit **HSB Current Ref**	Sets the maximum current to be drawn during a HSB stop. Higher n3-02 settings will shorten motor stopping times but cause increased motor current, and therefore increased motor heating.	100 to 200	150%	Programming
n3-03	High-Slip Braking Dwell Time at Stop **HSB DwelTim@ Stp**	Sets the amount of time the Drive will dwell at E1-09 (Minimum Frequency). If this time is set too low, the machine inertia can cause the motor to rotate slightly after the HSB stop is complete and the Drive output is shut off.	0.0 to 10.0	1.0sec	Programming
n3-04	High-Slip Braking Overload Time **HSB OL Time**	Sets the time required for a HSB Overload Fault to occur when the Drive output frequency does not change for some reason during a HSB stop. Normally this does not need to be adjusted.	30 to 1200	40sec	Programming
		Monitor Select			
o1-01 ♦	User Monitor Selection **User Monitor Sel**	Selects which monitor will be displayed upon power-up when o1-02 = 4.	6 to 53	6	Programming
o1-02	User Monitor Selection After Power-Up **Power-On Monitor**	Selects which monitor will be displayed upon power-up. 1: Frequency Ref 2: Output Freq 3: Output Current 4: User Monitor (set by o1-01)	1 to 4	1**	Programming
o1-03	Digital Operator Display Selection **Display Scaling**	Sets the units of the Frequency References (d1-01 through d1-17) and the Frequency Reference Monitor (U1-01). 0: Hz 1: % (100%. = E1-04) 2 to 39: RPM. (Enter the number of motor poles.) 40 to 39999: User display  Desired set/display value is set at Max. output frequency. 4 digit number. The number of digits from the right the decimal point is displayed. Example: If “200.0 is displayed at Max. output frequency, set “12000”. When o1-03≥40 (user units), the unit selected in o1-09 will be displayed for D1-01 to D1-17, U1-01, U1-02, and U1-20	0 to 39999	0	Programming
o1-05	LCD Brightness Adjustment **LCD Contrast**	Set Value / Description: 5 – LCD display becomes dark 3 – Standard setting 1 – LCD display becomes light	0 to 5	3	Programming
o1-06	User Monitor Selection Mode **Monitor Mode Sel**	Selects the “U1” monitors displayed on the 4th and 5th lines of the digital operator display. 0: 3 Mon Sequential (Displays the next 2 sequential U1 monitors). 1: 3 Mon Selectable (Displays U1 monitors set by o1-07 and o1-08).	0 or 1	0**	Programming
o1-07	Second Line User Monitor Selection **2nd Monitor Sel**	Sets the “U1” monitor always displayed on the 4th line of the digital operator display. Effective only when o1-06 = 1. (Continued on following page)	1 to 53	2**	Programming

** Factory setting changes to “2” when b5-01=1

Table 1: Parameter List (Continued)

Parameter No.	Parameter Name **Digital Operator Display**	Description	Setting Range	Factory Setting	Menu Location
o1-08	Third Line User Monitor Selection **3rd Monitor Sel**	Sets the "U1" monitor always displayed on the 5th line of the digital operator display. Effective only when o1-06 = 1.	1 to 53	3**	Programming
o1-09 ♦	Frequency Reference Display Units **Frq Display Unit**	Sets unit display for the frequency reference parameters and frequency related monitors when o1-03≥40. 0: WC:InchOfWater 1: PSI:lb/SqrInch 2: GPM:Gallons/Min 3: F:DegFahrenheit 4: CFM:Cubic ft/Min 5: CMH:Cubic M/Hr 6: LPH:Liters/Hr 7: LPS:Liters/Sec 8: Bar:Bar 9: Pa:Pascals 10: C:DegCelsius 11: Mtr:Meters	0 to 11	0	Programming
		Key Selections			
o2-01	Local/Remote Key Function Selection **Local/Remote Key**	Determines the status of the Local/Remote key, if present. 0: Disabled 1: Enabled Has no function when H/O/A operator is connected.	0 or 1	1	Programming
o2-02	OFF Key Function During Auto Run **Oper OFF Key**	Determines if the off key on the digital operator will stop the drive when drive is operating from external terminals or serial communications. 0: Disabled 1: Enabled	0 or 1	1	Programming
o2-03	User Parameter Default Value **User Defaults**	Allows storing of current parameter values as a User Initialization Selection at parameter A1-03. 0: No Change (No user parameter set active). 1: Set Defaults (Saves current parameter settings as user initialization. A1-03 now allows selecting <1110> for user initialization. 2: Clear All (Clears the currently saved user initialization. A1-03 no longer allows selecting <1110>.	0 to 2	0	Programming
o2-04	Drive/kVA Selection **Inverter Model #**	Sets the kVA of the drive. Enter the number based on drive Model #. Use the □□□□ portion of the CIMR-E7□□□□ Model Number. Reference Appendix B	0 to FF	kVA Dependent	Programming
o2-05	Frequency Reference Setting Method Selection **Operator M.O.P.**	Determines if the Data/Enter key must be used to input a frequency reference from the digital operator. 0: Disabled - Data/Enter key must be pressed to enter a frequency reference. 1: Enabled - Data/Enter key is not required. The frequency reference is adjusted by the up and down arrow keys on the digital operator without having to press the data/enter key.	0 or 1	1	Programming
o2-06	Operation Selection when Digital Operator is Disconnected **Oper Detection**	Determines if the drive will stop when the digital operator is removed. 0: Disabled - The drive will not stop when the digital operator is removed. 1: Enabled - The drive will fault (OPR) and coast to stop when the operator is removed.	0 or 1	1	Programming
o2-07	Cumulative Operation Time Setting **Elapsed Time Set**	Sets the initial value of the elapsed operation timer.	0 to 65535	0 hours	Programming
o2-08	Cumulative Operation Time Selection **Elapsed Time Run**	Sets how time is accumulated for the elapsed timer (o2-07). 0: Power-On Time (Time accumulates whenever drive is powered) 1: Running Time (Time accumulates only when drive is running) (Continued on following page).	0 or 1	1	Programming

♦ Denotes that parameter can be changed when the drive is running.
** Factory settings change when b5-01=1 as follows: o1-06=1, o1-07=38, o1-08=24.

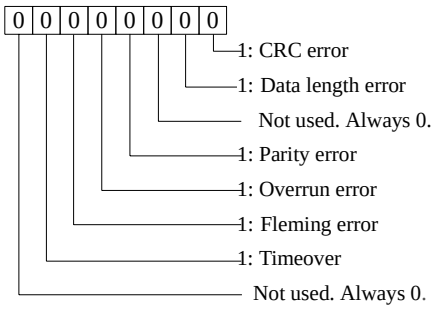
Table 1: Parameter List (Continued)

Parameter No.	Parameter Name **Digital Operator Display**	Description	Setting Range	Factory Setting	Menu Location
o2-09	Initialization Specification Selection **Init Mode Sel**	Determines parameter values after a drive initialization (A1-03) is executed. This should always be set to "1" American Spec. 1: American spec **⚠WARNING** Parameter o2-09 should always be set to "1: American Spec." (Do not set.) This parameter does not normally require adjustment. Possible damage to equipment or injury may occur if this setting is changed from "1: American Spec." o2-09 is a macro parameter that can change the default values of terminal I/O and many other parameters in the drive. Consult the Yaskawa factory for details. This parameter is not available in software version > 1020.	1	1	Programming
o2-10	Cumulative Cooling Fan Operation Time Setting **Fan ON Time Set**	Sets the initial value of the heatsink fan operation time.	0 to 65535	0 hours	Programming
o2-12	Fault Trace/Fault History Clear Function **FLT Trace Init**	Clears the fault memory contained in the U2 and U3 monitors. 0: Disabled (no effect) 1: Enabled - resets U2 and U3 monitors, and returns o2-12 to zero	0 or 1	0	Programming
o2-14	kWh User Monitor (U1-29) Initialization **kWh MonitorClear**	Used to reset the kilowatt Hour monitor to zero 0: Disabled (no change) 1: Clear all - Resets U1-29 to zero and returns o2-14 to zero.	0 or 1	0	Programming
o2-15	Hand Key Function Selection **Oper Hand Key**	Enables or disables the "Hand" key on the digital operator. 0: Disabled 1: Enabled	0 or 1	1	Programming
		COPY Function			
o3-01	Copy Function Selection **Copy Function Sel**	This parameter controls the copying of parameters to and from the digital operator. 0: COPY SELECT (no function) 1: INV -> OP READ - All parameters are copied from the drive to the digital operator. 2: OP -> INV WRITE - All parameters are copied from the digital operator into the drive. 3: OP<-->INV VERIFY - Parameter settings in the drive are compared to those in the digital operator. NOTE: When using the copy function, the drive model number and software number (U1-14) must match or an error will occur.	0 to 3	0	Programming
o3-02	Read Allowed Selection **Read Allowable**	Enables and disables all digital operator copy functions. 0: Disabled - No digital operator copy functions are allowed 1: Enabled - Copying allowed	0 to 1	0	Programming
		Auto-Tuning			
T1-02	Motor Rated Power **Mtr Rated Power**	Sets the motor rated power in kW. NOTE: T1-02 should be left at the Drive default (the last 3 digits of the Drive model number).	0.00 to 650.00	kVA Dependent	Auto-Tuning
T1-04	Motor Rated Current **Rated Current**	Sets the motor rated current. (Used only during an auto-tune).	kVA Dependent	kVA Dependent	Auto-Tuning

Monitor List

Table 2: Monitor List

Parameter No.	Parameter Name **Digital Operator Display**	Description
		Monitor
U1-01	Frequency Reference **Frequency Ref**	Frequency reference (speed command) monitor when in auto mode, frequency reference (speed command) setting location when in hand mode. Units changeable via o1-03.
U1-02	Output Frequency **Output Freq**	Output frequency (speed) monitor. Units changeable via o1-03.
U1-03	Output Current **Output Current**	Output current monitor
U1-06	Output Voltage **Output Voltage**	Displays Drive output voltage
U1-07	DC Bus Voltage **DC Bus Voltage**	Displays DC Bus Voltage
U1-08	Output Power **Output kWatts**	Displays Drive output power
U1-10	Input Terminal Status **Input Term Sts**	Displays Drive input terminal status 0 0 0 0 0 0 0 0 1: FWD. run (Terminal S1) is ON. 1: REV. run (Terminal S2) is ON. 1: Multi-function input 1 (Terminal S3) is ON. 1: Multi-function input 2 (Terminal S4) is ON. 1: Multi-function input 3 (Terminal S5) is ON. 1: Multi-function input 4 (Terminal S6) is ON. 1: Multi-function input 5 (Terminal S7) is ON.
U1-11	Output Terminal Status **Output Term Sts**	Output terminal ON/OFF Check 0 0 0 0 0 0 0 0 1: Multi-function Contact 1 output 1 (Terminal M1-M2) is ON 1: Multi-function Contact 2 output 1 (Terminal M3-M4) is ON Not used 1: Fault output (Terminal MA/MB-MC) is ON
U1-12	Drive Operation Status **Int Ctl Sts 1**	0 0 0 0 0 0 0 0 1: During running 1: During zero speed 1: During reverse 1: During reset signal input 1: During speed agree 1: Drive operation ready 1: During fault detection (Minor fault) 1: During fault detection (Major fault)

Parameter No.	Parameter Name **Digital Operator Display**	Description
		Monitor
U1-13	Cumulative Operation Time **Elapsed Time**	Displays total operating or power-on time of the Drive.
U1-14	Software Number **FLASH ID**	Displays Drive's software number.
U1-15	Terminal A1 Input Voltage **Term A1 Level**	Displays the input voltage on Terminal A1, as a percentage of 10V DC.
U1-16	Terminal A2 Input Voltage **Term A2 level**	Displays the input current (or voltage) on Terminal A2, as a percentage of 20mA (or 10 V DC).
U1-18	Motor Secondary Current (I_q) **Mot SEC Current**	Displays the amount of current being used by the motor to produce torque (Iq).
U1-20	Output Frequency After Soft Start **SFS Output**	Displays the frequency reference (speed command) after the accel and decel ramps.
U1-24	PI Feedback Value **PI Feedback**	Displays the feedback signal when PI control is used.
U1-28	CPU Number **CPU ID**	Displays control board hardware revision.
U1-29	kWh **kWh Lo 4 Digits**	Displays the accumulated kWh.
U1-30	MWh **kWh Hi 5 Digits**	Displays the accumulated MWh.
U1-34	First Parameter Causing an OPE **OPE Detected**	Displays the parameter number causing an “OPE” fault.
U1-36	PI Input **PI Input**	Displays the “error” in the PI regulator. (U1-36 = PI Setpoint - PI Feedback)
U1-37	PI Output **PI Output**	Displays the output of the PI as a percentage of maximum frequency (E1-04).
U1-38	PI Setpoint **PI Setpoint**	Displays the setpoint of the PI regulator (U1-38 = PI reference + PI bias)
U1-39	Memobus Communication Error Code **Transmit Err**	
U1-40	Heatsink Cooling Fan Operation Time **FAN Elapsed Time**	Displays total operating time of the heatsink cooling fan.
U1-51	Auto Mode Frequency Reference Value **Auto Mode Fref**	Displays the frequency reference (speed command) when in auto mode.
U1-52	Hand Mode Frequency Reference Value **HAND Mode Fref**	Displays the frequency reference (speed command) when in hand mode, or displays Terminal A2 when differential mode is selected.
U1-53	PI Feedback 2 Value **PI Feedback 2**	Displays PI feedback 2 value.

Fault Trace List

Table 3: Fault Trace List

Fault Trace	
U2-01	Current Fault **Current Fault**
U2-02	Previous Fault **Last Fault**
U2-03	Frequency Reference at Most Recent Fault **Frequency Ref**
U2-04	Output Frequency at Most Recent Fault **Output Freq**
U2-05	Output Current at Most Recent Fault **Output Current**
U2-07	Output Voltage at Most Recent Fault **Output Voltage**
U2-08	DC Bus Voltage at Most Recent Fault **DC Bus Voltage**
U2-09	Output Power at Most Recent Fault **Output kWatts**
U2-11	Input Terminal Status at Most Recent Fault. The format is the same as for U1-10. **Input Term Sts**
U2-12	Output Terminal Status at Most Recent Fault. The format is the same as for U1-11. **Output Term Sts**
U2-13	Drive Operation Status at Most Recent Fault. The format is the same as for U1-12. **Inverter Status**
U2-14	Cumulative Operation Time at Most Recent Fault **Elapsed time**
(Note) Fault trace is not executed at CPF00, CPF01, CPF03, UVI and UV2.	

Fault History List

Table 4: Fault History List

Fault History	
U3-01	Most Recent Fault **Last Fault**
U3-02	2nd Most Recent Fault **Fault Message 2**
U3-03	3rd Most Recent Fault **Fault Message 3**
U3-04	4th Most Recent Fault **Fault Message 4**
U3-05	Cumulative Operation Time at Most Recent Fault **Elapsed Time 1**
U3-06	Cumulative Operation Time at 2nd Most Recent Fault **Elapsed Time 2**
U3-07	Cumulative Operation Time at 3rd Most Recent Fault **Elapsed Time 3**
U3-08	Cumulative Operation Time at 4th Most Recent Fault **Elapsed Time 4**
U3-09	5th Most Recent Fault **Fault Message 5**
U3-10	6th Most Recent Fault **Fault Message 6**
U3-11	7th Most Recent Fault **Fault Message 7**
U3-12	8th Most Recent Fault **Fault Message 8**
U3-13	9th Most Recent Fault **Fault Message 9**
U3-14	10th Most Recent Fault **Fault Message 10**
U3-15	Cumulative Operation Time at 5th Most Recent Fault **Elapsed Time 5**
U3-16	Cumulative Operation Time at 6th Most Recent Fault **Elapsed Time 6**
U3-17	Cumulative Operation Time at 7th Most Recent Fault **Elapsed Time 7**
U3-18	Cumulative Operation Time at 8th Most Recent Fault **Elapsed Time 8**
U3-19	Cumulative Operation Time at 9th Most Recent Fault **Elapsed Time 9**
U3-20	Cumulative Operation Time at 10th Most Recent Fault **Elapsed Time 10**
(Note) Faults such as CPF00, CPF01, CPF02, CPF03, UV1, and UV02 are not stored in fault history.	

Decimal to Hex Conversion:

Decimal	Hex	Decimal	Hex
1	1	51	33
2	2	52	34
3	3	53	35
4	4	54	36
5	5	55	37
6	6	56	38
7	7	57	39
8	8	58	3A
9	9	59	3B
10	A	60	3C
11	B	61	3D
12	C	62	3E
13	D	63	3F
14	E	64	40
15	F	65	41
16	10	66	42
17	11	67	43
18	12	68	44
19	13	69	45
20	14	70	46
21	15	71	47
22	16	72	48
23	17	73	49
24	18	74	4A
25	19	75	4B
26	1A	76	4C
27	1B	77	4D
28	1C	78	4E
29	1D	79	4F
30	1E	80	50
31	1F	81	51
32	20	82	52
33	21	83	53
34	22	84	54
35	23	85	55
36	24	86	56
37	25	87	57
38	26	88	58
39	27	89	59
40	28	90	5A
41	29	91	5B
42	2A	92	5C
43	2B	93	5D
44	2C	94	5E
45	2D	95	5F
46	2E	96	60
47	2F	97	61
48	30	98	62
49	31	99	63
50	32	100	64

Notes:

Appendix B
Capacity Related Parameters

This appendix lists the parameters affected by the Drive Capacity setting of o2-04.

Drive Capacity Selection..... B-2
Parameters Affected by o-04..... B-3
Capacity Related Parameter Values..... B-4

Drive Capacity Selection

Parameter o2-04 sets the Drive capacity according to the model number. Parameter o2-04 will need to be adjusted when replacing a control board.

If a Control PCB is changed, the first time the Drive is powered up, parameter o2-04 must be set to the appropriate value listed in *Table B.1* for the Drive model number. After properly setting parameter 02-04, a 2-wire or 3-wire initialization must be performed by setting parameter A1-03=2220 or A1-03=3330, respectively. This will automatically program the values of all other parameters listed in *Table B.2* to the factory settings for that particular Drive rating.

Table B.1 Drive Capacity Selection

Voltage	Model Number	o2-04 Setting	Nominal Hp
208-240VAC	CIMR-P7U20P4	0	0.5/0.75
	CIMR-P7U20P7	1	1
	CIMR-P7U21P5	2	1.5/2
	CIMR-P7U22P2	3	3
	CIMR-P7U23P7	4	5
	CIMR-P7U25P5	5	7.5
	CIMR-P7U27P5	6	10
	CIMR-P7U2011	7	15
	CIMR-P7U2015	8	20
	CIMR-P7U2018	9	25
	CIMR-P7U2022	A	30
	CIMR-P7U2030	B	40
208-230VAC	CIMR-P7U2037	C	50
	CIMR-P7U2045	D	60
	CIMR-P7U2055	E	75
	CIMR-P7U2075	F	75/100
	CIMR-P7U2090	10	125
	CIMR-P7U2110	11	150
480VAC	CIMR-P7U40P4	20	0.5/0.75
	CIMR-P7U40P7	21	1
	CIMR-P7U41P5	22	1.5/2
	CIMR-P7U42P2	23	3
	CIMR-P7U43P7	24	5
	CIMR-P7U45P5	26	7.5
	CIMR-P7U47P5	27	10
	CIMR-P7U49P0	3C	15
	CIMR-P7U4011	28	20
	CIMR-P7U4015	29	25
	CIMR-P7U4018	2A	30
	CIMR-P7U4024	3D	40
	CIMR-P7U4030	2C	50
	CIMR-P7U4037	2D	60
	CIMR-P7U4045	2E	75
	CIMR-P7U4055	2F	100
	CIMR-P7U4075	30	125
	CIMR-P7U4090	31	150
	CIMR-P7U4110	32	200
	CIMR-P7U4160	34	250
	CIMR-P7U4185	35	300/350
	CIMR-P7U4220	36	400/450
	CIMR-P7U4300	37	500+

◆ Parameters Affected by o2-04

The factory setting of the following parameters may change when the Drive capacity is changed.

Table B.2 Parameters Affected by o2-04

Parameter Number	Parameter Name **Digital Operator Display**
b8-04	Energy Saving Coefficient Value **Energy Save COEF**
C6-02	Carrier Frequency Selection **CarrierFreq Sel**
C6-03	Carrier Frequency Upper Limit **CarrierFreq Max**
E2-01	Motor Rated Current **Motor Rated FLA**
E2-03	Motor No Load Current **No-Load Current**
E2-05	Motor Line-to-Line Resistance **Term Resistance**
L2-02	Momentary Power Loss Ride-thru Time **PwrL Ridethru t**
L2-03	Momentary Power Loss Minimum Base Block Time **PwrL Baseblock t**
L2-04	Momentary Power Loss Voltage Recovery Ramp Time **PwrL V/F Ramp t**
L8-02	Overheat Pre-Alarm Level **OH Pre-Alarm Lvl**
L8-06	Input Phase Loss Detection Level **Ph Loss In Lvl**
o2-04	Drive/kVA Selection **Inverter Model #**

◆ Capacity Related Parameter Values

The following tables detail the factory default settings for the parameters that are affected by the setting of parameter o2-04.

Table B.3 208/240VAC Drives

Drive Model CIMR-_ _ _	Nominal Hp	Factory Default for b8-04	Factory Default for C6-02	Factory Default for E2-01	Factory Default for E2-03	Factory Default for E2-05	Factory Default for L2-02	Factory Default for L2-03	Factory Default for L2-04	Factory Default for L8-02	Factory Default for L8-06
20P4	0.5/0.75	288.2	10kHz	1.9	1.2	9.842	0.1	0.1	0.3	95°C	5
20P7	2	223.7	10kHz	3.3	1.8	5.156	0.1	0.2	0.3	95°C	7.5
21P5	1.5/2	169.4	10kHz	6.2	2.8	1.997	0.2	0.3	0.3	95°C	10
22P2	3	156.8	8kHz	8.5	3.0	1.601	0.3	0.4	0.3	100°C	12
23P7	5	122.9	10kHz	14.0	4.5	0.771	0.5	0.5	0.3	95°C	12
25P5	7.5	94.75	15kHz	19.6	5.1	0.399	1.0	0.6	0.3	95°C	10
27P5	10	72.69	15kHz	26.6	8.0	0.288	1.0	0.7	0.3	95°C	17
2011	15	70.44	8kHz	39.7	11.2	0.230	1.0	0.8	0.3	95°C	21
2015	20	63.13	10kHz	53.0	15.2	0.138	2.0	0.9	0.3	90°C	17
2018	25	57.87	10kHz	65.8	15.7	0.101	2.0	1.0	0.6	100°C	15
2022	30	51.79	10kHz	77.2	18.5	0.079	2.0	1.0	0.6	90°C	24
2030	40	46.27	10kHz	105.0	21.9	0.064	2.0	1.1	0.6	90°C	20
2037	50	38.16	5kHz	131.0	38.2	0.039	2.0	1.1	0.6	95°C	18
2045	60	35.78	5kHz	160.0	44.0	0.030	2.0	1.2	0.6	100°C	20
2055	75	31.35	8kHz	190.0	45.6	0.022	2.0	1.2	0.1	105°C	17
2075	75/100	23.10	2kHz	260.0	72.0	0.023	2.0	1.3	0.1	110°C	16
2090	125	20.65	2kHz	260.0	72.0	0.023	2.0	1.5	0.1	100°C	18
2110	150	18.12	2kHz	260.0	72.0	0.023	2.0	1.7	0.1	95°C	20

Note: b8-04 = Energy Savings Coefficient
C6-02 = Carrier Frequency
E2-01 = Motor Rated Current
E2-03 = Motor No-Load Current
E2-05 = Motor Line-to-Line Resistance
L2-02 = Momentary Power Loss Ride-Thru Time
L2-03 = Momentary Power Loss Minimum Base Block Time
L2-04 = Momentary Power Loss Voltage Recovery Ramp Time
L8-02 = Overheat Pre-Alarm Level
L8-06 = Input Phase Loss Detection Level

Table B.4 480VAC Drives											
Drive Model CIMR-_ _ _	Nominal Hp	Factory Default for b8-04	Factory Default for C6-02	Factory Default for E2-01	Factory Default for E2-03	Factory Default for E2-05	Factory Default for L2-02	Factory Default for L2-03	Factory Default for L2-04	Factory Default for L8-02	Factory Default for L8-06
40P4	0.5/0.75	576.40	15kHz	1.0	0.6	38.198	0.1	0.1	0.3	95°C	5
40P7	1	447.40	15kHz	1.6	0.8	22.459	0.1	0.2	0.3	95°C	7.5
41P5	1.5/2	338.80	15kHz	3.1	1.4	10.100	0.2	0.3	0.3	95°C	10
42P2	3	313.60	15kHz	4.2	1.5	6.495	0.3	0.4	0.3	90°C	10
43P7	5	245.80	15kHz	7.0	2.3	3.333	0.5	0.5	0.3	95°C	12
45P5	7.5	189.50	15kHz	13.3	2.6	1.595	1.0	0.6	0.3	95°C	10
47P5	10	145.38	15kHz	19.9	4.0	1.152	1.0	0.7	0.3	90°C	20
49P0	15	145.46	15kHz	21.0	4.4	0.922	1.0	0.8	0.3	95°C	23
4011	20	140.88	8kHz	26.5	5.6	0.922	2.0	0.8	0.3	95°C	23
4015	25	126.26	10kHz	32.9	7.6	0.550	2.0	0.9	0.3	95°C	17
4018	30	115.74	10kHz	52.3	7.8	0.403	2.0	1.0	0.6	98°C	17
4024	40	89.08	10kHz	52.0	8.6	0.269	2.0	1.1	0.6	85°C	20
4030	50	92.54	8kHz	65.6	10.9	0.269	2.0	1.1	0.6	85°C	20
4037	60	76.32	8kHz	79.7	19.1	0.155	2.0	1.1	0.6	85°C	20
4045	75	71.56	8kHz	95.0	22.0	0.122	2.0	1.2	0.6	90°C	20
4055	100	67.20	5kHz	130.0	24.0	0.088	2.0	1.2	1.0	90°C	20
4075	125	46.20	5kHz	130.0	36.0	0.092	2.0	1.3	1.0	98°C	16
4090	150	38.91	8kHz	156.0	40.0	0.056	2.0	1.5	1.0	108°C	16
4110	200	36.23	5kHz	190.0	49.0	0.046	2.0	1.7	1.0	100°C	16
4160	250	30.13	5kHz	270.0	70.0	0.029	2.0	1.8	1.0	108°C	14
4185	300/350	30.57	2kHz	310.0	81.0	0.025	2.0	0.7	1.0	95°C	15
4220	400/450	27.13	2kHz	370.0	96.0	0.020	2.0	0.8	1.0	100°C	15
4300	500+	21.76	2kHz	500.0	130.0	0.014	2.1	0.9	1.0	95°C	15

Note: b8-04 = Energy Savings Coefficient
C6-02 = Carrier Frequency
E2-01 = Motor Rated Current
E2-03 = Motor No-Load Current
E2-05 = Motor Line-to-Line Resistance
L2-02 = Momentary Power Loss Ride-Thru Time
L2-03 = Momentary Power Loss Minimum Base Block Time
L2-04 = Momentary Power Loss Voltage Recovery Ramp Time
L8-02 = Overheat Pre-Alarm Level
L8-06 = Input Phase Loss Detection Level

Notes:

Appendix C
Specifications

This appendix details the standard Drive Specifications.

Standard Drive Specifications C-2

Standard Drive Specifications

The standard Drive specifications are listed in the following tables.

◆ 208-240Vac

Table C.1 208-240Vac Drive Specifications

Model Number CIMR-P7U			20P4	20P7	21P5	22P2	23P7	25P5	27P5	2011	2015	2018	2022	2030
Output ratings	Rated output capacity (kVA)		1.4	1.8	3.0	4.1	6.4	8.8	12.0	18.0	23.0	29.0	34.0	44.0
	Motor HP	208V	0.5/0.75	1	1.5/2	3	5	7.5	10	15	20	25	30	40
		230V	0.5/0.75	1	1.5/2	3	5	7.5	10	15	20	25	30	40
	Rated output current (A)		3.6	4.6	7.8	10.8	16.8	23.0	31.0	46.2	59.4	74.8	88.0	115.0
	Max. output voltage (V)		3-phase; 200, 208, 220, 230, or 240Vac (Proportional to input voltage)											
	Max. output frequency (Hz)		120 Hz											
Power supply characteristics	Rated voltage (V) Rated frequency (Hz)		3-phase, 200/208/220/230/240Vac, 50/60 Hz											
	Rated input current (A)		4.3	5.5	9.4	13	20	24	37	53	70	89	98	120
	Allowable voltage fluctuation		+ 10%, - 15%											
	Allowable frequency fluctuation		±5%											
Control characteristics	Measures for power supply harmonics	DC Reactor	Optional										Built-in	
		12-Pulse Rectification	Not possible										Possible	

Note: The maximum applicable motor output is given for a standard 4-pole motor. When selecting the actual motor and Drive, be sure that the Drive's rated output current is applicable for the motor's rated current.
A phase-shifting transformer is required on the power supply for 12-pulse rectification.

Table C.1 208-230Vac Drive Specifications (Continued)

Model Number CIMR-P7U			2037	2045	2055	2075	2090	2110
Output ratings	Rated output capacity (kVA)		62.0	73.0	82	120.0	140.0	160.0
	Motor HP	208V	50	60	75	100	125	150
		230V	50/60	75	-	100/125	-	150
	Rated output current (A)		162.0	192.0	215	312.0	360.0	415.0
	Max. output voltage (V)		3-phase; 200, 208, 220, 230, or 240Vac (Proportional to input voltage)					
	Max. output frequency (Hz)		120 Hz					
Power supply characteristics	Rated voltage (V) Rated frequency (Hz)		3-phase, 200/208/220/230/240Vac, 50/60 Hz					
	Rated input current (A)		180	212	237	350	396	457
	Allowable voltage fluctuation		+ 10%, - 15%					
	Allowable frequency fluctuation		±5%					
Control characteristics	Measures for power supply harmonics	DC Reactor	Built-in					
		12-Pulse Rectification	Possible					

Note: The maximum applicable motor output is given for a standard 4-pole motor. When selecting the actual motor and Drive, be sure that the Drive's rated output current is applicable for the motor's rated current.
A phase-shifting transformer is required on the power supply for 12-pulse rectification.

◆ 480Vac

Table C.2 480VAC Drive Specifications

	Model Number CIMR-P7U		40P4	40P7	41P5	42P2	43P7	45P5	47P5	49P0	4011	4015
Output ratings	Rated output capacity (kVA)		1.4	1.6	2.8	4.0	5.8	9.5	13.0	16.0	21.0	26.0
	Motor HP (460V)		0.5/0.75	1	1.5/2	3	5	7.5	10	15	20	25
	Rated output current (A)		1.8	2.1	3.7	5.3	7.6	12.5	17.0	21.0	27.0	34.0
	Max. output voltage (V)		3-phase; 380, 400, 415, 440, 460, or 480VAC (Proportional to input voltage.)									
	Max. output frequency (Hz)		120 Hz									
Power supply characteristics	Rated voltage (V) Rated frequency (Hz)		3-phase, 380, 400, 415, 440, 460 or 480VAC, 50/60 Hz									
	Rated input current (A)		2.2	2.5	4.4	6.4	9.0	15	20	26	33	40
	Allowable voltage fluctuation		+ 10%, - 15%									
	Allowable frequency fluctuation		±5%									
Control characteristics	Measures for power supply harmonics	DC Reactor	Optional									
		12-pulse Rectification	Not possible									

Table C.2 480VAC Drive Specifications (Continued)

	Model Number CIMR-P7U		4024	4030	4037	4045	4055	4075	4090	4110	4160	4185	4220
Output ratings	Rated output capacity (kVA)		40.0	51.0	59.0	73.0	95.0	120.0	140.0	180.0	230.0	315.0	390.0
	Motor HP (460V)		40	50	60	75	100	125	150	200	250	300/350	400/450
	Rated output current (A)		52.0	67.2	77.0	96.0	125.0	156.0	180.0	240.0	304.0	414.0	515.0
	Max. output voltage (V)		3-phase, 380, 400, 415, 440, 460 or 480VAC (Proportional to input voltage)										
	Max. output frequency (Hz)		120 Hz										
Power supply characteristics	Max. voltage (V) Rated frequency (Hz)		3-phase, 380, 400, 415, 440, 460, or 480VAC, 50/60 Hz										
	Rated input current (A)		57	74	85	106	134	172	198	264	334	456	567
	Allowable voltage fluctuation		+ 10%, - 15%										
	Allowable frequency fluctuation		±5%										
Control characteristics	Measures for power supply harmonics	DC Reactor	Built-in										
		12-Pulse Rectification	Possible										

Note: The maximum applicable motor output is given for a standard 4-pole motor. When selecting the actual motor and Drive, be sure that the Drive's rated output current is applicable for the motor's rated current.

A 3-wire phase-shifting transformer is required on the power supply for 12-pulse rectification.

Table C.3 Common Drive Specifications		
Model Number CIMR-P7U		Specification
Control Characteristics	Control method	Sine wave PWM V/f control
	Speed range	40:1
	Speed control accuracy	±2 to 3% (77°F ± 50°F) (25°C ± 10°C)
	Frequency accuracy (temperature characteristics)	Digital references: ± 0.01% (14°F to 104°F) (-10°C to +40°C)
		Analog references: ±0.1% (77°F ± 50°F) (25°C ±10°C)
	Frequency setting resolution	Digital references: 0.01 Hz
		Analog references: 0.025/50 Hz (10 bit with sign)
	Frequency setting signal (Speed Command)	0-10 Vdc, 4-20 mA
	Acceleration/Deceleration time	0.0 to 6000.0 s (2 selectable combinations of independent acceleration and deceleration settings)
	Main control functions	Restarting for momentary power loss, bi-directional speed search, overtorque detection, 5 preset speeds, acceleration/deceleration time changes, S-curve acceleration, 3-wire sequence, auto-tuning, cooling fan ON/OFF control, torque compensation, jump frequencies, upper and lower limits for frequency references, DC braking for starting and stopping, high-slip braking, PI control (with sleep function), energy-saving control, Modbus communications (RS-485/422, 19.2 kbps maximum), fault reset, and copy function
Protective Functions	Motor protection	Protection by electronic thermal overload relay
	Fuse blown protection	Stops for fuse blown
	Overload capacity and maximum current	110% of rated output current for 60 seconds
	Overload protection	110% of rated output current for 60 seconds
	Overvoltage protection	208-240Vac: Stops when main-circuit DC voltage is above 410 V 480Vac: Stops when main-circuit DC voltage is above 820 V
	Undervoltage protection	208-240Vac: Stops when main-circuit DC voltage is below 190 V 480Vac: Stops when main-circuit DC voltage is below 380 V
	Momentary power loss ridethru	Power Interruptions of 15 ms or more By selecting the momentary power loss method, operation can be continued if power is restored within 2 s
	Cooling fin overheating	Protection by thermistor
	Stall prevention	Stall prevention during acceleration, deceleration, or running
	Grounding protection	Protection by electronic circuits. (50% of inverter rated current)
	Charge indicator	Lit when the main circuit DC voltage is approx. 50 Vdc or more
Enclosure Type		Enclosed wall-mounted type (NEMA 1): CIMR-P7U20P4 thru 2030 and 40P4 thru 4055 Open chassis type (IP00): CIMR-P7U2022 thru 2110 and 4030 thru 4300
Environment	Ambient operating temperature	14°F to 104°F (-10°C to 40°C) NEMA 1 type 14°F to 113°F (–10°C to 45°C) Open chassis type
	Ambient operating humidity	95% max. (with no condensation)
	Storage temperature	-4°F to 140°F (- 20°C to + 60°C) short-term temperature during transportation
	Application site	Indoor (no corrosive gas, dust, etc.)
	Altitude	3300 ft. (1000 m), higher altitudes by derate
	Vibration	10 to 20 Hz, 32 ft/sec^2 (9.8 m/s^2) max.; 20 to 50 Hz, 6.5 ft/sec^2 (2 m/s^2) max.
Approval Agency		UL File E131457

Appendix D
Communication

This appendix details the specifications, connections, and programming of the Drive for Modbus communications.

Using Modbus Communication D-2
Modbus Function Code Details..... D-7
Modbus Data Tables..... D-9
Modbus Self-Diagnosis..... D-14

Using Modbus Communication

Serial communication can be performed with Direct Digital Controllers (DDCs) or similar devices using the Modbus protocol.

◆ Modbus Communication Configuration

Modbus communication is configured using 1 master (PLC) and a maximum of 31 slaves. Serial communication between master and slave is normally initiated by the master and responded to by the slaves.

The master performs serial communication with one slave at a time. Consequently, the slave address of each slave must be initially set, so that the master can perform serial communication using that address. Slaves receiving commands from the master perform the specified functions, and send a response back to the master.

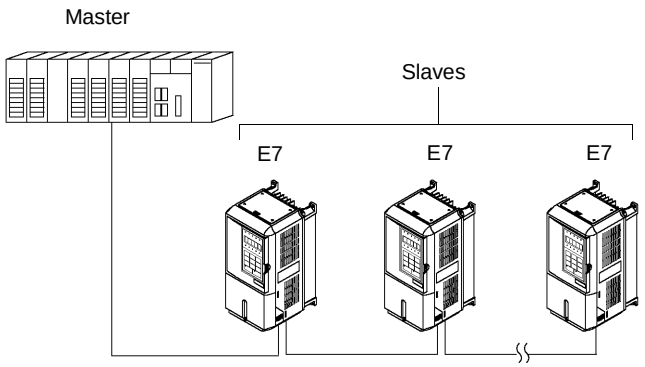


Fig D. 1 Example of Connections between Master and Drive

◆ Communication Specifications

The Modbus communication specifications are shown below:

Table D.1 Modbus Communication Specifications

Item	Specifications
Interface	RS-422, RS-485
Communications Cycle	Asynchronous (Start-stop synchronization)
Communications Parameters	Baud rate: Select from 1200, 2400, 4800, 9600, and 19200 bps. Data length: 8 bits fixed Parity: Select from even, odd, or none. Stop bits: 1 bit selected
Communications Protocol	Modbus
Number of Connectable Units	31 units max.

◆ Communication Connection Terminal

Modbus communication uses the following terminals: S+, S-, R+, and R-. The terminating resistance must be turned ON only if the Drive is at the very end of the Serial Communication chain. Set the terminating resistance by turning ON pin 1 of switch S1.

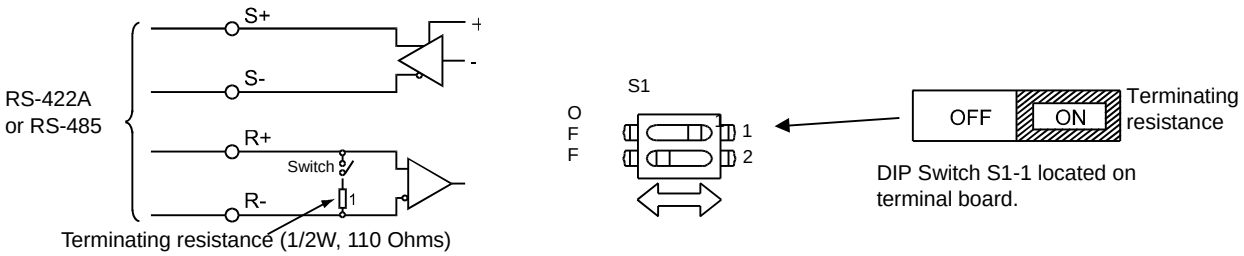


Fig. D.2 Communication Connection Terminals and Terminating Resistance

IMPORTANT

1. Separate the communication cables from the main circuit cables and control circuit wiring.
2. Use shielded cables for the communication cable, and use proper shield clamps.
3. When using RS-485 communication, connect S+ to R+, and S- to R-, on the control circuit terminal board. See Fig. D-3 below.
4. Shield at one end only.

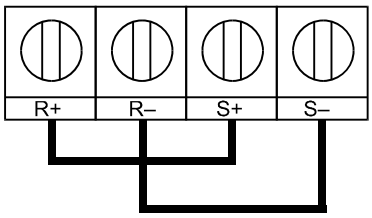


Fig. D.3 RS-485 Communication Connection

◆ Procedure for Setting Up Communication

Use the following procedure to perform communication with the PLC.

1. Turn OFF the input to the Drive power and connect the communication cable between the PLC and the Drive.
2. Turn ON the input power to the Drive.
3. Set the required communication parameters (H5-01 to H5-09) using the Digital Operator.
4. Turn OFF the input to the Drive power, and check that the Digital Operator display has completely disappeared.
5. Turn ON the input power to the Drive once again.
6. Perform communication with the PLC.

■Related Parameters

Table D.2 Serial Communication Related Parameters

Parameter No.	Parameter Name **Digital Operator Display**	Description	Setting Range	Factory Setting	Chapter Ref #	Menu Location
b1-01	Frequency Reference Selection **Reference Source**	Selects the speed command (frequency reference) input source. 0: Operator - Digital preset speed d1-01 1: Terminals - Analog Input Terminal A1 (or Terminal A2 see parameter H3-13) 2: Serial Com - RS-485 terminals R+, R-, S+ and S- 3: Option PCB - Option board connected at 2CN	0 to 3	1		Quick Setting
b1-02	Run Command Selection **Run Source**	Selects the run command input source. 0: Operator - "Hand" and "Off" keys on digital operator 1: Terminal - Contact Closure on Terminal S1 2: Serial Com - RS-485 terminals R+, R-, S+ and S- 3: Option PCB - Option board connected at 2CN	0 to 3	1		Quick Setting
H5-01	Drive Node Address **Serial Comm Adr**	Selects drive station node number (address) for terminals R+, R-, S+, S-.* Set H5-01 to 0 to disable Drive responses to Modbus communications.	0 to 20 (Modbus) 0 to FF (N2) 0 to 63 (P1)	1F[#]		Programming
H5-02	Communication Speed Selection **Serial Baud Rate**	Selects the baud rate for terminals R+, R-, S+ and S-*. 0: 1200 Baud 1: 2400 Baud 2: 4800 Baud 3: 9600 Baud 4: 19200 Baud	0 to 4	3		Programming
H5-03	Communication Parity Selection **Serial Com Sel**	Selects the communication parity for terminals R+, R-, S+ and S-.* 0: No Parity 1: Even Parity 2: Odd Parity	0 to 2	0		Programming
H5-04	Stopping Method after Communication Error **Serial Fault Sel**	Selects the stopping method when a communication error is detected. 0: Ramp to Stop 1: Coast to Stop 2: Fast-Stop 3: Alarm Only	0 to 3	3		Programming
H5-05	Communication Error Detection Selection **Serial Flt Dtct**	Enables or disables the communications time-out detection function. 0: Disabled - A communications loss will NOT cause a communications fault. 1: Enabled - If communications is lost for more than the time specified in parameter H5-09, a communi-cations fault will occur.	0 or 1	1		Programming
H5-06	Drive Transmit Wait Time **Transmit WaitTIM**	Sets the time from when the drive receives data to when the drive sends data.	5 to 65	5ms		Programming
H5-07	RTS Control Selection **RTS Control Sel**	Enables or disables request to send (RTS) control: 0: Disabled 1: Enabled	0 or 1	1		Programming
H5-09	Communication Error Detection Time **CE Detect Time**	Determines how long communications must be lost before a fault is annunciated. Works in conjunction with parameters H5-05 and H5-04.	0.0 to 10.0	2.0sec		Programming

* After these parameters are changed drive power must be cycled before the changes will take effect.

[#] Hex, see page A-30

Modbus communication can perform the following operations regardless of the settings in b1-01 and b1-02:

1. Monitoring operation status of the Drive
2. Setting and reading Drive parameters
3. Resetting faults
4. Input multi-function commands

IMPORTANT An OR operation is performed between the multi-function command input from the DDC and the command input from multi-function digital input terminals S3 to S7.

■ Message Format

In Modbus communication, the master sends commands to the slave, and the slave responds. The message format is configured for both sending and receiving as shown below. The length of the data packets is changed by the command (function) contents.

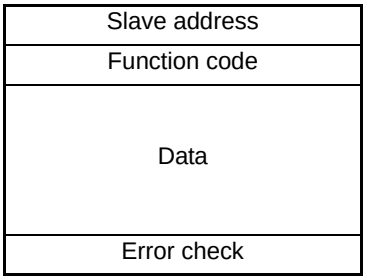


Fig. D.4 Message Format

The space between messages must support the following:

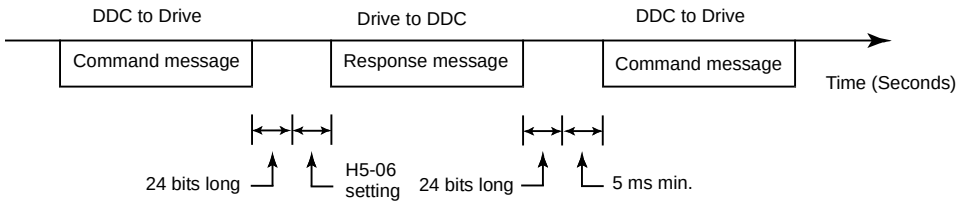


Fig. D.5 Message Spacing

Slave Address

Set the Drive address from 0 to 32. If 0 is selected, commands from the master will be broadcast (i.e., the Drive will not return responses).

Function Code

The function code specifies commands. There are four function codes, as shown below.

Table D.3 Modbus Function Codes

Function Code (Hexadecimal)	Function	Command Message		Response Message	
		Min. (Bytes)	Max. (Bytes)	Min.* (Bytes)	Max. (Bytes)
03H	Reading/Holding Register Contents	8	8	7	37
06H	Write In Single Holding Register	8	8	8	8
08H	Loopback Test	8	8	8	8
10H	Write In Several Holding Registers	11	41	8	8

* Minimum bytes for a normal Response Message (error response message is always 5 bytes).

Data

Configure consecutive data by combining the storage register address (test code for a loopback address) and the data the register contains. The data length changes depending on the command details.

Error Check

Errors are detected during communication using CRC-16. Perform calculations using the following method:

1. The factory setting for CRC-16 communication is typically zero, but when using the Modbus system, set the factory setting to one (e.g., set all 16 bits to 1).
2. Calculate CRC-16 using MSB as slave address LSB, and LSB as the MSB of the final data.
3. Calculate CRC-16 for response messages from the slaves and compare them to the CRC-16 in the response messages.

Modbus Function Code Details

◆ Reading/Holding Register Contents (03H)

Read the contents of the storage register only for specified quantities. The addresses must be consecutive, starting from a specified address. The data content of the storage register are separated into higher 8 bits and lower 8 bits.

The following table shows message examples when reading status signals, error details, data link status, and frequency references from the slave 2 Drive.

Command Message

Slave Address		02H
Function Code		03H
Start Address	Higher	00H
	Lower	20H
Quantity	Higher	00H
	Lower	04H
CRC-16	Higher	45H
	Lower	F0H

Response Message (During Normal Operation)

Slave Address		02H
Function Code		03H
Data quantity		08H
1st storage register	Higher	00H
	Lower	65H
Next storage register	Higher	00H
	Lower	00H
Next storage register	Higher	00H
	Lower	00H
Next storage register	Higher	01H
	Lower	F4H
CRC-16	Higher	AFH
	Lower	82H

Response Message (During Error)

Slave Address		02H
Function Code		83H
Error code		03H
CRC-16	Higher	F1H
	Lower	31H

Fig. D.6 Function Code 03H Message Example

◆ Write In Single Holding Register (06H)

Command Message

Slave address		01H
Function code		06H
Register Address	Upper	00H
	Lower	01H
Setting Data	Upper	00H
	Lower	03H
CRC-16	Upper	98H
	Lower	0BH

Response Message (During Normal Operation)

Slave address		01H
Function code		06H
Register Address	Upper	00H
	Lower	01H
Setting Data	Upper	00H
	Lower	03H
CRC-16	Upper	98H
	Lower	0BH

Response Message (During Error)

Slave address		01H
80H + Function Code		86H
Error code		21H
CRC-16	Upper	82H
	Lower	78H

Fig. D.7 Function Code 06H Message Example

◆ Loopback Test (08H)

The loopback test returns the command message directly as the response message without changing the contents to check the communications between the master and slave. Set user-defined test code and data values.

The following table shows a message example when performing a loopback test with the slave 1 Drive.

Command Message

Slave address		01H
Function code		08H
Test Code	Higher	00H
	Lower	00H
Data	Higher	A5H
	Lower	37H
CRC-16	Higher	DAH
	Lower	8DH

Response Message (During Normal Operation)

Slave address		01H
Function code		08H
Test Code	Higher	00H
	Lower	00H
Data	Higher	A5H
	Lower	37H
CRC-16	Higher	DAH
	Lower	8DH

Response Message (During Error)

Slave address		01H
Function code		89H
Error Code		01H
CRC-16	Higher	86H
	Lower	50H

Fig. D.8 Function Code 08H Message Example

◆ Write In Several Holding Registers (10H)

Write the specified data to the registers from the specified addresses. The written data must be consecutive, starting from the specified address in the command message: Higher 8 bits, then lower 8 bits, in storage register address order.

The following table shows an example of a message when a forward run command has been set at a speed command of 60.0 Hz in the slave 1 Drive by the PLC.

Command Message

Slave Address		01H
Function Code		10H
Start Address	Higher	00H
	Lower	01H
Quantity	Higher	00H
	Lower	02H
No. of data		04H
Lead data	Higher	00H
	Lower	01H
Next data	Higher	02H
	Lower	58H
CRC-16	Higher	63H
	Lower	39H

Response Message (During Normal Operation)

Slave Address		01H
Function Code		10H
Start Address	Higher	00H
	Lower	01H
Quantity	Higher	00H
	Lower	02H
CRC-16	Higher	10H
	Lower	08H

Response Message (During Error)

Slave Address		01H
Function Code		90H
Error code		02H
CRC-16	Higher	CDH
	Lower	C1H

* No. of data = 2 x (quantity)

Fig. D.9 Function Code 10H Message Example

IMPORTANT Set the number of data specified using command messages as quantity of specified messages x 2. Handle response messages in the same way.

Modbus Data Tables

The data tables are shown below. The types of data are as follows: Reference data, monitor data and broadcast data.

◆ Reference Data

The reference data table is shown below. Reference data can be read and written to.

Table D.4 Reference Data

Register No.	Contents		
0000H	Reserved		
0001H	Frequency reference		
	Bit 0	Run Forward	1: Run Forward
	Bit 1	Run Reverse	1: Run Reverse
	Bit 2	External fault	1: Fault (EFO)
	Bit 3	Fault reset	1: Reset command
	Bit 4	ComNet	
	Bit 5	ComCtrl	
	Bit 6	Multi-function digital input command 3	
	Bit 7	Multi-function digital input command 4	
	Bit 8	Multi-function digital input command 5	
	Bit 9	Multi-function digital input command 6	
	Bit A	Multi-function digital input command 7	
	Bits B to F	Not used	
0002H	Frequency reference (Set units using parameter o1-03)		
0003H to 0005H	Not used		
0006H	PI Setpoint		
0007H	Analog output 1 setting (-11 V = 726 to 11 V = 726) → 10V = 660		
0008H	Analog output 2 setting (-11 V = 726 to 11 V = 726) → 10V = 660		
0009H	Multi-function contact output setting		
	Bit 0	Digital output 1 (Terminal M1-M2)	1: ON 0: OFF
	Bit 1	Digital output 2 (Terminal M3-M4)	1: ON 0: OFF
	Bit 2	Not Used	
	Bits 3 to 5	Not used	
	Bit 6	Set fault contact (terminal MA-MC) output using bit 7. 1: ON 0: OFF	
	Bit 7	Fault contact (terminal MA-MC)	1: ON 0: OFF
	Bits 8 to F	Not used	
000AH to 000EH	Not used		
000FH	Reference selection settings		
	Bit 0	Not used	
	Bit 1	Input PI setpoint 1: Enabled 0: Disabled	
	Bits 3 to B	Not used	
	C	Broadcast data terminal S5 input 1: Enabled 0: Disabled	
	D	Broadcast data terminal S6 input 1: Enabled 0: Disabled	
	E	Broadcast data terminal S7 input 1: Enabled 0: Disabled	
	F	Not used	

Note: Write 0 to all unused bits. Also, do not write data to reserved registers.

Monitor Data

The following table shows the monitor data. Monitor data can only be read.

Table D.5 Monitor Data

Register No.	Contents	
0020H	Drive status	
	Bit 0	Operation 1: Operating 0: Stopped
	Bit 1	Reverse operation 1: Reverse operation 0: Forward operation
	Bit 2	Drive startup complete 1: Completed 0: Not completed
	Bit 3	Fault 1: Fault
	Bit 4	Data setting error 1: Error
	Bit 5	Multi-function digital output 1 (terminal M1 - M2) 1: ON 0: OFF
	Bit 6	Multi-function digital output 2 (terminal M3 - M4) 1: ON 0: OFF
	Bit 7	Not used
	Bits 8 to F	Not used
0021H	Fault details	
	Bit 0	Overcurrent (OC) Ground fault (GF)
	Bit 1	Main circuit overvoltage (OV)
	Bit 2	Drive overload (OL2)
	Bit 3	Drive overheat (OH1, OH2)
	Bit 4	Not used
	Bit 5	Fuse blown (PUF)
	Bit 6	PI feedback reference lost (FbL)
	Bit 7	External error (EF, EFO)
	Bit 8	Hardware error (CPF)
	Bit 9	Motor overload (OL1) or overtorque 1 (OL3) detected
	Bit A	PG broken wire detected (PGO), Overspeed (OS), Speed deviation (DEV)
	Bit B	Main circuit undervoltage (UV) detected
	Bit C	Main circuit undervoltage (UV1), control power supply error (UV2), inrush prevention circuit error (UV3), power loss
	Bit D	Missing output phase (LF)
	Bit E	Modbus communications error (CE)
	Bit F	Operator disconnected (OPR)
0022H	Data link status	
	Bit 0	Writing data
	Bit 1	Not used
	Bit 2	Not used
	Bit 3	Upper and lower limit errors
	Bit 4	Data integrity error
	Bits 5 to F	Not used
0023H	Frequency reference	U1-01
0024H	Output frequency	U1-02
0025H	Output voltage reference	U1-06
0026H	Output current	U1-03
0027H	Output power	U1-08
0028H	Torque reference	U1-09
0029H	Not used	
002AH	Not used	

Table D.5 Monitor Data			
Register No.	Contents		
002BH	Sequence input status		
	Bit 0	Input terminal S1 1: ON 0: OFF	
	Bit 1	Input terminal S2 1: ON 0: OFF	
	Bit 2	Multi-function digital input terminal S3 1: ON 0: OFF	
	Bit 3	Multi-function digital input terminal S4 1: ON 0: OFF	
	Bit 4	Multi-function digital input terminal S5 1: ON 0: OFF	
	Bit 5	Multi-function digital input terminal S6 1: ON 0: OFF	
	Bit 6	Multi-function digital input terminal S7 1: ON 0: OFF	
	Bits 7 to F	Not used	
002CH	Drive status		
	Bit 0	Operation	1: Operating
	Bit 1	Zero speed	1: Zero speed
	Bit 2	Frequency agree	1: Matched
	Bit 3	Desired frequency agree	1: Matched
	Bit 4	Frequency detection 1	1: Output frequency ≤ L4-01
	Bit 5	Frequency detection 2	1: Output frequency ≥ L4-01
	Bit 6	Drive startup completed	1: Startup completed
	Bit 7	Low voltage detection	1: Detected
	Bit 8	Baseblock	1: Drive output baseblock
	Bit 9	Frequency reference mode	1: Not communication 0: Communication
	Bit A	Run command mode	1: Not communication 0: Communication
	Bit B	Overtorque detection	1: Detected
	Bit C	Frequency reference lost	1: Lost
	Bit D	Retrying error	1: Retrying
	Bit E	Error (including Modbus communications time-out) 1:Error occurred	
	Bit F	Modbus communications time-out 1: Timed out	
002DH	Multi-function digital output status		
	Bit 0	Multi-function digital output 1 (terminal M1-M2) 1: ON 0: OFF	
	Bit 1	Multi-function digital output 2 (terminal M3-M4): 1: ON 0: OFF	
	Bit 2	Not used	
	Bits 3 to F	Not used	
002EH - 0030H	Not used		
0031H	Main circuit DC voltage		
0032H - 0037H	Not used		
0038H	PI feedback level (Input equivalent to 100%/Max. output frequency; 10/1%; without sign)		
0039H	PI input level (±100%/±Max. output frequency; 10/1%; with sign)		
003AH	PI output level (±100%/±Max. output frequency; 10/1%; with sign)		
003BH	CPU software number		
003CH	Flash software number		
003DH	Communication error details		
	Bit 0	CRC error	
	Bit 1	Invalid data length	
	Bit 2	Not used	
	Bit 3	Parity error	
	Bit 4	Overrun error	
	Bit 5	Framing error	
	Bit 6	Time-out	
	Bits 7 to F	Not used	
003EH	KVA setting		
003FH	Control method		

Note: Communication error details are stored until an error reset is input (errors can be reset while the Drive is operating).

Broadcast Data

The following table shows the broadcast data. Broadcast data can be written to.

Table D.6 Broadcast Data

Register Address	Contents	
0001H	Operation signal	
	Bit 0	Run command 1: Operating 0: Stopped
	Bit 1	Reverse operation command 1: Reverse 0: Forward
	Bits 2 and 3	Not used
	Bit 4	External error 1: Fault (set using H1-01)
	Bit 5	Error Fault 1: Reset command (set using H1-02)
	Bits 6 to B	Not used
	Bit C	Multi-function digital input terminal S5 input
	Bit D	Multi-function digital input terminal S6 input
	Bit E	Multi-function digital input terminal S7 input
	Bit F	Not used.
0002H	Frequency reference	30000/100%

Note: Bit signals not defined in the broadcast operation signals use local node data signals continuously.

Enter Command

When writing parameters to the Drive from the PLC using Modbus communication, the parameters are temporarily stored in the constant data area in the Drive. To enable these parameters in the parameter data area, use the Enter command.

There are two types of Enter commands:

1. Enter commands that enable parameter data in RAM

2. Enter commands that write data to EEPROM (non-volatile memory) in the Drive at the same time as enabling data in RAM.

The following table shows the Enter command data. Enter command data can only be written.

The Enter command is enabled by writing 0 to register number 0900H or 0910H.

Table D.7 Enter Command

Register No.	Contents
0900H	Write parameter data to EEPROM
0910H	Parameter data is not written to EEPROM, but refreshed in RAM only.

IMPORTANT

The maximum number of times you can write to EEPROM using the Drive is 100,000. Do not frequently execute Enter commands (0900H) written to EEPROM.
The Enter command registers are write-only. Consequently, if reading these registers, the register address will become invalid (Error code: 02H).

Error Codes

The following table shows Modbus communication error codes.

Table D.8 Error Codes

Error Code	Contents
01H	Function code error A function code other than 03H, 08H, or 10H has been set by the PLC.
02H	Invalid register number error • The register address you are attempting to access is not recorded anywhere. • With broadcast sending, a start address other than 0000H, 0001H, or 0002H has been set.
03H	Invalid quantity error • The number of data packets being read or written is outside the range of 1 to 16. • In write mode, the number of data packets in the message is not No. of packets x 2.
21H	Data setting error • Upper limit or lower limit error has occurred in the control data or when writing parameters. • When writing parameters, the parameter setting is invalid.
22H	Write mode error • Attempting to write parameters to the Drive during run. • Attempting to write via Enter commands during run. • Attempting to write parameters other than A1-00 to A1-05, E1-03, or 02-04 when a CPF03 (defective EEPROM) fault has occurred. • Attempting to write read-only data.
23H	Writing during main circuit undervoltage (UV) fault • Writing parameters to the Drive during UV (main circuit undervoltage) alarm. • Writing via Enter commands during UV (main circuit undervoltage) alarm.
24H	Writing error during parameters processing Attempting to write parameters while processing parameters in the Drive.

Slave Not Responding

In the following cases, the slave will ignore the write function.

- When a communication error (overrun, framing, parity, or CRC-16) is detected in the command message.
- When the slave address in the command message and the slave address in the Drive do not agree.
- When the data that configures the message and the data time length exceed 24 bits.
- When the command message data length is invalid.

IMPORTANT If the slave address specified in the command message is 0, all slaves execute the write function, but do not return response messages to the master.

Modbus Self-Diagnosis

The Drive has a built-in function for self-diagnosing the operations of serial communication interface circuits. The self-diagnosis function connects the communication parts of the send and receive terminals, receives the data sent by the Drive, and checks if communication is being performed normally.

Perform the self-diagnosis function using the following procedure.

1. Turn ON the power supply to the Drive, and set parameter H1-05 (Terminal S7 Function Selection) to 67 (Comm Test Mode).
2. Turn OFF the power supply to the Drive.
3. Perform wiring according to the following diagram while the power supply is turned OFF.
4. Turn ON the terminating resistance. (Turn ON pin 1 on DIP switch 1.)
5. Turn ON the power supply to the Drive again.

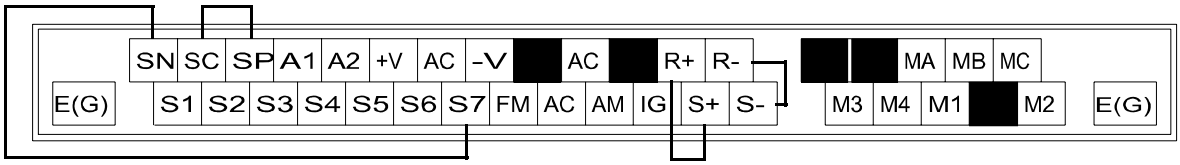


Fig. D.10 Communication Terminal Connection for Self -Diagnosis Function

6. During normal self-diagnostic operation, the Digital Operator displays the frequency reference value. If an error occurs, a CE (Modbus communication error) alarm will be displayed on the Digital Operator, the fault contact output will be turned ON, and the Drive operation ready signal will be turned OFF.

Appendix E
Peripheral Devices

This appendix describes recommended branch short circuit protection and peripheral devices.

Branch Circuit Short Circuit Protection..... E-2
Branch Circuit Overload Protection..... E-5
Peripheral Devices..... E-6

Branch Circuit Short Circuit Protection

The following peripheral devices may be required between the AC main circuit power supply and the Drive input terminals L1(R), L2(S), and L3(T). Refer to applicable codes to determine the devices necessary for a given installation. Use Table E.1 or E.2 when selecting fuses and circuit breakers per the NEC. When selecting semiconductor fuses to provide Drive input I^2t protection and comply with UL, CSA, NEC, and CEC branch circuit short circuit protection requirements, select one of the fuses in Table E.3 or E.4.

Fuse Type: UL designated Time-Delay or Non-Time-Delay Fuse
Class: CC, J, T, RK1 or RK5
Designators (typical):KTK, FNQ, FRS, LPJ, LPS, JKS, JJN, or JJS
Voltage Rating: 250V for Drives with 208-240V input
600V for Drives with 480V input

Circuit Breaker Type: Inverse Time (MCCB) or Instantaneous Trip (MCP)
Voltage Rating: 600V

Table E.1 Recommended Fuse and Circuit Breaker Ratings per NEC (208-240Vac Input)

Model CIMR-P7U	Hp	Input Amps *1 (Continuous Rating)	Output Amps *1 (Continuous Rating)	Fuse Selection Criteria		Circuit Breaker Selection Criteria
				Maximum Time-Delay Fuse Rating (A)	Maximum Non-Time-Delay Fuse Rating (A)	Maximum CB Rating (A)
20P4	0.5/0.75	4.3	3.6	6	12	15
20P7	1	5.5	4.6	8	12	15
21P5	1.5/2	9.4	7.8	15	15	15
22P2	3	13	10.8	20	20	20
23P7	5	20	16.8	30	30	35
25P5	7.5	24	23	40	50	45
27P5	10	37	31	60	80	80
2011	15	53	46.2	80	80	100
2015	20	70	59.4	110	125	125
2018	25	89	74.8	125	150	150
2022	30	98	88	150	150	175
2030	40	120	115	200	200	225
2037	50	180	162	250	250	300
2045	60	212	192	300	300	350
2055	75	237	215	350	350	450
2075	75/100	350	312	450	450	600
2090	125	396	360	600	600	700
2110	150	457	415	700	700	900

*1 Input and Output Amps are based on the Normal Duty (ND) current rating. Consult the Specification section for details on the Heavy Duty (HD) and Normal Duty (ND) ratings.

Table E.2 Recommended Fuse and Circuit Breaker Ratings per NEC (480Vac Input)						
Model CIMR-P7U	Hp	Input Amps *1 (Continuous Rating)	Output Amps *1 (Continuous Rating)	Fuse Selection Criteria		Circuit Breaker Selection Criteria
				Maximum Time-Delay Fuse Rating (A)	Maximum Non-Time-Delay Fuse Rating (A)	Maximum CB Rating (A)
40P4	0.5/0.75	2.2	1.8	4	10	15
40P7	1	2.5	2.1	4	10	15
41P5	1.5/2	4.4	3.7	8	12	15
42P2	3	6.4	5.3	10	15	15
43P7	5	9	7.6	15	20	20
44P0	-	10.4	8.7	15	30	20
45P5	7.5	15	12.5	25	30	30
47P5	10	20	17	30	30	40
49P0	15	26	21	45	50	60
4011	20	33	27	45	50	60
4015	25	40	34	60	70	80
4018	30	48	40	70	80	90
4022	-	55	50.4	80	80	100
4024	40	57	52	100	100	125
4030	50	74	67.2	100	100	125
4037	60	85	77	125	125	150
4045	75	106	96	150	150	200
4055	100	134	125	200	200	225
4075	125	172	156	250	250	300
4090	150	198	180	300	300	400
4110	200	264	240	350	350	450
4132	-	286	260	400	400	600
4160	250	334	304	450	450	700
4185	300/350	456	414	600	600	800
4220	400/450	567	515	700	700	1000
4300	500+	743	675	900	900	1200
*1 Input and Output Amps are based on the Normal Duty (ND) current rating. Consult the Specification section for details on the Heavy Duty (HD) and Normal Duty (ND) ratings.						

Table E.3 Semiconductor Fuses for Drive I^2t Protection and Branch Circuit Short Circuit Protection (200V Series)									
Drive Model No. CIMR-P7*	Recommended			Alternate 1			Alternate 2		
	Fuse Mfr.	Model No.	Rating	Fuse Mfr.	Model No.	Rating	Fuse Mfr.	Model No.	Rating
20P4	Ferraz	A60Q12-2	600V, 12A	Ferraz	A070GRB006T13	700V, 6A	Bussmann	FWH-20A14F	500V, 20A
20P7	Ferraz	A60Q12-2	600V, 12A	Ferraz	A070GRB006T13	700V, 6A	Bussmann	FWH-20A14F	500V, 20A
21P5	Ferraz	A60Q15-2	600V, 15A	Ferraz	A70QS25-22F	700A, 25A	Bussmann	FWH-20A14F	500V, 20A
22P2	Ferraz	A60Q20-2	600V, 20A	Ferraz	6,900CPGRC14.51/25	690V, 25A	Bussmann	FWH-25A14F	500V, 25A
23P7	Ferraz	A60Q30-2	600V, 30A	Ferraz	A70QS32-14F	700A, 32A	Bussmann	FWH-45B	500V, 45A
25P5	Ferraz	A50P50-4	500V, 50A	Ferraz	A70QS50-14F	700V, 50A	Bussmann	FWH-80B	500V, 80A
27P5	Ferraz	A50P80-4	500V, 80A	Ferraz	A50QS70-4	500V, 70A	Bussmann	FWH-80B	500V, 80A
2011	Ferraz	A50P80-4	500V, 80A	Ferraz	A50QS100-4	500V, 100A	Bussmann	FWH-100B	500V, 100A
2015	Ferraz	A50P125-4	500V, 125A	Ferraz	A50QS150-4	500V, 150A	Bussmann	FWH-175B	500V, 175A
2018	Ferraz	A50P150-4	500V, 150A	Ferraz	A50QS175-4	500V, 175A	Bussmann	FWH-200B	500V, 200A
2022	Ferraz	A50P150-4	500V, 150A	Ferraz	A50QS200-4	500V, 200A	Bussmann	FWH-200B	500V, 200A
2030	Ferraz	A50P200-4	500V, 200A	Bussmann	FWH-200B	500V, 200A	Bussmann	FWH-225B	500V, 225A
2037	Ferraz	A50P250-4	500V, 250A	Ferraz	A30QS275-4	300V, 275A	Bussmann	170M4610	690V, 315A
2045	Ferraz	A50P300-4	500V, 300A	Ferraz	A30QS350-4	300V, 350A	Bussmann	FWH-350A	500V, 350A
2055	Ferraz	A50P350-4	500V, 350A	Bussmann	FWH-400A	500V, 400A	Bussmann	FWH-450A	500V, 450A
2075	Ferraz	A50P450-4	500V, 450A	Ferraz	A070URD33KI0550	700V, 550A	Bussmann	FWH-500A	500V, 500A
2090	Ferraz	A50P600-4	500V, 600A	Ferraz	A70P600-4	700V, 600A	Bussmann	FWH-600A	500V, 600A
2110	Ferraz	A50P600-4	500V, 600A	Ferraz	A70P700-4	700V, 700A	Bussmann	FWH-700A	500V, 700A
* Denotes letter A through Z									

Table E.4 Semiconductor Fuses for Drive I^2t Protection and Branch Circuit Short Circuit Protection (400V Series)									
Drive Model No. CIMR-P7*	Recommended			Alternate 1			Alternate 2		
	Fuse Mfr.	Model No.	Rating	Fuse Mfr.	Model No.	Rating	Fuse Mfr.	Model No.	Rating
40P4	Ferraz	A60Q10-2	600V, 10A	Ferraz	A070GRB006T13	700V, 6A	Ferraz	A70QS16-14F	690V, 16A
40P7	Ferraz	A60Q10-2	600V, 10A	Ferraz	A070GRB006T13	700V, 6A	Ferraz	A70QS16-14F	690V, 16A
41P5	Ferraz	A60Q12-2	600V, 12A	Ferraz	6,900CPGRC14.51/25	690V, 25A	Ferraz	A70QS20-14F	690V, 20A
42P2	Ferraz	A60Q15-2	600V, 15A	Ferraz	A70QS25-22F	700V, 25A	Ferraz	A70QS20-14F	690V, 20A
43P7	Ferraz	A60Q20-2	600V, 20A	Ferraz	A70QS20-14F	700V, 20A	Ferraz	A70QS25-14F	690V, 25A
44P0	Ferraz	A60Q30-2	600V, 30A	Ferraz	A70QS32-14F	700V, 32A	Ferraz	A70QS40-14F	690V, 40A
45P5	Ferraz	A60Q30-2	600V, 30A	Ferraz	A70QS32-14F	700V, 32A	Ferraz	A70QS40-14F	690V, 40A
47P5	Ferraz	A60Q30-2	600V, 30A	Ferraz	A70QS40-14F	700V, 40A	-	-	-
49P0	Ferraz	A70P50-4	700V, 50A	Ferraz	A50QS50-4	500V, 50A	Bussmann	FWH-80B	500V, 80A
4011	Ferraz	A70P50-4	700V, 50A	Ferraz	A50QS50-4	500V, 50A	Bussmann	FWH-80B	500V, 80A
4015	Ferraz	A70P70-4	700V, 70A	Ferraz	A50QS80-4	500V, 80A	Bussmann	FWH-100B	500V, 100A
4018	Ferraz	A70P80-4	700V, 80A	Ferraz	A50QS100-4	500V, 100A	Bussmann	FWH-125B	500V, 125A
4022	Ferraz	A70P80-4	700V, 80A	Ferraz	A50QS100-4	500V, 100A	Bussmann	FWH-125B	500V, 125A
4024	Ferraz	A70P100-4	700V, 100A	Ferraz	A50QS125-4	500V, 125A	Bussmann	FWH-125B	500V, 125A
4030	Ferraz	A70P100-4	700V, 100A	Ferraz	A50QS125-4	500V, 125A	Bussmann	FWH-125B	500V, 125A
4037	Ferraz	A70P125-4	700V, 125A	Ferraz	A50QS125-4	500V, 125A	Bussmann	FWH-150B	500V, 150A
4045	Ferraz	A70P150-4	700V, 150A	Ferraz	A50QS150-4	500V, 150A	Bussmann	FWH-175B	500V, 175A
4055	Ferraz	A70P200-4	700V, 200A	Ferraz	A70QS200-4	700V, 200A	Bussmann	FWH-200B	500V, 200A
4075	Ferraz	A70P250-4	700V, 250A	Ferraz	A50QS250-4	500V, 250A	Bussmann	FWH-250A	500V, 250A
4090	Ferraz	A70P300-4	700V, 300A	Ferraz	A50QS300-4	500V, 300A	Bussmann	170M4611	690V, 350A
4110	Ferraz	A70P350-4	700V, 350A	Ferraz	A50P350-4	500V, 350A	Bussmann	170M4611	690V, 350A
4132	Ferraz	A70P400-4	700V, 400A	Ferraz	A70P500-4	700V, 500A	Bussmann	170M5610	690V, 500A
4160	Ferraz	A70P450-4	700V, 450A	Ferraz	A70QS700-4	700V, 700A	Bussmann	FWH-600A	500V, 600A
4185	Ferraz	A70P600-4	700V, 600A	Ferraz	A70QS700-4	700V, 700A	Bussmann	FWH-700A	500V, 700A
4220	Ferraz	A70P700-4	700V, 700A	Bussmann	FWH-800A	500V, 800A	Bussmann	FWH-1000A	500V, 1000A
4300	Ferraz	A70P900-4	700V, 900A	Bussmann	FWH-1000A	500V, 1000A	Bussmann	FWH-1200A	500V, 1200A
* Denotes letter A through Z									

Branch Circuit Overload Protection

All models have built-in UL evaluated motor overload protection. Motor overload protection is also provided in accordance with the NEC and CEC. Additional branch circuit overload protection is not required for single motor applications.

Peripheral Devices

The following peripheral devices may be required to be mounted between the AC main circuit power supply and the Drive input terminals R/LI, S/L2, and T/L3.

CAUTION

Never connect a general LC/RC noise filter to the Drive output circuit.
Never connect a phase-advancing capacitor to the input or output sides, or a surge suppressor to the output side of the Drive. When magnetic contactor is installed between the Drive and the motor, never turn it on or off during operation.

For more details on peripheral devices, contact the manufacturer.

Magnetic Contactor

Mount a surge protector on the coil. When using a magnetic contactor to start and stop the Drive, do not exceed one start per hour.

AC and DC reactor

When using models P7U20P4 thru P7U2018 and P7U40P4 thru P7U4018 on a power supply transformer with a capacity of 600kVA or more, install an AC or DC reactor. The reactor improves the input power factor and provides protection to the rectifier circuit within the Drive.

Noise filter

Use a noise filter exclusively for the Drive if radio noise generated from the Drive causes other control devices to malfunction.

Appendix F
EMC Compatibility

EMC Compatibility..... F-2
Electromagnetic Compatibility (EMC)..... F-3

EMC Compatibility

◆ Introduction

This section describes the measures necessary to comply with the EMC (Electro Magnetic Compatibility) Directive. The manual's installation and wiring instructions must be followed for compliance.

Yaskawa products are tested by authorized organizations using the standards listed below.

Product standard: EN 61800-3:1996
EN 61000-3-2; A1, A2, A14:2000

◆ Measures to Ensure Conformity of Installed Yaskawa Drives to EMC Directive

Yaskawa Drives are not required to be installed in a switch cabinet.

It is not possible to give detailed instructions for all possible types of installations, therefore this manual provides general guidelines.

All electrical equipment produces radio and line-borne interference at various frequencies. The power leads pass this on to the surrounding environment like an antenna. Connecting an item of electrical equipment (e.g. Drive) to a supply without a line filter can allow High Frequency (HF) or Low Frequency (LF) interference to penetrate the power distribution system. The basic countermeasures are isolation of the wiring of control and power components, proper grounding, and shielding of cables.

A large contact area is necessary for low-impedance grounding of HF interference. The use of grounding, straps instead of cables is therefore highly recommended.

Cable shields must be connected with ground clips.

◆ Cable Installation

Measures Against Line-Borne Interference:

Line filter and Drive must be mounted on the same metal plate. Mount the two components as close to each other as possible, with cables kept as short as possible (see Figure G-2).

Use a power cable with a well-grounded shield. Use a shielded motor cable not exceeding 82 feet (25 m) in length. Arrange all grounds to maximize the end of the lead area in contact with ground (e.g. metal plate).

Use a shielded cable with braided shield and ground the maximum possible area of the shield. It is advisable to ground the shield by connecting the cable to the ground plate with metal clips (see Figure G-1).

Electromagnetic Compatibility (EMC)

◆ Recommended EMC Filters

Drive Model CIMR-P7U	EMC Filter				
	Model Number	Current Rating	Weight lb. (kg)	Dimensions inches (mm)	Nominal Hp
208-240 Vac					
20P4	FS5972-10-07	10 A	2.43 (1.1)	5.500 x 13 x 1.875 (141 x 330 x 46)	0.5/0.75
20P7					1
21P5					1.5/2
22P2	FS5972-18-07	18 A	2.87 (1.3)	5.500 x 13 x 1.875 (141 x 330 x 46)	3
23P7	FS5973-35-07	35 A	3.09 (1.4)	5.500 x 13 x 1.875 (141 x 330 x 46)	5
25P5					7.5
27P5	FS5973-60-07	60 A	6.61 (3)	8 x 14 x 2.375 (206 x 355 x 60)	10
2011	FS5973-100-07	100 A	10.8 (4.9)	9.3125 x 16 x 3.125 (236 x 408 x 80)	15
2015					20
2018					25
2022	FS5973-130-35	130 A	9.48 (4.3)	3.5315 x 14.40625 x 7 (90 x 366 x 180)	30
2030					40
2037	FS5973-160-40	160 A	13.23 (6)	4.750 x 17.750 x 6.6875 (120 x 451 x 170)	50
2045	FS5973-240-37	240 A	24.25 (11)	5.125 x 24 x 9.4375 (130 x 610 x 240)	60
2055					75
480 Vac					
40P4	FS5972-10-07	10 A	2.43 (1.1)	5.500 x 13 x 1.875 (141 x 330 x 46)	0.5/0.75
40P7					1
41P5	FS5972-18-07	18 A	2.87 (1.3)	5.50 x 13 x 1.875 (141 x 330 x 46)	1.5/2
42P2					3
43P7					5
45P5					7.5
47P5					10
49P0/4011	FS5972-35-07	35 A	4.63 (2.1)	8.125 x 14 x 1.9375 (206 x 355 x 50)	15
4015	FS5972-60-07	60 A	8.82 (4)	9.250 x 16 x 2.50 (236 x 408 x 65)	25
4018					30
4024/4030	FS5972-70-52	70 A	7.5 (3.4)	3 x 13 x 7.250 (80 x 329 x 185)	40/50
4037	FS5972-130-35	130 A	10.36 (4.7)	3.5 x 14.375 x 7 (90 x 366 x 180)	60
4045					75
4055					100

Drive Model CIMR-P7U	EMC Filter				
	Model Number	Current Rating	Weight lb. (kg)	Dimensions inches (mm)	Nominal Hp
4075	FS5972-170-40	170 A	13.23 (6)	4.750 x 17.750 x 6.6675 (120 x 451 x 170)	125
4090	FS5972-250-37	250 A	24.25 (11)	5.125 x 24 x 9.4375 (130 x 610 x 240)	150
4110					200

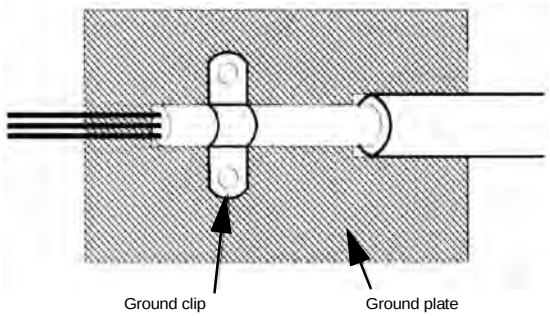


Fig G.1 Grounding Surface Layout

The grounding surfaces must be highly conductive bare metal. Remove any varnish or paint from grounding surfaces.

- Ground the cable shields at both ends.
- Ground the motor of the machine/application.

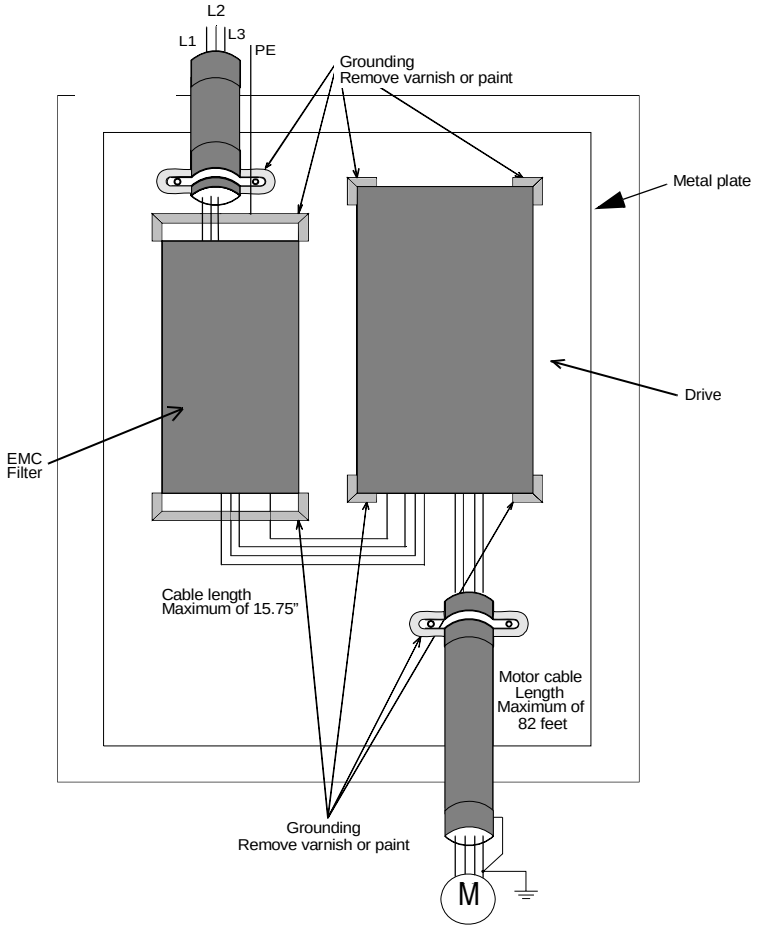


Fig G.2 EMC Filter Layout

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Drives Technical Support in USA and Canada

Technical Support for Inverters and Drives is available by phone as follows:
Normal: Monday through Friday during the hours of 8 a.m. to 5:00 p.m. C.S.T.
Emergency: After normal hours, 7 days a week including weekends and holidays

To contact Drives Technical Support, please call 1-800-YASKAWA (927-5292).
From the menu, dial 2 for Inverter and Drive Products, then 5 for Technical Support.

Drives Technical Support can also be reached by e-mail at DriveSupport@yaskawa.com.
Support information, such as technical manuals, FAQs, instruction sheets and software downloads are available at our website, www.drives.com.

When calling for technical support, please have the following materials available:

- The appropriate Technical Manual in hand because the support associate may refer to this
- Complete nameplate information from the drive and the motor.
  (Confirm that Drive Nameplate Output amps is greater than Motor Nameplate amps)
- A list of your parameter settings
- A sketch of the electrical powertrain, from AC line to motor, including filters and disconnects

Field Service, Start Up Assistance, Factory Repair, Replacement Parts, and Other Support

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Training is conducted at Yaskawa training centers, at customer sites, and via the internet.
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Support in Other Countries

Yaskawa is a multi-national company with offices and service representation around the world.
To obtain support, always contact the local distributor first for guidance and assistance.
Contact the closest Yaskawa office listed for further assistance.

P7 Drive

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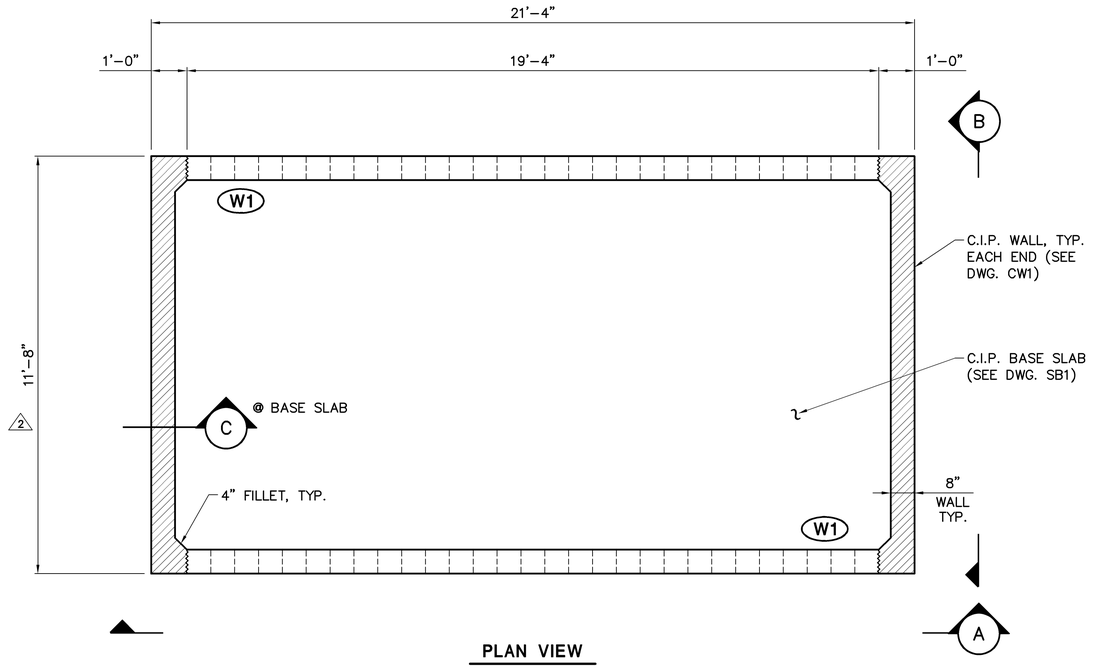
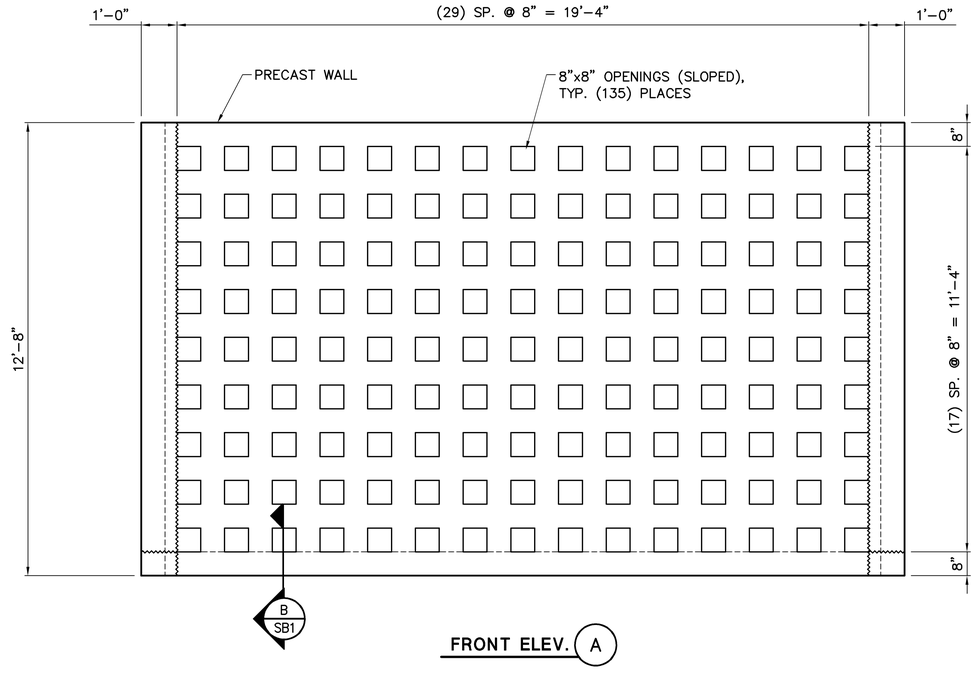
Appendix B

HCC Wall Gate Figures



PLAN VIEW



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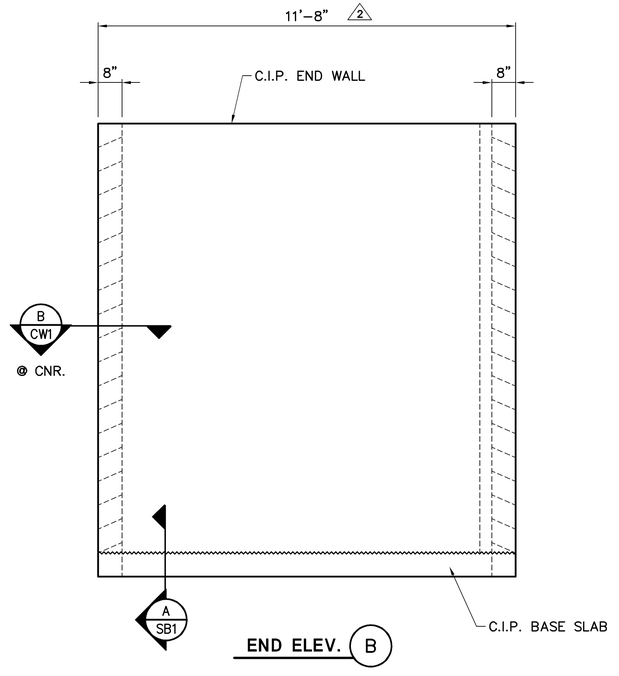

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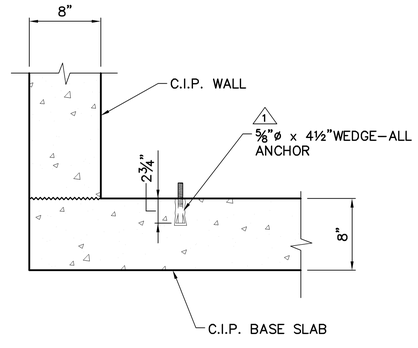

SECTION C

C.T.C.
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05/16/2008
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No.	Revisions	By	App'd	Date
2	REV. BOX WIDTH	PDT	CW	5/12/08
1	REV. BOX WIDTH, ADD FLR. ANCHOR	PDT	CW	5/1/08

CONTRACTOR :

Design
Drawn PDT
Checked CW
Approved

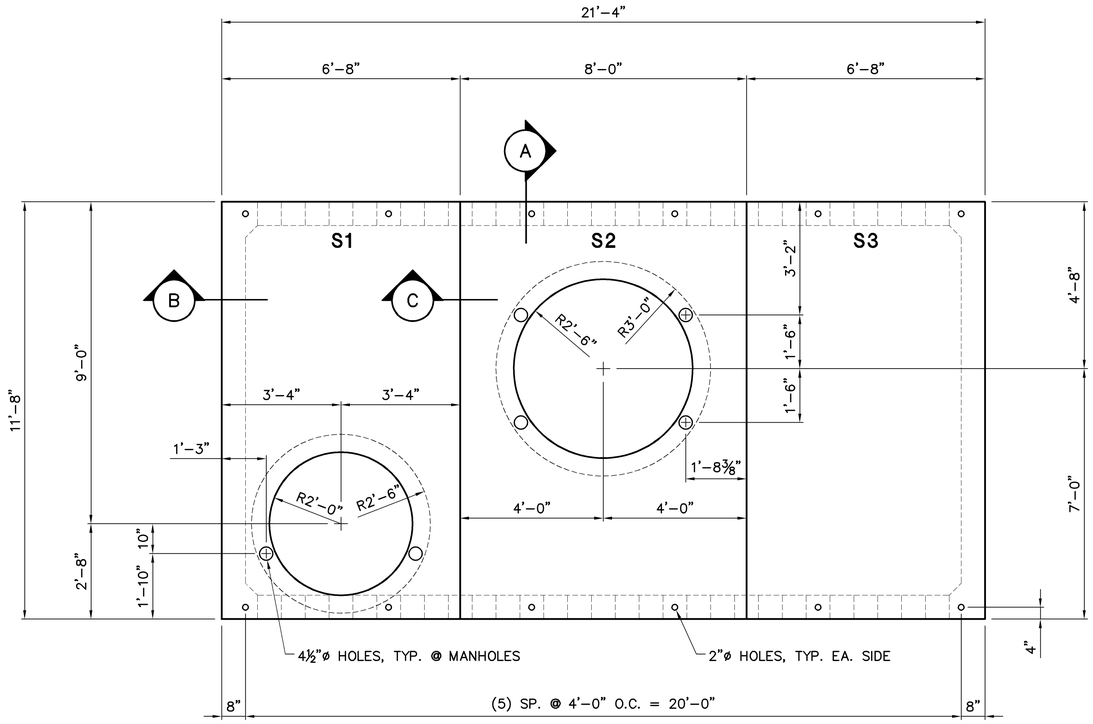
DO NOT SCALE

CONCRETE TECHNOLOGY CORP.
MANUFACTURERS OF PRESTRESSED CONCRETE
1123 PORT OF TACOMA ROAD
TACOMA, WASHINGTON 98421

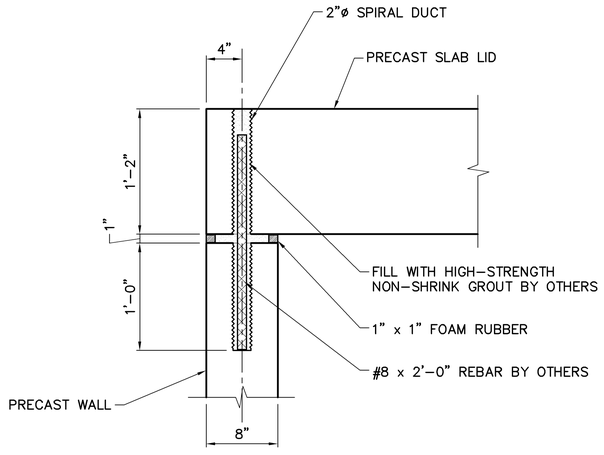
BNSF - SKYKOMISH GATES
SKYKOMISH, WASHINGTON

CONCRETE BOXES

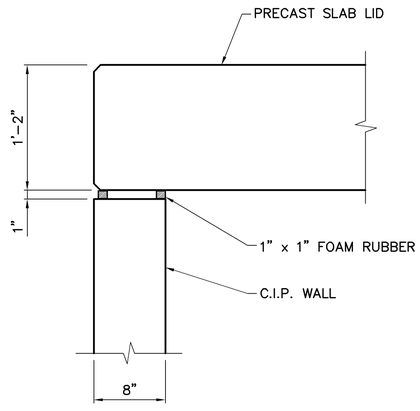
Date MARCH 2008
Sh. No. 1 of
Dwg. No. P–1
Job. No. 08042A
2



PLAN VIEW



SECTION A



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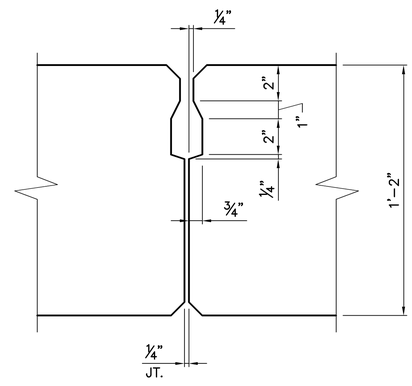

SECTION C

C.T.C.
FOR APPROVAL
05/16/2008
IMPORTANT
Production and/or delivery
may be re-scheduled
unless drawings are
RETURNED APPROVED
by
MAY 30, 2008

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No.	Revisions	By	App'd	Date

CONTRACTOR : (206) 625–6298
BNSF
2454 OCCIDENTAL AVE. S., SUITE 1A
SEATTLE, WA 98134

Design
Drawn PDT
Checked CW
Approved

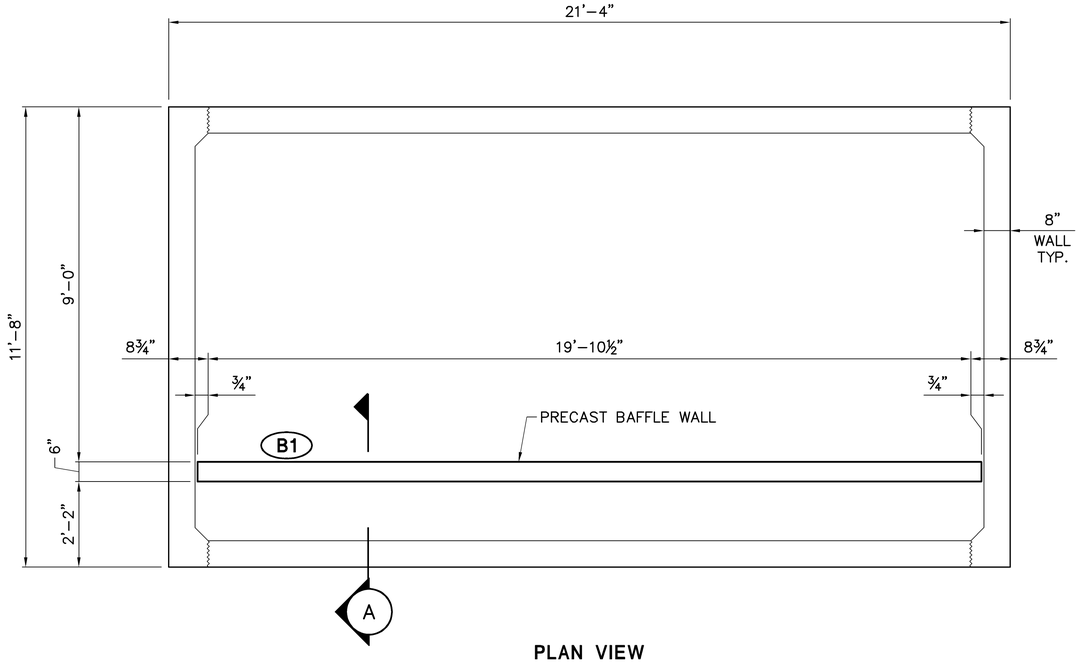
DO NOT SCALE

CONCRETE TECHNOLOGY CORP.
MANUFACTURERS OF PRESTRESSED CONCRETE
1123 PORT OF TACOMA ROAD
TACOMA, WASHINGTON 98421

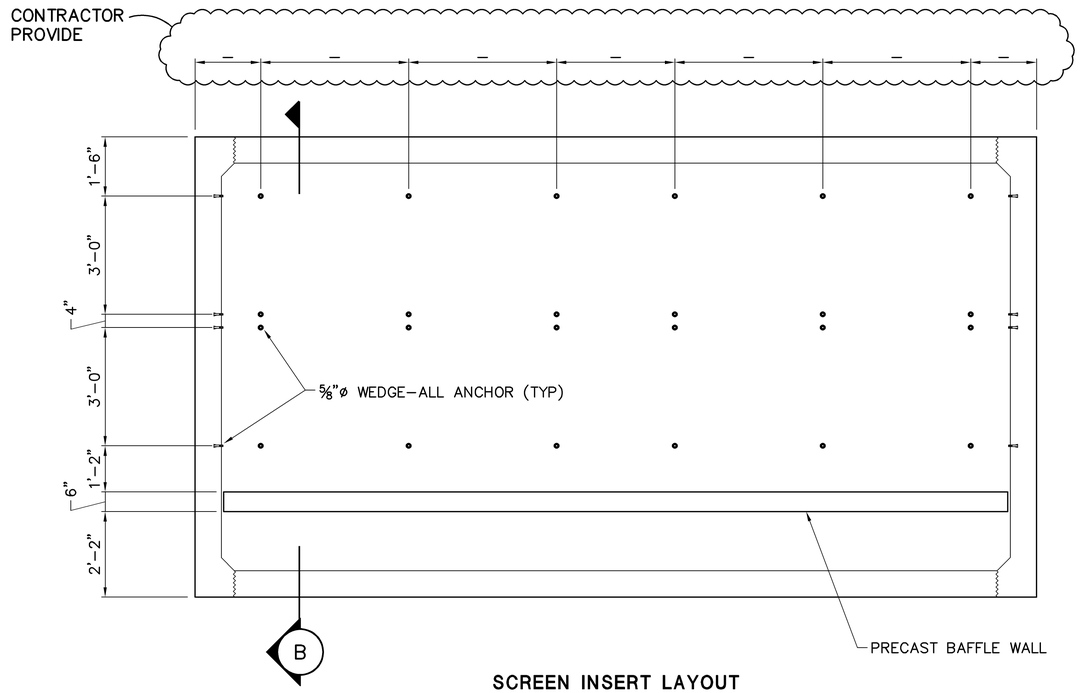
BNSF - SKYKOMISH GATES
SKYKOMISH, WASHINGTON

CONCRETE BOX LID

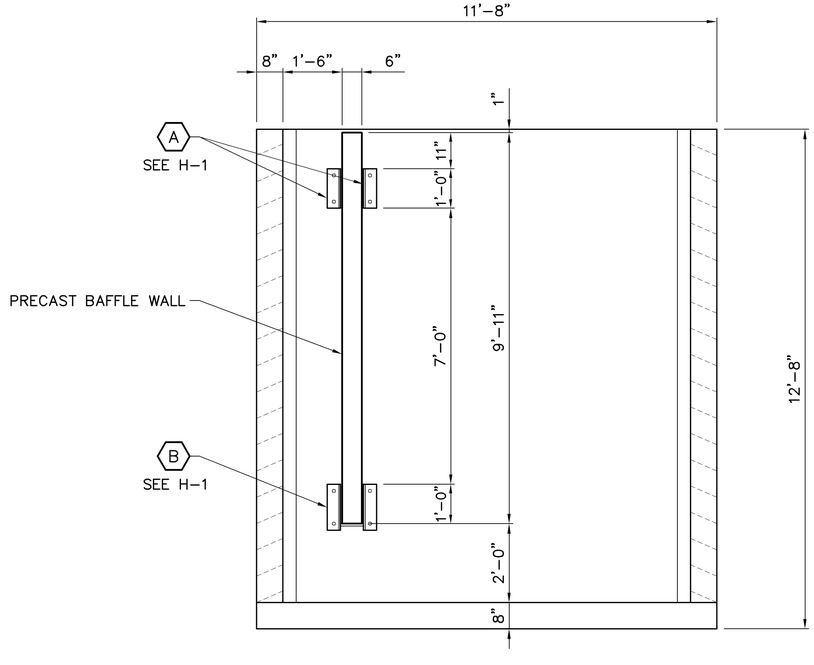
Date MAY 2008
Sh. No. of
Dwg. No. P–2
Job. No. 08042B



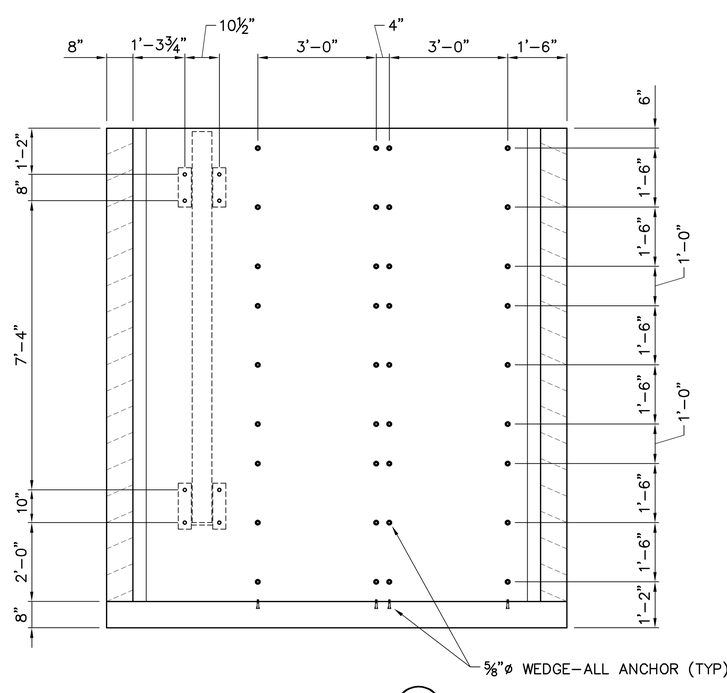
PLAN VIEW



SCREEN INSERT LAYOUT
PLAN VIEW



SECTION A



ELEVATION B

C.T.C.
FOR APPROVAL
05/16/2008
IMPORTANT
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MAY 30, 2008

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No.	Revisions	By	App'd	Date

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MANUFACTURERS OF PRESTRESSED CONCRETE
1123 PORT OF TACOMA ROAD
TACOMA, WASHINGTON 98421

BNSF - SKYKOMISH GATES
SKYKOMISH, WASHINGTON

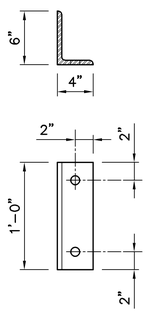
PRECAST BAFFLE WALL

Date MAY 2008
Sh. No. of
Dwg. No. P–3
Job. No. 08042C

CONCRETE TECHNOLOGY CORP.
HARDWARE ORDER

DATE 5/15/08
RE-ISSUE
SHEET OF

JOB: BNSF SKYKOMISH BOXES | JOB NO.: 08042C



Assembly A **Make** 40

STEEL L 4 x 6 x ½ x 1'-0"

REBAR

ANCHORS

WT. 16.2#/EA.

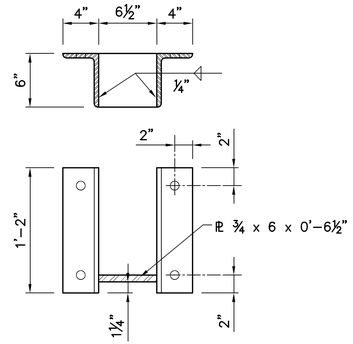
SPECIAL INSTRUCTIONS

FINISH [X] PRIME [ ] GALV. TAPE EDGES [ ] YES [ ] NO

CONCRETE TECHNOLOGY CORP.
HARDWARE ORDER

DATE 5/15/08
RE-ISSUE
SHEET OF

JOB: BNSF SKYKOMISH BOXES | JOB NO.: 08042C



Assembly B **Make** 20

STEEL (2) L 4 x 6 x ½ x 1'-2"
(1) PL ¾ x 6 x 0'-6½"

REBAR

ANCHORS

WT. 46.0#/EA.

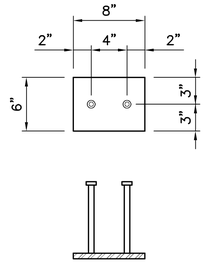
SPECIAL INSTRUCTIONS

FINISH [X] PRIME [ ] GALV. TAPE EDGES [ ] YES [ ] NO

CONCRETE TECHNOLOGY CORP.
HARDWARE ORDER

DATE 5/15/08
RE-ISSUE
SHEET OF

JOB: BNSF SKYKOMISH BOXES | JOB NO.: 08042C



Assembly C **Make** 20

STEEL PL ½ x 6 x 0'-8"

REBAR

ANCHORS (2) ⅝"ø x 8" STUDS

WT. 8.5#/EA.

SPECIAL INSTRUCTIONS

FINISH [X] PRIME [ ] GALV. TAPE EDGES [ ] YES [ ] NO

CONCRETE TECHNOLOGY CORP.
HARDWARE ORDER

DATE
RE-ISSUE
SHEET OF

JOB: | JOB NO.:

Assembly **Make**

STEEL

REBAR

ANCHORS

WT.

SPECIAL INSTRUCTIONS

FINISH [ ] PRIME [ ] GALV. TAPE EDGES [ ] YES [ ] NO

CONCRETE TECHNOLOGY CORP.
HARDWARE ORDER

DATE
RE-ISSUE
SHEET OF

JOB: | JOB NO.:

Assembly **Make**

STEEL

REBAR

ANCHORS

WT.

SPECIAL INSTRUCTIONS

FINISH [ ] PRIME [ ] GALV. TAPE EDGES [ ] YES [ ] NO

CONCRETE TECHNOLOGY CORP.
HARDWARE ORDER

DATE
RE-ISSUE
SHEET OF

JOB: | JOB NO.:

Assembly **Make**

STEEL

REBAR

ANCHORS

WT.

SPECIAL INSTRUCTIONS

FINISH [ ] PRIME [ ] GALV. TAPE EDGES [ ] YES [ ] NO

CONCRETE TECHNOLOGY CORP.
HARDWARE ORDER

DATE
RE-ISSUE
SHEET OF

JOB: | JOB NO.:

C.T.C.
FOR APPROVAL
05/16/2008
IMPORTANT
Production and/or delivery may be re-scheduled unless drawings are RETURNED APPROVED by
MAY 30, 2008

Assembly **Make**

STEEL

REBAR

ANCHORS

WT.

SPECIAL INSTRUCTIONS

FINISH [ ] PRIME [ ] GALV. TAPE EDGES [ ] YES [ ] NO

No.	Revisions	By	App'd	Date

CONTRACTOR : (206) 625-6298
BNSF
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SEATTLE, WA 98134

Design
Drawn PDT
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TACOMA, WASHINGTON 98421

BNSF - SKYKOMISH GATES
SKYKOMISH, WASHINGTON

HARDWARE

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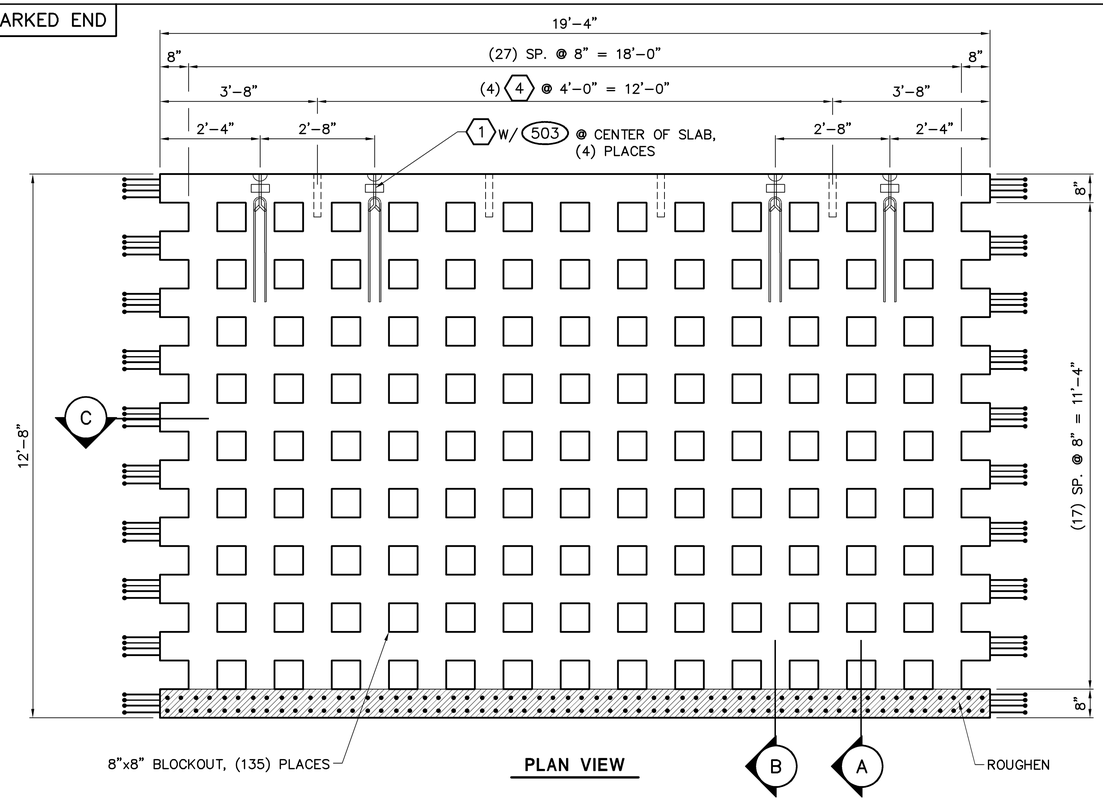
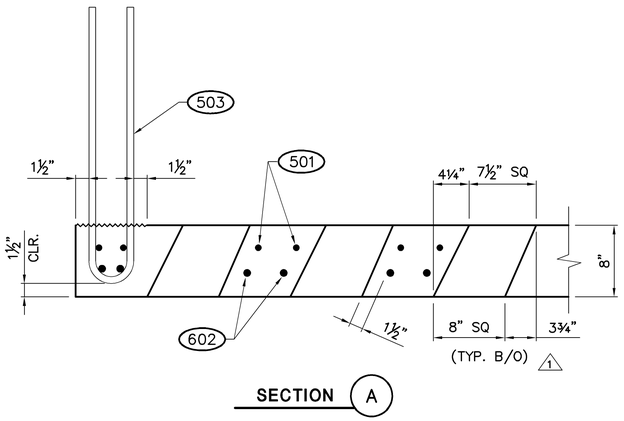
Date MAY 2008
Sh. No. of
Dwg. No. H-1
Job. No. 08042C

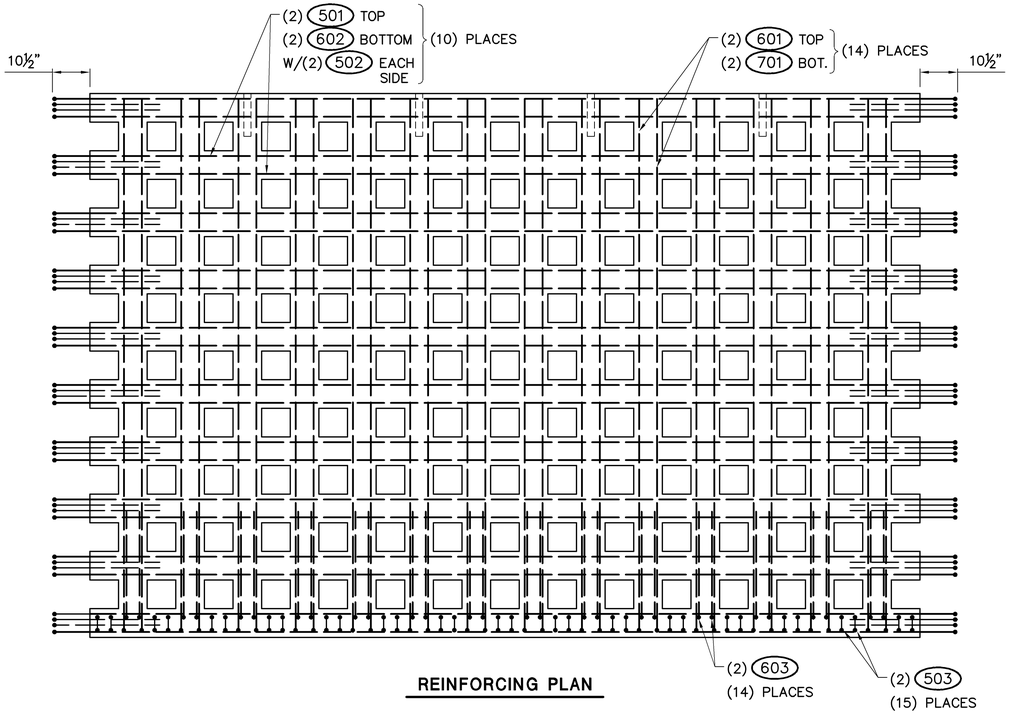
MARKED END



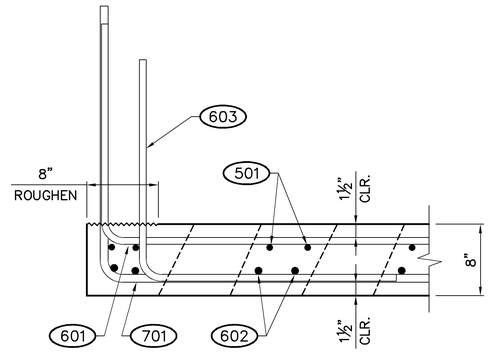
PLAN VIEW



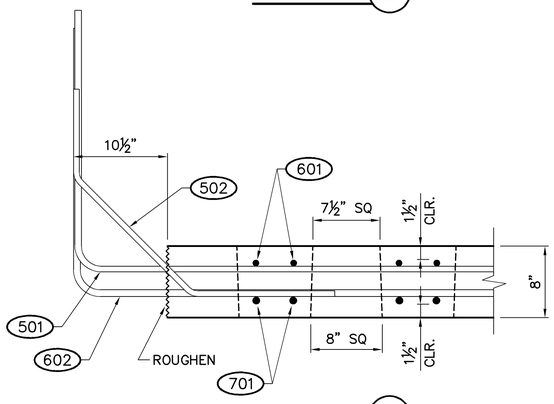
SECTION A



REINFORCING PLAN



SECTION B

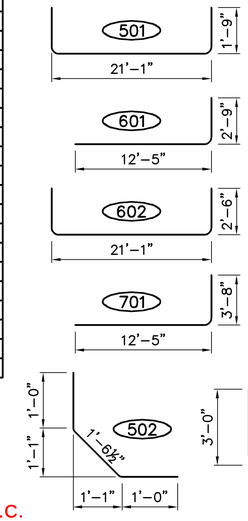


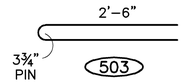
SECTION C

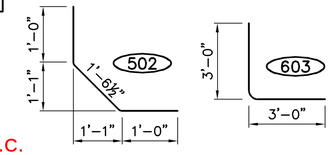
REINFORCEMENT SCHEDULE

GRADE	BAR MARK NUMBER	QUANTITY	STRAIGHT	NO. BENDS	CUTTING LENGTH
60	501	20		2	24'–7"
	502	40		2	3'–6½"
	503	34		1	5'–4"
	601	28		1	15'–2"
	602	20		2	26'–1"
	603	28		1	6'–0"
	701	28		1	16'–1"

REBAR TYPE — BAR SIZE / MARK NUMBER — X402







STIRRUP/TIE PIN ø (UNO)
#3 = 1½"
#4 = 2"
#5 = 2½"
#6 = 4½"
#7 = 5¼"
#8 = 6"

C.T.C.
FOR APPROVAL
05/16/2008
IMPORTANT
Production and/or delivery may be re-scheduled unless drawings are RETURNED APPROVED by
MAY 30, 2008

GENERAL NOTES

CONCRETE: STRENGTH @ STRIPPING....4,000 P.S.I.
STRENGTH @ 28 DAYS....6,000 P.S.I.
VOLUME: 4.60 CU. YD.

FINISHES: TOP..... FLOAT FINISH
SIDES, SOFFIT, ENDS.... FORM FINISH

PLANT HANDLING: STORE VERTICAL.

INSERT & ASSEMBLY SCHEDULE

1	6T RL–7 ERECTION ANCHOR W/ SHEAR PLATE			4	80
4	2"ø x 1'–0" SPIRAL DUCT		X	4	80

MARK	DESCRIPTION	PRIME	GALV.	PER PIECE	TOTAL QUANTITIES

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No.	Revisions	By	App'd	Date
1	REV. BLOCKOUT	PDT	CW	5/1/08

CONTRACTOR : (206) 625–6298
BNSF
2454 OCCIDENTAL AVE. S., SUITE 1A
SEATTLE, WA 98134

Design
Drawn PDT
Checked CW
Approved

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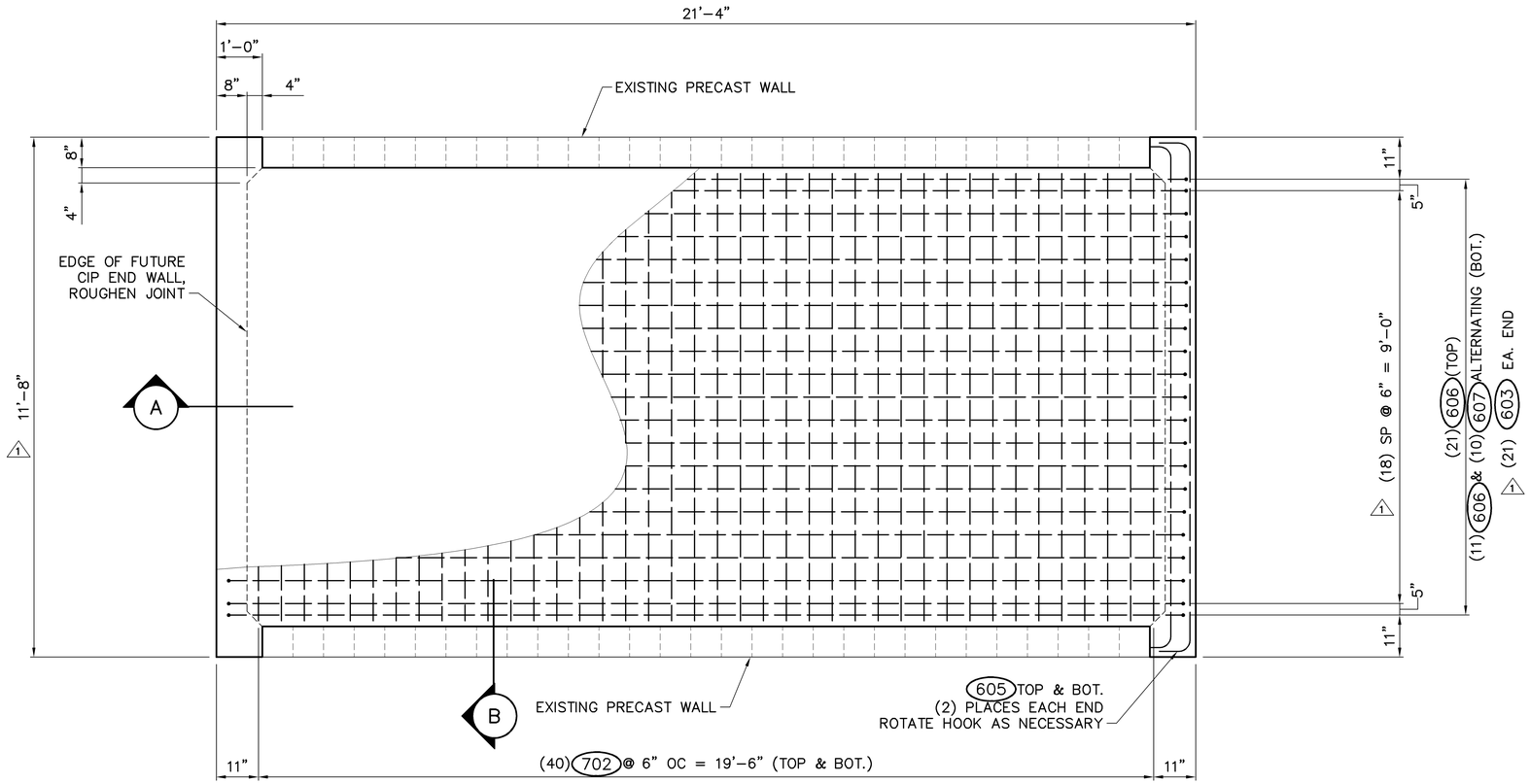
CONCRETE TECHNOLOGY CORP.
MANUFACTURERS OF PRESTRESSED CONCRETE
1123 PORT OF TACOMA ROAD
TACOMA, WASHINGTON 98421

BNSF - SKYKOMISH GATES
SKYKOMISH, WASHINGTON

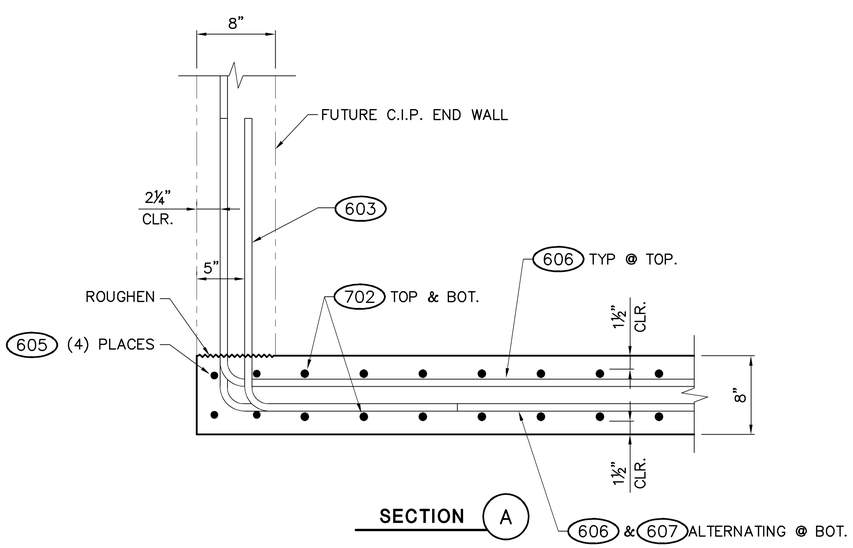
PRODUCTION DRAWING
PRECAST BOX WALL
MARK: W1 QTY. 20 WT. 19.70 KIPS

Date MARCH 2008
Sh. No. of
Dwg. No. W1 1
Job. No. 08042A

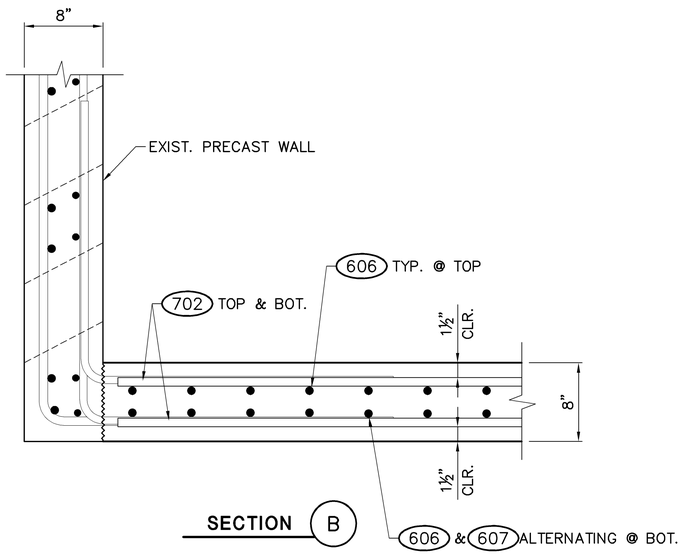
MARKED END



PLAN VIEW



SECTION A

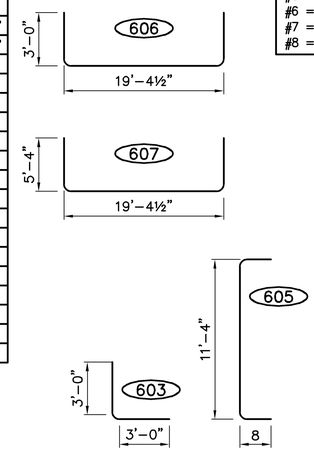


SECTION B

REINFORCEMENT SCHEDULE

GRADE	BAR MARK NUMBER	QUANTITY	STRAIGHT	NO. BENDS	CUTTING LENGTH
60	603	42		1	6'–0"
	605	8		2	12'–8"
	606	32		2	25'–4½"
	607	10		2	30'–0½"
	702	80	X		10'–1"

REBAR TYPE — BAR SIZE / MARK NUMBER (X402)



STIRRUP/TIE PIN ø (UNO)
#3 = 1½"
#4 = 2"
#5 = 2½"
#6 = 4½"
#7 = 5¼"
#8 = 6"

C.T.C.
FOR APPROVAL
05/16/2008
IMPORTANT
Production and/or delivery may be re-scheduled unless drawings are
RETURNED APPROVED
by
MAY 30, 2008

GENERAL NOTES

CONCRETE: STRENGTH @ STRIPPING....4,000 P.S.I. **VOLUME:** 5.50 **CU. YD.**
STRENGTH @ 28 DAYS....6,000 P.S.I.

FINISHES: TOP..... FLOAT FINISH (ROUGHEN AS SHOWN)

INSERT & ASSEMBLY SCHEDULE

MARK	DESCRIPTION	PRIME	GALV.	QUANTITIES PER PIECE	QUANTITIES TOTAL

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No.	Revisions	By	App'd	Date
1	REV. WIDTH, REINFORCING	PDT	CW	5/1/08

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SEATTLE, WA 98134

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Checked CW
Approved

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MANUFACTURERS OF PRESTRESSED CONCRETE
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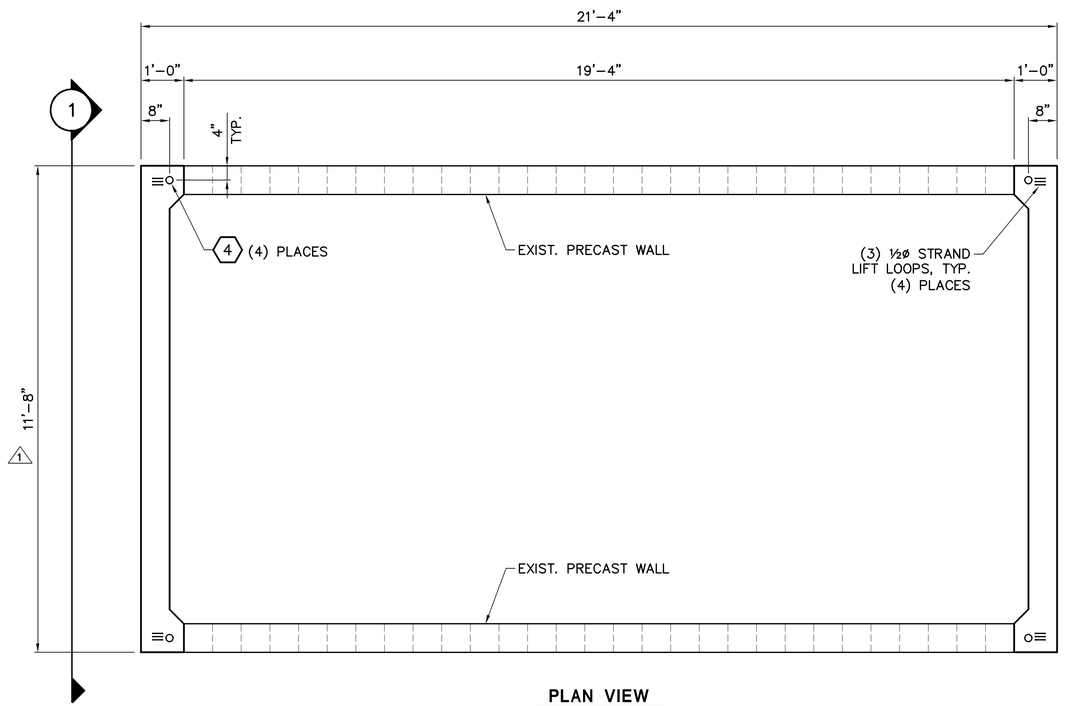
TACOMA, WASHINGTON 98421

BNSF - SKYKOMISH GATES
SKYKOMISH, WASHINGTON

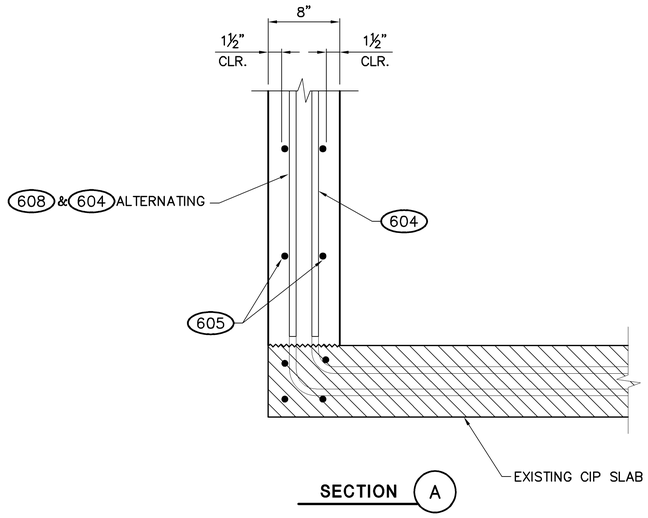
PRODUCTION DRAWING

C.I.P. BASE SLAB
MARK: SB1 QTY. 10 WT. 23.80 KIPS

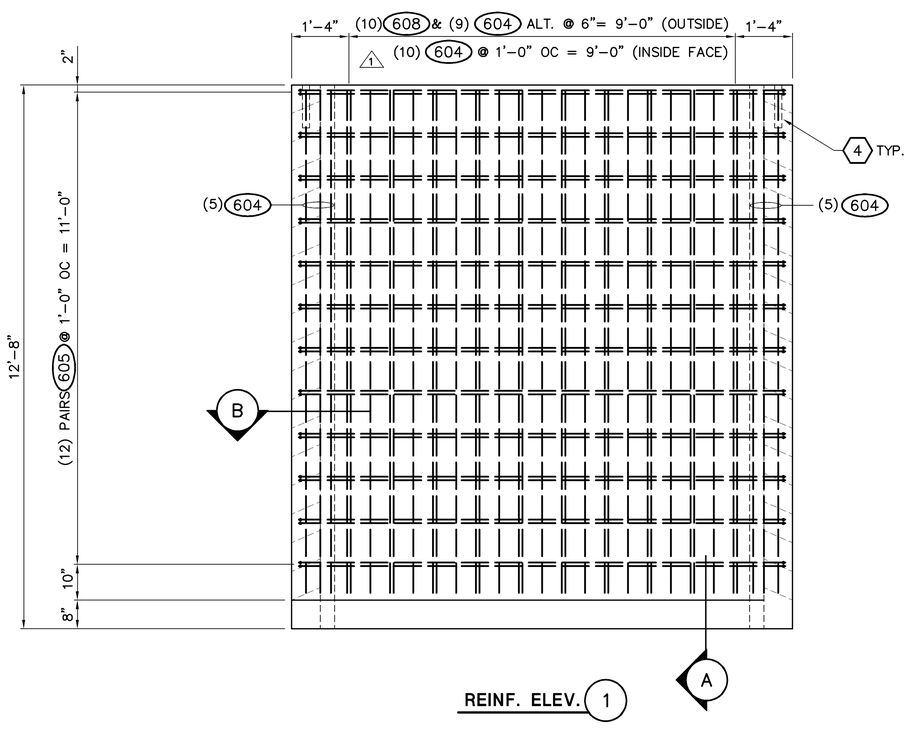
Date MARCH 2008
Sh. No. of
Dwg. No. SB1 1
Job. No. 08042A



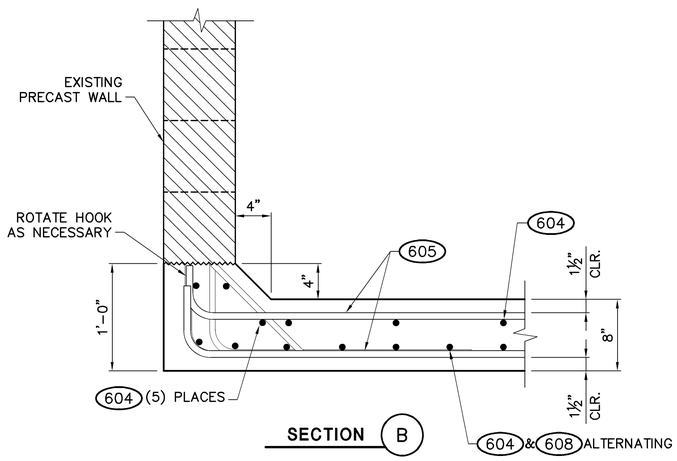
PLAN VIEW



SECTION A



REINF. ELEV. 1

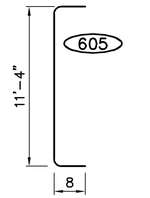


SECTION B

REINFORCEMENT SCHEDULE

GRADE	BAR MARK NUMBER	QUANTITY	STRAIGHT	NO. BENDS	CUTTING LENGTH
60					
	604	58	X		11'–9"
	605	48		2	12'–8"
	608	20	X		9'–6"

REBAR TYPE X402 — BAR SIZE / MARK NUMBER



STIRRUP/TIE PIN ø (UNO)
#3 = 1½"
#4 = 2"
#5 = 2½"
#6 = 4½"
#7 = 5¼"
#8 = 6"

C.T.C.
FOR APPROVAL
05/16/2008
IMPORTANT
Production and/or delivery may be re-scheduled unless drawings are RETURNED APPROVED by
MAY 30, 2008

GENERAL NOTES

CONCRETE: STRENGTH @ STRIPPING.... 4,000 P.S.I.
STRENGTH @ 28 DAYS...6,000 P.S.I.
VOLUME: 7.40 CU. YD.

FINISHES: TOP..... FLOAT FINISH
SIDES, SOFFIT, ENDS.... FORM FINISH

PLANT HANDLING: –

INSERT & ASSEMBLY SCHEDULE

4	2"ø x 1'–0" SPIRAL DUCT		X	4	40
	(3) ½"ø 270 KSI LIFT LOOPS AT EACH PICK POINT (10'–0", 9")			12	120
MARK	DESCRIPTION	PRIME	GALV.	PER PIECE	TOTAL QUANTITIES

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No.	Revisions	By	App'd	Date
1	REV. WIDTH, REINFORCING	PDT	CW	5/1/08

CONTRACTOR : (206) 625–6298
BNSF
2454 OCCIDENTAL AVE. S., SUITE 1A
SEATTLE, WA 98134

Design
Drawn PDT
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Approved

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MANUFACTURERS OF PRESTRESSED CONCRETE
1123 PORT OF TACOMA ROAD
TACOMA, WASHINGTON 98421

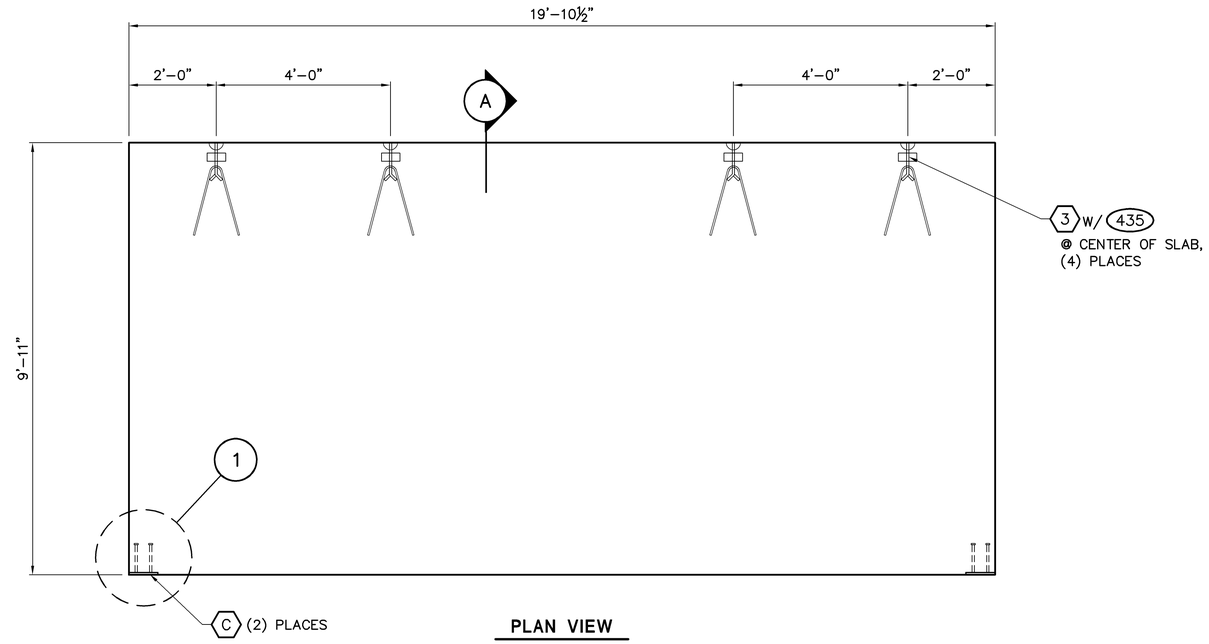
BNSF - SKYKOMISH GATES
SKYKOMISH, WASHINGTON

PRODUCTION DRAWING

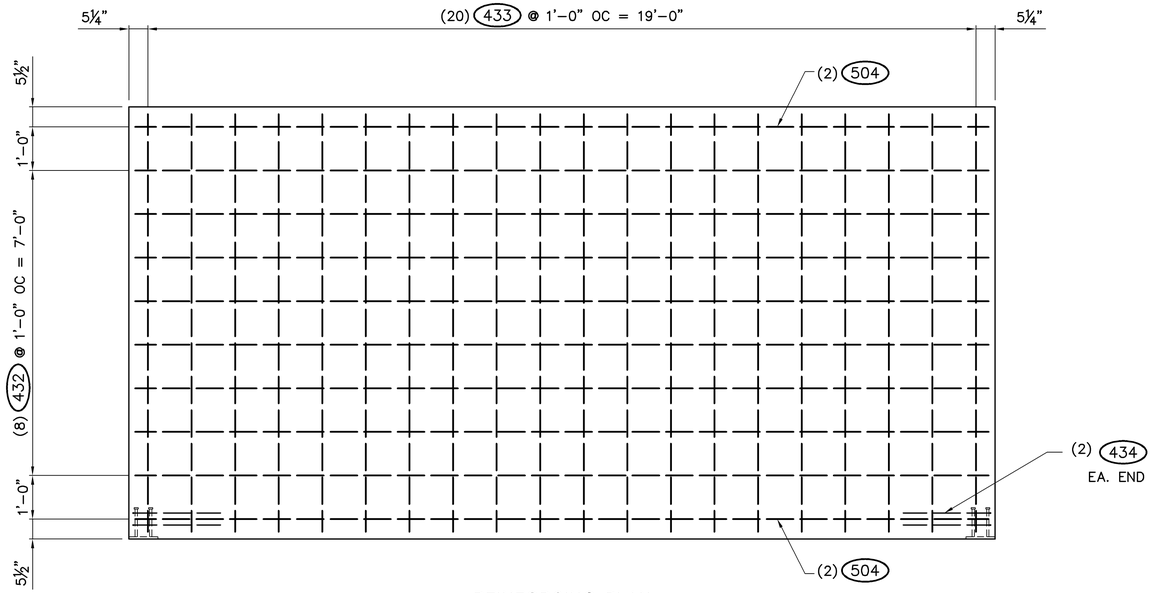
C.I.P. END WALL
MARK: CW1 QTY. 10 WT. 32.00 KIPS

Date MARCH 2008
Sh. No. of
Dwg. No. CW1 1
Job. No. 08042A

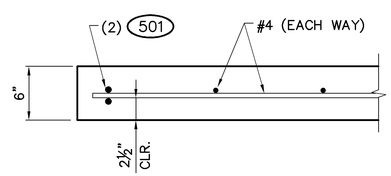
MARKED END



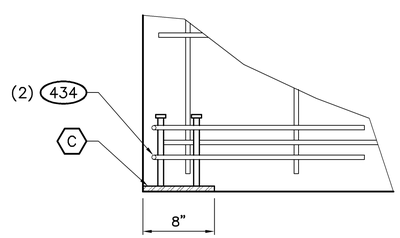
PLAN VIEW



REINFORCING PLAN



SECTION A

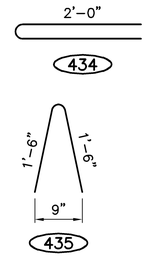


DETAIL 1

REINFORCEMENT SCHEDULE

GRADE	BAR MARK NUMBER	QUANTITY	STRAIGHT	NO. BENDS	CUTTING LENGTH
60	432	8	X		19'–7"
	433	20	X		9'–7"
	434	4		2	4'–3"
	435	4		1	3'–0"
	504	4	X		19'–7"

REBAR TYPE X402 — BAR SIZE / MARK NUMBER



STIRRUP/TIE PIN ø (UNO)
#3 = 1½"
#4 = 2"
#5 = 2½"
#6 = 4½"
#7 = 5¼"
#8 = 6"

C.T.C.
FOR APPROVAL
05/16/2008
IMPORTANT
Production and/or delivery may be re-scheduled unless drawings are RETURNED APPROVED by
MAY 30, 2008

GENERAL NOTES

CONCRETE: STRENGTH @ STRIPPING....4,000 P.S.I.
STRENGTH @ 28 DAYS....6,000 P.S.I.
VOLUME: 3.70 CU. YD.

FINISHES: TOP..... GOOD WOOD FLOAT FINISH

INSERT & ASSEMBLY SCHEDULE

MARK	DESCRIPTION	PRIME	GALV.	PER PIECE	TOTAL QUANTITIES
C	PL ½ x 6 x 0'–8" W/ (2) ⅝"ø x 8" STUDS	X		2	20
3	4T RL–7 ERECTION ANCHOR W/ SHEAR PLATE			4	40

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No.	Revisions	By	App'd	Date

CONTRACTOR : (206) 625–6298
BNSF
2454 OCCIDENTAL AVE. S., SUITE 1A
SEATTLE, WA 98134

Design
Drawn PDT
Checked CW
Approved

DO NOT SCALE

CONCRETE TECHNOLOGY CORP.
MANUFACTURERS OF PRESTRESSED CONCRETE
1123 PORT OF TACOMA ROAD
TACOMA, WASHINGTON 98421

BNSF - SKYKOMISH GATES
SKYKOMISH, WASHINGTON

PRODUCTION DRAWING
PRECAST BAFFLE WALL
MARK: B1 **QTY.** 10 **WT.** 15.8 **KIPS**

Date MAY 2008
Sh. No. of
Dwg. No. B1
Job. No. 08042C

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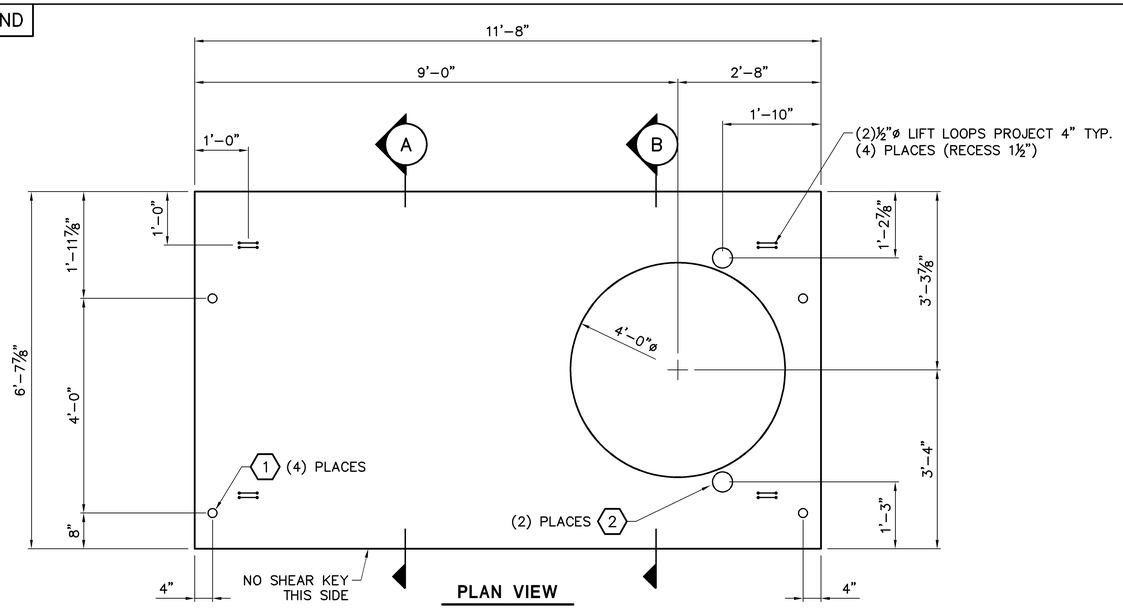
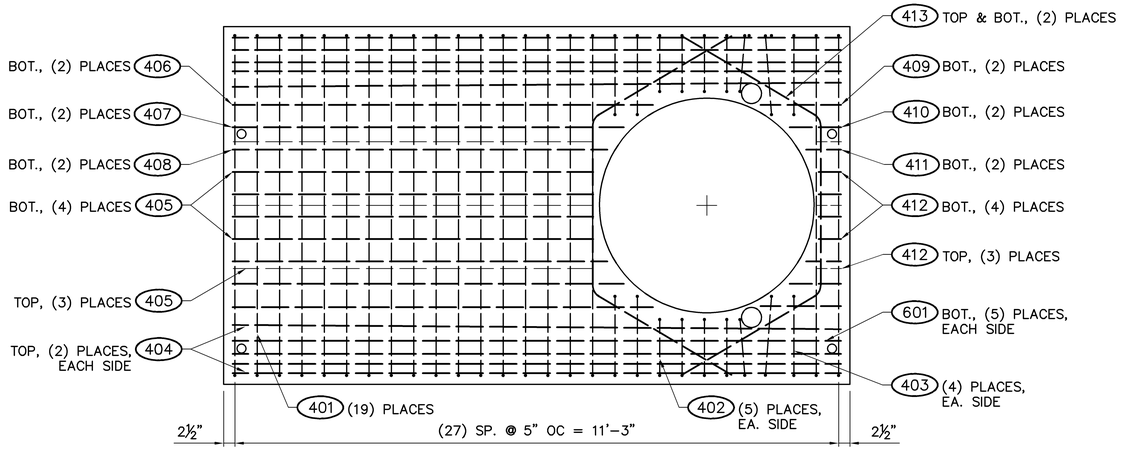
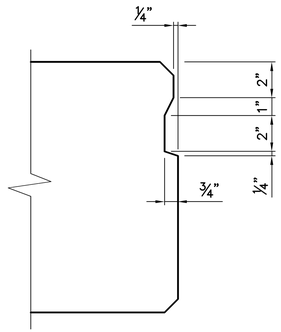


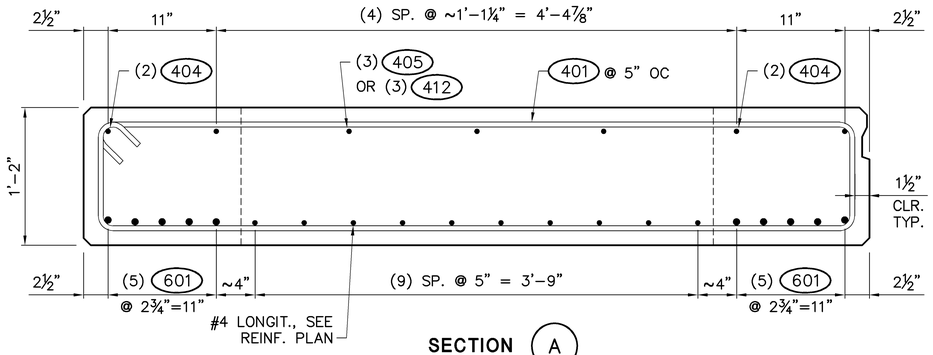
PLAN VIEW



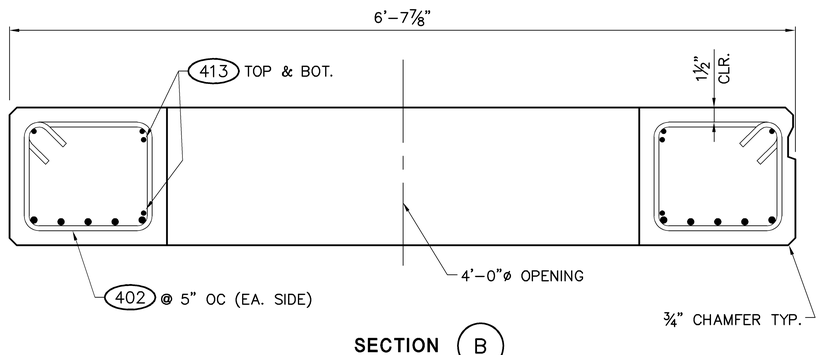
REINFORCING PLAN



SHEAR KEY



SECTION A

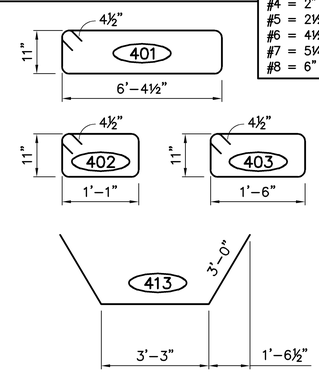


SECTION B

REINFORCEMENT SCHEDULE

GRADE	BAR MARK NUMBER	QUANTITY	STRAIGHT	NO. BENDS	CUTTING LENGTH
60	401	19		5	15'–4"
	402	10		5	4'–9"
	403	8		5	5'–7"
	404	4	X		11'–4"
	405	7	X		6'–8"
	406	2	X		7'–10"
	407	2	X		7'–2"
	408	2	X		6'–10"
	409	2	X		1'–6"
	410	2	X		0'–11"
	411	2	X		0'–8"
	412	7	X		0'–5"
	413	4		2	9'–3"
	601	10	X		11'–4"

REBAR TYPE — BAR SIZE / MARK NUMBER (X402)



STIRRUP/TIE PIN ø (UNO)
#3 = 1½"
#4 = 2"
#5 = 2½"
#6 = 4½"
#7 = 5¼"
#8 = 6"

C.T.C.
FOR APPROVAL
05/16/2008
IMPORTANT
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MAY 30, 2008

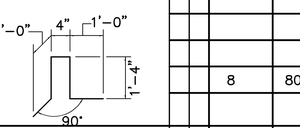
GENERAL NOTES

CONCRETE: STRENGTH @ STRIPPING....4000 P.S.I.
STRENGTH @ 28 DAYS....6000 P.S.I.
VOLUME: 2.8 **CU. YD.**

FINISHES: TOP..... GOOD WOOD FLOAT FINISH

INSERT & ASSEMBLY SCHEDULE

				MARK	DESCRIPTION	PRIME	GALV.	PER PIECE	TOTAL QUANTITIES
1	2"ø x 1'–2" SPIRAL DUCT		X	4	40				
2	4½" O.D. SCH. 40 PVC PIPE SLEEVE			2	20				
	½"ø 270KSI LIFT LOOP (2)LOOPS @ EA. POINT			8	80				



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No.	Revisions	By	App'd	Date

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BNSF
2454 OCCIDENTAL AVE S. SUITE #1A
SEATTLE, WA 98134

Design CW
Drawn PDT
Checked CW
Approved

DO NOT SCALE

CONCRETE TECHNOLOGY CORP.
MANUFACTURERS OF PRESTRESSED CONCRETE
1123 PORT OF TACOMA ROAD
TACOMA, WASHINGTON 98421

BNSF - SKYKOMISH GATES
SKYKOMISH, WASHINGTON

PRODUCTION DRAWING
PRECAST SLAB LID
MARK: S1 **QTY.** 10 **WT.** 12.2 **KIPS**

Date MAY 2008
Sh. No. of
Dwg. No. S1
Job. No. 08042B

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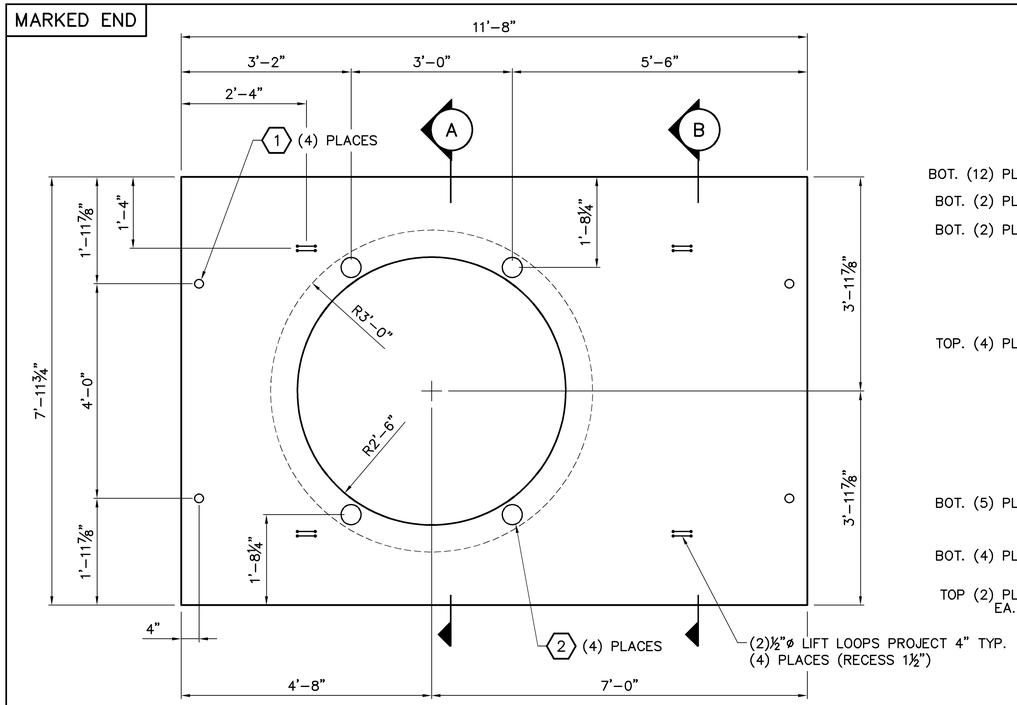
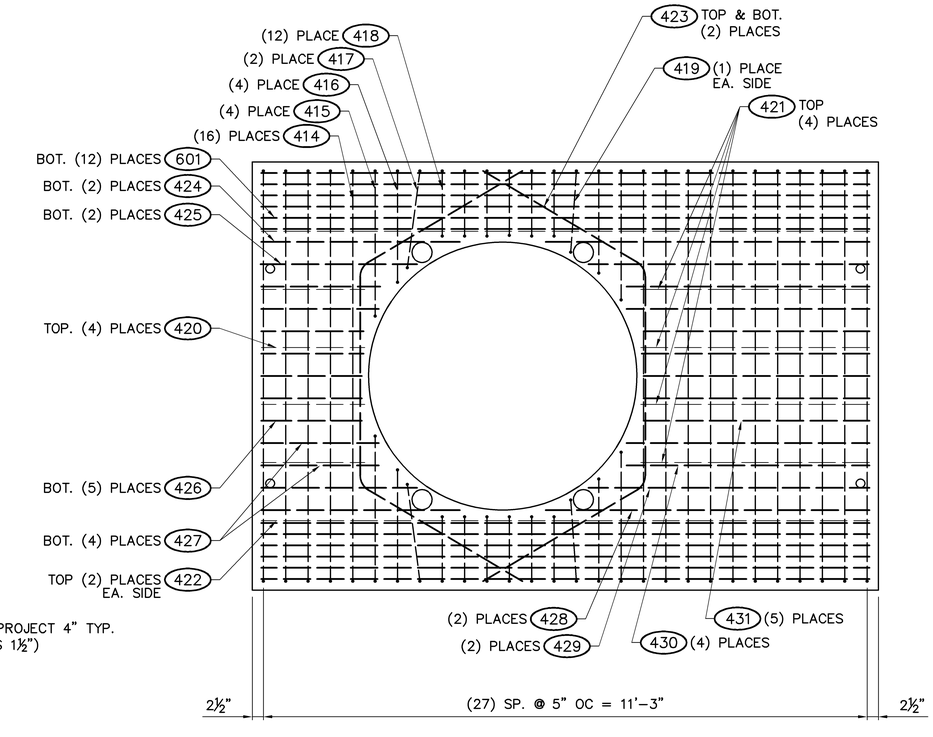
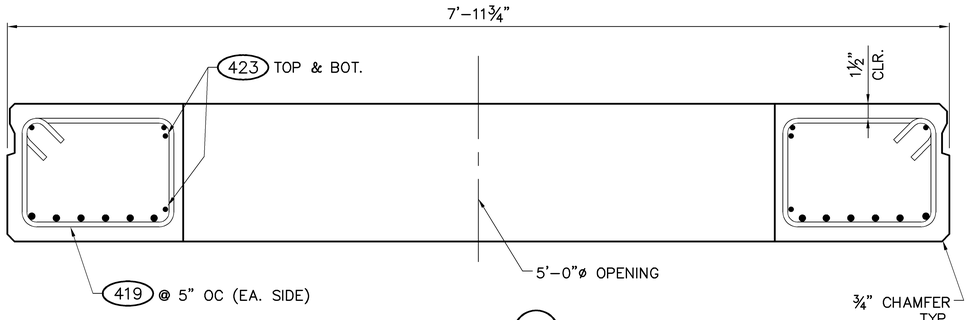


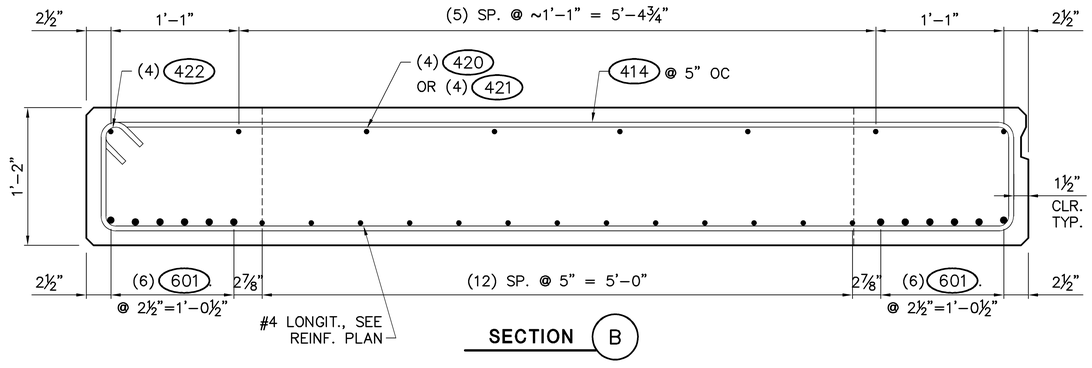
PLAN VIEW



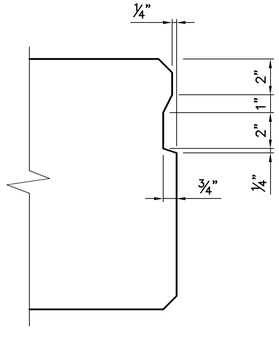
REINFORCING PLAN



SECTION A



SECTION B



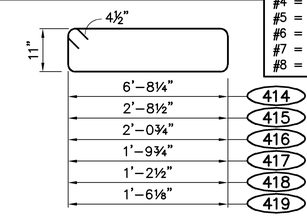
SHEAR KEY

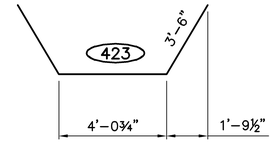
REINFORCEMENT SCHEDULE

GRADE	BAR MARK NUMBER	QUANTITY	STRAIGHT	NO. BENDS	CUTTING LENGTH
60	414	16		5	16'-0"
	415	4		5	8'-0"
	416	4		5	6'-8½"
	417	2		5	6'-2½"
	418	12		5	5'-0"
	419	2		5	5'-7¼"
	420	4	X		1'-11"
	421	4	X		4'-3"
	422	4	X		11'-4"
	423	4		2	11'-0¾"
	424	2	X		3'-8¼"
	425	2	X		2'-10¼"
	426	5	X		1'-10"
	427	4	X		2'-2¼"
	428	2	X		6'-0"
	429	2	X		5'-2¾"
	430	4	X		4'-6¼"
	431	5	X		4'-2½"
	601	12	X		11'-4"

REBAR TYPE — BAR SIZE / MARK NUMBER (X402)

STIRRUP/TIE PIN ø (UNO)
#3 = 1½"
#4 = 2"
#5 = 2½"
#6 = 4½"
#7 = 5¼"
#8 = 6"





C.T.C.
FOR APPROVAL
05/16/2008
IMPORTANT
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MAY 30, 2008

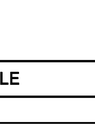
GENERAL NOTES

CONCRETE: STRENGTH @ STRIPPING....4000 P.S.I.
STRENGTH @ 28 DAYS....6000 P.S.I.
VOLUME: 3.2 CU. YD.

FINISHES: TOP..... GOOD WOOD FLOAT FINISH

INSERT & ASSEMBLY SCHEDULE

				PER PIECE	TOTAL
1	2"ø x 1'-2" SPIRAL DUCT		X	4	40
2	4½" O.D. SCH. 40 PVC PIPE SLEEVE			4	40
	½"ø 270KSI LIFT LOOP (2)LOOPS @ EA. POINT			8	80
MARK	DESCRIPTION	PRIME	GALV.	QUANTITIES	



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No.	Revisions	By	App'd	Date

CONTRACTOR :

Design CW
Drawn PDT
Checked CW
Approved

DO NOT SCALE

CONCRETE TECHNOLOGY CORP.
MANUFACTURERS OF PRESTRESSED CONCRETE
1123 PORT OF TACOMA ROAD
TACOMA, WASHINGTON 98421

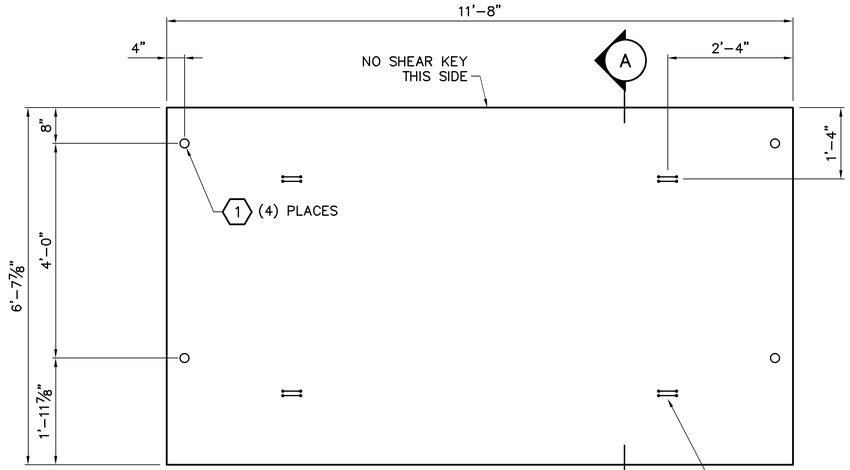
BNSF - SKYKOMISH GATES
SKYKOMISH, WASHINGTON

PRODUCTION DRAWING

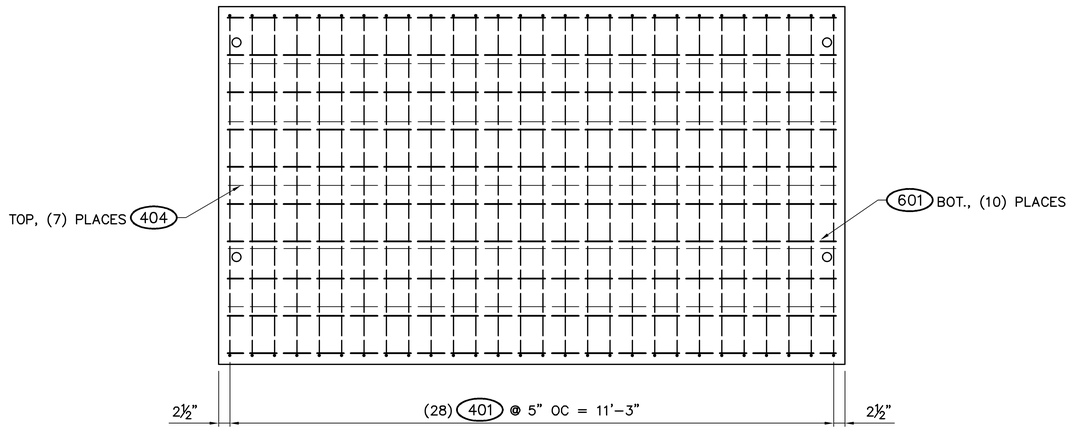
PRECAST SLAB LID
MARK: S2 QTY. 10 WT. 13.7 KIPS

Date MAY 2008
Sh. No. of
Dwg. No. S2
Job. No. 08042B

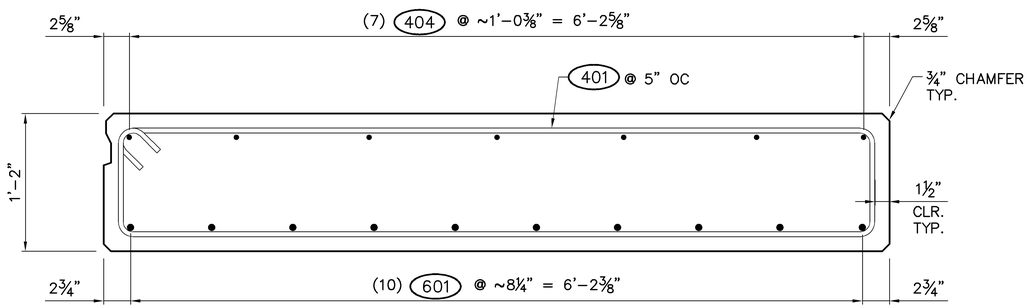
MARKED END



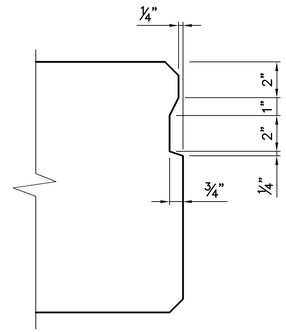
PLAN VIEW



REINFORCING PLAN



SECTION A

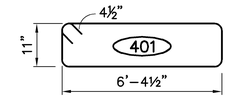


SHEAR KEY

REINFORCEMENT SCHEDULE

GRADE	BAR MARK NUMBER	QUANTITY	STRAIGHT	NO. BENDS	CUTTING LENGTH
60	401	28		5	15'–4"
	404	7	X		11'–4"
	601	10	X		11'–4"

REBAR TYPE — BAR SIZE / MARK NUMBER (X402)



STIRRUP/TIE PIN ø (UNO)
#3 = 1½"
#4 = 2"
#5 = 2½"
#6 = 4½"
#7 = 5¼"
#8 = 6"

C.T.C.
FOR APPROVAL
05/16/2008
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MAY 30, 2008

GENERAL NOTES

CONCRETE: STRENGTH @ STRIPPING...._____ P.S.I.
STRENGTH @ 28 DAYS...._____ P.S.I.
VOLUME: 3.4 **CU. YD.**

FINISHES: TOP..... GOOD WOOD FLOAT FINISH

INSERT & ASSEMBLY SCHEDULE

MARK	DESCRIPTION	PRIME	GALV.	PER PIECE	TOTAL QUANTITIES
1	2"ø x 1'–2" SPIRAL DUCT		X	4	40
	½"ø 270KSI LIFT LOOP (2)LOOPS @ EA. POINT			8	80

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No.	Revisions	By	App'd	Date

CONTRACTOR :

Design CW
Drawn PDT
Checked CW
Approved

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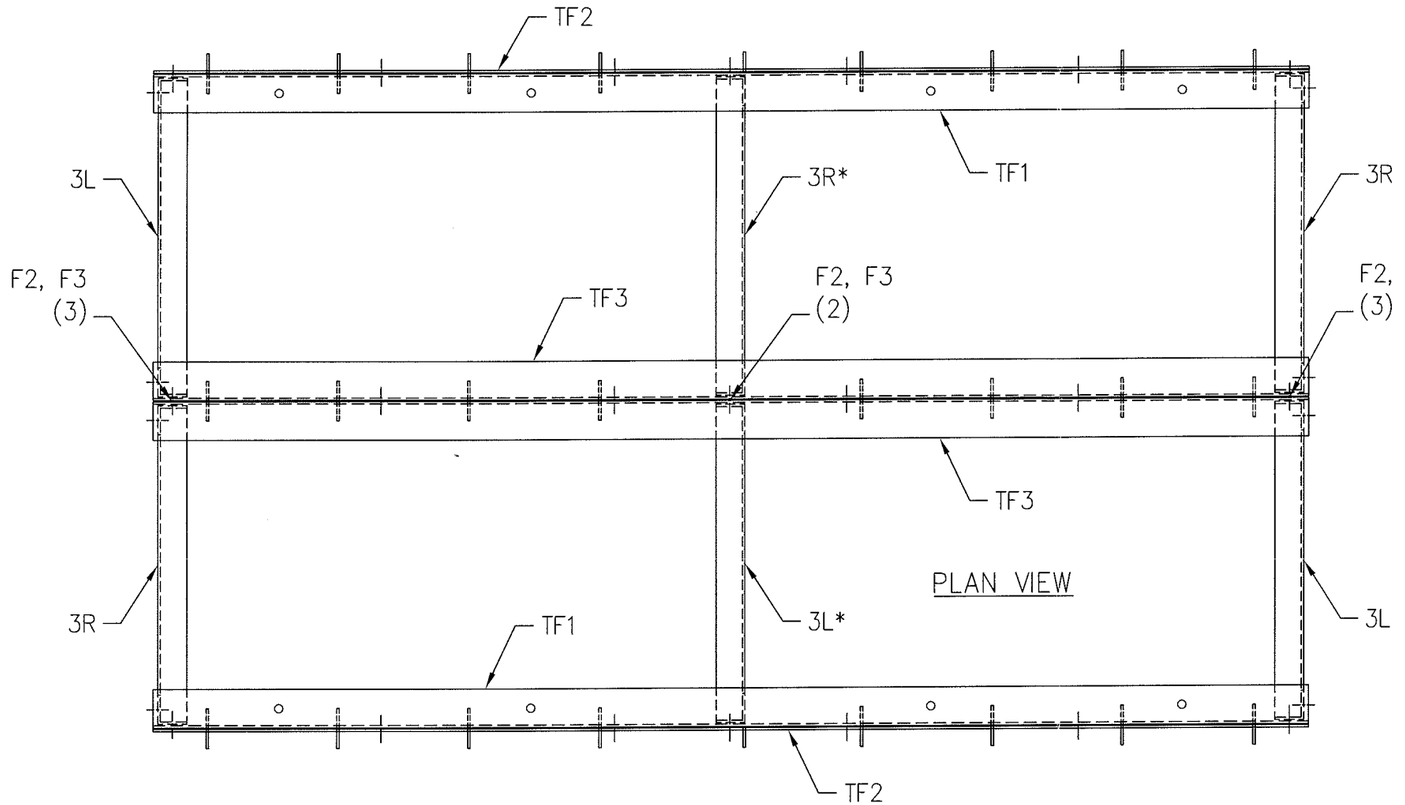
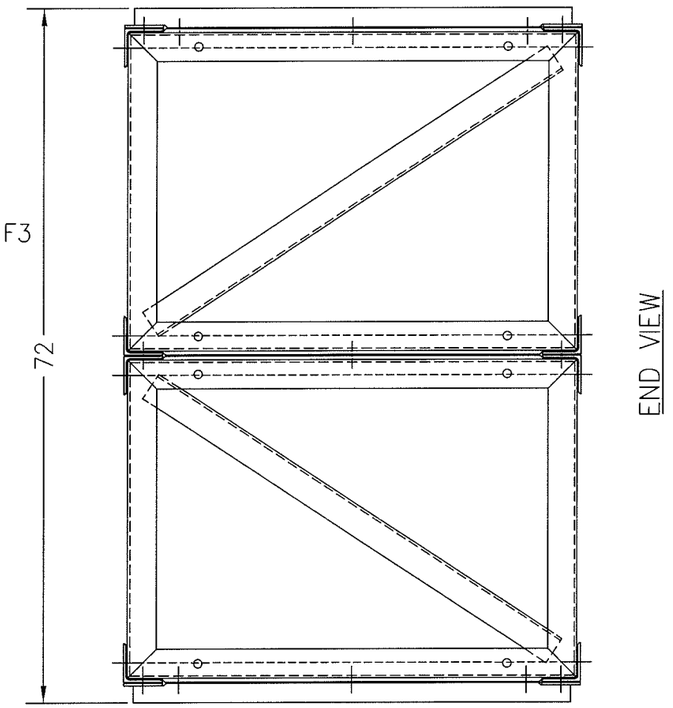
CONCRETE TECHNOLOGY CORP.
MANUFACTURERS OF PRESTRESSED CONCRETE
1123 PORT OF TACOMA ROAD
TACOMA, WASHINGTON 98421

BNSF - SKYKOMISH GATES
SKYKOMISH, WASHINGTON

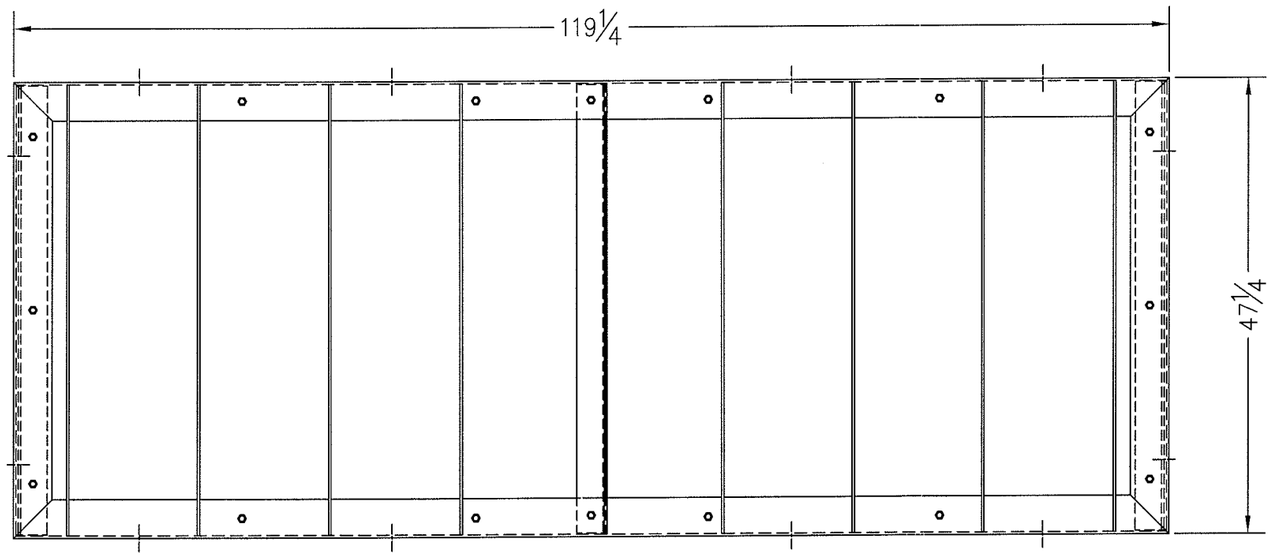
PRODUCTION DRAWING
PRECAST SLAB LID
MARK: S3 QTY. 10 WT. 14.5 KIPS

Date MAY 2008
Sh. No. of
Dwg. No. S3
Job. No. 08042B





END VIEW



ELEV VIEW

WT=1800 LB

USE FASTENER COMBO (F2/F3)
WHERE SHOWN (8) PLACES
USE (F1/F3) AT ALL OTHER
LOCATIONS

MAKE (20) ASSEMBLIES

ITEM NO.	QUANTITY	NAME	SIZE, DESCRIPTION, MATERIAL or SUPPLIER'S PART NUMBER
F3	48	NUT	1/2 NC SS HEX NUT
F2	8	BOLT	1/2 NC X 2.00 SS HEX BOLT
F1	40	BOLT	1/2 NC X 1.50 SS HEX BOLT
3R*	1	MID FRAME BRACE	SEE DETAIL DRAWING MF0508-31
3L*	1	MID FRAME BRACE	SEE DETAIL DRAWING MF0508-31
3R	2	FRAME SIDE	SEE DETAIL DRAWING MF0508-30
3L	2	FRAME SIDE	SEE DETAIL DRAWING MF0508-30
TF3	2	FRAME SUB-ASM	SEE DETAIL DRAWING MF0508-23
TF2	2	FRAME SUB-ASM	SEE DETAIL DRAWING MF0508-22
TF1	2	FRAME SUB-ASM	SEE DETAIL DRAWING MF0508-21

DATE	BY	REV	COMMENTS	DATE	BY

MACHINE & FABRICATION INDUSTRIES, INC.
7032 S. 196TH ST
KENT, WA 98032

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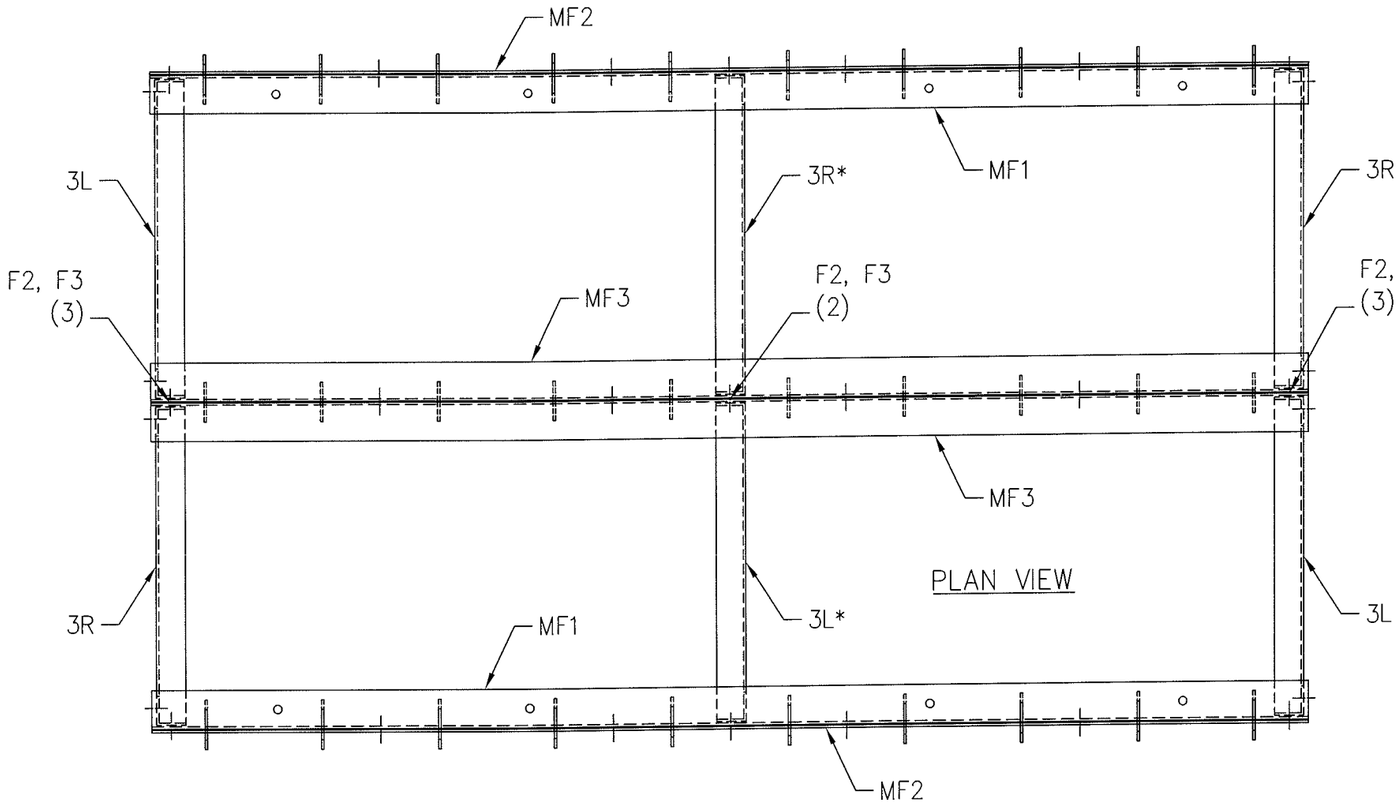
SCALE: DO NOT SCALE

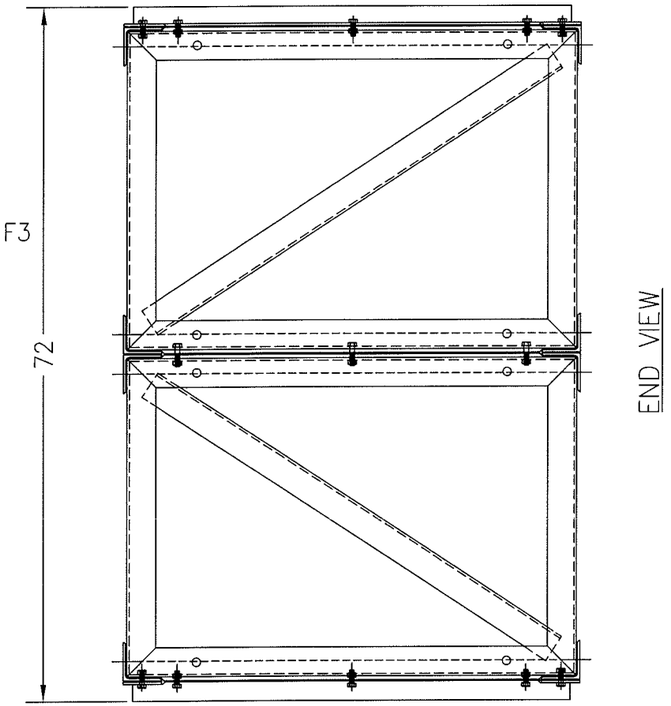
DRAWN	JMK	DATE	6/4/08
CHECKED	.	DATE	XX/XX/XX
APPROVED	.	DATE	XX/XX/XX

SUBTITLE: SKYKOMISH FILTRATION
FRAME – TOP ASM

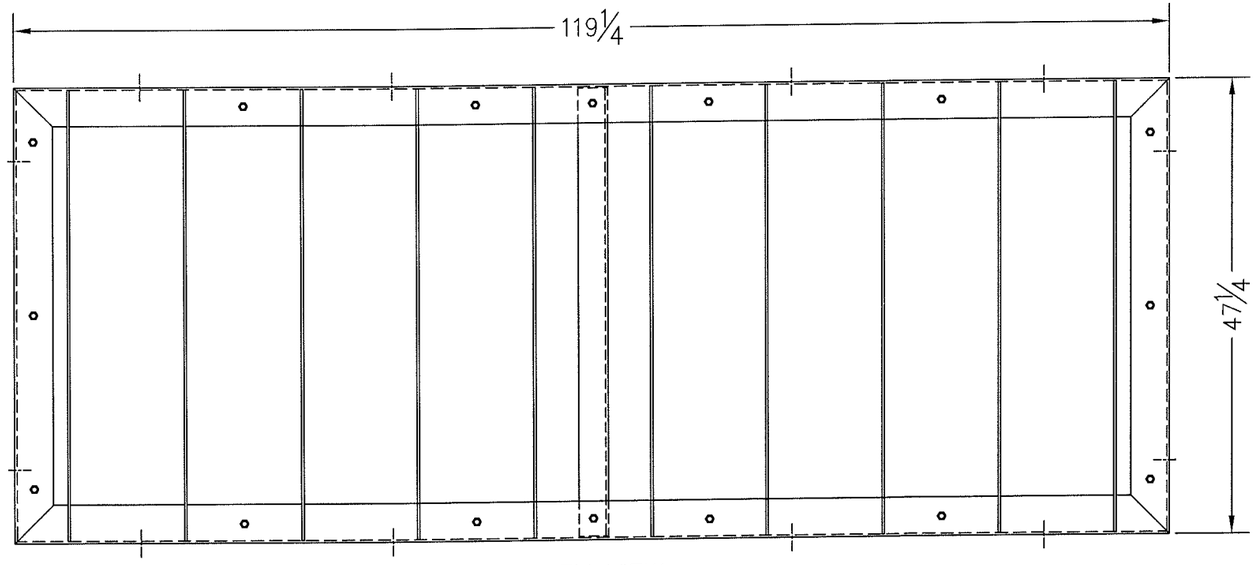
TITLE: BNSF

SHEET
DRAWING NO: MF0508-11
REV:
PLOT INFO:
BORDER SCALE: 1=16





END VIEW



ELEV VIEW

WT=1850 LB

USE FASTENER COMBO (F2/F3)
WHERE SHOWN (8) PLACES
USE (F1/F3) AT ALL OTHER
LOCATIONS

MAKE (20) ASSEMBLIES

ITEM NO.	QUANTITY	NAME	SIZE, DESCRIPTION, MATERIAL or SUPPLIER'S PART NUMBER
F3	48	NUT	1/2 NC SS HEX NUT
F2	8	BOLT	1/2 NC X 2.00 SS HEX BOLT
F1	40	BOLT	1/2 NC X 1.50 SS HEX BOLT
3R*	1	MID FRAME BRACE	SEE DETAIL DRAWING MF0508-31
3L*	1	MID FRAME BRACE	SEE DETAIL DRAWING MF0508-31
3R	2	FRAME SIDE	SEE DETAIL DRAWING MF0508-30
3L	2	FRAME SIDE	SEE DETAIL DRAWING MF0508-30
MF3	2	FRAME SUB-ASM	SEE DETAIL DRAWING MF0508-26
MF2	2	FRAME SUB-ASM	SEE DETAIL DRAWING MF0508-25
MF1	2	FRAME SUB-ASM	SEE DETAIL DRAWING MF0508-24

DATE	BY	REV	COMMENTS	DATE	BY

MACHINE & FABRICATION INDUSTRIES, INC.
7032 S. 196TH ST
KENT, WA 98032

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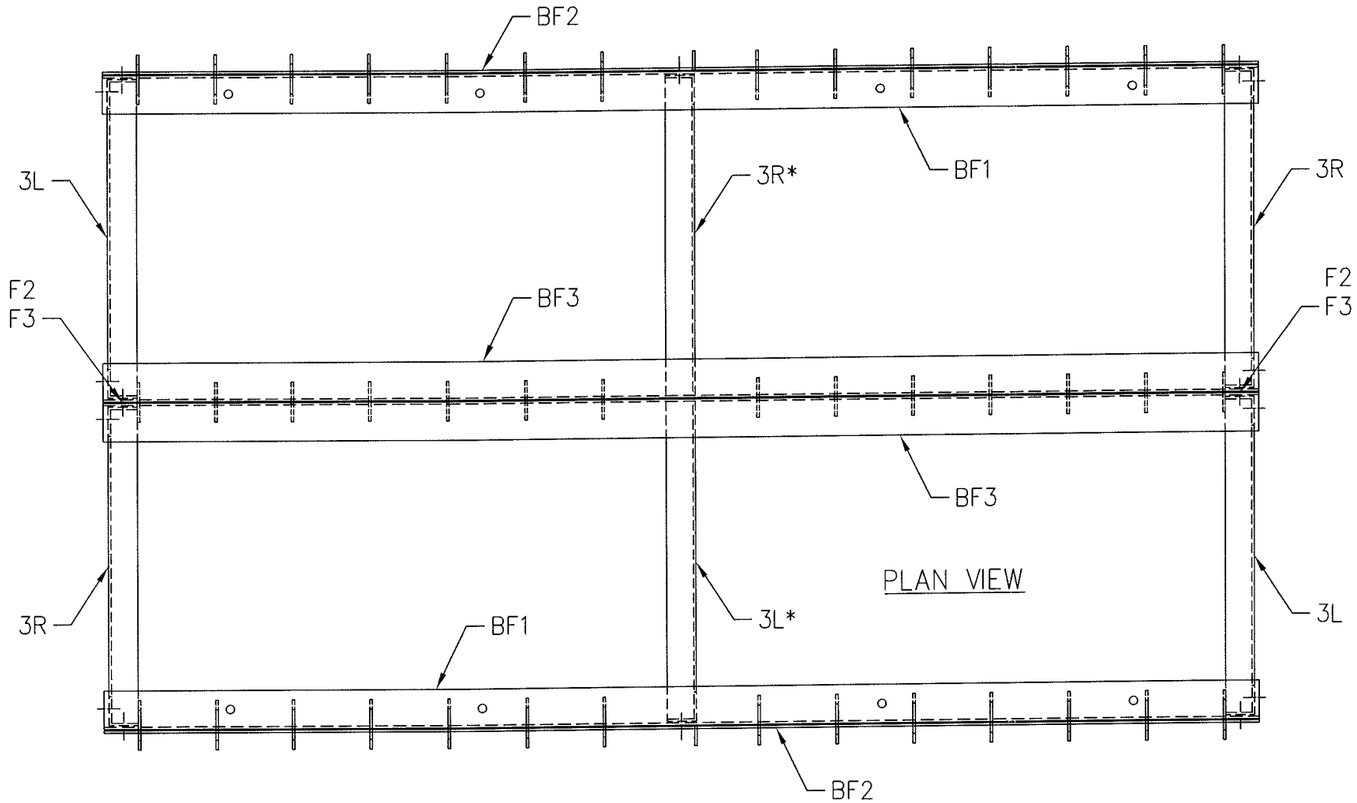
SCALE: DO NOT SCALE

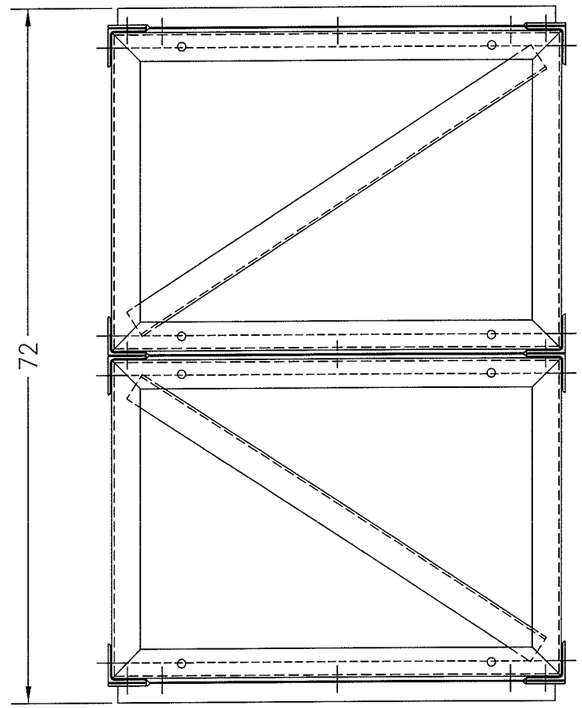
DRAWN	JMK	DATE	6/4/08
CHECKED	.	DATE	XX/XX/XX
APPROVED	.	DATE	XX/XX/XX

SUBTITLE: SKYKOMISH FILTRATION
FRAME -MID ASM

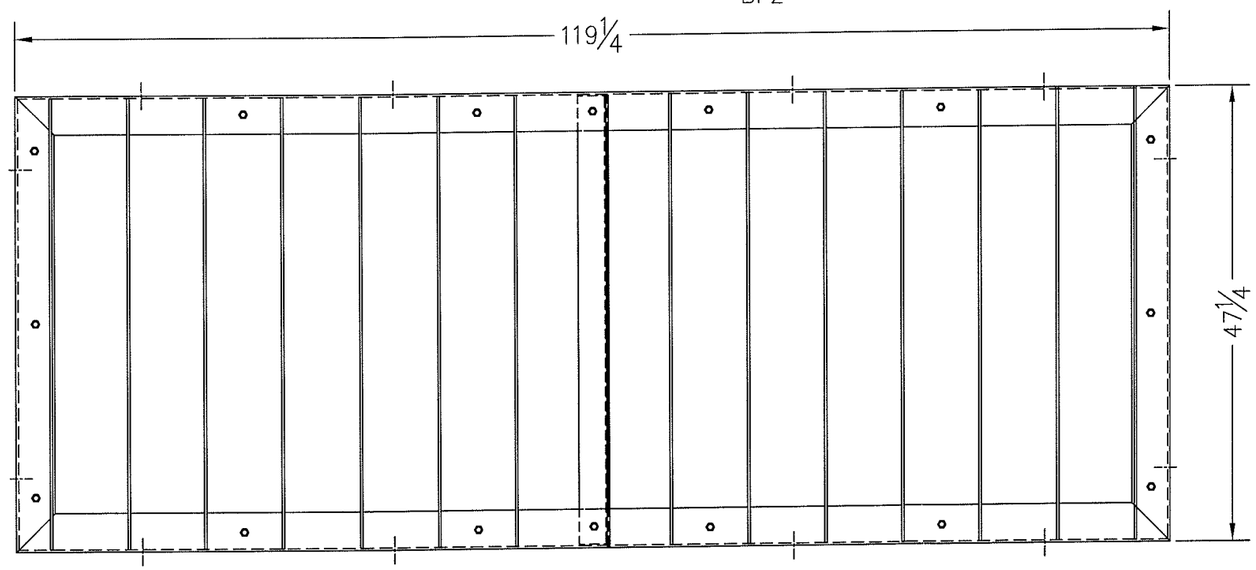
TITLE: BNSF

SHEET
DRAWING NO: MF0508-12
REV:
PLOT INFO:
BORDER SCALE: 1=16





END VIEW



ELEV VIEW

WT=2025 LB

USE FASTENER COMBO (F2/F3)
WHERE SHOWN (8) PLACES
USE (F1/F3) AT ALL OTHER
LOCATIONS

MAKE (20) ASSEMBLIES

ITEM NO.	QUANTITY	NAME	SIZE, DESCRIPTION, MATERIAL or SUPPLIER'S PART NUMBER
F3	48	NUT	1/2 NC SS HEX NUT
F2	8	BOLT	1/2 NC X 2.00 SS HEX BOLT
F1	40	BOLT	1/2 NC X 1.50 SS HEX BOLT
3R*	1	MID FRAME BRACE	SEE DETAIL DRAWING MF0508-31
3L*	1	MID FRAME BRACE	SEE DETAIL DRAWING MF0508-31
3R	2	FRAME SIDE	SEE DETAIL DRAWING MF0508-30
3L	2	FRAME SIDE	SEE DETAIL DRAWING MF0508-30
BF3	2	FRAME SUB-ASM	SEE DETAIL DRAWING MF0508-29
BF2	2	FRAME SUB-ASM	SEE DETAIL DRAWING MF0508-28
BF1	2	FRAME SUB-ASM	SEE DETAIL DRAWING MF0508-27

DATE	BY	REV	COMMENTS	DATE	BY

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KENT, WA 98032

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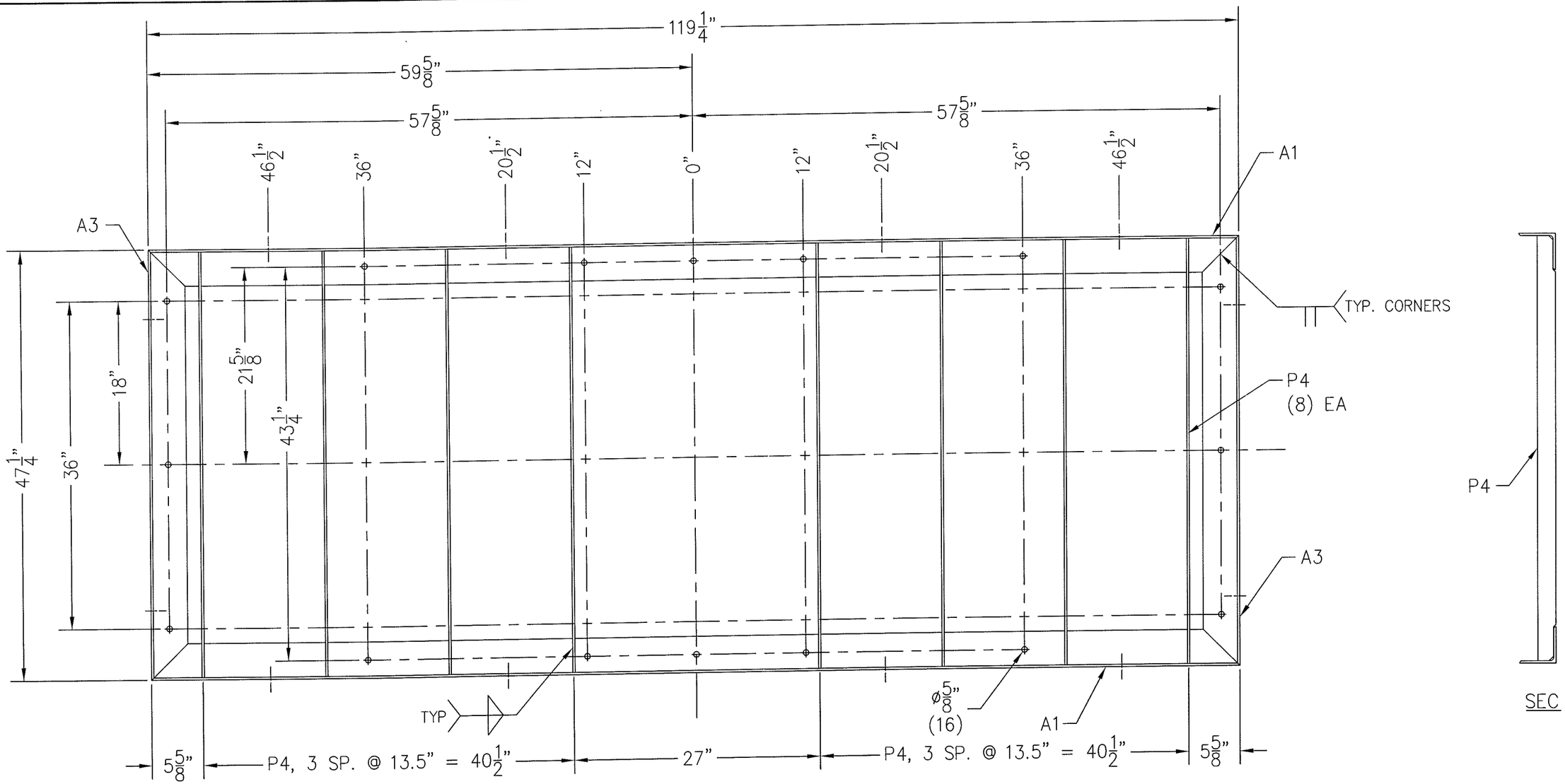
SCALE: DO NOT SCALE

DRAWN	JMK	DATE	6/4/08
CHECKED	.	DATE	XX/XX/XX
APPROVED	.	DATE	XX/XX/XX

SUBTITLE: SKYKOMISH FILTRATION
FRAME – BOTTOM ASM

TITLE: BNSF

SHEET
DRAWING NO: MF0508-13
REV:
PLOT INFO:
BORDER SCALE: 1=16



TYPE 1 FRAME SIDE – TOP
MAKE 40

TF1

SAND BLAST AND EPOXY PAINT PER SPECIFICATION

ITEM NO.	QUANTITY	NAME	SIZE, DESCRIPTION, MATERIAL or SUPPLIER'S PART NUMBER
P4	8	PLATE	PL 1/4 X 2 X 46.75 (SEE DETAIL)
A3	2	ANGLE	PL 1/4 X 4 X 47.25 (SEE DETAIL)
A1	2	ANGLE	PL 1/4 X 4 X 119.25 (SEE DETAIL)

REV	COMMENTS	DATE	BY	REV	COMMENTS	DATE	BY

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KENT, WA 98032

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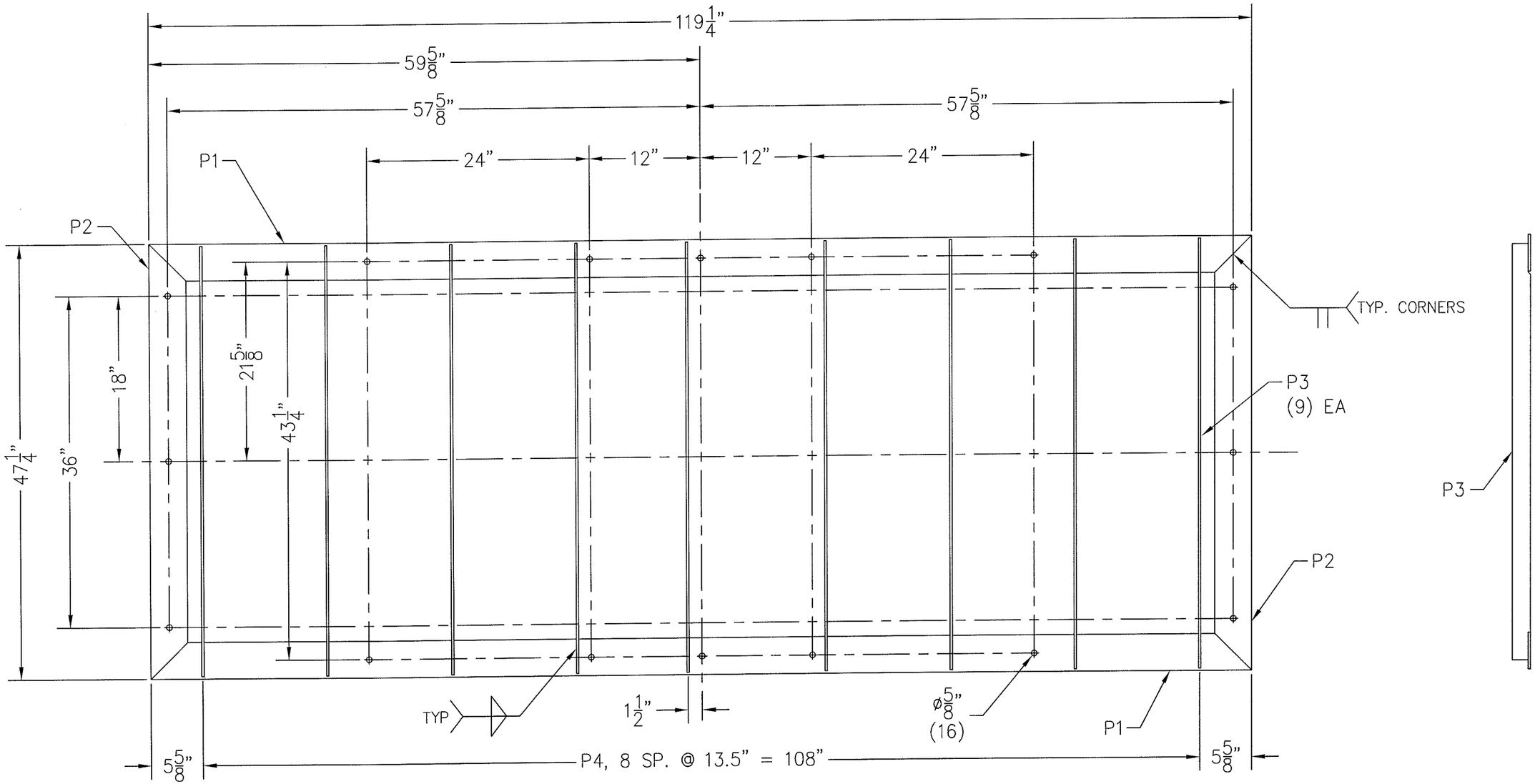
SCALE: DO NOT SCALE			
DRAWN	JMK	DATE	6/4/08
CHECKED	.	DATE	XX/XX/XX
APPROVED	.	DATE	XX/XX/XX

SUBTITLE: SKYKOMISH FILTRATION
FRAME TYPE 1 – TOP

TITLE: BNSF

SHEET
DRAWING NO: MF0508-21
REV:
PLOT INFO:
BORDER SCALE: 1=12



TYPE 2 (EDGE) FRAME SIDE – TOP
MAKE 40

TF2

SAND BLAST AND EPOXY PAINT PER SPECIFICATION

ITEM NO.	QUANTITY	NAME	SIZE, DESCRIPTION, MATERIAL or SUPPLIER'S PART NUMBER
P3	9	PLATE	PL 1/4 X 2 X 45.25 (SEE DETAIL)
P2	2	PLATE	PL 1/4 X 4 X 47.25 (SEE DETAIL)
P1	2	PLATE	PL 1/4 X 4 X 119.25 (SEE DETAIL)

REV	COMMENTS	DATE	BY	REV	COMMENTS	DATE	BY

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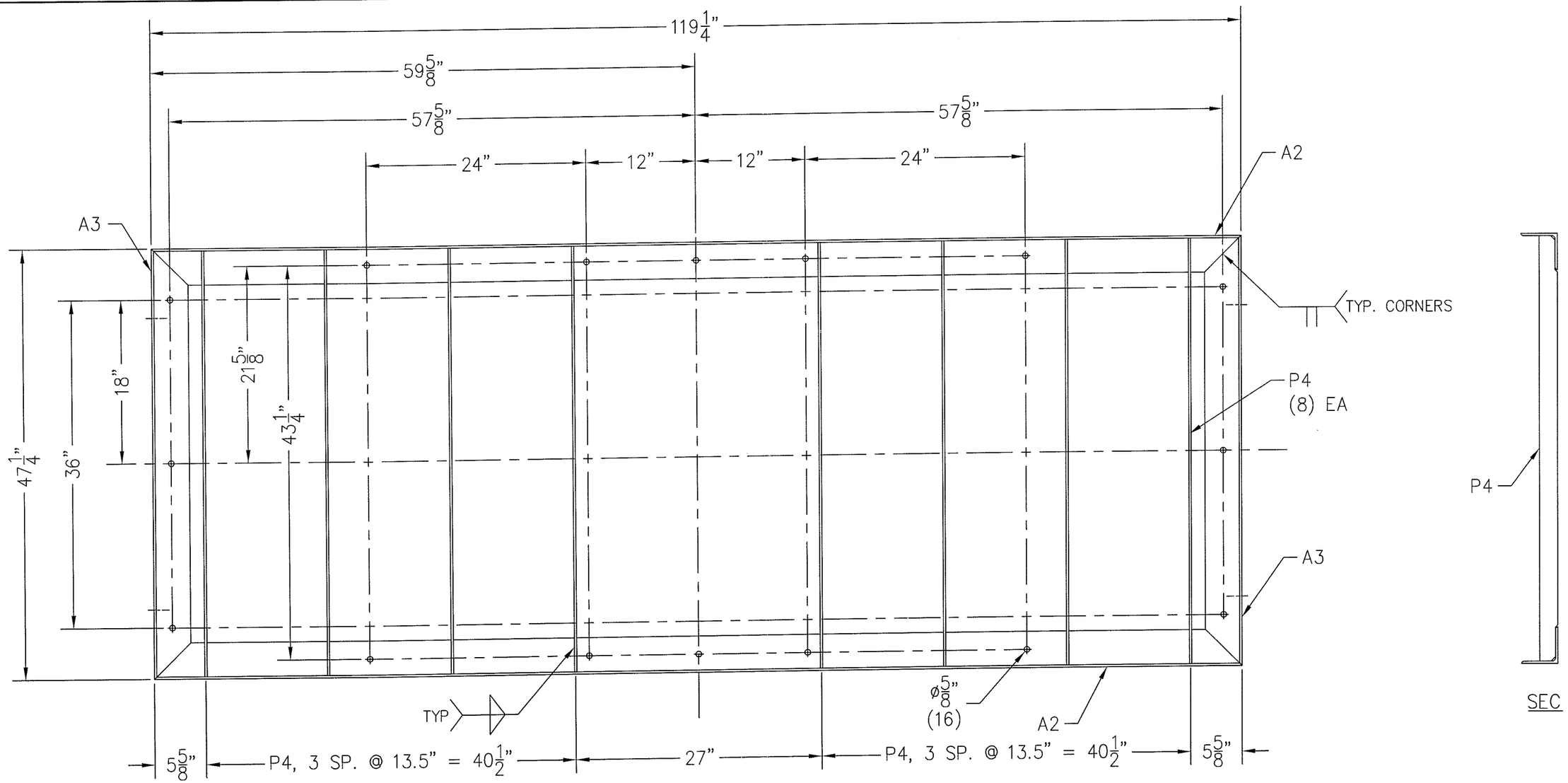
SCALE: DO NOT SCALE

DRAWN	JMK	DATE	6/4/08
CHECKED	.	DATE	XX/XX/XX
APPROVED	.	DATE	XX/XX/XX

SUBTITLE: SKYKOMISH FILTRATION
FRAME TYPE 2 – TOP

TITLE: BNSF

SHEET
DRAWING NO: MF0508-22
REV:
PLOT INFO:
BORDER SCALE: 1=12



TYPE 3 FRAME SIDE – TOP
MAKE 40

TF3

SAND BLAST AND EPOXY PAINT PER SPECIFICATION

ITEM NO.	QUANTITY	NAME	SIZE, DESCRIPTION, MATERIAL or SUPPLIER'S PART NUMBER
P4	8	PLATE	PL 1/4 X 2 X 46.75 (SEE DETAIL)
A3	2	ANGLE	PL 1/4 X 4 X 47.25 (SEE DETAIL)
A2	2	ANGLE	PL 1/4 X 4 X 119.25 (SEE DETAIL)

REV	COMMENTS	DATE	BY	REV	COMMENTS	DATE	BY

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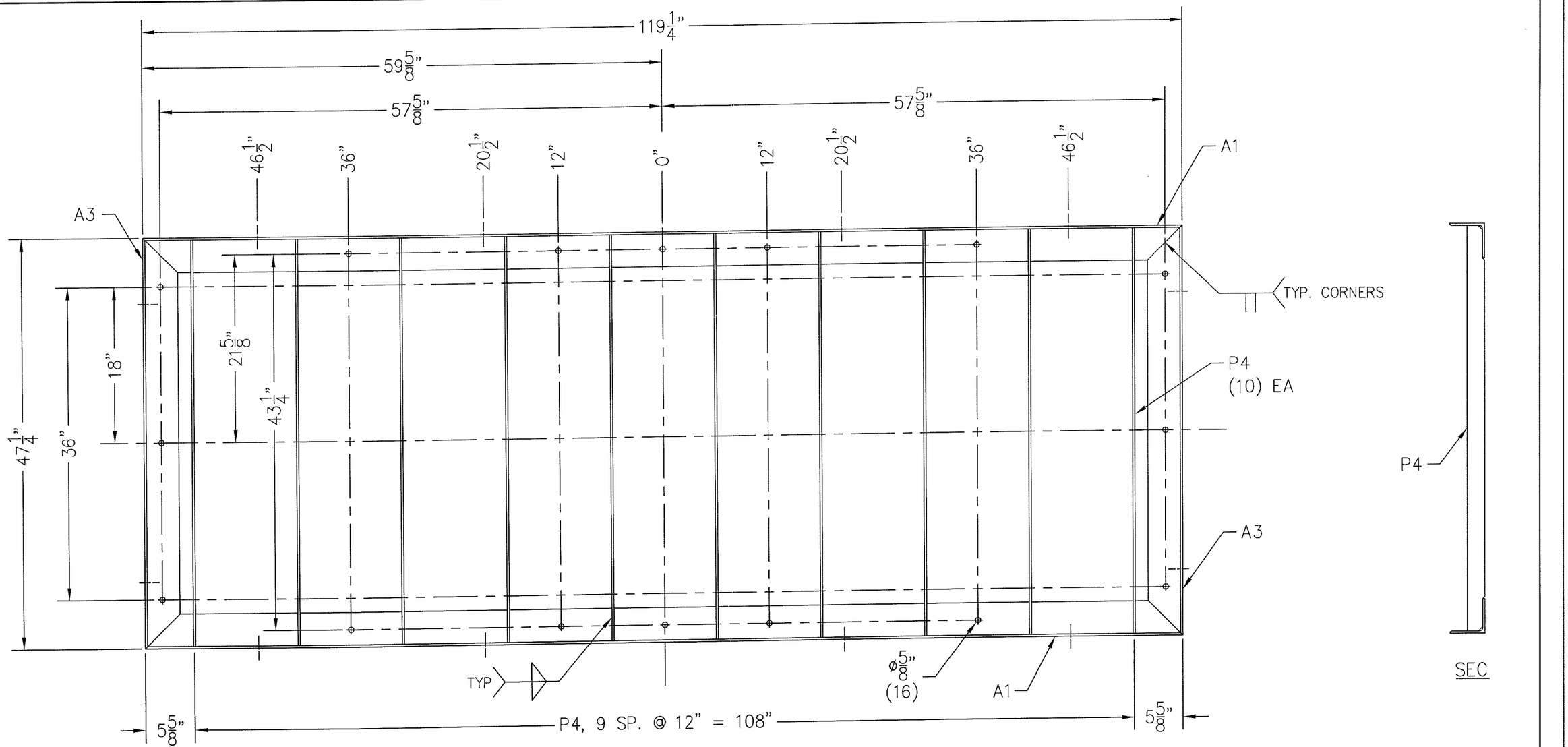
SCALE: DO NOT SCALE

DRAWN	JMK	DATE	6/4/08
CHECKED	.	DATE	XX/XX/XX
APPROVED	.	DATE	XX/XX/XX

SUBTITLE: SKYKOMISH FILTRATION
FRAME TYPE 3 – TOP

TITLE: BNSF

SHEET
DRAWING NO: MF0508-23
REV:
PLOT INFO:
BORDER SCALE: 1=12



TYPE 1 FRAME SIDE – MIDDLE
MAKE 40

MF1

SAND BLAST AND EPOXY PAINT PER SPECIFICATION

ITEM NO.	QUANTITY	NAME	SIZE, DESCRIPTION, MATERIAL or SUPPLIER'S PART NUMBER
P4	10	PLATE	PL 1/4 X 2 X 46.75 (SEE DETAIL)
A3	2	ANGLE	PL 1/4 X 4 X 47.25 (SEE DETAIL)
A1	2	ANGLE	PL 1/4 X 4 X 119.25 (SEE DETAIL)

REV	COMMENTS	DATE	BY	REV	COMMENTS	DATE	BY

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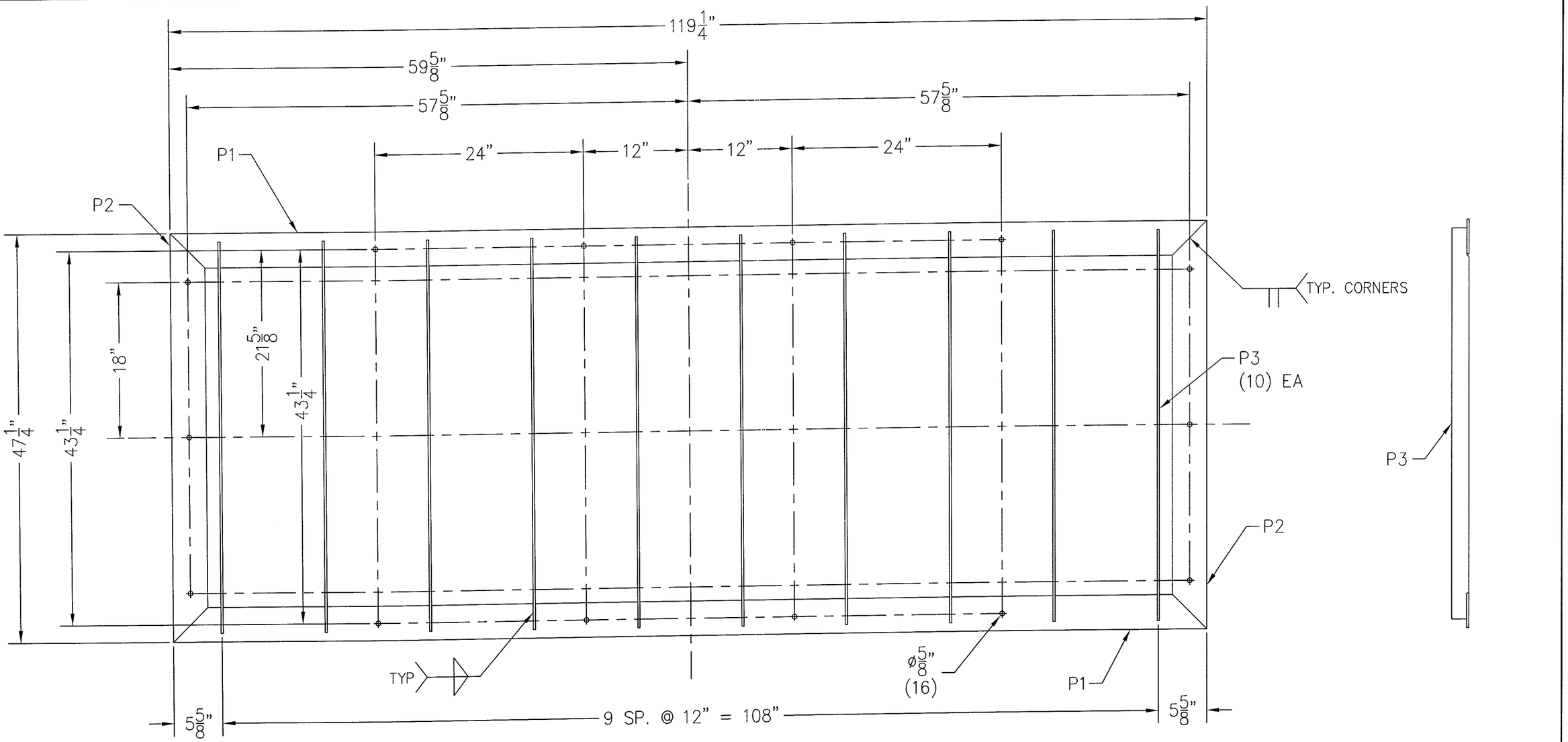
SCALE: DO NOT SCALE

DRAWN	JMK	DATE	6/4/08
CHECKED	.	DATE	XX/XX/XX
APPROVED	.	DATE	XX/XX/XX

SUBTITLE: SKYKOMISH FILTRATION
FRAME TYPE 1 – MIDDLE

TITLE: BNSF

SHEET
DRAWING NO: MF0508-24
REV:
PLOT INFO: BORDER SCALE: 1=12



TYPE 2 (EDGE) FRAME SIDE – MIDDLE
MAKE 40

MF2

SAND BLAST AND EPOXY PAINT PER SPECIFICATION

ITEM NO.	QUANTITY	NAME	SIZE, DESCRIPTION, MATERIAL or SUPPLIER'S PART NUMBER
P3	10	PLATE	PL 1/4 X 2 X 45.25 (SEE DETAIL)
P2	2	PLATE	PL 1/4 X 4 X 47.25 (SEE DETAIL)
P1	2	PLATE	PL 1/4 X 4 X 119.25 (SEE DETAIL)

REV	COMMENTS	DATE	BY

REV	COMMENTS	DATE	BY

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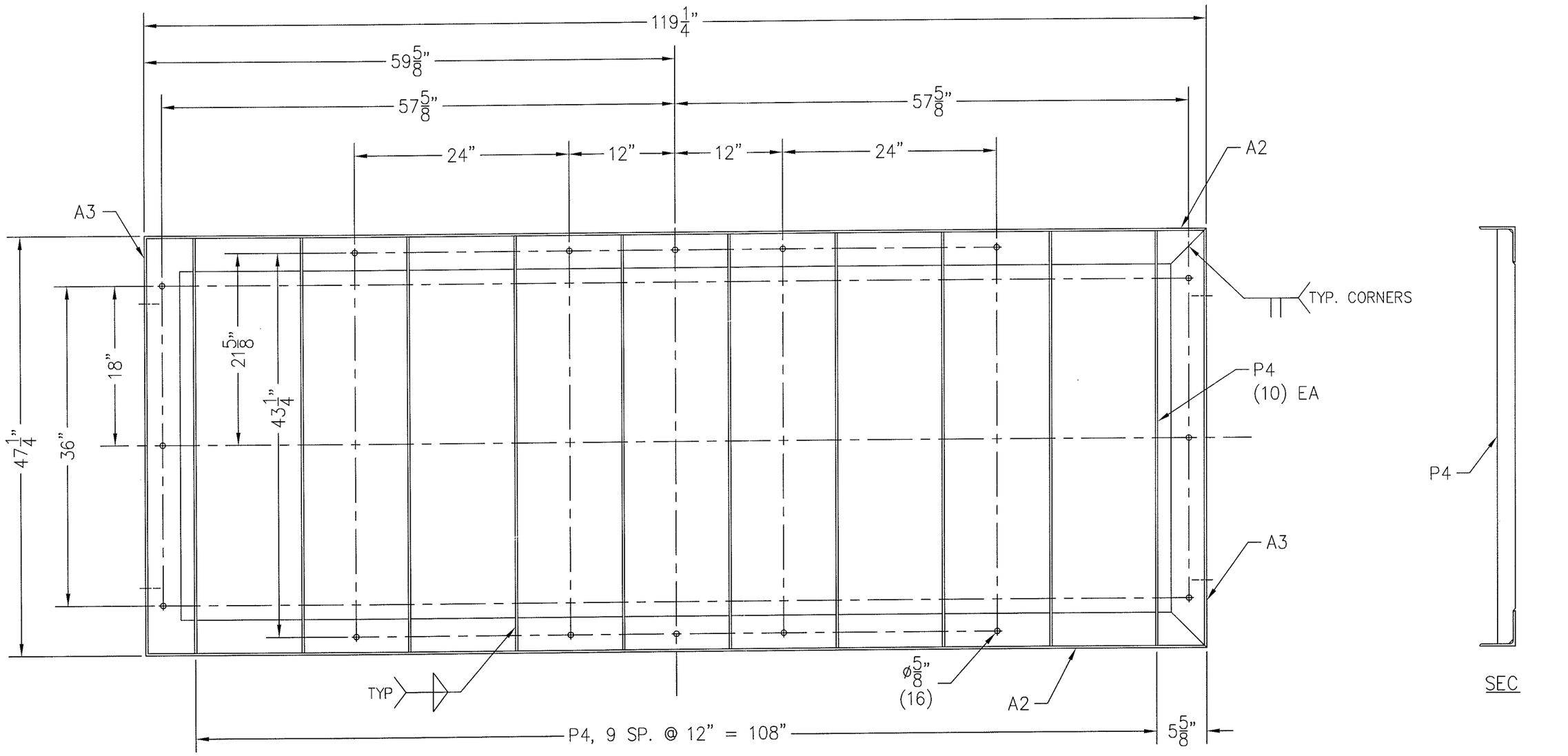
SCALE: DO NOT SCALE

DRAWN	JMK	DATE	6/4/08
CHECKED	.	DATE	XX/XX/XX
APPROVED	.	DATE	XX/XX/XX

SUBTITLE: SKYKOMISH FILTRATION
FRAME TYPE 2 – MIDDLE

TITLE: BNSF

SHEET
DRAWING NO: MF0508-25
REV:
PLOT INFO:
BORDER SCALE: 1=12



TYPE 3 FRAME SIDE – MIDDLE
MAKE 40

MF3

SAND BLAST AND EPOXY PAINT PER SPECIFICATION

ITEM NO.	QUANTITY	NAME	SIZE, DESCRIPTION, MATERIAL or SUPPLIER'S PART NUMBER
P4	10	PLATE	PL 1/4 X 2 X 46.75 (SEE DETAIL)
A3	2	ANGLE	PL 1/4 X 4 X 47.25 (SEE DETAIL)
A2	2	ANGLE	PL 1/4 X 4 X 119.25 (SEE DETAIL)

COMMENTS	DATE	BY

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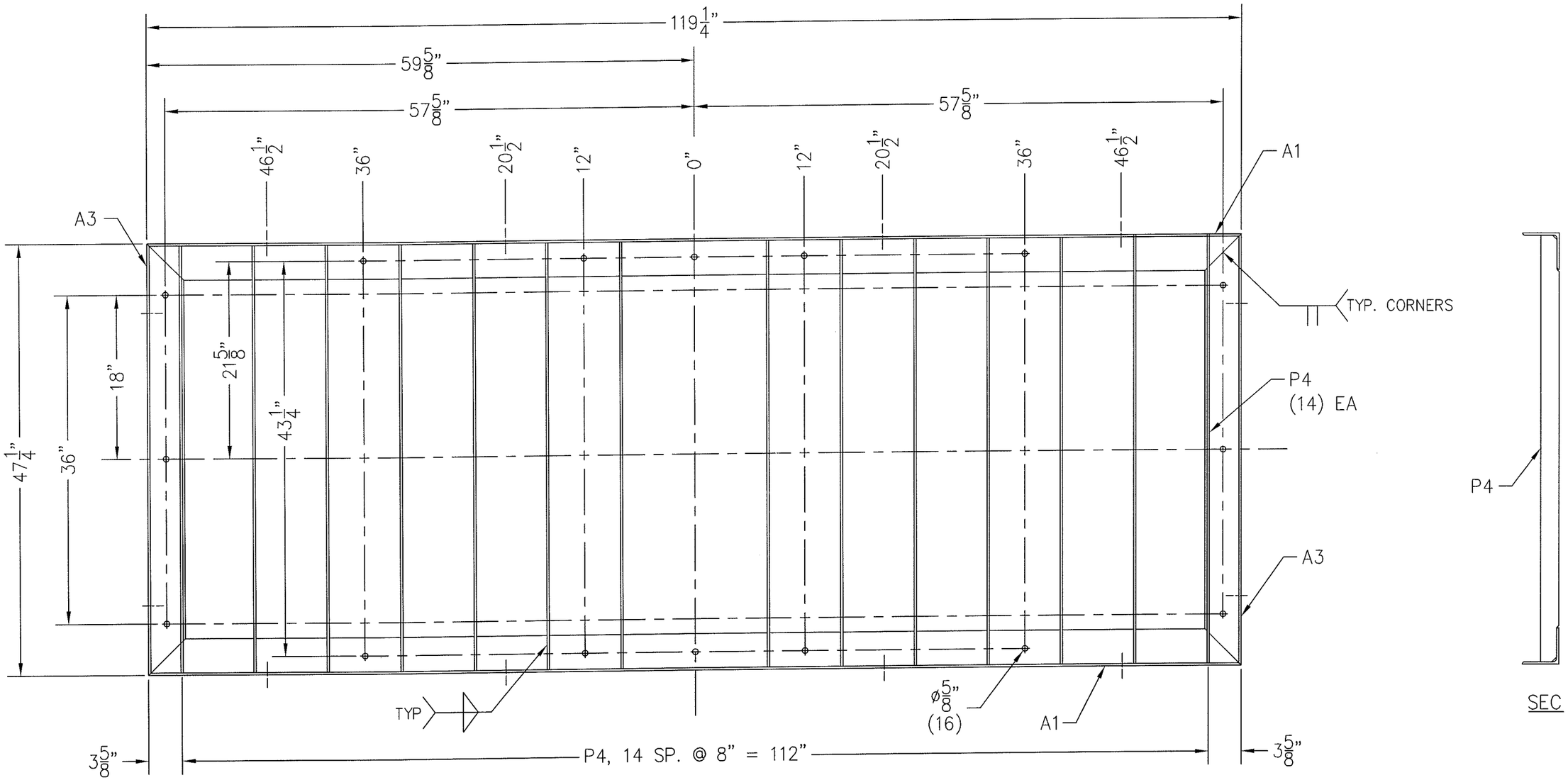
SCALE: DO NOT SCALE

DRAWN	JMK	DATE	6/4/08
CHECKED	.	DATE	XX/XX/XX
APPROVED	.	DATE	XX/XX/XX

SUBTITLE: SKYKOMISH FILTRATION
FRAME TYPE 3 – MIDDLE

TITLE: BNSF

SHEET
DRAWING NO: MF0508-26
REV:
PLOT INFO:
BORDER SCALE: 1=12



TYPE 1 FRAME SIDE – BOTTOM
MAKE 40

BF1

SAND BLAST AND EPOXY PAINT PER SPECIFICATION

ITEM NO.	QUANTITY	NAME	SIZE, DESCRIPTION, MATERIAL or SUPPLIER'S PART NUMBER
P4	14	PLATE	PL 1/4 X 2 X 46.75 (SEE DETAIL)
A3	2	ANGLE	PL 1/4 X 4 X 47.25 (SEE DETAIL)
A1	2	ANGLE	PL 1/4 X 4 X 119.25 (SEE DETAIL)

REV	COMMENTS	DATE	BY	REV	COMMENTS	DATE	BY

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KENT, WA 98032

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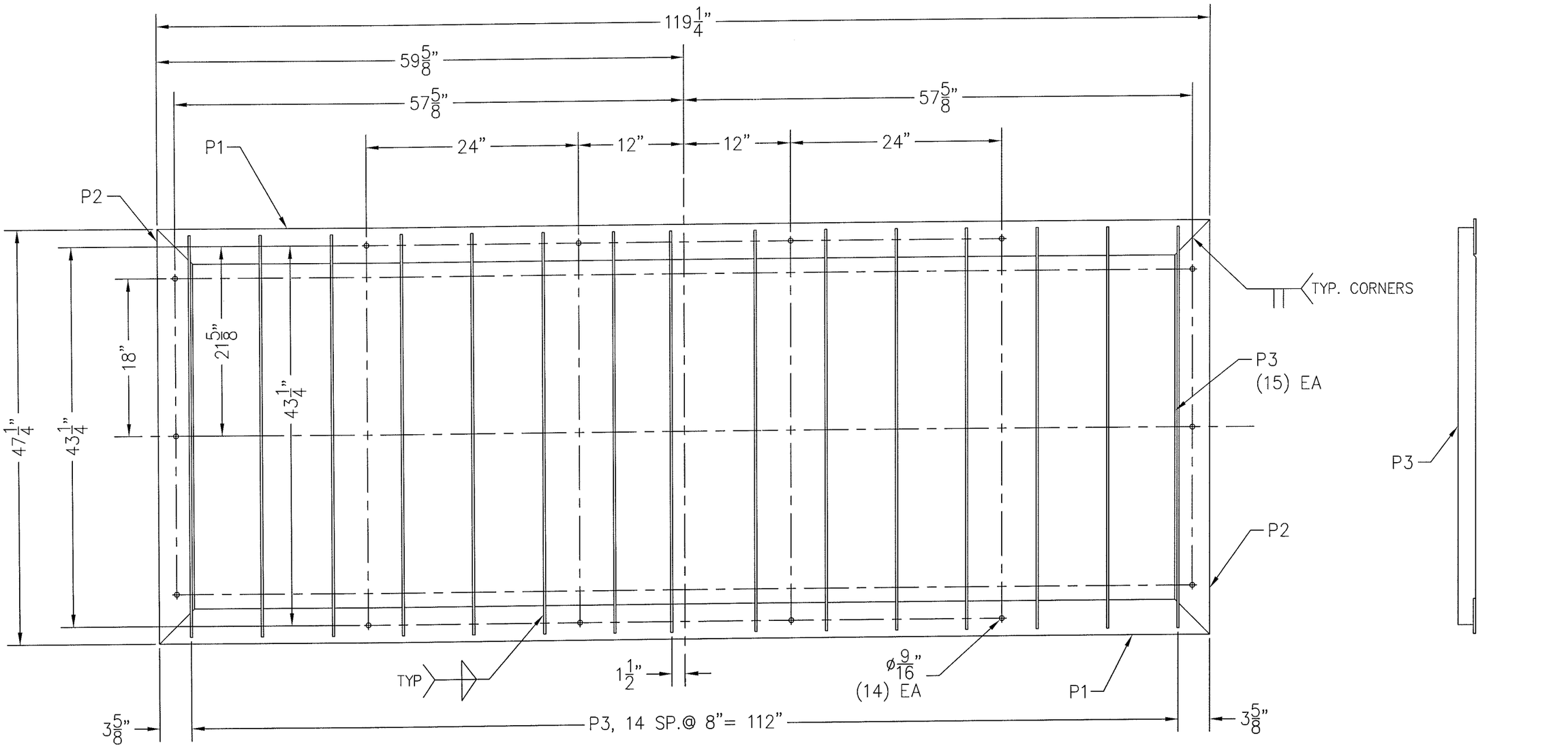
SCALE: DO NOT SCALE

DRAWN	JMK	DATE	6/4/08
CHECKED	.	DATE	XX/XX/XX
APPROVED	.	DATE	XX/XX/XX

SUBTITLE: SKYKOMISH FILTRATION
FRAME TYPE 1 – BOTTOM

TITLE: BNSF

SHEET
DRAWING NO: MF0508-27
REV:
PLOT INFO:
BORDER SCALE: 1=12



TYPE 2 (EDGE) FRAME SIDE – BOTTOM
MAKE 40

BF2

SAND BLAST AND EPOXY PAINT PER SPECIFICATION

ITEM NO.	QUANTITY	NAME	SIZE, DESCRIPTION, MATERIAL or SUPPLIER'S PART NUMBER
P3	15	PLATE	PL 1/4 X 2 X 45.25 (SEE DETAIL)
P2	2	PLATE	PL 1/4 X 4 X 47.25 (SEE DETAIL)
P1	2	PLATE	PL 1/4 X 4 X 119.25 (SEE DETAIL)

REV	COMMENTS	DATE	BY	REV	COMMENTS	DATE	BY

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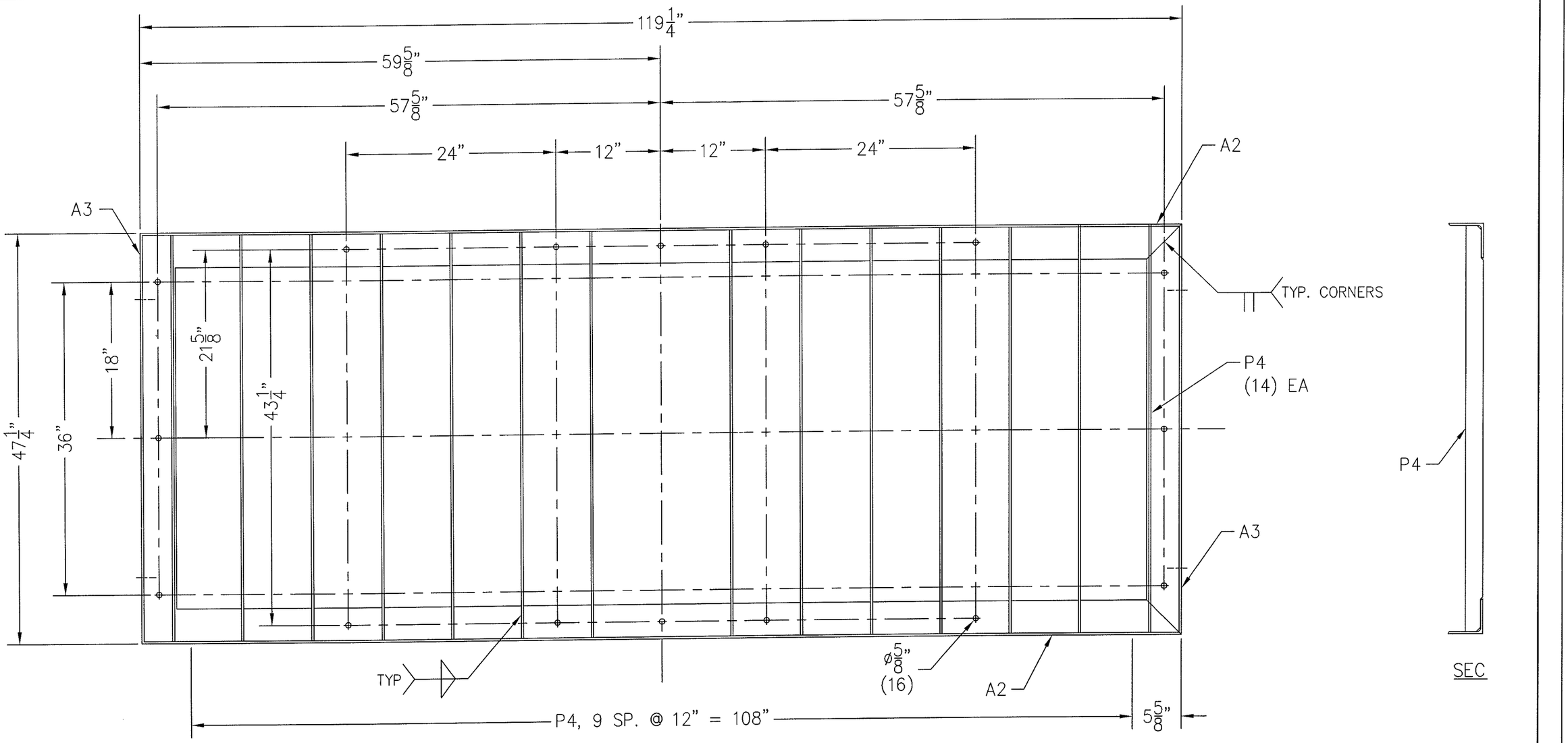
SCALE: DO NOT SCALE

DRAWN	JMK	DATE	6/4/08
CHECKED	.	DATE	XX/XX/XX
APPROVED	.	DATE	XX/XX/XX

SUBTITLE: SKYKOMISH FILTRATION
FRAME TYPE 2 – BOTTOM

TITLE: BNSF

SHEET
DRAWING NO: MF0508-28
REV:
PLOT INFO:
BORDER SCALE: 1=12



TYPE 3 FRAME SIDE – BOTTOM
MAKE 40

BF3

SAND BLAST AND EPOXY PAINT PER SPECIFICATION

ITEM NO.	QUANTITY	NAME	SIZE, DESCRIPTION, MATERIAL or SUPPLIER'S PART NUMBER
P4	14	PLATE	PL 1/4 X 2 X 46.75 (SEE DETAIL)
A3	2	ANGLE	PL 1/4 X 4 X 47.25 (SEE DETAIL)
A2	2	ANGLE	PL 1/4 X 4 X 119.25 (SEE DETAIL)

COMMENTS	DATE	BY

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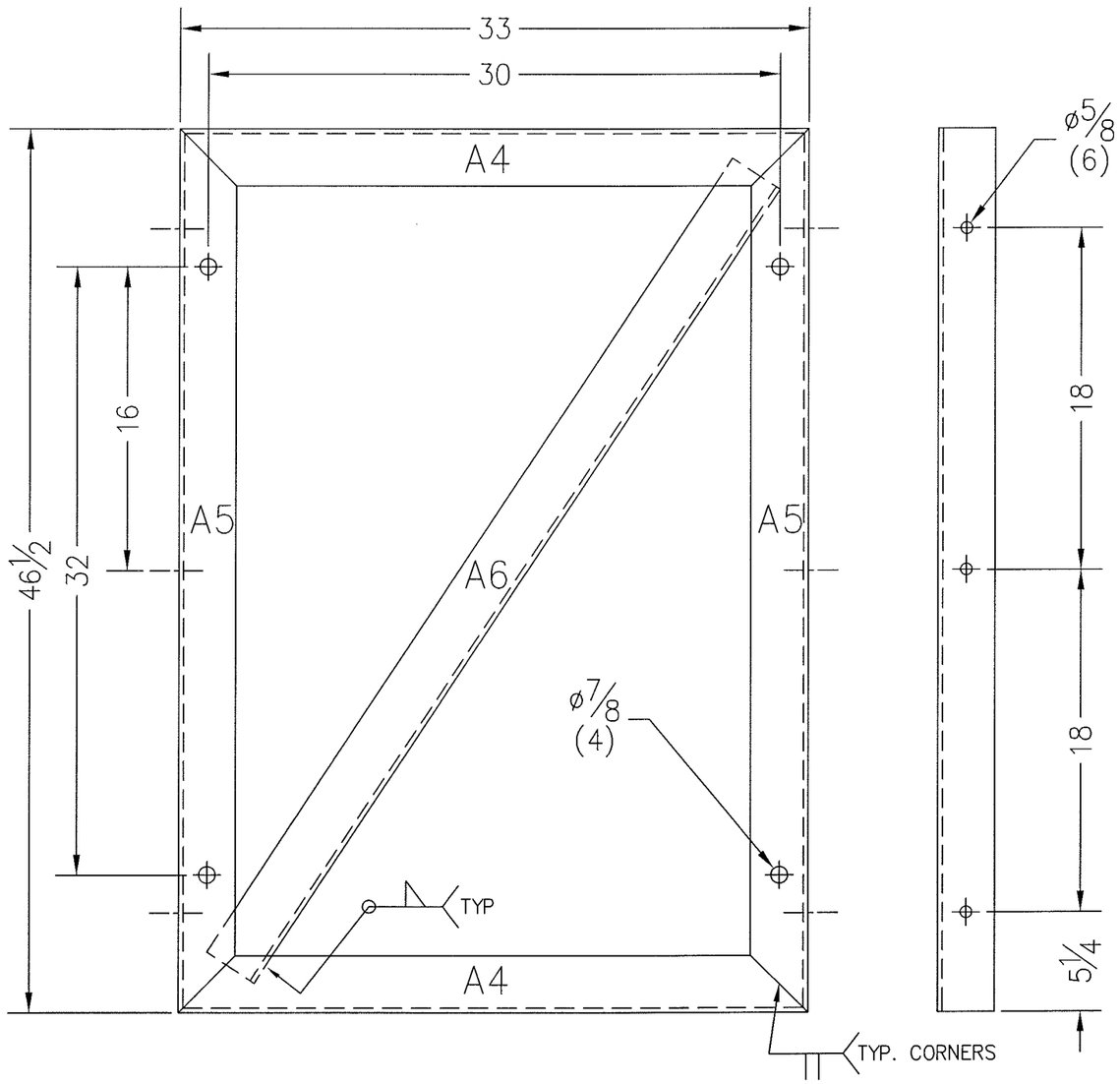
SCALE: DO NOT SCALE

DRAWN	JMK	DATE	6/4/08
CHECKED	.	DATE	XX/XX/XX
APPROVED	.	DATE	XX/XX/XX

SUBTITLE: SKYKOMISH FILTRATION
FRAME TYPE 3 – BOTTOM

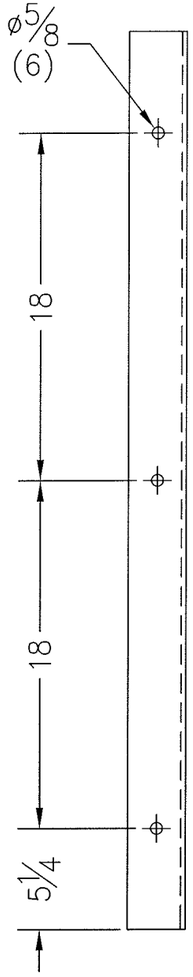
TITLE: BNSF

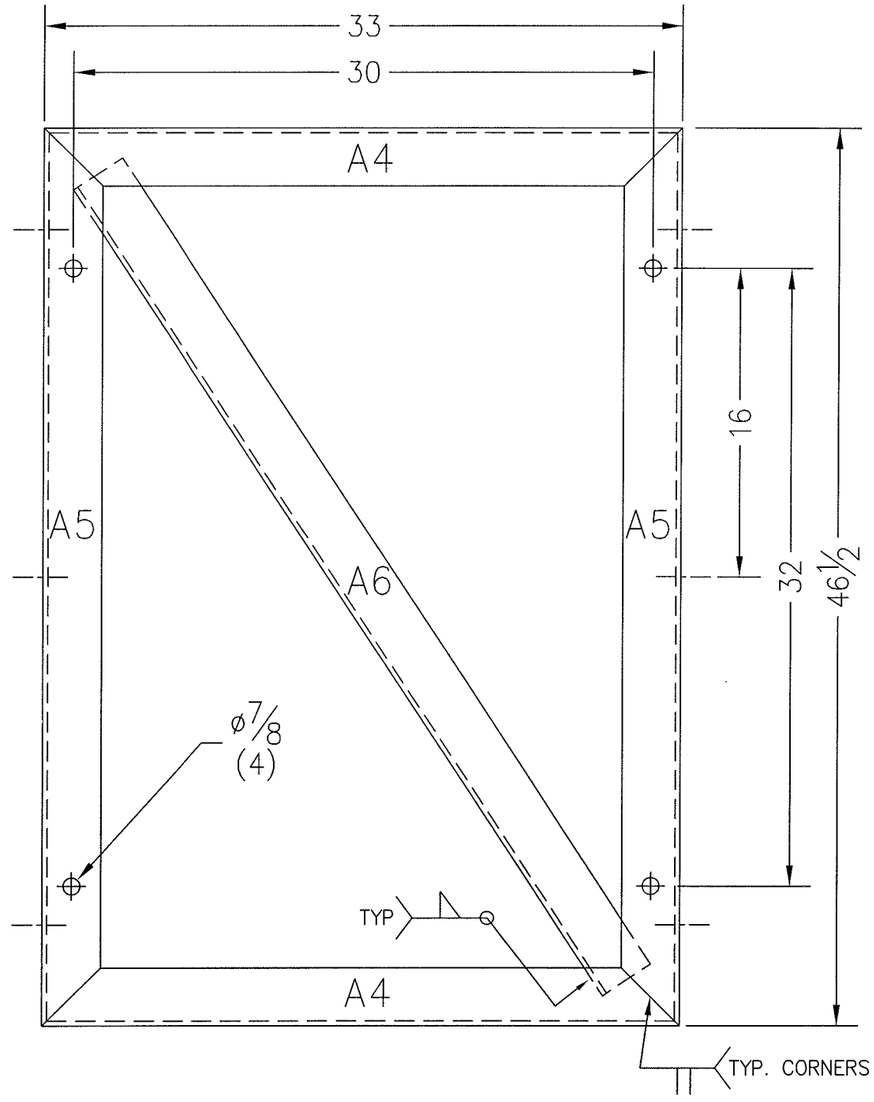
SHEET
DRAWING NO: MF0508-29
REV:
PLOT INFO:
BORDER SCALE: 1=12



FRAME END – TYPE 3L
PROJECT TOTAL = 120

SAND BLAST AND EPOXY PAINT PER SPECIFICATION





FRAME END – TYPE 3R
PROJECT TOTAL = 120

NOTE: DIMS ARE BASED ON 47.25 HIGH
X 72.00 WIDE FRAME ASSEMBLIES

ITEM NO.	QUANTITY	NAME	SIZE, DESCRIPTION, MATERIAL or SUPPLIER'S PART NUMBER
A6	1	ANGLE	L3X3X1/4 X 50.00 (SEE MF0508-45)
A5	2	ANGLE	L3X3X1/4 X 46.50 (SEE MF0508-46)
A4	2	ANGLE	L3X3X1/4 X 33.00 (SEE MF0508-45)

ITEM NO.	QUANTITY	NAME	SIZE, DESCRIPTION, MATERIAL or SUPPLIER'S PART NUMBER
A6	1	ANGLE	L3X3X1/4 X 50.00 (SEE MF0508-45)
A5	2	ANGLE	L3X3X1/4 X 46.50 (SEE MF0508-46)
A4	2	ANGLE	L3X3X1/4 X 33.00 (SEE MF0508-45)

REV	COMMENTS	DATE	BY	REV	COMMENTS	DATE	BY

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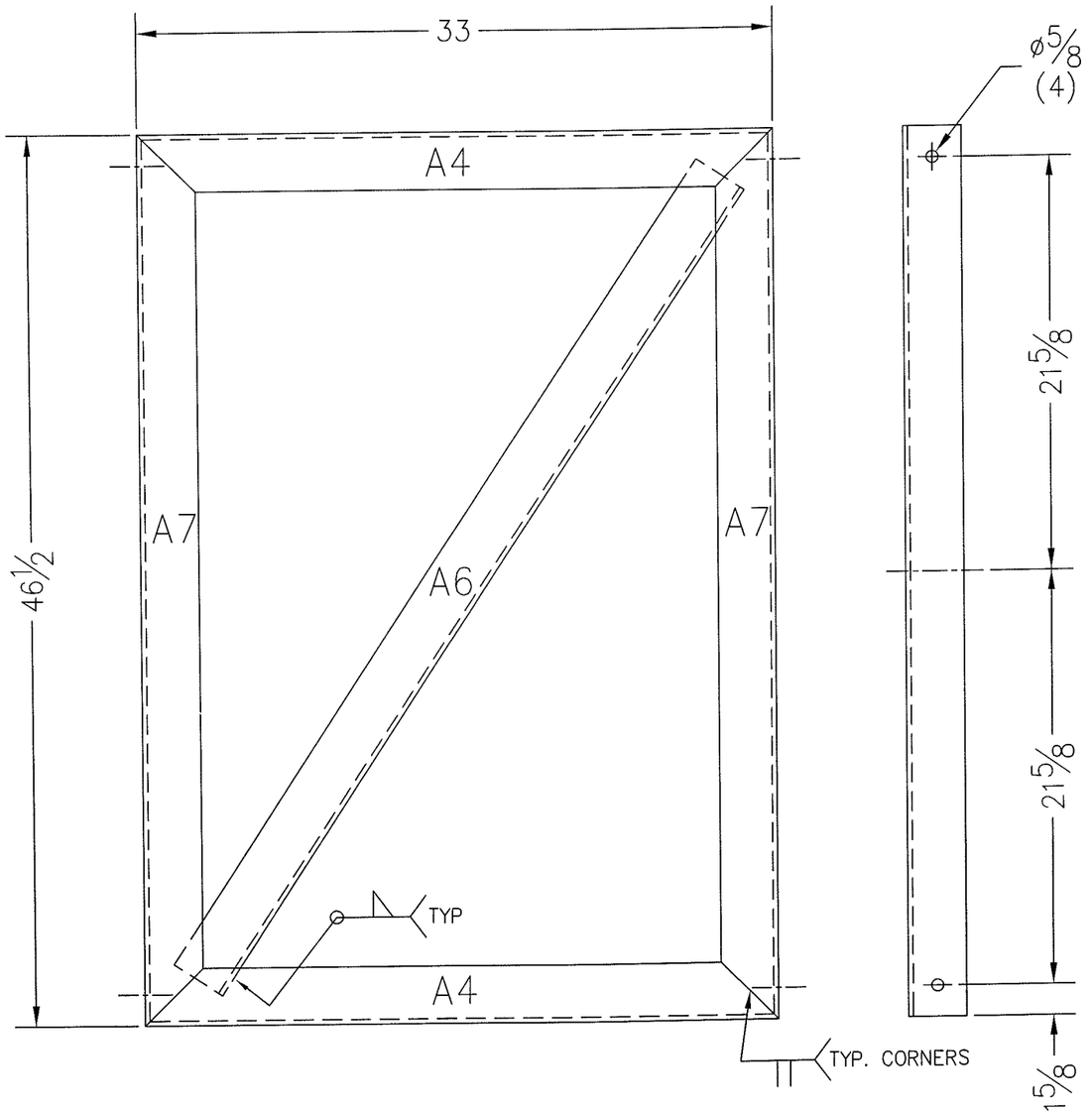
SCALE: DO NOT SCALE

DRAWN	JMK	DATE	6/4/08
CHECKED	.	DATE	XX/XX/XX
APPROVED	.	DATE	XX/XX/XX

SUBTITLE: SKYKOMISH FILTRATION
END FRAMES 3L & 3R

TITLE: BNSF

SHEET
DRAWING NO: MF0508-30
REV:
PLOT INFO:
BORDER SCALE: 1=8

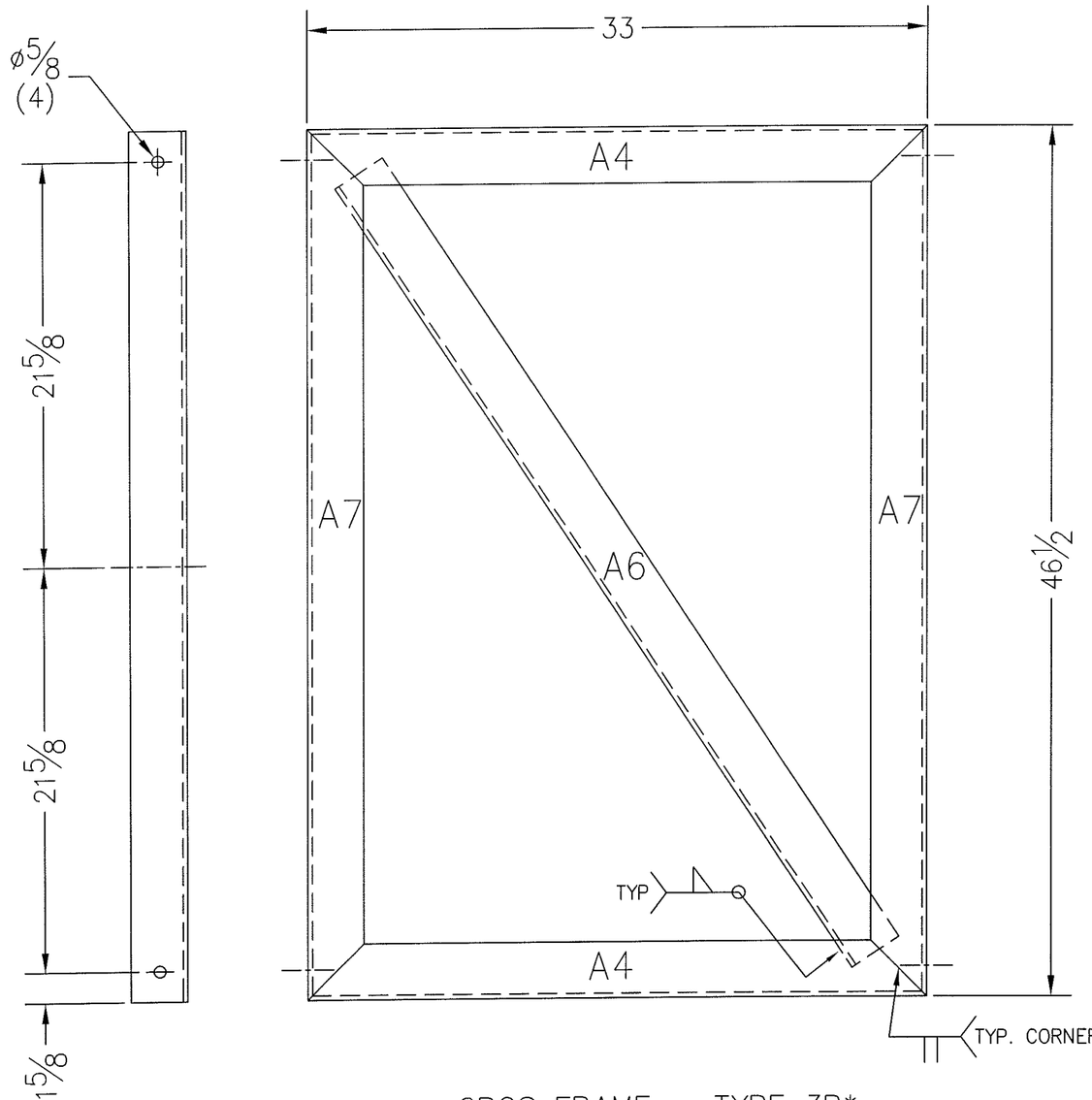


CROSS FRAME – TYPE 3L*
PROJECT TOTAL = 60

SAND BLAST AND EPOXY PAINT PER SPECIFICATION

ITEM NO.	QUANTITY	NAME	SIZE, DESCRIPTION, MATERIAL or SUPPLIER'S PART NUMBER
A7	2	ANGLE	L3X3X1/4 X 46.50 (SEE MF0508-46)
A6	1	ANGLE	L3X3X1/4 X 50.00 (SEE MF0508-45)
A4	2	ANGLE	L3X3X1/4 X 33.00 (SEE MF0508-45)

REV	COMMENTS	DATE	BY	REV	COMMENTS	DATE	BY



CROS FRAME – TYPE 3R*
PROJECT TOTAL = 60

NOTE: DIMS ARE BASED ON 47.25 HIGH
X 72.00 WIDE FRAME ASSEMBLIES

ITEM NO.	QUANTITY	NAME	SIZE, DESCRIPTION, MATERIAL or SUPPLIER'S PART NUMBER
A7	2	ANGLE	L3X3X1/4 X 46.50 (SEE MF0508-46)
A6	1	ANGLE	L3X3X1/4 X 50.00 (SEE MF0508-45)
A4	2	ANGLE	L3X3X1/4 X 33.00 (SEE MF0508-45)

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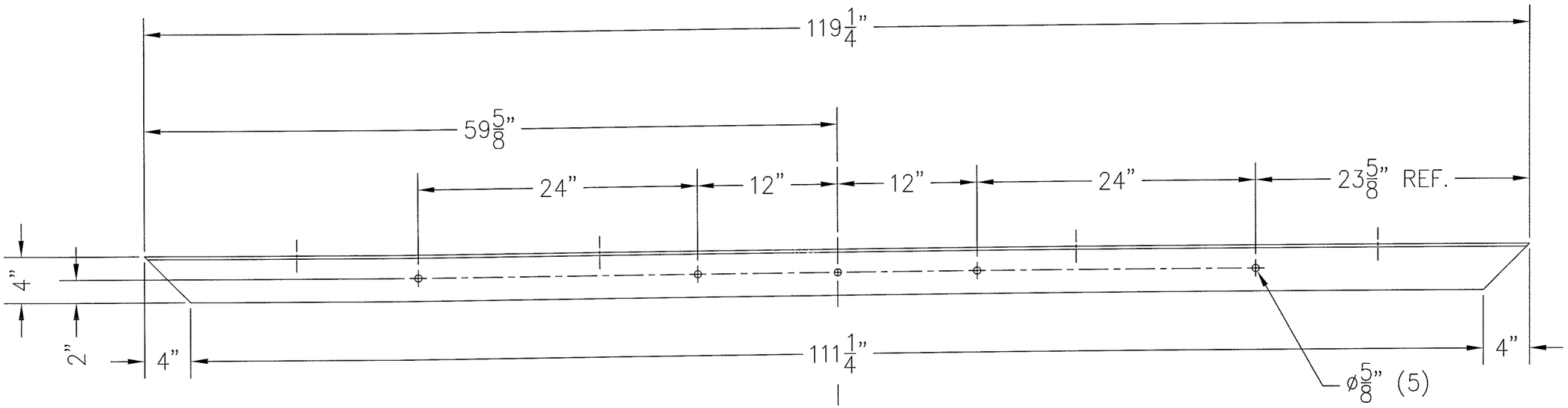
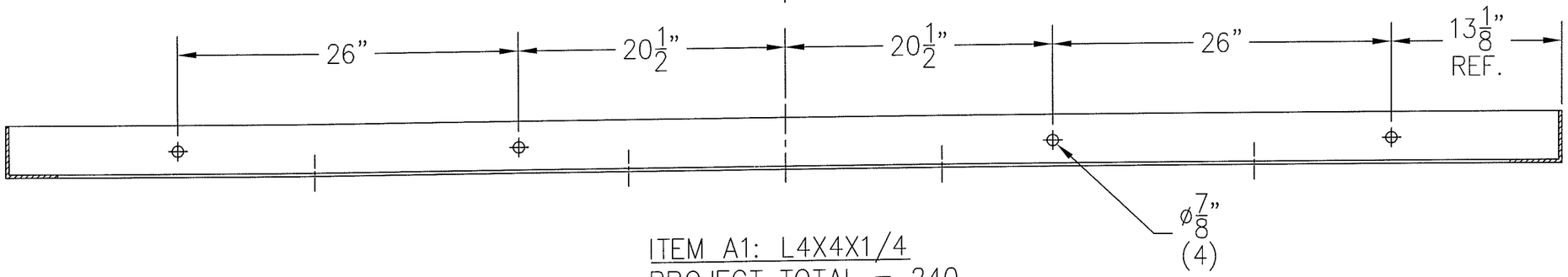
DRAWN	JMK	DATE	6/4/08
CHECKED	.	DATE	XX/XX/XX
APPROVED	.	DATE	XX/XX/XX

SUBTITLE: SKYKOMISH FILTRATION
CROSS FRAMES 3L* & 3R*

SHEET
DRAWING NO: MF0508-31
REV: .
PLOT INFO:
BORDER SCALE: 1=8

TITLE: BNSF





ITEM A1: L4X4X1/4
PROJECT TOTAL = 240

	COMMENTS	DATE	BY

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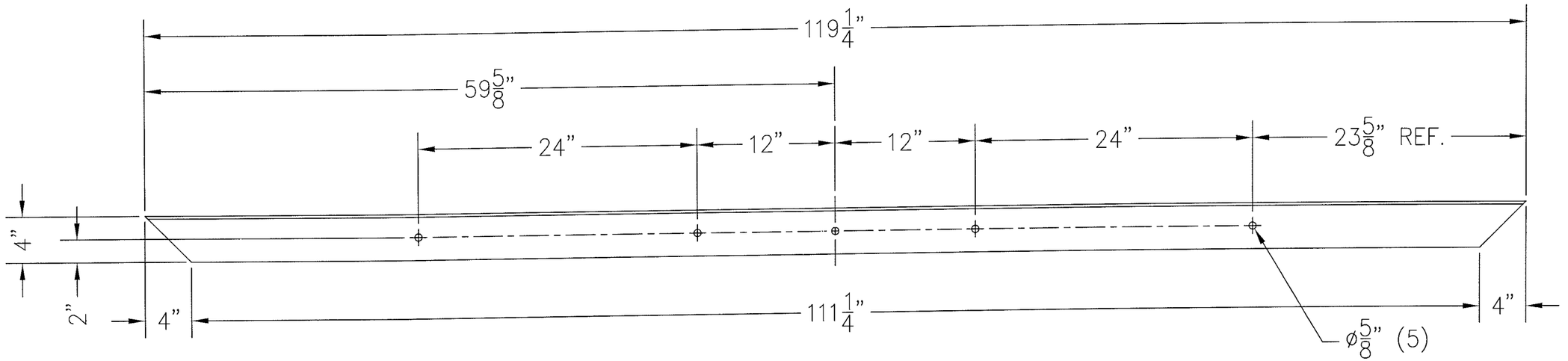
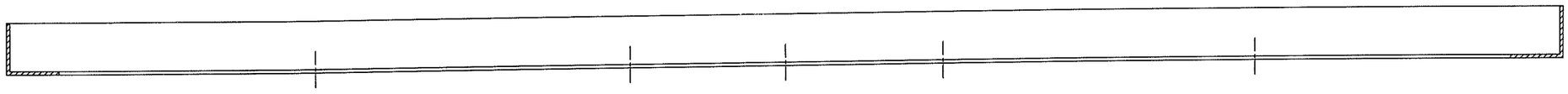
DRAWN	JMK	DATE	6/4/08
CHECKED	.	DATE	XX/XX/XX
APPROVED	.	DATE	XX/XX/XX

SUBTITLE: SKYKOMISH FILTRATION
FRAME TYPE 1 – ANGLE A1

TITLE: BNSF

SHEET
DRAWING NO: MF0508-41
REV:
PLOT INFO:
BORDER SCALE: 1=10





ITEM A2: L4X4X1/4
PROJECT TOTAL = 240

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DRAWN	JMK	DATE	6/4/08
CHECKED	.	DATE	XX/XX/XX
APPROVED	.	DATE	XX/XX/XX

SUBTITLE: SKYKOMISH FILTRATION
FRAME TYPE 3 – ANGLE A2

TITLE: BNSF

SHEET
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REV:
PLOT INFO:
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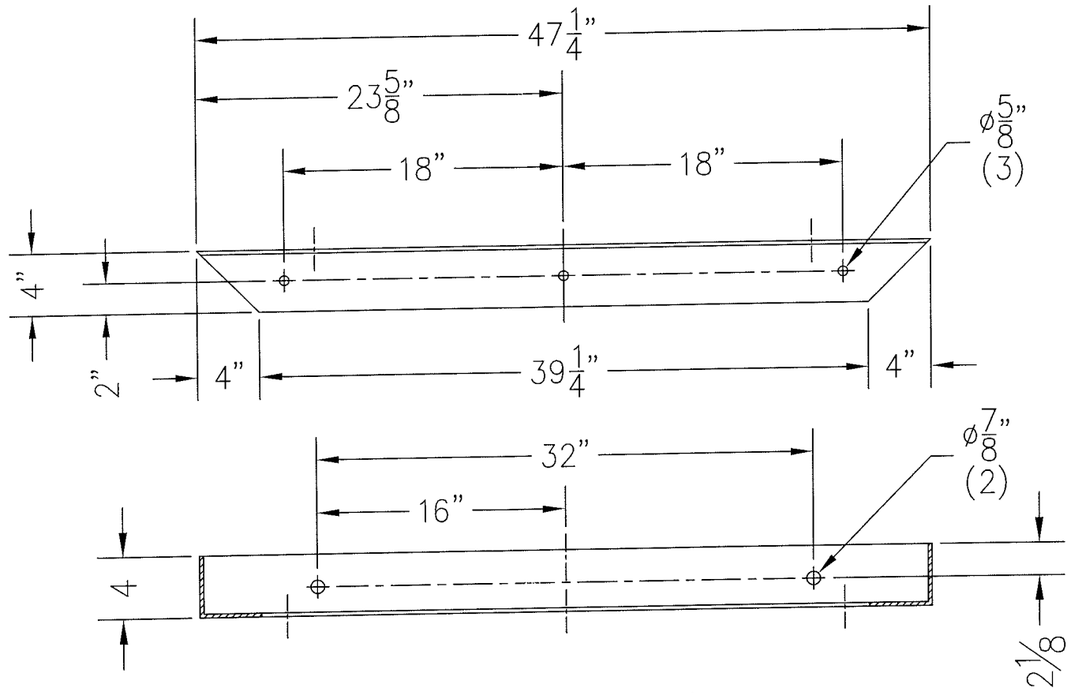

ITEM A3: L4X4X1/4
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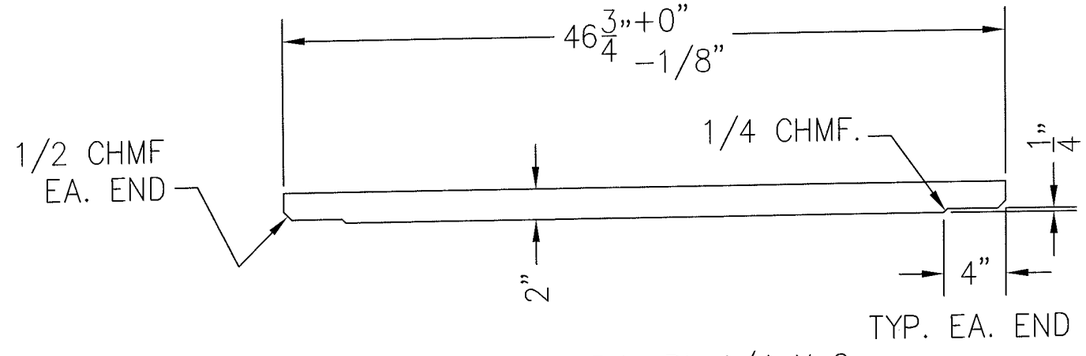

ITEM P4: PL 1/4 X 2
PROJECT TOTAL = 2560

COMMENTS	DATE	BY

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DRAWN	JMK	DATE	6/4/08
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APPROVED	.	DATE	XX/XX/XX

SUBTITLE: SKYKOMISH FILTRATION
FRAME TYPE 1 & 3 PIECES

TITLE: BNSF

SHEET
DRAWING NO: MF0508-43
REV:
PLOT INFO:
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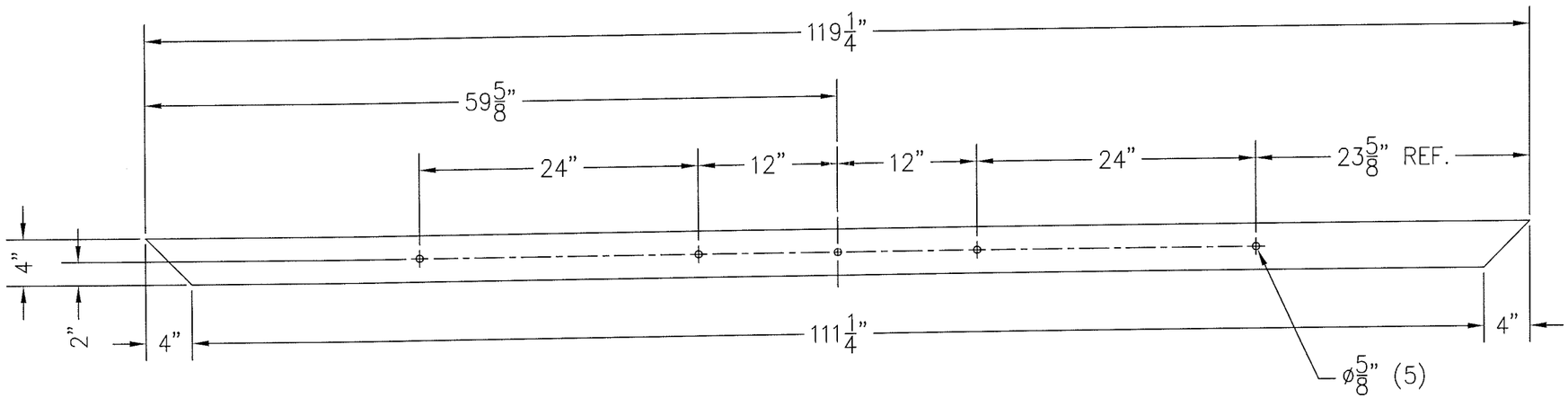
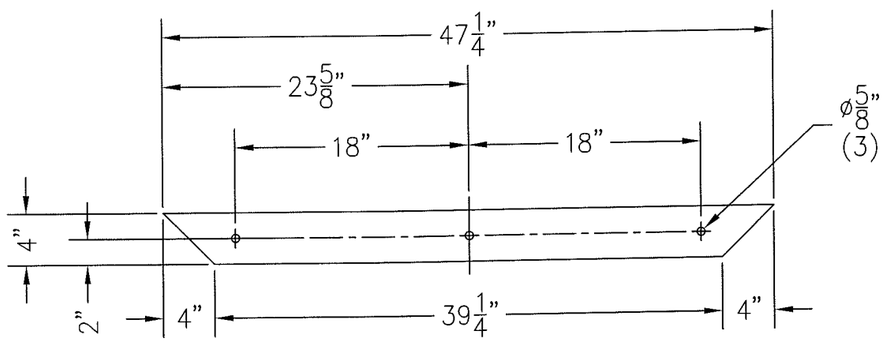


ITEM P1: PL 4X1/4
PROJECT TOTAL = 240



ITEM P2: PL 4X1/4
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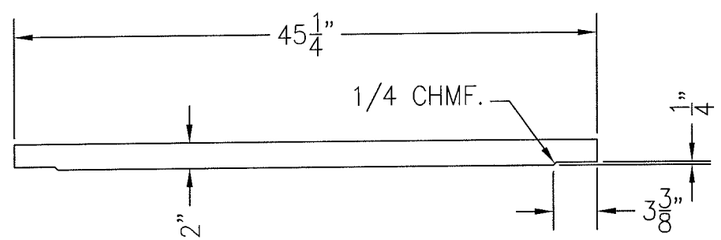

TYP. EA. END

ITEM P3: PL 1/4 X 2
PROJECT TOTAL = 1360

COMMENTS	DATE	BY

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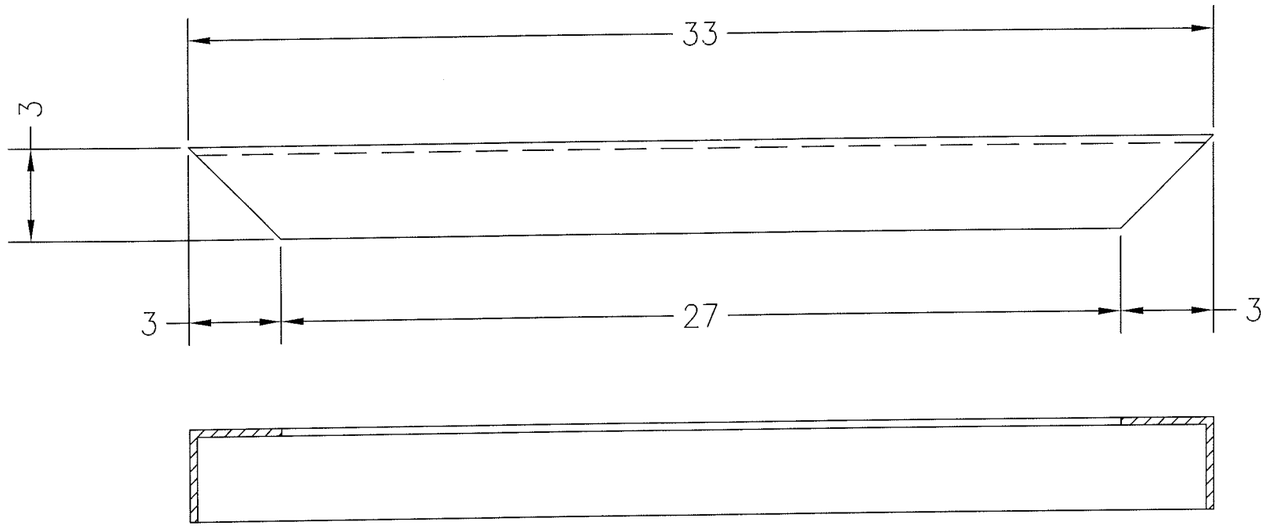
DRAWN	JMK	DATE	6/4/08
CHECKED	.	DATE	XX/XX/XX
APPROVED	.	DATE	XX/XX/XX

SUBTITLE: SKYKOMISH FILTRATION
FRAME TYPE 2 PIECES

TITLE: BNSF

SHEET
DRAWING NO: MF0508-44
REV:
PLOT INFO:
BORDER SCALE: 1=12



ITEM A4: L3X3X1/4
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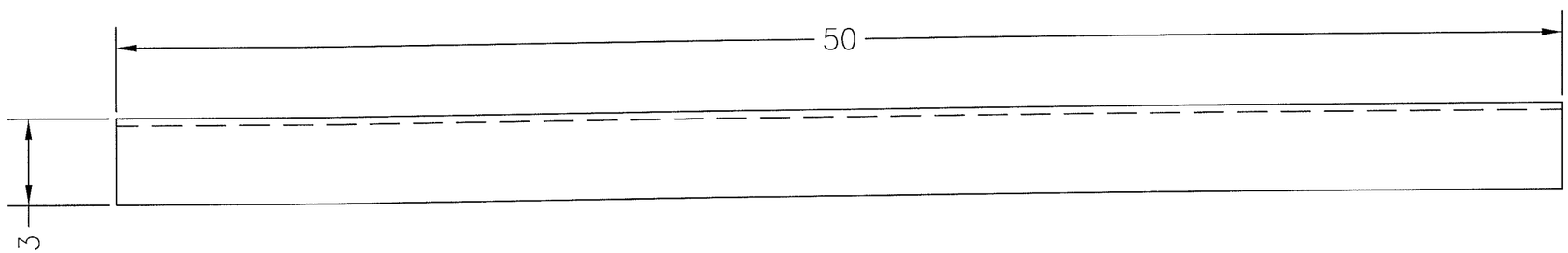

ITEM A6: L3X3X1/4
PROJECT TOTAL = 360

REV	COMMENTS	DATE	BY	REV	COMMENTS	DATE	BY

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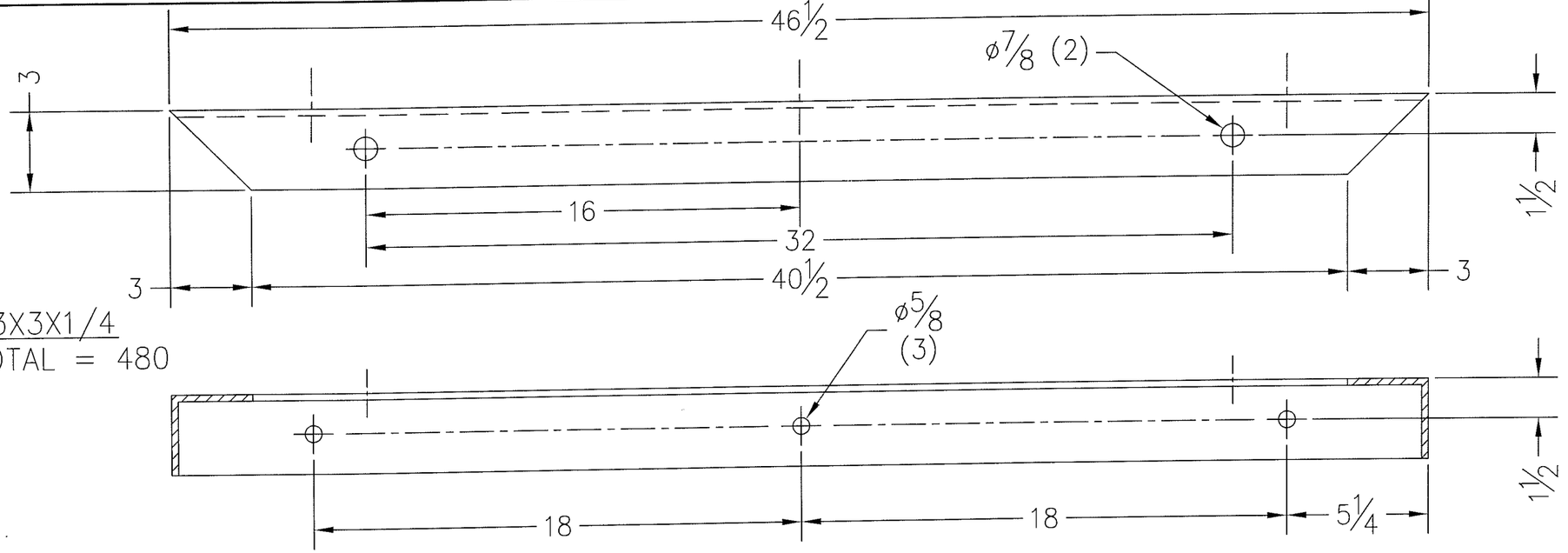
SCALE: DO NOT SCALE

DRAWN	JMK	DATE	6/4/08
CHECKED	.	DATE	XX/XX/XX
APPROVED	.	DATE	XX/XX/XX

SUBTITLE: SKYKOMISH FILTRATION PIECES A4 & A6

TITLE: BNSF

SHEET
DRAWING NO: MF0508-45
REV:
PLOT INFO:
BORDER SCALE: 1=5



ITEM A5: L3X3X1/4
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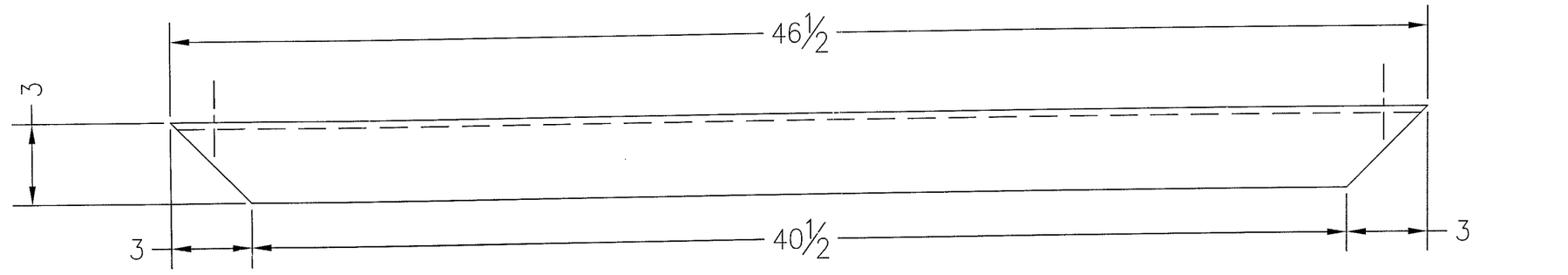

ITEM A7: L3X3X1/4
PROJECT TOTAL = 240

COMMENTS	DATE	BY	REV	COMMENTS	DATE	BY

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SCALE: DO NOT SCALE

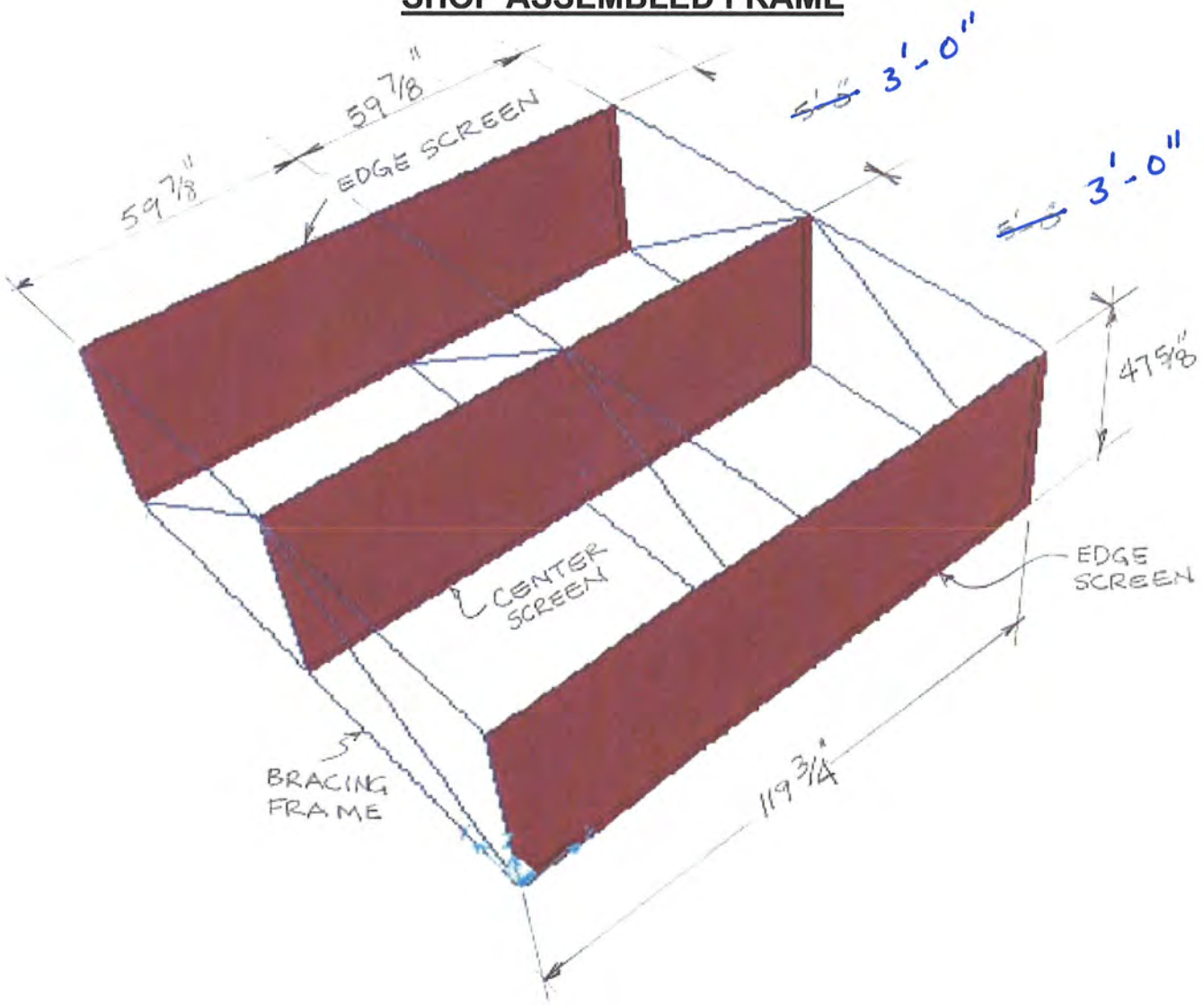
DRAWN	JMK	DATE	6/4/08
CHECKED	.	DATE	XX/XX/XX
APPROVED	.	DATE	XX/XX/XX

SUBTITLE: SKYKOMISH FILTRATION
PIECES A5 & A7

TITLE: BNSF

SHEET
DRAWING NO: MF0508-46
REV:
PLOT INFO:
BORDER SCALE: 1=5

SHOP ASSEMBLED FRAME



EACH SHOP ASSEMBLED FRAME IS COMPOSED OF:

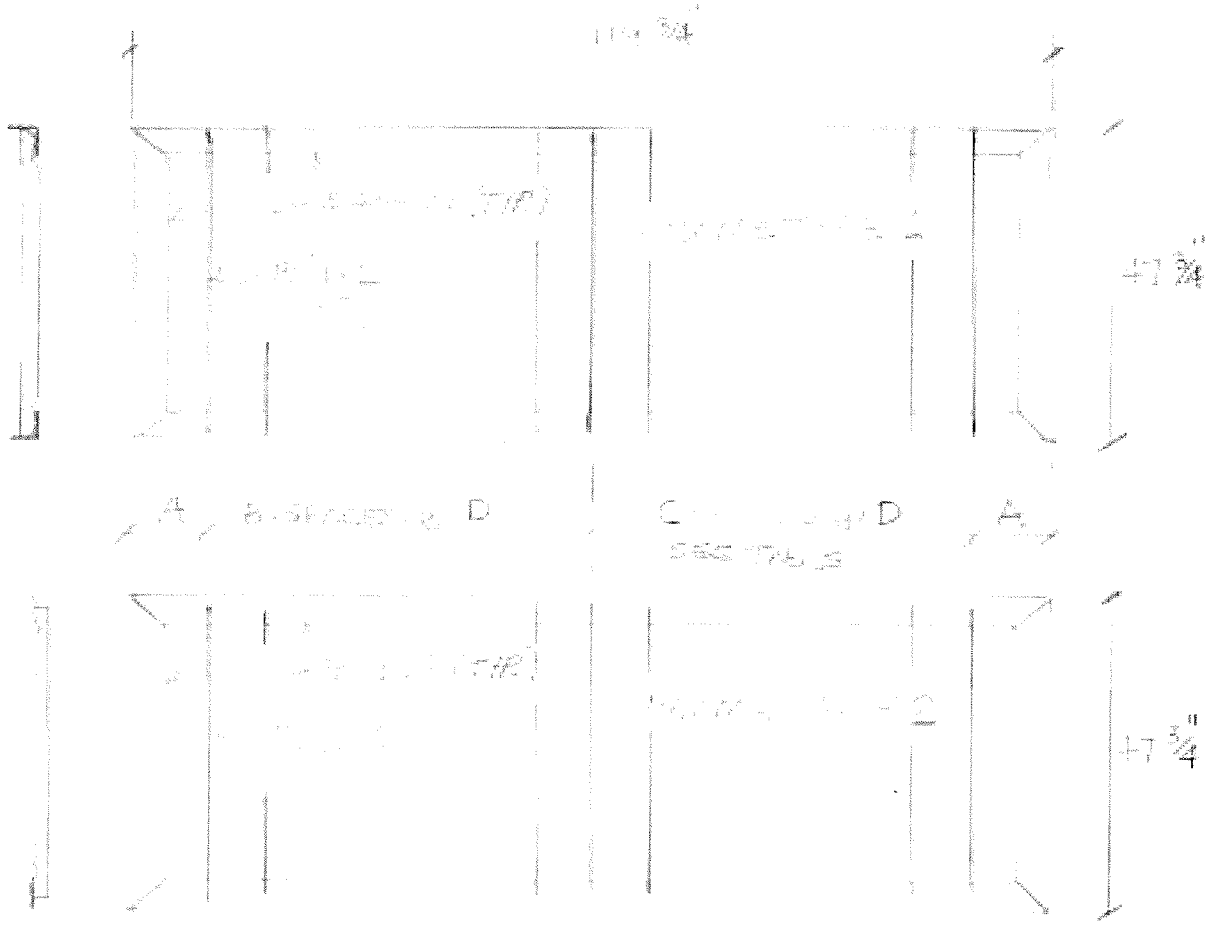
TWO EDGE SCREENS
ONE CENTER SCREEN
THREE BRACING FRAMES TYPE 3R
THREE BRACING FRAMES TYPE 3L

EACH EDGE SCREEN IS COMPOSED OF:

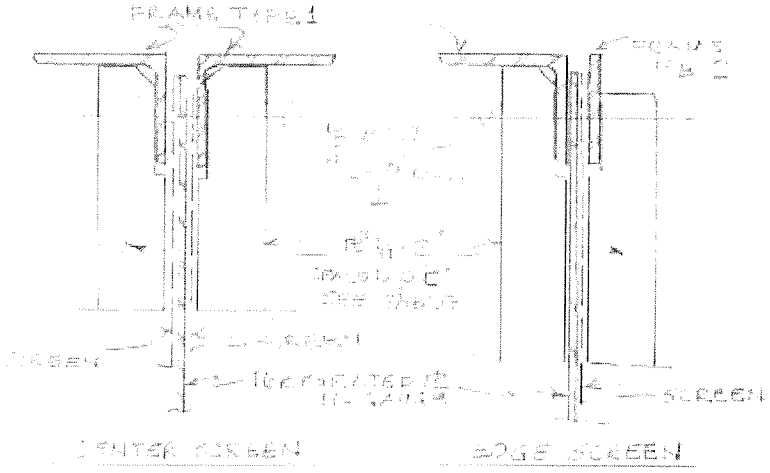
FRAME TYPE 1 ABOUT 10' BY 4'
11-GAUGE PERFORATED PLATE ABOUT 10' BY 4'
SCREEN ABOUT 10' BY 4'
FRAME TYPE 2 ABOUT 10' BY 4'

EACH CENTER SCREEN IS COMPOSED OF:

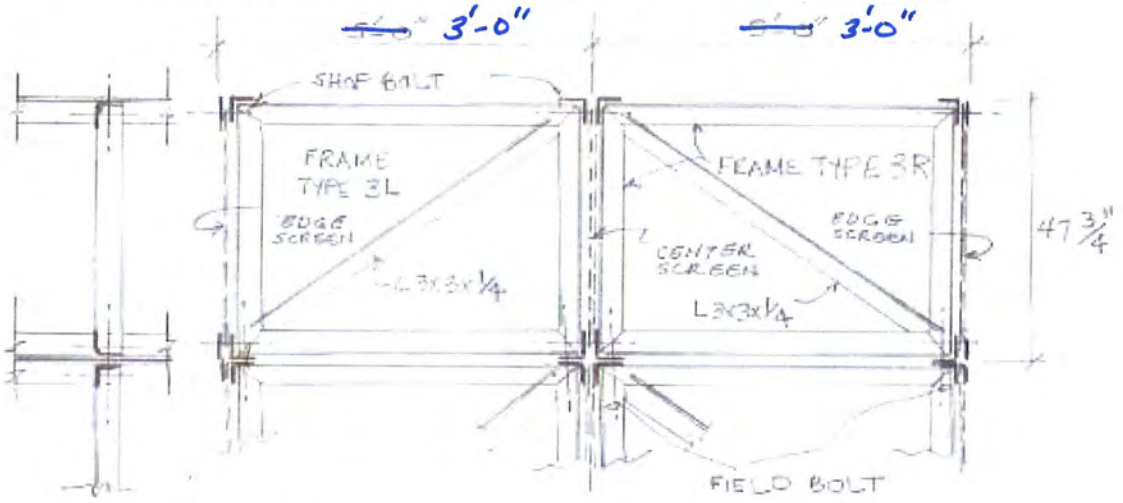
TWO FRAMES TYPE 1 ABOUT 10' BY 4'
11-GAUGE PERFORATED PLATE ABOUT 10' BY 4'
TWO SCREENS ABOUT 10' BY 4'



FRAME TYPE	FRAME LEVEL	A in.	B # OF SPACES	C # OF SPACES	D in.
1 & 2	BOTTOM	3.88	7	7	8.0
1 & 2	MIDDLE	5.88	4	5	12.0
1 & 2	TOP	5.88	4	4	13.5

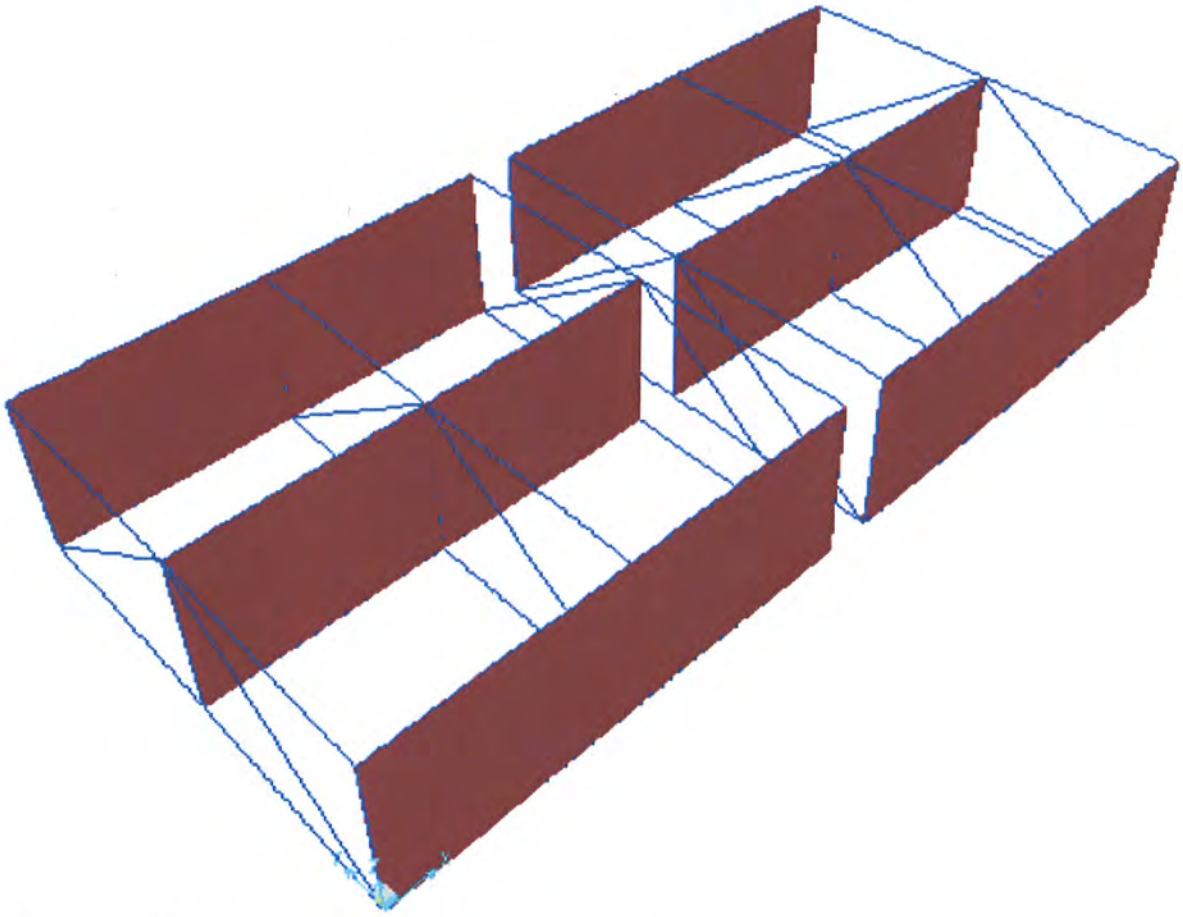


BRACING FRAME DETAIL & FIELD ASSEMBLY



BRACING FRAMES TYPE 3 DETAIL

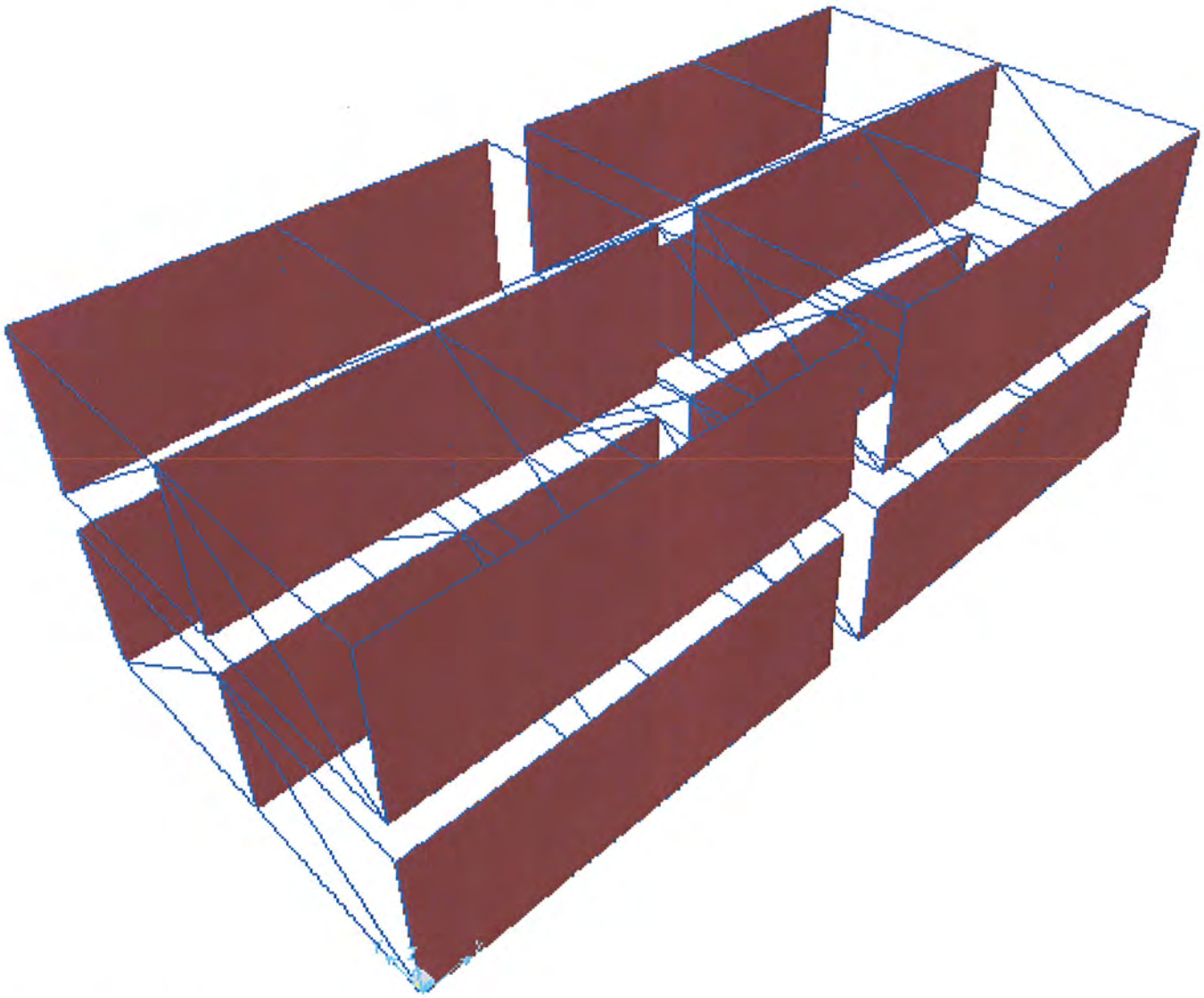
BOTTOM LEVEL



FIELD ASSEMBLEY STEP 1 :

EACH BOTTOM FRAME TO BE BOLTED TO BOTH THE CONCRETE BOX BASE SLAB AND TO THE ADJACENT CONCRETE END WALL AS WELL AS TO THE OTHER BOTTOM FRAME

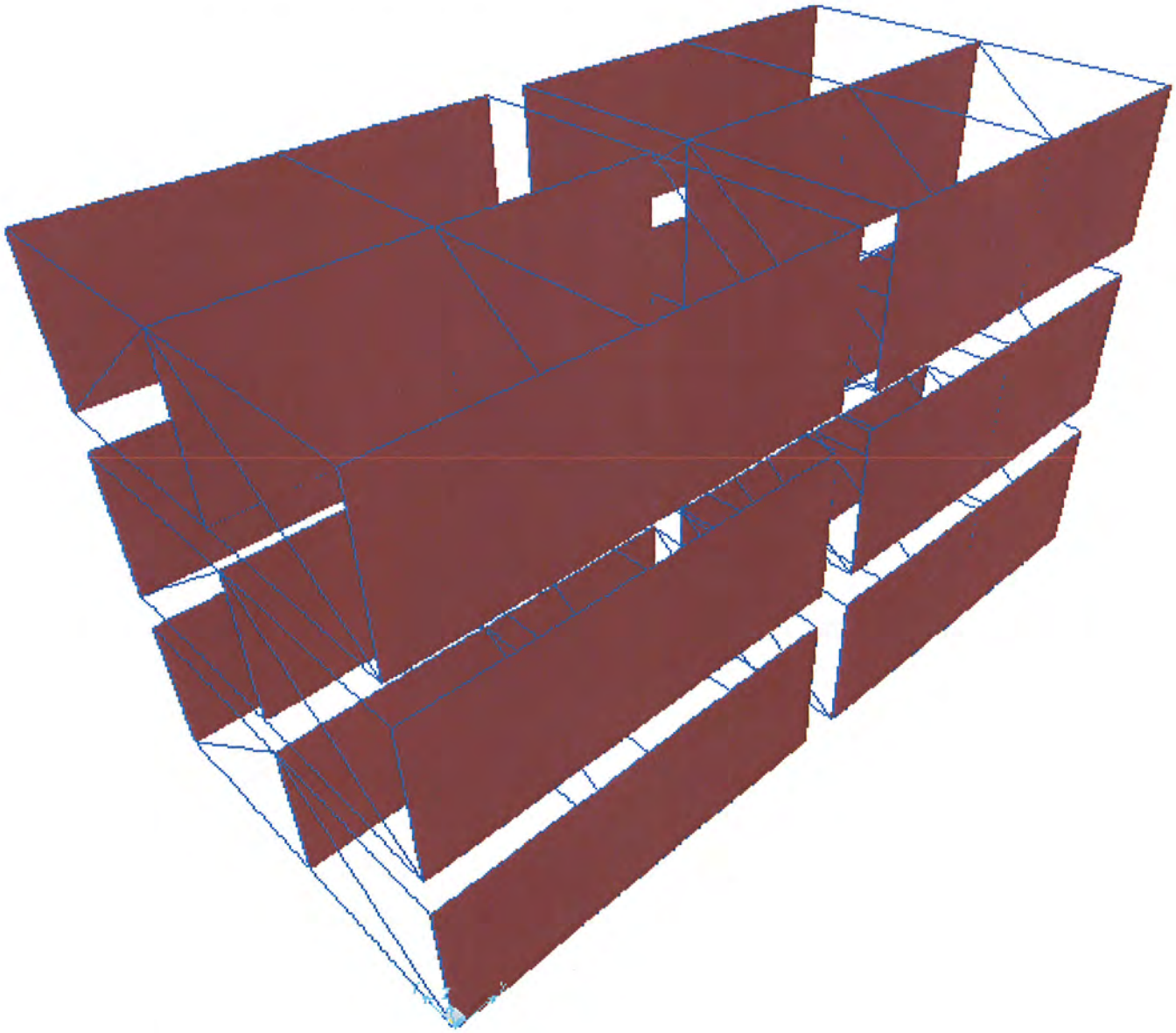
BOTTOM & MIDDLEL LEVELS



FIELD ASSEMBLEY STEP 2 :

EACH MIDDLE FRAME TO BE BOLTED TO THE ADJACENT CONCRETE END WALL AND TO THE BOTTOM FRAME BELOW IT AS WELL AS THE OTHER MIDDLE FRAME.

BOTTOM, MIDDLEL & TOP LEVELS



FIELD ASSEMBLEY STEP 3 :

EACH TOP FRAME TO BE BOLTED TO THE ADJACENT CONCRETE END WALL AND TO THE MIDDLE FRAME BELOW IT AS WELL AS THE OTHER MIDDLE FRAME.

NOTES :

1 USE 0.5"-THICK BY 4"-WIDE NEOPRENE STRIPS BETWEEN THE FRAME ANGLES AND THE CONCRETE BASE SLAB AND BETWEEN THE FRAME ANGLES AND THE CONCRETE END WALLS.

2 PLACE A STRIP OF COMPRESSIBLE MATERIAL ON THE TOP OF THE TOP LEVEL FRAME TO SEAL THE GAP BETWEEN THE CONCRETE BOX LID AND THE TOP LEVEL FRAMES.

Appendix C

Groundwater Modeling Report

S.S. PAPADOPULOS & ASSOCIATES, INC.
ENVIRONMENTAL & WATER-RESOURCE CONSULTANTS

Memorandum

Date: December 5, 2007

From: Michael J. Riley

To: Grant Hainsworth, ENSR

Subject: Skykomish Site Groundwater Model

This memorandum describes the groundwater modeling conducted to support the design of a groundwater containment and extraction system for the former BNSF rail yard in Skykomish, Washington.

Background

A groundwater model using the USGS MODFLOW groundwater flow code was initially constructed for the Skykomish site in 2001 to evaluate remedial action alternatives near the river. The model was updated for the present analysis to reflect more recent data. Model changes included:

- Refinement of model layers to represent top and thickness of silt layer,
- Representation of an area where the silt appears to be missing,
- Refinement and re-orientation of the grid to better represent containment alternatives between the railroad tracks and Railroad Avenue.

The geographical extent of the model is shown in Figure 1.

Model Setup

The original model used a uniform grid spacing of 20 feet by 20 feet oriented north, south, east and west. Site features require that the containment wall be oriented parallel to the railroad tracks and located between the tracks and Railroad Avenue. Consequently, the model grid was rotated slightly such that model rows are parallel to the tracks and Railroad Avenue. In addition, the width of the model rows was refined to a minimum width of 5 feet from south of the railroad tracks to Railroad Avenue. The model grid is shown in Figure 2.

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www.sspa.com • e-mail: mriley@sspa.com

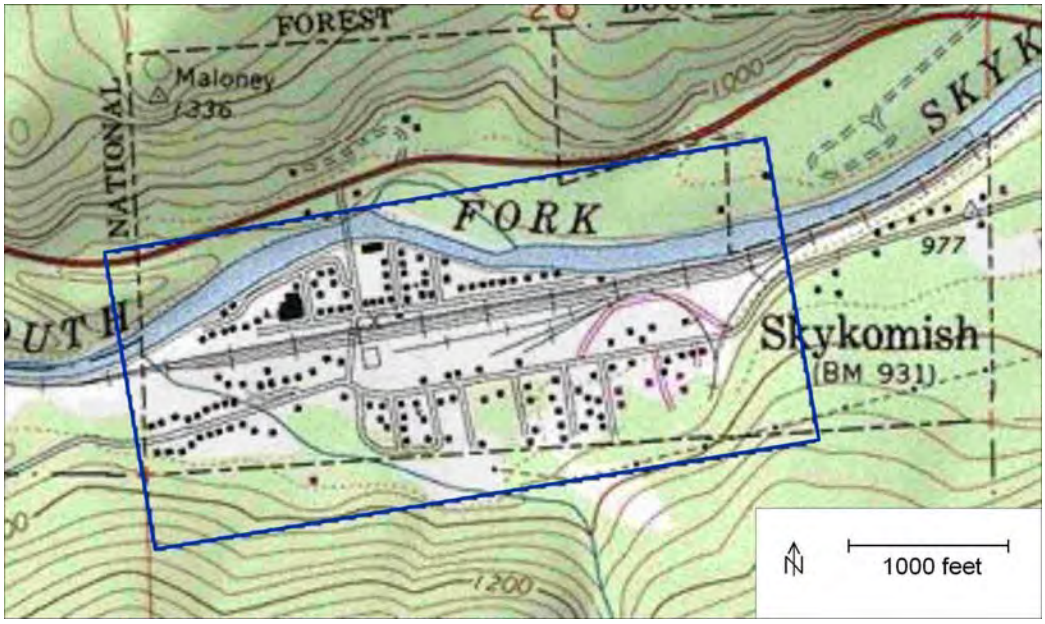

Figure 1. Geographical extent of groundwater flow model.
(Map created by TOPO!, National Geographic, 2003)

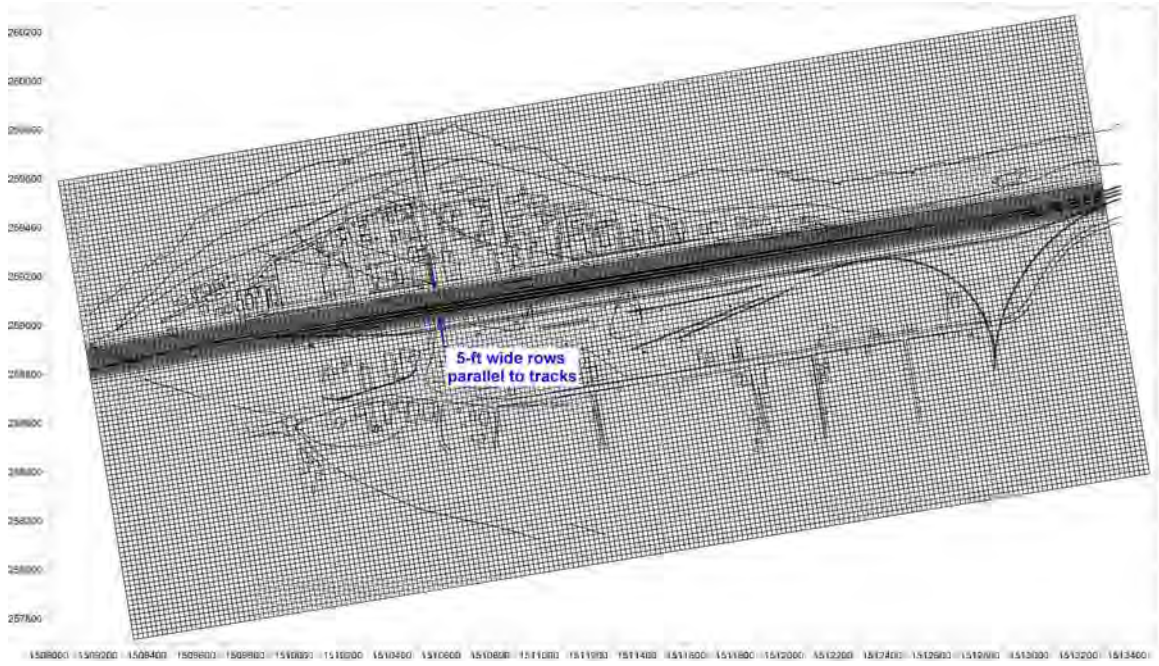

Figure 2. Model grid: uniform column spacing of 20 feet; variable row spacing from 5 to 20 feet. Scale is in Washington State coordinates (ft).

The model consists of three geologic units: upper sand aquiver (water table aquifer), silt layer, and lower sand aquifer. Regional bedrock underlies the lower aquifer. The bedrock is composed of metamorphic rock, which is considered to have very low water bearing capacity and consequently is not included in the model. The water table aquifer is represented by one model layer, the silt layer is represented by three model layers, and the lower sand aquifer is represented by one model layer.

The thickness of the upper sand aquifer was interpolated from site borings that extended to at least the top of the silt. The thickness of the silt was interpolated from site borings that extended into the silt. Most of these borings did not fully penetrate the silt. Consequently, the silt thickness represented in the model is the minimum thickness of the silt based on site data. The deepest site borings extend 40 to 45 feet below ground surface and do not extend to the bottom of the lower sand aquifer. Consequently, the thickness of the lower aquifer was arbitrarily set at 50 feet, which is substantially thicker than the saturated thickness of the water table aquifer. A typical model section through approximately the center of the model domain is shown in Figure 3.

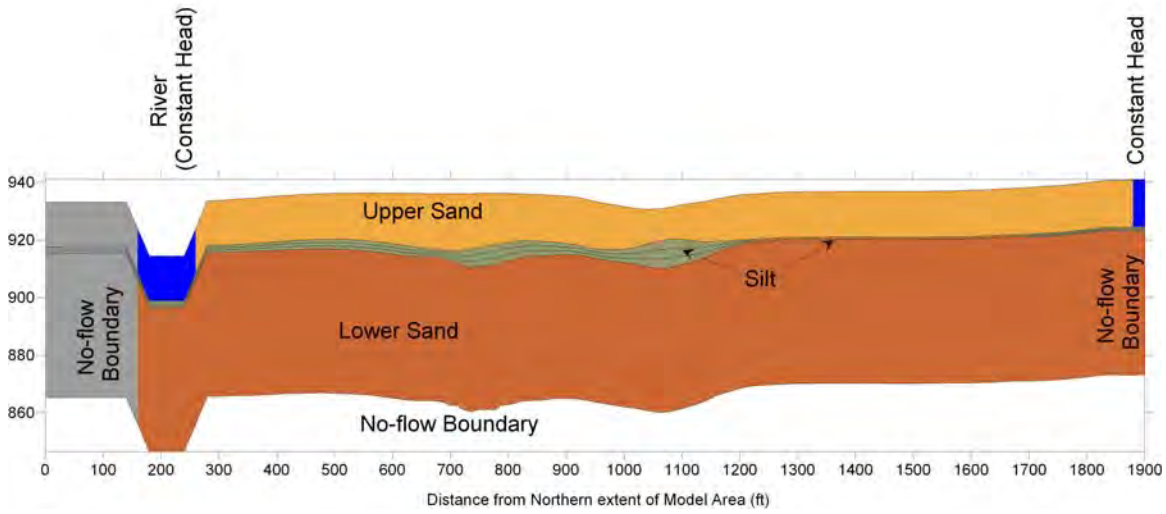

Figure 3. Typical model cross section showing geologic units and model layers.

Model boundary conditions are set at Maloney Creek, the Skykomish River, the southern extent of the model east of Maloney Creek, and the eastern extent of the model area. Maloney Creek and the eastern extent of the model area are defined as no-flow boundaries. The Skykomish River and the southern model boundary east of Maloney Creek are defined as constant head boundaries in the top model layer. The north side of the Skykomish River and bedrock at the bottom of the model are also defined as no-flow boundaries. Boundary conditions are noted in cross section on Figure 3 and in plan view on Figure 4.

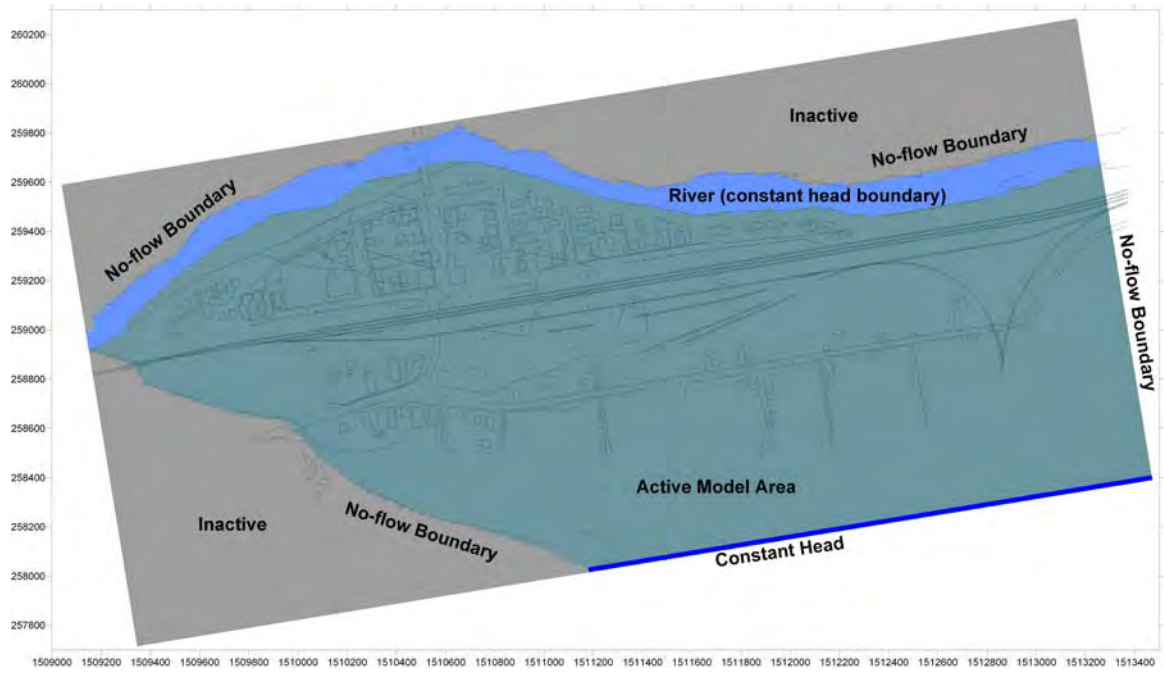

Figure 4. Plan view of model area showing boundary conditions.

One site boring did not encounter silt at the expected depth and this area was defined as an area of direct contact between the upper and lower aquifers. To be conservative, the area where the silt is missing was extended to nearby borings where the silt was encountered. The area extrapolated as missing the silt layer is shown in Figure 5 along with borings and minimum silt thickness that bound this area.

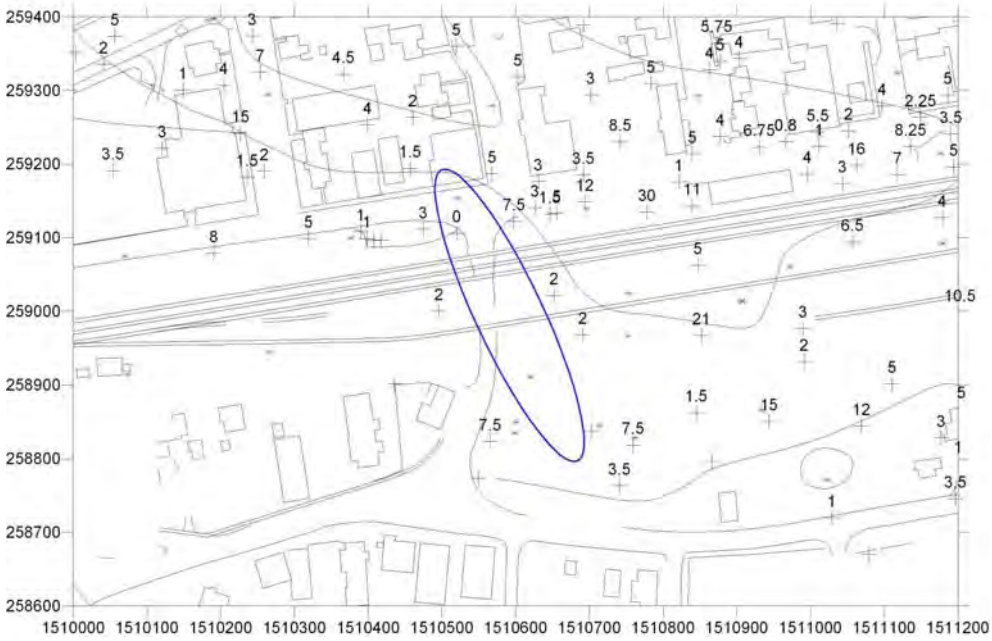

Figure 5. Extent of area interpreted as missing the silt layer. Numeric values are thickness of silt encountered at borings. Most of these borings did not penetrate the silt and therefore represent minimum silt thickness.

In the model, the silt layers are continuous and cannot be truncated to represent the missing silt zone. Consequently, the missing silt was defined by setting hydraulic parameters in this area to be representative of the upper sand aquifer providing direct hydraulic continuity between the upper and lower aquifers.

Model Calibration

Calibration is the process of adjusting model parameters to achieve a reasonable fit between model results and data. Data used for calibration consist of water level data collected from 1996 to 2007. The historic water level data were averaged to provide representative time-averaged water levels for the site for use in a steady-state model calibration. Wells with product thickness of more than a few tenths of a foot were not included in the calibration data set.

Model parameters consist of vertical and horizontal hydraulic conductivity of the sand aquifers and the silt, upland boundary head, river stage and recharge. The vertical and horizontal hydraulic conductivity of the upper sand aquifer were based on the range of values calculated from the PW-1 pump test conducted in September 2007 (see Attachment 1). The hydraulic conductivity of the silt was taken from literature values with a horizontal conductivity of 2 ft/d and vertical anisotropy of 0.01. The lower aquifer was assigned a horizontal hydraulic

conductivity of 50 ft/d and a vertical anisotropy of 0.01. A localized hydraulic conductivity zone was also defined under the river to represent coarse river bed sediments. This zone was assigned a vertical hydraulic conductivity of 200 ft/d and a vertical anisotropy of 0.01.

The stage of the Skykomish River was based on stage measurements taken at five locations along the river bank. These data were collected from January 2005 to February 2007. The data at a measurement location were averaged over the period of record. The average stage at each location provides a stage profile along the river, which was then interpolated onto the model grid and used for the constant head boundary on the river.

During calibration, the river stage and the hydraulic conductivity of the silt, lower sand, and river bed sediments were not modified. Rather, model calibration was achieved by modifying the vertical and horizontal conductivity of the water table aquifer within the range of values from the PW-1 pump test, recharge within a reasonable range given precipitation at the site, and the upland constant head boundary. The results of the calibration are shown in Figure 6.

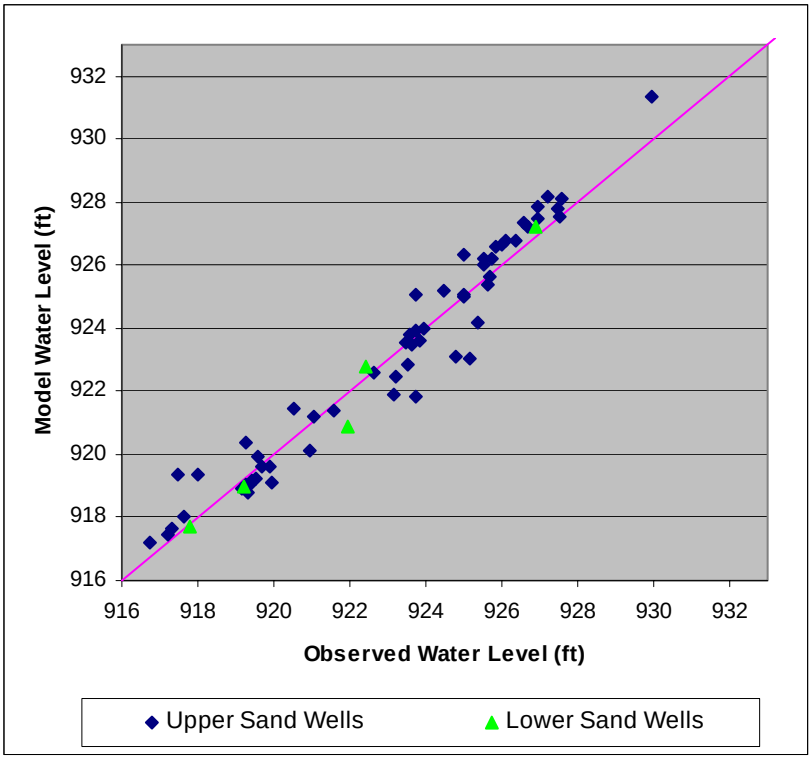

Figure 6. Model to data comparison from model calibration.

The model calibration shown above has an root mean square error of 0.79 ft and a regression coefficient greater than 0.97. This calibration was achieved using a horizontal hydraulic conductivity for the shallow aquifer of 160 ft/d and a vertical anisotropy of 0.005. These

compare favorably with the pump test results, which gave a horizontal hydraulic conductivity in the range of 150 to 200 ft/d and a vertical anisotropy on the order of 0.001.

Recharge was set at 33 inches per year, which is approximately 30 percent of annual precipitation[1]. This recharge would be relatively high for urban areas, but given the large unpaved areas, the limited storm water system, and flat topography over most of the model area, 30 percent of precipitation going to groundwater recharge on an annual basis is reasonable.

The upland boundary condition was set at an elevation of 937 ft. This is within 5 feet of ground surface at the southern model boundary so the boundary water level could not be much higher than this. The model was tested without a southern constant head boundary. This produced large unsaturated areas in the southern part of the model area and adversely affected model convergence and mass balance and therefore was considered not a reasonable representation of site hydrology.

Model Application and Design Analysis

The calibrated model was used to estimate the effect of a containment wall between the railroad tracks and Railroad Avenue on groundwater flow patterns and to estimate groundwater extraction rates to remove groundwater flowing from the former rail yard. This analysis was conducted using the groundwater flow model with the particle tracking code, Path3D. The particle path analysis tracks the movement of groundwater and is used to determine if groundwater is flowing around the containment wall or being captured by extraction wells. Examples of full and incomplete containment using a particle tracking analysis are shown in Figure 7.

The conceptual design for the containment wall includes flow-through gates with a treatment cell at the gates. The gates and treatment cells are provided to prevent contaminated groundwater from bypassing the wall in the event that the extraction wells shut down. One treatment gate was stipulated for the area where the silt is missing. Because this is toward the western extent of the wall, a second gate would be needed toward the eastern end of the wall.

Model simulations indicated that it was difficult to get complete capture along the middle part of the wall without a third, centrally located gate. The western gate was projected to be 60 feet wide to span the distance where the silt may be missing. The width of the central and eastern gates was not dictated by physical constraints and 40 feet was found to be adequate width at these locations.

[1] Based on precipitation record from Baring, Washington located 7 miles west of Skykomish.

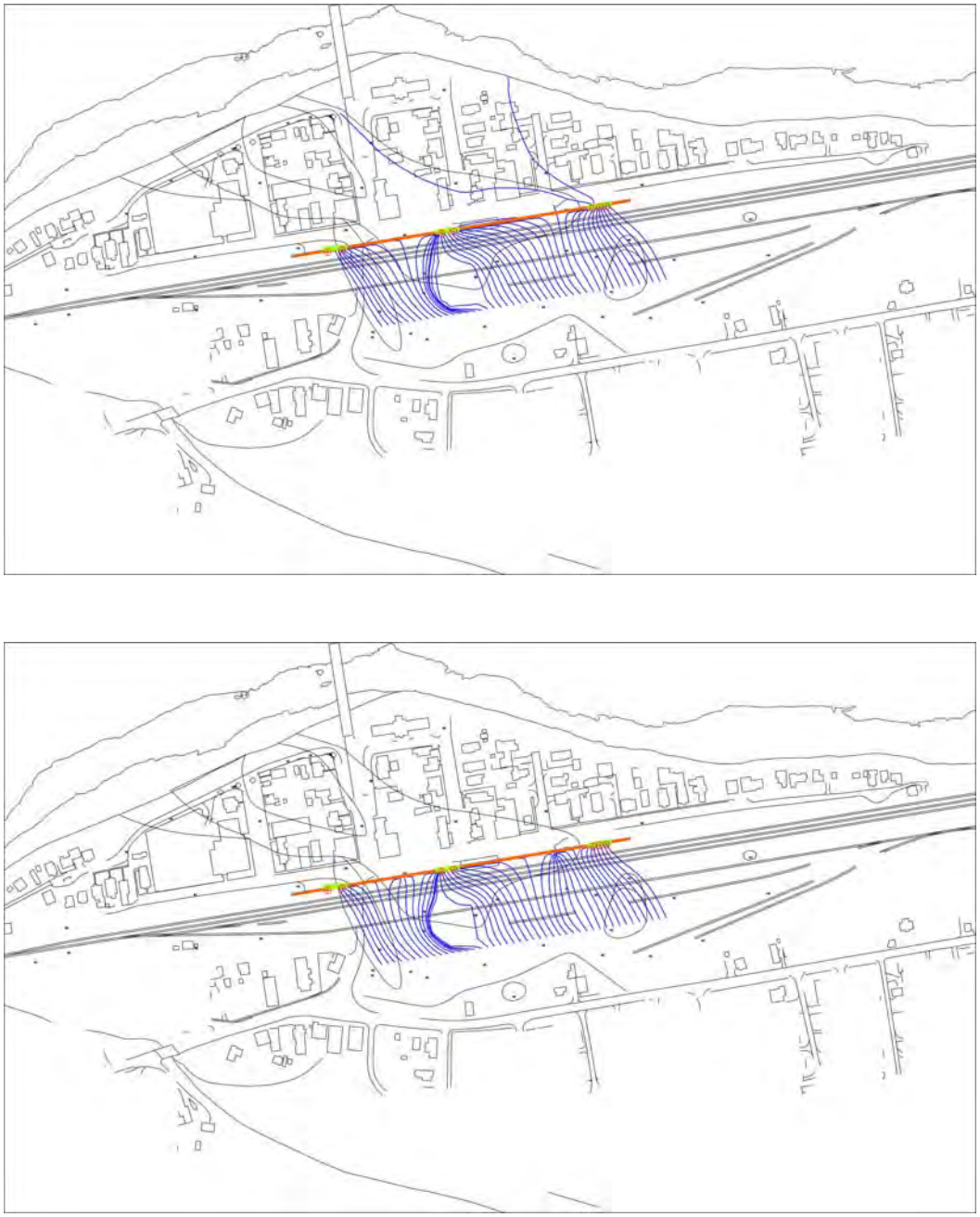

Figure 7. Examples of incomplete and complete capture indicated from a particle path analysis. The upper figure shows particles passing through a gate while the lower figure shows that all particles are captured by extraction wells with none passing through the gates.

Extraction wells were located at each gate and the model used to estimate the pump rate required to capture groundwater flowing from the rail yard. Three extraction wells were located at the western gate, two extraction wells at the central gate and one at the eastern gate.

Four containment wall designs were considered in the modeling. The first assumed a gravel-backfill trench along the upgradient side of the wall with wells screened in the trench. The second did not include a gravel trench, but the wells were located directly in front of the gates in native material. The third also did not include the gravel trench, but the wells were located approximately 20 feet upgradient from the trench. The last alternative considered a wall with gates and a trench located on the upgradient side of the gates, but only in front of the gates and not extending along the entire wall. In this last scenario, the western most gate and trench would be constructed to an elevation of 912 feet and grouted below this elevation where the silt layer is missing. In all cases, the wall was assigned a horizontal hydraulic conductivity of 0.01 ft/day. In designs with a gravel-backfill trench, the trench was assigned a horizontal hydraulic conductivity of 1000 ft/day. The values used for the trench and the wall are typical hydraulic conductivity values for gravel and clay, respectively.

A summary of model results for the extraction well scenarios is provided in the following table. The gate and well locations used in the simulations are shown in Figure 8.

Design Description	**Pump Rates at Gates (gpm)**		
	West	**Central**	**East**
Backfill trench at containment wall	24	16	6
No trench at containment wall	21	16	6
Upgradient of the containment wall	27	16	7
Short trenches at gates only[1]	21	12	12

1) Wall and trench at western gate constructed to elevation 912 with grouting below and two wells at eastern gate.

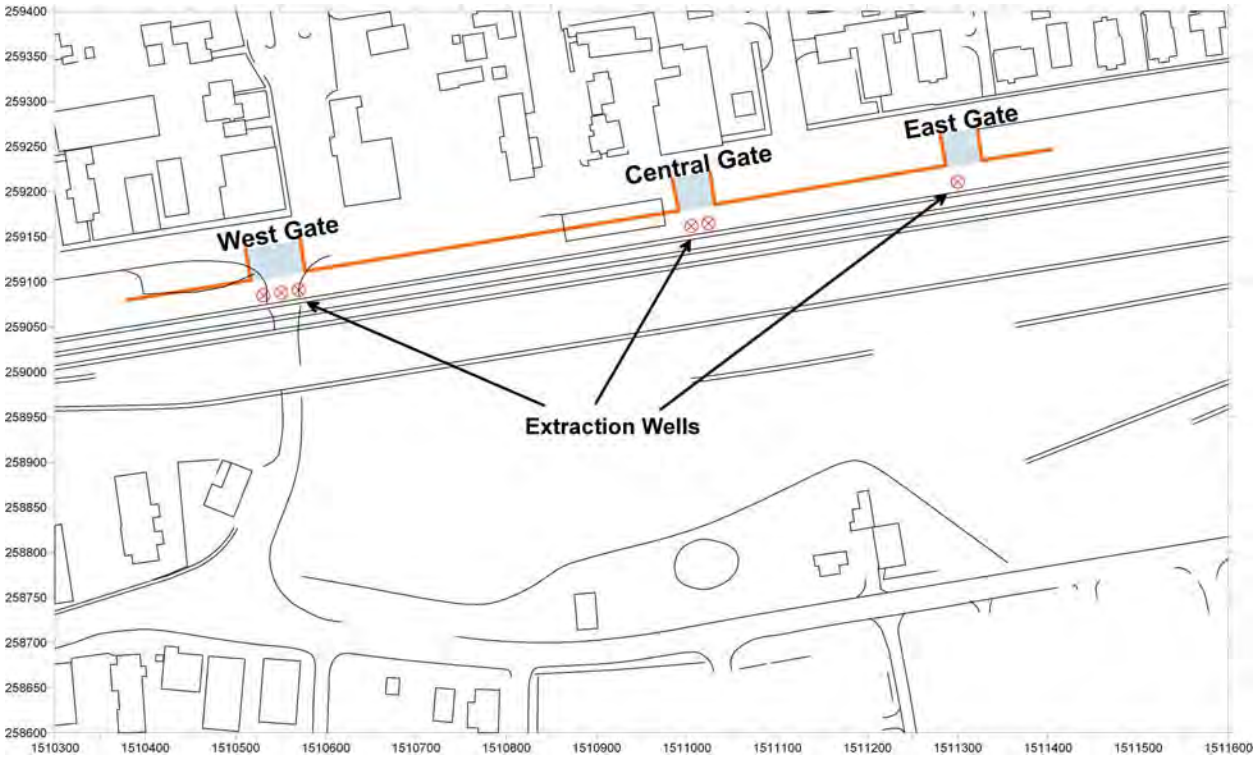

Figure 8. Wall, gate and extraction well locations for the design simulations.
(Backfill trench not shown and difference in well locations too small to show at this scale.)

Sensitivity Analysis

For a sensitivity analysis, the model was applied to a high water level condition. Water level data were analyzed to identify the appropriate period to use for the sensitivity analysis. Contours of time average water level data used for the calibration data set are shown in Figure 9. The transect line shown passes approximately through the center of the site. Wells along this transect were used to evaluate groundwater levels and gradients at the site (Figure 10). The highest water levels occurred during the January 31, 2006 sampling event.

The water level data indicates that groundwater gradients do not change substantially with changes in water level. Consequently, increased groundwater flow at higher water levels is largely due to increased saturated thickness rather than changing gradient.

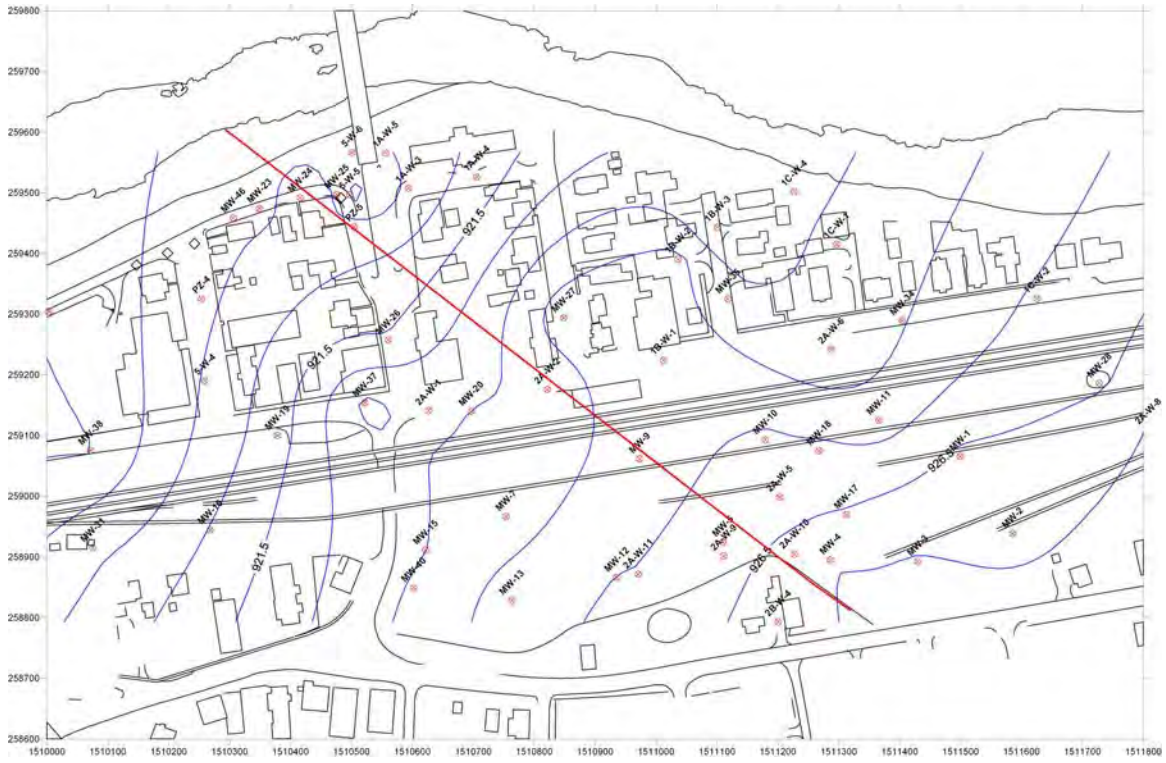

Figure 9. Water level contours for time averaged water level data.

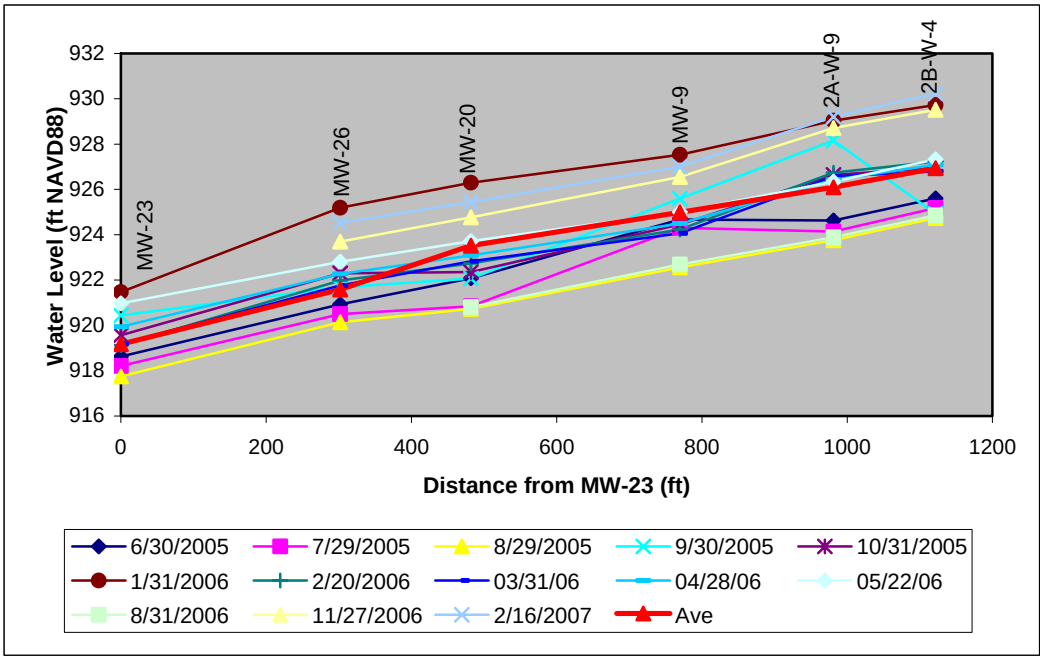

Figure 10. Historic water level gradients along the transect shown in Figure 9.

In addition to examining water level data, changes in river stage were also analyzed. Water level profiles on the river are shown in Figure 11. River profiles show the highest stage occurred on May 22, 2006, which does not coincide with the highest groundwater levels. However, the second highest historic stage measurements coincide with the highest groundwater levels on January 31, 2006. River data from January 31, 2006 were converted to constant head cell elevations in the same manner as the time averaged stage data used in model calibration.

The model was recalibrated for the high water level condition, but for simplicity, only the wells shown in Figure 9 were used in the calibration. Matching these data indicates that the model is representing the greater saturation thickness and increased groundwater flow through the center of the site. The model was recalibrated by only changing the river stage boundary and the recharge rate. The results of the recalibration are shown in Figure 12. The recalibration was achieved using a recharge rate of 0.0137 ft/d, which corresponds to 5.1 inches of recharge for the month of January. This gives a 20 percent recharge rate for precipitation recorded in January 2006, which is well within the reasonable range of recharge as a percent of precipitation.

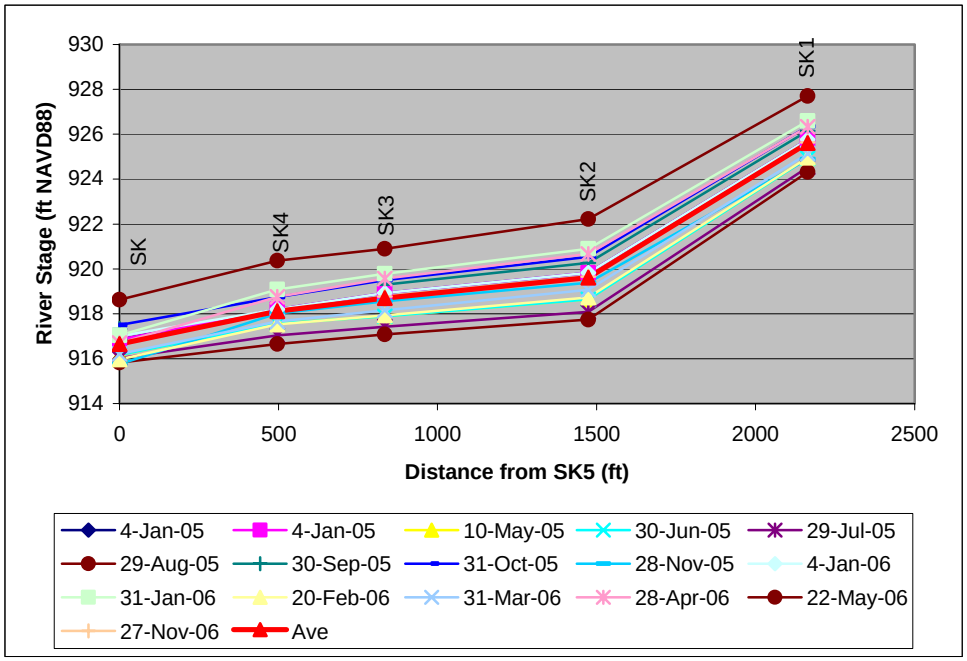

Figure 11. Historic water level data.

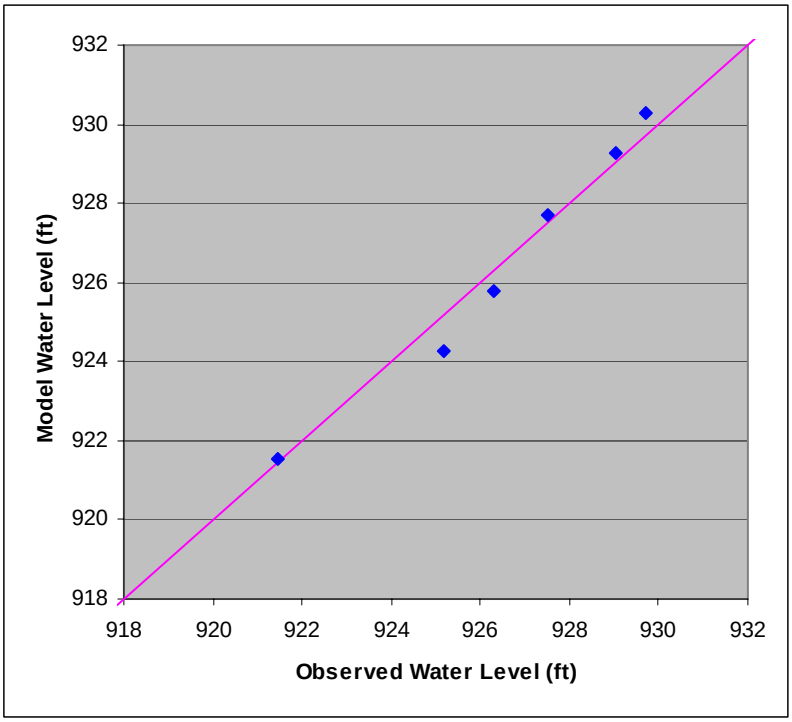

Figure 12. Model-data comparison from the high water level recalibration.

After recalibration and using the higher river stage and recharge rate, the model was used to analyze the extraction rate to maintain capture with the high groundwater flow rate. The analysis was only done for the condition without the gravel trench and extraction wells located at the gates and the design with short trenches in front of the gates. Model results for the high water level condition are provided in the following table.

Design Description	Pump Rates at Gates (gpm)		
	West	Central	East
No trench at containment wall	30	22	8
Short trenches at gates only[1]	30	22	18

1) Wall and trench at western gate constructed to elevation 912 with grouting below and two wells at eastern gate.

The high flow simulation resulted in approximately a 40 to 50 percent increase in pumping rate. The pump rates are on the order of 10 gpm per well, which is sustainable based on the PW-1 test.

Shutdown Analysis

The purpose of the treatment gates is to provide a means of treating water that passes through the wall if the pumping wells shutdown. To analyze the effectiveness of the gates to capture groundwater without pumping wells, the particle path analysis was applied without pumping. Three scenarios were included in this analysis:

- the wall with the gravel-backfill trench and average flow conditions
- the wall without the backfill trench and average flow conditions
- the wall without the backfill trench and high flow conditions.

The results of this analysis were essentially identical in all three cases. Figure 13 shows the particle path lines for the high flow condition.

Figure 13. Particle path lines in the event of shutdown of extraction wells for an extended period with high water levels at the site.

In each case, some particles flowed around the ends of the wall instead of through the gates. Consequently, it is recommended that treatment segments be included on each end of the wall. The path lines indicate that a treatment segment of approximately 55 feet is needed at the west end of the wall and a treatment segment of 25 feet on the east end.

Injection Analysis

The above analyses were conducted with the assumption that groundwater disposal would not be by re-injection upgradient of the wall. However, the Cleanup Action Plan requires injection of treated groundwater to assist in flushing contaminants from the rail yard area to the extraction wells. Also, upgradient injection of treated groundwater may be used to protect Maloney Creek from groundwater discharge from the rail yard area to the creek. Consequently, an analysis of the effect of groundwater injection on the performance of the containment wall and extraction system was conducted.

A line of injection wells was added to the model extending approximately parallel to and north of Maloney Creek (Figure 14). The analysis approach was to specify an injection rate at the wells and determine if capture was achieved at the extraction wells. Injection at the same rate as groundwater extraction (100 percent re-injection) showed that the extraction wells could not maintain capture at the wall. Consequently, the injection rate was progressively declined until capture was attained.

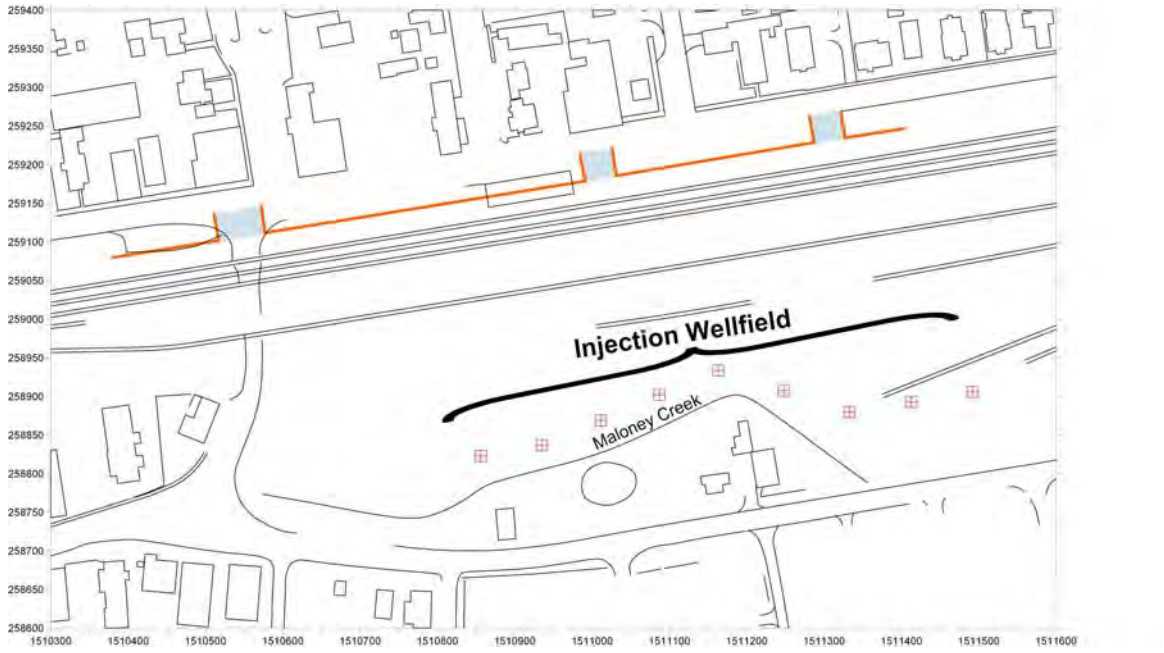

Figure 14. Location of injection wells near Maloney Creek

The injection analysis found that only a small fraction of about 20 percent of the extracted and treated groundwater can be re-injected without affecting capture at the containment wall. At re-injection rates above 25 percent, full containment by the extraction wells is not achieved and groundwater passes through the gates. The east gate is most susceptible to breakthrough and even with increased pumping at this location and an additional well, the re-injection rate could not be pushed above 22 percent.

Overall, re-injection has a negative impact on the performance of the extraction system with little benefit:

- only a small fraction of the treated groundwater can be re-injected
- re-injection makes full capture of groundwater at the containment wall more difficult
- re-injection requires increased pumping rates at the extraction wells
- improved flushing is minimal as groundwater flow rate only increased 16 percent (based on the higher extraction rate required for capture)

- the increased flushing rate will not substantially affect cleanup timeframe.

The adverse effect on capture, increased pumping, and limited increase in flushing rate result in a negative recommendation for re-injection.

There may be a benefit to re-injection near Maloney Creek to prevent contaminated groundwater from discharging to the creek. However, a more thorough analysis of the relationship between groundwater and Maloney Creek should first be conducted.

Summary and Conclusion

The groundwater flow model developed for the Skykomish site was modified to better represent a containment wall between the railroad tracks and Railroad Avenue. The model was calibrated to historic data, much of which has been collected since the original model was developed. The calibrated model was used to simulate the effect of a containment wall with treatment gates and four design configurations for the wall and extraction wells:

- containment wall with a gravel-backfill trench along the entire length of the wall and extraction wells located in the gravel-backfill trench in front of the gates
- containment wall without a gravel-backfill trench and extraction wells located in front of the gates
- containment wall without a gravel-backfill trench with extraction wells located 20 feet upgradient of the gates
- containment wall with short gravel-backfilled trenches located in front of the gates with extraction wells located in the trench.

The sensitivity of the model to higher groundwater levels and higher river stage was tested by applying the higher river stage as a boundary condition and recalibrating the model to the higher groundwater levels. This analysis produced reasonable results as the model was recalibrated by only modifying the recharge rate, which was within a reasonable range relative to precipitation.

The results of this analysis are summarized in the following table.

Design Description	**Pump Rates at Gates (gpm)**		
	West	**Central**	**East**
Backfill trench at containment wall	24	16	6
No trench at containment wall	21	16	6
Upgradient of the containment wall	27	16	7
Short trenches at gates only[1]	21	12	12
No trench and high water level calibration	30	22	8
Short trenches at gates only[1] and high water levels	30	22	18

1) Wall and trench at western gate constructed to elevation 912 with grouting below and two wells at eastern gate.

S.S. PAPADOPULOS & ASSOCIATES, INC.
ENVIRONMENTAL & WATER-RESOURCE CONSULTANTS

Memorandum

Date: May 8, 2008

From: Michael J. Riley

To: Grant Hainsworth, ENSR

Subject: Skykomish Site Groundwater Model: HCC Design Setup

This memorandum describes the groundwater modeling setup to evaluate the HCC design. The model structure was previously presented in a memorandum dated December 5, 2007 and in a presentation January 8, 2008 to address comments from Ecology/CDM dated December 18, 2007.

Design Considerations

The overall layout for the HCC design is based on Ecology's selected conceptual design from January 10, 2008. This design consists of:

- Containment wall and extraction wells along the north BNSF property line to contain groundwater from the rail yard.
- Treatment gates to treat groundwater that may by-pass the wall in the event of extraction well shutdown.
- Trench segments along the wall to aid in directing groundwater to the treatment gates
- Extraction and injection wells in an area considered to contain free product

The locations of the rail yard containment and free product areas are shown in Figure 1.

Other design considerations include constructability with respect to railroad tracks, development plans by the Town of Skykomish, saturated thickness for extraction wells, and overall groundwater flow direction.

The design was evaluated in two steps. The most critical step is the location of treatment gates that intercept groundwater during shutdown of the extraction wells. This criteria defines the length of the wall and number and length of gates. For this evaluation, high water level conditions were used to simulate groundwater movement at high groundwater flow rates. The second step was used to define the average pumping rates of the extraction wells. For this evaluation, annual average groundwater levels and flow rates were used.

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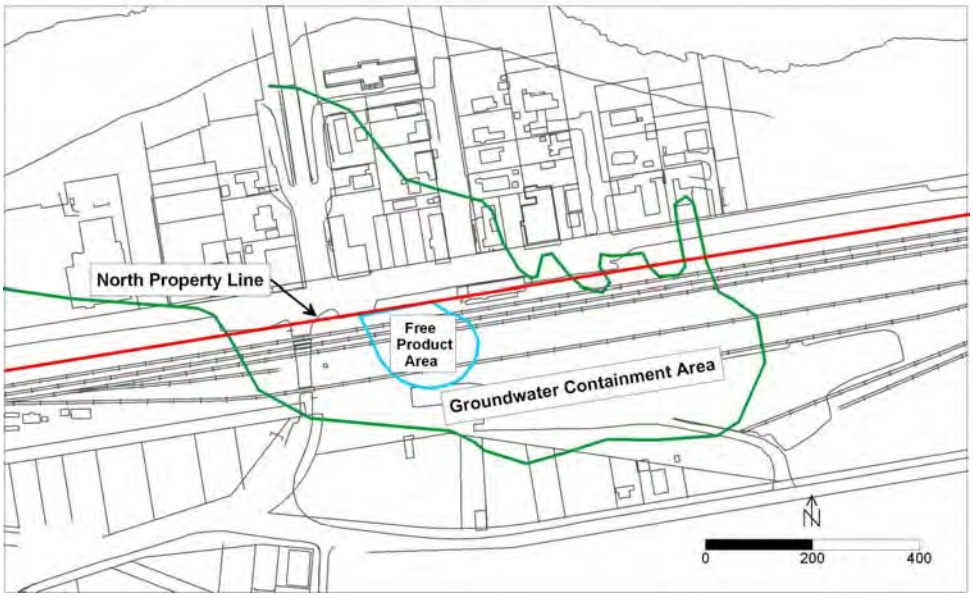

Figure 1. Skykomish site area showing groundwater containment area and free product area south of the north property line.

The treatment gates under design are concrete vaults approximately 20 feet long with a 6-ft thick segment of treatment media that groundwater flows through in the vault. The hydraulic conductivity of the treatment media has been tested and is approximately 0.02 cm/s. For design purposes, a more conservative hydraulic conductivity of 0.01 cm/s (approximately 30 ft/d) was used since this will increase the potential for groundwater to flow around the wall rather than through the gates.

Design Analysis

The groundwater flow model was used to estimate the effect of a containment wall between the railroad tracks and Railroad Avenue on groundwater flow patterns and to estimate groundwater extraction rates to remove groundwater flowing from the former rail yard. This analysis was conducted using the groundwater flow model with the particle tracking code, Path3D. The particle path analysis tracks the movement of groundwater and is used to determine if groundwater is flowing around the containment wall or being captured by extraction wells.

Previous model simulations indicated that a gate is needed near each end of the wall to prevent groundwater movement around the wall and a centrally located gate is necessary to control groundwater movement through the wall. Due to land use limitations, the preferred location for

the central gate is at the location of the railroad depot. The location of gates and flow paths during high water level conditions are shown in Figure 2, which shows that groundwater from the rail yard passes though the gates.

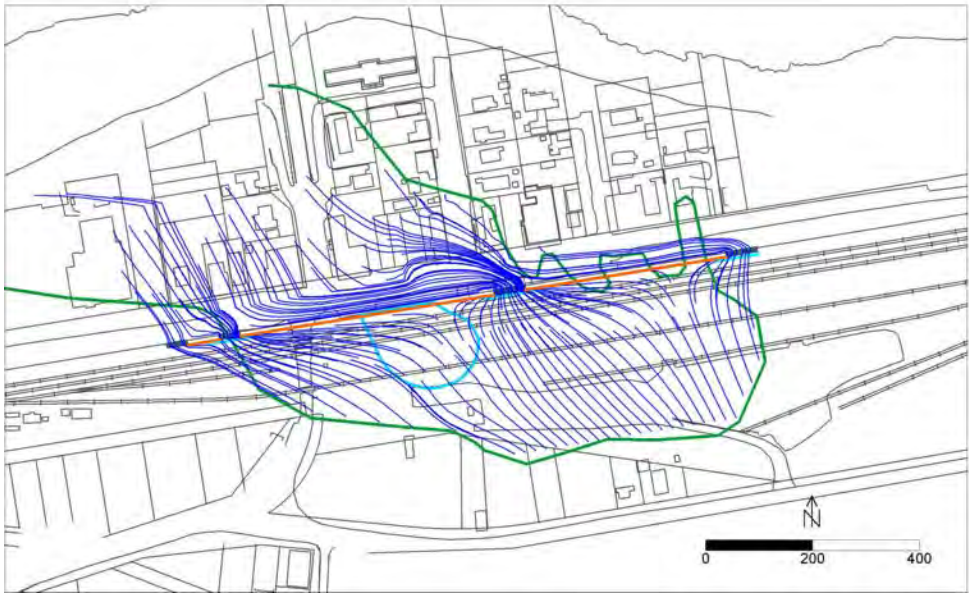

Figure 2. Location of wall and gates to intercept groundwater flow (blue lines) in the event of extraction system shutdown.

Extraction wells are located at the central and western gates and the model was used to estimate the pump rate required to capture groundwater flowing from the rail yard. Three extraction wells were located at the western gate and five extraction wells at the central gate. Due to limited saturated thickness at the eastern gate, an injection well was simulated at this location to force groundwater flow toward the center gate.

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The final step in the design was evaluation of injection and extraction in the area containing free product. The objective of the free product area injection and extraction wells is to enhance flushing within the free product area and push free product away from the wall. Figure 2 shows that groundwater largely flows from southeast to northwest across this area. This limits the location of injection wells along the wall to the area of the groundwater divide between the central and western gates, if the extraction wells are to contain the free product within the free product area. To enhance extraction and flushing, three extraction wells are located in the area. The well layout and capture effectiveness of wells is shown in Figure 3.

Figure 3. Location of injection and extraction wells and groundwater flow paths.

Figure 3 shows that the extraction wells capture groundwater from the containment area in the rail yard and that the free product area extraction wells capture groundwater within the free product area including water injected at the free product area injection well.

Summary of Design

Overall length of wall including gates	1120 ft
Overall length of gates	200 ft
Western gates (2)	40 ft each
Central and eastern gates	60 ft each
Total extraction rate	44 gpm
Western gate extraction	12 gpm
Central gate extraction	20 gpm
free product area extraction	12 gpm
Total injection rate	10 gpm
Eastern gate injection	5 gpm
free product area injection	5 gpm

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Effect of the Wall and Gates on Groundwater Levels

The HCC design has the effect of reducing groundwater levels. During pumping, water levels throughout the town are decreased by the effect of pumping (Figure 4). The decline in groundwater levels is greatest at the extraction wells and decreases with distance from the wall. The decline is more extensive north of the wall due to the combination of groundwater removal at the wall and reduced groundwater flow around the wall. The condition shown compares water levels prior to 2006 without pumping and a wall to water levels after the 2006 and 2008 excavations with pumping and the wall discussed above. Water levels will decline slightly more after excavations are completed in 2011, particularly north of the wall.

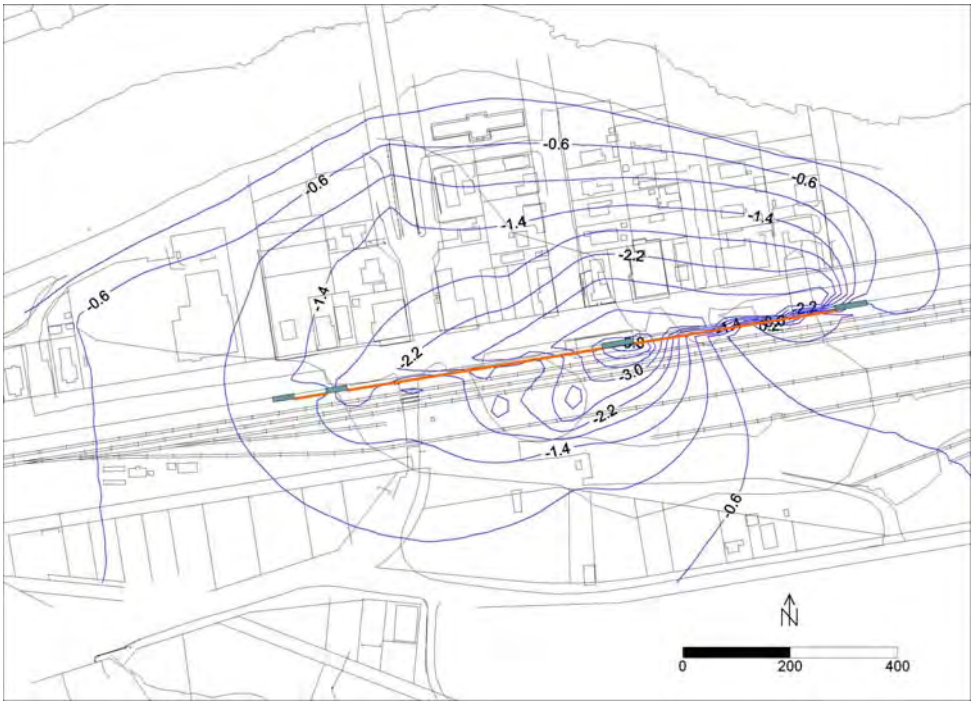

Figure 4. Decline in groundwater levels during groundwater pumping under high water level conditions.

During shutdown, water levels rebound south of the wall (Figure 5). The wall causes groundwater to backup on the south side of the wall resulting in higher water levels on the south side of the wall than under normal groundwater flow without a wall in place. The greatest increase in groundwater level occurs at the wall and the increase dissipates to the south reaching only approximately 0.5 ft near the former Maloney Creek channel.

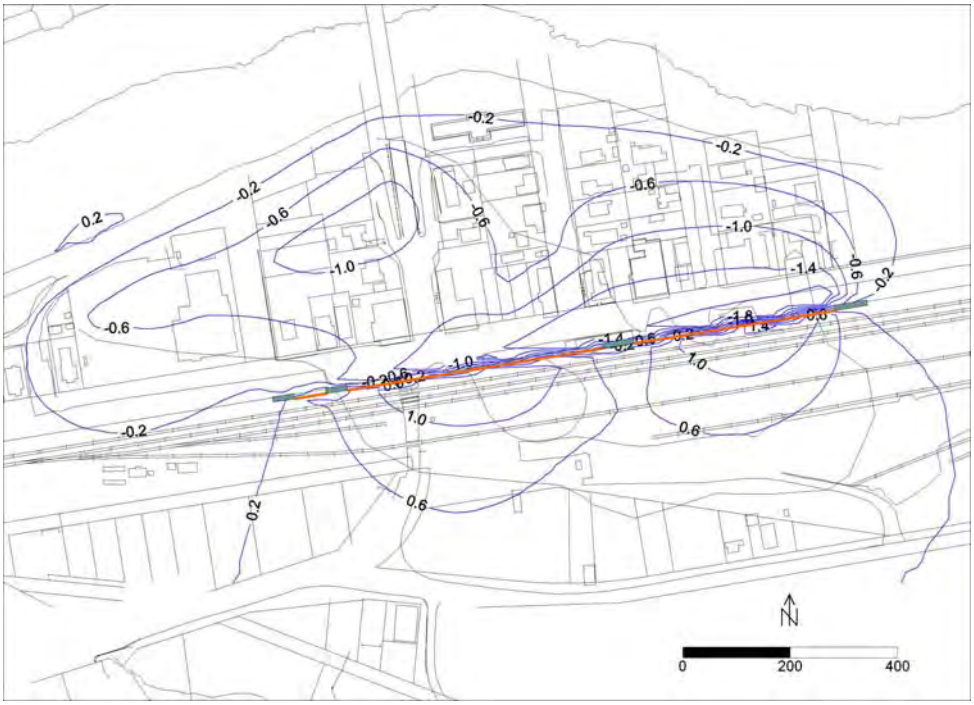

Figure 5. Change in groundwater levels during system shutdown under high water level conditions.

North of the wall, groundwater levels are reduced even during shutdown due to flow resistance around the ends of the wall and through the gates. The decline in water levels is less than during pumping, but is still on the order of 0.5 to 1.0 ft under much of the town. After excavations are completed in 2011, water levels will decline slightly on both sides of the wall, so the increase in water levels south of the wall shown in Figure 5 will be less after 2011.

Re-injection and Flushing

Re-injection of extracted and treated groundwater was evaluated with respect to two objectives:

- Enhanced flushing of soil in the rail yard
- Enhanced flushing in the free product area (see Figure 1)

Flushing in the rail yard was simulated by locating a line of injection wells upgradient of the rail yard and downgradient of the former Maloney Creek channel. Simulations indicated that only approximately 20 percent of extracted groundwater could be re-injected without causing loss of capture at the HCC gates. As seen in Figures 4 and 5, water levels do not change substantially in

the rail yard during either pumping or shutdown. Similarly, water levels do not change substantially in the rail yard due to injection upgradient of the rail yard. Consequently, the overall effect of upgradient flushing is minor due to the following conditions:

- The groundwater flux rate does not change substantially with only 20 percent re-injected groundwater and therefore does not materially affect expected cleanup timeframes.
- The water table does not increase substantially to enhance flushing of soils in the vadose zone.

While upgradient flushing does not achieve desired objects with respect to groundwater flushing, it does make capture and control of groundwater at the HCC wall more difficult. Consequently, upgradient flushing has limited benefit relative to potential adverse impacts.

Re-injection of extracted and treated groundwater in the free product area has two objectives:

- Reduce the potential for free product to pool against the wall
- Enhance free product collection in the free product area.

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As shown in Figure 3, this is accomplished by a combination of injection and extraction within the free product footprint. Flow paths for the injection/extraction network are shown in Figure 6.

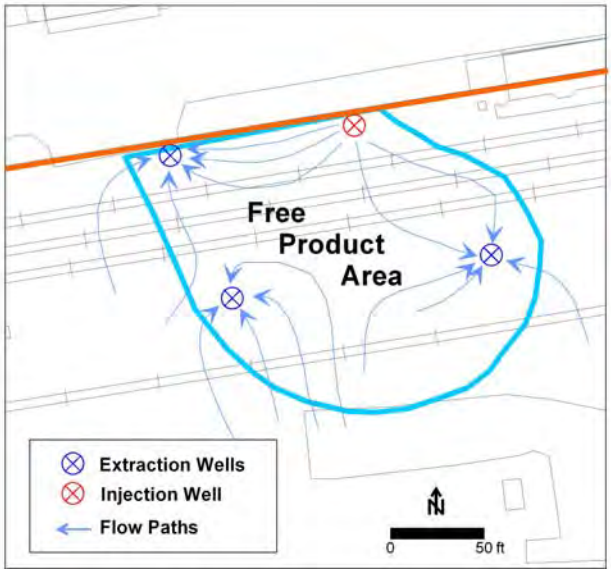

Figure 6. Detail of flow in the free product area with groundwater injection and extraction.

The flow paths show that water from the injection well will primarily flow to the eastern extraction well and the western extraction well located near the wall. Injected water will flow along the wall between the injection well and the western extraction well and reduce the potential for free product to poll against the wall. At the same time, the extraction wells will flush the free product area meeting both objectives of the injection/extraction system in the free product area.

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Appendix D

Manufacturers' Equipment Information/Cut Sheets – Field Equipment

Signet 2551 Magmeter Flow Sensor

Available in a variety of wetted materials and ideal for pipe sizes up to DN 300 (12 in.)

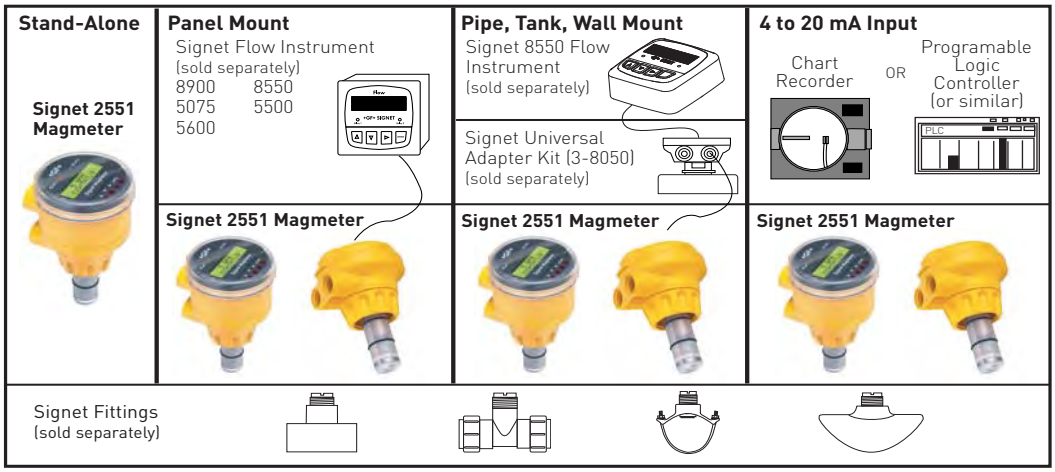
Description

The Signet 2551 Magmeter is an insertion style magnetic flow sensor that features no moving parts. The patented* sensor design is available in corrosion-resistant materials to provide long-term reliability with minimal maintenance costs. Material options include PP with stainless steel, PVDF with stainless steel, PVDF with Hastelloy-C, or PVDF with Titanium. Utilizing the comprehensive line of Signet installation fittings, sensor alignment and insertion depth is automatic. These versatile, simple-to-install sensors deliver accurate flow measurement over a wide dynamic range in pipe sizes ranging from DN15 to DN300 (0.5 to 12 inches), satisfying the requirements of many diverse applications.

Signet 2551 Magmeters offer many output options of frequency/digital (S^3L), 4 to 20 mA or relays which are available on both the blind and display versions. The frequency or digital (S^3L) sensor output can be used with Signet's extensive line of flow instruments while the 4 to 20mA output can be used for a direct input to PLCs, chart recorders, etc. Both the 4 to 20 mA output and digital (S^3L) sensor interface is available for long distance signal transmission of up to 1,000 ft. An additional benefit is the empty pipe detection which features a zero flow output when the sensors are not completely wetted. Also, the frequency output is bi-directional while the 4 to 20mA output can be set for uni- or bi-directional flow using the display or the RS232 set-up tool which connects to PCs for programming capabilities.

In addition the display version of the 2551 Magmeter is available with relays and features permanent and resettable total values which can be seen on the display. Also, the display contains multi-languages with English, Spanish, German, French, Italian and Portuguese menu options.

System Overview



Features

- **Patented Magmeter technology**
- **No moving parts**
- **Bi-directional flow**
- **Empty pipe detection**
- **Installs into pipe sizes DN 15 to DN 300 (0.5 to 12 in.)**
- **Flow rate range 0.05 to 10 m/s (0.15 to 33 ft/s)**
- **Accurate measurement even in dirty liquids**
- **Blind 4 to 20 mA, digital/frequency, relay output**
- **No pressure drop**
- **Corrosion resistant materials; PP or PVDF with SS, Hastelloy C, or Titanium**
- **Multi-language display menu available**

Applications

- **Chemical Processing**
- **Demineralization Regeneration**
- **Water and Waste Water Monitoring**
- **Metal Recovery and Landfill Leachate**
- **Commercial Pools, Spas, and Aquariums**
- **HVAC**
- **Irrigation**
- **Scrubber Control**
- **Neutralization Systems**
- **Industrial Water Distribution**

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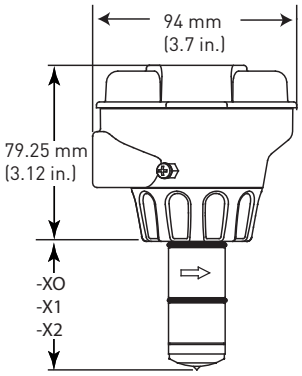
* U.S. Patent No: 7,055,396 B1

Dimensions

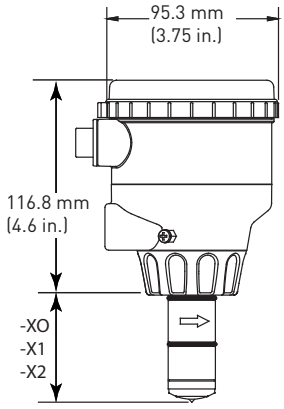
Blind Version



Pipe Range
1/2 to 4 in. -XO = 58 mm (2.3 in.)
5 to 8 in. -X1 = 91 mm (3.6 in.)
10 to 12 in. -X2 = 167 mm (6.6 in.)

X = Sensor Body P, T, V, or W

Display Version



Pipe Range
1/2 to 4 in. -XO = 58 mm (2.3 in.)
5 to 8 in. -X1 = 91 mm (3.6 in.)
10 to 12 in. -X2 = 167 mm (6.6 in.)

X = Sensor Body P, T, V, or W

Specifications

General

Pipe size range:DN15 to DN 300 (0.5 in. to 12 in.)
Flow Range
- Minimum: 0.05 m/s (0.15 ft/s)
- Maximum: 10 m/s (33 ft/s)

Linearity: ±1% reading plus 0.01m/s (0.033 ft/s)
Repeatability: ±0.5% of reading @ 25°C (77°F)
Minimum Conductivity: 20 µS/cm

Wetted Materials:

Sensor body/Electrodes and Grounding ring:
- -P0, -P1, -P2: Polypropylene/316LSS
- -T0, -T1, -T2: PVDF/Titanium
- -V0, -V1, -V2: PVDF/Hastelloy-C
- -W0, -W1, -W2: PVDF/316LSS

O-rings:
- FPM (standard)
- EPDM, Kalrez (optional)

Case: PBT
Display Window: Polyamide
Protection rating: NEMA 4X/IP65

Electrical

Power Requirements
- 4 to 20 mA: 21.6 to 26.4 VDC, 22.1 mA max.
- Frequency: 5 to 26.4 VDC, 15 mA max.
- Digital (S^3L): 5 to 6.5 VDC, 15 mA max.
- Auxiliary (only required for units with relays): 9 to 24 VDC, 0.4A max

Reverse polarity and short circuit protected

Current output (4 to 20 mA):
- Loop Accuracy: 32 µA max. error (25°C @ 24 VDC)
- Isolation: Low voltage < 48 VAC/DC from electrodes and auxiliary power
- Maximum cable: 300 m (1000 ft.)
- Error condition: 22.1 mA
- Max. Loop Resistance: 300Ω
- Compatible with PLC, PC or similar equipment

Frequency output:
- Output modes: Freq., Freq÷10 or Mirror Relay
- Max. Pull-up Voltage: 30 VDC
- Max. Current Sink: 50 mA, current limited
- Maximum cable: 300 m (1000 ft.)
- Compatible with Signet Model 5075, 5500, 5600, 8550, 8900

Digital (S^3L) Output:
- Serial ASCII, TTL level 9600 bps
- Compatible with Model Signet 8900 instrument

Relay Specifications
- #1, #2 Type: Mechanical SPDT
  Rating: 5A @ 30 VDC max.,
  5A @ 250 VDC max.
- #3 Type: Solid State
  Rating: 50mA @ 30 VDC,
  50mA @ 42 VAC

Hysteresis: User adjustable, plus timer delay
Trigger Delay: Adjustable (0 to 9999.9 sec.)

Relay Modes: Off, Low, High, Window, and Proportional Pulse
Relay Source: Flow Rate, Resettable Totalizer
Error Condition: Selectable; Fail Open or Closed

Display

Characters: 2 x 16
Contrast: User-set in four levels
Backlighting (only on relay versions):
Requires external 9-24 VDC, 0.4 mA max.

Environmental Requirements

Storage Temperature:
-20° to 70°C (-4° to 158°F)
Relative Humidity :
0 to 95% (non-condensing)
Operating Temperature
- Ambient: -10° to 70°C (14° to 158°F)
- Media: 0° to 85°C (32° to 185°F)

Max. operating pressure:
10.3 bar @ 25°C (150 psi @ 77°F)
1.4 bar @ 85°C (20 psi @ 185°F)

See Temperature and Pressure Graphs for more information

Standards and Approvals
- CE
- UL, CUL (for display versions with relays)

- NEMA 4X / IP65 Enclosure (with cap installed)
- EMC: EN55011: 1998 +A1:99+A2:02 Class B Emissions
  EN61326: 1997 +A1:98+A2:01
  EN61000-6-2:2001
- Safety: EN61010-1:2001
- U.S. Patent No. 7,055,396 B1

Ordering Information

Sensor Part No.					
3-2551					
	Sensor Body (Transducer) and electrodes/grounding ring materials - Choose one				
	-P	Polypropylene and 316L SS			
	-T	PVDF and Titanium			
	-V	PVDF and Hastelloy C			
	-W	PVDF and 316L SS			
		Pipe size - Choose one			
		0	DN15 to DN100 (1/2 to 4 in.)		
		1	DN125 to DN200 (5 to 8 in.)		
		2	DN250 to DN300 (10 to 12 in.)		
			Display Options - Choose One		
			-1	No Display	
			-2	With Display, two SPDT relays, one solid state relay	
			-4	With Display	
				Output options - Choose One	
				1	Frequency, Digital (S^3L)
				2	4 to 20 mA output
3-2551	**-P**	**0**	**-2**	**2**	**Example Part Number**

Application Tips:

- Note minimum process liquid conductivity requirement is 20 µs/cm
- Install sensor using standard Signet installation fittings for best results
- Sensor is capable of retrofitting into existing 515 and 2536 fittings.

Mfr. Part No.	Code
3-2551-P0-11	**159 001 105**
3-2551-P0-12	**159 001 110**
3-2551-P0-21	**159 001 267**
3-2551-P0-22	**159 001 273**
3-2551-P0-41	**159 001 261**
3-2551-P0-42	**159 001 279**
3-2551-P1-11	**159 001 106**
3-2551-P1-12	**159 001 111**
3-2551-P1-21	**159 001 268**
3-2551-P1-22	**159 001 274**
3-2551-P1-41	**159 001 262**
3-2551-P1-42	**159 001 280**
3-2551-P2-11	**159 001 107**
3-2551-P2-12	**159 001 112**
3-2551-P2-21	**159 001 435**
3-2551-P2-22	**159 001 438**
3-2551-P2-41	**159 001 432**
3-2551-P2-42	**159 001 441**
3-2551-T0-11	**159 001 108**
3-2551-T0-12	**159 001 113**
3-2551-T0-21	**159 001 436**
3-2551-T0-22	**159 001 439**
3-2551-T0-41	**159 001 433**
3-2551-T0-42	**159 001 442**
3-2551-T1-11	**159 001 109**
3-2551-T1-12	**159 001 114**
3-2551-T1-21	**159 001 437**
3-2551-T1-22	**159 001 440**
3-2551-T1-41	**159 001 434**
3-2551-T1-42	**159 001 443**
3-2551-T2-11	**159 001 448**
3-2551-T2-12	**159 001 449**
3-2551-T2-21	**159 001 454**
3-2551-T2-22	**159 001 455**
3-2551-T2-41	**159 001 460**
3-2551-T2-42	**159 001 461**

Mfr. Part No.	Code
3-2551-V0-11	**159 001 257**
3-2551-V0-12	**159 001 259**
3-2551-V0-21	**159 001 269**
3-2551-V0-22	**159 001 275**
3-2551-V0-41	**159 001 263**
3-2551-V0-42	**159 001 281**
3-2551-V1-11	**159 001 258**
3-2551-V1-12	**159 001 260**
3-2551-V1-21	**159 001 270**
3-2551-V1-22	**159 001 276**
3-2551-V1-41	**159 001 264**
3-2551-V1-42	**159 001 282**
3-2551-V2-11	**159 001 450**
3-2551-V2-12	**159 001 451**
3-2551-V2-21	**159 001 456**
3-2551-V2-22	**159 001 457**
3-2551-V2-41	**159 001 462**
3-2551-V2-42	**159 001 463**
3-2551-W0-11	**150 001 230**
3-2551-W0-12	**159 001 231**
3-2551-W0-21	**159 001 271**
3-2551-W0-22	**159 001 277**
3-2551-W0-41	**159 001 265**
3-2551-W0-42	**159 001 283**
3-2551-W1-11	**159 001 232**
3-2551-W1-12	**159 001 233**
3-2551-W1-21	**159 001 272**
3-2551-W1-22	**159 001 278**
3-2551-W1-41	**159 001 266**
3-2551-W1-42	**159 001 284**
3-2551-W2-11	**159 001 452**
3-2551-W2-12	**159 001 453**
3-2551-W2-21	**159 001 458**
3-2551-W2-22	**159 001 459**
3-2551-W2-41	**159 001 464**
3-2551-W2-42	**159 001 465**

Accessories and Replacement Parts

Mfr. Part No.	Code	Description
O-Rings		
1220-0021	**198 801 186**	O-ring, FPM (Viton®)
1224-0021	**198 820 006**	O-ring, EPDM
1228-0021	**198 820 007**	O-ring, FFPM (Kalrez®)
Replacement Transducers		
3-2551-P0	**159 001 211**	PP/316LSS, DN15 to DN100 (0.5 to 4 in.) pipe
3-2551-P1	**159 001 212**	PP/316LSS, DN125 to DN200 (5 to 8 in.) pipe
3-2551-P2	**159 001 444**	PP/316LSS, DN250 to DN300 (10 to 12 in.) pipe
3-2551-T0	**159 001 213**	PVDF/Titanium, DN15 to DN100 (0.5 to 4 in.) pipe
3-2551-T1	**159 001 214**	PVDF/Titanium, DN125 to DN200 (5 to 8 in.) pipe
3-2551-T2	**159 000 445**	PVDF/Titanium, DN250 to DN300 (10 to 12 in.) pipe
3-2551-V0	**159 001 376**	PVDF/Hastelloy-C, DN15 to DN100 (0.5 to 4 in.) pipe
3-2551-V1	**159 001 377**	PVDF/Hastelloy-C, DN125 to DN200 (5 to 8 in.) pipe
3-2551-V2	**159 000 446**	PVDF/Hastelloy-C, DN250 to DN300 (10 to 12 in.) pipe
3-2551-W0	**159 001 234**	PVDF/316LSS, DN15 to DN100 (0.5 to 4 in.) pipe
3-2551-W1	**159 001 235**	PVDF/316LSS, DN125 to DN200 (5 to 8 in.) pipe
3-2551-W2	**159 001 447**	PVDF/316LSS, DN250 to DN300 (10 to 12 in.) pipe
Replacement Electronics Module		
3-2551-11	**159 001 215**	Magmeter electronics, frequency or digital (S^3L) output
3-2551-12	**159 001 215**	Magmeter electronics, 4 to 20mA output
3-2551-21	**159 001 372**	Magmeter Display Electronics, frequency or digital (S^3L) output
3-2551-22	**159 001 373**	Magmeter Display Electronics, 4 to 20mA output, w/relays
3-2551-41	**159 001 374**	Magmeter Display Electronics, frequency or digital (S^3L) output, w/relays
3-2551-42	**159 001 375**	Magmeter Display Electronics, 4 to 20mA output
Other		
7300-7524	**159 000 687**	24VDC Power Supply 7.5W, 300mA
7300-1524	**159 000 688**	24VDC Power Supply 15W, 600mA
7300-3024	**159 000 689**	24VDC Power Supply 30W, 1.3A
7300-5024	**159 000 690**	24VDC Power Supply 50W, 2.1A
7300-1024	**159 000 691**	24VDC Power Supply 100W, 4.2A
3-8551.521	**159 001 378**	Clear plastic cap for display
1222-0042	**159 001 379**	O-ring for clear plastic cap, EPDM

Please refer to Wiring, Installation, Accessories and Fittings sections for more information.

Signet 8550 Flow Transmitters

Member of the ProcessPro® Family of Instruments

Panel Mount

Pipe, Wall, Tank and Integral Mount

Features

- **2 or 4 wire power**
- **Available with single or dual input/output**
- **4 to 20 mA Scaleable outputs**
- **Permanent & reset-table totalizers**
- **Relay options available**
- **NEMA 4X enclosure with self-healing window**
- **Output simulation for complete system testing**

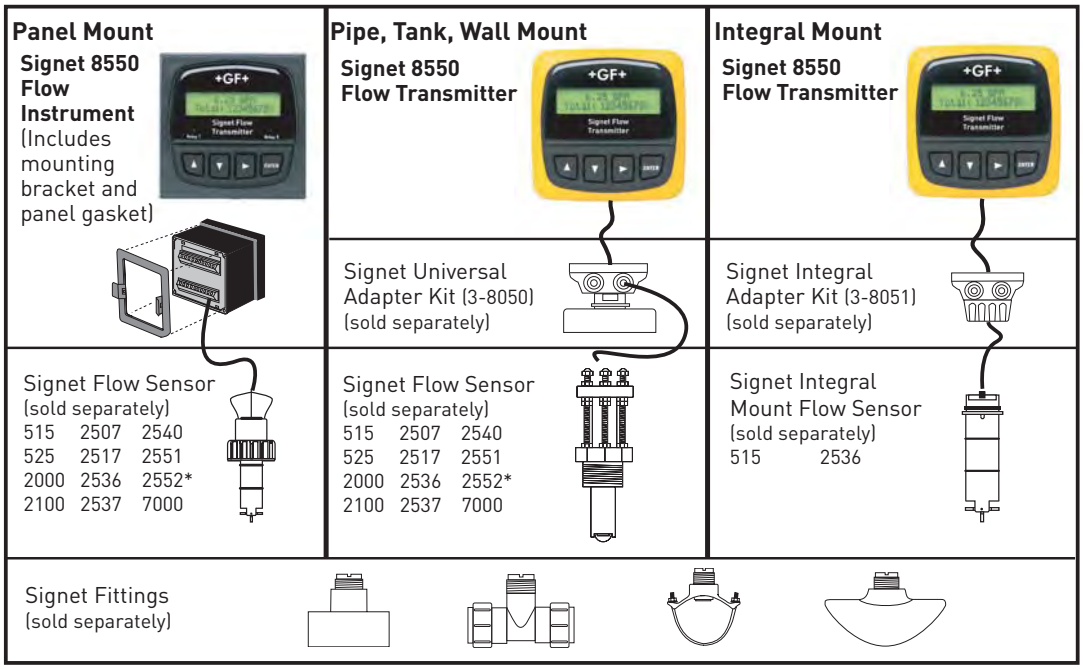
Description

Signet 8550 Flow Transmitters are advanced instruments that convert the signal from all Signet flow sensors into a 4 to 20 mA signal for long distance transmission. Configuration flexibility is maximized with single or dual input/output, two optional relays for process control, two packaging options for integral/pipe mount or panel installation, and scalability for virtually any flow range or engineering unit. State-of-the-art electronic design ensures long-term reliability, signal stability, and simple user setup and operation.

Applications

- **Flow control and monitoring**
- **Filtration or softener regeneration**
- **Effluent totalization**
- **Pump protection**
- **Feed pump pulsing**
- **Ratio control**
- **Water distribution**
- **Leak detection**

System Overview

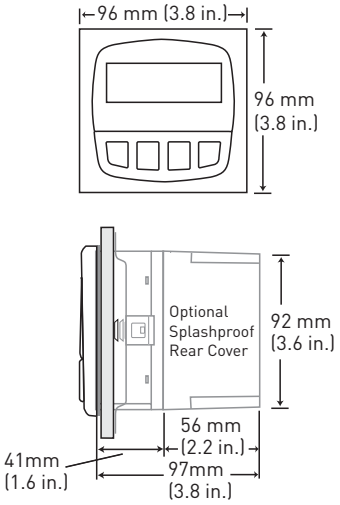


*Contact your local Georg Fischer Sales Office for availability

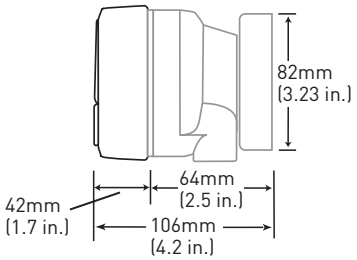
+GF+

Dimensions

3-8550-XP



Field version with universal mount



Model 8550 Ordering Notes:

1) Use the field mount version to directly mount the instrument to the Model 515 or 2536 integral mount sensor. See sensor data sheet for more information.
2) Field mount and sensor can be ordered in a package. See Integral Mount for more information.
3) Panel Cutout should be 92 mm X 92 mm (3.62 in X 3.62 in.).
4) An optional splash proof rear cover for the panel mount version can be ordered seperately if needed.

Please refer to Wiring, Installation, and Accessories sections for more information.

Specifications

General

Compatibility:
Signet Flow Sensors with frequency outputs (all except 7001)
Accuracy: ± 0.5% of reading @ 25°C
Display: Alphanumeric 2 x 16 LCD
Update rate: 1 second
Contrast: User selectable, 5 levels

Materials

- Enclosure: PBT
- Panel Case Gasket: Neoprene
- Window: Polyurethane coated polycarbonate
- Keypad: Sealed 4-key silicone rubber

Electrical

Power: 12 to 24 VDC ±10%, regulated
(-1) 61 mA max.; (-2) 200 mA max.;
(-3) 122 mA max.
Sensor Input range: 0.5 to 1500 Hz
Sensor power:

- 2-wire: 5 VDC ± 1% @ 1.5 mA
- 3 or 4 wire: 5 VDC ± 1% @ 20 mA
Optically isolated from current loop
Short circuit protected

Current output

- 4 to 20 mA, isolated, passive, fully adjustable and reversible
- Max loop impedance:
50Ω max. @ 12 V
325Ω max. @ 18 V
600Ω max. @ 24 V
- Update rate: 100 ms
- Accuracy: ±0.03 mA

Electrical (continued)

Relay output

- Mechanical SPDT contacts: Hi, Lo, Pulse, Off
- Maximum voltage rating:
30VDC @ 5A , 250 VAC @ 5A resistive load
- Hysteresis: User selectable
- Maximum 300 pulses/min.

Open-collector output :
Hi, Lo, Pulse, Off

- Open-collector, optically isolated, 50 mA max. sink, 30 VDC max. pull-up voltage.
- Hysteresis: User selectable
- Maximum 300 pulses/min.

Environmental

Rating: NEMA 4X/IP65 (front)
Operating temperature:
-10°C to 70°C (14°F to 158°F)
Storage temperature:
-15°C to 80°C (5°F to 176°F)
Relative humidity:
0 to 95%, non-condensing

Shipping Weight: 0.325kg (0.8 lbs.)

Standards and Approvals

- CE, UL, CUL listed
- Manufactured under ISO 9001:2000 for Quality and ISO 14001:2004 for Environmental Management

Ordering Information

Instrument Part Number			
3-8550	ProcessPro® Flow Transmitter		
	Sensor input, sensor power, outputs - choose one		
	-1		One input, 2 or 4 wire, 4 to 20 mA and open collector for Hi, Lo, Pulse, or Frequency
	-2		One input, 4 wire, 4 to 20 mA and 2 relays for Hi, Lo, or Pulse
	-3		Two inputs, 2 or 4 wire, two 4 to 20 mA ouputs and 2 open collectors for Hi, Lo, Pulse, or Freq.
		Field or Panel mount - choose one	
		-	Field mount
		P	Panel mount; includes mounting bracket and panel gasket
3-8550	**- 1**		**Example Part Number - Field mount**
3-8550	**- 2**	**P**	**Example Part Number - Panel mount**

Mfr. Part No.	Code
3-8550-1	**159 000 047**
3-8550-1P	**159 000 048**
3-8550-2	**159 000 049**
3-8550-2P	**159 000 050**
3-8550-3	**159 000 051**
3-8550-3P	**159 000 052**

Accessories and Replacement Parts

Mfr. Part No.	Code	Description
Mounting Accessories		
3-8050	**159 000 184**	Universal mounting kit
3-8051	**159 000 187**	Flow Integral Mount NPT
3-0000.596	**159 000 641**	Heavy duty wall mount bracket
3-5000.598	**198 840 225**	Surface Mount Bracket
3-8050.395	**159 000 186**	Splashproof rear cover
Liquid tight connectors and other		
3-9000.392	**159 000 368**	Liquid tight connector kit for rear cover (includes 3 connectors)
3-9000.392-1	**159 000 839**	Liquid tight connector kit, NPT (1 piece)
3-9000.392-2	**159 000 841**	Liquid tight connector kit, PG13.5 (1 piece)
3-8050.396	**159 000 617**	RC Filter kit (for relay use)

Signet 8550-1 Flow Transmitter

English

3-8550.090-1 Rev L 6/06 English

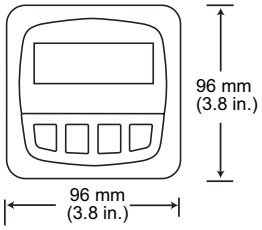
WARNING!
- Remove power to unit before wiring input and output connections.
- Follow instructions carefully to avoid personal injury.

Contents

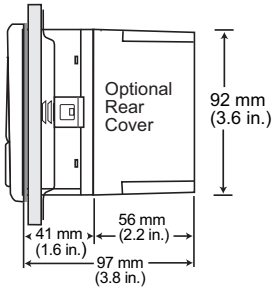
1. Specifications
2. Installation
3. Electrical Connections
4. Menu Functions

1. Specifications

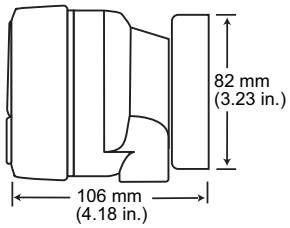
Dimensions



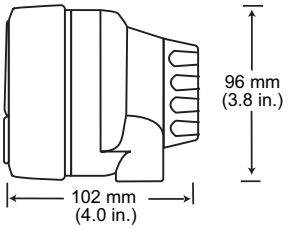
FRONT VIEW
Field Mount &
Panel Mount



SIDE VIEW
Panel Mount



SIDE VIEW
Field Mount w/
8050 Universal base



SIDE VIEW
Field Mount w/
8051 Integral kit

General
Compatibility: Signet Flow Sensors (w/freq out)

Enclosure:
- Rating: NEMA 4X/IP65 front
- Case: PBT
- Panel case gasket: Neoprene
- Window: Polyurethane coated polycarbonate
- Keypad: Sealed 4-key silicone rubber
- Weight: Approx. 325g (12 oz.)

Display:
- Alphanumeric 2 x 16 LCD
- Update rate: 1 second
- Contrast: User selected, 5 levels
- Display accuracy: ±0.5% of reading @ 25ºC
- Thermal sensitivity shift: ±0.005% of reading per ºC

Electrical
- Power: 12 to 24 VDC ±10%, regulated
  61 mA max current

Sensor Input:
- Range: 0.5 to 1500 Hz
- Sensor power: 2-wire: 1.5 mA @ 5 VDC ± 1%
  3 or 4 wire: 20 mA @ 5 VDC ± 1%
  Optically isolated from current loop
- Short circuit protected

Current output:
- 4 to 20 mA, isolated, fully adjustable and reversible
- Max loop impedance: 50 Ω max. @ 12 V
  325 Ω max. @ 18 V
  600 Ω max. @ 24 V
- Update rate: 100 ms
- Accuracy: ±0.03 mA

Open-collector output, optically isolated:
- 50 mA max. sink, 30 VDC maximum pull-up voltage.
- Programmable for:
  - High or Low setpoint with adjustable hysteresis
  - Pulse operation (max rate: 300 pulses/min).

Environmental
- Operating temperature: -10 to 70°C (14 to 158°F)
- Storage temperature: -15 to 80°C (5 to 176°F)
- Relative humidity: 0 to 95%, non-condensing
- Maximum altitude: 2000 m (6562 ft)
- Insulation category: II
- Pollution degree: 2

Standards and Approvals
- CE, UL listed
- Immunity & Emissions: EN61326
- Manufactured under ISO 9001 and ISO 14001

2. Installation

ProcessPro transmitters are available in two styles: panel mount and field mount. The panel mount is supplied with the necessary hardware to install the transmitter. This manual includes complete panel mounting instructions.
Field mounting requires one of two separate mounting kits. The 3-8051 integral kit joins the sensor and instrument together into a single package. The 3-8050 Universal kit enables the transmitter to be installed virtually anywhere.
Detailed instructions for integral mounting or other field installation options are included with the 3-8051 Integral kit or the 3-8050 Universal kit.

2.1 Panel Installation

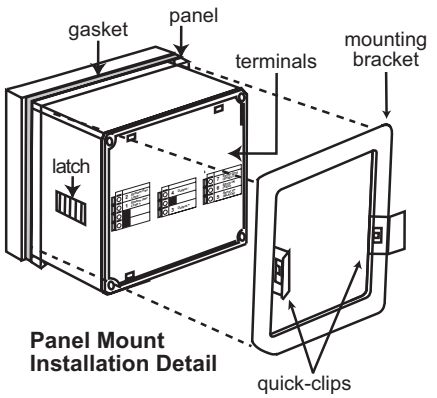
1. The panel mount transmitter is designed for installation using a 1/4 DIN Punch. For manual panel cutout, an adhesive template is provided as an installation guide. Recommended clearance on all sides between instruments is 1 inch.

2. Place gasket on instrument, and install in panel.

3. Slide mounting bracket over back of instrument until quick-clips snap into latches on side of instrument.

4. To remove, secure instrument temporarily with tape from front or grip from rear of instrument. DO NOT RELEASE.

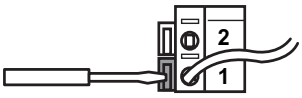
Press quick-clips outward and remove.



Panel Mount Installation Detail

3. Electrical Connections

Caution: Failure to fully open terminal jaws before removing wire may permanently damage instrument.



Wiring Procedure

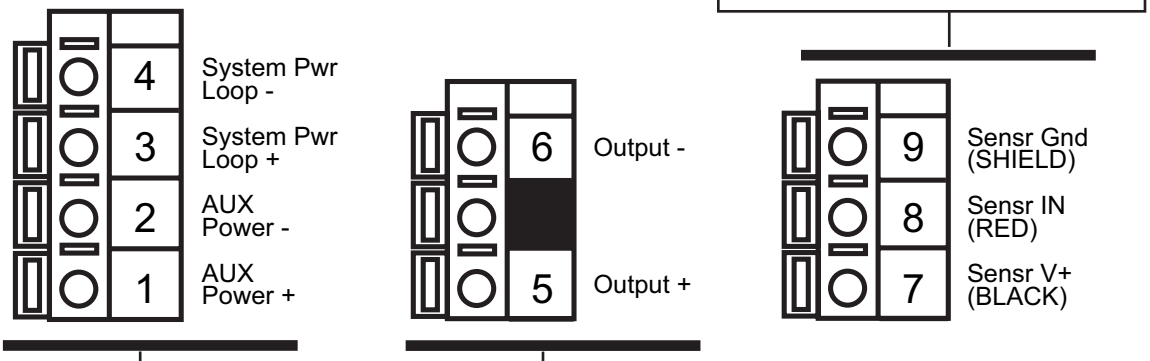
1. Remove 0.5 - 0.625 in. (13-16 mm) of insulation from wire end.
2. Press the orange terminal lever downward with a small screwdriver to open terminal jaws.
3. Insert exposed (non-insulated) wire end in terminal hole until it bottoms out.
4. Release orange terminal lever to secure wire in place. Gently pull on each wire to ensure a good connection.

Wiring Removal Procedure

1. Press the orange terminal lever downward with a small screwdriver to open terminal jaws.
2. When fully open, remove wire from terminal.

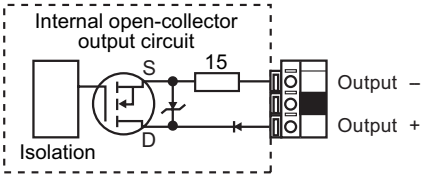
Terminals 3 and 4: Loop Power
12-24 VDC ±10% system power and current loop output.
Max. loop impedance:
50 Ω max. @ 12 V
325 Ω max. @ 18 V
600 Ω max. @ 24 V

Terminals 7-9: Flow sensor input



Terminals 1 and 2: AUXILIARY power
Used only if the flow sensor requires more than 1.5 mA current. For Signet sensors this is limited to the following products:

- 2000
- 2507
- 2551
- Open Collector Input

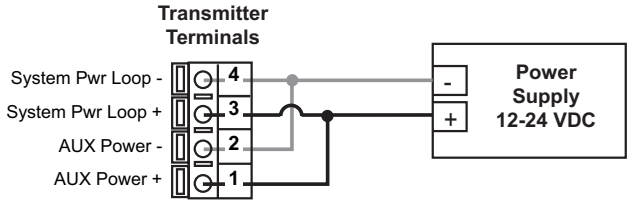


Terminals 5 and 6: Open-collector Output
A transistor output, programmable (see CALIBRATE menu) as:

- High or Low setpoint with adjustable hysteresis
- Volumetric pulse
- Frequency based on flow rate
- May be disabled (Off) if not used.

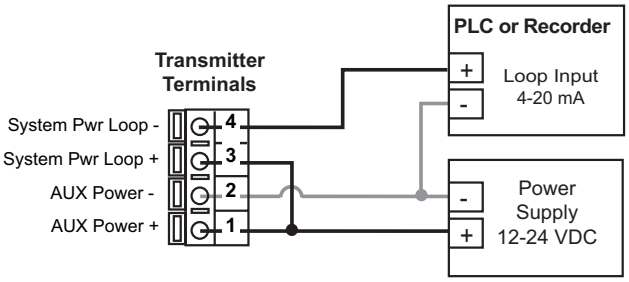
3.1 System Power/Loop Connections

Stand-alone application, no current loop used



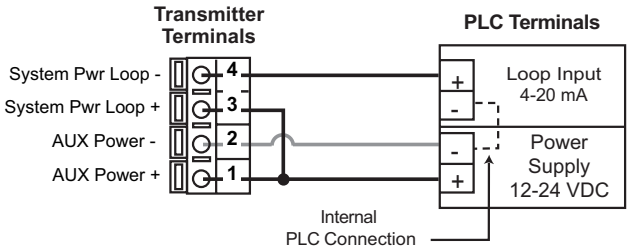
* See AUX POWER Note

Connection to a PLC/Recorder, separate supply



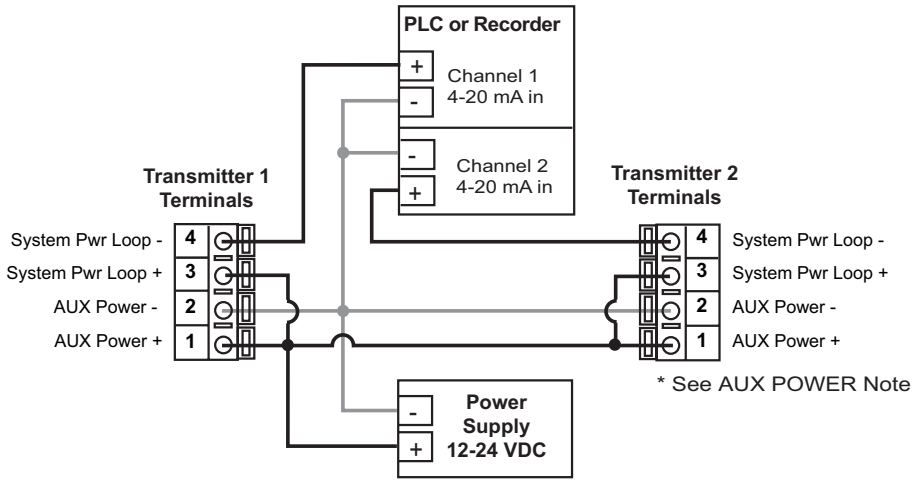
* See AUX POWER Note

Connection to a PLC with built-in power supply



* See AUX POWER Note

Example: Two transmitters connected to PLC/Recorder with separate power supply



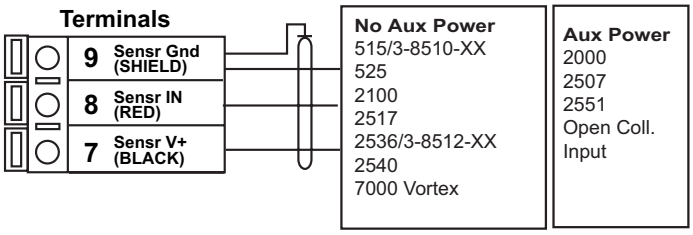
* See AUX POWER Note

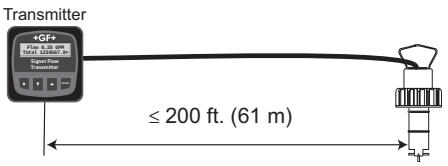
Auxiliary Power note:
AUXILIARY power is used only if the flow sensor requires more than 1.5 mA current.
For Signet sensors this is limited to the following products: 2000, 2507, 2551, open collector input signals.

3.2 Sensor Input Connections

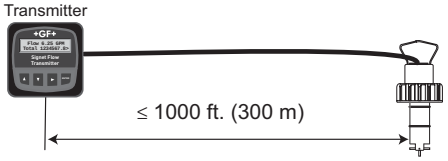
Wiring Tips:

- Do not route sensor cable in conduit containing AC power wiring. Electrical noise may interfere with sensor signal.
- Routing sensor cable in grounded metal conduit will help prevent electrical noise and mechanical damage.
- Seal cable entry points to prevent moisture damage.
- Only one wire should be inserted into a terminal. Splice double wires outside the terminal.





Maximum cable length is 200 ft. for 515/8510-XX, 525 , 2517 and any sinusoidal flow signal.



Maximum cable length is 1000 ft. for 2536/8512-XX, 2540, vortex, and any open collector flow signal.

3.3 Open Collector Output

The Open collector output can be used as a switch that responds when the flow rate moves above or below a setpoint, or it can be used to generate a pulse that is relative to the flow volume or to the flow rate.

- **Low**

Output triggers when the flow rate is less than the setpoint. The output will relax when the flow rate moves above the setpoint plus the hysteresis value.

- **High**

Output triggers when the flow rate is greater than the setpoint. The output will relax when the flow rate drops below the setpoint plus the hysteresis value.

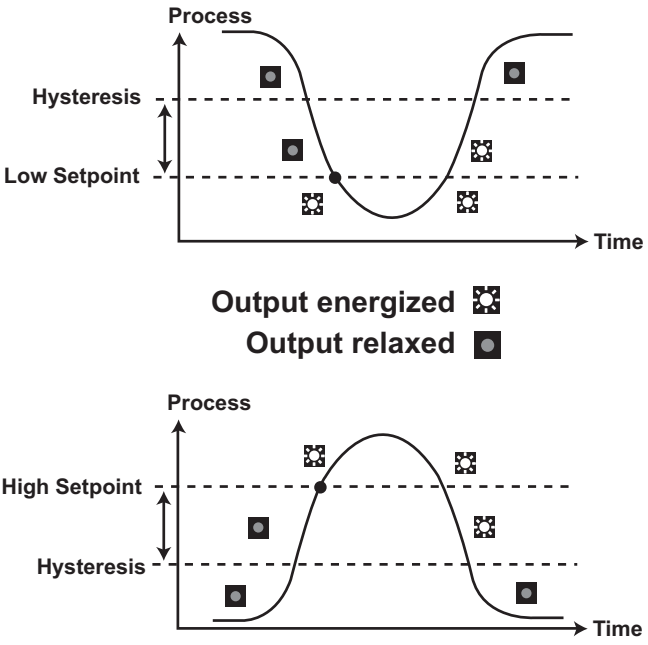
- **Frequency**

Output is a pulse stream that is based on the input flow sensor signal. Set for 1 (input frequency = output frequency). Set for even numbers (2, 4, 6, 8 . . . . 254 maximum) to scale output frequency.

- **Pulse**

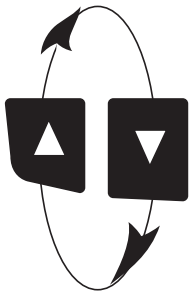
Output is a pulse based on the volume of fluid that passes the sensor. Set any value from 0.0001 to 99999.

The output may be disabled (Off) if not used.



VIEW menu

- During normal operation, the ProcessPro displays the VIEW menu.
- When using the CALIBRATE or OPTIONS menus, the ProcessPro will return to the VIEW menu if no activity occurs for 10 minutes.
- To select the item you want displayed, press the UP or DOWN arrow keys. The items will scroll in a continuous loop. Changing the display selection does not interrupt system operations.
- No key code is necessary to change display selection.
- Output settings cannot be edited from the VIEW menu.



View Menu

Display	Description
`0.0 GPM` `Total: 12345678 >`	Monitor the flow rate and the resettable totalizer. Press the RIGHT ARROW key to reset the totalizer. If the Reset is locked, you will need to enter the Key Code first. Lock or Unlock the totalizer in the OPTIONS menu. This is the permanent View display.

All of the displays below are temporary. After ten minutes the display will return to the permanent display.

`Perm: 12345678` `Gallons`	Monitor the Permanent Totalizer value.
`Loop Output:` `12.00 mA`	Monitor the 4-20 mA Loop output.
`Last CAL:` `04-20-06`	Monitor date for scheduled maintenance or date of last calibration. (See description in Calibrate Menu.)

ProcessPro Editing Procedure:

Step 1. Press and hold ENTER key:
- 2 seconds to select the CALIBRATE menu
- 5 seconds to select the OPTIONS menu.

Step 2. The Key Code is UP-UP-UP-DOWN keys in sequence.
- After entering the Key Code, the display will show the first item in the selected menu.

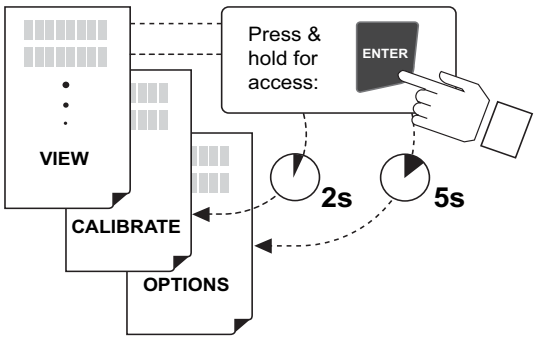
Step 3. Scroll menu with UP or DOWN arrow keys.

Step 4. Press RIGHT ARROW key to select menu item to be edited.
- The first display element will begin flashing.

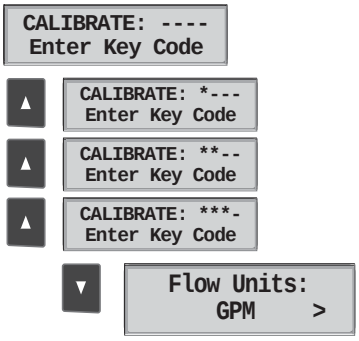
Step 5. Press UP or DOWN keys to edit the flashing element.
- RIGHT ARROW key advances the flashing element.

Step 6. Press ENTER key to save the new setting and return to Step 3.

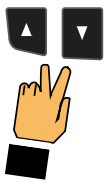
Notes on Step 1:
- The View Menu is normally displayed.
- The CALIBRATE and OPTIONS menus require a KEY CODE.



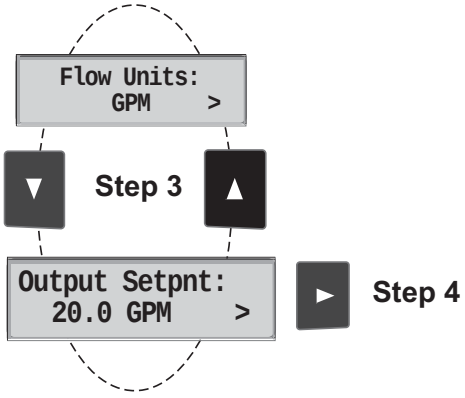
Notes on Step 2:
If no key is pressed for 5 minutes while display is showing "Enter Key Code", the display will return to the VIEW menu.



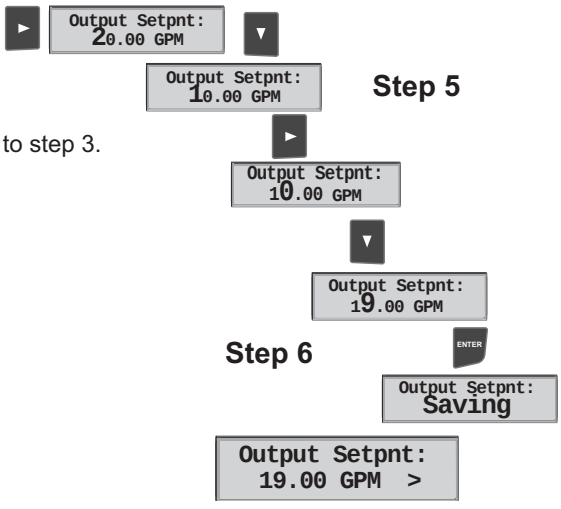
Notes on Steps 3 and 4:
- Refer to pages 6 and 7 for complete listing of menu items and their use.
- From the Step 3 display, pressing the UP and DOWN keys simultaneously will return the display to the VIEW menu.
- If no key is pressed for 10 minutes, display will also return to the VIEW menu.



Step 3: Finished Editing?
Press the UP and DOWN keys simultaneously after saving the last setting to return to normal operation.



Notes on Steps 5 and 6:
- All output functions remain active during editing.
- Only the flashing element can be edited.
- RIGHT ARROW key advances the flashing element in a continuous loop.
- Edited value is effective immediately after pressing ENTER key.
- If no key is pressed for 10 minutes unit will restore the last saved value and return to step 3.
- Step 6 (pressing ENTER key) always returns you to Step 3.
- Repeat steps 3-6 until all editing is completed.



Step 5: Made an Error?

Press the UP and DOWN keys simultaneously while any element is flashing. This will recall the last saved value of the item being edited and return you to Step 3.

Calibrate Menu

Display (Factory settings shown)	Description
Flow Units: GPM >	The first three characters set the Flow Rate units of measure. They have no effect on calculations. They may be any alpha or numeric character, upper or lower case. The last character sets the Flow rate Timebase. Select S (seconds), M (minutes), H (hours) or D (days).
Flow K-Factor: 60 >	This setting tells the transmitter how to convert the input frequency from the flow sensor into a flow rate. The K-factor is unique to the sensor model and to the pipe size and schedule. Refer to data in the sensor manual for the correct value. Limits: 0.0001 to 99999. (The K-factor cannot be set to 0)
Total Units: Gallons >	This setting identifies the Totalizer units. It has no effect on any calculation. It serves as a label only. Each character can be any alpha or numeric selection, upper or lower case.
Total K-Factor 60 >	This setting tells the transmitter how to convert the input frequency from the flow sensor into a volumetric total. It also is used as the basis for the Open Collector pulse mode. The setting is usually the same as the Flow K-factor, or different by x10 or x100. Limits: 0.0001 to 99999. (The K-factor cannot be set to 0)
Loop Range: GPM 000.00 → 100.00 >	Select the minimum and maximum values for the 4-20 mA Current loop output. The 8550 will allow any values from 0.0000 to 99999.
Output Mode: Low >	Select the desired mode of operation for the Open Collector output. Options available are High, Low, volumetric Pulse, or Frequency. The signal may be disabled (Off) if not used.
Output Setpnt: 10.0 GPM >	In Low or High Mode, the Open Collector output will be activated when the Flow rate reaches this value. Be sure to modify this setting if you change the Flow Units.
Output Hys: 5.0 GPM >	The Open Collector output will be deactivated at Setpoint ± Hysteresis, depending on High or Low Setpoint selection. (See details on page 4.)
Output Volume: 100.00 Gallons >	In Pulse mode, the Open collector output will generate one pulse when this volume of flow passes the sensor. The measurement is based on the Total K-factor. The 8550 will allow any value from 0.0001 to 99999.
Output PlsWdth: 0.1 Seconds >	In Pulse mode, this setting defines the duration of the Open Collector output pulse. The 8550 allows any value from 0.1 seconds to 999.9 seconds.
Output Freq.: Divide by 1 >	In Frequency mode, the Open Collector output will simulate the sensor frequency, divided by this setting. Set for 1 (input frequency = output frequency). Set for even numbers (2, 4, 6, 8 . . . 254 maximum) to scale output frequency.
Last CAL: 4-20-06	Use this “note pad” to record important dates, such as annual recertification or scheduled maintenance.

Options Menu

Display (Factory settings shown)	Description
Contrast: 3 >	Adjust the LCD contrast for best viewing. A setting of 1 is lower contrast, 5 is higher. Select lower contrast if the display is in warmer ambient surroundings.
Flow Decimal *****. >	Set the decimal to the best resolution for your application. The display will automatically scale up to this restriction. Select *****., ****.*, ***.**, **.*** or *.****
Total Decimal ******.** >	Set the totalizer decimal to the best resolution for your application. Select ********., *******.*, or ******.**
Averaging: Off >	OFF provides the quickest output response to changes in flow. Longer averaging period produces more stable display and output response. Select OFF, 8 s, 20 s, 50 s or 120 s.
Sensitivity 0 >	Sensitivity works in conjunction with Averaging to balance response time with signal stability. Selections are 0 to 9. Select 0 (zero) for the minimum sensitivity, or 9 for the maximum sensitivity. The function is described below.
Total Reset: Lock Off >	Lock Off : No key code required to reset the resettable totalizer. Lock On : The Key Code must be entered to reset the resettable totalizer.
Loop Adjust: 4.00 mA > Loop Adjust: 20.00 mA >	Adjust the minimum and maximum current output. The display value represents the precise current output. Adjustment limits: • 3.80 mA < 4.00 mA > 5.00 mA • 19.00 mA < 20.00 mA > 21.00 mA Use this setting to match the system output to any external device.
Output Active: Low >	Active HIGH: This setting is used to turn a device (pump, valve) ON at the setpoint. Active LOW: This setting is used to turn a device OFF at the setpoint.
Test Loop: >	Press UP or DOWN keys to manually order any output current value from 3.6 mA to 21.00 mA to test current loop output.
Test Output: >	Press UP or DOWN keys to manually toggle the state of open collector output.

No AVERAGING, no SENSITIVITY

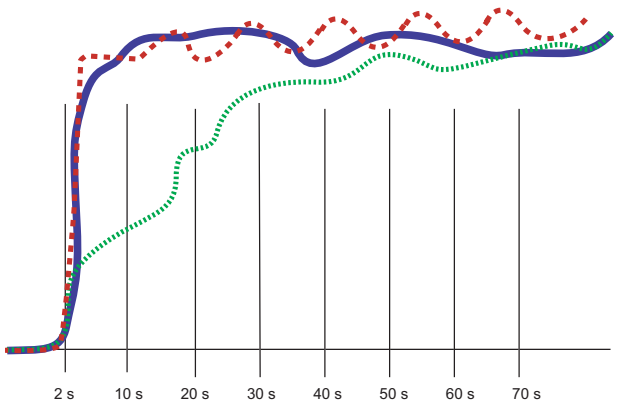
With AVERAGING set to 0 (zero) and with SENSITIVITY set to zero, the 8550 responds to every unstable shift in the flow. The dashed red line represents the actual output of the flow sensor in unstable flow conditions.

AVERAGING only

With AVERAGING set to 50 seconds and SENSITIVITY still set to zero the flow rate is stabilized, but a sharp change in flow rate is not represented for 50 seconds or longer. (dotted green line).

AVERAGING and SENSITIVITY

With AVERAGING at 50 seconds and SENSITIVITY set to 4 OR 5, the flow rate is stabilized, while the sudden shift in flow is reflected very quickly. (Solid blue line)



NOTE: The SENSITIVITY function is ineffective if the AVERAGING function is set to zero (seconds).

Troubleshooting

Display Condition	Possible Causes	Suggested Solutions
"- - - - -"	Flow rate exceeds display capability	• Increase Flow units time base • Move flow decimal one place to the right
"Pulse Overrun"	• Open Collector pulse rate exceeds maximum of 300 pulses per minute. • Pulse width set too wide.	• Increase Pulse volume setting • Decrease pulse width setting. • Reduce system flow rate
"Value must be more than 0"	K-factors cannot be set to 0.	Enter K-factor from 0.0001 to 99999
Open Collector is always activated	• Hysteresis value too large • Defective transmitter	• Change the hysteresis value • Replace transmitter

Ordering Information

Mfr. Part No.	Code	Description
3-8550-1	159 000 047	Flow transmitter, Field mount
3-8550-1P	159 000 048	Flow transmitter, Panel mount
3-8550-2	159 000 049	Flow transmitter, Field mount with relays
3-8550-2P	159 000 050	Flow transmitter, Panel mount with relays
3-8550-3	159 000 051	Flow transmitter, Field mount with dual input/output
3-8550-3P	159 000 052	Flow transmitter, Panel mount with dual input/output

Accessories

Mfr. Part No.	Code	Description
3-8050	159 000 184	Universal mounting kit
3-8051	159 000 187	Flow Integral Mnt NPT
3-8050.395	159 000 186	Splashproof rear cover
3-8050.396	159 000 617	RC Filter kit (for relay use)
3-0000.596	159 000 641	Heavy duty wall mount bracket
3-5000.598	198 840 225	Surface Mount Bracket
3-5000.399	198 840 224	5 x 5 inch adapter plate for Signet retrofit
3-9000.392	159 000 368	Liquid tight connector kit for rear cover (includes 3 connectors)
3-9000.392-1	159 000 839	Liquid tight connector kit, NPT (1 piece)
3-9000.392-2	159 000 841	Liquid tight connector kit, PG13.5 (1 piece)
7300-7524	159 000 687	24 VDC Power Supply 7.5 W, 300mA
7300-1524	159 000 688	24 VDC Power Supply 15 W, 600mA
7300-3024	159 000 689	24 VDC Power Supply 30 W, 1.3 A
7300-5024	159 000 690	24 VDC Power Supply 50 W, 2.1 A
7300-1024	159 000 691	24 VDC Power Supply 100 W, 4.2 A

+GF+

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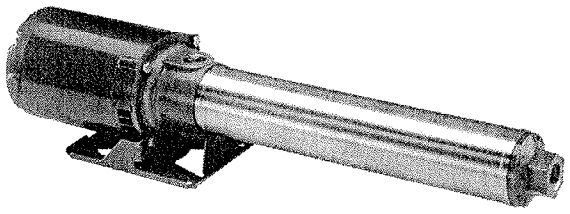
ITT

Residential Water Systems

Goulds Pumps

5GB, 7GB, 10GB, 18GB, 25GB, 33GB

High Pressure Multi-Stage Booster Pump



FEATURES

- **Multi-stage Design:** Provides steady, quiet, vibration free, operation.
- **Optional Stainless Steel Construction:** Standard cast iron for general service or stainless for filtration applications.
- **O-Ring Casing Seal:** Reliable high pressure sealing with easy disassembly for maintenance or repair.
- **Impellers and Diffusers:** Glass filled engineered composite material with a fixed impeller design. High resistance to corrosion and abrasion.
- **Bowls:** 300 stainless steel rabbit lock for positive alignment with no gaskets required.
- **Variable Capacity:** Centrifugal pump design permits selection of flow within a range for each size.
- **Mechanical Seal:** A variety of face materials and elastomers to match application needs.
- **Motors:** Close coupled NEMA 56J motors in open drip proof or totally enclosed design. Single phase and three phase available. Ball bearings carry all radial and axial thrust loads. Designed for continuous operation.

GOULDS PUMPS

Goulds Pumps is a brand of ITT Corporation.

www.goulds.com

Engineered for life

APPLICATIONS

- Residential, commercial or agricultural pressure wash
- Reverse osmosis
- Evaporative cooling systems/misters
- Booster service
- Spray systems
- Water circulation
- Filtration
- HVAC
- General purpose pumping

SPECIFICATIONS

Pump:

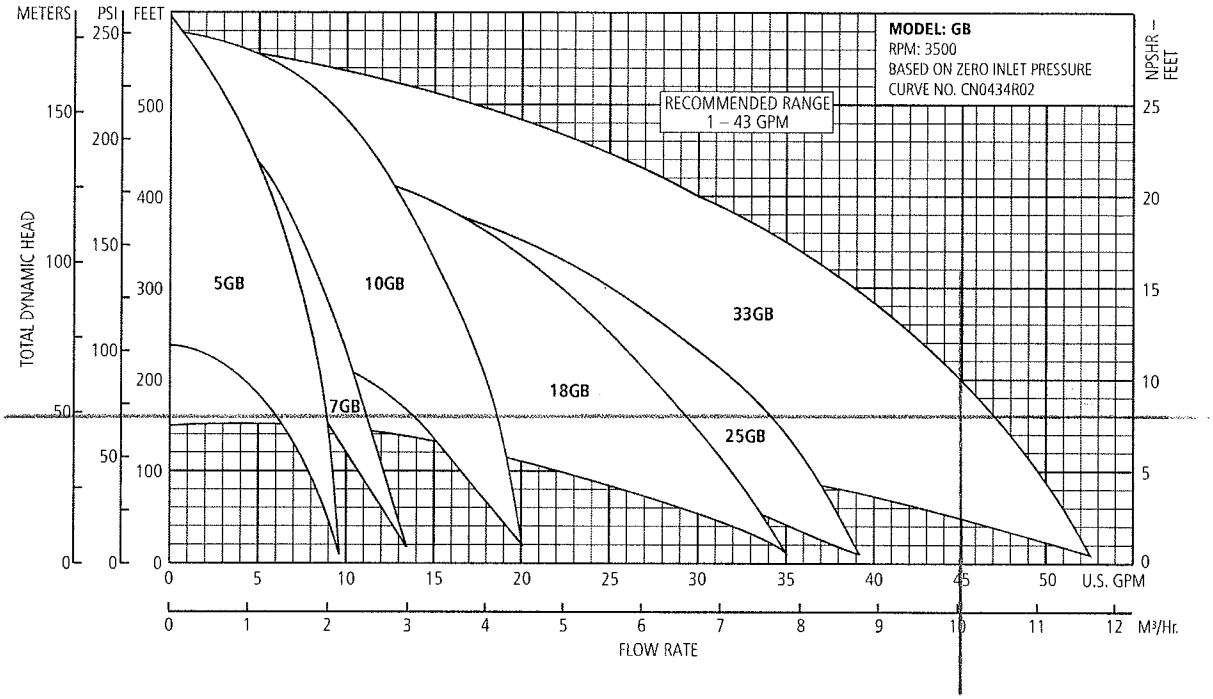
- Maximum suction (inlet) pressure: 75 PSI.
- Maximum Liquid Temperature: 160° F (71° C).
- Rotation: Clockwise when viewed from motor end.
- Maximum lift with foot valve: 10 ft. check NPSH curve.

Motor:

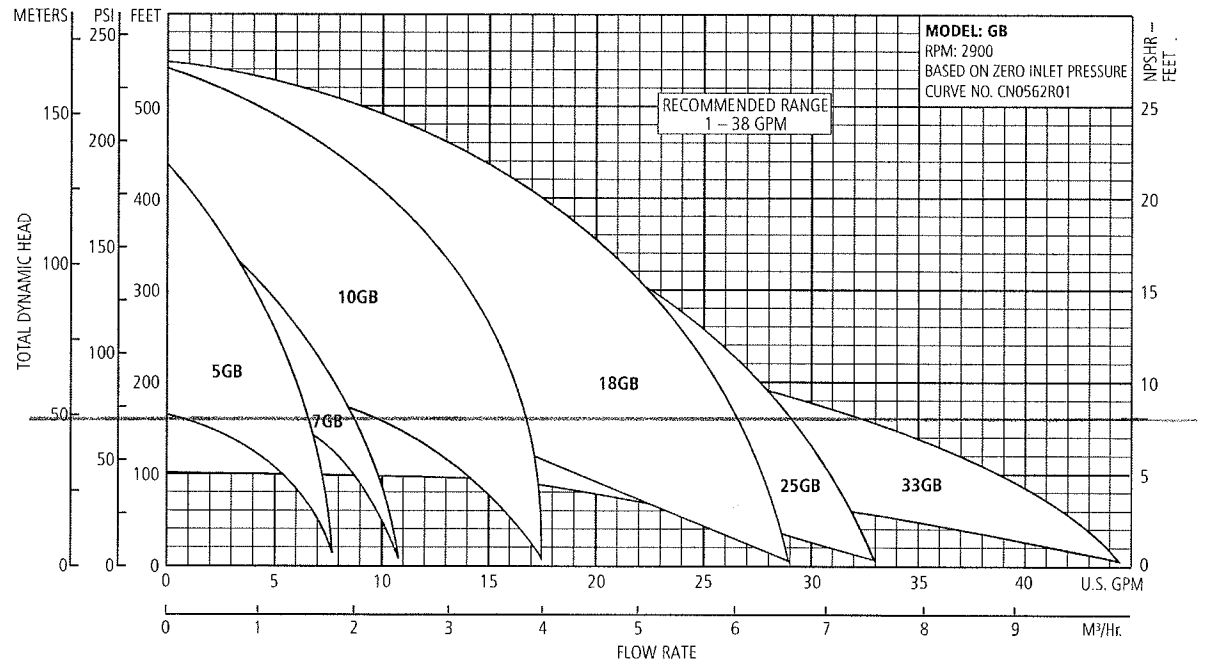
- NEMA standard 56J frame.
- Open drip proof or totally enclosed fan cooled enclosures available as standard. Consult factory for other options.
- 60 Hz, 3500 RPM. Single phase (115/230 V), three phase 208-230 (3 HP, 230 V) or three phase (208-230/460 V).
- Single phase motors have built-in capacitor and overload with automatic reset.

Note: For three phase motors, overload protection must be provided in starter unit. Starter and heaters must be ordered separately.

PERFORMANCE COVERAGE 60 HZ, 3500 RPM



PERFORMANCE COVERAGE 50 HZ, 2900 RPM



GB NUMBERING SYSTEM

The various versions of the Series GB are identified by a product code number on the pump label. This number is also the catalog number for the pump. The meaning of each digit in the product code number is shown below. The following are the standard 60 Hz product numbers and are built with Single Phase ODP motors and standard staging. The cast iron version uses Seal Code 0 and the stainless version uses Seal Code 4.

Order No.		Description				
Cast Iron	Stainless	HP	Phase	Voltage	Enclosure	Stages
5GBC03	5GBS03	⅓①	1	115-230	ODP	7
5GBC05	5GBS05	½				9
5GBC07	5GBS07	¾				14
5GBC10	5GBS10	1				17
7GBC05	7GBS05	½				9
7GBC07	7GBS07	¾				13
7GBC10	7GBS10	1				16
10GBC07	10GBS07	¾				8
10GBC10	10GBS10	1				10
10GBC15	10GBS15	1½				15
10GBC20	10GBS20	2				17

① Unit is supplied with ½ HP motor.
* All 3 HP motors are 230V only.

Order No.		Description				
Cast Iron	Stainless	HP	Phase	Voltage	Enclosure	Stages
18GBC07	18GBS07	¾	1	115-230*	ODP	5
18GBC10	18GBS10	1				7
18GBC15	18GBS15	1½				9
18GBC20	18GBS20	2				13
18GBC30	18GBS30	3				15
25GBC07	25GBS07	¾				5
25GBC10	25GBS10	1				7
25GBC15	25GBS15	1½				9
25GBC20	25GBS20	2				10
25GBC30	25GBS30	3				14
33GBC10	33GBS10	1				5
33GBC15	33GBS15	1½				7
33GBC20	33GBS20	2				9
33GBC30	33GBS30	3				13

GB NUMBERING SYSTEM

For optional motor enclosures, seals and three phase configurations use the following product code system.

Example Code

5 GB C 05 1 5 J 0

MECHANICAL SEAL AND O-RING
0 = Standard on Cast Iron and 4 = Standard on Stainless Steel.
For Optional Mechanical Seal modify catalog order no. with Seal Code listed below.

Mechanical Seal (⅝" seal)						
Seal Code	Rotary	Stationary	Elastomers	Metal Parts	Part No.	Casing O-Ring
0	Carbon	Ceramic	BUNA	18-8SS	10K10	BUNA
3		Sil-Carbide	EPR	316SS	10K18	EPR
4			Viton		10K55	Viton

NUMBER OF STAGES

A = 1	D = 4	G = 7	K = 10	N = 13	R = 16	U = 19	X = 22
B = 2	E = 5	H = 8	L = 11	P = 14	S = 17	V = 20	Y = 23
C = 3	F = 6	J = 9	M = 12	Q = 15	T = 18	W = 21	Z = 24

DRIVER
1 = 1 PH, ODP
2 = 3 PH, ODP
3 = 3 PH, 575V ODP
4 = 1 PH, TEFC
5 = 3 PH, TEFC

DRIVER: HERTZ/POLE/RPM
1 = 60 Hz, 2 pole, 3500 RPM
2 = 50 Hz, 2 pole, 2900 RPM

HP RATING

03 = ⅓ HP	10 = 1 HP	50 = 5 HP
05 = ½ HP	20 = 2 HP	
07 = ¾ HP	30 = 3 HP	

Note: ⅓ HP Single Phase unit is supplied with ½ HP mootr.

MATERIAL – DISCHARGE, HEAD AND SUCTION HOUSING
C = Cast Iron
S = Stainless Steel

PUMP MODEL
GB

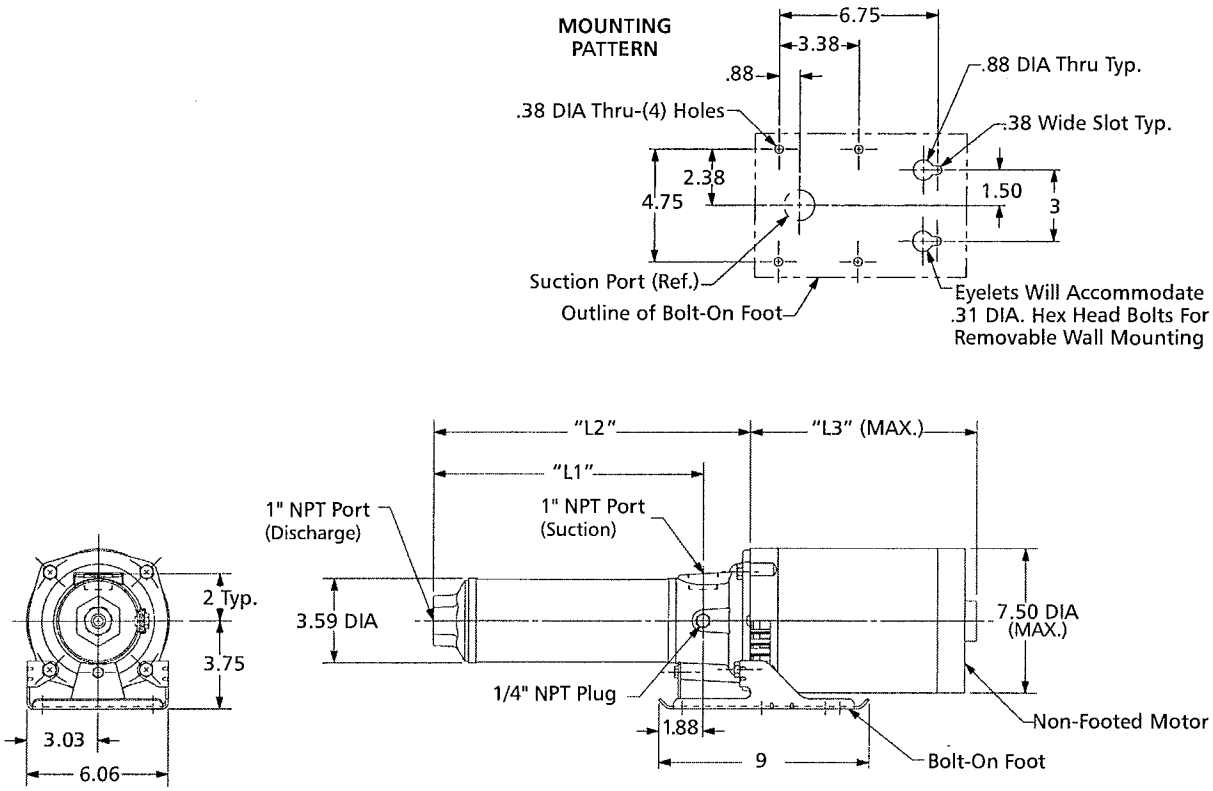
GALLONS PER MINUTE
5 7 10 18 25 33

Note: Not recommended for operation beyond recommended range specified on H-Q curve.

For critical application conditions consult factory.

Note: Not all combinations of motor, impeller and seal options are available for every pump model. Please check with Goulds Pumps on non-cataloged numbers.

DIMENSIONS AND WEIGHTS FOR 60 HZ AND 50 HZ PUMPS



DIMENSIONS AND WEIGHTS FOR 60 HZ PUMPS

Size	Stages	L1 Approx.	L2 Approx.	HP	L3 Max.	Max. Wt. lbs.
5GB	7	9.19	11.19	⅓	10.5	41
	9	10.62	12.62	½	10.5	41
	14	15.12	17.12	¾	10.62	46
	17	17.12	19.12	1	11.25	50
HAVE → 7GB	9	11.88	13.88	½	10.5	41
	13	14.44	16.44	¾	10.62	46
	16	16.88	18.88	1	11.25	50
10GB	8	10.94	12.94	¾	10.62	46
	10	12.31	14.31	1	11.25	50
	15	15.81	17.81	1½	11.31	47
	17	17.19	19.19	2	12.06	67
18GB	5	9.69	11.69	¾	10.62	46
	7	11.38	13.38	1	11.25	50
	9	13.12	15.12	1½	11.31	47
	13	16.50	18.50	2	12.06	67
	15	18.25	20.25	3	13.03	69
25GB	5	10.12	12.12	¾	10.62	46
	7	12.00	14.00	1	11.25	50
	9	13.88	15.88	1½	11.31	47
	10	14.81	16.81	2	13.03	67
	14	18.56	20.56	3	13.03	69
33GB	5	11.77	13.77	1	11.25	51
	7	14.25	16.25	1½	11.31	55
	9	16.66	18.66	2	13.03	69
	13	21.47	23.47	3	13.03	70
NEED →	19	29.03	31.03	5	14.25	78

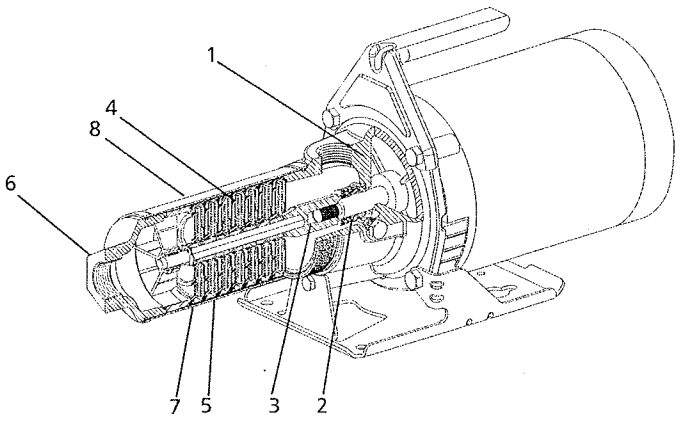
Δ = 17.15 17.15

DIMENSIONS AND WEIGHTS FOR 50 HZ PUMPS

Size	Stages	L1 Approx.	L2 Approx.	HP	L3 Max.	Max. Wt. lbs.
5GB	7	9.19	11.19	⅓	10.5	41
	10	11.31	13.31	½	10.5	42
	16	16.50	18.50	¾	10.62	47
	19	18.50	20.50	1	11.25	51
7GB	10	12.60	14.60	½	10.5	42
	15	15.87	17.87	¾	10.62	47
	18	18.31	20.31	1	11.25	51
10GB	9	11.63	13.63	¾	10.62	47
	11	13.00	15.00	1	11.25	51
	17	17.19	19.19	1½	11.31	48
	23	21.32	23.32	2	12.06	68
18GB	8	12.23	14.23	1	11.25	51
	12	15.68	17.68	1½	11.31	48
	16	19.06	21.06	2	12.06	68
	23	25.07	27.07	3	13.03	70
25GB	5	10.12	12.12	¾	10.62	46
	7	12.00	14.00	1	11.25	50
	10	14.82	16.82	1½	11.31	48
	14	18.56	20.56	2	13.03	68
	21	25.13	27.13	3	13.03	70
33GB	6	13.00	15.00	1	11.25	52
	10	17.88	19.88	2	13.03	70
	14	22.69	24.69	3	13.03	71

MATERIALS OF CONSTRUCTION

Item	Description	Material
1	Motor Adapter	Cast Iron or Cast 304 Stainless Steel
2	Mechanical Seal	0=Carbon/Ceramic/BUNA 3=Carbon/Silcar/EPR 4=Carbon/Silcar/Viton
3	Shaft Coupling	Stainless Steel
4	Impeller/Diffuser	Engineered Composite
5	Bowl	304 Stainless Steel
6	Discharge Head	Cast Iron or Cast 304 Stainless Steel
7	Hex Shaft	Stainless Steel
8	Casing	304 Stainless Steel



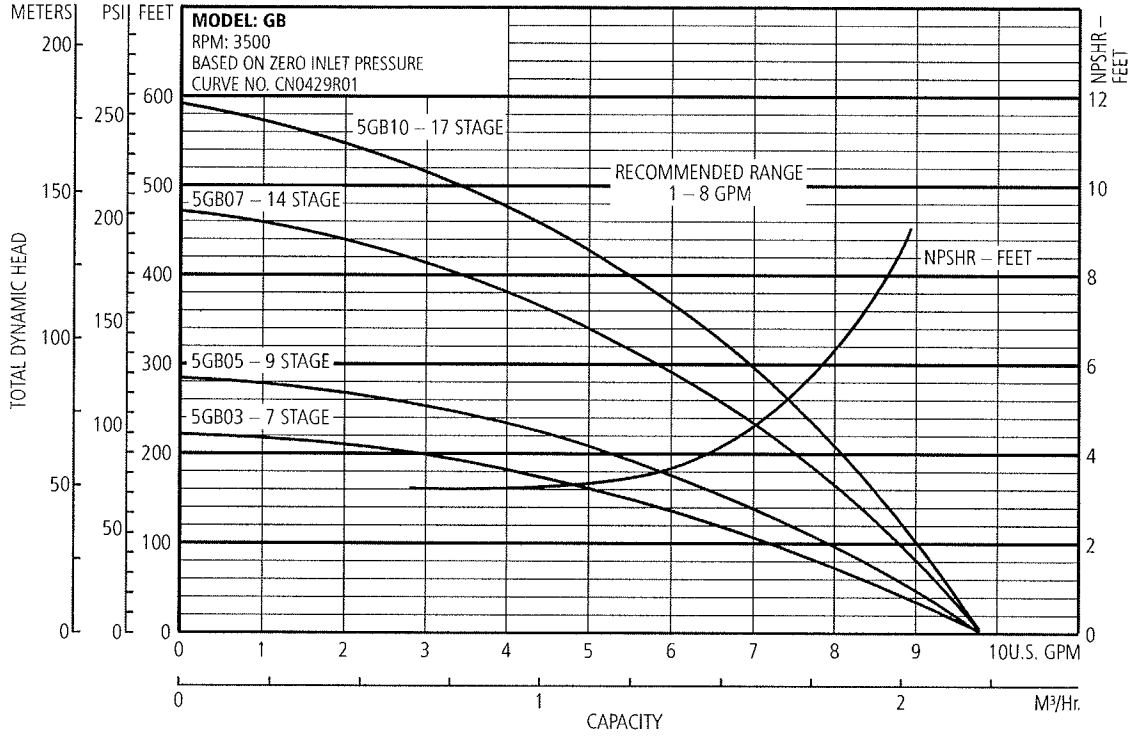
5GB SPECIFICATIONS

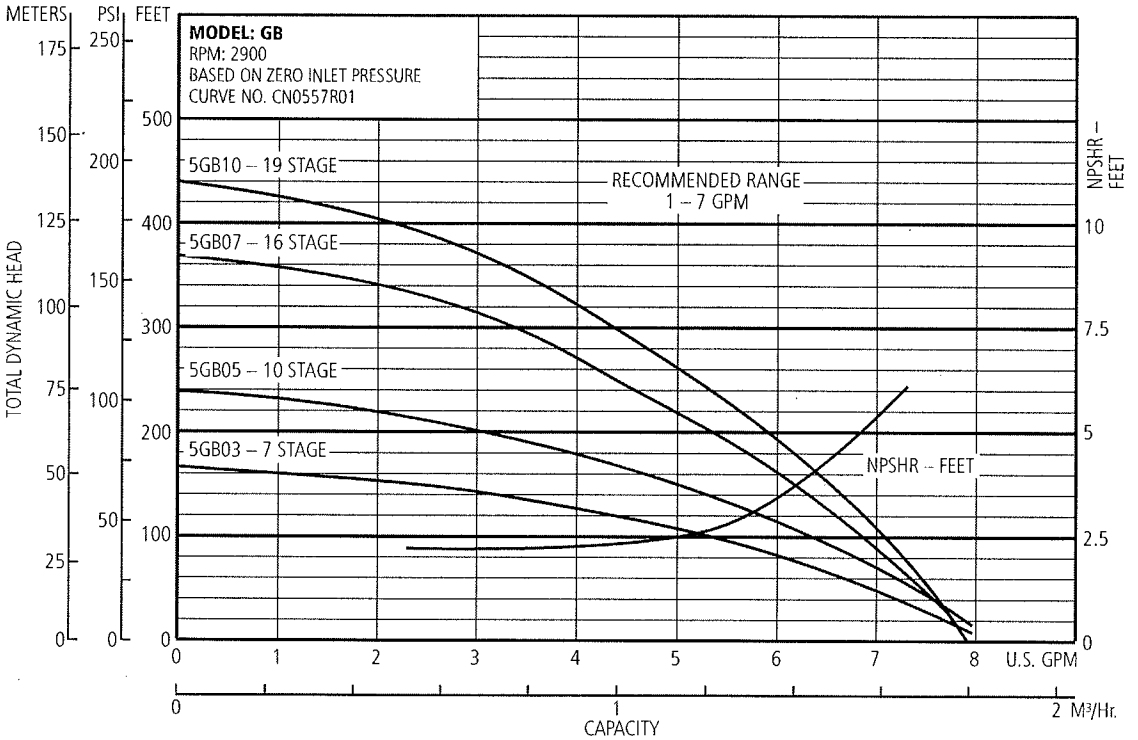
- Capacities: to 8 GPM.
- Maximum Flow: 8 GPM.
- Minimum Flow: 1 GPM.
- Heads: to 600 ft. (260 PSI).
- Pipe Connections: 1" NPT Suction and Discharge.

WARNINGS

- Pumps used on open spray applications must be plugged into electrical service which is protected by a Ground Fault Service Interruptor. Failure to do so may result in serious personal injury or death and property damage.
- Do not run pump dry.
- Do not run pump below minimum flow.
- If positive suction pressure is not available, be sure pump and suction line (with foot valve) are primed before starting pump.

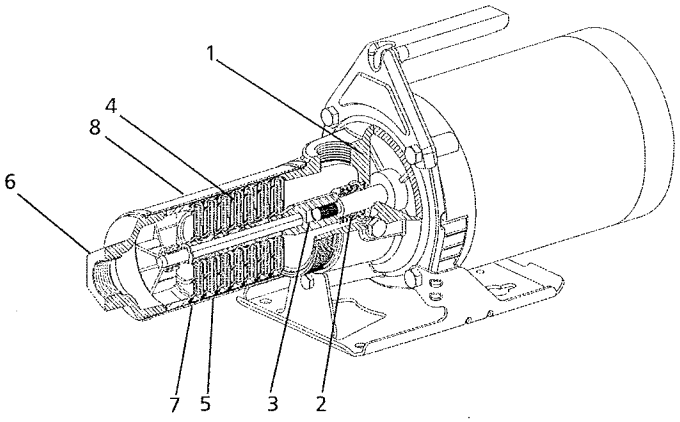
5GB PERFORMANCE CURVES





MATERIALS OF CONSTRUCTION

Item	Description	Material
1	Motor Adapter	Cast Iron or Cast 304 Stainless Steel
2	Mechanical Seal	0=Carbon/Ceramic/BUNA 3=Carbon/Silcar/EPR 4=Carbon/Silcar/Viton
3	Shaft Coupling	Stainless Steel
4	Impeller/Diffuser	Engineered Composite
5	Bowl	304 Stainless Steel
6	Discharge Head	Cast Iron or Cast 304 Stainless Steel
7	Hex Shaft	Stainless Steel
8	Casing	304 Stainless Steel



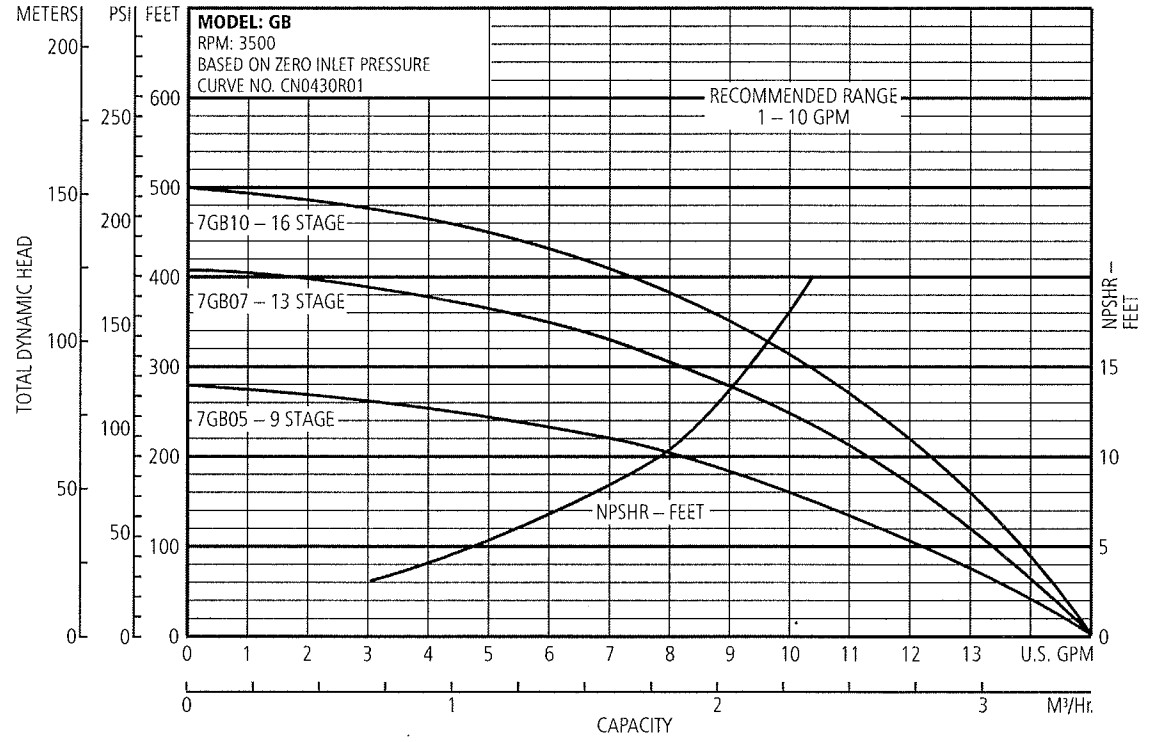
7GB SPECIFICATIONS

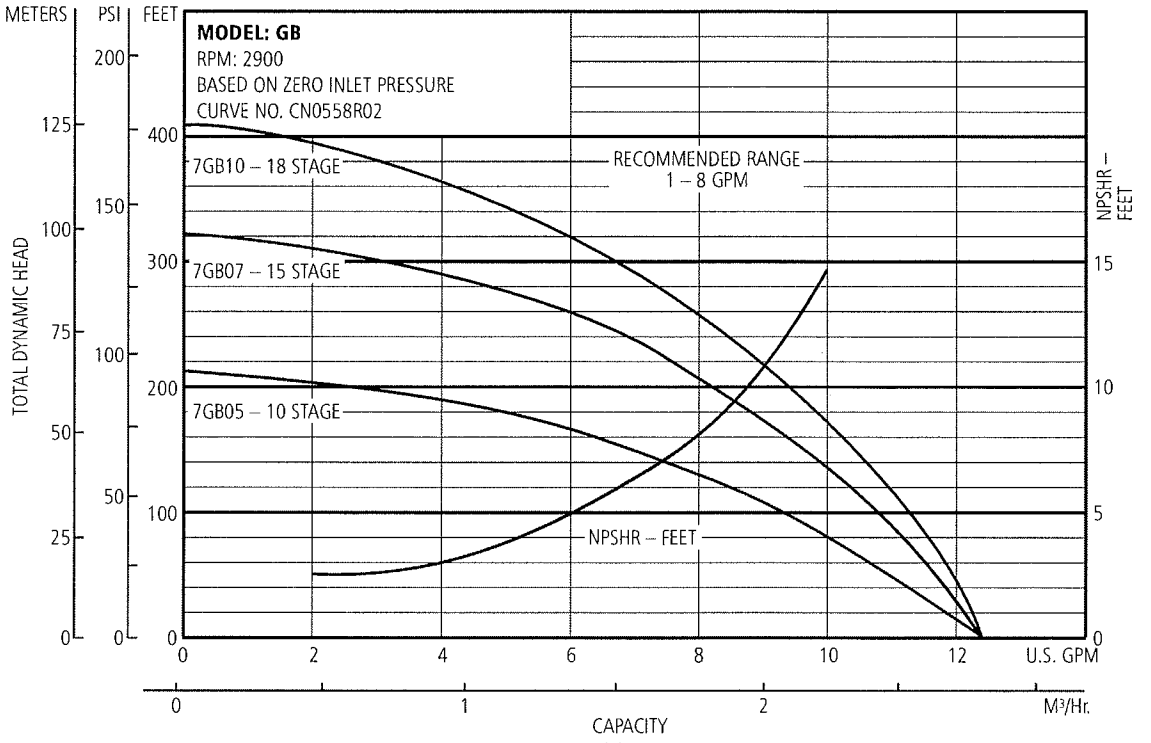
- Capacities: to 10 GPM.
- Maximum Flow: 10 GPM.
- Minimum Flow: 1 GPM.
- Heads: to 500 ft. (216 PSI).
- Pipe Connections: 1" NPT Suction and Discharge.

WARNINGS

- Pumps used on open spray applications must be plugged into electrical service which is protected by a Ground Fault Service Interruptor. Failure to do so may result in serious personal injury or death and property damage.
- Do not run pump dry.
- Do not run pump below minimum flow.
- If positive suction pressure is not available, be sure pump and suction line (with foot valve) are primed before starting pump.

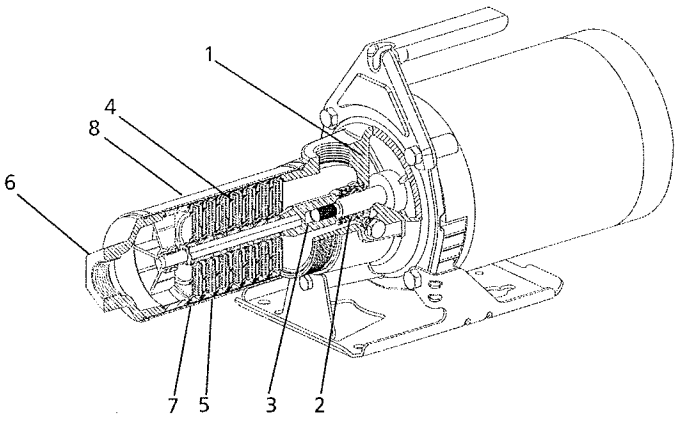
7GB PERFORMANCE CURVES





MATERIALS OF CONSTRUCTION

Item	Description	Material
1	Motor Adapter	Cast Iron or Cast 304 Stainless Steel
2	Mechanical Seal	0=Carbon/Ceramic/BUNA 3=Carbon/Silcar/EPR 4=Carbon/Silcar/Viton
3	Shaft Coupling	Stainless Steel
4	Impeller/Diffuser	Engineered Composite
5	Bowl	304 Stainless Steel
6	Discharge Head	Cast Iron or Cast 304 Stainless Steel
7	Hex Shaft	Stainless Steel
8	Casing	304 Stainless Steel



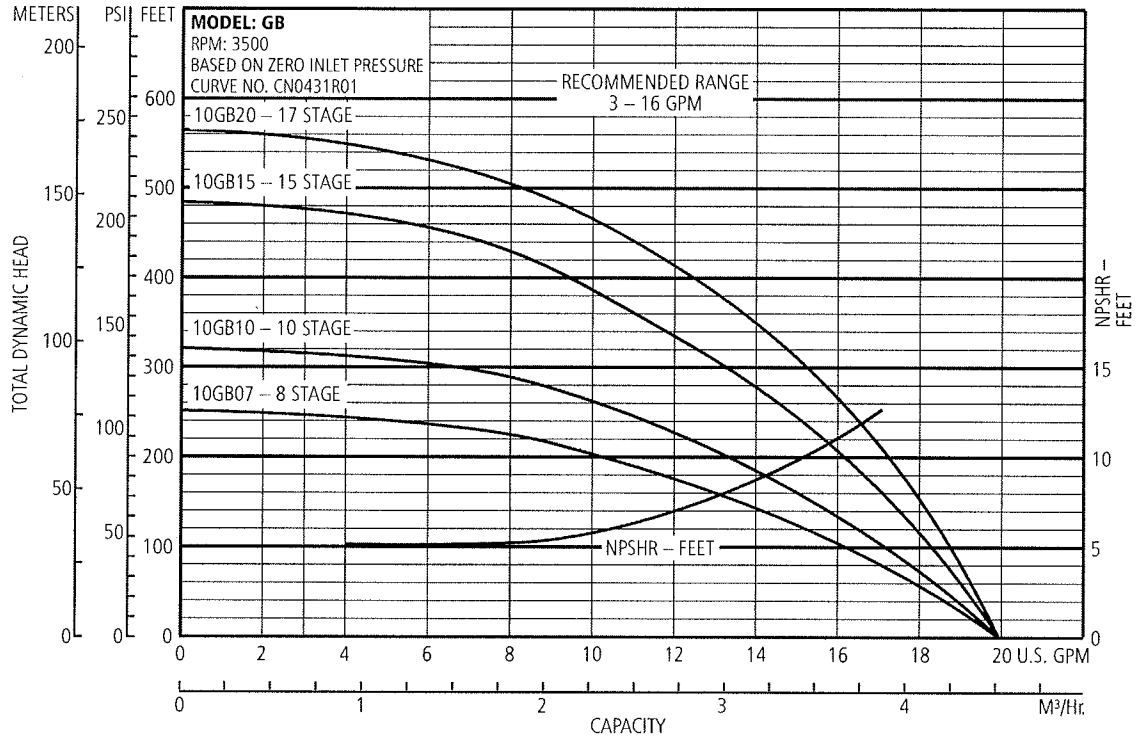
10GB SPECIFICATIONS

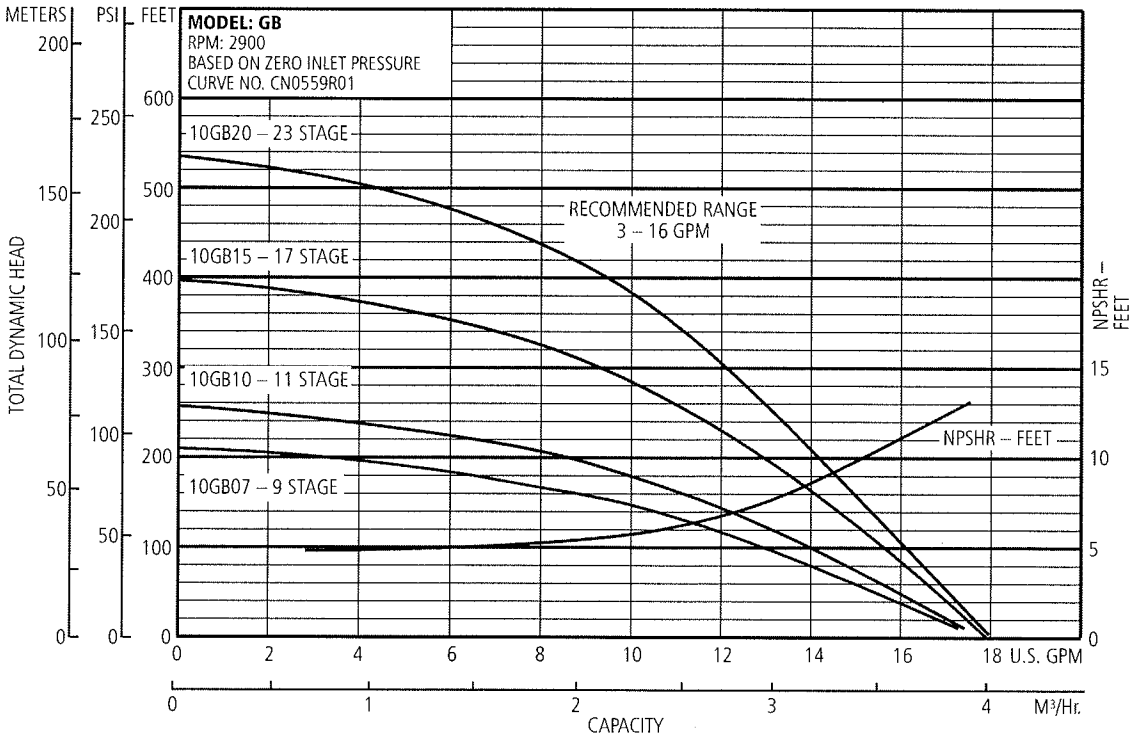
- Capacities: to 16 GPM.
- Minimum Flow: 3 GPM.
- Heads: to 560 ft. (242 PSI).
- Three phase units require
- Pipe Connections: 1" NPT separate starters.
- Maximum Flow: 16 GPM.

WARNINGS

- Pumps used on open spray applications must be plugged into electrical service which is protected by a Ground Fault Service Interruptor. Failure to do so may result in serious personal injury or death and property damage.
- Do not run pump dry.
- Do not run pump below minimum flow.
- If positive suction pressure is not available, be sure pump and suction line (with foot valve) are primed before starting pump.

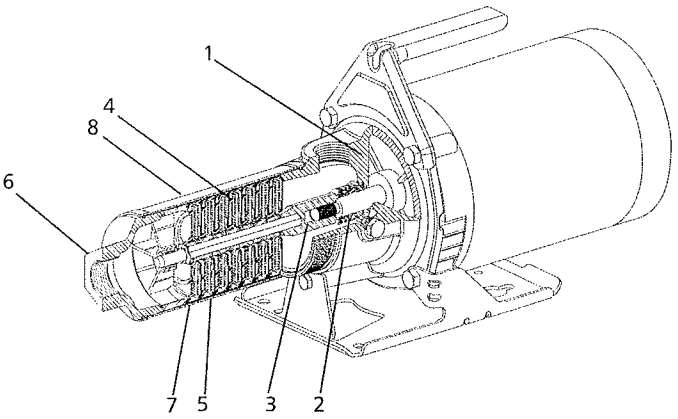
10GB PERFORMANCE CURVES





MATERIALS OF CONSTRUCTION

Item	Description	Material
1	Motor Adapter	Cast Iron or Cast 304 Stainless Steel
2	Mechanical Seal	0=Carbon/Ceramic/BUNA 3=Carbon/Silcar/EPR 4=Carbon/Silcar/Viton
3	Shaft Coupling	Stainless Steel
4	Impeller/Diffuser	Engineered Composite
5	Bowl	304 Stainless Steel
6	Discharge Head	Cast Iron or Cast 304 Stainless Steel
7	Hex Shaft	Stainless Steel
8	Casing	304 Stainless Steel



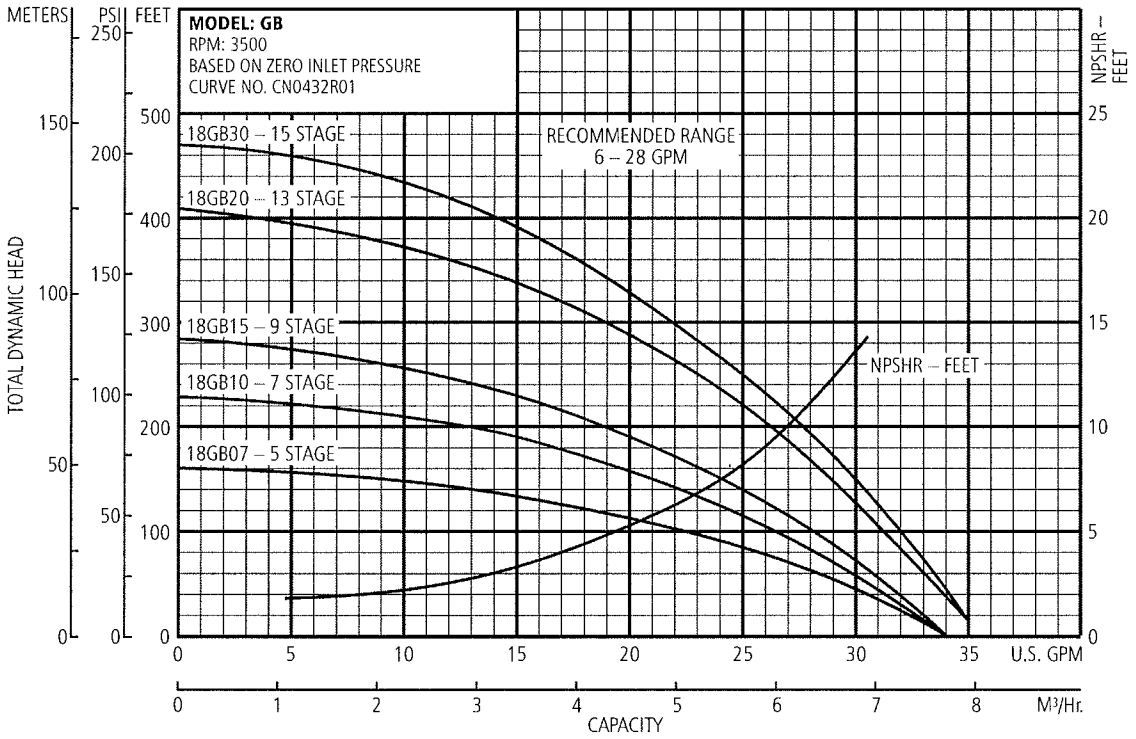
18GB SPECIFICATIONS

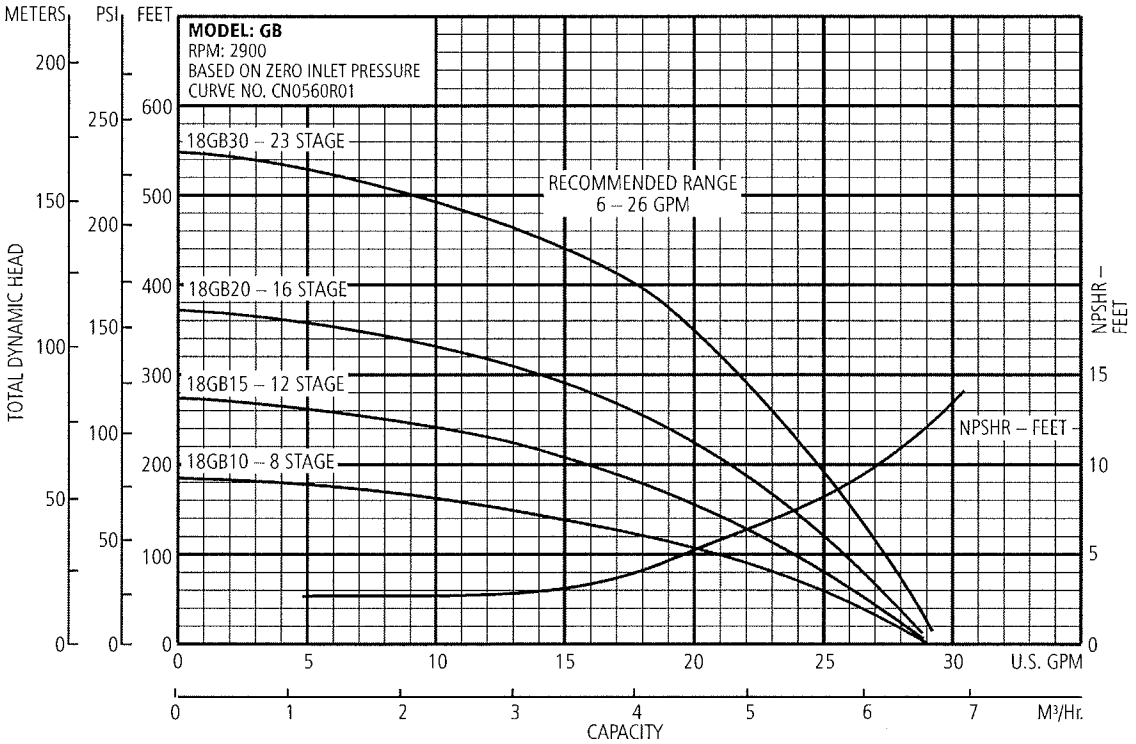
- Capacities: to 28 GPM.
- Minimum Flow: 6 GPM.
- Heads: to 470 ft. (203 PSI).
- Three phase units require
- Pipe Connections: 1" NPT separate starters.
- Maximum Flow: 28 GPM.

WARNINGS

- Pumps used on open spray applications must be plugged into electrical service which is protected by a Ground Fault Service Interruptor. Failure to do so may result in serious personal injury or death and property damage.
- Do not run pump dry.
- Do not run pump below minimum flow.
- If positive suction pressure is not available, be sure pump and suction line (with foot valve) are primed before starting pump.

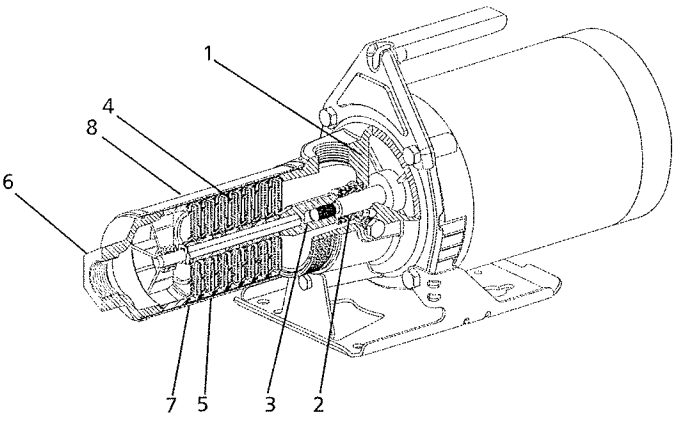
18GB PERFORMANCE CURVES





MATERIALS OF CONSTRUCTION

Item	Description	Material
1	Motor Adapter	Cast Iron or Cast 304 Stainless Steel
2	Mechanical Seal	0=Carbon/Ceramic/BUNA 3=Carbon/Silcar/EPR 4=Carbon/Silcar/Viton
3	Shaft Coupling	Stainless Steel
4	Impeller/Diffuser	Engineered Composite
5	Bowl	304 Stainless Steel
6	Discharge Head	Cast Iron or Cast 304 Stainless Steel
7	Hex Shaft	Stainless Steel
8	Casing	304 Stainless Steel



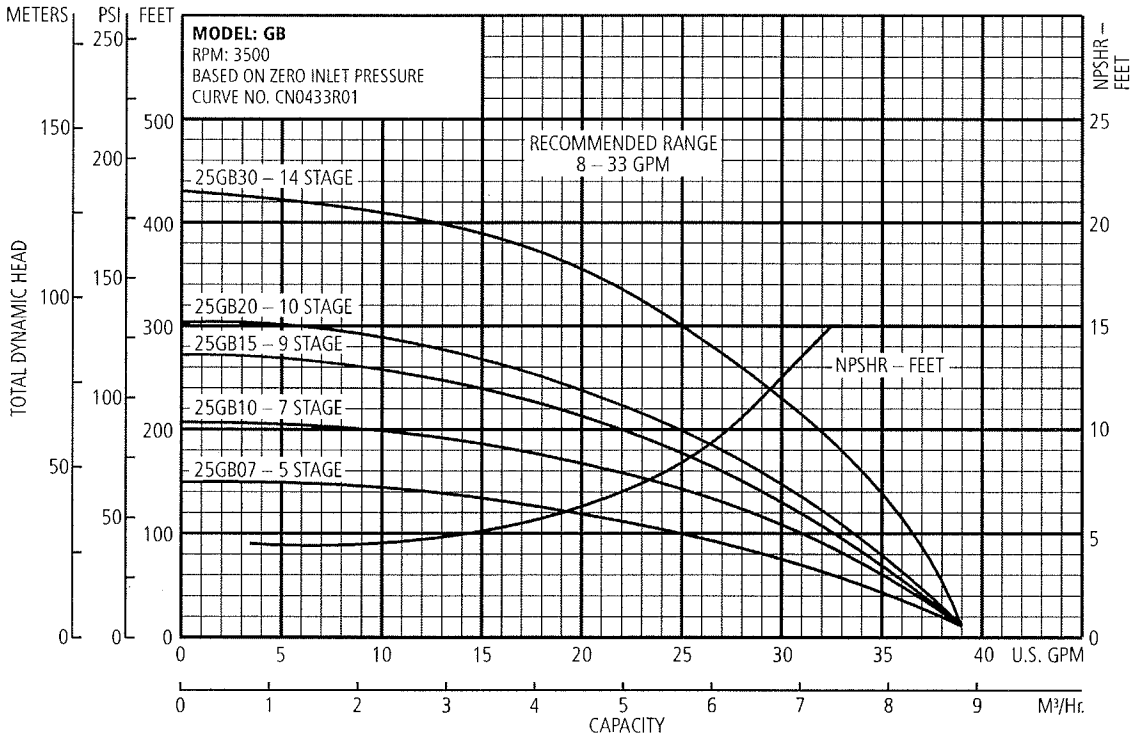
25GB SPECIFICATIONS

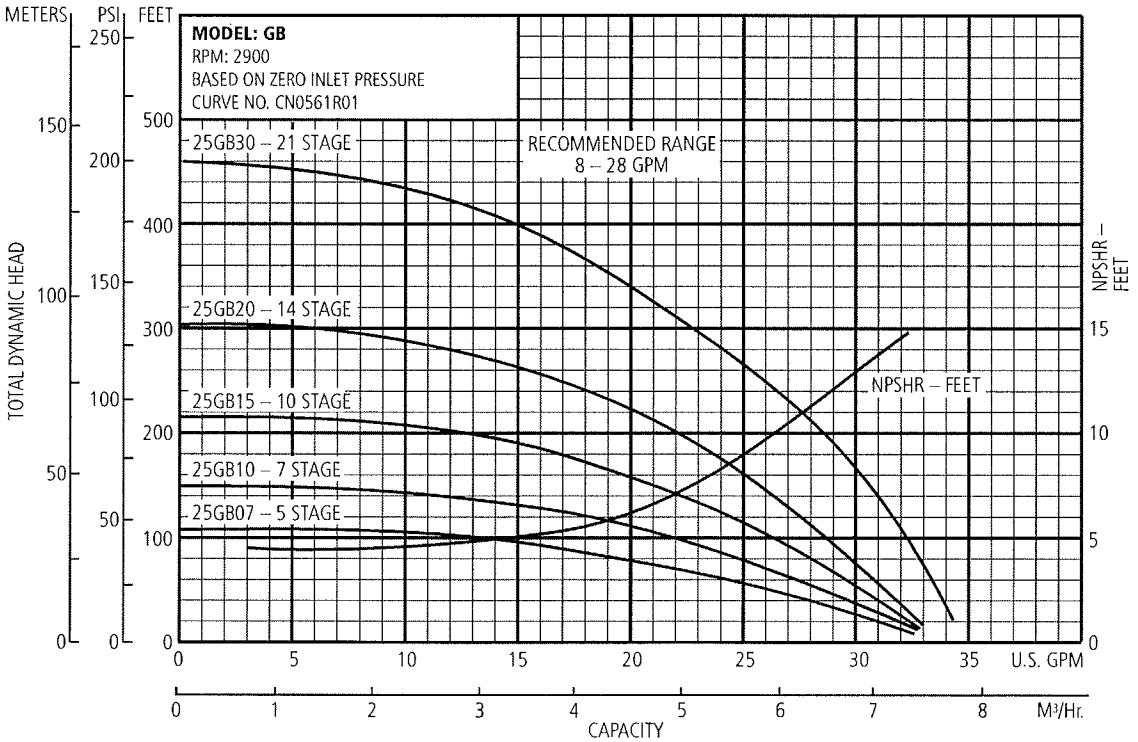
- Capacities: to 33 GPM.
- Minimum Flow: 8 GPM.
- Heads: to 430 ft. (186 PSI).
- Three phase units require
- Pipe Connections: 1" NPT separate starters.
- Maximum Flow: 33 GPM.

WARNINGS

- Pumps used on open spray applications must be plugged into electrical service which is protected by a Ground Fault Service Interruptor. Failure to do so may result in serious personal injury or death and property damage.
- Do not run pump dry.
- Do not run pump below minimum flow.
- If positive suction pressure is not available, be sure pump and suction line (with foot valve) are primed before starting pump.

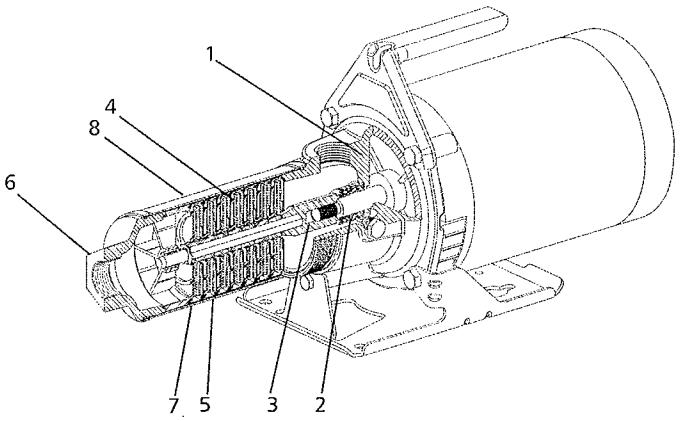
25GB PERFORMANCE CURVES





MATERIALS OF CONSTRUCTION

Item	Description	Material
1	Motor Adapter	Cast Iron or Cast 304 Stainless Steel
2	Mechanical Seal	0=Carbon/Ceramic/BUNA 3=Carbon/Silcar/EPR 4=Carbon/Silcar/Viton
3	Shaft Coupling	Stainless Steel
4	Impeller/Diffuser	Engineered Composite
5	Bowl	304 Stainless Steel
6	Discharge Head	Cast Iron or Cast 304 Stainless Steel
7	Hex Shaft	Stainless Steel
8	Casing	304 Stainless Steel



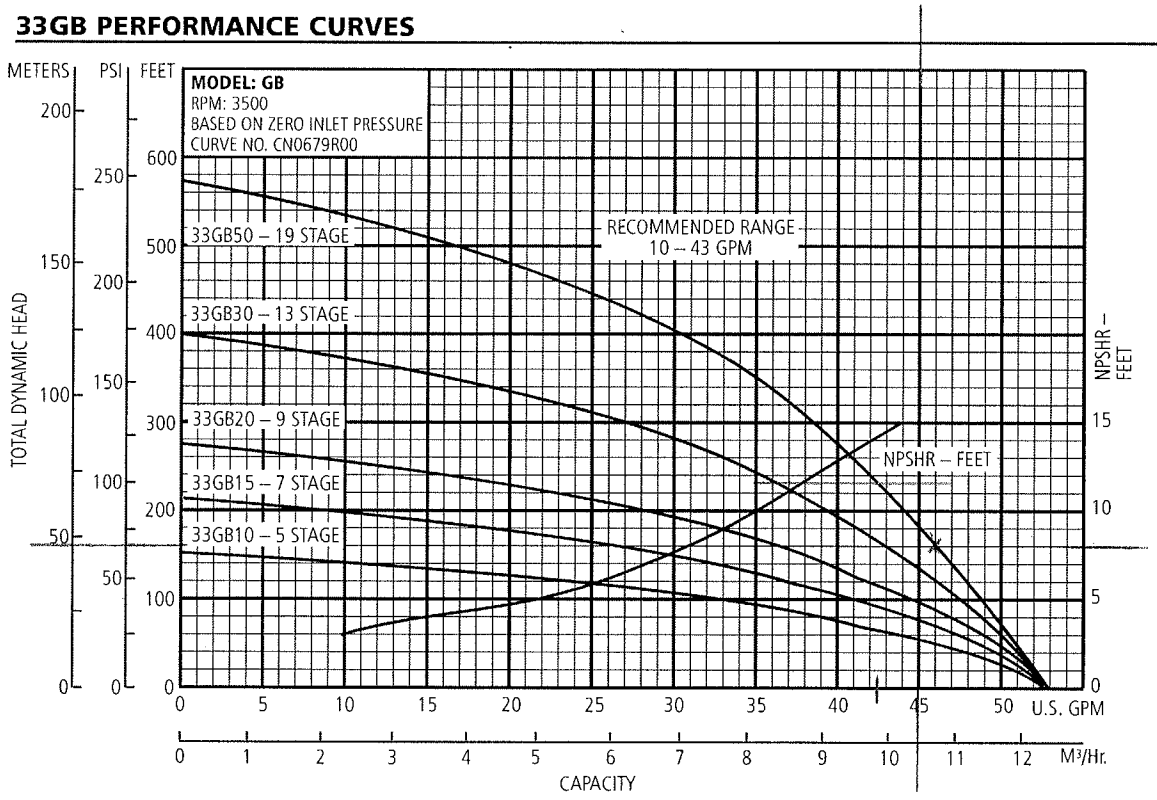
33GB SPECIFICATIONS

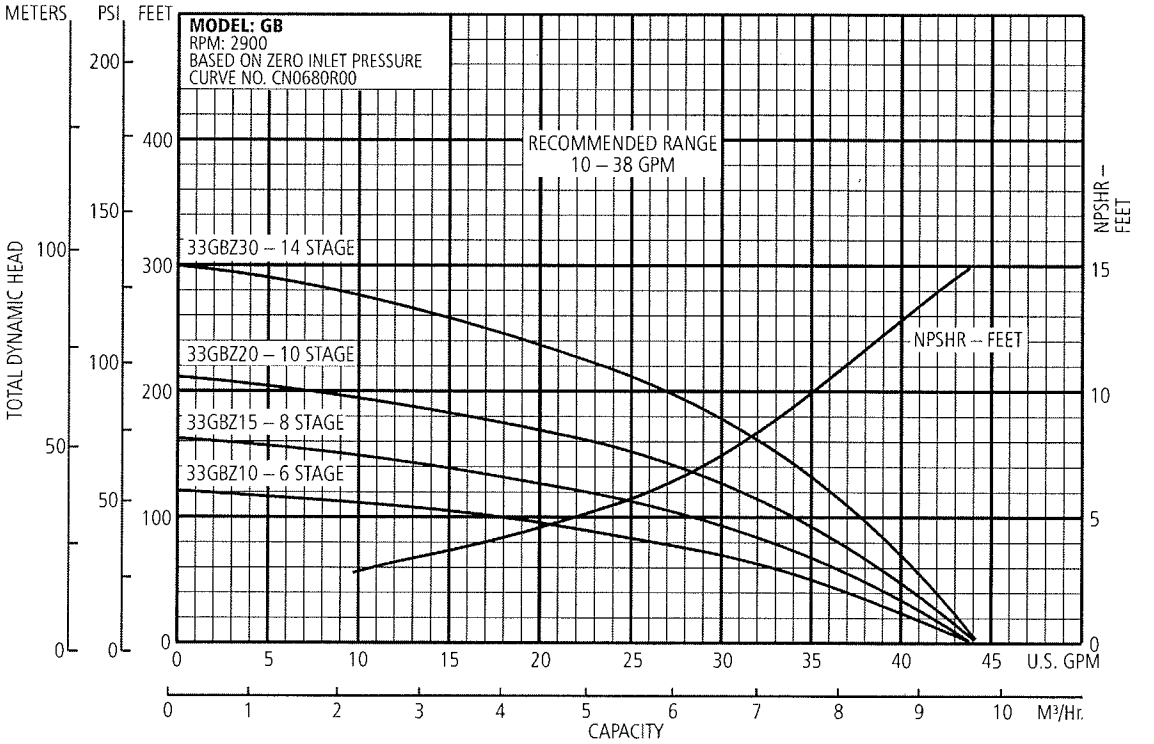
- Capacities: to 33 GPM.
- Minimum Flow: 10 GPM.
- Heads: to 575 ft. (249 PSI).
- Three phase units require
- Pipe Connections: 1" NPT separate starters.
- Maximum Flow: 33 GPM.

WARNINGS

- Pumps used on open spray applications must be plugged into electrical service which is protected by a Ground Fault Service Interruptor. Failure to do so may result in serious personal injury or death and property damage.
- Do not run pump dry.
- Do not run pump below minimum flow.
- If positive suction pressure is not available, be sure pump and suction line (with foot valve) are primed before starting pump.

33GB PERFORMANCE CURVES





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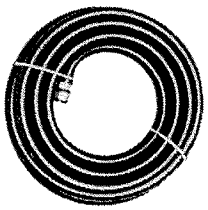
Residential Water Systems

ACCESSORIES

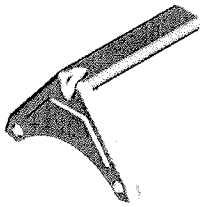
HOSE



AM3-5 – Discharge Hose
¾" male x ¾" female, 250 PSI hose, 40 ft. section, flexible.

AM4 – Suction Hose
¾" female x ¾" female, 150 PSI hose, 4 ft. section flexible.

HANDLE



4K452
Formed carbon steel handle is standard on 7GB WaterGun® and can be ordered separately for use on other sizes.

PIPE ADAPTER

AM5-1
¾" male HT x 1" male NPT hose to pipe adapter, stainless steel. Converts suction and discharge to ¾" male NPT hose.

GOULDS PUMPS

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SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE.

BGB5-33 March, 2008

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Wastewater

Goulds Pumps

Wastewater Pumps

Dewatering, Effluent and Sewage

Installation, Operation and Maintainence Instructions

GOULDS PUMPS

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- a subsidiary of ITT Industries, Inc.

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Owner's Information

Pump Model Number: _____

Pump Serial Number: _____

Control Model Number: _____

Dealer: _____

Dealer Phone No. _____

Date of Purchase: _____ Installation: _____

Current Readings at Startup:

1Ø	3Ø	L1-2	L2-3	L3-1
Amps: _____	Amps: _____	_____	_____	_____
Volts: _____	Volts: _____	_____	_____	_____

SAFETY INSTRUCTIONS

TO AVOID SERIOUS OR FATAL PERSONAL INJURY OR MAJOR PROPERTY DAMAGE, READ AND FOLLOW ALL SAFETY INSTRUCTIONS IN MANUAL AND ON PUMP.

THIS MANUAL IS INTENDED TO ASSIST IN THE INSTALLATION AND OPERATION OF THIS UNIT AND MUST BE KEPT WITH THE PUMP.

This is a **SAFETY ALERT SYMBOL.** When you see this symbol on the pump or in the manual, look for one of the following signal words and be alert to the potential for personal injury or property damage.

⚠ DANGER Warns of hazards that **WILL** cause serious personal injury, death or major property damage.

⚠ WARNING Warns of hazards that **CAN** cause serious personal injury, death or major property damage.

⚠ CAUTION Warns of hazards that **CAN** cause personal injury or property damage.

NOTICE: INDICATES SPECIAL INSTRUCTIONS WHICH ARE VERY IMPORTANT AND MUST BE FOLLOWED.

THOROUGHLY REVIEW ALL INSTRUCTIONS AND WARNINGS PRIOR TO PERFORMING ANY WORK ON THIS PUMP.

MAINTAIN ALL SAFETY DECALS.

⚠ WARNING All electrical work must be performed by a qualified technician. Always follow the National Electrical Code (NEC), or the Canadian Electrical Code, as well as all local, state and provincial codes. Code questions should be directed to your local electrical inspector. Failure to follow electrical codes and OSHA safety standards may result in personal injury or equipment damage. Failure to follow manufacturer's installation instructions may result in electrical shock, fire hazard, personal injury or death, damaged equipment, provide unsatisfactory performance, and may void manufacturer's warranty.

⚠ WARNING Standard units are not designed for use in swimming pools, open bodies of water, hazardous liquids, or where flammable gases exist. These fluids and gases may be present in containment areas. Tank or wetwell must be vented per local codes.

Only pumps specifically Listed for Class 1, Division 1 are allowable in hazardous liquids and where flammable gases may exist. *See specific pump catalog bulletins or pump nameplate for all agency Listings*.

⚠ WARNING Disconnect and lockout electrical power before installing or servicing any electrical equipment. Many pumps are equipped with automatic thermal overload protection which may allow an overheated pump to restart unexpectedly.

⚠ CAUTION All three phase (3Ø) control panels for submersible pumps must provide Class 10, quick-trip, overload protection.

PRE-INSTALLATION CHECKS

Open all cartons and inspect for shipping damage. Report any damage to your supplier or shipping carrier immediately.

Important: Always verify that the pump nameplate Amps, Voltage, Phase and HP ratings match your control panel and power supply.

Many of our sewage pumps are oil-filled. If there are any signs of oil leakage or if the unit has been stored for an extended period check the oil level in the motor dome and the seal housing, if so equipped.

Check the motor cover oil level through the pipe plug on top of the unit. The motor chamber oil should just cover the motor. Do not overfill, leave room for expansion!

To check the seal housing oil level, where used, lay the unit on its side with the fill plug at 12 o'clock. Remove the plug. The oil should be within ½" (13mm) of the top. If low, refill with an ASTM 150 turbine oil. Replace the plug.

Oil is available in 5 gallon cans through our distributors. You can also source oil locally at motor repair shops. Typical oil brands are: Shell Turbo 32, Sunoco Sunvis 932, Texaco Regal R&O 32, Exxon Nuto 32 and Mobil DTE Light.

Check the strain relief nut on power cable strain assemblies. Power cables should be torqued to 75 in. lbs. for #16 cables and 80 in. lbs. for all other cable assemblies. Seal/heat sensor cables, where used, should be torqued to 75 in. lbs.

Warranty does not cover damage caused by connecting pumps and controls to an incorrect power source (voltage/phase supply).

Record the model numbers and serial numbers from the pumps and control panel on the front of this instruction manual for future reference. Give it to the owner or affix it to the control panel when finished with the installation.

LIFTING OF PUMP

DO NOT LIFT, CARRY OR HANG PUMP BY THE ELECTRICAL CABLES. DAMAGE TO THE ELECTRICAL CABLES CAN CAUSE SHOCK, BURNS OR DEATH.

Lift the pump with an adequately sized chain or cable attached to the lifting eye bolt. **DO NOT** damage electrical and sensor cables while raising and lowering unit.

OPTIONAL GUIDE RAIL OR LIFT-OUT SYSTEM

In many effluent and sewage basins or lift stations it is advisable to install the pump on a guide rail system or on a lift-out adapter to facilitate installation and removal for inspection and/or service. Most codes do not allow personnel to enter a wetwell without the correct protective equipment and training. Guide rails are designed to allow easy removal of the pump without the need for entry into the wetwell or need to disturb piping. The guide rail or lift-out adapter should locate the pump opposite the influent

opening preventing stagnate areas where solids can settle. The basin or pit must be capable of supporting the weight of the pump and guide rail. The pit floor must be flat.

NOTICE: FOLLOW THE INSTRUCTIONS THAT ARE PROVIDED WITH THE GUIDE RAIL ASSEMBLY.

PIPING

Discharge piping should be no smaller than the pump discharge diameter and kept as short as possible, avoiding unnecessary fittings to minimize friction losses.

Install an adequately sized check valve matched to the solids handling capability of the pump to prevent fluid backflow. Backflow can allow the pump to "turbine" backwards and may cause premature seal and/or bearing wear. If the pump is turning backwards when it is called on to start the increased torque may cause damage to the pump motor and/or motor shaft and some single-phase pumps may actually run backwards.

Install an adequately sized gate valve **AFTER** the check valve for pump, plumbing and check valve maintenance.

Important – Before pump installation. Drill a $\frac{3}{16}$" (4.8mm) relief hole in the discharge pipe. It should be located within the wetwell, 2" (51mm) above the pump discharge but below the check valve. The relief hole allows any air to escape from the casing. Allowing liquid into the casing will insure that the pump can start when the liquid level rises. Unless a relief hole is provided, a bottom intake pump could "air lock" and will not pump water even though the impeller turns.

All piping must be adequately supported, so as not to impart any piping strain or loads on the pump.

The pit access cover must be of sufficient size to allow for inspection, maintenance and crane or hoist service.

WIRING AND GROUNDING

Important notice: Read Safety Instructions before proceeding with any wiring.

⚠ Use only stranded copper wire to pump/motor and ground. The ground wire must be at least as large as the power supply wires. Wires should be color coded for ease of maintenance and troubleshooting.

⚠ Install wire and ground according to the National Electrical Code (NEC), or the Canadian Electrical Code, as well as all local, state and provincial codes.

⚠ Install an all leg disconnect switch where required by code.

⚠ Disconnect and lockout electrical power before performing any service or installation.

⚠ The electrical supply voltage and phase must match all equipment requirements. Incorrect voltage or phase can cause fire, motor and control damage, and voids the warranty.

⚠ All splices must be waterproof. If using splice kits follow manufacturer's instructions.

⚠ WARNING Select the correct type and NEMA grade junction box for the application and location. The junction box must insure dry, safe wiring connections.

⚠ WARNING Seal all controls from gases present which may damage electrical components.

⚠WARNING Hazardous voltage

FAILURE TO PERMANENTLY GROUND THE PUMP, MOTOR AND CONTROLS BEFORE CONNECTING TO POWER CAN CAUSE SHOCK, BURNS OR DEATH.

SELECTING AND WIRING PUMP CONTROL PANELS AND SWITCHES

FLOAT SWITCH TYPES

There are two basic float switch designs; single-action and wide-angle. Single-action switches operate over a range of 15° so they open and close quickly. Wide-angle floats operate over a 90° swing with the tether length between the float body and the pivot point controlling the On-Off range. The design determines how many floats are required with different systems or controls.

Floats may be normally open (NO) for pump down applications or to empty a tank. Normally closed (NC) switches are used to pump up or to fill a tank.

A single-action control switch may be used only with a control panel, never direct connected to a pump.

The wide-angle, pump down switches may be used as direct connected pump switches or as control switches.

SETTING THE FLOAT SWITCHES

There are no absolute rules for where to set the float switches, it varies from job to job.

Suggested Rules to Follow:
All floats should be set below the Inlet pipe!

Off Float: Best: set so the water level is always above the top of the pump (motor dome). **Next Best:** set so the water level is not more than 6" below the top of the pump.

On Float: set so the volume of water between the On and Off floats allows pumps of 1½ HP and under to operate for 1 minute minimum. Two (2) HP and larger pumps should run a minimum of 2 minutes. Basin literature states the gallons of storage per inch of basin height.

Lag/Alarm Float(s): should be staggered above the Off and On floats. Try to use most of the available storage provided by the basin, save some space for reserve storage capacity. *See Diagrams and Charts in Float Switch Chart Section.*

PANEL WIRING DIAGRAMS

Our control panels are shipped with instructions and wiring diagrams. Use those instructions in conjunction with this IOM. Electrical installation should be performed only by qualified technicians. Any problem or questions pertaining to another brand control must be referred to that control supplier or manufacturer. Our technical people have no technical schematics or trouble shooting information for other companies' controls.

ALARMS

We recommend the installation of an alarm on all Wastewater pump installations. Many standard control panels come equipped with alarm circuits. If a control panel is not used, a stand alone high liquid level alarm is available. The alarm alerts the owner of a high liquid level in the system so they can contact the appropriate service personnel to investigate the situation.

SINGLE PHASE PUMPS
Single phase (1Ø) pumps may be operated using a piggyback or hard wired float switch, a contactor, or a Simplex or Duplex control panel. *See Figures 1, 2 and 5*.

All 1/3 and ½ HP, 115 or 230 volt pumps, and some ¾ and 1 HP pumps, are supplied with plug style power cords. They may be plugged into piggyback float switches for simple installations. It is allowable to remove the plugs in order to hardwire or connect to a Simplex or Duplex controller. Removing the plug neither voids the warranty nor violates the agency Listings. *See Figure 5*.

PLUG-CONNECTED UNITS MUST BE CONNECTED TO A PROPERLY GROUNDED, GROUNDING TYPE RECEPTACLE.

ON NON-PLUG UNITS, DO NOT REMOVE CORD AND STRAIN RELIEF. DO NOT CONNECT CONDUIT TO PUMP.

Pumps with bare lead power cords can be hard-wired to a float switch, wired to a 1Ø contactor, a Simplex controller or a Duplex controller. Always verify that the float switch is rated for the maximum run amperage, maximum starting amperage, and the HP rating on the pump. Single-phase wastewater pumps contain on-winding overloads, unless noted on the pump nameplate. *See Figures 1 and 2*.

THREE PHASE PUMPS:
As a Minimum a 3Ø pump requires a 3 pole circuit breaker/fused circuit, an across the line magnetic starter rated for the pump HP, and ambient compensated Quick Trip Class 10 overloads.

SINGLE AND THREE PHASE CONTROL PANELS:
Control panels are available as Simplex (controls 1 pump) or Duplex (controls 2 pumps). Our standard SES Series Panels are available with many standard features and can be built with our most popular options. We also custom build panels which offer many more design options than the SES panels. Custom control panels are available in many different configurations. Custom panel quote requests may be forwarded to Customer Service through any authorized distributor.

Our "SES" Duplex panels feature a solid-state printed circuit board design with standard high level alarm circuits. Other standard features are: an auxiliary dry alarm contact for signaling a remote alarm and float switch position indicator lights. Our 3Ø panels have built-in, adjustable, Class 10 overloads. The adjustable overloads on all our 3Ø panels mean less labor for the installer and no need to order specific overloads. Most SES panels are in stock for immediate delivery.

On pumps equipped with seal fail and/or heat (high temperature) sensors it is recommended that you use our control panel with the appropriate options. The pump sensors do not function without a seal fail relay or terminal connection in the control panel and a warning device such as a bell, horn or light.

Seal Failure Circuit - Some dual seal pumps are equipped with a standard, built-in seal failure circuit, which may also be called a moisture detection circuit. This circuit must be connected to a control panel with an optional seal fail relay. The panel must be special ordered with the seal fail relay and alarm. There are also stand alone seal fail panels such as the A4-3 or A4-4 available as standard items. The pumps can be identified by an extra control cable exiting the motor cover. The cable contains two wires, a black wire, connects to panel "terminal" going to "probe"; and a white wire, connects to the panel "terminal" going to the relay ground. Do not connect to the panel ground screw. Follow the wiring instructions supplied with the panel.

Heat Sensor and Seal Failure Circuit - Some pumps are equipped with a seal fail and normally closed, on-winding high temperature thermostats (heat sensors). The pumps have a control cable with four (4) leads, black (probe) and green (relay ground) for the seal fail circuit and red and white for the high temperature circuit. Connect the high temperature (heat sensor) circuit to the panel terminal strip as indicated on the panel drawing using the red and white wires. The high temperature panel circuit is also an optional item which you must specifically order when you order your control panel. The high temperature circuit is different from the Class 10 overloads which are always required on three phase pumps. *Follow the wiring instructions supplied with the panel*.

INSTALLATION

Connect the pump(s) to the guide rail pump adapters or to the discharge piping. Slide rail bases should be anchored to the wetwell floor.

Complete all wiring per the control panel wiring diagrams and NEC, Canadian, state, provincial and/or local codes. This a good time to check for proper rotation of the motors/impellers.

DO NOT PLACE HANDS IN PUMP SUCTION WHILE CHECKING MOTOR ROTATION. TO DO SO WILL CAUSE SEVERE PERSONAL INJURY.

Always verify correct rotation. Correct rotation is indicated on the pump casing. Three phase motors are reversible. It is allowable to bump or jog the motor for a few seconds to check impeller rotation. It is easier to check rotation before installing the pump. Switch any two power leads to reverse rotation.

Lower the pump(s) into the wetwell.

Check to insure that the floats will operate freely and not contact the piping.

OPERATION

Once the piping connections are made and checked you can run the pumps.

Piggyback Switch Operation – Plug the piggyback switch into a dedicated grounded outlet and then plug the pump into the switch. Test the pump by filling the wetwell until the pump goes On. If the pumps run but fail to pump, they are probably air locked, drill the relief holes per the instructions in the Piping Section.

Check the operating range to insure a minimum one minute run time and that the pump goes Off in the correct position.

Control Panel Operation – Fill the wetwell with clear water.

Use the pump H-O-A (Hand-Off-Automatic) switches in Hand to test the pumps. If they operate well in Hand proceed to test Automatic operation. If the pumps run but fail to pump, they are probably air locked, drill the relief holes per the instructions in the Piping Section.

Place Control Panel switch(es) in Automatic position and thoroughly test the operation of the ON, OFF, and Alarm floats by filling the wetwell with clear water. **Important:** Failure to provide a Neutral from the power supply to a 1Ø, 230 volt Control Panel will not allow the panel control circuit to operate. The Neutral is necessary to complete the 115 volt control circuit.

Check voltage and amperage and record the data on the front of this manual for future reference. Compare the amperage readings to the pump nameplate maximum amperage. If higher than nameplate amperage investigate cause. Operating the pump off the curve, i.e. with too little head or with high or low voltage will increase amperage. The motor will operate properly with voltage not more than 10% above or below pump nameplate ratings. Performance within this range will not necessarily be the same as the published performance at the exact rated nameplate frequency and voltage. Correct the problem before proceeding. Three phase unbalance is also a possible cause. *See Three Phase Power Unbalance and follow the instructions*.

Reset the Alarm circuit, place pump switch(es) in the Automatic position and Control Switch in ON position. The system is now ready for automatic operation.

Explain the operation of the pumps, controls and alarms to the end user. Leave the paperwork with the owner or at the control panel if in a dry, secure location.

FLOAT SWITCH AND PANEL CHART

The purpose of this chart is to show the required switch quantities and the function of each switch in a typical wastewater system. The quantities required vary depending on the switch type, single-action or wide-angle. Switch quantities also vary by panel type: simplex with and without alarms, and duplex with alarms.

Duplex Panels using single-action switches:

Three Float Panel Wiring

SW1	Bottom	Pumps Off
SW2	Middle	1st Pump On
SW3	Top	2nd Pump & Alarm On

Four Float Panel Wiring ②

SW1	Bottom	Pumps Off
SW2	2nd	1st Pump On
SW3	3rd	2nd Pump On
SW4	Top	Alarm On

Duplex Panels using wide-angle switches:

Three Float Panel Wiring

SW1	Bottom	1st Pump On/Both Off
SW2	Top	2nd Pump & Alarm On

Four Float Panel Wiring

SW1	Bottom	1st Pump On/Both Off
SW2	Middle	2nd Pump On
SW3	Top	Alarm On

Simplex Panel using single-action switches:

Simplex Panel with Alarm ①

SW1	Bottom	Pump Off
SW2	Middle	Pump On
	SW3	Top Alarm On/Off

Simplex Panel with No Alarm

SW1	Bottom	Pump Off
SW2	Top	Pump On

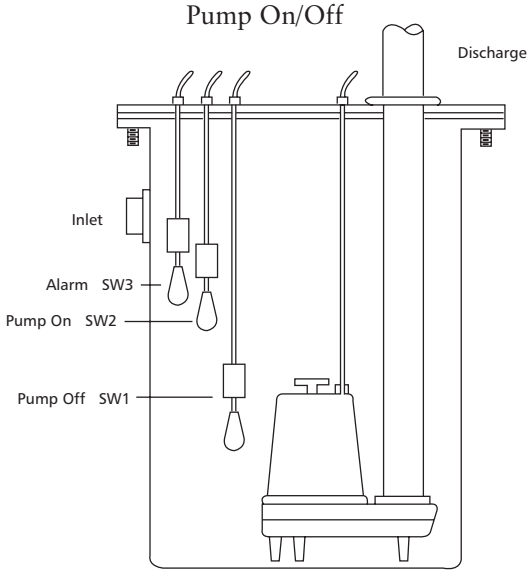
Simplex Panel using wide-angle switches:

Simplex Panel with Alarm

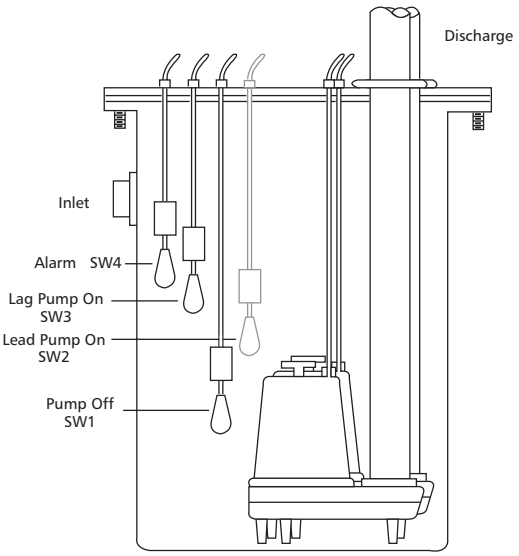
SW1	Bottom	Pump On/Off
SW2	Top	Alarm On/Off

Simplex Panel with No Alarm

SW1	Pump On/Off



Simplex ①



Duplex ②

THREE PHASE POWER UNBALANCE

A full three phase supply consisting of three individual transformers or one three phase transformer is recommended. "Open" delta or wye connections using only two transformers can be used, but are more likely to cause poor performance, overload tripping or early motor failure due to current unbalance.

Check the current in each of the three motor leads and calculate the current unbalance as explained below.

If the current unbalance is 2% or less, leave the leads as connected.

If the current unbalance is more than 2%, current readings should be checked on each leg using each of the three possible hook-ups. Roll the motor leads across the starter in the same direction to prevent motor reversal.

To calculate percent of current unbalance:

A. Add the three line amp values together.

B. Divide the sum by three, yielding average current.

C. Pick the amp value which is furthest from the average current (either high or low).

D. Determine the difference between this amp value (furthest from average) and the average.

E. Divide the difference by the average. Multiply the result by 100 to determine percent of unbalance.

Current unbalance should not exceed 5% at service factor load or 10% at rated input load. If the unbalance cannot be corrected by rolling leads, the source of the unbalance must be located and corrected. If, on the three possible hookups, the leg farthest from the average stays on the same power lead, most of the unbalance is coming from the power source.

Contact your local power company to resolve the imbalance.

	Hookup 1			Hookup 2			Hookup 3		
Starter Terminals	L1	L2	L3	L1	L2	L3	L1	L2	L3
	⊥ T	⊥ T	⊥ T	⊥ T	⊥ T	⊥ T	⊥ T	⊥ T	⊥ T
Motor Leads	R	B	W	W	R	B	B	W	R
	T3	T1	T2	T2	T3	T1	T1	T2	T3

Example:

T3-R = 51 amps	T2-W = 50 amps	T1-B = 50 amps
T1-B = 46 amps	T3-R = 48 amps	T2-W = 49 amps
T2-W = 53 amps	T1-B = 52 amps	T3-R = 51 amps
Total = 150 amps	Total = 150 amps	Total = 150 amps
÷ 3 = 50 amps	÷ 3 = 50 amps	÷ 3 = 50 amps
− 46 = 4 amps	− 48 = 2 amps	− 49 = 1 amps
4 ÷ 50 = .08 or 8%	2 ÷ 50 = .04 or 4%	1 ÷ 50 = .02 or 2%

INSULATION RESISTANCE READINGS

Normal Ohm and Megohm Values between all leads and ground

Condition of Motor and Leads	Ohm Value	Megohm Value
A new motor (without drop cable).	20,000,000 (or more)	20 (or more)
A used motor which can be reinstalled in well.	10,000,000 (or more)	10 (or more)
Motor in well. Readings are for drop cable plus motor.		
New motor.	2,000,000 (or more)	2 (or more)
Motor in good condition.	500,000 - 2,000,000	.5 - 2
Insulation damage, locate and repair.	Less than 500,000	Less than .5

Insulation resistance varies very little with rating. Motors of all HP, voltage and phase ratings have similar values of insulation resistance.

Insulation resistance values above are based on readings taken with a megohmmeter with a 500V DC output. Readings may vary using a lower voltage ohmmeter, consult factory if readings are in question.

Engineering data for specific models may be found in your catalog and on our website (address is on the cover).

Control panel wiring diagrams are shipped with the control panels. Please use the control panel drawings in conjunction with this instruction manual to complete the wiring.

PUMP OPERATION			
Minimum Submergence		**Maximum Fluid Temperature**	
Continuous Duty	Fully Submerged	Continuous Operation	104º F 40º C
Intermittent Duty	6" Below Top of Motor	Intermittent Operation	140º F 60º C

Pumpmaster and Pumpmaster Plus - Hard Wired

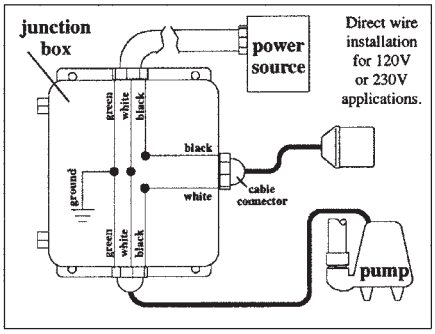


Figure 1

Single-Action Float Switch "Typical" Installation

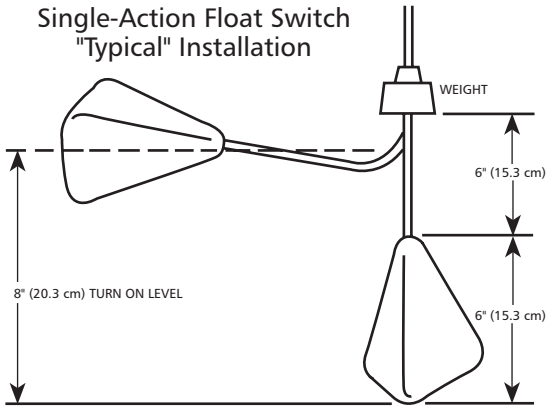


Figure 4

Double Float - Hard Wired

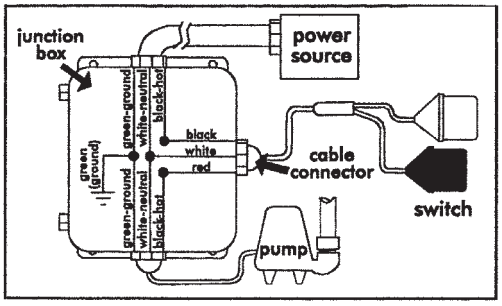


Figure 2

Wide-Angle Float Switch

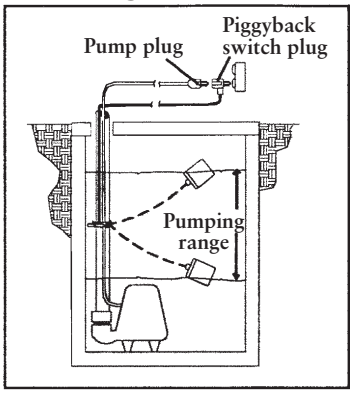


Figure 5

Determining Pumping Range

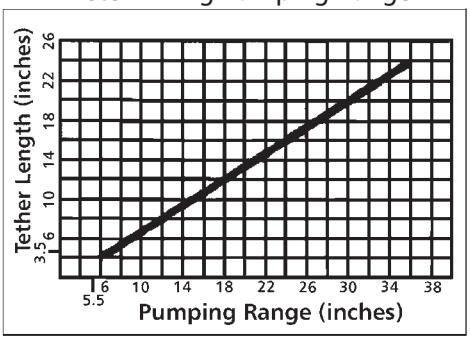


Figure 3

Three Phase Connection Diagram

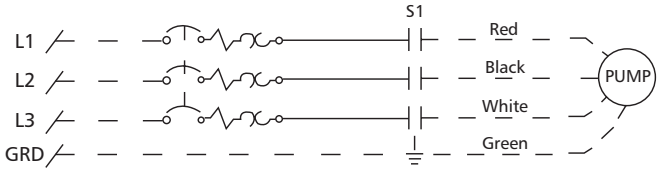
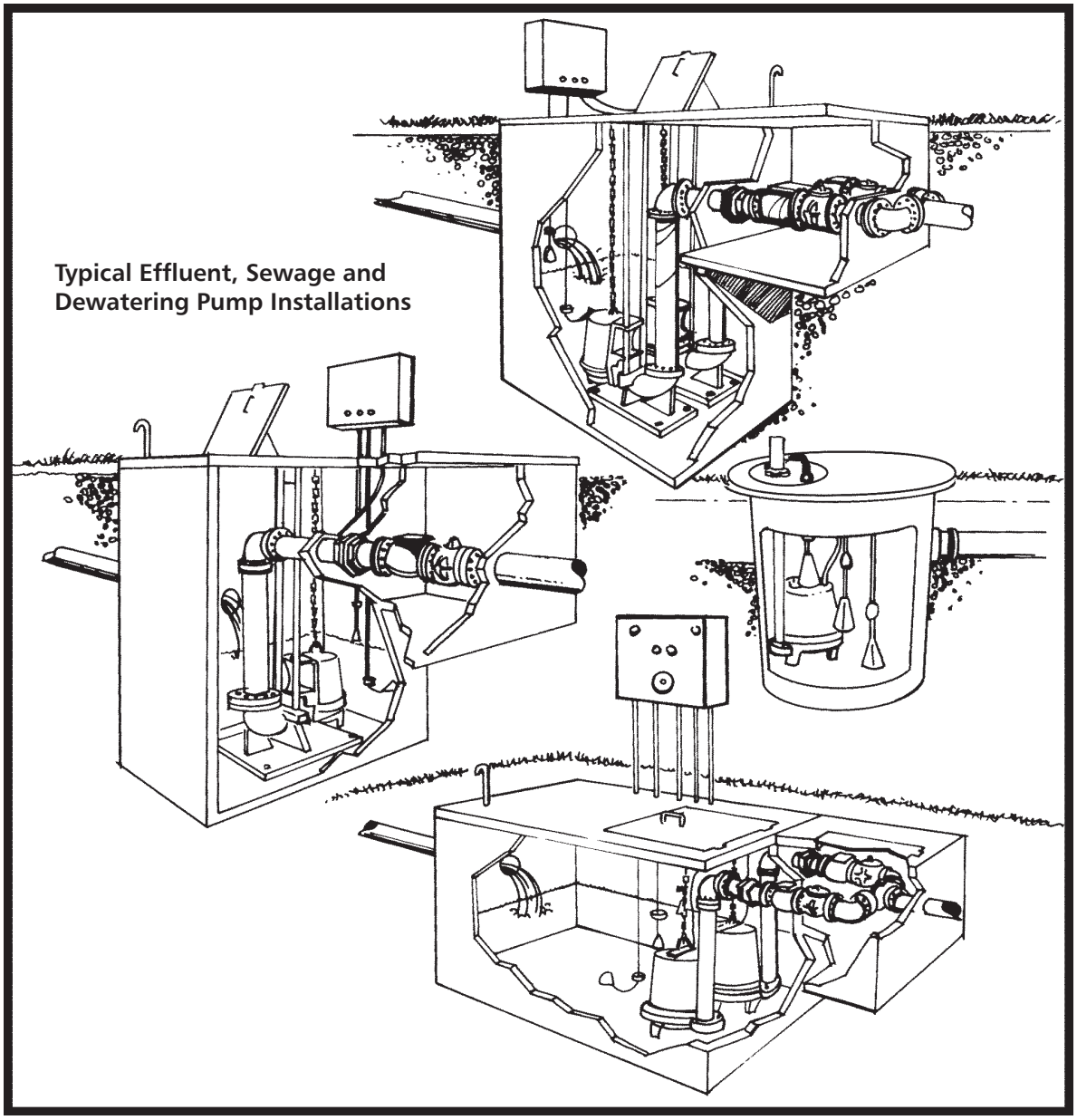


Figure 6

⚠WARNING
Hazardous voltage

FAILURE TO DISCONNECT AND LOCKOUT ELECTRICAL POWER BEFORE ATTEMPTING ANY SERVICE CAN CAUSE SHOCK, BURNS OR DEATH.

SYMPTOM	PROBABLE CAUSE	RECOMMENDED ACTION
MOTOR NOT RUNNING	Motor thermal protector tripped.	Allow motor to cool. Insure minimum pump submergence. Clear debris from casing and impeller.
NOTE: If circuit breaker "OPENS" repeatedly, **DO NOT** reset. Call qualified electrician.	Open circuit breaker or blown fuse.	Determine cause, call a qualified electrician.
	Pump impeller binding or jammed.	Check motor amp draw. If two or more times higher than listed on pump nameplate, impeller is locked, motor bearings or shaft is damaged. Clear debris from casing and impeller, consult with dealer.
a) Manual operation	Power cable is damaged.	
	Inadequate electrical connection in control panel.	
b) Automatic operation	No neutral wire connected to control panel.	Resistance between power leads and ground should read infinity. If any reading is incorrect, call a qualified electrician.
	Inadequate electrical connection in control panel.	Inspect control panel wiring. Call a qualified electrician.
NOTE: Check the pump in manual mode first to confirm operation. If pump operates, the automatic control or wiring is at fault. If pump does not operate, see above.	Defective liquid level switch.	With switch disconnected, check continuity while activating liquid level switch. Replace switch, as required.
	Insufficient liquid level to activate controls.	Allow liquid level to rise 3" to 4" (76 mm - 101 mm) above turn-on level.
	Liquid level cords tangled.	Untangle cords and insure free operation.
PUMP WILL NOT TURN OFF	Liquid level cords tangled.	Untangle cords and insure free operation.
	Pump is air locked.	Shut off pump for approximately one minute, then restart. Repeat until air lock clears. If air locking persists in a system with a check valve, a $\frac{3}{16}$" (4.8 mm) hole may be drilled in the discharge pipe approximately 2" (51 mm) above the discharge connection.
	Influent flow is matching pump's discharge capacity.	Larger pump may be required.
LITTLE OR NO LIQUID DELIVERED BY PUMP	Check valve installed backwards, plugged or stuck closed.	Check flow arrow on valve and check valve operation.
	Excessive system head.	Consult with dealer.
	Pump inlet plugged.	Inspect and clear as required.
	Improper voltage or wired incorrectly.	Check pump rotation, voltage and wiring. Consult with qualified electrician.
	Pump is air locked.	See recommended action, above.
	Impeller is worn or damaged.	Inspect impeller, replace as required.
	Liquid level controls defective or improperly positioned.	Inspect, readjust or replace as required.
PUMP CYCLES CONSTANTLY	Discharge check valve inoperative.	Inspect, repair or replace as required.
	Sewage containment area too small.	Consult with dealer.
	Liquid level controls defective or improperly positioned.	Inspect, readjust or replace as required.
	Influent excessive for this size pump.	Consult with dealer.


Typical Effluent, Sewage and
Dewatering Pump Installations

GOULDS PUMPS LIMITED WARRANTY

This warranty applies to all water systems pumps manufactured by Goulds Pumps.

Any part or parts found to be defective within the warranty period shall be replaced at no charge to the dealer during the warranty period. The warranty period shall exist for a period of twelve (12) months from date of installation or eighteen (18) months from date of manufacture, whichever period is shorter.

A dealer who believes that a warranty claim exists must contact the authorized Goulds Pumps distributor from whom the pump was purchased and furnish complete details regarding the claim. The distributor is authorized to adjust any warranty claims utilizing the Goulds Pumps Customer Service Department.

The warranty excludes:

(a) Labor, transportation and related costs incurred by the dealer;
(b) Reinstallation costs of repaired equipment;
(c) Reinstallation costs of replacement equipment;
(d) Consequential damages of any kind; and,
(e) Reimbursement for loss caused by interruption of service.

For purposes of this warranty, the following terms have these definitions:

(1) "Distributor" means any individual, partnership, corporation, association, or other legal relationship that stands between Goulds Pumps and the dealer in purchases, consignments or contracts for sale of the subject pumps.
(2) "Dealer" means any individual, partnership, corporation, association, or other legal relationship which engages in the business of selling or leasing pumps to customers.
(3) "Customer" means any entity who buys or leases the subject pumps from a dealer. The "customer" may mean an individual, partnership, corporation, limited liability company, association or other legal entity which may engage in any type of business.

THIS WARRANTY EXTENDS TO THE DEALER ONLY.

GOULDS PUMPS

Goulds Pumps and the ITT Engineered Blocks Symbol are registered trademarks and tradenames of ITT Industries Inc.

SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE.

IM107R03 March, 2006

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Engineered for life

Goulds Pumps

Bombas para aguas residuales, para extracción de agua, para efluente y para alcantarillado

Instrucciones de instalación, funcionamiento y mantenimiento

GOULDS PUMPS

Goulds Pumps es una marca de fábrica de ITT Water Technology, Inc. - un subsidiario de ITT Industries, inc.

www.goulds.com

Engineered for life

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Información del propietario

Número de modelo de la bomba: _____

Número de serie de la bomba: _____

Número de modelo del control: _____

Agente: _____

No. telefónico del agente: _____

Fecha de compra: _____ Instalación: _____

Lecturas actuales en el momento de la puesta en marcha:

1Ø		3Ø		L1-2	L2-3	L3-1
Amperios:	_____	Amperios:	_____	_____	_____	_____
Voltios:	_____	Voltios:	_____	_____	_____	_____

INSTRUCCIONES DE SEGURIDAD

PARA EVITAR LESIONES PERSONALES GRAVES O AÚN FATALES Y SERIOS DAÑOS MATERIALES, LEA Y SIGA TODAS LAS INSTRUCCIONES DE SEGURIDAD EN EL MANUAL Y EN LA BOMBA.

ESTE MANUAL HA SIDO CREADO COMO UNA GUÍA PARA LA INSTALACIÓN Y OPERACIÓN DE ESTA UNIDAD Y SE DEBE CONSERVAR JUNTO A LA BOMBA.

Éste es un **SÍMBOLO DE ALERTA DE SEGURIDAD**. Cuando vea este símbolo en la bomba o en el manual, busque una de las siguientes palabras de señal y esté alerta a la probabilidad de lesiones personales o daños materiales.

⚠ PELIGRO Advierte los peligros que **CAUSARÁN** graves lesiones personales, la muerte o daños materiales mayores.

⚠ ADVERTENCIA Advierte los peligros que **PUEDEN** causar graves lesiones personales, la muerte o daños materiales mayores.

⚠ PRECAUCIÓN Advierte los peligros que **PUEDEN** causar lesiones personales o daños materiales.

AVISO: INDICA INSTRUCCIONES ESPECIALES QUE SON MUY IMPORTANTES Y QUE SE DEBEN SEGUIR.

EXAMINE BIEN TODAS LAS INSTRUCCIONES Y ADVERTENCIAS ANTES DE REALIZAR CUALQUIER TRABAJO EN ESTA BOMBA.

MANTENGA TODAS LAS CALCOMANÍAS DE SEGURIDAD.

⚠ ADVERTENCIA Todo el trabajo eléctrico debe ser realizado por un técnico calificado. Siempre siga el Código Eléctrico de EE.UU. (NEC) o el Código Eléctrico Canadiense, además de todos los códigos locales, estatales y provinciales. Las preguntas acerca del código deben ser dirigidas al inspector eléctrico local. Si se hace caso omiso a los códigos eléctricos y normas de seguridad de OSHA, se pueden producir lesiones personales o daños al equipo. Si se hace caso omiso a las instrucciones de instalación del fabricante, se puede producir electrochoque, peligro de incendio, lesiones personales o aún la muerte, daños al equipo, rendimiento insatisfactorio y podría anularse la garantía del fabricante.

⚠ ADVERTENCIA Las unidades estándar no están diseñadas para usarse en albercas, masas abiertas de agua, líquidos peligrosos o donde existan gases inflamables. Estos fluidos y gases podrían estar presentes en áreas de contención. El tanque o pozo debe ser ventilado de acuerdo con los códigos locales.

En lugares con líquidos inflamables o donde pudiese haber gases inflamables sólo deben usarse bombas específicamente clasificadas para áreas de Clase 1, División 1. *Consulte los boletines de catálogos de bombas específicas o la placa de identificación de la bomba con respecto a las listas de agencias.*

⚠ ADVERTENCIA Desconecte y bloquee la corriente eléctrica antes de instalar o dar servicio a cualquier equipo eléctrico. Muchas bombas están equipadas con protección automática contra la sobrecarga térmica, la cual podría permitir que una bomba demasiado caliente rearranque inesperadamente.

⚠ PRECAUCIÓN Todos los paneles de control trifásicos (3Ø) para bombas sumergibles deben incluir protección contra sobrecarga de Clase 10, de disparo rápido.

VERIFICACIONES PRELIMINARES A LA INSTALACIÓN

Abra todas las cajas e inspeccione el equipo para determinar si se ocasionaron daños durante el envío. Notifique cualquier daño a su proveedor o a la compañía de transporte de inmediato.

Importante: Siempre verifique que las clasificaciones de corriente, tensión, fase y potencia en la placa de identificación de la bomba correspondan con las del panel de control y fuente de alimentación.

Muchas de nuestras bombas para alcantarillado están llenas con aceite. Si hay alguna señal de fuga de aceite o si la unidad estuvo almacenada durante largo tiempo, verifique el nivel de aceite en la cúpula del motor y la caja del sello, en caso de haberla.

Verifique el nivel de aceite de la cubierta del motor a través del tapón de la tubería en el extremo superior de la unidad. El aceite en la cámara del motor debe cubrir apenas el motor. ¡No llene en exceso, deje espacio para expansión!

Para verificar el nivel de aceite de la caja del sello, en caso que se use, coloque la unidad de lado con el tapón de llenado en la posición de las 12:00 horas. Retire el tapón. El aceite debe estar a menos de ½ pulg. (13 mm) del borde superior. Si el nivel está bajo, agregue aceite para turbinas ASTM 150. Reinstale el tapón.

Puede obtenerse aceite en latas de 5 galones de nuestros distribuidores. También puede obtener aceite a nivel local en talleres de reparación de motores. Las marcas típicas de aceite son: Shell Turbo 32, Sunoco Sunvis 932, Texaco Regal R&O 32, Exxon Nuto 32 y Mobil DTE Light.

Inspeccione la tuerca de alivio de tensión en los conjuntos de protección contra tirones de los cables de alimentación. Torsión de los cables de alimentación: 75 pulg.-lbs. para cables #16 y 80 pulg.-lbs. para todos los otros tipos de cable. La torsión de los cables de sensores de sello/calor, cuando se usen, debe ser de 75 pulg.-lbs.

La garantía no cubre daños causados por conectar bombas y controles a la fuente de energía incorrecta (fuente de tensión/fase).

Anote los números de modelos y números de serie de las bombas y del panel de control en la sección delantera de este manual de instrucciones para referencia futura. Entregue el manual al propietario o adjúntelo al panel de control una vez finalizada la instalación.

LEVANTAMIENTO DE LA BOMBA

⚠ ADVERTENCIA

Un voltaje peligroso puede producir golpes eléctricos, quemaduras o la muerte.

NO LEVANTE NI TRANSPORTE NI CUELGUE LA BOMBA DE LOS CABLES ELÉCTRICOS. EL DAÑO A LOS CABLES ELÉCTRICOS PUEDE PRODUCIR ELECTROCHOQUE, QUEMADURAS O AÚN LA MUERTE.

Levante la bomba con una cadena o cable de tamaño adecuado conectado al perno de ojo de levantamiento. **NO** dañe los cables eléctricos o de los sensores al subir y bajar la unidad.

RIEL CORREDIZO O SISTEMA DE LEVANTAMIENTO OPCIONAL

En muchos estanques de efluente y aguas negras o estaciones de levantamiento se recomienda instalar la bomba en un sistema de riel corredizo o sobre un adaptador de levantamiento para facilitar la instalación y retiro para inspección y/o servicio. La mayoría de los códigos no permiten que el personal entre al pozo sumidero sin el equipo de protección y la capacitación correctos. Los rieles corredizos están diseñados para facilitar el retiro de la bomba sin necesidad de entrar al pozo o perturbar la tubería. El riel corredizo o el adaptador de levantamiento debe situar la bomba opuesta a la abertura para el líquido de entrada, evitando las áreas estancadas donde pudiesen asentarse sólidos. El estanque o fosa debe ser capaz de soportar el peso de la bomba y del riel de deslizamiento. El piso de la fosa debe ser plano.

AVISO: SIGA LAS INSTRUCCIONES INCLUIDAS CON EL CONJUNTO DEL RIEL CORREDIZO.

TUBERÍAS

La tubería de descarga no debe ser más pequeña que el diámetro de descarga de la bomba y debe mantenerse lo más corta posible, evitando los accesorios innecesarios para reducir al mínimo las pérdidas por fricción.

Instale una válvula de retención de tamaño adecuado que corresponda con la capacidad de manejo de sólidos de la bomba para evitar el contraflujo de fluido. El contraflujo puede hacer que la bomba "gire" en dirección inversa, produciendo un desgaste prematuro del sello y/o del cojinete. Si la bomba gira en sentido inverso al arrancar, el aumento de torsión puede dañar el motor y/o el eje del motor de la bomba y algunas bombas monofásicas hasta podrían funcionar en sentido inverso.

Instale una válvula de compuerta de tamaño adecuado **DESPUÉS** de la válvula de retención para facilitar el mantenimiento de la bomba, las tuberías y la válvula de retención.

Importante – antes de instalar la bomba. Perfore un orificio de alivio de $^{3}/_{16}$ pulg. (4.8 mm) en la tubería de descarga. Debe situarse dentro del pozo, a 2 pulg. (51 mm) sobre la descarga de la bomba, pero debajo de la válvula de retención. El orificio de alivio permite el escape de aire de la carcasa. Al permitir que entre líquido a la carcasa se asegura que la bomba pueda arrancar cuando el nivel de líquido aumente. A menos que se proporcione un orificio de alivio, una bomba de toma inferior podría "obstruirse con aire" y no bombear agua, a pesar de que el impulsor gire.

Todas las tuberías deben estar apoyadas correctamente, de modo que no se apliquen esfuerzos o cargas de las tuberías a la bomba.

La cubierta de acceso a la fosa debe ser de tamaño suficiente para permitir realizar el servicio de inspección, mantenimiento y levantamiento con grúa o montacargas.

CABLEADO Y CONEXIÓN A TIERRA

Aviso importante: Lea las instrucciones de seguridad antes de proseguir con el cableado.

⚠ Use únicamente alambre trenzado de cobre para la bomba/motor y la conexión a tierra. El alambre de conexión a tierra debe ser al menos del mismo tamaño que los alambres de la fuente de alimentación. Los alambres deben codificarse con colores para facilitar el mantenimiento y la identificación y resolución de problemas.

⚠ Instale los cables y la conexión a tierra de acuerdo con el Código Eléctrico de EE.UU. (NEC) o el Código Eléctrico Canadiense, además de los códigos locales, estatales y provinciales.

⚠ Instale un desconectador de todos los circuitos donde el código lo requiera.

⚠ Desconecte y bloquee la corriente eléctrica antes de instalar o dar servicio.

⚠ La tensión y fase de la fuente de alimentación debe corresponder con todos los requerimientos del equipo. La tensión o fase incorrecta puede producir incendio, daño al motor o a los controles y anula la garantía.

⚠ Todos los empalmes debe ser impermeables. Si utiliza juegos de empalme, siga las instrucciones del fabricante.

⚠ADVERTENCIA Seleccione una caja de conexiones NEMA del tipo correcto para la aplicación y ubicación. La caja de conexiones debe garantizar conexiones de cableado seguras y secas.

⚠ADVERTENCIA Selle todos los controles de los gases presentes que pudiesen dañar los componentes eléctricos.

⚠ADVERTENCIA
Tensión peligrosa

LA FALLA DE CONECTAR A TIERRA PERMANENTEMENTE LA BOMBA, EL MOTOR Y LOS CONTROLES, ANTES DE CONECTAR LA CORRIENTE ELÉCTRICA, PUEDE CAUSAR ELECTROCHOQUE, QUEMADURAS O LA MUERTE.

SELECCIÓN Y CABLEADO DE LOS INTERRUPTORES Y PANELES DE CONTROL DE LA BOMBA

TIPOS DE INTERRUPTORES DE FLOTADOR

Hay dos tipos de diseños de interruptor de flotador: de acción simple y de ángulo amplio. Los interruptores de acción simple funcionan en un rango de 15º, de manera que pueden abrirse y cerrarse con rapidez. Los flotadores de ángulo amplio funcionan con un giro de 90º con el largo de la traba entre el cuerpo del flotador y el punto de pivote controlando al rango de encendido-apagado. El diseño determina cuántos flotadores se requieren con los diferentes sistemas o controles.

Los flotadores pueden estar normalmente abiertos (NO) para aplicaciones de reducción de nivel o para vaciar un tanque. Los interruptores normalmente cerrados (NC) se utilizan para aumentar el nivel o para llenar un tanque.

Un interruptor de control de acción simple sólo puede usarse con un panel de control, pero nunca directamente conectado a una bomba.

Los interruptores de ángulo ancho de reducción de nivel pueden usarse como interruptores directamente conectados a la bomba o como interruptores de control.

INSTALACIÓN DE LOS INTERRUPTORES DE FLOTADOR

No hay reglas absolutas acerca de dónde instalar los interruptores de flotador, varía de trabajo a trabajo.

Reglas sugeridas a seguir:
¡Todos los flotadores deben instalarse debajo de la tubería de entrada!

Flotador de apagado: Primera preferencia: instálelo de manera que el nivel del agua quede siempre sobre el extremo superior de la bomba (cúpula del motor). Segunda preferencia: instálelo de manera que el nivel del agua quede a no más de 6 pulg. por debajo del extremo superior de la bomba.

Flotador de encendido: instálelo de manera que el volumen de agua entre los flotadores de encendido y apagado permita bombas de 1½ HP y menores funcionar al menos 1 minuto. Las bombas de dos (2) HP y mayores deben funcionar al menos 2 minutos. La literatura sobre estanques establece los galones de almacenaje por pulgada de altura del estanque.

Flotador(es) de retardo/alarma: deben escalonarse sobre los flotadores de apagado y encendido. Trate de utilizar la mayoría del almacenaje disponible ofrecido por el estanque, ahorre espacio para la capacidad de almacenaje de reserva. *Consulte los diagramas y tablas en la Sección de Tablas de Interruptores de Flotador.*

DIAGRAMAS DE CABLEADO DEL PANEL
Nuestros paneles de control se envían con instrucciones y diagramas de cableado. Utilice dichas instrucciones en conjunto con este manual de instrucciones (IOM). La instalación eléctrica debe ser realizada por técnicos calificados únicamente. Cualquier problema o preguntas con respecto al control de otras marcas debe dirigirse a ese proveedor o al fabricante del control. Nuestro personal técnico no tiene diagramas esquemáticos técnicos o información de identificación y resolución de problemas de los controles de otras compañías.

ALARMAS
Recomendamos la instalación de una alarma en todas las bombas para aguas residuales. Muchos paneles de control estándar vienen equipados con circuitos de alarma. Si no se usa un panel de control, se ofrece una alarma por alto nivel de líquido independiente. La alarma alerta al propietario acerca de una situación de alto nivel de líquido en el sistema, de manera que pueda comunicarse con el personal de servicio apropiado para que investigue la situación.

BOMBAS MONOFÁSICAS
Las bombas monofásicas (1Ø) pueden operarse utilizando un interruptor de flotador en tándem o de conexión directa, un contactador o un panel de control simple o doble. *Ver las Figuras 1,2 y 5*.

Todas las bombas de ⅓ y ½ HP, de 115 ó 230 voltios y algunas bombas de ¾ y de 1 HP están equipadas con cables de alimentación estilo enchufe. Pueden enchufarse a interruptores de flotador en tándem para instalaciones sencillas. Se permite quitar los enchufes para conectar directamente o conectar a un controlador simple o doble. El retiro del enchufe no anula la garantía ni viola las aprobaciones de las agencias. *Ver la figura 5*.

LAS UNIDADES CON ENCHUFE DEBEN CONECTARSE A UN TOMACORRIENTES TIPO TIERRA CONECTADO CORRECTAMENTE A TIERRA.

EN EL CASO DE UNIDADES SIN ENCHUFE, NO QUITE EL CABLE NI EL PROTECTOR CONTRA TIRONES. NO CONECTE EL TUBO-CONDUCTO A LA BOMBA.

Las bombas con cables de alimentación con conductores desnudos pueden conectarse directamente a un interruptor de flotador, cablearse a un contactador de 1 fase, a un controlador simple o doble. Siempre verifique que el interruptor de flotador esté clasificado para el amperaje de funcionamiento máximo, amperaje de arranque máximo y la capacidad nominal de potencia de la bomba. Las bombas monofásicas para aguas residuales contienen sobrecargas de devanado de encendido, a menos que se especifique lo contrario en la placa de identificación de la bomba. *Ver las Figuras 1 y 2*.

BOMBAS TRIFÁSICAS:
Como mínimo, una bomba trifásica requiere un cortacircuitos/circuito con fusible trifásico, un arrancador magnético en la línea clasificado para la potencia de la bomba y sobrecargas Clase 10, de disparo rápido y compensación ambiental.

PANELES DE CONTROL MONOFÁSICOS Y TRIFÁSICOS:
Los paneles de control pueden ser simples (controlan 1 bomba) o dobles (controlan 2 bombas). Nuestros paneles Serie SES se ofrecen con muchas características estándar y pueden construirse con nuestras opciones más populares. También construimos paneles de acuerdo con las especificaciones del cliente, los cuales ofrecen muchas más opciones que los paneles SES. Los paneles de control construidos de acuerdo con las especificaciones del cliente se ofrecen en muchas configuraciones diferentes. Las solicitudes de cotizaciones para paneles a la medida pueden enviarse a Servicio a los Clientes mediante nuestro distribuidor autorizado.

Nuestros paneles "SES" dobles presentan un diseño de tablero de circuito impreso de estado sólido con circuitos de alarmas de alto nivel estándar. Otras características estándar son: un contacto de alarma seco auxiliar para señalizar una alarma remota y luces indicadoras de posición del interruptor de flotador. Nuestros paneles trifásicos tienen sobrecargas Clase 10 incorporadas y ajustables. Las sobrecargas ajustables en todos nuestros paneles trifásicos significa menos trabajo para el instalador y la eliminación de la necesidad de ordenar sobrecargas específicas. La mayoría de los paneles SES se mantienen en inventario para entrega inmediata.

En el caso de bombas equipadas con sensores de falla de sello y/o sensores de calor, se recomienda que use su panel de control con las opciones apropiadas. Los sensores de la bomba no funcionan sin un relé de falla de sello o una conexión terminal en el panel de control y un dispositivo de alarma tal como una campana, bocina o luz.

Circuito de falla de sello – Algunas bombas de sello doble están equipadas con un circuito de falla de sello que también se denomina circuito de detección de humedad. Este circuito debe estar conectado a un panel de control con un relé de falla de sello opcional. El panel debe ordenarse especialmente con el relé de falla de sello y la alarma. También hay paneles de falla de sello independientes como los A4-3 o A4-A disponibles como artículos estándar. Las bombas pueden identificarse por un cable de control adicional que sea de la tapa del motor. El cable contiene dos alambres, un alambre negro que se conecta al "terminal" del panel que va a la "sonda", y un alambre blanco que se conecta al "terminal" del panel que va a la tierra del relé. No los conecte al tornillo de tierra del panel. *Siga las instrucciones de cableado incluidas con el panel.*

Sensor de calor y circuito de falla de sello – Algunas bombas están equipadas con termostatos de falla de sello y de alta temperatura, de devanado de encendido, normalmente cerrados (sensores de calor). Las bombas tienen un cable de control con cuatro (4) conductores: negro (sonda) y verde (tierra del relé) para el circuito de falla del sello y rojo y blanco para el circuito de alta temperatura. Conecte el circuito de alta temperatura (sensor de calor) a la regleta de terminales del panel, tal como se indica en el dibujo del panel, con los alambres rojo y blanco. El circuito del panel de alta temperatura también es un artículo opcional que debe ordenar específicamente cuando ordene su panel de control. El circuito de alta temperatura es diferente de las sobrecargas Clase 10 que son siempre requeridas en las bombas trifásicas. *Siga las instrucciones de cableado incluidas con el panel.*

INSTALACIÓN

Conecte la(s) bomba(s) a los adaptadores de riel corredizo o a la tubería de descarga. Las bases del riel corredizo deben anclarse al piso del pozo.

Todas las conexiones deben realizarse de acuerdo con los diagramas de cableado del panel de control, el código eléctrico de EE.UU., el código canadiense y los códigos estatales, provinciales y/o locales. Éste es un buen momento para verificar la rotación apropiada de los motores/impulsores.

NO COLOQUE LAS MANOS EN LA SUCCIÓN DE LA BOMBA MIENTRAS VERIFICA LA ROTACIÓN DEL MOTOR. EL HACERLO PRODUCIRÁ GRAVES LESIONES PERSONALES.

Siempre verifique la rotación correcta. La rotación correcta se indica en la carcasa de la bomba. Los motores trifásicos son reversibles. Se permite arrancar brevemente o en marcha lenta el motor durante unos segundos para verificar la rotación del impulsor. Es más fácil verificar la rotación antes de instalar la bomba. Intercambie dos de los conductores de potencia cualquiera para invertir la rotación.

Baje la(s) bomba(s) al pozo sumidero.

Inspeccione para verificar que los flotadores funcionen libremente y que no hagan contacto con la tubería.

OPERACIÓN

Una vez que se hayan hecho y verificado las conexiones de las tuberías, se pueden poner en funcionamiento las bombas.

Operación de interruptor en tándem – Enchufe el interruptor en tándem a un tomacorrientes dedicado conectado a tierra y luego enchufe la bomba al interruptor. Pruebe la bomba llenando el pozo hasta que la bomba se active. Si las bombas funcionan pero no bombean, probablemente estén obstruidas con aire; perfore los orificios de alivio de acuerdo con las instrucciones en la Sección de Tuberías.

Verifique el intervalo de operación para asegurar un tiempo de funcionamiento mínimo de un minuto y que la bomba se apague en la posición correcta.

Operación del panel de control – Llene el pozo con agua limpia.

Utilice los interruptores H-O-A (manual – apagado – automático) de la bomba en la posición manual para probar las bombas. Si funcionan bien en la posición manual, pruebe la posición automática. Si las bombas funcionan pero no bombean, probablemente estén obstruidas con aire; perfore los orificios de alivio de acuerdo con las instrucciones en la Sección de Tuberías.

Coloque el (los) interruptor(es) del panel de control en la posición automática y pruebe minuciosamente el funcionamiento de los flotadores de ENCENDIDO, APAGADO y alarma llenando el pozo con agua limpia. **Importante:** Si no se proporciona un neutro desde la fuente de alimentación a un panel de control monofásico de 230 voltios, el circuito de control del panel no operará. Es necesario el neutro para completar el circuito de control de 115 voltios.

Verifique la tensión y la corriente y anote los datos en la sección delantera de este manual para referencia futura. Compare las lecturas de amperaje con el amperaje máximo indicado en la placa de identificación de la bomba. Si es más alto que el amperaje de la placa de identificación, investigue la causa. Si la bomba se hace funcionar fuera de la curva; es decir, con demasiado poca carga o con tensión alta o baja, aumentará el amperaje. El motor funcionará correctamente con tensión no más de un 10% por encima o por debajo de las clasificaciones en la placa de identificación de la bomba. El rendimiento dentro de este rango no será necesariamente igual al rendimiento publicado a la frecuencia y tensión exactas indicadas en la placa de identificación. Corrija el problema antes de continuar. También es posible que la causa sea un desbalance trifásico. *Consulte la sección de Desbalance de potencia trifásica y siga las instrucciones.*

Reposicione el circuito de alarma, coloque el (los) interruptor(es) de la bomba en posición automática y el interruptor de control en la posición de encendido. Ahora la unidad está lista para la operación automática.

Explique la operación de las bombas, controles y alarmas al usuario final. Entregue la documentación al propietario o déjela en un lugar seco y seguro en el panel de control.

TABLA DEL PANEL E INTERRUPTORES DE FLOTADOR

El propósito de esta tabla es mostrar las cantidades de interruptores requeridas y la función de cada interruptor en un sistema de aguas residuales típicas. Las cantidades requeridas varían dependiendo del tipo de interruptor: de acción simple o de ángulo amplio. Las cantidades de interruptores varían también de acuerdo con el tipo de panel: simple con y sin alarmas y doble con alarmas.

Paneles dobles utilizando interruptores de acción simple:

Cableado del panel de tres flotadores

SW1	Fondo	Bombas apagadas
SW2	Medio	Primera bomba del medio encendida
SW3	Extremo superior	Segunda bomba y alarma encendidas

Cableado del panel de cuatro flotadores ②

SW1	Fondo	Bombas apagadas
SW2	Segundo	Primera bomba encendida
SW3	Tercero	Segunda bomba encendida
SW4	Extremo superior	Alarma encendida

Paneles dobles utilizando interruptores de ángulo amplio:

Cableado del panel de tres flotadores

SW1	Fondo	Primera bomba encendida/ ambas apagadas
SW2	Extremo superior	Segunda bomba y alarma encendidas

Cableado del panel de cuatro flotadores

SW1	Fondo	Primera bomba encendida/ ambas apagadas
SW2	Medio	Segunda bomba encendida
SW3	Extremo superior	Alarma encendida

Paneles simples utilizando interruptores de acción simple:

Panel simple con alarma ①

SW1	Fondo	Bomba apagada
SW2	Medio	Bomba encendida
SW3	Extremo superior	Alarma encendida/apagada

Panel simple sin alarma

SW1	Fondo	Bomba apagada
SW2	Extremo superior	Bomba encendida

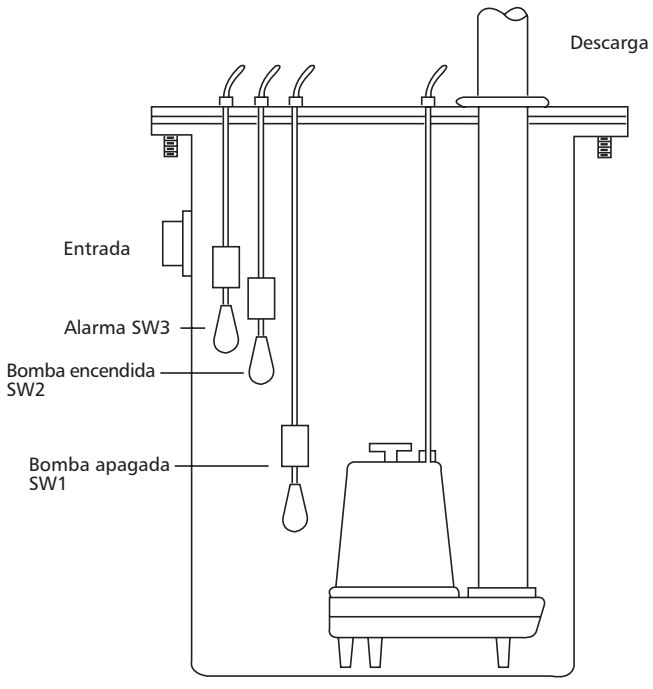
Paneles simples utilizando interruptores de ángulo amplio:

Panel simple con alarma

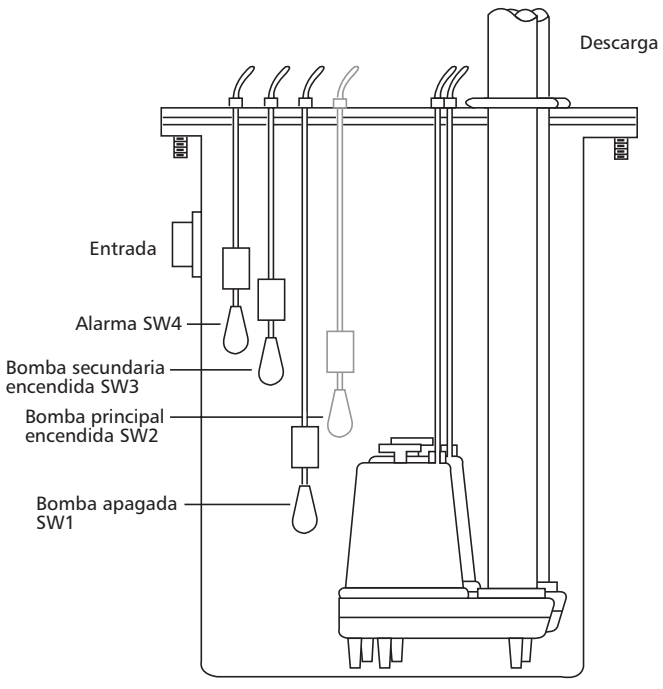
SW1	Fondo	Bomba encendida/apagada
SW2	Extremo superior	Alarma encendida/apagada

Panel simple sin alarma

SW1	Bomba encendida/apagada



Simple ①



Doble ②

DESBALANCE DE POTENCIA TRIFÁSICA

Se recomienda un suministro trifásico completo incluyendo tres transformadores individuales o un transformador trifásico. Se pueden usar conexiones en estrella o en triángulo "abierto" empleando sólo dos transformadores, pero hay más posibilidad de que produzcan un rendimiento inadecuado, disparo por sobrecarga o falla prematura del motor debido al desbalance de corriente.

Mida la corriente en cada uno de los tres conductores del motor y calcule el desbalance de corriente en la forma que se explica abajo.

Si el desbalance de corriente es del 2% o menos, deje los conductores tal como están conectados. Si el desbalance de corriente es de más del 2%, hay que verificar las lecturas de corriente en cada derivación empleando cada una de las tres conexiones posibles. Enrolle los conductores del motor en el arrancador en la misma dirección para evitar una inversión del motor.

Para calcular el porcentaje de desbalance de corriente:

A. Sume los tres valores de corriente de línea.

B. Divida la suma por tres, con lo cual se obtiene la corriente promedio.

C. Seleccione el valor de corriente más alejado de la corriente promedio (ya sea alto o bajo).

D. Determine la diferencia entre este valor de corriente (más alejado del promedio) y el promedio.

E. Divida la diferencia por el promedio. Multiplique el resultado por 100 para determinar el porcentaje de desbalance.

El desbalance de corriente no debe exceder el 5% con la carga del factor de servicio o el 10% con la carga de entrada nominal. Si el desbalance no puede corregirse enrollando los conductores, la causa del desbalance debe determinarse y corregirse. Si, en las tres conexiones posibles, la derivación más alejada del promedio está en el mismo conductor de potencia, entonces la mayoría del desbalance proviene de la fuente de potencia.

Contacte a la compañía de electricidad local para solucionar el desbalance.

	Conexión 1			Conexión 2			Conexión 3		
Terminales del arrancador	L1	L2	L3	L1	L2	L3	L1	L2	L3
	⊥ T	⊥ T	⊥ T	⊥ T	⊥ T	⊥ T	⊥ T	⊥ T	⊥ T
Conductores del motor	R T3	B T1	W T2	W T2	R T3	B T1	B T1	W T2	R T3

Ejemplo:

T3-R = 51 amps	T2-W = 50 amps	T1-B = 50 amps
T1-B = 46 amps	T3-R = 48 amps	T2-W = 49 amps
T2-W = 53 amps	T1-B = 52 amps	T3-R = 51 amps
Total = 150 amps	Total = 150 amps	Total = 150 amps
÷ 3 = 50 amps	÷ 3 = 50 amps	÷ 3 = 50 amps
− 46 = 4 amps	− 48 = 2 amps	− 49 = 1 amps
4 ÷ 50 = .08 or 8%	2 ÷ 50 = .04 or 4%	1 ÷ 50 = .02 or 2%

LECTURAS DE RESISTENCIA DEL AISLAMIENTO

Valores normales en ohmios y megaohmios entre todos los conductores y tierra

Condición del motor y los conductores	Valor en ohmios	Valor en Megaohmios
Un motor nuevo (sin cable de bajada).	20,000,000 (o más)	20 (o más)
Un motor usado que puede reinstalarse en el pozo.	10,000,000 (o más)	10 (o más)
Motor en el pozo. Las lecturas son para el cable de bajada más el motor.		
Motor nuevo.	2,000,000 (o más)	2 (o más)
El motor está en buenas condiciones.	500,000 - 2,000,000	.5 - 2
Daño de aislamiento, localícelo y repárelo.	Menos de 500,000	Menos de 0.5

La resistencia del aislamiento varía muy poco con la clasificación. Los motores de todas las clasificaciones de potencia, tensión y fase tienen valores similares de resistencia de aislamiento.

Los valores de resistencia de aislamiento anteriores están basados en lecturas obtenidas con un megaohmiómetro con salida de 500 V CC. Las lecturas pueden variar utilizando un ohmiómetro de tensión más baja; consulte con la fábrica si tiene dudas acerca de las lecturas.

Los datos de ingeniería para modelos específicos pueden encontrarse en su catálogo y en nuestro sitio Web (dirección en la cubierta).

Los diagramas de cableado del panel de control se envían con los paneles de control. Utilice los dibujos del panel de control junto con este manual de instrucciones para completar el cableado.

OPERACIÓN DE LA BOMBA			
Sumersión mínima		**Temperatura máxima del fluido**	
Servicio continuo	Sumergida totalmente	Operación continua	104º F 40º C
Servicio intermitente	6 pulg. por debajo del extremo superior del motor	Operación intermitente	140º F 60º C

Pumpmaster y Pumpmaster Plus - Cableado directo

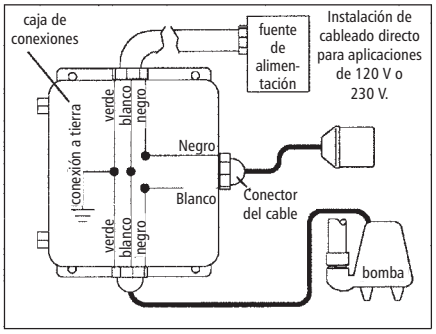


Figura 1

Flotador doble – de cableado directo

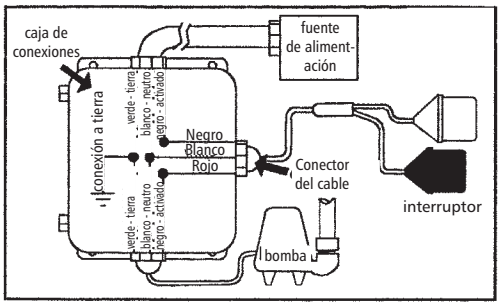


Figura 2

Determinación del rango de bombeo

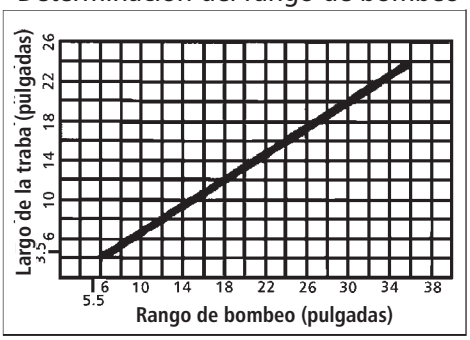


Figura 3

Interruptor de flotador de acción simple Instalación "típica"

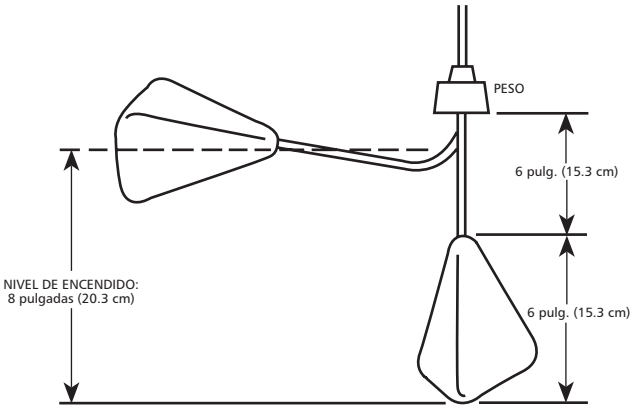


Figura 4

Interruptor de flotador de ángulo amplio

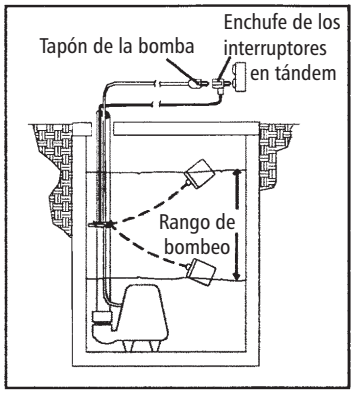


Figura 5

Diagrama de conexión trifásica

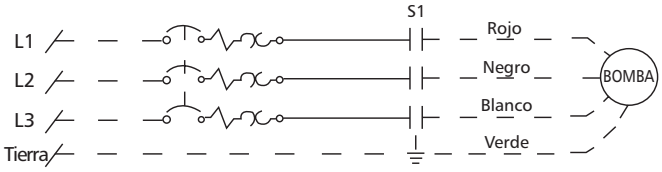
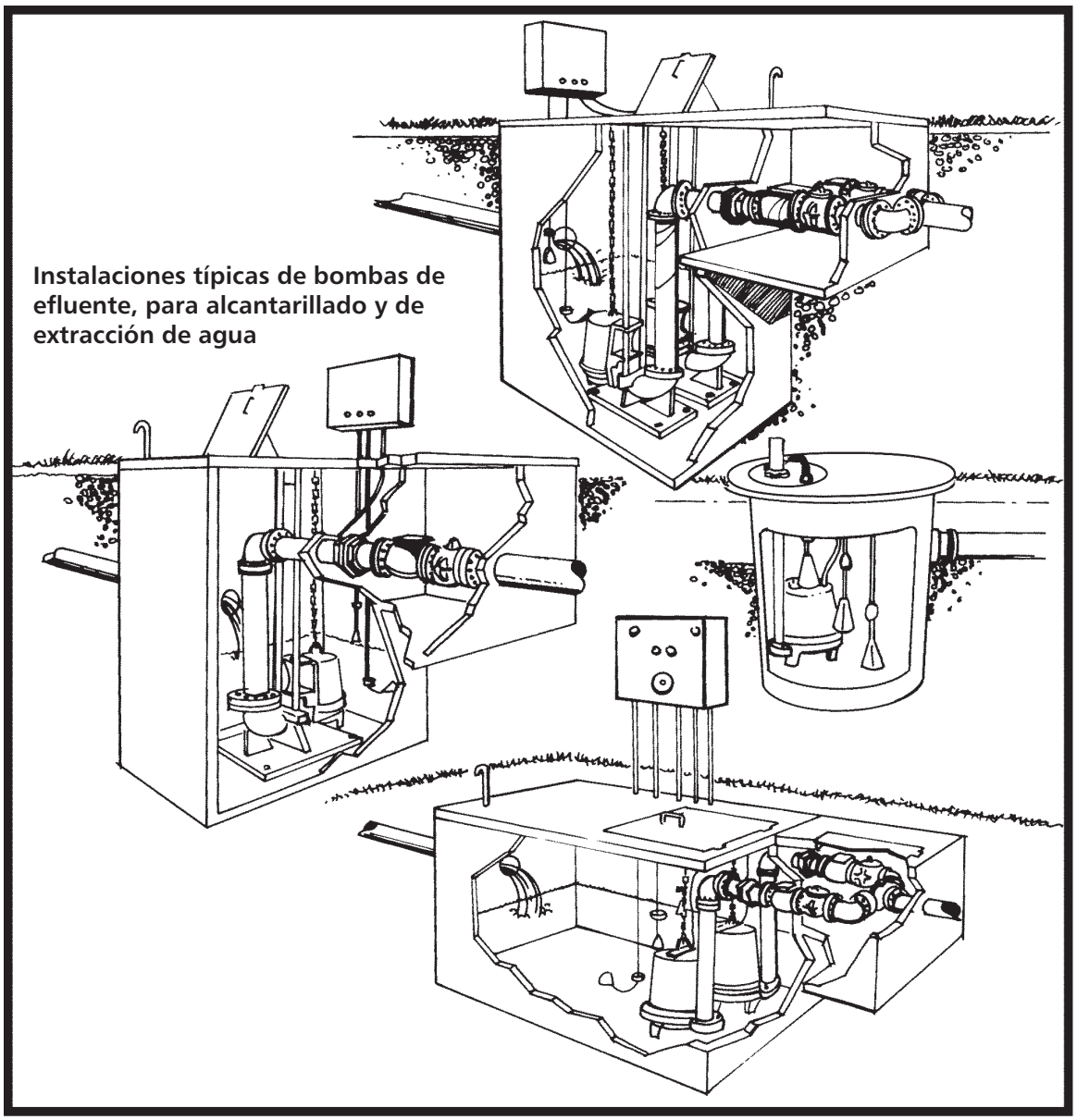


Figura 6

⚠ADVERTENCIA
Tensión peligrosa

LA FALLA DE DESCONECTAR Y BLOQUEAR LA CORRIENTE ELÉCTRICA ANTES DE INTENTAR CUALQUIER SERVICIO, PUEDE CAUSAR ELECTROCHOQUE, QUEMADURAS O LA MUERTE.

SÍNTOMA	CAUSA PROBABLE	ACCIÓN RECOMENDADA
EL MOTOR NO ESTÁ FUNCIONANDO **NOTA:** Si el cortacircuitos se "ABRE" repetidamente, **NO** lo reposicione. Llame a un electricista calificado.	Se disparó el protector térmico del motor	Deje que se enfríe el motor. Asegure la sumersión mínima de la bomba. Limpie los residuos de la carcasa y el impulsor.
	Cortacircuitos abierto o fusible quemado.	Determine la causa, llame a un electricista calificado.
	Impulsor de la bomba rozando o atascado.	Determine el consumo de corriente del motor. Si es dos veces más alto que el indicado en la placa de identificación de la bomba, el impulsor está trabado, los cojinetes del motor o el eje está dañado. Limpie los residuos de la carcasa y el impulsor, consulte con el agente.
a) Operación manual	El cable de alimentación está dañado.	
	Conexiones eléctricas inadecuadas en el panel de control.	
b) Operación automática	No hay alambre neutro conectado al panel de control.	La resistencia entre los conductores de alimentación y tierra debe indicar infinito. Si alguna lectura es incorrecta, llame a un electricista calificado.
	Conexiones eléctricas inadecuadas en el panel de control.	Inspeccione las conexiones del panel de control. Llame a un electricista calificado.
NOTA: Inspeccione la bomba en modo manual primero para confirmar el funcionamiento. Si la bomba funciona, el control automático o el cableado está defectuoso. Si la bomba no funciona, vea arriba.	Interruptor de nivel de líquido defectuoso para activar los controles.	Con el interruptor desconectado, verifique la continuidad mientras activa el interruptor de nivel de líquido. Reemplace el interruptor, según se requiera.
	Nivel de líquido insuficiente para activar los controles.	Deje que el nivel de líquido aumente de 3 a 4 pulgadas (76 mm –101 mm) sobre el nivel de activación.
	Cordones de los sensores de nivel de líquido enredados.	Desenrede los cordones y asegure el funcionamiento libre.
LA BOMBA NO SE APAGA	Cordones de los sensores de nivel de líquido enredados.	Desenrede los cordones y asegure el funcionamiento libre.
	La bomba está atascada con aire.	Apague la bomba durante aproximadamente un minuto y arránquela nuevamente. Repita hasta que se despeje la obstrucción de aire. Si la obstrucción de aire persiste en un sistema con tubo con válvula de retención, puede perforarse un agujero de 3/16 pulg. (4.8 mm) en el tubo de descarga aproximadamente a 2 pulgadas (51 mm) de la conexión de descarga.
	El flujo de líquido entrante coincide con la capacidad de descarga de la bomba.	Podría requerirse una bomba más grande.
LA BOMBA ENTREGA POCO O NADA DE LÍQUIDO	La válvula de retención está instalada invertida, está obstruida o atascada en posición cerrada.	Verifique la flecha de flujo en la válvula y verifique el funcionamiento de ésta.
	Carga excesiva del sistema.	Consulte con el agente.
	Entrada a la bomba obstruida.	Inspeccione y despeje, según sea requerido.
	Tensión incorrecta, o conectada incorrectamente.	Verifique la rotación, la tensión y las conexiones de la bomba. Consulte con un electricista calificado.
	La bomba está atascada con aire.	Consulte la acción recomendada, arriba.
	El impulsor está gastado o dañado.	Inspeccione el impulsor, reemplácelo según sea necesario.
	Los controles de nivel de líquido están defectuosos o instalados incorrectamente.	Inspeccione, reajuste o reemplace, según sea requerido.
LA BOMBA CICLA CONSTANTEMENTE	La válvula de retención de la descarga no funciona.	Inspeccione, repare o reemplace, según sea requerido.
	El área de contención de aguas negras es demasiado pequeña.	Consulte con el agente.
	Los controles de nivel de líquido están defectuosos o instalados incorrectamente.	Inspeccione, reajuste o reemplace, según sea requerido.
	Cantidad excesiva de líquido entrante para una bomba de este tamaño.	Consulte con el agente.



Instalaciones típicas de bombas de efluente, para alcantarillado y de extracción de agua

GARANTÍA LIMITADA DE GOULDS PUMPS

Esta garantía es aplicable a todas las bombas para sistemas de agua fabricadas por Goulds Pumps.

Toda parte o partes que resulten defectuosas dentro del período de garantía serán reemplazadas sin cargo para el comerciante durante dicho período de garantía. Tal período de garantía se extiende por doce (12) meses a partir de la fecha de instalación, o dieciocho (18) meses a partir de la fecha de fabricación, cualquiera se cumpla primero.

Todo comerciante que considere que existe lugar a un reclamo de garantía deberá ponerse en contacto con el distribuidor autorizado de Goulds Pumps del cual adquiriera la bomba, y ofrecer información detallada con respecto al reclamo. El distribuidor está autorizado a liquidar todos los reclamos por garantía a través del Departamento de Servicios a Clientes de Goulds Pumps.

La presente garantía excluye:

(a) La mano de obra, el transporte y los costos relacionados en los que incurra el comerciante;

(b) los costos de reinstalación del equipo reparado;

(c) los costos de reinstalación del equipo reemplazado;

(d) daños emergentes de cualquier naturaleza; y

(e) el reembolso de cualquier pérdida causada por la interrupción del servicio.

A los fines de esta garantía, los términos "Distribuidor", "Comerciante" y "Cliente" se definen como sigue:

(1) "Distribuidor" es aquel individuo, sociedad, corporación, asociación u otra entidad jurídica que opera entre Goulds Pumps y el comerciante para la compra, consignación o contratos de venta de las bombas en cuestión.

(2) "Comerciante" es todo individuo, sociedad, corporación, asociación u otra entidad jurídica que realiza negocios de venta o alquiler-venta (leasing) de bombas a clientes.

(3) "Cliente" es toda entidad que compra o que adquiere bajo la modalidad de leasing las bombas en cuestión de un comerciante. El término "cliente" puede significar un individuo, una sociedad, una corporación, una sociedad de responsabilidad limitada, una asociación o cualquier otra entidad jurídica con actividades en cualquier tipo de negocios.

LA PRESENTE GARANTÍA SE EXTIENDE AL COMERCIANTE ÚNICAMENTE

GOULDS PUMPS

Goulds Pumps y el símbolo ITT Engineered Blocks son marcas registradas y marcas comerciales de ITT Industries.

LAS ESPECIFICACIONES ESTÁN SUJETAS A CAMBIO SIN PREVIO AVISO.

IM107R03 Marzo, 2006

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Engineered for life

Goulds Pumps

Pompes à eaux usées

Assèchement, effluents et eaux d'égout

Directives d'installation, d'utilisation et d'entretien

Goulds Pumps est une marque d'ITT Water Technology, Inc., une filiale d'ITT Industries, Inc.

www.goulds.com

Engineered for life

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Informations pour le propriétaire

Numéro de modèle de la pompe : _____

Numéro de série de la pompe : _____

N° de modèle du tableau de commande : _____

Détaillant : _____

N° de téléphone du détaillant : _____

Date d'achat : _____ d'installation : _____

Courant mesuré au démarrage :

1 Ø	3 Ø	L1-2	L2-3	L3-1
A : _____	A :	_____	_____	_____
V : _____	V :	_____	_____	_____

CONSIGNES DE SÉCURITÉ

AFIN DE PRÉVENIR LES BLESSURES GRAVES OU MORTELLES ET LES DOMMAGES MATÉRIELS IMPORTANTS, LIRE ET SUIVRE TOUTES LES CONSIGNES DE SÉCURITÉ FIGURANT DANS LE MANUEL ET SUR LA POMPE.

LE PRÉSENT MANUEL A POUR BUT DE FACILITER L'INSTALLATION ET L'UTILISATION DE LA POMPE ET DOIT ÊTRE CONSERVÉ PRÈS DE CELLE-CI.

Le symbole ci-contre est un **SYMBOLE DE SÉCURITÉ** employé pour signaler les mots-indicateurs dont on trouvera la description ci-dessous. Sa présence sert à attirer l'attention afin d'éviter les blessures et les dommages matériels.

⚠ DANGER Prévient des risques qui **VONT** causer des blessures graves, la mort ou des dommages matériels importants.

⚠ AVERTISSEMENT Prévient des risques qui **PEUVENT** causer des blessures graves, la mort ou des dommages matériels importants.

⚠ ATTENTION Prévient des risques qui **PEUVENT** causer des blessures ou des dommages matériels.

AVIS : SERT À ÉNONCER LES DIRECTIVES SPÉCIALES DE GRANDE IMPORTANCE QUE L'ON DOIT SUIVRE.

LIRE SOIGNEUSEMENT CHAQUE DIRECTIVE ET AVERTISSEMENT AVANT D'EFFECTUER TOUT TRAVAIL SUR LA POMPE.

N'ENLEVER AUCUNE DÉCALCOMANIE DE SÉCURITÉ.

⚠ AVERTISSEMENT L'installation électrique doit être entièrement effectuée par un technicien qualifié. Il faut toujours suivre les prescriptions du code provincial ou national de l'électricité et les règlements locaux. Adresser toute question relative au code à un inspecteur en électricité. Le non-respect du code et des politiques de santé et de sécurité au travail peut entraîner des blessures et des dommages matériels. L'inobservation des directives d'installation fournies par le fabricant peut se traduire par un choc électrique, un incendie, des blessures ou la mort, ainsi que par des dommages matériels, des performances non satisfaisantes et l'annulation de la garantie du fabricant.

⚠ AVERTISSEMENT Les pompes standard ne sont pas conçues pour les piscines, l'eau libre, les liquides dangereux ni les endroits pouvant contenir des gaz inflammables. Ces fluides peuvent être présents dans les installations de confinement (puits collecteurs, réservoirs ou fosses humides). On doit aérer ces installations suivant les codes locaux.

Seules les pompes de classe 1, division 1, peuvent servir dans les liquides dangereux et les endroits pouvant contenir des gaz inflammables. *Le nom des organismes de normalisation pertinents figure sur la plaque signalétique de la pompe ou dans les feuillets du catalogue décrivant les pompes en question.*

⚠ AVERTISSEMENT Verrouiller la source de courant en position ouverte avant de procéder à l'installation ou à l'entretien de tout dispositif électrique. Le protecteur thermique de certains moteurs de pompe coupe le courant lorsqu'il y a surcharge thermique et le rétablit automatiquement, redémarrant ainsi la pompe inopinément.

⚠ ATTENTION Chaque tableau de commande triphasé pour pompe submersible doit assurer une protection rapide de classe 10 contre la surcharge.

VÉRIFICATIONS AVANT INSTALLATION

Ouvrir tous les cartons et vérifier si le matériel est endommagé. Signaler immédiatement tout dommage au fournisseur ou au transporteur.

Important : on doit toujours vérifier si les valeurs nominales inscrites sur la plaque signalétique (intensité, tension, puissance et nombre de phases) conviennent au tableau de commande et à la source de courant.

Le compartiment moteur d'un bon nombre de nos pompes à eaux d'égout est rempli d'huile isolante. S'il y a des traces d'huile sur la pompe ou si cette dernière a été entreposée longtemps, vérifier le niveau d'huile du compartiment et, si la pompe en est dotée, du logement de garniture.

Enlever le bouchon de l'orifice de remplissage du compartiment moteur (sur le dessus de celui-ci), puis vérifier le niveau d'huile par l'orifice. L'huile devrait seulement recouvrir le moteur. Ne pas trop en mettre pour que l'huile puisse se dilater !

Pour vérifier le niveau d'huile du logement de garniture, mettre la pompe sur le côté, le bouchon de remplissage en haut, puis enlever le bouchon. Le niveau de l'huile devrait être à tout au plus 13 mm (½ po) du haut. Au besoin, utiliser de l'huile pour turbines ASTM 150, puis remettre le bouchon.

On peut se procurer de l'huile isolante en contenants de 5 gallons US chez nos distributeurs. On peut aussi en acheter chez un réparateur de moteurs électriques. Les marques d'huiles types sont : Shell Turbo 32, Sunoco Sunvis 932, Texaco Regal R&O 32, Exxon Nuto 32 et Mobil DTE Light.

Vérifier si l'écrou presse-garniture du serre-câble d'alimentation est suffisamment serré. Le couple de serrage est de 75 lbf·po pour les câbles de calibre 16 et de 80 lbf·po pour tout autre câble. Il est cependant de 75 lbf·po pour les câbles de capteur de chaleur ou d'humidité.

La garantie ne couvre pas les dommages dus au branchement de la pompe et du tableau de commande à une source de courant dont la tension ou le nombre de phases sont inappropriés.

Inscrire à titre documentaire les numéros de modèle et de série de la pompe ainsi que le numéro de modèle du tableau de commande dans les Informations pour le propriétaire. Une fois l'installation achevée, remettre le manuel au propriétaire ou l'attacher au tableau de commande.

LEVAGE DE LA POMPE

NE PAS LEVER, TRANSPORTER NI SUSPENDRE LA POMPE PAR LE CÂBLE D'ALIMENTATION : L'ENDOMMAGEMENT DU CÂBLE POURRAIT CAUSER UN CHOC ÉLECTRIQUE, DES BRÛLURES OU LA MORT.

Lever la pompe par son boulon à œil ou sa poignée avec un filin ou une chaîne de grosseur appropriée. **NE PAS** endommager le câble d'alimentation ni celui des capteurs durant la manutention de la pompe.

SYSTÈME DE LEVAGE OPTIONNEL À RAIL DE GUIDAGE OU À ADAPTATEUR COULISSANT

Dans le cas de bon nombre de cuves à effluents et de postes de relèvement d'eaux d'égout, il est conseillé de monter la pompe sur un rail de guidage ou avec un adaptateur coulissant pour pouvoir descendre, retirer, inspecter et entretenir celle-ci plus facilement. La plupart des codes n'autorisent pas le personnel à entrer dans une fosse humide sans la formation ni l'équipement protecteur appropriés. Le rail et l'adaptateur sont conçus pour faciliter la mise en place et la sortie de la pompe, et ce, sans disjoindre la tuyauterie. Le rail et l'adaptateur devraient être placés de façon à ce que la pompe soit face à l'orifice d'arrivée de l'influent pour empêcher la formation de zones de stagnation et, ainsi, de dépôts. Le fond du puits collecteur ou de la cuve doit être plat et suffisamment résistant pour supporter le poids de la pompe et du rail de guidage.

AVIS : SUIVRE LES DIRECTIVES FOURNIES AVEC LE RAIL DE GUIDAGE.

TUYAUTERIE

Afin de réduire les pertes de charge (par frottement) au minimum, la tuyauterie de refoulement devrait être aussi courte que possible et dépourvue d'accessoires et de raccords superflus. Son diamètre devrait être au moins égal à celui de l'orifice de refoulement de la pompe.

Prévenir le retour du liquide : poser sur le tuyau de refoulement un clapet de non-retour de calibre convenant à la grosseur des solides que la pompe peut laisser passer. Le retour du liquide peut faire tourner la pompe en sens inverse, provoquant ainsi l'usure prématurée des garnitures mécaniques et des roulements. S'il y a « rotation en sens inverse » au moment du démarrage, le couple accru produit peut abîmer le moteur ou l'arbre de pompe, ou les deux, et même forcer certaines pompes monophasées à continuer à tourner en sens inverse.

Poser **EN AVAL** (après) du clapet de non-retour un robinet-vanne de calibre approprié pour permettre l'entretien de la pompe, de la tuyauterie et du clapet.

Important : avant d'installer la pompe et afin de prévenir la formation de poches d'air dans celle-ci, percer un trou-purgeur d'air de 4,8 mm ($\frac{3}{16}$ po) dans le tuyau de refoulement, à environ 51 mm (2 po) au-dessus de l'orifice de refoulement de la pompe, mais avant le clapet de non-retour et à l'intérieur de la fosse humide. On permettra ainsi au liquide d'entrer dans la pompe par gravité, surtout si l'orifice d'aspiration est situé en dessous, et préviendra la formation de poches d'air qui empêcheraient le pompage du liquide même si la roue de la pompe tourne.

La tuyauterie doit être supportée correctement pour n'appliquer sur la pompe aucune charge pouvant la déformer.

Couvercles et trappes de visite doivent être assez grands pour permettre l'inspection et l'entretien de la pompe ainsi que l'emploi d'un dispositif de levage.

CÂBLAGE ET MISE À LA TERRE

Avis important : lire les Consignes de sécurité avant de procéder au câblage.

N'utiliser que du fil torsadé en cuivre pour la mise à la terre et l'alimentation du moteur. Le calibre du fil de terre doit être au moins égal à celui des fils d'alimentation du moteur, et les fils devraient tous être chromocodés pour faciliter l'entretien et le diagnostic des anomalies.

Poser le fil de terre et les autres fils suivant les prescriptions du code provincial ou national de l'électricité.

Installer un sectionneur tout conducteur si le code l'exige.

Verrouiller la source de courant en position ouverte avant de procéder à l'installation ou à l'entretien de la pompe.

Le nombre de phases et la tension d'alimentation doivent convenir à tout l'équipement. Un nombre de phases et une tension inappropriés annulent la garantie et peuvent causer un incendie et des dommages au moteur et au tableau de commande.

Chaque jonction de fils doit être étanche. Si l'on emploie un nécessaire de jonction (« *kit* »), suivre les directives du fabricant.

AVERTISSEMENT — Choisir la boîte de jonction du type et de la classe NEMA convenant au type et au lieu d'utilisation. La boîte doit assurer une jonction de fils sûre et étanche.

AVERTISSEMENT — Étancher les commandes afin d'empêcher les gaz d'en détériorer les composants.

AVERTISSEMENT
Tension dangereuse

OMETTRE LA MISE À LA TERRE PERMANENTE DE LA POMPE, DU MOTEUR ET DES COMMANDES AVANT LE BRANCHEMENT À LA SOURCE DE COURANT PEUT CAUSER UN CHOC ÉLECTRIQUE, DES BRÛLURES OU LA MORT.

SÉLECTION ET CÂBLAGE DES CONTACTEURS ET DES TABLEAUX DE COMMANDE

TYPES DE CONTACTEURS À FLOTTEUR

Deux types de contacteurs à flotteur sont normalement utilisés : à simple effet ou à grand déplacement angulaire. Le type détermine le nombre de contacteurs requis avec les différents systèmes et tableaux de commande. Les contacteurs à simple effet fonctionnent dans un angle de 15° et s'ouvrent et se ferment donc rapidement. La longueur du câble (la distance entre le point pivot du câble et le boîtier du contacteur) des contacteurs à grand

déplacement angulaire (90°) régit les niveaux démarrage-arrêt de la pompe.

Les contacteurs à flotteur peuvent être du type normalement ouvert (NO) pour le vidage (fosses ou réservoirs) et du type normalement fermé (NF) pour le remplissage.

Les contacteurs à simple effet doivent être connectés seulement aux tableaux de commande, jamais directement aux pompes.

Les contacteurs à grand déplacement angulaire pour le vidage peuvent être branchés aux pompes comme aux tableaux de commande.

RÉGLAGE DES CONTACTEURS À FLOTTEUR

Il n'existe pas de règle absolue pour le réglage des contacteurs à flotteur, lequel peut varier d'une installation à l'autre.

Règles suggérées :
Tous les contacteurs à flotteur devraient être placés sous l'orifice d'arrivée de l'influent !

Contacteur d'arrêt : (1er choix) — le régler pour que le niveau du liquide soit toujours au-dessus du compartiment moteur. **(2e choix) —** le régler pour que le niveau du liquide ne puisse être à plus de 6 po sous le dessus du compartiment moteur.

Contacteur de démarrage : le régler pour que la plage de pompage permette aux pompes de 1½ hp ou moins de fonctionner pendant au moins une (1) minute. Les pompes de 2 hp et plus devraient fonctionner durant au moins deux (2) minutes. Le catalogue donne la capacité de chaque cuve en gallons US par pouce de hauteur.

Contacteur(s) de pompe secondaire et d'alarme : s'il n'y en a qu'un, le placer plus haut que les contacteurs d'arrêt et de démarrage, et, s'il y en a deux, on devrait en outre les décaler (v. les illustrations dans la section *Tableaux de commande et fonction des contacteurs à flotteur*). Essayer d'utiliser tout l'espace de stockage disponible de la cuve, mais prévoir un espace de réserve.

SCHÉMAS DE CÂBLAGE DES TABLEAUX DE COMMANDE

Des directives et des schémas de câblage sont fournis avec nos tableaux de commande. Utiliser les directives en question conjointement avec celles du présent manuel. L'installation électrique ne doit être effectuée que par des techniciens qualifiés. Adresser toute question relative aux autres marques de tableau de commande au fournisseur ou au fabricant de ces marques. Notre personnel technique ne dispose pas des schémas ni des informations de dépannage des autres marques.

DISPOSITIFS D'ALARME

Il est recommandé de poser un dispositif d'alarme dans toute installation à pompe(s) à eaux usées. De nombreux tableaux de commande standard en sont munis. S'il n'y a pas de tableau de commande, on peut employer un dispositif d'alarme niveau haut, autonome, qui se déclenchera si le liquide atteint un niveau trop élevé, avertissant ainsi le personnel d'entretien, qui apportera alors les correctifs appropriés.

POMPES MONOPHASÉES

Les pompes monophasées peuvent être utilisées avec un contacteur à flotteur simple ou double à fiche-prise ou à raccordement fixe, avec un contacteur ordinaire ou avec un tableau de commande pour pompe simple ou double. *Voir les fig. 1, 2 et 5*.

Toutes les pompes de 1/3 et de ½ hp (115 ou 230 V), ainsi que certaines pompes de ¾ et de 1 hp, sont munies d'un cordon d'alimentation à fiche pouvant être branchée sur la fiche-prise du contacteur à flotteur s'il s'agit d'une installation à pompe simple. On peut enlever la fiche du cordon d'alimentation et connecter celui-ci par raccordement fixe à un tableau de commande pour pompe simple ou double. L'enlèvement de la fiche n'annulera pas la garantie ni l'enregistrement auprès des organismes de normalisation pertinents. *Voir la fig. 5*.

LES POMPES CONNECTÉES PAR FICHE DOIVENT L'ÊTRE À UNE PRISE AVEC TERRE MISE À LA TERRE CORRECTEMENT.

S'IL S'AGIT D'UNE POMPE SANS FICHE, NE PAS ENLEVER LE CORDON D'ALIMENTATION NI SON SERRE-CÂBLE NI CONNECTER UN CONDUIT À LA POMPE.

Les pompes dont le bout des fils du cordon d'alimentation est dénudé peuvent être branchées par raccordement fixe à un contacteur à flotteur, à un contacteur ordinaire monophasé ou à un tableau de commande pour pompe simple ou double. On doit toujours s'assurer que le contacteur à flotteur convient à l'intensité de marche, à l'intensité maximale au démarrage et à la puissance nominales de la pompe. Sauf indication contraire sur la plaque signalétique, les pompes monophasées pour eaux usées sont munies d'une protection d'enroulement contre les surcharges. *Voir les fig. 1 et 2*.

POMPES TRIPHASÉES

Les pompes triphasées nécessitent au moins un démarreur magnétique à branchement direct convenant à la puissance nominale de la pompe, un circuit à fusible(s) ou à disjoncteur tripolaire, ainsi que des limiteurs de surcharge rapides de classe 10 compensés en fonction des conditions ambiantes.

TABLEAUX DE COMMANDE MONOPHASÉS ET TRIPHASÉS

Les tableaux de commande viennent en deux versions : pour pompe simple ou pour pompe double. Nos tableaux de la série SES offrent de nombreuses fonctions standard auxquelles on peut ajouter nos options les plus populaires. En outre, nous fournissons des tableaux sur demande dont les fonctions sont beaucoup plus nombreuses que celles de la série SES. Les tableaux faits sur demande sont offerts en versions variées. On peut adresser toute demande de prix pour ce type de tableau au service à la clientèle (*Customer Service*) par l'entremise d'un distributeur agréé.

Nos tableaux de commande pour pompe double de la série SES possèdent un circuit imprimé muni d'un circuit d'alarme niveau haut standard. Il existe d'autres accessoires standard : contacts d'alarme secs auxiliaires signalant les alarmes à distance et voyants indicateurs de position pour contacteurs à flotteur. Des limiteurs de surcharge réglables de classe 10 sont intégrés dans nos tableaux de commande triphasés, éliminant ainsi du travail pour l'installateur et l'obligation de commander des limiteurs particuliers. La plupart des tableaux de la série SES sont en stock et prêts à livrer.

Avec les pompes à capteurs de chaleur et d'humidité (décèle les défaillances de garniture), il est recommandé d'utiliser notre tableau de commande et les accessoires optionnels appropriés. Ces capteurs ne fonctionneront pas si le tableau de commande n'est pas équipé du relais, du bornier et de l'avertisseur (sonnerie ou voyant) appropriés.

Circuit de détection des défaillances de garniture — certaines pompes à double garniture comportent un circuit de détection intégré pour les défaillances de garniture, décelées par un capteur d'humidité. Il faut relier le circuit au relais en option monté dans le tableau de commande. On doit commander le tableau expressément avec le relais et l'avertisseur précités. Il existe aussi des tableaux standard (A4-3 et A4-4) séparés pour la détection des défaillances de garniture. Les pompes à capteur d'humidité se distinguent par le câble de capteur supplémentaire sortant de l'enveloppe de moteur. Le câble possède deux conducteurs, à brancher dans le tableau : le noir à la borne réservée au capteur («*probe*») et le blanc à la borne terre («*ground*») destinée au relais (pas sur la vis de terre du tableau). *Suivre les directives de câblage fournies avec le tableau*.

Circuits de détection de chaleur et des défaillances de garniture — des pompes sont munies d'un circuit de détection des défaillances de garniture à capteurs d'humidité, ainsi que d'un circuit de détection de chaleur à thermostats (capteurs de chaleur) normalement fermés pour hautes températures montés sur l'enroulement. Ces pompes ont un câble à quatre (4) conducteurs, à brancher dans le tableau : le noir à la borne pour le capteur («*probe*») et le vert à celle de terre («*ground*») du relais du circuit du capteur d'humidité ; et le rouge et le blanc aux bornes pour le circuit du capteur de chaleur, selon le schéma de câblage du tableau. Comme le circuit du capteur de chaleur est optionnel, on doit le commander expressément avec le tableau, et il fonctionne différemment des limiteurs de surcharge de classe 10 qui sont toujours requis sur les pompes triphasées. *Suivre les directives de câblage fournies avec le tableau*.

INSTALLATION

Fixer à la ou aux pompes le raccord rapide pour le rail de guidage, l'adaptateur coulissant ou la tuyauterie de refoulement. Le pied d'assise du rail devrait être assujetti au fond de la fosse humide par des boulons d'ancrage.

Effectuer le câblage selon les schémas de câblage des tableaux de commande, les prescriptions du code provincial ou national de l'électricité et les règlements locaux. À ce stade-ci, il est suggéré de vérifier le sens de rotation de l'arbre de moteur ou de la roue.

ÉVITER LES BLESSURES GRAVES : NE PAS S'INTRODUIRE LES DOIGTS DANS L'ORIFICE D'ASPIRATION DE LA POMPE PENDANT LA VÉRIFICATION DU SENS DE ROTATION.

On doit toujours vérifier si la pompe tourne dans le sens indiqué sur le corps de pompe, ce qui est plus facile à faire avant l'installation de la pompe. Les moteurs triphasés peuvent tourner dans les deux sens. Il est donc permis de les mettre en marche, puis de les arrêter immédiatement tout en en observant le sens de rotation. Pour inverser celui-ci, intervertir deux des fils d'alimentation du moteur.

Descendre la ou les pompes dans la fosse humide.

S'assurer que les contacteurs à flotteur peuvent bouger librement, mais sans pouvoir atteindre la tuyauterie.

MISE EN MARCHE

Une fois le raccordement de la tuyauterie achevé et vérifié, on peut mettre la ou les pompes en marche.

Vérification du fonctionnement des contacteurs à flotteur à fiche-prise — brancher d'abord la fiche-prise du contacteur sur une prise de courant indépendante mise à la terre, puis la prise de la pompe sur la fiche-prise du contacteur. Essayer la pompe en remplissant d'eau la fosse humide jusqu'à ce que la pompe démarre. Si le débit de la pompe est faible ou nul, c'est qu'il y a probablement présence d'air dans la pompe. Percer alors un trou-purgeur d'air selon les indications de la section Tuyauterie.

Vérifier la durée de fonctionnement de la pompe pour s'assurer qu'elle est d'au moins une minute et que la plage de pompage est correcte.

Vérification du fonctionnement du tableau de commande — remplir d'eau la fosse humide.

Essayer d'abord la pompe en mode manuel en plaçant le commutateur «*Hand-Off-Auto*» (manuel-arrêt-automatique) du tableau de commande à *Hand*. Si la pompe fonctionne bien, l'essayer en mode automatique. Si le débit de la pompe est faible ou nul, c'est qu'il y a probablement présence d'air dans la pompe. Percer alors un trou-purgeur d'air selon les indications de la section Tuyauterie.

Faire fonctionner la pompe en mode automatique (*Auto*) et vérifier minutieusement le fonctionnement des contacteurs de démarrage, d'arrêt et d'alarme en remplissant d'eau la fosse humide. **Important :** omettre de brancher le fil neutre de la source de courant à tout tableau de commande alimenté en courant monophasé de 230 V empêchera le circuit de commande du tableau de fonctionner. Le neutre est nécessaire pour alimenter (115 V) le circuit de commande.

Mesurer l'intensité et la tension du courant au démarrage et les inscrire à titre documentaire dans les Informations pour le propriétaire. Comparer l'intensité mesurée à l'intensité maximale indiquée sur la plaque signalétique de la pompe. Si l'intensité mesurée est supérieure, en chercher la cause. L'utilisation de la pompe hors de sa courbe de performances, c.-à-d. à une hauteur de charge trop faible ou à une tension trop basse ou trop haute, augmentera l'intensité du courant. Le moteur fonctionnera correctement si sa tension d'alimentation se situe dans les limites suivantes : tension nominale (plaque signalétique) ± 10 %. Les performances obtenues dans ces limites ne seront pas forcément identiques à celles de la courbe de performances correspondant aux valeurs de courant nominales inscrites sur la plaque signalétique. Apporter les correctifs nécessaires avant de continuer. Le déséquilibre du courant triphasé peut en outre altérer les performances. *Si c'est le cas, suivre les directives de la section Déséquilibre du courant triphasé.*

Réarmer le dispositif d'alarme, puis mettre la pompe en mode automatique (*Auto*) et le circuit de commande du tableau sous tension (interrupteur «*Control On-Off*» à *On*). Le système est maintenant prêt à fonctionner automatiquement.

Expliquer le fonctionnement de la pompe et des dispositifs de commande et d'alarme à l'utilisateur, puis lui laisser la documentation ou l'attacher au tableau de commande s'il est installé dans un endroit sec, fermé.

TABLEAUX DE COMMANDE ET FONCTION DES CONTACTEURS À FLOTTEUR

L'objet de la présente section est d'indiquer le nombre de contacteurs à flotteur requis et le rôle de chacun dans les systèmes d'évacuation des eaux usées types. Le nombre varie selon le type de contacteur : à simple effet ou à grand déplacement angulaire, mais aussi selon le type de tableau de commande : pour pompe simple avec ou sans alarme ou pour pompe double avec alarme.

Tableaux de commande pour pompe double à contacteurs à simple effet :

Trois contacteurs à flotteur

SW1	Inférieur	Pompes hors fonction
SW2	Intermédiaire	1re pompe en fonction
SW3	Supérieur	2e pompe et alarme en fonction

Quatre contacteurs à flotteur ②

SW1	Inférieur	Pompes hors fonction
SW2	Deuxième (du bas)	1re pompe en fonction
SW3	Troisième (du bas)	2e pompe en fonction
SW4	Supérieur	Alarme en fonction

Tableaux de commande pour pompe double à contacteurs à grand déplacement angulaire :

Trois contacteurs à flotteur

SW1	Inférieur	1re pompe en fonction ou les deux hors fonction
SW2	Supérieur	2e pompe et alarme en fonction

Quatre contacteurs à flotteur

SW1	Inférieur	1re pompe en fonction ou les deux hors fonction
SW2	Intermédiaire	2e pompe en fonction
SW3	Supérieur	Alarme en fonction

Tableaux de commande pour pompe simple à contacteurs à simple effet :

Trois contacteurs à flotteur avec alarme ①

SW1	Inférieur	Pompe hors fonction
SW2	Intermédiaire	Pompe en fonction
SW3	Supérieur	Alarme en fonction ou hors fonction

Deux contacteurs à flotteur sans alarme

SW1	Inférieur	Pompe hors fonction
SW2	Supérieur	Pompe en fonction

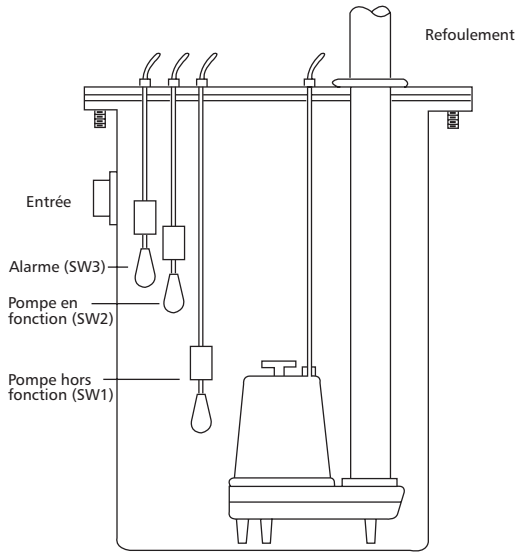
Tableaux de commande pour pompe simple à contacteurs à grand déplacement angulaire :

Deux contacteurs à flotteur avec alarme

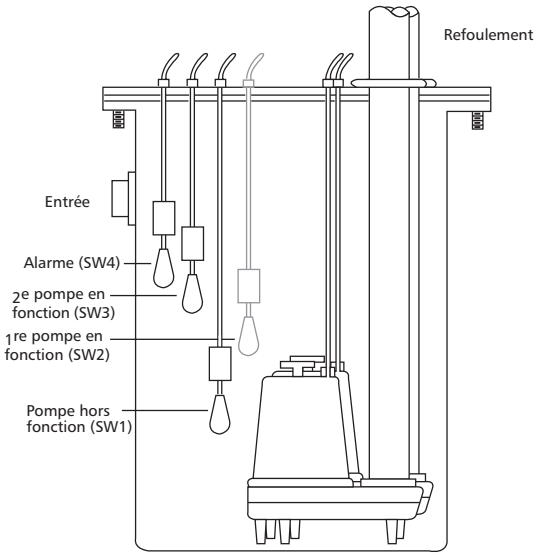
SW1	Inférieur	Pompe en fonction ou hors fonction
SW2	Supérieur	Alarme en fonction ou hors fonction

Un contacteur à flotteur sans alarme

SW1		Pompe en fonction ou hors fonction



Système à pompe simple ①



Système à pompe double ②

DÉSÉQUILIBRE DU COURANT TRIPHASÉ

Un circuit d'alimentation électrique entièrement triphasé est recommandé. Il peut être constitué de trois transformateurs distincts ou d'un transformateur triphasé. On peut aussi utiliser deux transformateurs montés en étoile ou en triangle « ouverts », mais il est possible qu'un tel montage crée un déséquilibre de courant se traduisant par des performances médiocres, le déclenchement intempestif du limiteur de surcharge et la défaillance prématurée du moteur.

Vérifier l'intensité du courant sur chacun des trois fils de moteur, puis calculer le déséquilibre du courant.

Si le déséquilibre est de 2 % ou moins, ne pas changer la connexion des fils.

S'il dépasse 2 %, on devrait vérifier l'intensité du courant sur chaque conducteur, dans les trois montages possibles ci-dessous. Afin de maintenir le sens de rotation du moteur, suivre l'ordre numérique indiqué dans chaque montage pour la connexion des fils de moteur.

Pour calculer le pourcentage de déséquilibre du courant :

A. Faire l'addition des trois intensités de courant de ligne mesurées.

B. Diviser le total par 3 pour obtenir l'intensité moyenne.

C. Prendre l'écart d'intensité le plus grand par rapport à la moyenne.

D. Soustraire cet écart de la moyenne.

E. Diviser la différence par la moyenne, puis multiplier le résultat par 100 pour obtenir le pourcentage de déséquilibre.

Le déséquilibre de courant ne devrait pas excéder 5 % en charge avec facteur de surcharge et 10 % en charge d'entrée nominale. Si l'on ne peut éliminer le déséquilibre en connectant les fils de moteur dans l'ordre numérique indiqué, on doit en trouver la cause et la rectifier. Si, dans les trois montages, l'écart d'intensité le plus grand par rapport à la moyenne est toujours sur le même conducteur, la cause du déséquilibre vient surtout de la source de courant.

On s'adressera alors à la société d'électricité pour rectifier le déséquilibre de courant.

	1er montage			2e montage			3e montage		
Bornes de démarreur	L1	L2	L3	L1	L2	L3	L1	L2	L3
	⊥ T	⊥ T	⊥ T	⊥ T	⊥ T	⊥ T	⊥ T	⊥ T	⊥ T
Fils de moteur	R	B	W	W	R	B	B	W	R
	T3	T1	T2	T2	T3	T1	T1	T2	T3

Exemples :

T3-R = 51 A	T2-W = 50 A	T1-B = 50 A
T1-B = 46 A	T3-R = 48 A	T2-W = 49 A
T2-W = 53 A	T1-B = 52 A	T3-R = 51 A
Total = 150 A	Total = 150 A	Total = 150 A
÷ 3 = 50 A	÷ 3 = 50 A	÷ 3 = 50 A
– 46 A = 4 A	– 48 A = 2 A	– 49 A = 1 A
4 ÷ 50 = 0,08 ou 8 %	2 ÷ 50 = 0,04 ou 4 %	1 ÷ 50 = 0,02 ou 2 %

VALEURS DE RÉSISTANCE D'ISOLEMENT DU MOTEUR

Valeurs normalement mesurées en ohms et en mégohms entre chaque fil et le fil de terre

État du moteur et des fils	Valeurs en ohms	Valeurs en mégohms
Moteur neuf sans câble d'alimentation	20 000 000 (et plus)	20 (et plus)
Moteur usagé réutilisable en fosse	10 000 000 (et plus)	10 (et plus)
Moteur en fosse — valeurs mesurées : câble d'alimentation plus moteur		
Moteur neuf	2 000 000 (et plus)	2 (et plus)
Moteur en bon état	500 000 à 2 000 000	0,5 à 2
Isolation endommagée (la réparer)	Moins de 500 000	Moins de 0,5

La valeur de résistance d'isolement varie très peu d'un moteur à l'autre, peu importent la puissance, la tension d'alimentation et le nombre de phases du moteur.

Les valeurs de résistance d'isolement ci-dessus sont tirées de mesures prises avec un mégohmmètre et une tension de sortie de 500 V c.c. Les valeurs mesurées peuvent varier si l'on utilise un ohmmètre avec une tension moindre. Communiquer avec le personnel technique de l'usine en pareil cas.

On trouvera les données techniques sur des modèles particuliers dans le catalogue et à l'adresse du site Web inscrite au bas de la première page.

Les schémas de câblage des tableaux de commande sont fournis avec ces derniers. S'en servir conjointement avec les directives du présent manuel pour effectuer le câblage.

SERVICE DE LA POMPE			
Hauteur d'immersion minimale		**Température maximale du liquide**	
Service continu	Immersion totale	Service continu	40 °C (104 °F)
Service intermittent	6 po sous le dessus du compartiment moteur	Service intermittent	60 °C (140 °F)

Raccordement fixe des contacteurs à flotteur Pumpmaster et Pumpmaster Plus

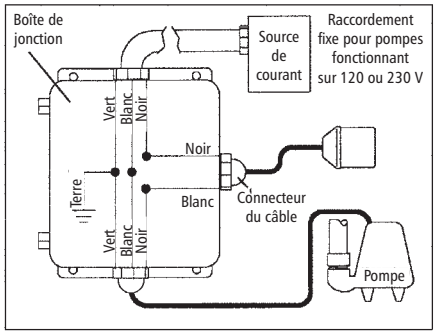


Figure 1

Raccordement fixe pour contacteur à flotteur double

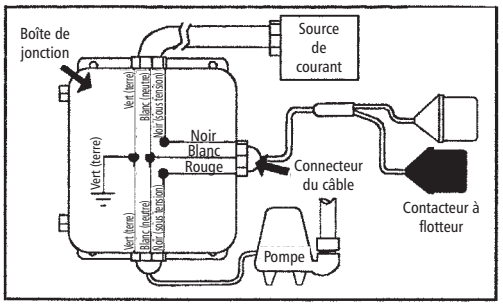


Figure 2

Détermination de la plage de pompage

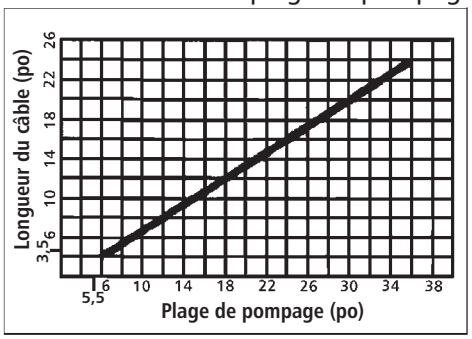


Figure 3

Installation type à contacteur à flotteur à simple effet

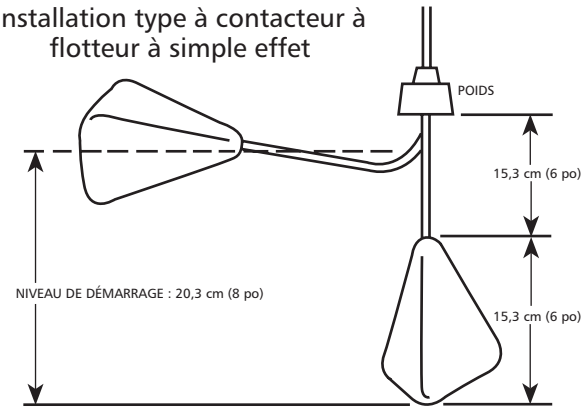


Figure 4

Contacteur à flotteur à grand déplacement angulaire

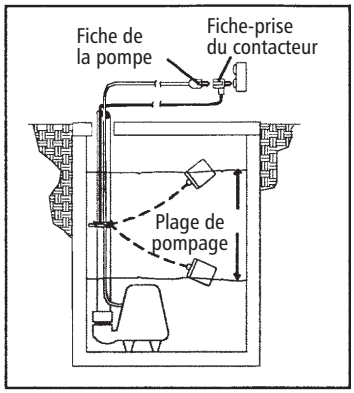


Figure 5

Schéma de câblage triphasé

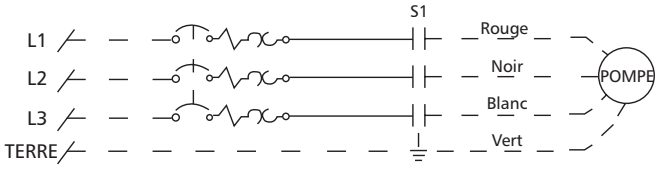
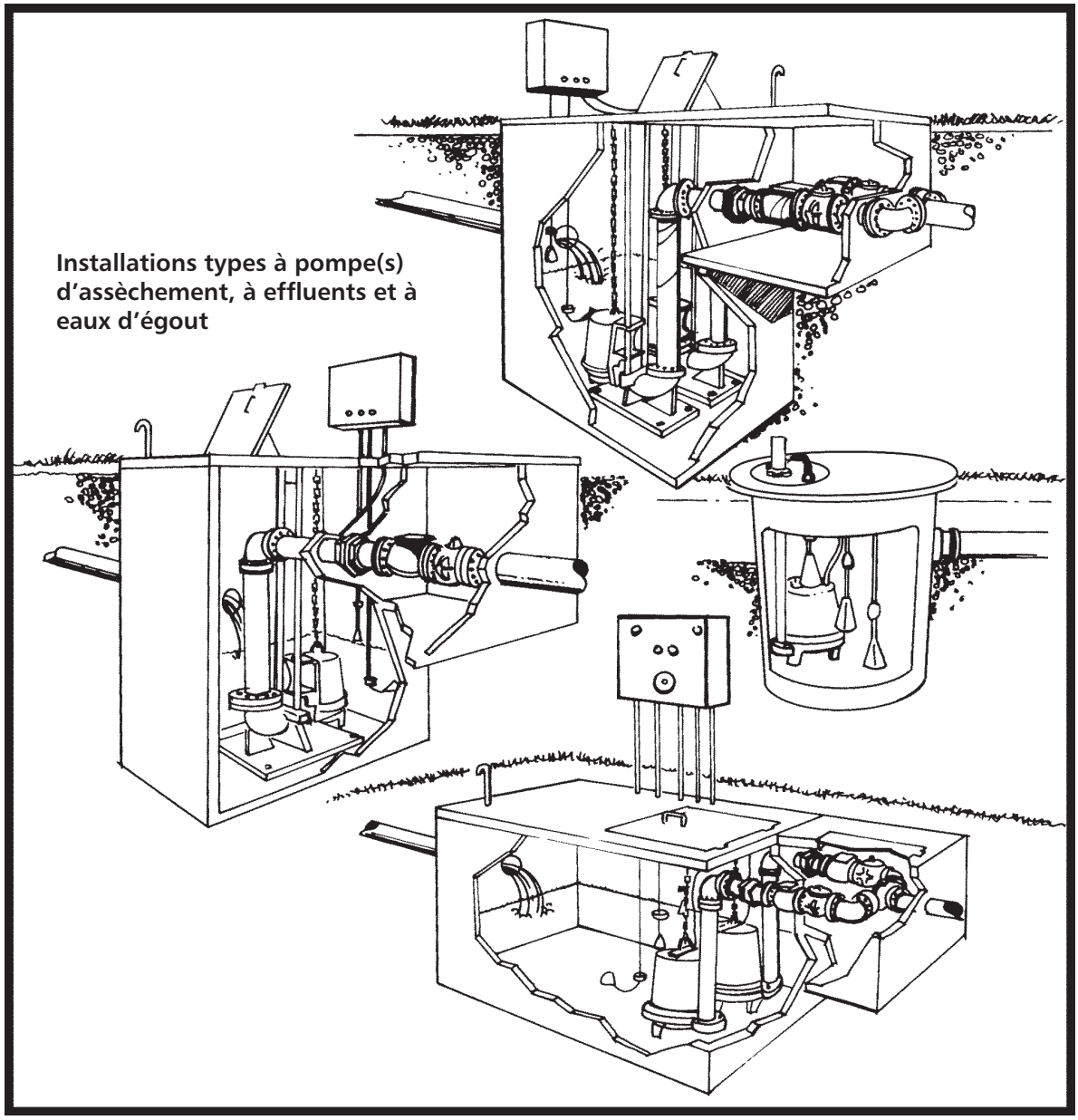


Figure 6



Installations types à pompe(s) d'assèchement, à effluents et à eaux d'égout

AVERTISSEMENT
Tension dangereuse

OMETTRE DE VERROUILLER LA SOURCE DE COURANT EN POSITION OUVERTE AVANT D'EFFECTUER TOUT TRAVAIL D'ENTRETIEN SUR LA POMPE PEUT CAUSER UN CHOC ÉLECTRIQUE, DES BRÛLURES OU LA MORT.

ANOMALIES	CAUSES PROBABLES	CORRECTIFS RECOMMANDÉS
NON-FONCTIONNEMENT DU MOTEUR *NOTA* : si le disjoncteur ne cesse de s'«OUVRIR», **NE PLUS** le réarmer. S'adresser à un électricien.	Protecteur thermique du moteur déclenché	Laisser le moteur refroidir. Vérifier si la hauteur d'immersion est suffisante. Enlever les débris du corps de pompe et de la roue.
	Disjoncteur ouvert ou fusible sauté	En déterminer la cause et s'adresser à un électricien.
	Roue bloquée ou grippée	Mesurer le courant (A) consommé par le moteur. Si l'intensité est au moins deux fois plus élevée que celle qui figure sur la plaque signalétique de la pompe, la roue est grippée, ou bien les roulements ou l'arbre du moteur sont endommagés. Enlever les débris du corps de pompe et de la roue. Consulter le détaillant.
a) Mode manuel	Câble d'alimentation endommagé	
	Mauvaise connexion dans le tableau de commande	
b) Mode automatique	Fil neutre non connecté au tableau de commande	La valeur de résistance mesurée entre les fils d'alimentation et le fil de terre devrait être infinie. Si elle n'est pas appropriée, appeler un électricien.
	Mauvaise connexion dans le tableau de commande	Inspecter le câblage du tableau de commande. Appeler un électricien.
NOTA : vérifier si la pompe peut fonctionner en mode manuel d'abord. Si oui, la commande automatique ou le câblage sont défectueux. Dans la négative, voir les indications ci-dessus.	Contacteur à flotteur défectueux	Débrancher le contacteur à flotteur et en vérifier la continuité en l'actionnant. Le remplacer au besoin.
	Liquide trop bas pour actionner les commandes	Laisser le liquide monter de 76 à 101 mm (3 à 4 po) au-dessus du niveau de démarrage.
	Câbles de contacteur à flotteur enchevêtrés	Démêler les câbles de contacteur à flotteur et s'assurer que les contacteurs peuvent bouger librement.
NON-ARRÊT DE LA POMPE	Câbles de contacteur à flotteur enchevêtrés	Démêler les câbles de contacteur à flotteur et s'assurer que les contacteurs peuvent bouger librement.
	Poche d'air dans la pompe	Arrêter la pompe pendant environ une minute, puis la remettre en marche. Répéter l'opération jusqu'à ce que la poche d'air s'élimine. Si le problème persiste et que le tuyau de refoulement comporte un clapet de non-retour, on peut percer un trou-purgeur d'air de 4,8 mm ($^3/_{16}$ po) de diamètre dans le tuyau à environ 51 mm (2 po) en aval de l'orifice de refoulement de la pompe.
	Débit de l'influent égal à celui de la pompe	Il faut peut-être une pompe plus puissante.
DÉBIT DE REFOULEMENT FAIBLE OU NUL	Clapet de non-retour posé à l'envers, obstrué ou coincé en position fermée	Vérifier l'orientation de la flèche sur le clapet de non-retour et le fonctionnement de ce dernier.
	Hauteur de charge trop élevée du système	Consulter le détaillant.
	Entrée de pompe obstruée	Inspecter et dégager l'entrée au besoin.
	Connexions ou tension inappropriées	Vérifier le sens de rotation de la pompe, la tension et le câblage. Consulter un électricien.
	Poche d'air dans la pompe	Voir le correctif recommandé pertinent ci-dessus.
	Roue usée ou endommagée	Inspecter la roue et la remplacer au besoin.
	Contacteurs à flotteur défectueux ou mal placés	Inspecter, régler ou remplacer les contacteurs au besoin.
CYCLE DE FONCTIONNEMENT RÉPÉTÉ SANS ARRÊT	Clapet de non-retour défectueux	Inspecter, réparer ou remplacer le clapet au besoin.
	Installation de confinement des eaux d'égout trop petite	Consulter le détaillant.
	Contacteurs à flotteur défectueux ou mal placés	Inspecter, régler ou remplacer les contacteurs au besoin.
	Débit de l'influent supérieur à celui de la pompe	Consulter le détaillant.

ITT

Eaux usées

GARANTIE LIMITÉE DE GOULDS PUMPS

La présente garantie s'applique à chaque pompe de système d'alimentation en eau fabriquée par Goulds Pumps.

Toute pièce se révélant défectueuse durant la période de garantie sera remplacée sans frais pour le détaillant durant ladite période, qui dure douze (12) mois à compter de la date d'installation ou dix-huit (18) mois à partir de la date de fabrication, soit la période qui expirera la première.

Le détaillant qui, aux termes de cette garantie, désire effectuer une demande de règlement doit s'adresser au distributeur Goulds Pumps agréé chez lequel la pompe a été achetée et fournir tous les détails à l'appui de sa demande. Le distributeur est autorisé à régler toute demande par le biais du service à la clientèle de Goulds Pumps.

La garantie ne couvre pas :

a) les frais de main-d'oeuvre ou de transport ni les frais connexes encourus par le détaillant ;

b) les frais de réinstallation de l'équipement réparé ;

c) les frais de réinstallation de l'équipement de remplacement ;

d) les dommages indirects de quelque nature que ce soit ;

e) ni les pertes découlant de la panne.

Aux fins de la présente garantie, les termes ci-dessous sont définis comme suit :

1) «Distributeur» signifie une personne, une société de personnes, une société de capitaux, une association ou autre entité juridique servant d'intermédiaire entre Goulds Pumps et le détaillant pour les achats, les consignations ou les contrats de vente des pompes en question.
2) «Détaillant» veut dire une personne, une société de personnes, une société de capitaux, une association ou autre entité juridique dont les activités commerciales sont la vente ou la location de pompes à des clients.
3) «Client» signifie une entité qui achète ou loue les pompes en question chez un détaillant. Un «client» peut être une personne, une société de personnes, une société de capitaux, une société à responsabilité limitée, une association ou autre entité juridique se livrant à quelque activité que ce soit.

CETTE GARANTIE SE RAPPORTE AU DÉTAILLANT SEULEMENT.

GOULDS PUMPS

Goulds Pumps et le logo à blocs siglés ITT sont des marques déposées et de commerce d'ITT Industries.

LES CARACTÉRISTIQUES PEUVENT CHANGER SANS PRÉAVIS.

IM107R03 Mars, 2006

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Engineered for life

Redi-Flo4

Stainless Steel Submersible Pumps for Environmental Applications

(US) **Installation and operating instructions**

Please leave these instructions with the pump for future reference.

SAFETY WARNING

Grundfos Stainless Steel Submersible Pumps

Your Grundfos Redi-Flo4 Environmental Pump is of the utmost quality. Combined with proper installation, your Grundfos pump will give you many years of reliable service.

To ensure the proper installation of the pump, carefully read the complete manual before attempting to install the pump.

Shipment Inspection

Examine the components carefully to make sure no damage has occurred to the pump-end, motor, cable or control box during shipment.

This Grundfos Redi-Flo4 Environmental Pump should remain in its shipping carton until it is ready to be installed. The carton is specially designed to protect it from damage. During unpacking and prior to installation, **make sure that the pump is not contaminated, dropped or mishandled.**

The motor is equipped with an electrical cable. **Under no circumstance should the cable be used to support the weight of the pump.**

You will find a loose data plate wired to the pump. It should be securely mounted at the well or attached to the control box.

PRE-INSTALLATION CHECKLIST

Before beginning installation, the following checks should be made. They are all critical for the proper installation of this submersible pump.

A. Condition of the Well

If the pump is to be installed in a new well, the well should be fully developed and bailed or blown free of cuttings and sand. Dispose of discharged materials in accordance with the specific job site requirements. The stainless steel construction of the Redi-Flo4 Environmental Pump makes it resistant to abrasion; however, no pump, made of any material, can forever withstand the destructive wear that occurs when constantly pumping sandy groundwater.

Determine the maximum depth of the well, and the drawdown level at the pump's maximum capacity. Pump selection and setting depth should be based on this data.

The inside diameter of the well casing should be checked to ensure that it is not smaller than the size of the pump and motor.

PRE-INSTALLATION CHECKLIST

B. Condition of the Water

Redi-Flo4 pumps are designed for pumping cold groundwater that is free of air or gases. Decreased pump performance and life expectancy can occur if the groundwater is not cold or contains air or gases.

C. Installation Depth

Pumping sand or well sediment can occur when the pump motor is installed lower than the top of the well screen or within five feet of the well bottom. This can reduce the performance and life expectancy of the pump and should be avoided.

If the pump is to be installed in a lake, containment pond, tank or large diameter well, the water velocity passing over the motor must be sufficient to ensure proper motor cooling. The minimum recommended water flow rates which ensure proper cooling are listed in Table A.

D. Electrical Supply

The motor voltage, phase and frequency indicated on the motor nameplate should be checked against the actual electrical supply.

WIRE CABLE TYPE

The wire cable used between the pump and control box or panel should be approved for submersible pump applications. The conductor insulation should have a continuous Teflon® jacket with no splices and must be suitable for use with submersible pumps.

INSTALLATION

The riser pipe or hose should be properly sized and selected based on estimated flow rates and friction-loss factors.

A back-up wrench should be used when the riser pipe is attaching a riser pipe or metallic nipple to the pump. The pump should only be gripped by the flats on the top of the discharge chamber. **The body of the pump, cable guard or motor should not be gripped under any circumstance.**

If Steel Riser Pipe Is Used:

An approved pipe thread compound should be used on all joints. Make sure the joints are adequately tightened in order to resist the tendency of the motor to loosen the joints when stopping and starting.

When tightened, the first section of the riser pipe must not come in contact with the check valve retainer in the discharge chamber of the pump.

INSTALLATION

After the first section of the riser pipe has been attached to the pump, the lifting cable or elevator should be clamped to the pipe. **Do not clamp the pump.** When raising the pump and riser section, be careful not to place bending stress on the pump by picking it up by the pump-end only.

Make sure that the electrical cables are not cut or damaged in any way when the pump is being lowered in the well.

The drop cable should be secured to the riser pipe at frequent intervals to prevent sagging, looping or possible cable damage.

If Plastic or Flexible Riser Pipe Is Used:

Use the correct compound recommended by the pipe manufacturer or specific job specifications. Besides making sure that joints are securely fastened, the use of a torque arrester is recommended when using these types of pipe.

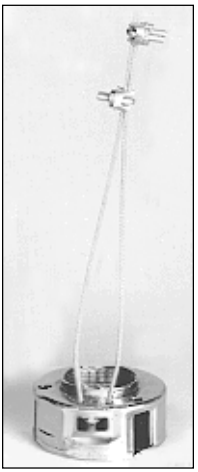
Do not connect the first plastic or flexible riser section directly to the pump. Always attach a metallic nipple or adapter into the discharge chamber of the pump. When tightened, the threaded end of the nipple or adapter must not come in contact with the check valve retainer in the discharge chamber of the pump.

The drop cable should be secured to the riser pipe at frequent intervals using an approved clip or tape to prevent sagging, looping and possible cable damage.

IMPORTANT - Plastic and flexible pipe tend to stretch under load. This stretching must be taken into account when securing the cable to the riser pipe. Leave enough slack between clips or taped points to allow for this stretching. This tendency for plastic and flexible pipe to stretch will also affect the calculation of the pump setting depth. If the depth setting is critical, check with the manufacturer of the pipe to determine how to compensate for pipe stretch.

When these types of pipe are used, it is recommended that a safety cable be attached to the pump to lower and raise it. The discharge piece of Redi-Flo4 submersibles is designed to accommodate this cable (Figure 4).

FIGURE 4



Protect the Well from Contamination

While installing the pump, proper care should be used not to introduce foreign objects or contaminants into the well. The well should be finished off above grade to protect against surface water from entering the well, causing contamination.

NOTE: Teflon® is a registered trademark of DuPont.

ELECTRICAL

WARNING: To reduce the risk of electrical shock during operation of this pump requires the provision of acceptable grounding. If the means of connection to the supply connected box is other than grounded metal conduit, ground the pump back to the service by connecting a copper conductor, at least the size of the circuit supplying the pump, to the grounding screw provided within the wiring compartment.

All electrical work should be performed by a qualified electrician in accordance with the latest edition of the National Electrical Code, local codes and regulations.

Verification of the electrical supply should be made to ensure the voltage, phase and frequency match that of the motor. Motor voltage, phase, frequency and full-load current information can be found on the nameplate attached to the motor. Motor electrical data can be found in Table C.

If voltage variations are larger than ± 10%, do not operate the pump.

Direct on-line starting is used due to the extremely fast run-up time of the motor (0.1 second maximum), and the low moment of inertia of the pump and motor. Direct on-line starting current (locked rotor amp) is between 4 and 6.5 times the full-load current.

Engine-Driven Generators

If the Redi-Flo4 pump is going to be operated using an engine driven generator, we suggest the manufacturer of the generator be contracted to ensure the proper generator is selected and used. See Table B for generator sizing guide.

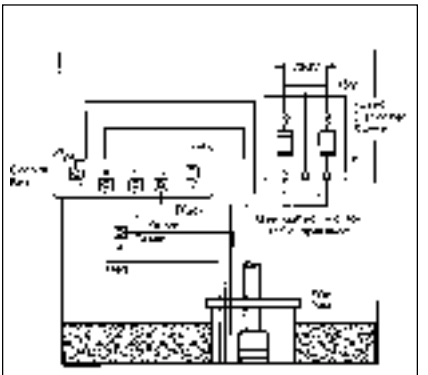
Control Box/Panel Wiring

Single-phase motors must be connected as indicated in the motor control box. A typical single-phase wiring diagram using a Grundfos control box is shown (Figure 5-A).

High Voltage Surge Arresters

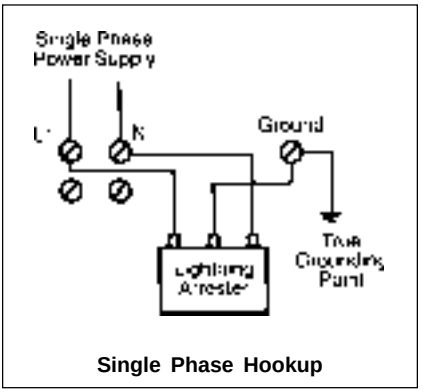
A high voltage surge arrester should be used to protect the motor against lightning and switching surges. The correct voltage-rated surge arrester should be installed on the supply(line) side of the control box (Figure 5-B). **The arrester must be grounded in accordance with the National Electric Code, local codes and regulations.**

FIGURE 5-A



Single-Phase Wiring Diagram for GRUNDFOS Control Boxes

FIGURE 5-B



Single Phase Hookup

ELECTRICAL

Control Box and Surge Arrester Grounding

The control box shall be permanently grounded in accordance with the National Electrical Code and local codes or regulations. The ground wire should be a bare copper conductor at least the same size as the drop cable wire size. The ground wire should be run as short a distance as possible and be securely fastened to a true grounding point.

True grounding points are considered to be: a grounding rod driven into the water strata, steel well casing submerged into the water lower than the pump setting level, and steel discharge pipes without insulating couplings. If plastic discharge pipe and well casing are used, a properly sized bare copper wire should be connected to a stud on the motor and run to the control panel. Do not ground to a gas supply line. Connect the grounding wire to the ground point first and then to the terminal in the control box or panel.

Wiring Checks

Before making the final wiring connections of the drop cable to the control box terminal, it is a good practice to check the insulation resistance to ensure that the cable is good. Measurements for a new installation must be at least 1,000,000 ohm. Do not start the pump if the measurement is less than this. If it is higher, finish wiring and verify that all electrical connections are made in accordance with the wiring diagram. Check to ensure the control box and high voltage surge arrester have been grounded.

START-UP

After the pump has been set into the well and the wiring connections have been made, the following procedures should be performed:

A. Attach a temporary horizontal length of pipe with installed gate valve to the riser pipe.

B. If required, make provisions to capture discharged fluids for disposal.

C. Adjust the gate valve one-third open.

D. Start the pump and let it operate until the water runs clear of sand and silt.

E. As the water clears, slowly open the gate valve in small increments until the desired flow rate of clear water is reached. The pump should not be operated beyond its maximum flow rating and should not be stopped until the groundwater runs clear.

F. If the groundwater is clean and clear when the pump is first started, the valve should still be opened until the desired flow rate is reached.

G. Disconnect the temporary piping arrangements and complete the final piping connections.

H. **Under no circumstances should the pump be operated for any prolonged period of time with the discharge valve closed.** This can result in motor damage due to overheating. A properly sized relief valve should be installed at the well head to prevent the pump from running against a closed valve.

I. Start the pump and test the system. Check and record the voltage and current draw on each motor lead.

OPERATION

A. The pump and system should be periodically checked for water quantity, pressure, drawdown, periods of cycling, and operation of controls. **Under no circumstances should be the pump be operated for any prolonged periods of time with the discharge valve closed.** This can result in motor and pump damage due to overheating. A properly sized relief valve should be installed at the well head to prevent the pump from running against a closed valve.

B. If the pump fails to operate, or there is a loss of performance, refer to Troubleshooting, Section 7.

TROUBLESHOOTING

The majority of problems that develop with submersible pumps are electrical, and most of these problems can be corrected without pulling the pump from the well. The following charts cover most of the submersible service work. As with any troubleshooting procedure, start with the simplest solution first; always make all the above-ground checks before pulling the pump from the well.

Usually only two instruments are needed – a combination voltmeter/ammeter, and an ohmmeter. These are relatively inexpensive and can be obtained from most water systems suppliers.

WHEN WORKING WITH ELECTRICAL CIRCUITS, USE CAUTION TO AVOID ELECTRICAL SHOCK. It is recommended that rubber gloves and boots be worn and that care is taken to have metal control boxes and motors grounded to power supply ground or steel drop pipe or casing extending into the well. WARNING: Submersible motors are intended for operation in a well. When not operated in a well, failure to connect motor frame to power supply ground may result in serious electrical shock.

TROUBLESHOOTING

Preliminary Tests

SUPPLY VOLTAGE

How to Measure

By means of a voltmeter, which has been set to the proper scale, measure the voltage at the control box. On single-phase units, measure between line and neutral.

What it Means

When the motor is under load, the voltage should be within ± 10% of the nameplate voltage. Larger voltage variation may cause winding damage.

Large variations in the voltage indicate a poor electrical supply and the pump should not be operated until these variations have been corrected.

If the voltage constantly remains high or low, the motor should be changed to the correct supply voltage.

CURRENT MEASUREMENT

How to Measure

By use of an ammeter, set on the proper scale, measure the current on each power lead at the control box. See the Electrical Data, Table C, for motor amp draw information.

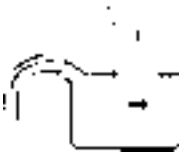
Current should be measured when the pump is operating at a constant discharge pressure with the motor fully loaded.

What it Means

If the amp draw exceeds the listed service factor amps (SFA), check for the following:

1. Loose terminals in control box or possible cable defect. Check winding and insulation resistances.
3. Too high or low supply voltage.
4. Motor windings are shorted.
5. Pump is damaged causing a motor overload.

WINDING RESISTANCE



How to Measure

Turn off power and disconnect the drop cable leads in the control box. Using an ohmmeter, set the scale selectors to Rx1 for values under 10 ohms and Rx10 for values over 10 ohms.

Zero-adjust the meter and measure the resistance between leads. Record the values.

Motor resistance values can be found in Electrical Data, Table C. Cable resistance values are in Table D.

What it Means

If all the ohm values are normal, and the cable colors correct, the windings are not damaged. If any one ohm value is less than normal, the motor may be shorted. If any one ohm value is greater than normal, there is a poor cable connection or joint. The windings or cable may also be open. If some of the ohm values are greater than normal and some less, the drop cable leads are mixed. To verify lead colors, see resistance values in Electrical Data, Table C.

INSULATION RESISTANCE

How to Measure

Turn off power and disconnect the drop cable leads in the control box. Using an ohm or mega ohmmeter, set the scale selector to Rx 100K and zero-adjust the meter.

Measure the resistance between the lead and ground (discharge pipe or well casing, if steel).

What it Means

For ohm values, refer to table below. Motors of all Hp, voltage, phase and cycle duties have the same value of insulation resistance.

TROUBLESHOOTING CHART

OHM VALUE	MEGAOHM VALUE	CONDITION OF MOTOR AND LEADS
		Motor not yet installed:
2,000,000 (or more)	2.0	New Motor.
1,000,000 (or more)	1.0	Used motor which can be reinstalled in the well.
		Motor in well (Ohm readings are for drop cable plus motor):
500,000 - 1,000,000	0.5 - 1.0	A motor in reasonably good condition.
20,000 - 500,000	0.02 - 0.5	A motor which may have been damaged by lightning or with damaged leads. Do not pull the pump for this reason.
10,000 - 20,000	0.01 - 0.02	A motor which definitely has been damaged or with damaged cable. The pump should be pulled and repairs made to the cable or the motor replaced. The motor will still operate, but probably not for long.
less than 10,000	0 - 0.01	A motor which has failed or with completely destroyed cable insulation. The pump must be pulled and the cable repaired or the motor replaced. The motor will not run in this condition.

A. Pump Does Not Run

POSSIBLE CAUSES	HOW TO CHECK	HOW TO CORRECT
1. No power at pump panel.	Check for voltage at panel.	If no voltage at panel, check feeder panel for tripped circuits.
2. Fuses are blown or circuit breakers are tripped.	Remove fuses and check for continuity with ohmmeter.	Replace blown fuses or reset circuit breaker. If new fuses blow or circuit breaker trips, the electrical installation and motor must be checked.
3. Defective controls.	Check all safety and pressure switches for operation. Inspect contacts in control devices.	Replace worn or defective parts.
4. Motor and/or cable are defective.	Turn off power. Disconnect motor leads from control box. Measure the lead to lead resistances with the ohmmeter (Rx1). Measure lead to ground values with ohmmeter (Rx100K). Record measured values.	If open motor winding or ground is found, remove pump and recheck values at the surface. Repair or replace motor or cable.
5. Defective capacitor.	Turn off the power, then discharge capacitor. Disconnect leads and check with an ohmmeter (Rx100K). When meter is connected, the needle should jump forward and slowly drift back.	If there is no needle movement, replace the capacitor.

TROUBLESHOOTING CHART

B. Pump Runs But Does Not Deliver Water

POSSIBLE CAUSES	HOW TO CHECK	HOW TO CORRECT
1. Groundwater level in well is too low or well is collapsed.	Check well draw-down.	Lower pump if possible. If not, throttle discharge valve and install water level control.
2. Integral pump check valve is blocked.	Install pressure gauge, start pump, gradually close the discharge valve and read pressure at shut-off. After taking reading, open valve to its previous position. Convert PSI to feet. (For water: PSI x 2.31 ft/PSI = ____ ft.), and add this to the total vertical distance from the pressure gauge to the water level in the well while the pump is running. Refer to the specific pump curve for the shut-off head for that pump model. If the measured head is close to the curve, pump is probably OK.	If not close to the pump curve, remove pump and inspect discharge section. Remove blockage, repair valve and valve seat if necessary. Check for other damage. Rinse out pump and reinstall.
3. Inlet strainer is clogged.	Same as B.2 above.	If not close to the pump curve, remove pump and inspect. Clean strainer, inspect integral check valve for blockage, rinse out pump and reinstall.
4. Pump is damaged.	Same as B.2 above.	If damaged, repair as necessary. Rinse out pump and re-install.

C. Pump Runs But at Reduced Capacity

POSSIBLE CAUSES	HOW TO CHECK	HOW TO CORRECT
1. Draw-down is larger than anticipated.	Check drawdown during pump operation.	Lower pump if possible. If not, throttle discharge valve and install water level control.
2. Discharge piping or valve leaking.	Examine system for leaks.	Repair leaks.
3. Pump strainer or check valve are clogged.	Remove pump and inspect.	Clean, repair, rinse out pump and reinstall.
4. Pump worn.	Same as B.2 above.	If not close to pump curve, remove pump and inspect.

D. Pump Cycles Too Much

POSSIBLE CAUSES	HOW TO CHECK	HOW TO CORRECT
1. Pressure switch is not properly adjusted or is defective.	Check pressure setting on switch and operation. Check voltage across closed contacts.	Re-adjust switch or replace if defective.
2. Level control is not properly set or is defective.	Check setting and operation.	Re-adjust setting (refer to manufacturer data.) Replace if defective.
3. Plugged snifter valve or bleed orifice.	Examine valve and orifice for dirt or corrosion.	Clean and/or replace if defective.

TROUBLESHOOTING CHART

E. Fuses Blow or Circuit Breakers Trip

POSSIBLE CAUSES	HOW TO CHECK	HOW TO CORRECT
1. High or low voltage.	Check voltage at pump panel. If not within ± 10%, check wire size and length of run to pump panel.	If wire size is correct, contact power company. If not, correct and/or replace as necessary.
2. Control box wiring and components.	Check that control box parts match the parts list. Check to see that wiring matches wiring diagram. Check for loose or broken wires or terminals.	Correct as required.
3. Defective capacitor.	Turn off power and discharge capacitor. Check using an ohmmeter (Rx100K). When the meter is connected, the needle should jump forward and slowly drift back.	If no meter movement, replace the capacitor.
4. Starting relay (Franklin single-phase motors only).	Check resistance of relay coil with an ohmmeter (Rx1000K). Check contacts for wear.	Replace defective relay.

TECHNICAL DATA

Table A

Minimum Water Flow Requirements for Submersible Pump Motors

MOTOR DIAMETER	CASING OR SLEEVE I.D. IN INCHES	MIN. FLOW PAST THE MOTOR (GPM)
4"	4	1.2
	5	7
	6	13
	7	21
	8	30

NOTES:

1. A flow inducer or sleeve must be used if the water enters the well above the motor or if there is insufficient water flow past the motor.
2. The minimum recommended water velocity over 4" motors is 0.25 feet per second.

Table B

Guide for Engine-Driven Generators in Submersible Pump Applications

	MINIMUM KILOWATT RATING OF GENERATOR FOR THREE-WIRE SUBMERSIBLE PUMP MOTORS	
MOTOR HP	EXTERNALLY REGULATED GENERATOR	INTERNALLY REGULATED GENERATOR
0.33 HP	1.5 KW	1.2 KW
0.50	2.0	1.5
0.75	3.0	2.0
1.0	4.0	2.5
1.5	5.0	3.0

NOTES:

1. Table is based on typical 80°C rise continuous duty generators with 35% maximum voltage dip during start-up of single phase motors.
2. Contact the manufacturer of the generator to assure the unit has adequate capacity to run the submersible motor.
3. If the generator rating is in KVA instead of kilowatts, multiply the above ratings by 1.25 to obtain KVA.

TECHNICAL DATA

Table C

Electrical Data – 60 Hz Submersible Pump Motors

GRUNDFOS MOTORS

HP	PH	VOLT	SER. FACT.	CIRC. BRK. OR STD. FUSE	DUAL ELEMENT FUSE	AMPERAGE FULL LOAD	AMPERAGE LOCK ROTOR	AMPERAGE S.F. AMPS	FULL LOAD EFF.	FULL LOAD POWER FACTOR	LINE-TO-LINE RESISTANCE (OHMS) Blk-Yel	LINE-TO-LINE RESISTANCE (OHMS) Red-Yel	LINE-TO-LINE RESISTANCE (OHMS) Delta	KVA CODE **	MAX. THRUST (LBS)	GRUNDFOS PART NO.
4-Inch, Single Phase, 2-Wire Motors (control box not required)																
1/3	1	230	1.75	15	5	3.4	25.7	4.6	59.0	77.0	6.8-8.2			S	770	79.952301
1/2	1	230	1.60	15	7	4.5	34.5	6.0	62.0	76.0	5.2-6.3			R	770	79.952302
3/4	1	230	1.50	20	9	6.9	40.5	8.4	62.0	75.0	3.2-3.8			N	770	79.952303
1	1	230	1.40	25	12	8.0	48.4	9.8	63.0	82.0	2.5-3.1			M	770	79.952304
1-1/2	1	230	1.30	35	15	10.0	62.0	13.1	64.0	85.0	1.9-2.3			L	770	79.952305
4-Inch, Single Phase, 3-Wire Motors																
1/3	1	230	1.75	15	5	3.4	14.0	4.6	59.0	77.0	6.8-8.3	17.3-21.1		L	770	79.453301
1/2	1	230	1.60	15	7	4.5	21.5	6.0	62.0	76.0	4.7-5.7	15.8-19.6		L	770	79.453302
3/4	1	230	1.50	20	9	6.9	31.4	8.4	62.0	75.0	3.2-3.9	14-17.2		L	770	79.453303
1	1	230	1.40	25	12	8.0	38.0	9.8	63.0	82.0	2.6-3.1	10.3-12.5		K	770	79.453304
1-1/2	1	230	1.30	35	15	9.4	45.9	11.6	69.0	89.0	1.9-2.3	7.8-9.6		H	770	79.453305

FRANKLIN MOTORS

(refer to the Franklin Submersible Motors Application Maintenance Manual)

TECHNICAL DATA

Table D

Total Resistance of Drop Cable (OHMS)

The values shown in this table are for copper conductors. Values are for the total resistance of drop cable from the **control box to the motor and back.**

To determine the resistance:

1. Disconnect the drop cable leads from the control box.
2. Record the size and length of drop cable.
3. Determine the cable resistance from the table.
4. Add drop cable resistance to motor resistance. Motor resistances can be found in the Electrical Data Chart, Table C.
5. Measure the resistance between each drop cable lead using an ohmmeter. Meter should be set on Rx1 and zero-balanced for this measurement.
6. The measured values should be approximately equal to the calculated values.

Wire Resistances

DISTANCE FROM CONTROL BOX TO PUMP MOTOR (FT.)	12 AWG WIRE RESISTANCE (OHMS)	14 AWG WIRE RESISTANCE (OHMS)
10	0.03	0.05
20	0.06	0.10
30	0.10	0.15
40	0.13	0.21
50	0.16	0.26
60	0.19	0.31
70	0.23	0.36
80	0.26	0.41
90	0.29	0.46
100	0.32	0.51
110	0.36	0.57
120	0.39	0.62
130	0.42	0.67
140	0.45	0.72
150	0.49	0.77
160	0.52	0.82
170	0.55	0.87
180	0.58	0.93
190	0.62	0.98
200	0.65	1.03

NOTES

NOTES

LIMITED WARRANTY

Redi-Flo4 Environmental Pumps manufactured by GRUNDFOS PUMPS CORPORATION (GRUNDFOS) are warranted to the original user only to be free of defects in material and workmanship for a period of 24 months from date of installation, but not more than 30 months from date of manufacture. GRUNDFOS' liability under this warranty shall be limited to repairing or replacing at GRUNDFOS' option, without charge, F.O.B. GRUNDFOS' factory or authorized service station, any product of GRUNDFOS' manufacture. GRUNDFOS will not be liable for any costs of removal, installation, transportation, or any other charges which may arise in connection with a warranty claim. Products which are sold but not manufactured by GRUNDFOS are subject to the warranty provided by the manufacturer of said products and not by GRUNDFOS' warranty. GRUNDFOS will not be liable for damage or wear to products caused by abnormal operating conditions, accident, abuse, misuse, unauthorized alteration or repair, or if the product was not installed in accordance with GRUNDFOS' printed installation and operating instructions.

To obtain service under this warranty, the defective product must be returned to the distributor or dealer of GRUNDFOS' products from which it was purchased together with proof of purchase and installation date, failure date, and supporting installation data. Unless otherwise provided, the distributor or dealer will contact GRUNDFOS or an authorized service station for instructions. Any defective product to be returned to GRUNDFOS or a service station must be sent freight prepaid; documentation supporting the warranty claim and/or a Return Material Authorization must be included if so instructed.

GRUNDFOS WILL NOT BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES, LOSSES, OR EXPENSES ARISING FROM INSTALLATION, USE, OR ANY OTHER CAUSES. THERE ARE NO EXPRESS OR IMPLIED WARRANTIES, INCLUDING MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, WHICH EXTEND BEYOND THOSE WARRANTIES DESCRIBED OR REFERRED TO ABOVE.

Some jurisdictions do not allow the exclusion or limitation of incidental or consequential damages and some jurisdictions do not allow limitations on how long implied warranties may last. Therefore, the above limitations or exclusions may not apply to you. This warranty gives you specific legal rights and you may also have other rights which vary from jurisdiction to jurisdiction.

Grundfos Pumps Corporation
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Telephone: (913) 227-3400
Fax: (913) 227-3500

Grundfos Canada, Inc.
2941 Brighton Rd.
Oakville, Ontario L6H 6C9
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Fax: (905) 829-9512

Bombas Grundfos de Mexico, S.A. de C.V.
Boulevard TLC #15, Parque Industrial Stiva Aeropuerto
C.P. 66600 Apodaca, N.L. Mexico
Telephone: 52-8-144-4000
Fax: 52-8-144-4010

L-RF-IO-001	Rev. 07/03
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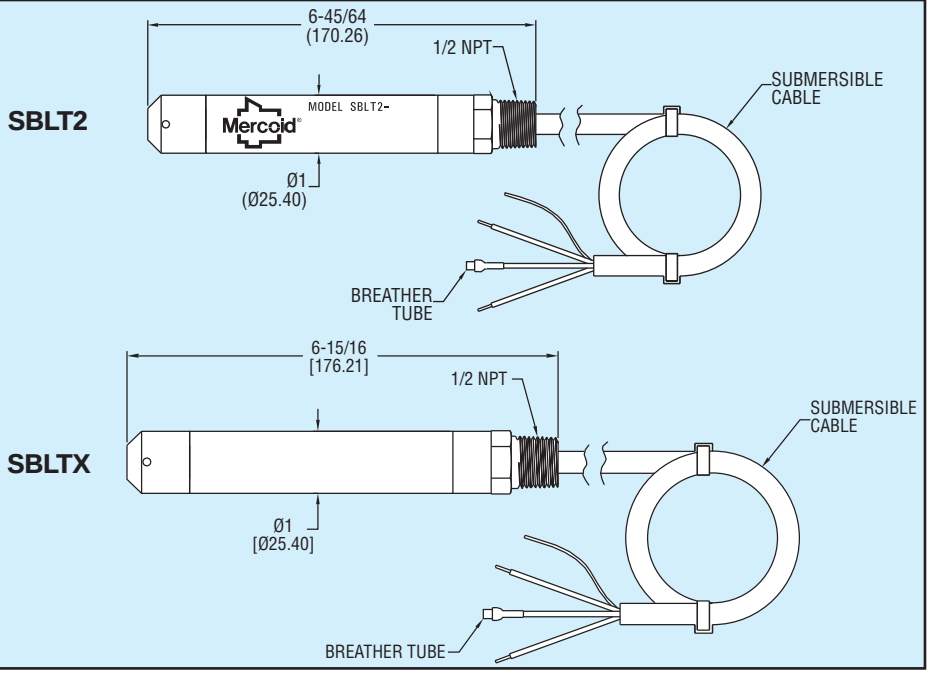
Series SBLT2 & SBLTX

Submersible Level Transmitter

Perfect for Ground Water and Wells, Lightning Protected or Intrinsically Safe



SBLT2 and SBLTX Submersible Level Transmitters are manufactured for years of trouble free service in the harshest applications. Both measure the height of liquid above the position in the tank referenced to atmospheric pressure. The transmitter consists of a piezoresistive sensing element, encased in a 316 SS housing. Bullet nose design protects the diaphragm from damage.

The SBLT2 incorporates lightning and surge protection utilizing dual arrestor technology, grounded to case, eliminating both power supply surges and lightning ground strike transients (surge protection is not guaranteed and is not covered by warranty). The SBLTX is UL approved intrinsically safe for use in hazardous locations when used with proper barrier.

Units comes equipped with a 270-pound tensile strength shielded and vented cable. Ventilation tube in the cable automatically compensates for changes in atmospheric pressure above the tank. The vent is protected with a maintenance free filter eliminating particulate or water droplets from entering the transducer.

- Excellent chemical compatibility
- Lightning and surge protection on SBLT2 models
- Maintenance free vent filter
- UL approved intrinsically safe on SBLTX models
- Slim design for tight applications

APPLICATIONS

- Well monitoring; Ground water monitoring; Environmental remendiation; Surface water monitoring; Down hold; Water Tanks.

SPECIFICATIONS

Service: Compatible liquids.
Wetted Materials: 316 SS, 316L SS, Buna-N; Cable: Polyurethane or ETFE; Bullet Nose: PVC.
Accuracy: ±0.25% of full scale.
Temperature Limit: SBLT2: 0 to 150°F (-18 to 66°C); SBLTX: 0 to 176°F (-18 to 80°C).
Compensated Temperature Range: SBLT2: 0 to 140°F (-18 to 60°C); SBLTX: 0 to 176°F (-18 to 80°C).
Thermal Effect: ±0.02% full scale/°F.
Pressure Limit: 2X full scale.
Power Requirement: SBLT2: 13 to 30 VDC; SBLTX: 10 to 28 VDC.
Output Signal: 4 to 20 mA DC, 2-wire.
Response Time: 50 ms.
Max. Loop Resistance: 900 ohms at 30 VDC.
Electrical Connections: Wire pigtail.
Mounting Orientation: Suspended in tank below level being measured.
Weight: 2.2 lb (1.0 kg).
Electrical Protection: SBLT2: Lightning and surge protection; SBLTX: None.
Agency Approvals: SBLT2: None; SBLTX: CE, UL intrinsically safe for Class I, Div. 1, Groups A, B, C, D; Class II, Div. 1, Groups E, F, G; Class III Div. 1. (According to control drawing 01-700797-00)

Model Number	Range psi (ft wc) [m wc]	Cable Length ft (m)	Cable Type
SBLT2-5-40-ETFE	5 (11.54) [3.52]	40 (12.2)	ETFE
SBLT2-10-40-ETFE	10 (23.09) [7.04]	40 (12.2)	ETFE
SBLT2-15-60-ETFE	15 (34.63) [10.56]	60 (18.3)	ETFE
SBLT2-20-60-ETFE	20 (46.18) [14.08]	60 (18.3)	ETFE
SBLT2-5-40	5 (11.54) [3.52]	40 (12.2)	Polyurethane
SBLT2-10-40	10 (23.09) [7.04]	40 (12.2)	Polyurethane
SBLT2-15-60	15 (34.63) [10.56]	60 (18.3)	Polyurethane
SBLT2-20-60	20 (46.18) [14.08]	60 (18.3)	Polyurethane

OPTIONS

Intrinsically Safe Approval- Change model number from SBLT2 to SBLTX

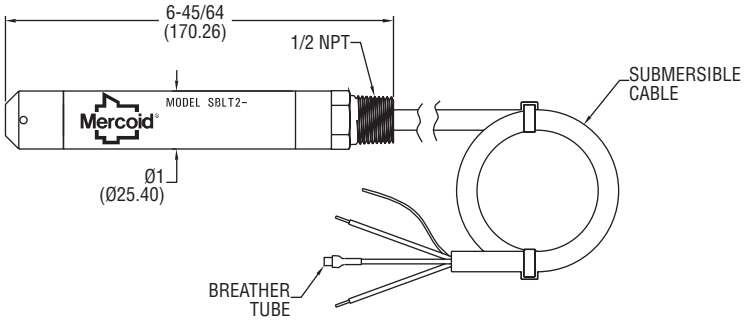
Custom ranges or Cable Lengths

ACCESSORIES

MTL5041, intrinsically safe galvanic isolator
MTL7706, intrinsically safe zener barrier

Series SBLT2 Submersible Level Transmitter

Specifications - Installation and Operating Instructions



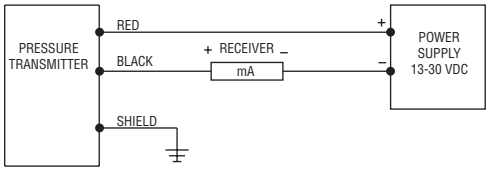
The SBLT2 Submersible Level Transmitter is manufactured for years of trouble free service. The transmitter consists of a piezoresistive sensing element, encased in a 316 SS housing. Superior lightning and surge protection utilizing dual arrestor technology, grounded to case, eliminating both power supply surges and lightning ground strike transients. Bullet nose design protects diaphragm from damage. Comes equipped with a 270-pound tensile strength, shielded, vented cable. Ventilation tube in the cable automatically compensates for changes in atmospheric pressure above the tank.

APPLICATIONS

• Well monitoring; Ground water monitoring; Environmental remediation; Surface water monitoring; Down hole; Water Tanks

ELECTRICAL INSTALLATION

An external power supply delivering 13-30 VDC with minimum current capability of 40 mA DC (per transmitter) is required to power the control loop. See figure below for connection of the power supply, transmitter and receiver.



The maximum receiver load resistance (RLmax) for the DC power supply voltage (Vsup) is expressed by the formula:

$$RLmax = \frac{Vsup - 13V}{0.02A}$$

Shielded cable is recommended for control loop wiring.

SPECIFICATIONS

Service: Compatible liquids.
Wetted Materials: 316 SS, 316L SS, Buna-N; Cable: Polyurethane or ETFE; Bullet Nose: PVC.
Accuracy: ±0.25% of full scale.
Temperature Limit: 0 to 150°F (-18 to 66°C).
Compensated Temperature Range: 0 to 140°F (-18 to 60°C).
Thermal Effect: Less than ±0.02%/°F.
Pressure Limit: 2X full scale.
Power Requirement: 13 to 30 VDC.
Output Signal: 4 to 20 mA DC, 2-wire.
Response Time: 50 ms.
Max. Loop Resistance: 850 ohms at 30 VDC.
Electrical Connections: Wire pigtail.
Mounting Orientation: Suspended in tank below level being measured.
Weight: 2.2 lb (1.0 kg).
Electrical Protection: Lightning and surge protection.

Model Number Guide:

Example	SBLT2	20	40		SBLT2-20-40
Construction	SBLT2				Bullet style submersible level transmitter, Polyurethane cable
Range		XXX			In psi (5000 psi maximum)
Cable Length			XXX		In feet (1500 feet maximum)
Options				ETFE	ETFE cable

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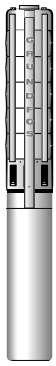
GRUNDFOS®

Redi-Flo4 Environmental Submersible Pumps

10E

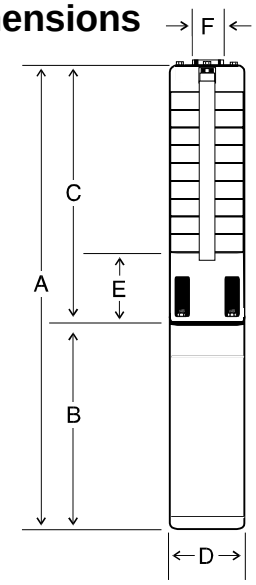
Submittal Data 3450 RPM 60 Hertz



JOB or CUSTOMER:	
ENGINEER:	
CONTRACTOR:	
SUBMITTED BY:	DATE:
APPROVED BY:	DATE:
ORDER NO:	DATE:
SPECIFICATION REF:	

QUANTITY	TAG NO.	MODEL NO.	GPM	FEET	VOLT	PHASE	COMMENTS

Dimensions



Technical Data

FLOW RANGE: 5 to 14 U.S. GPM

MOTORS: Grundfos MS402E Environmental Submersible Motor (Standard)
Maximum Operating Temperature: 104°F (40°C)
Maximum Submergence Pressure: 220 PSI
Maximum Number of Starts Per Hour: 100
Minimum Recommended Flow Past Motor: 0.25 ft./sec.

(NOTE: Franklin Pollution Recovery motor is optional.)

DISCHARGE SIZE: 1 ¼" NPT

MATERIALS OF CONSTRUCTION: See reverse side.

INSTALLATION: Unit to be installed vertically for submerged operation.

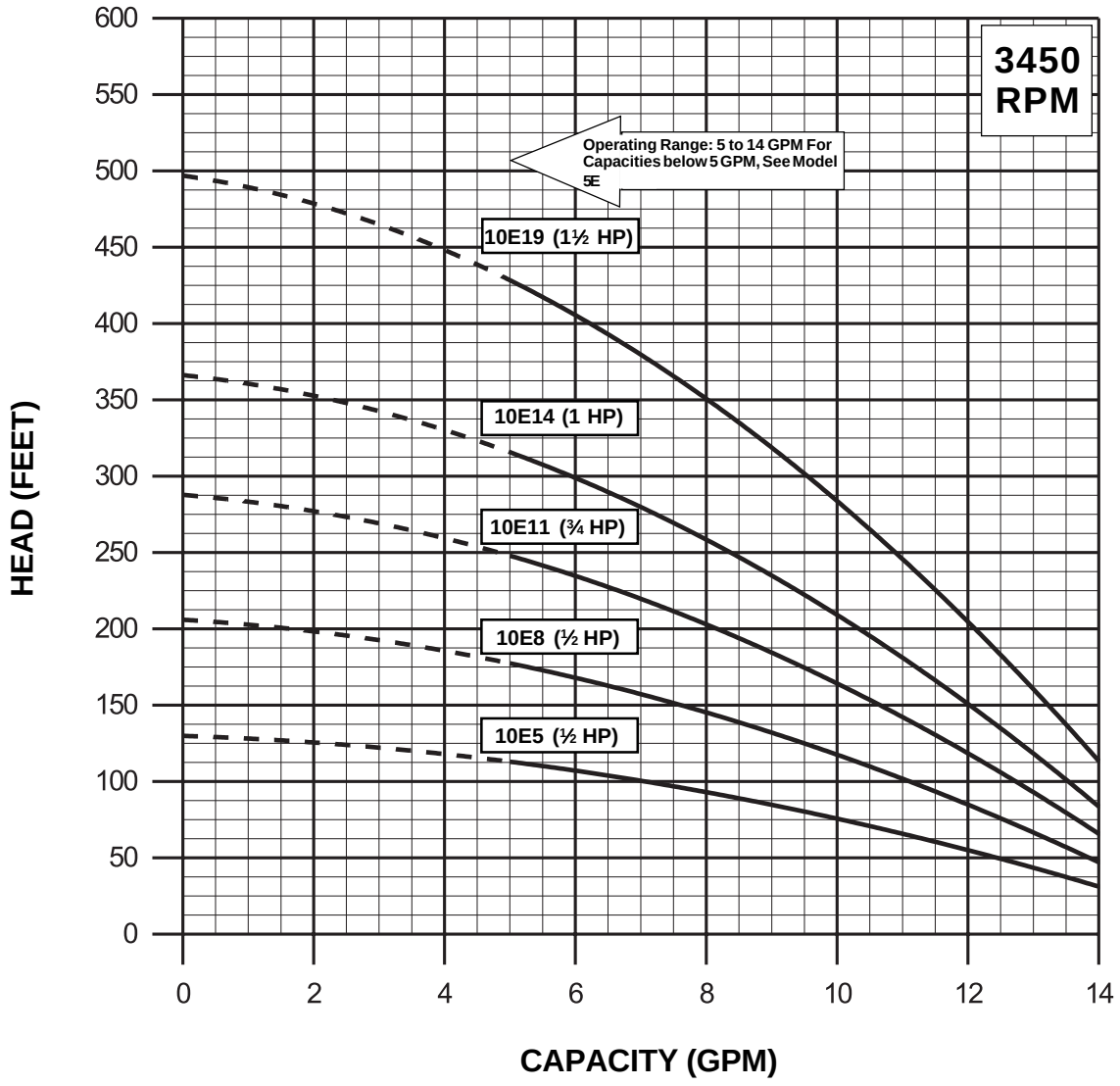
Electrical Data, Dimensions, and Weights

Pump Type	Motors				DIMENSIONS IN INCHES							
	HP	SF	PH	Volts	Overall Length A	Motor Length B	Pump End Length C	Max. Dia. D	Inlet E	Disch. Pipe Size (NPT) F	Net Weight (Lbs.)†	Ship. Weight (Lbs.)†
10E5	½	1.60	1	230	21 1/8	10 13/16	10 5/16	3 31/32	3 1/4	1 1/4	25	26
10E8	½	1.60	1	230	23 9/16	10 13/16	12 3/4	3 31/32	3 1/4	1 1/4	26	28
10E11	¾	1.50	1	230	26 9/16	11 3/8	15 3/16	3 31/32	3 1/4	1 1/4	28	30
10E14	1	1.40	1	230	29 11/16	12	17 11/16	3 31/32	3 1/4	1 1/4	31	32
10E19	1 ½	1.30	1	230	35 3/8	13 9/16	21 13/16	3 31/32	3 1/4	1 1/4	35	37

† Data for Grundfos MS402E motors. † Does not include motor leads.

Performance Curves

10E



Materials of Construction

REDI-FLO4 PUMP END

Description	Material
Check Valve Housing, Check Valve, Diffuser Chamber, Impeller, Suction Interconnector, Inlet Screen, Pump Shaft, Straps, Cable Guard, Priming Inducer	304 SS
Check Valve Seat	304 SS & Teflon®
Impeller Seal Ring	Teflon®
Coupling	316/431 SS
Intermediate Bearings	Teflon®

GRUNDFOS ENVIRONMENTAL MOTOR

Description	Material
NEMA Top, Studs & Fasteners, Stator Housing, Fill Plug Screw	304 SS
Nuts	316 SS
Sand Slinger	FPM
Shaft Extension	431 SS
Diaphragm	FPM
Fill Plug Washer	Teflon®

GRUNDFOS ENVIRONMENTAL MOTOR LEADS

Description	Material
Connector Sleeve	304 SS
Connector Potting	Scotch Cast #4® Epoxy w/FPM Cap
Connector Plug	FPM
Lead Insulation	Teflon®
Conductor	Stranded Copper, 12 AWG

NOTES: Specifications are subject to change without notice.
Teflon® is a registered trademark of DuPont.
Scotch Cast #4® is a registered trademark of 3M Company.

GRUNDFOS®

GRUNDFOS Pumps Corporation • 3131 N. Business Park Ave. Fresno, CA 93727
Customer Service Centers: Allentown, PA • Fresno, CA
Phone: (800)333-1366 • **Fax: (800)333-1363**
Canada: Oakville, Ontario • **Mexico:** Apodaca, N.L.

L-RF4-TL-010 | Rev. 4/01
PRINTED IN USA

B3885

ITT

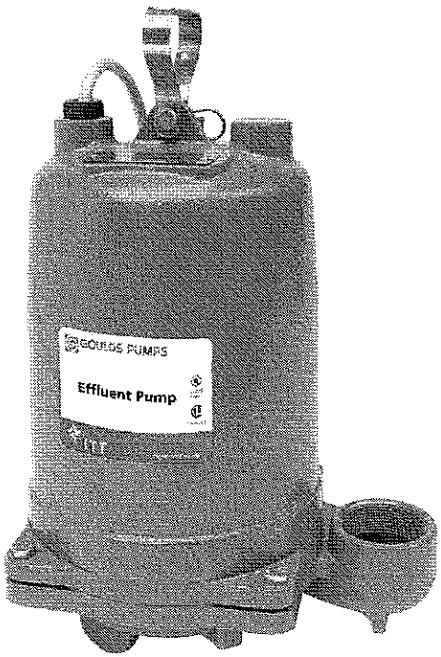
Wastewater

Goulds Pumps

WE Series Model 3885

Submersible Effluent Pump

PROSURANCE AVAILABLE FOR
RESIDENTIAL APPLICATIONS.



FEATURES

- **Impeller:** Cast iron, semi-open, non-clog with pump-out vanes for mechanical seal protection. Balanced for smooth operation. Silicon bronze impeller available as an option.
- **Casing:** Cast iron volute type for maximum efficiency. 2" NPT discharge.
- **Mechanical Seal:** Silicon Carbide vs. Silicon Carbide sealing faces. Stainless steel metal parts, BUNA-N elastomers.
- **Shaft:** Corrosion-resistant, stainless steel. Threaded design. Locknut on all models to guard against component damage on accidental reverse rotation.
- **Fasteners:** 300 series stainless steel.
- Capable of running dry without damage to components.
- Designed for continuous operation when fully submerged.

GOULDS PUMPS

Goulds Pumps is a brand of ITT Corporation.

www.goulds.com

Engineered for life

ITT

GOULDS PUMPS
Wastewater

APPLICATIONS

Specifically designed for the following uses:

- Homes, Farms, Trailer Courts, Motels, Schools, Hospitals, Industry, Effluent Systems

SPECIFICATIONS

Pump

- Solids handling capabilities: ¾" maximum.
- Discharge size: 2" NPT.
- Capacities: up to 140 GPM.
- Total heads: up to 128 feet TDH.
- Temperature: 104°F (40°C) continuous, 140°F (60°C) intermittent.
- See order numbers on reverse side for specific HP, voltage, phase and RPM's available.

MOTORS

- Fully submerged in high-grade turbine oil for lubrication and efficient heat transfer.
- Class B insulation on ⅓ – 1½ HP models.
- Class F insulation on 2 HP models.

Single phase (60 Hz):

- Capacitor start motors for maximum starting torque.
- Built-in overload with automatic reset.
- SJTOW or STOW severe duty oil and water resistant power cords.
- ⅓ – 1 HP models have NEMA three prong grounding plugs.
- 1½ HP and larger units have bare lead cord ends.

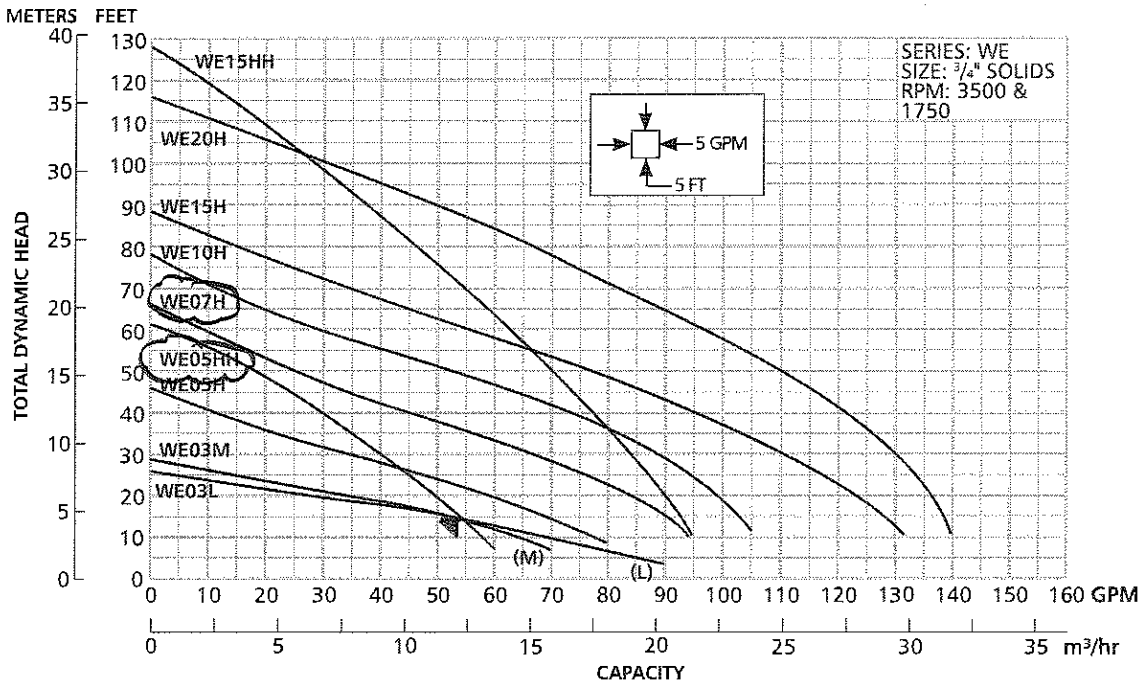
Three phase (60 Hz):

- Class 10 overload protection must be provided in separately ordered starter unit.
- STOW power cords all have bare lead cord ends.

- **Designed for Continuous Operation:** Pump ratings are within the motor manufacturer's recommended working limits, can be operated continuously without damage when fully submerged.
- **Bearings:** Upper and lower heavy duty ball bearing construction.
- **Power Cable:** Severe duty rated, oil and water resistant. Epoxy seal on motor end provides secondary moisture barrier in case of outer jacket damage and to prevent oil wicking. Standard cord is 20'. Optional lengths are available.
- **O-ring:** Assures positive sealing against contaminants and oil leakage.

AGENCY LISTINGS

Tested to UL 778 and CSA 22.2 108 Standards
By Canadian Standards Association File #LR38549
Goulds Pumps is ISO 9001 Registered.



MODELS

Order Number	HP	Phase	Volts	RPM	Impeller Diameter (in.)	Maximum Amps	Locked Rotor Amps	KVA Code	Full Load Efficiency %	Resistance Start	Resistance Line-Line	Power Cable Size	Weight (lbs.)
WE0311L	0.33	1	115	1750	5.38	10.7	30.0	M	54	11.9	1.7	16/3	56
WE0318L			208			6.8	19.5	K	51	9.1	4.2		
WE0312L			230			4.9	14.1	L	53	14.5	8.0		
WE0311M			115			10.7	30.0	M	54	11.9	1.7		
WE0318M			208			6.8	19.5	K	51	9.1	4.2		
WE0312M			230			4.9	14.1	L	53	14.5	8.0		
WE0511H	0.5	1	115	3450	3.56	14.5	46.0	M	54	7.5	1.0	14/3	60
WE0518H			208			8.1	31.0	K	68	9.7	2.4	16/3	60
WE0512H			230			7.3	34.5	M	53	9.6	4.0		
WE0538H		3	200			4.9	22.6	R	68	NA	3.8	14/4	60
WE0532H			230			3.3	18.8	R	70	NA	5.8		
WE0534H			460			1.7	9.4	R	70	NA	23.2		
WE0537H			575			1.4	7.5	R	62	NA	35.3		
WE0511HH		1	115		3.88	14.5	46.0	M	54	7.5	1.0	14/3	60
WE0518HH			208			8.1	31.0	K	68	9.7	2.4	16/3	60
WE0512HH			230			7.3	34.5	M	53	9.6	4.0		
WE0538HH		3	200			4.9	22.6	R	68	NA	3.8	14/4	60
WE0532HH			230			3.6	18.8	R	70	NA	5.8		
WE0534HH			460			1.8	9.4	R	70	NA	23.2		
WE0537HH			575			1.5	7.5	R	62	NA	35.3		
WE0718H	0.75	1	208		4.06	11.0	31.0	K	68	9.7	2.4	14/3	70
WE0712H			230			10.0	27.5	J	65	12.2	2.7		
WE0738H		3	200			6.2	20.6	L	64	NA	5.7	14/4	70
WE0732H			230			5.4	15.7	K	68	NA	8.6		
WE0734H			460			2.7	7.9	K	68	NA	34.2		
WE0737H			575			2.2	9.9	L	78	NA	26.5		
WE1018H	1	1	208		4.44	14.0	59.0	K	68	9.3	1.1	14/3	70
WE1012H			230			12.5	36.2	J	69	10.3	2.1		
WE1038H		3	200			8.1	37.6	M	77	NA	2.7	14/4	70
WE1032H			230			7.0	24.1	L	79	NA	4.1		
WE1034H			460			3.5	12.1	L	79	NA	16.2		
WE1037H			575			2.8	9.9	L	78	NA	26.5		
WE1518H	1.5	1	208		4.56	17.5	59.0	K	68	9.3	1.1	14/3	80
WE1512H			230			15.7	50.0	H	68	11.3	1.6		
WE1538H		3	200			10.6	40.6	K	79	NA	1.9	14/4	80
WE1532H			230			9.2	31.7	K	78	NA	2.9		
WE1534H			460			4.6	15.9	K	78	NA	11.4		
WE1537H			575			3.7	13.1	K	75	NA	16.9		
WE1518HH		1	208		5.50	17.5	59.0	K	68	9.3	1.1	14/3	80
WE1512HH			230			15.7	50.0	H	68	11.3	1.6		
WE1538HH		3	200			10.6	40.6	K	79	NA	1.9	14/4	80
WE1532HH			230			9.2	31.7	K	78	NA	2.9		
WE1534HH			460			4.6	15.9	K	78	NA	11.4		
WE1537HH			575			3.7	13.1	K	75	NA	16.9		
WE2012H	2	1	230		5.38	18.0	49.6	F	78	3.2	1.2	14/3	83
WE2038H		3	200			12.0	42.4	K	78	NA	1.7	14/4	83
WE2032H			230			11.6	42.4	K	78	NA	1.7		
WE2034H			460			5.8	21.2	K	78	NA	6.6		
WE2037H			575			4.7	16.3	L	78	NA	10.5		

ITT

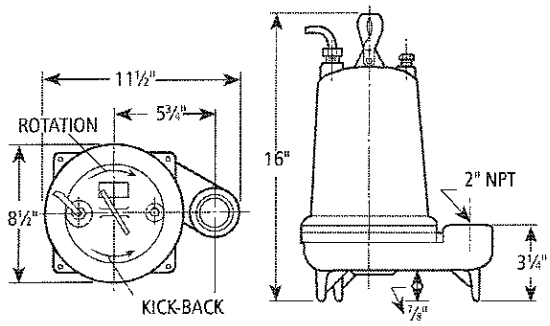
Wastewater

PERFORMANCE RATINGS (gallons per minute)

Order No.		WE03L	WE03M	WE05H	WE07H	WE10H	WE15H	WE05HH	WE15HH	WE20H
	HP	⅓	⅓	½	¾	1	1½	½	1½	2
	RPM	1750	1750	3500	3500	3500	3500	3500	3500	3500
Total Head Feet of Water	5	86	–	–	–	–	–	–	–	–
	10	70	63	78	94	–	–	58	95	–
	15	52	52	70	90	103	128	53	93	138
	20	27	35	60	83	98	123	49	90	136
	25	5	15	48	76	94	117	45	87	133
	30	–	–	35	67	88	110	40	83	130
	35	–	–	22	57	82	103	35	80	126
	40	–	–	–	45	74	95	30	77	121
	45	–	–	–	35	64	86	25	74	116
	50	–	–	–	25	53	77	–	70	110
	55	–	–	–	–	40	67	–	66	103
	60	–	–	–	–	30	56	–	63	96
	65	–	–	–	–	20	45	–	58	89
	70	–	–	–	–	–	35	–	55	81
	75	–	–	–	–	–	25	–	51	74
	80	–	–	–	–	–	–	–	47	66
	90	–	–	–	–	–	–	–	37	49
	100	–	–	–	–	–	–	–	28	30

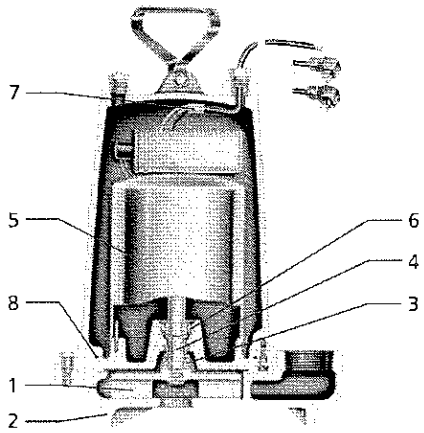
DIMENSIONS

(All dimensions are in inches. Do not use for construction purposes.)



COMPONENTS

Item No.	Description
1	Impeller
2	Casing
3	Mechanical Seal
4	Motor Shaft
5	Motor
6	Ball Bearings
7	Power Cable
8	Casing O-Ring



GOULDS PUMPS

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SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE.

B3885 June, 2008

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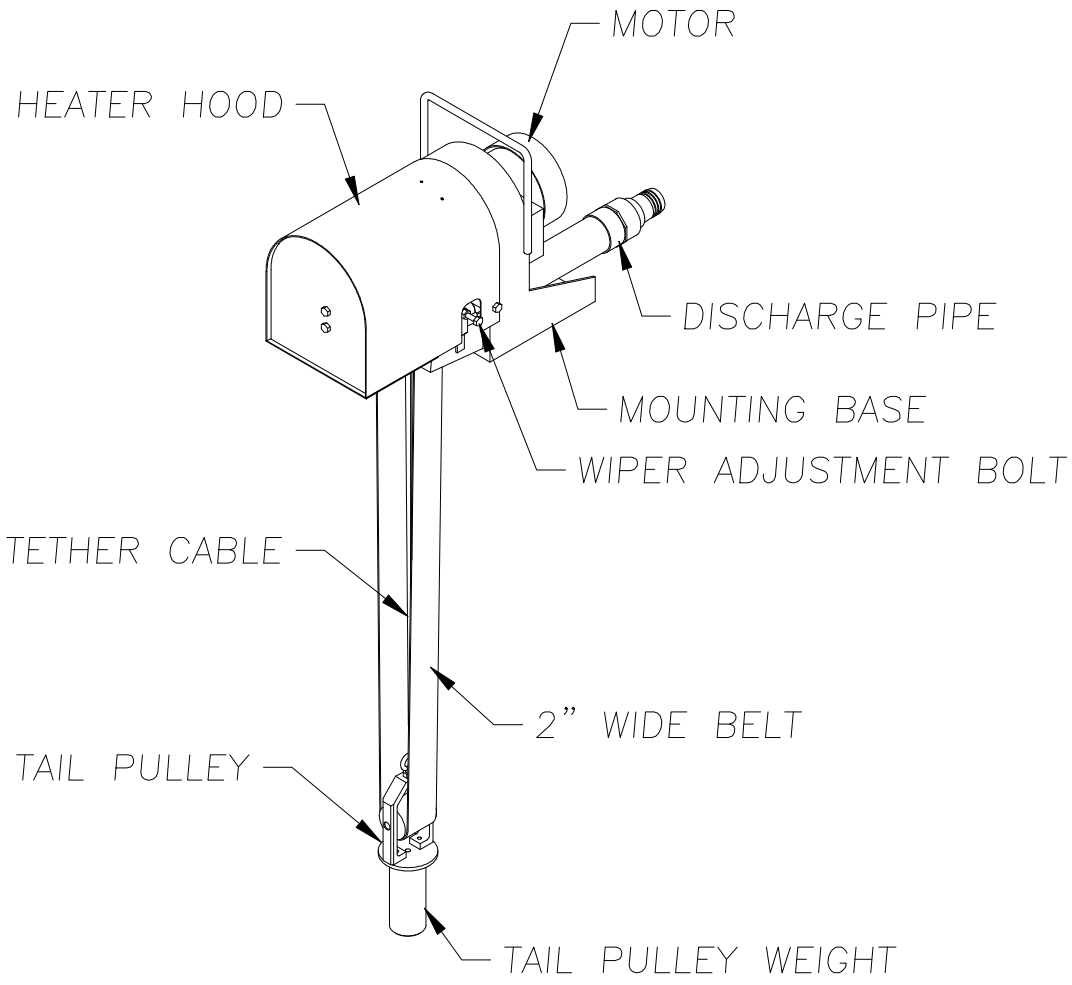
ABANAKI

PETROXTRACTOR® WELL OIL SKIMMER

MODEL PX-B w/Heater

Installation and Maintenance Instructions



Your Abanaki PetroXtractor® Well Oil Skimmer has been manufactured and packaged to rigorous standards of design and service. Proper installation and maintenance of the unit is essential for efficient oil removal and long lasting use.

We have tried to make these instructions as clear as possible. If you have any questions, please call: 1-800-358-7546

ABANAKI CORPORATION
17387 Munn Road
Chagrin Falls, OH 44023
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Fax: (440) 543-7404
1-800-358-SKIM (7546)
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PetroXtractor® PX-B w/Heater
Installation and Maintenance Instructions

Your Abanaki PetroXtractor® PX-B is shipped in one box, with these items:

1. Base Unit w/Heater.
2. Tether, Tail Pulley & Weight.
3. Belt.

Step 1. Mount the PetroXtractor®on the Abanaki Stand (optional), or a clean flat surface, approx. 6" to 12" above discharge drum using two 3/8"-16 bolts.

Step 2. Remove the heater hood by unbolting the two 1/4-20 bolts, one on each side, and lift off to the side, being carefull not to pull on the wiring connections.

Step 3. Make sure head pulley is parallel to base weldment. **(See Fig. 1)** To adjust, loosen or tighten the three bolts behind head pulley. These bolts are attached to the motor with adjusting springs between them.

Step 4. Loop the belt over the head pulley, threading one side between the wiper blades. **(See Fig. 2)**. **(Note: Use caution when working near sharp ends on head pulley spikes)** If belt has direction arrows on inside, make sure they match as shown in figure 2.

Step 5. Attach the discharge pipe onto the coupling on the back of the unit, underneath the motor. Attach the 1-1/4" I.D. discharge hose onto the discharge pipe and run opposite end into collection oil drum.

Step 6. Lower the belt into the well. Allow 6"-12" above the bottom. **The belt should <u>NOT</u> bottom out in the well.**

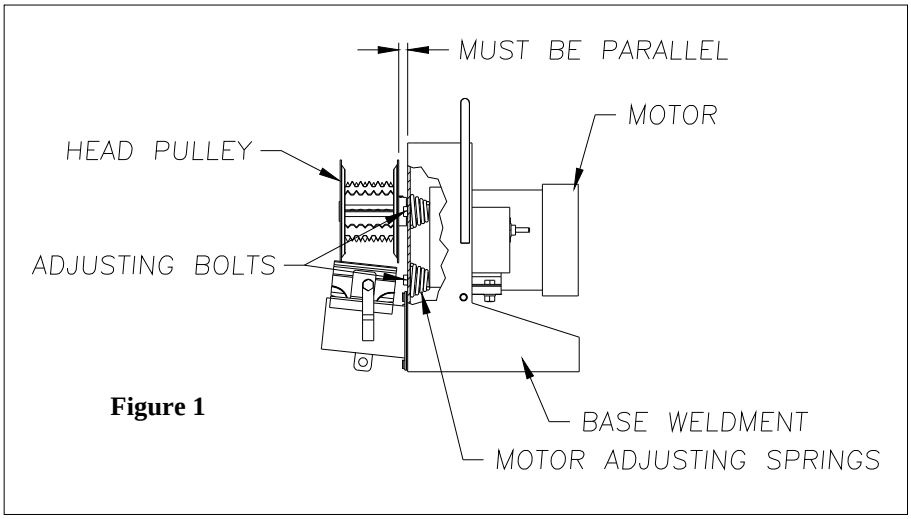

Figure 1

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Step 7. After tail pulley with belt is lowered into well and **ALL** weight is on the belt, hook the tail pulley retaining cable to the bottom of the trough with slack in the cable. **(See Fig. 2)**

Step 8. Adjustable wiper blade should just make contact with the belt. Carefully adjust the wiper adjusting bolt on the outside wiper blade so that both blades are gently wiping the belt. **(See Fig. 3)**

Step 9. Plug unit into a grounded outlet.

Step 10. To replace the heater hood, stand in front of unit with belt towards you. Be sure pressure wheel rolls to the right of head pulley centerline, push the cover straight down, bolt into place.

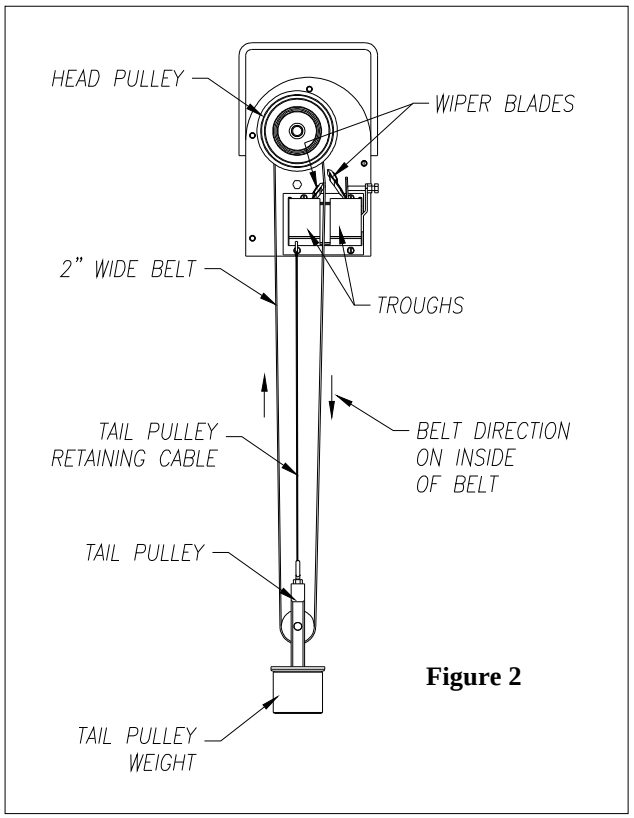

Figure 2

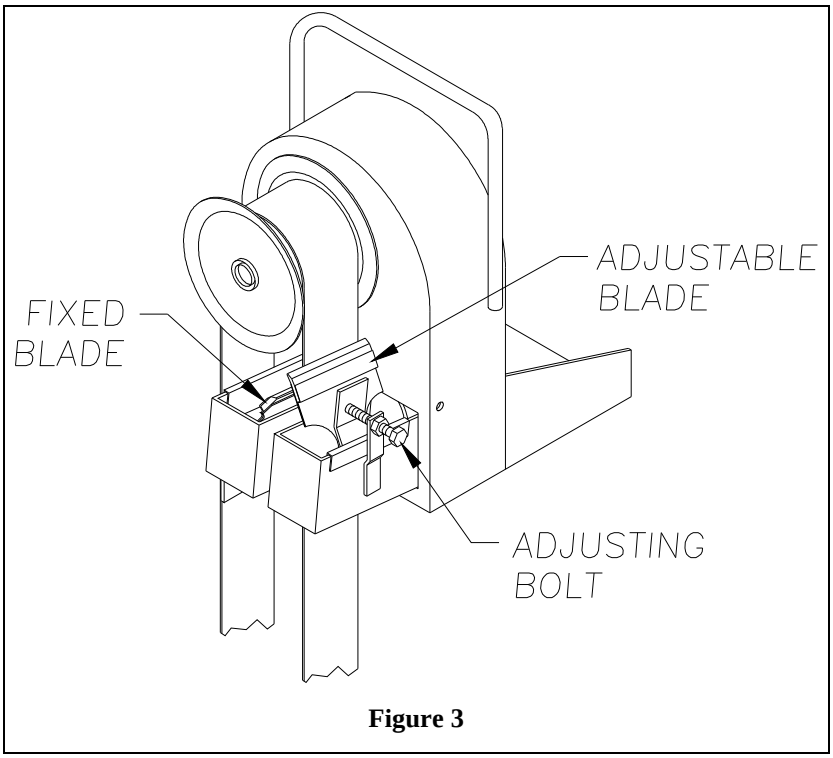

Figure 3

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Temperature Adjustment:

Thermostat contacts are normally closed, and open on temperature set point. 75°F is the standard setting. If temperature change is required:

1. Thru the access hole in the heater hood **(See Fig. 4)**, insert a flat head screwdriver into the brass slotted screw (located close to the tan wires). Turn clockwise to lower temperature, or counter clockwise to raise the temperature. DO NOT turn more than ¼ turn at a time, allowing air temperature to stabilize before proceeding. DO NOT turn adjusting screw more than seven (7) revolutions in either direction. This could damage the thermostat.
2. It shall be the customer's responsibility to carefully monitor the temperature within the heater hood. Temperature inside hood should be adjusted so that the flash point of recovered material is not reached. **NOTE!!!! FAILURE TO CHECK AND ADJUST TEMPERATURE COULD CAUSE RECOVERED MATERIAL TO IGNITE!!!!**

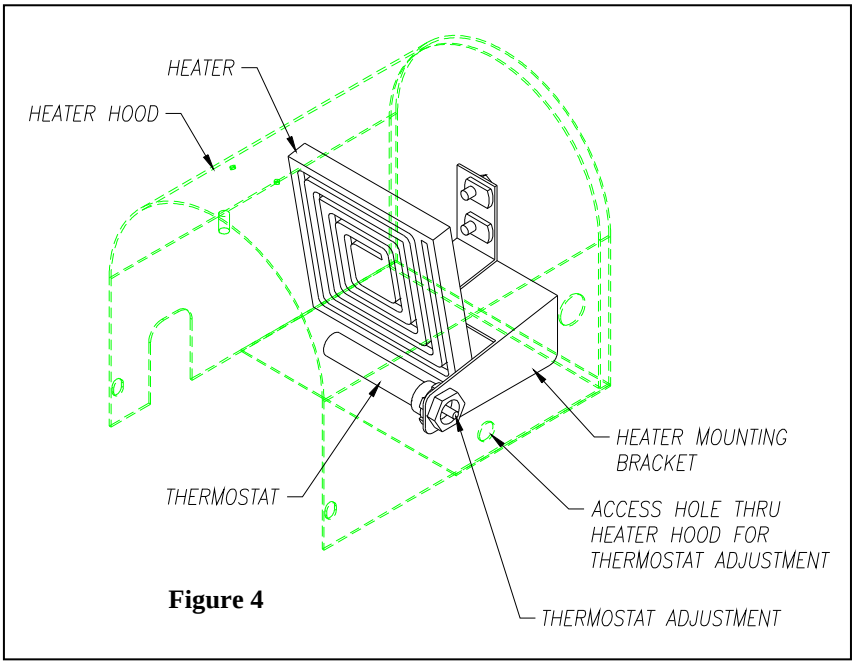
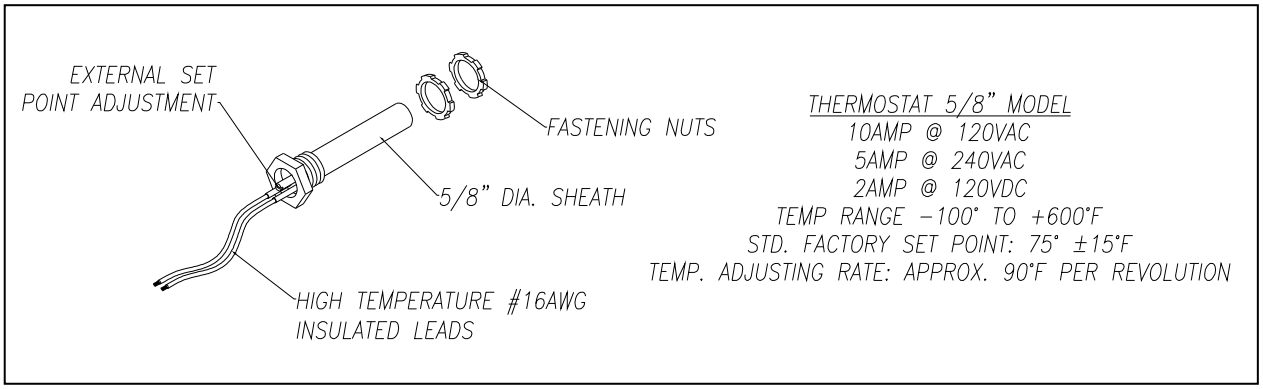


Figure 4



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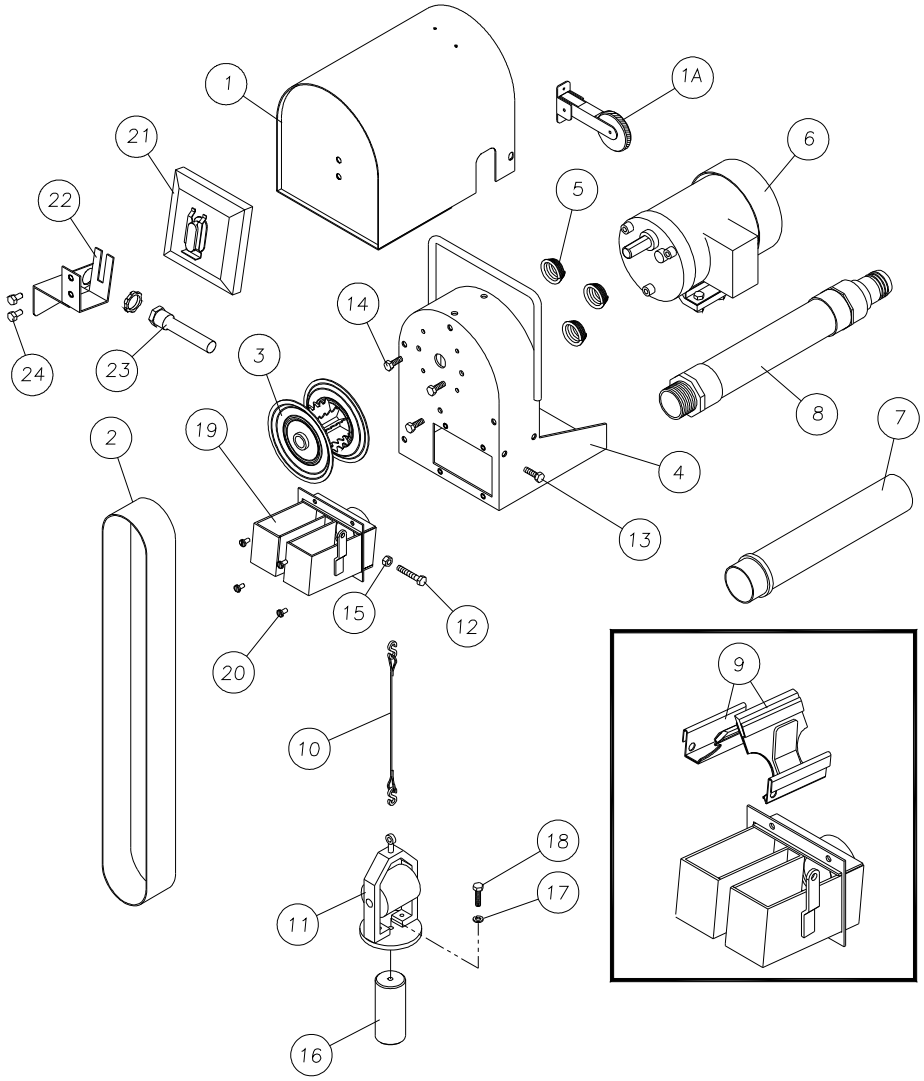

Item	Qty	Part Name	Item	Qty	Part Name	Item	Qty	Part Name
1	1	Heater Hood	8	1	Discharge Pipe	16	1	Weight
1A	1	Pressure Wheel	9	1	CRV Wiper Blade Set Hybrid Ceramic Wiper Set	17	1	1/4" Lockwasher
2	1	Belt (Elast.) or (Poly)	10	1	Retaining Cable	18	1	1/4-20 x 1" Hex Bolt
3	1	Spiked Head Pulley	11	1	Tail Pulley	19	1	2" Trough Weldment
4	1	Base Weldment	12	1	1/4-20 x 1-1/2" Full Thd Bolt	20	4	10-32 x 1/2" Lg. Pan Head
5	3	Motor Adjusting Springs	13	2	1/4-20 x 5/8" Hex Bolt	21	1	Heater
6	1	30 RPM Gear Motor w/plug 12 RPM Gear Motor w/plug	14	3	1/4-20 x 3/4" Hex Bolt	22	1	Heater Mounting Bracket
7	1	Discharge Hose	15	3	1/4-20 Hex Nut	23	1	Thermostat w/nut
						24	2	1/4-20 x 1/2" Hex Bolt

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PETROXTRACTOR MAINTENANCE

1. Belt is shipped on tail pulley. If it becomes necessary to remove, or to replace the belt, simply follow the steps below: **(See Fig. 5)**

A. If tail pulley has weight attached to bottom side, remove and set aside.
B. Remove one of the screws on tail pulley bottom, and loosen second screw.
C. Rotate bottom and either remove or replace belt.
D. Rotate bottom back. Tigthen the loose screw, and replace the screw removed.
E. Re-attach weight.

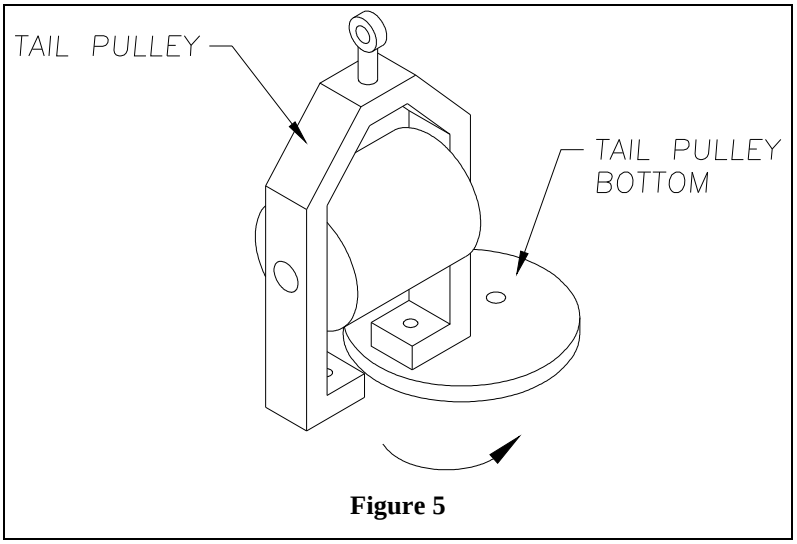

Figure 5

2. Check and clean head pulley. Particles embedded in wheel could damage the belt. **Note: Use caution when working near sharp ends on head pulley spikes.**

3. Check and adjust time setting on timer. (If ordered as an option)

4. Inspect discharge troughs and hose, cleaning if necessary.

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ITT

RSES

Wastewater

Goulds Pumps

Sump, Effluent and Sewage
REPAIR PARTS

Engineered for life

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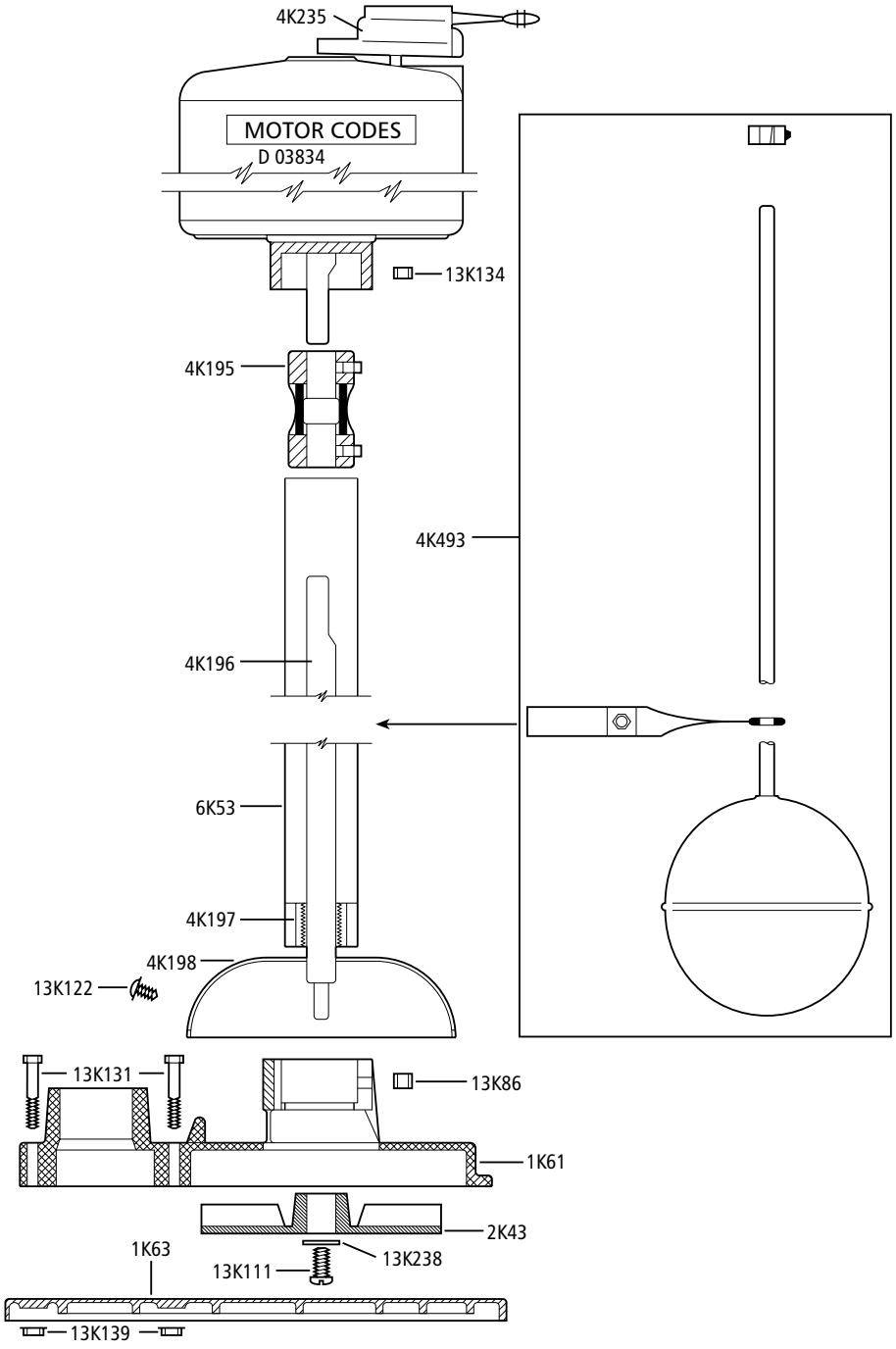
Note: Repair Motor List Prices are in the "K", "L" and Numeric Repair Part Price Book.

4K432 OIL SPECIFICATION:
5 gallon can of ASTM 150 Turbine Oil

COMPARABLE BRAND NAMES:

Sunoco	Sunvis 932
Mobil	DTE Light
Texaco	Regal R&O 32
Shell	Turbo 32
Gulf	Harmony 32
Amoco	Am. Industries Oil 32
Exxon	Nuto 32
Chevron	GST 32

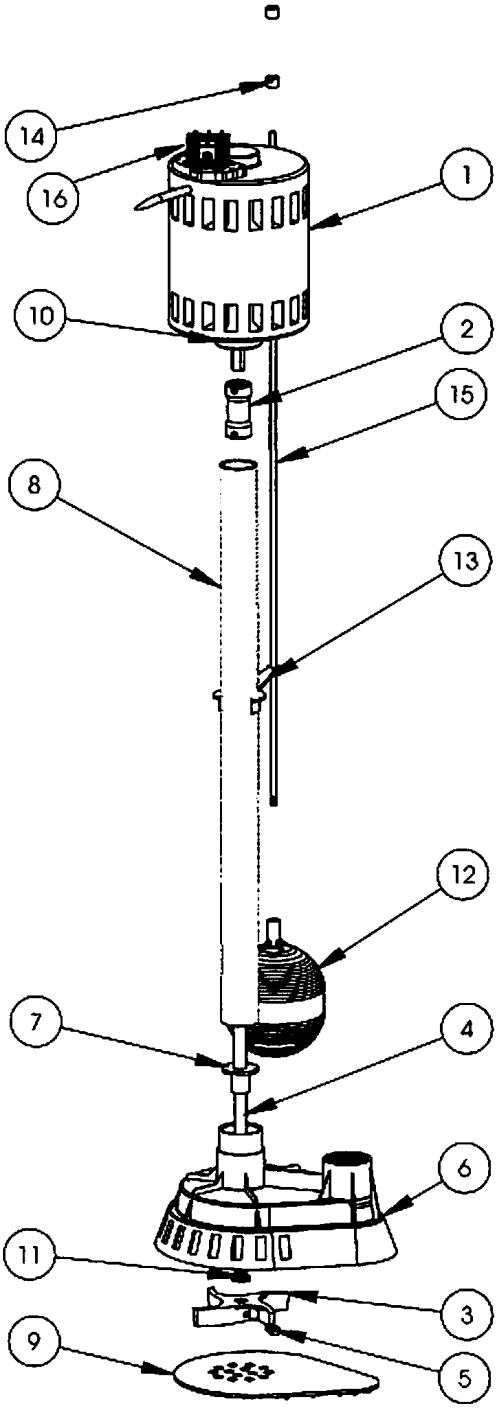
MODEL DVP (OBSOLETE) – Replace with CVP03 or PVP03)



Part No.	Part Name
1K61 1K610	Casing - Obsolete - No replacement
1K63	Base
2K43	Impeller
4K195	Coupling
4K196	Shaft
4K197	Bearing spider assembly
4K198	Suction strainer (obsolete, no replacement)
4K493	Float rod repair kit
4K235	Replacement switch
6K53	Column pipe with bearing
13K86	Set screw – casing 5/16
13K238	Impeller washer
13K111	Impeller bolt
13L122	Screw – strainer
13K131	Bolt – base to casing
13K134	Set screw – column 1/4
13K139	Flanged locknut

*Motor D03837–no longer available.

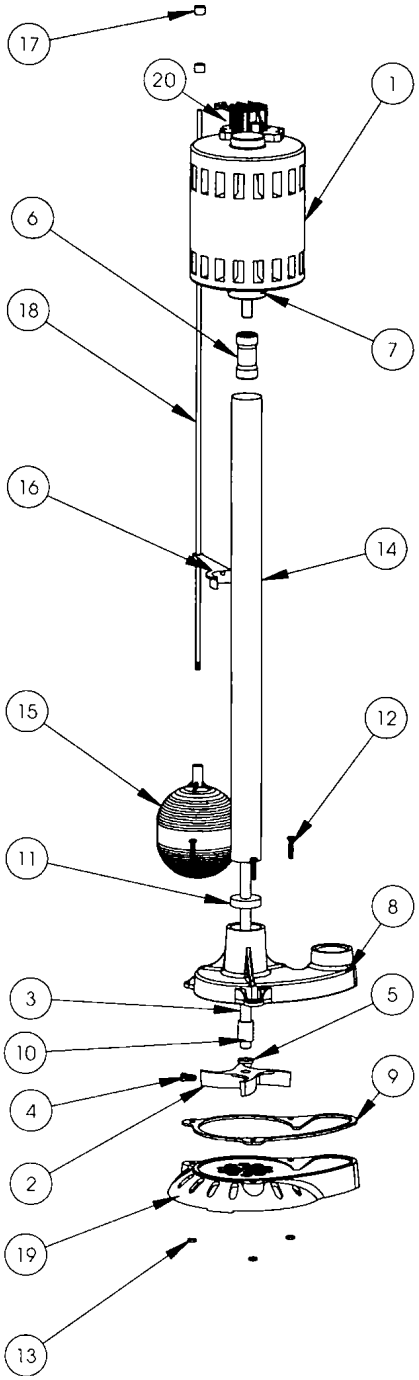
MODEL PVP03



Item Number	Part Number	Description	Quantity Required
1	3501000	Motor ⅓ HP with switch and cord	1
2	3513000	Coupling, ½ flexible	1
3	3511000	Impeller, CI	1
4	3523000	Shaft 304SS ½ X 23⅞	1
5	3507000	Set screw 5/16" – 18 X ½" SST sq. hd.	1
6	NA	Housing, PVC	1
7	NA	Bearing nylatron	1
8	NA	Column, PVC 1½ X 24 X .140	1
9	NA	Baseplate, PVC	1
10	3506000	Set screw ¼ – 20 X ¼ hex	3
11	3516000	Seal, cork, ½ X ¾ X ⅛	1
12	3519000	Float ball	1
13	3518000	Float rod guide	1
14	3521000	Float rod stop	2
15	3520000	Float rod	1
KITS			
6, 7, 8	NA	Housing assembly and column with bearing	1 Kit
12, 13, 14, 15	3524000	Kit: float rod, ball, guide, rod stops (2)	1 Kit
16	3527000	Switch kit	1 Kit

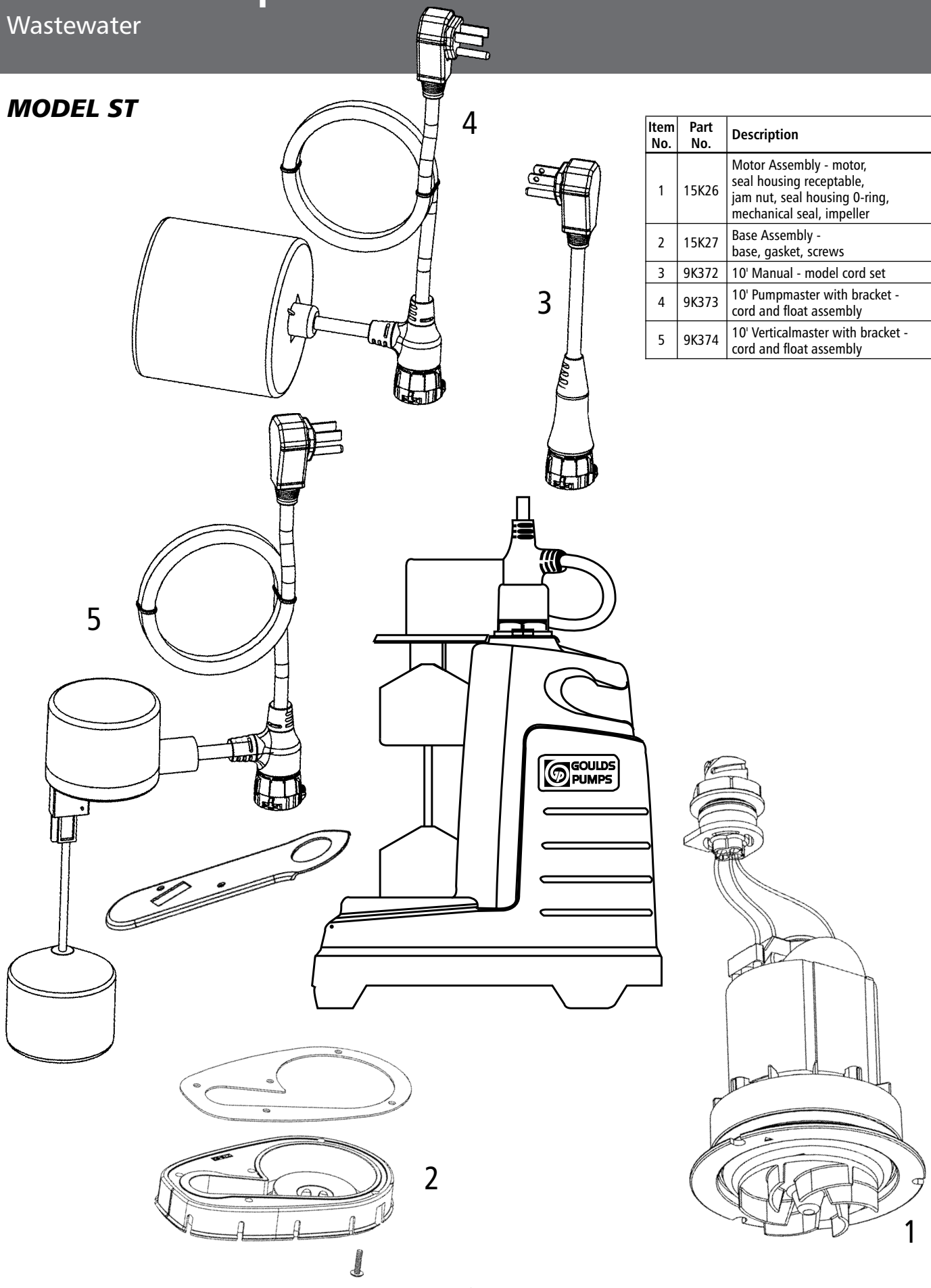
NA = No longer available

MODEL CVP03



Item Number	Part Number	Description	Quantity Required
1	3501000	Motor ⅓ HP with switch & cord	1
2	3511000	Impeller, cast iron	1
3	3523000	Shaft 304SS ½ X 23⅞	1
4	3507000	Set screw 5⁄16" – 18 X ½" SST sq. hd.	1
5	3516000	Seal, cork, ½ X ¾ X ⅛"	1
6	3513000	Coupling, ½ Flexible	1
7	3506000	Set scr ¼ – 20 X ¼ hex	3
8	3509000	Housing, cast iron, blue	1
9	3517000	Gasket, base	1
10	3514000	Bearing, pdrmtl .5 X. 75 X 1"	1
11	3515000	Washer, felt .5 x 1.5 x .375"	1
12	3508000	Screw 10-24 X 1 PH HD SS	3
13	3505000	Nut 10-24 Hex SS	3
14	3512000	Column, steel 1.5 x 24 x. 049"	1
15	3519000	Float ball	1
16	3518000	Float rod guide	1
17	3521000	Float rod stop	2
18	3520000	Float rod	1
19	3510000	Base, cast iron black	1
KITS			
8, 10, 11, 14	3522000	Housing assembly & column with bearing	1 Kit
15, 16, 17, 18	3524000	KIT; float rod, ball, guide, rod stops (2)	1 Kit
20	3527000	Switch kit	1 Kit

MODEL ST



Item No.	Part No.	Description
1	15K26	Motor Assembly - motor, seal housing receptable, jam nut, seal housing 0-ring, mechanical seal, impeller
2	15K27	Base Assembly - base, gasket, screws
3	9K372	10' Manual - model cord set
4	9K373	10' Pumpmaster with bracket - cord and float assembly
5	9K374	10' Verticalmaster with bracket - cord and float assembly

MODEL SPBB/SPBB2

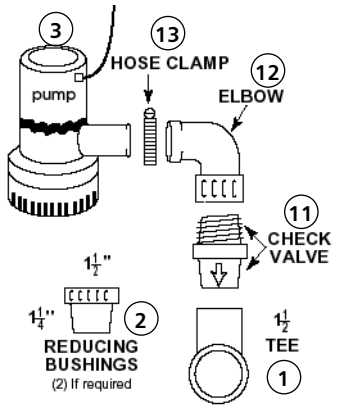


Figure 1

Item Number	Part Description	Material	Quantity Required	Repair Part SPBB	Repair Part SPBB2
1	Tee, 1½" Socket	Thermoplastic	1	6K146	
2	Reducing Bushing, 1½" x 1¼"	Thermoplastic	2	4K499	
3	Pump – 2000GPH or 3700GPH	Varies	1	9K318	9K499
4	Float Switch Assembly	—	1	9K319	
5	Fuse Holder	—	1	9K320	
6	Fuse - 15 Amps/25 Amps	—	1	9K321	9K565
7	Wire Terminals	—	1	9K322	
			1	9K323	
			2	9K324	
			3	9K325	
8	Terminals - Top Post Battery	—	2	9K326	
9	Battery Case	Thermoplastic	1	9K327	
10	Charger Assembly	—	1	9K328	
11	Check Valve - 1" MPT	Thermoplastic	1	6K147	6K174
12	Elbow - 1" FPT	Thermoplastic	1	6K148	6K175
13	Hose Clamp	—	1	4K497	
14	Pump / Switch Bracket	—	1	9K329	
15	Hose Clamp	—	1	4K498	

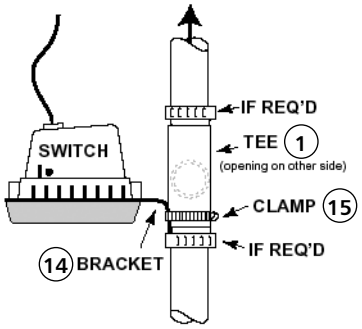


Figure 2

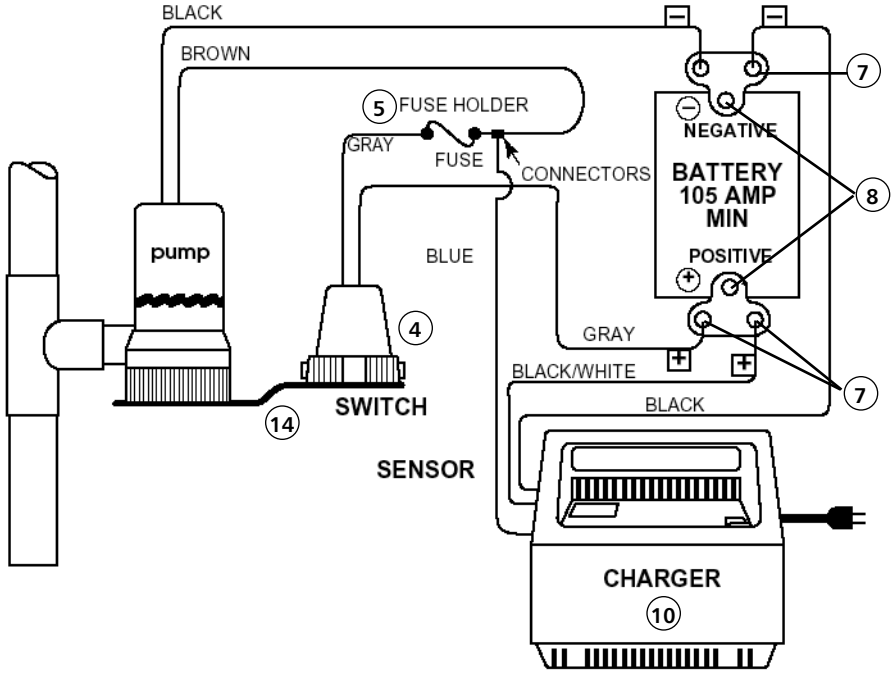


Figure 4

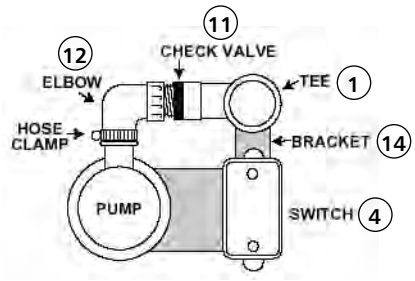
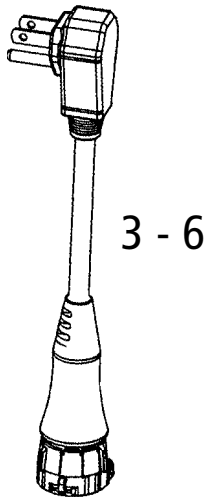
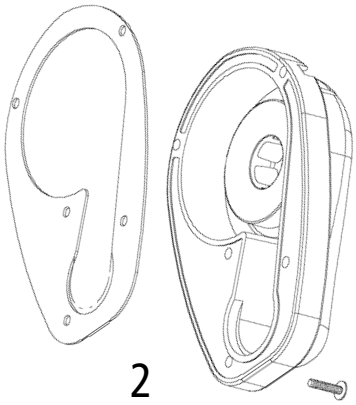


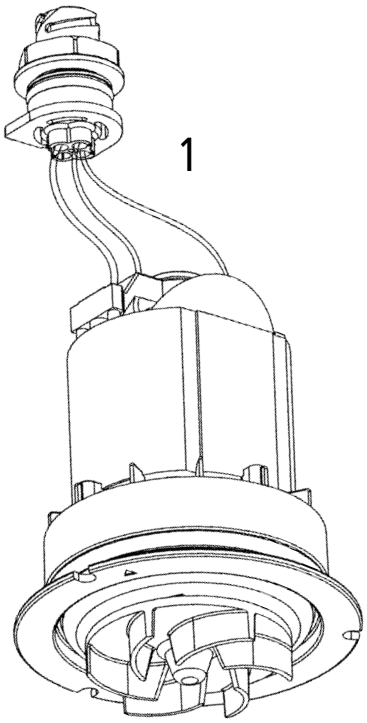
Figure 3

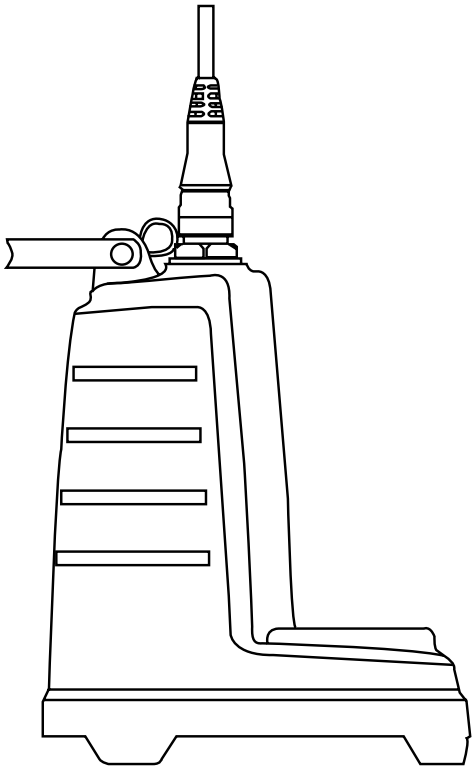
MODEL PE

Item Number	Part Name	Description	Repair Part Order Number
1	1/3 HP Motor Assembly – 115V	Motor, Seal Housing, Receptacle, Jam Nut, O-ring, Mechanical Seal, Impeller	15K26
	4/10 HP Motor Assembly – 115V		15K28
	1/2 HP Motor Assembly – 115V		15K29
	4/10 HP Motor Assembly – 230V		15K45
	1/2 HP Motor Assembly – 230V		15K46
2	Base Assembly	Base, Gasket, Screws	15K27
3	Cord Set – 115V	10' Manual – 115V with 5-15P Nema Plug	9K372
4		20' Manual – 115V with 5-15P Nema Plug - Standard	9K375
5		30' Manual – 115V with 5-15P Nema Plug	9K380
6		50' Manual – 115V with 5-15P Nema Plug	9K377
		30' Pumpmaster – 115V with 5-15P Nema Plug	9K446
—	Cord Set – 230V	20' Manual – 230V with 6-15P Nema Plug - Standard	9K421
—		30' Manual – 230V with 6-15P Nema Plug	9K422
—	Float Switch – 115V	10' Pumpmaster with Hardware - 115V, 13A	A2D11
		20' Pumpmaster with Hardware - 115V, 13A	A2D31
		30' Pumpmaster with Hardware - 115V, 13A	A2D51
—	Float Switch – 230V	20' Pumpmaster with Hardware - 230V, 13A	A2D32
		30' Pumpmaster with Hardware - 230V, 13A	A2D52

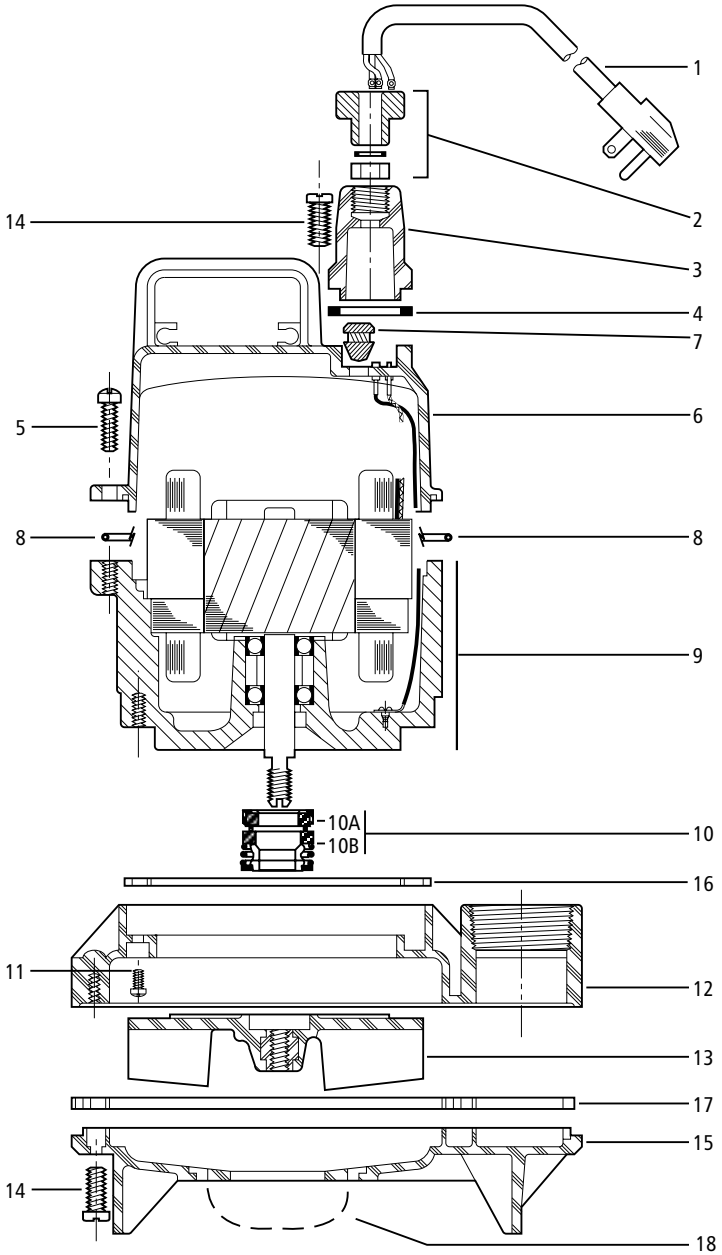








MODEL 3871 – EP04/EP05 Series



Item No.	Part Description	Material	Qty. Req.	Repair Part Order No.
1	10' Cord Set with Plug - 115 V	SJTOW - 16/3	1	9K207
	10' Cord Set with Plug - 230 V			9K208
	20' Cord Set with Plug - 115 V			9K209
	20' Cord Set with Plug - 230 V			9K210
	30' Cord Set with Plug - 115 V*			9K403
2	Strain Relief Assembly, Cord Set	Varies	1	5K113
3	Gland Nut Housing	Thermoplastic	1	9K226
4	O-ring - gland nut housing	Buna-N, AS 568A-024		5K197
5	Fillister Head Screw - Motor Cover	AISI 300 SS	4	13K347
6	Motor Cover	Thermoplastic	1	1K257
7	Oil Plug Grommet	Buna-N	1	6K87
8	O-ring - Motor Cover	Buna-N, AS 568A-161	1	5K196
9	Motor Assembly - 115V, 4/10 HP	Varies	1	1K282
	Motor Assembly - 230V, 4/10 HP			1K283
	Motor Assembly - 115 V, 1/2 HP			1K284
	Motor Assembly - 230 V, 1/2 HP			1K285
10	Mechanical Seal Assembly - Type 16	Carbon/Ceramic	1	10K32
11	Fillister Head Screw - Casing	AISI 300 SS	4	13K347
12	Casing	Thermoplastic	1	1K233
13	Impeller - (EP04 - 4/10 HP)	Thermoplastic	1	2K498
	Impeller - (EP05 - 1/2 HP)			2K731
14	Thread Forming Screw	AISI 300 SS	10	13K243
15	Base	Thermoplastic	1	1K258
16	Gasket - Motor Adapter	Composite	1	5K182
17	Gasket - Casing	Composite	1	5K219
18	Strainer	Thermoplastic	1	4K528
	Insulating Oil - see note on Index page	Turbine Oil - ATSM 150	—	4K432

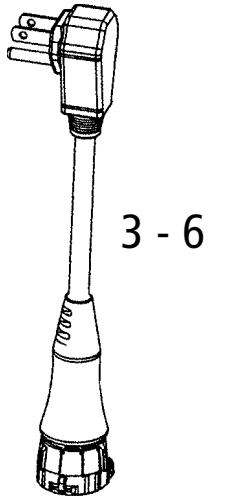
Item No. 9 *includes motor adapter, rotor, stator, tolerance ring, ground wire and ground screw.*

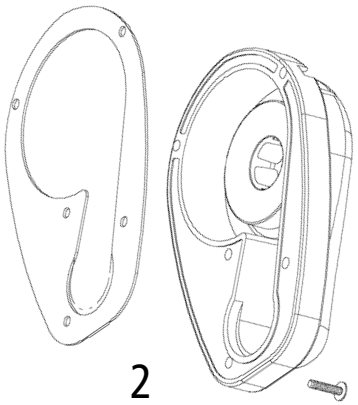
4/10 HP – 1 quart of insulating oil required.
1/2 HP – .85 quarts of insulating oil required.

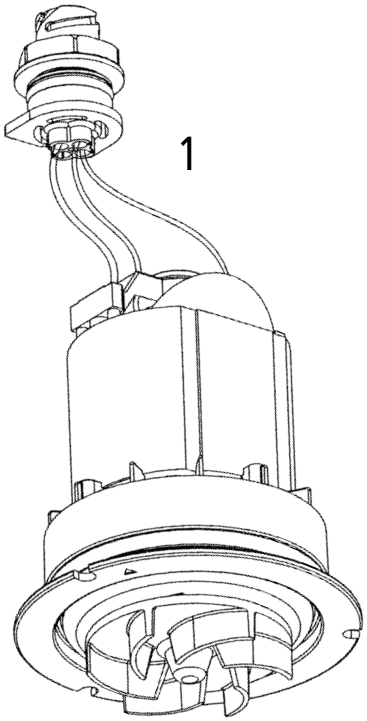
* Effective December 3, 2003.

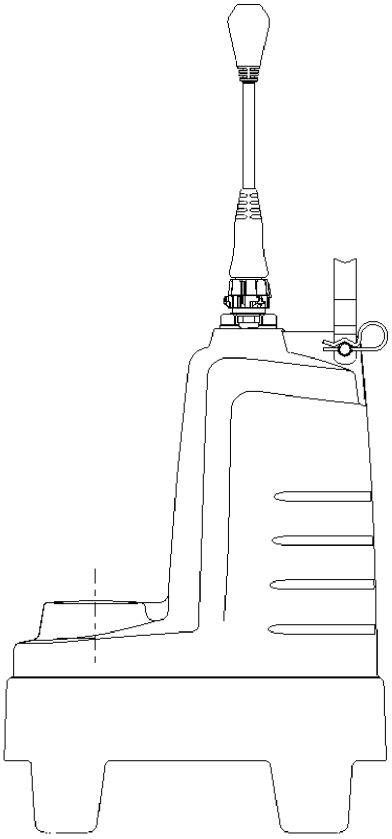
MODEL PS41, 51

Item Number	Part Name	Description	Repair Part Order Number
1	4/10 HP Motor Assembly – 115V	Motor, Seal Housing, Receptacle, Jam Nut, O-ring, Mechanical Seal, Impeller	15K30
	1/2 HP Motor Assembly – 115V		15K31
	4/10 HP Motor Assembly – 230V		15K47
	1/2 HP Motor Assembly – 230V		15K48
2	Base Assembly	Base, Gasket, Screws	15K39
3	Cord Set – 115V	10' Manual – 115V with 5-15P Nema Plug	9K372
4		20' Manual – 115V with 5-15P Nema Plug - Standard	9K375
5		30' Manual – 115V with 5-15P Nema Plug	9K380
6		50' Manual – 115V with 5-15P Nema Plug	9K377
		30' Pumpmaster – 115V with 5-15P Nema Plug	9K446
—	Cord Set – 230V	20' Manual – 230V with 6-15P Nema Plug - Standard	9K421
—		30' Manual – 230V with 6-15P Nema Plug	9K422
—	Float Switch – 115V	10' Pumpmaster with Hardware - 115V, 13A	A2D11
		20' Pumpmaster with Hardware - 115V, 13A	A2D31
		30' Pumpmaster with Hardware - 115V, 13A	A2D51
—	Float Switch – 230V	20' Pumpmaster with Hardware - 230V, 13A	A2D32
		30' Pumpmaster with Hardware - 230V, 13A	A2D52



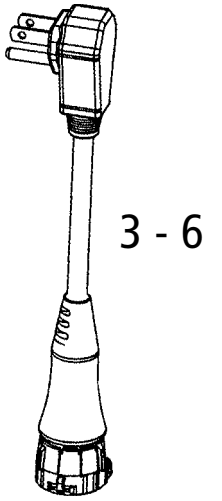


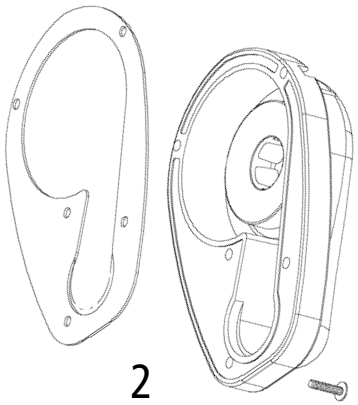


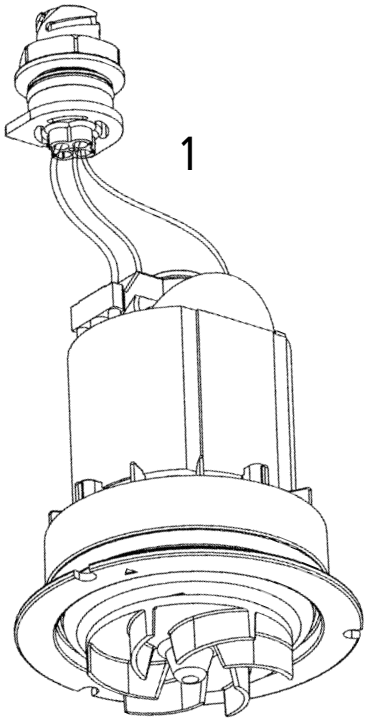


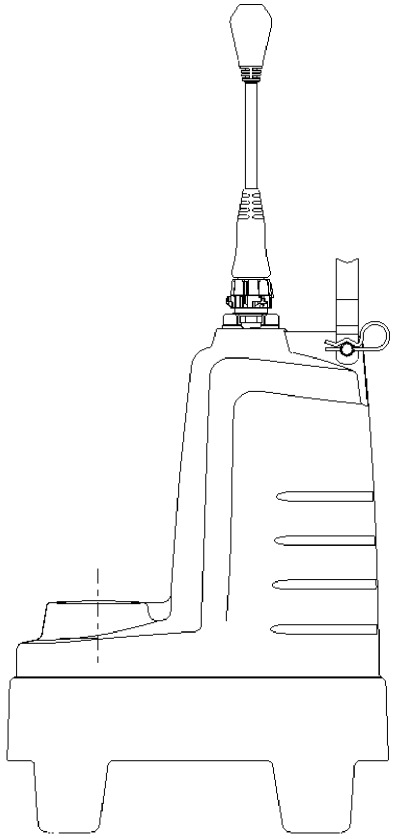
MODEL PV51 – Vortex

Item Number	Part Name	Description	Repair Part Order Number
1	½ HP Motor Assembly – 115V	Motor, Seal Housing, Receptacle, Jam Nut,	15K58
	½ HP Motor Assembly – 230V	O-Ring, Mechanical Seal, Impeller	15K59
2	Base Assembly	Base, Gasket, Screws	15K57
3	Cord Set – 115V	10' Manual – 115V with 5-15P Nema Plug	9K372
4		20' Manual – 115V with 5-15P Nema Plug - Standard	9K375
5		30' Manual – 115V with 5-15P Nema Plug	9K380
6		50' Manual – 115V with 5-15P Nema Plug	9K377
7		30' Pumpmaster – 115V with 5-15P Nema Plug	9K446
8	Cord Set – 230V	20' Manual – 230V with 6-15P Nema Plug - Standard	9K421
9		30' Manual – 230V with 6-15P Nema Plug	9K422
10	Float Switch – 115V	10' Pumpmaster with Hardware - 115V, 13A	A2D11
		20' Pumpmaster with Hardware - 115V, 13A	A2D31
		30' Pumpmaster with Hardware - 115V, 13A	A2D51
11	Float Switch – 230V	20' Pumpmaster with Hardware - 230V, 13A	A2D32
		30' Pumpmaster with Hardware - 230V, 13A	A2D52

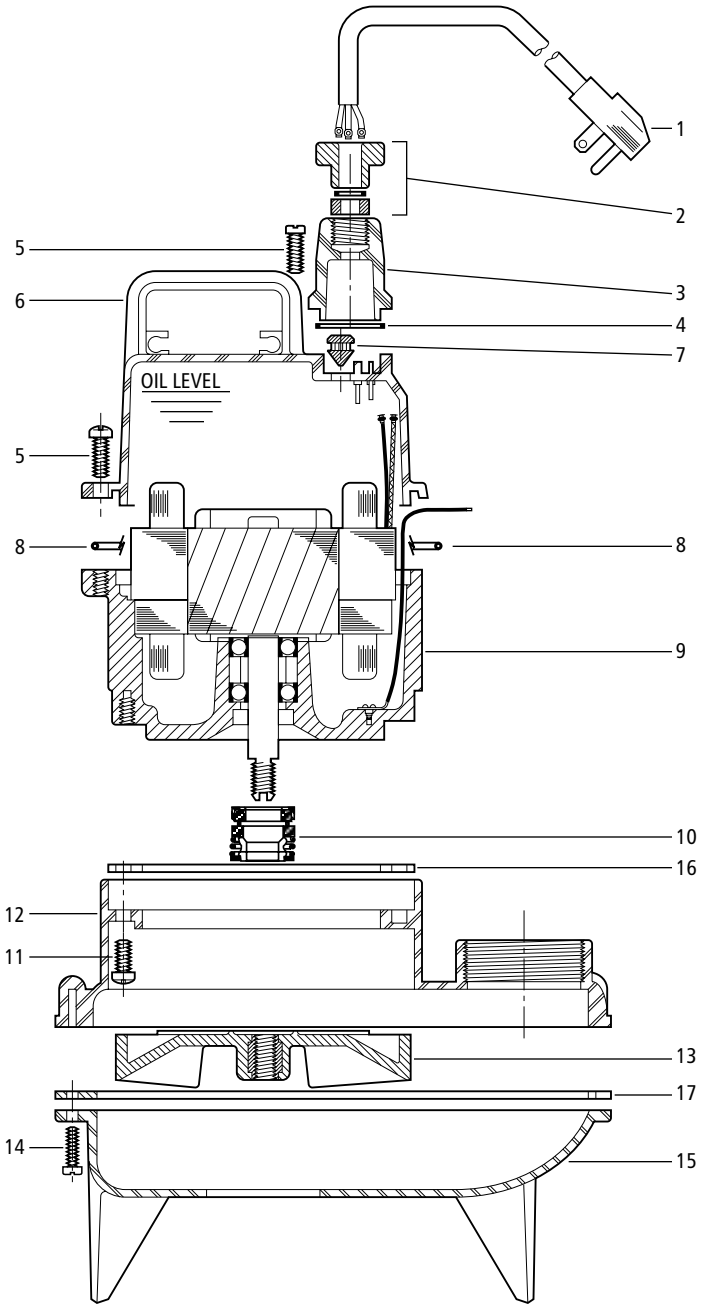








MODEL 3872 – WW05 Series



Item No.	Part Description	Material	Qty. Req.	Repair Part Order No.
1	10' Cord Set with Plug - 115 V	SJTOW - 16/3	1	9K207
	10' Cord Set with Plug - 230 V			9K208
	20' Cord Set with Plug - 115 V			9K209
	20' Cord Set with Plug - 230 V			9K210
2	Strain Relief Assembly, Cord Set	Varies	1	5K113
3	Gland Nut Housing	Thermoplastic	1	9K226
4	O-ring - gland nut housing	Buna-N, AS 568A-024		5K197
5	Fillister Head Screw - Motor Cover	AISI 300 SS	4	13K347
6	Motor Cover	Thermoplastic	1	1K257
7	Oil Plug Grommet	Buna-N	1	6K87
8	O-ring - Motor Cover	Buna-N, AS 568A-161	1	5K196
9	Motor Assembly - 115 V, 1/2 HP	Varies	1	1K284
	Motor Assembly - 230 V, 1/2 HP			1K285
10	Mechanical Seal Assembly - Type 16	Carbon/Ceramic	1	10K32
11	Fillister Head Screw - Casing	AISI 300 SS	4	13K347
12	Casing	Thermoplastic	1	1K274
13	Impeller	Thermoplastic	1	2K494
14	Thread Forming Screw	AISI 300 SS	10	13K243
15	Base	Thermoplastic	1	1K275
16	Gasket - Motor Adapter	Composite	1	5K182
17	Gasket - Casing	Composite	1	5K217
	Insulating Oil - see note on Index page	Turbine Oil - ATSM 150	—	4K432

Item No. 9 *includes motor adapter, rotor, stator, tolerance ring, ground wire and ground screw.*

1/2 HP – .85 quarts of insulating oil required.

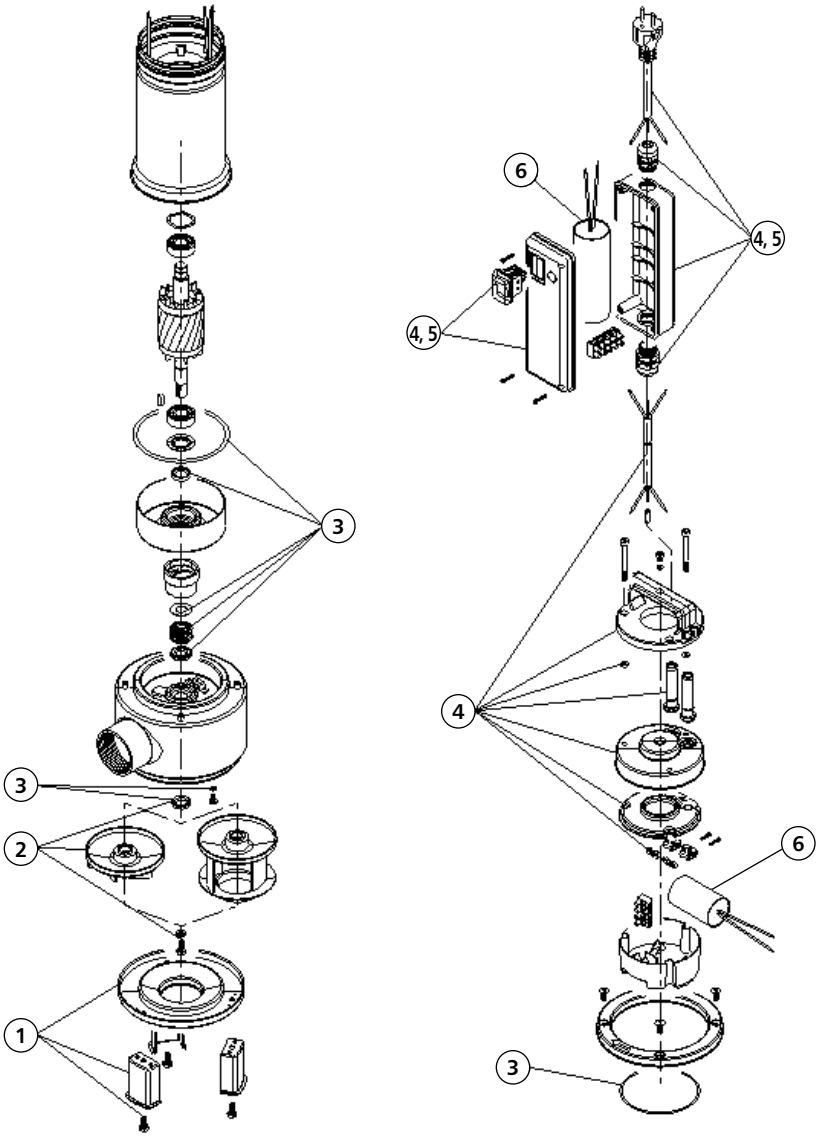
MODEL 1/2DM, 1/2DV

Item Number	Part Description		Repair Parts Order Number			
			½ HP	¾ HP	1 HP	1½ HP
1	Base Package (Suction Flange, Feet, Screws)		15L1	15L2		
2	**DV** Impeller Package (Impeller, Screw, Key, V-Ring)		15L3	15L4	15L5	15L6
	DM Impeller Package (Impeller, Screw, Key, V-Ring)		15L7	15L8	15L9	15L10
3	Pump Seal Package (V-Ring, Mechanical Seal, O-Rings)		15L11			
4*	Cord / Handle / Capacitor Box Assembly	115V, Single Phase	15L60	N/A		
	Cord / Handle Assembly	230V, Single Phase	15L61			N/A
		230/460V, Three Phase	15L62			
4**	Cord / Handle / Capacitor Box Assembly	115V, Single Phase	15L58	N/A		
		230V, Single Phase	15L13		15L59	N/A
5	Capacitor Box / Cord Assembly		15L51	N/A	15L57**	N/A
6	Capacitor - pumps built after June, 2002	115V, Single Phase	9L122	N/A		
		230V, Single Phase	9L113	9L123	9L124	N/A

* After 11/04

** Used from 6/02 to 11/04

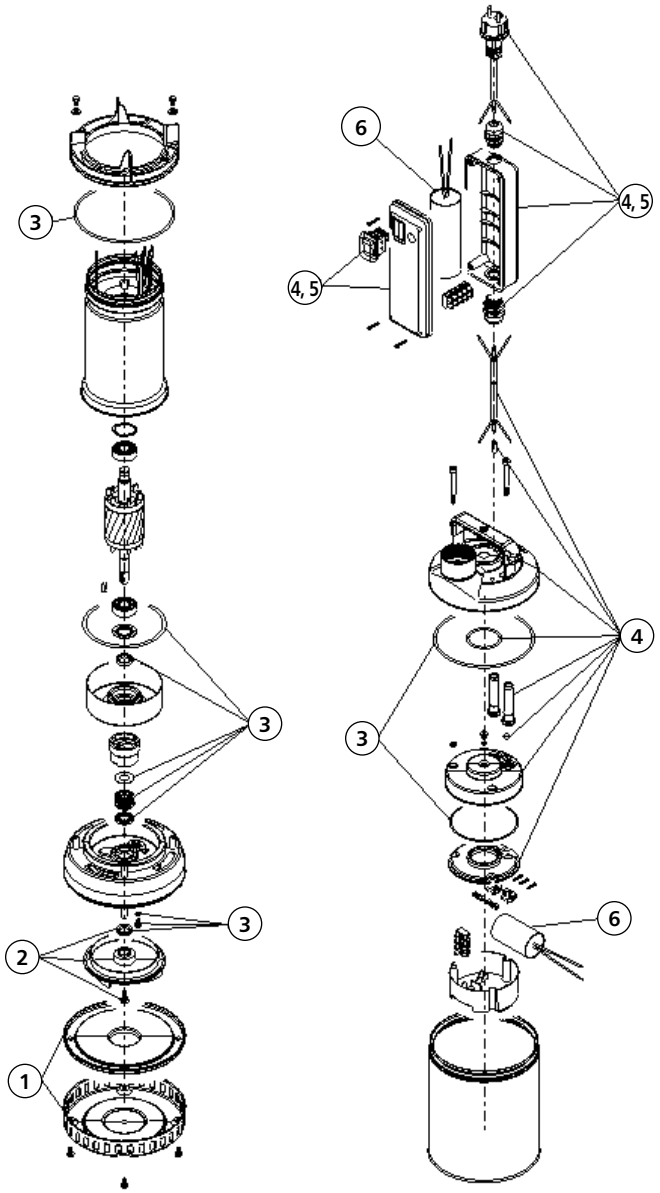
Capacitors not available for pumps before June, 2002.



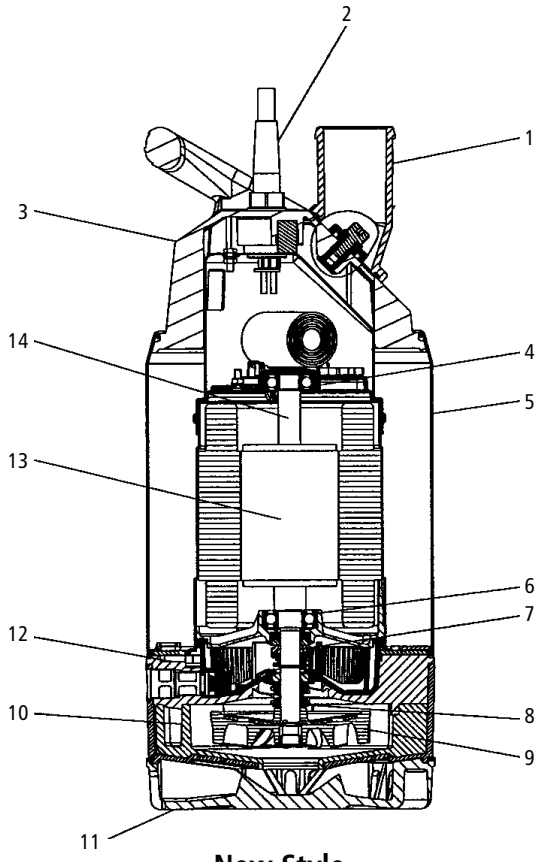
MODEL 1DW

Item Number	Part Description		Repair Parts Order Number			
			½ HP	¾ HP	1 HP	1½ HP
1	Strainer Package (Suction Flange and Strainer)		15L17			
2	Impeller Package (Impeller, Screw, Key, V-Ring)		15L19	15L20	15L21	15L22
3	Pump Seal Package (V-Ring, Mechanical Seal, O-Rings)		15L23			
4	Cord / Handle / Capacitor Box Assembly	115V, Single Phase	15L54	N/A		
		230V, Single Phase	15L55			N/A
	Cord / Handle Assembly	230/460V, Three Phase	15L56			
5	Capacitor Box / Cord Assembly		15L51		15L16	N/A
6	Capacitor - pumps built after June, 2002	115V, Single Phase	9L122	N/A		
		230V, Single Phase	9L113	9L123	9L124	N/A

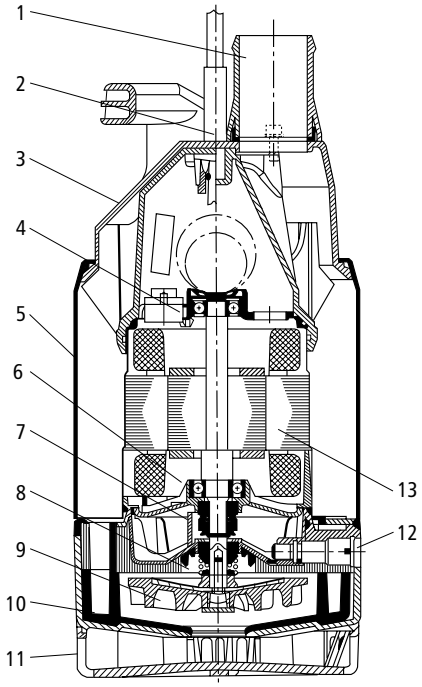
Capacitors not available for pumps before June, 2002.



MODEL 2DW



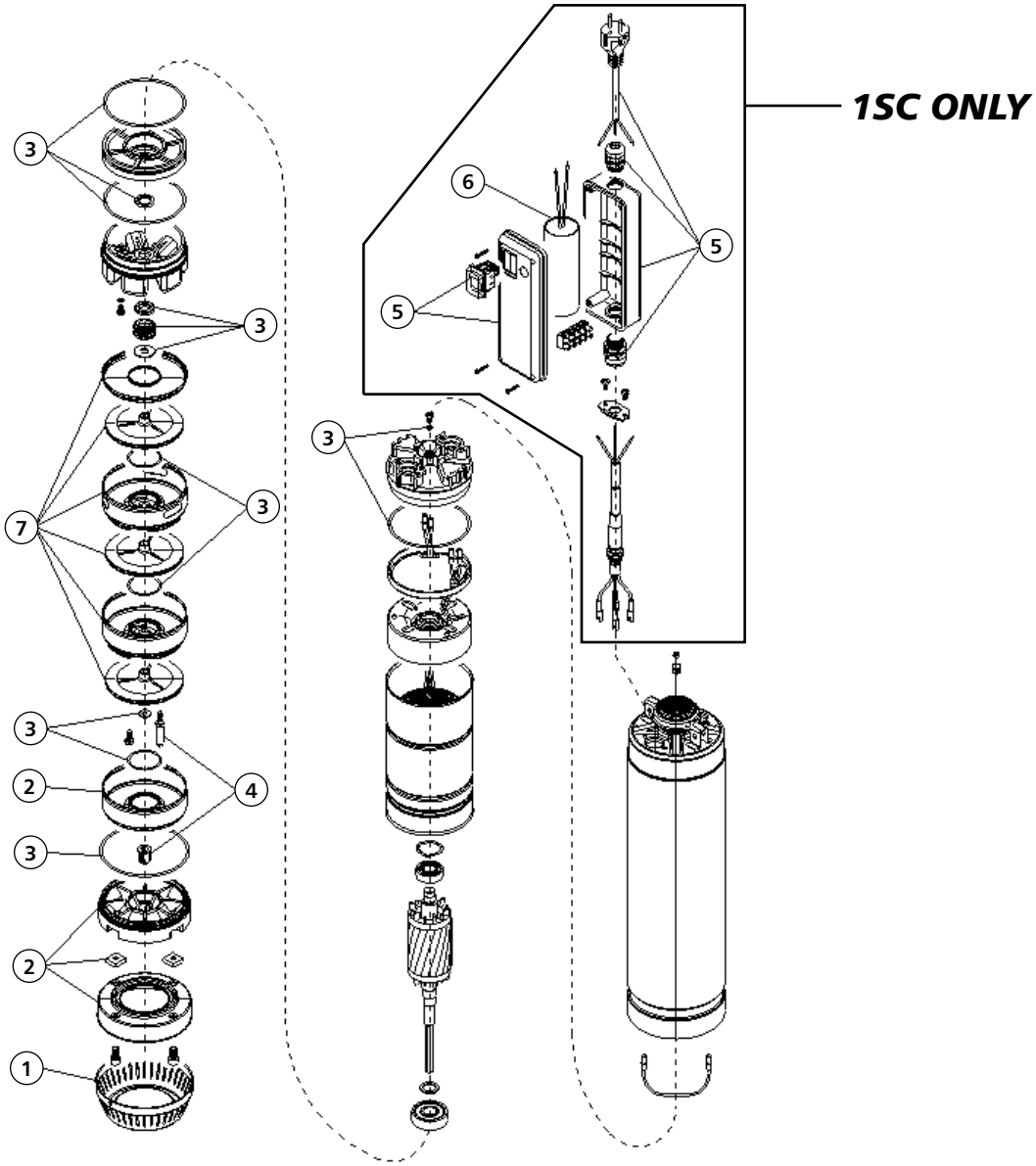
New Style



Old Style

Item No.	Part Description	Qty. R'qd.	Repair Part Order No.	
			After 8/05	Before 8/05
1	Discharge Connection Kit	1	6K171	6K167
2	Cordset - 1 Phase, 115V		9K497	9K386
	Cordset - 1 Phase, 230V		9K498	9K387
3	Handle / Cover		—	
4	Bearing - Upper		—	
5	Casing		—	
6	Bearing - Lower		—	
7	Mechanical Seal - Lower		—	
8	Mechanical Seal - Upper		—	
9	Impeller		—	
10	Diffuser		—	
11	Strainer		—	
12	Plug - Oil		—	
13	Motor		—	
Kits		**Kit**		
Impeller - ½ HP	Impeller, Impeller Screw, Protective Plug, Washer, Assembly Instructions	1	15K11	
Impeller - 1 HP			15K73	
Diffuser	Diffuser, Screws, Washers, Assembly Instruction		15K62	15K13
Mechanical Seal - Lower	Mechanical Face-Seal Unit, Assembly Instruction		15K14	
Mechanical Seal- Upper & Lower	Complete Mechanical Seal Kit		15K41	
Ball Bearing Kit	Upper and Lower Ball Bearings		15K42	
O-Ring Kit (Complete Set)	Complete O-Ring Set		15K63	15K43

MODELS SE and 1SC



MODEL SE

Item Number	Part Description		Repair Parts Order Number		
			8SE	16SE	26SE
1	Suction Strainer		15L28		
2	Lower Bearing Support Package		15L29		
3	Pump Seal Package (Mechanical Seal and O-Rings) – New		15L52		
4	Bushing Package		15L31	N/A	N/A
5	Power Cord - 16/3 SJTW x 10 ft. with Bare Leads	115V, Single Phase	9L120		
		230V, Single Phase			
6	Capacitor	115V, Single Phase	9L118 (50 mfd, 250V)		
		230V, Single Phase	9L119 (16 mfd, 450V)		
7	Impeller / Diffuser Package		15L53 (4)	15L33 (3)	15L34 (3)

MODEL 1SC - After 5/06

Item Number	Part Description		Repair Parts Order Number		
			½ HP – 3 Stage	¾ HP – 4 Stage	1 HP – 5 Stage
1	Suction Strainer		15L28		
2	Lower Bearing Support Package		15L29		
3	Pump Seal Package (Mechanical Seal and O-Rings) – New		15L52		
4	Bushing Package		N/A		15L31
5	Capacitor Box / Cord Assembly	115V, Single Phase	15L51	N/A	
	Cord Assembly	230V, Single Phase	9L121 (6-15P Plug)		
		230V, Three Phase	9L125		
6	Capacitor	115V, Single Phase	No Longer Available		
		230V, Single Phase	9L114 (25 mfd, 450V)		9L124 (30 mfd, 450V)
7	Impeller / Diffuser Package – Low Flow		15L33 (3)	15L33 (4)	15L33 (5)
	Impeller / Diffuser Package – High Flow		15L34 (3)	15L34 (4)	15L34 (5)

MODEL 1SC - 6/02 to 5/06

Item Number	Part Description		Repair Parts Order Number		
			½ HP – 3 Stage	¾ HP – 4 Stage	1 HP – 5 Stage
1	Suction Strainer		15L28		
2	Lower Bearing Support Package		15L29		
3	Pump Seal Package (Mechanical Seal and O-Rings) – New		(15L30 Obs.) - 15L52		
4	Bushing Package		15L31		
5	Capacitor Box / Cord Assembly	115V, Single Phase	15L51	N/A	
		230V, Single Phase	15L16		15L57
6	Capacitor	115V, Single Phase	9L122 (70 mfd, 250V)	N/A	
		230V, Single Phase	9L114 (25 mfd, 450V)		9L124 (30 mfd, 450V)
7	Impeller / Diffuser Package – Low Flow		15L33 (3)	15L33 (4)	15L33 (5)
	Impeller / Diffuser Package – High Flow		15L34 (3)	15L34 (4)	15L34 (5)

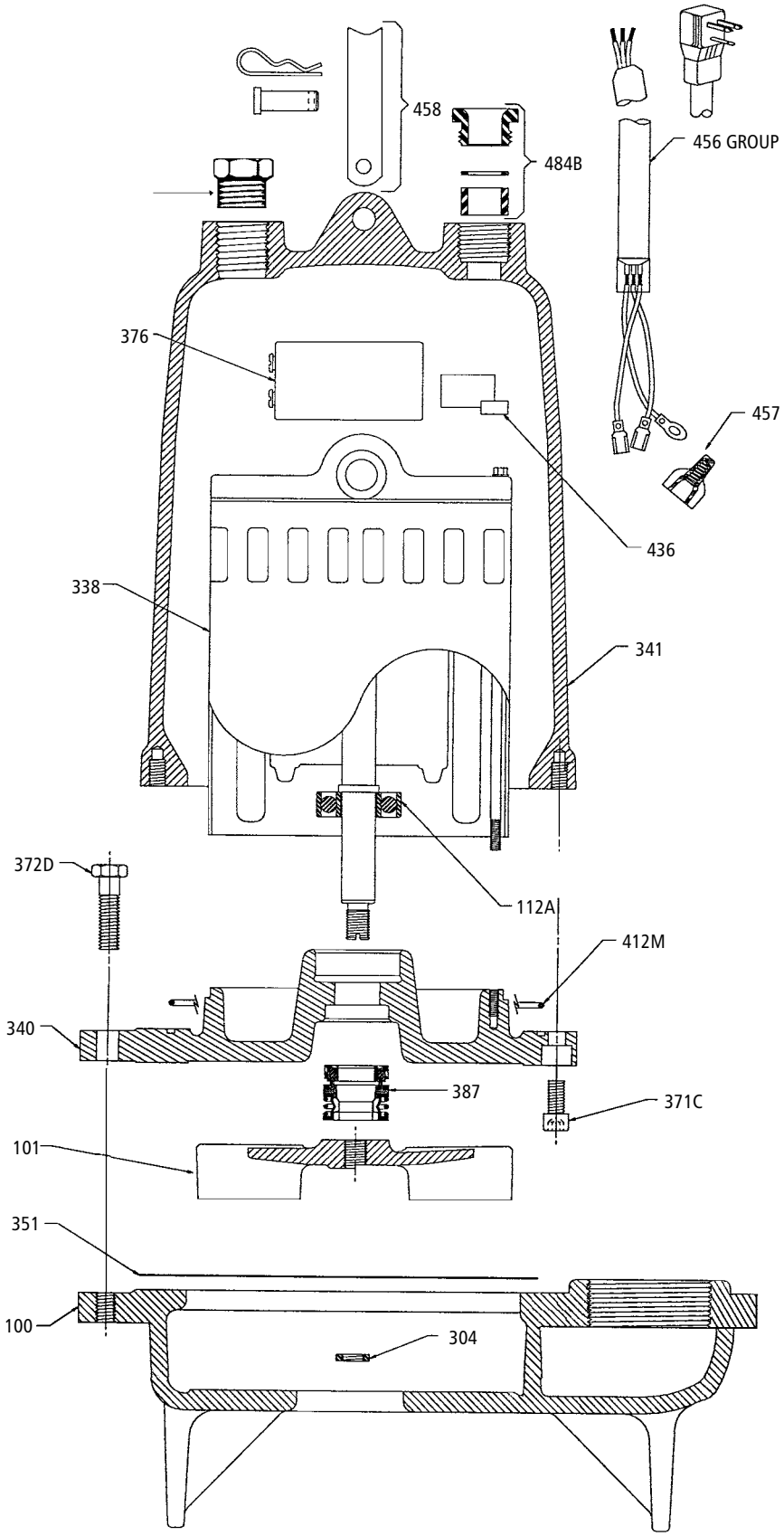
MODEL 1SC - 4/97 to 6/02

Item Number	Part Description		Repair Parts Order Number		
			½ HP – 3 Stage	¾ HP – 4 Stage	1 HP – 5 Stage
1	Suction Strainer		15L28		
2	Lower Bearing Support Package		15L29		
3	Pump Seal Package (Mechanical Seal and O-Rings) – New		(15L30 Obs.) - 15L52		
4	Bushing Package		15L31		
5	Capacitor Box / Cord Assembly	230V, Single Phase	15L16		15L32
6	Capacitor	115V, Single Phase	No Longer Available		
		230V, Single Phase	9L113 (20 mfd, 450V)		9L114 (25 mfd, 450V)
7	Impeller / Diffuser Package – Low Flow		15L33 (3)	15L33 (4)	15L33 (5)
	Impeller / Diffuser Package – High Flow		15L34 (3)	15L34 (4)	15L34 (5)

Old Pump had a single mechanical seal and the capacitor was located outside the pump.

New Pump has a dual mechanical seal and the capacitor is located inside the pump (except ½ HP, 1/60/115 V model).

MODEL 3885 – WE SERIES



CAPACITOR DATA		
"K" no.	MFD	VAC
9K197	161/193	110
9K351	30	370
9K352	200/240	220

MODEL 3885 – WE SERIES

Item No.	Part Description		Material	Qty. Reqd.	Repair Parts Order Number						Max. Wt. (lbs.)
					1725 RPM	3450 RPM					
					⅓ HP	½ HP	¾ HP	1 HP	1½ HP	2 HP	
100	Casing – ⅓ HP "L" Model Only 59115		Cast Iron	1	1K171	N/A					13.0
	Casing – All Others (M, H, HH) 59114				N/A	1K170					
101	Impeller		Cast Iron	1	2K158	2K220	2K219	2K218	2K217	2K840	2.0
	Impeller		Bronze		2K271	2K272	2K273	2K274	2K275	2K841	2½
	Impeller – High Head "HH"		Cast Iron		N/A	2K225	N/A	N/A	2K221	N/A	3½
	Impeller – High Head "HH"		Bronze		N/A	2K276	N/A	N/A	2K277	N/A	4.0
112A	Lower Ball Bearing		Steel	1	4K132					4K384	–
112B	Upper Ball Bearing		Steel	1	4K132						–
218	Insulating Turbine Oil		ASTM150		4K432 (1 gallon ⅓-1½ HP, .88 gallons 2 HP)						7½ lbs./gal.
304	Impeller Locknut - All		AISI 300 SS	1	13K286						–
338	Motor	1 Phase, 115V	Motor with Stainless Steel Shaft	1	118-121R	118-1222R	N/A	N/A	N/A	N/A	13.0 to 24.0
		1 Phase, 208V			118-1215R	118-1236R	118-1236R	118-1238R	118-1238R	N/A	
		1 Phase, 230V			118-122R	118-1223R	118-1232R	118-1233R	118-1234R	120-845R	
		3 Phase, 200 V			N/A	118-1333R	118-1334R	118-1335R	118-1336R	120-8425R	
		3 Phase, 230/460 V			N/A	118-1321R	118-1322R	118-1323R	118-1324R	120-8425R	
		3 Phase, 575 V			N/A	118-1328R	118-1330R	118-1330R	118-1331R	120-8435R	
340	Seal / Bearing Housing		Cast Iron	1	1K167					1K332	10.0
341	Motor Cover	1 Phase	Cast Iron	1	1K207				1K208		23.0
		3 Phase			N/A	1K208					
351	Casing Gasket - All Except "HH"		Composite	1	5K170						–
	Shim Set - "HH" Models Only		Plastic	1	5K169						–
358E	Plug – Motor Cover ⅜" NPT		AISI 300 SS	1	6K169						–
371C	Skt. Hd. Screw – Housing to Motor Cover		AISI 300 SS	4	13K271						–
372D	Hex Cap Screw – Housing to Casing		AISI 300 SS	4	13K186						–
376	Capacitor (1 Phase Only)	Start	Varies	1	9K197					9K352	–
		Run			N/A					9K351	
387	Mechanical Seal – Standard		Silicon Carbide	1	10K120					10K119	–
	Mechanical Seal – Optional		Tungsten Carbide	1	10K122					10K123	–
412M	O-ring – Motor Cover		BUNA-N, AS 568A-166	1	4K252						–
436	Motor Start Switch (1 Phase Only)			1	629002-2					9K356	
457	Wire Nut (Power Cable)	1 Phase	Special Nylon Housing	2	N/A					9K145	–
		3 Phase		up to 6	N/A	9K145					–
458	Handle Assembly		AISI 300 SS	1	4K243						–
484B	Strain Relief Assembly (Power Cable)	1 Phase	Varies	1	5K113				5K111		–
		3 Phase		1	N/A	5K111					–
	Loctite #271 - Impeller / Nut			1	AL27121						–

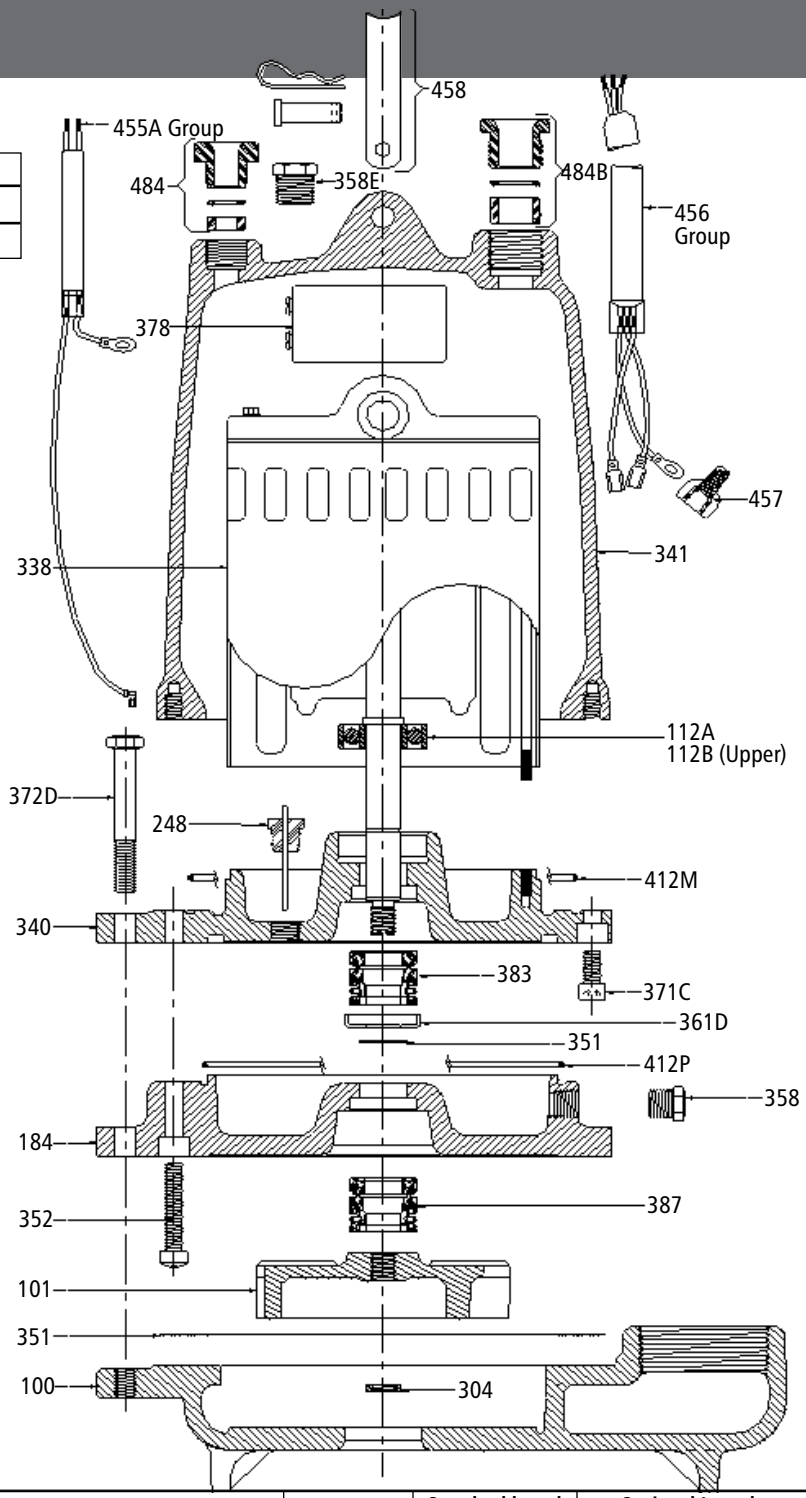
Item No. 456, Power Cables	Type and AWG Size	Standard length	Optional Lengths			Wt.
		20'	30'	50'	100'	(lbs./5 ft.)
1 PH: ⅓ HP, 115 V; standard with plug, optional length cords have bare leads.	SJTOW – 16/3	9K165	9K214	9K215	N/A	0.5
1 PH: ½ HP, 115 V; standard with plug, optional length cords have bare leads.	STOW – 14/3	9K385 - SJTOW	9K216*	9K161*	9K217*	0.9
1 PH: ⅓ & ½ HP, 208 & 230 V; standard with plug, opt. length cords have bare leads.	SJTOW – 16/3	9K164	9K214	9K215	N/A	0.5
1 PH: ¾ & 1 HP, 208 & 230 V; standard with plug, opt. length cords have bare leads.	STOW – 14/3	9K444 - SJTOW	9K216*	9K161*	9K217*	0.9
1 PH: 1½ HP, 208 & 230 V with bare leads.	STOW – 14/3	9K163	9K216*	9K161*	9K217*	0.9
1 PH: 2 HP, 230 V with bare leads.	STOW – 14/3	9K266	9K267	9K268	9K269	0.9
3 PH: ½ – 2 HP, 200–230/460/575 V with bare leads.	STOW – 14/4	9K153	9K218	9K154	9K219	1.1

* Requires 5K111 Strain Relief Assembly and 1K208 Motor Cover.

"P" option –9K445 1PH, 208/230 V, 14/3 SJTOW Cord with Plug, 30 ft.

MODEL 2ED

CAPACITOR DATA		
"K" no.	**MFD**	**VAC**
9K197	161/193	110



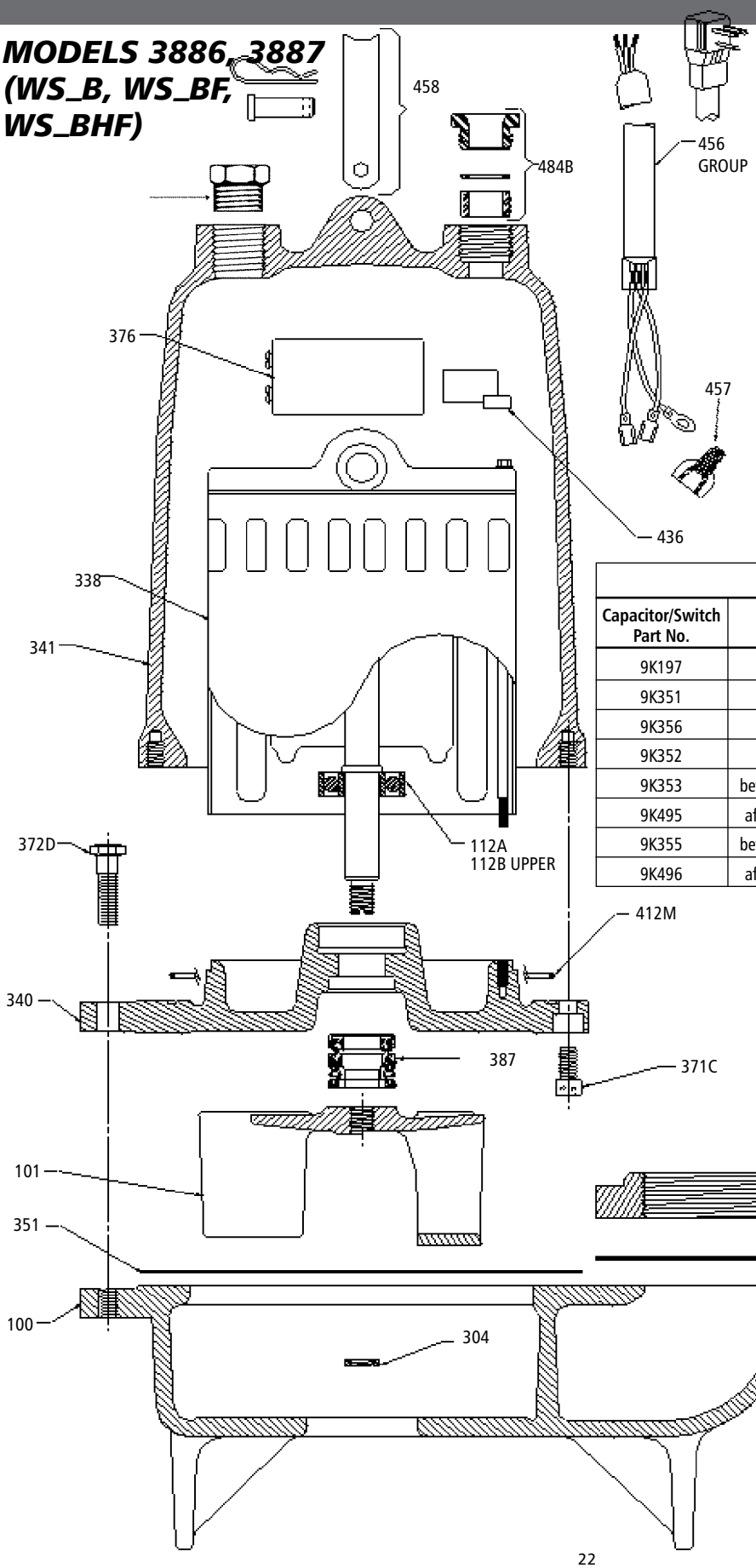
Item No. 456, Power Cables	Type and AWG Size	Standard length	Optional Lengths			Wt. (lbs./5 ft.)
		20'	30'	50'	100'	
1 PH: ⅓ HP, 115 V; standard with plug, optional lengths have bare leads.	SJTOW – 16/3	9K165	9K214	9K215	N/A	0.5
1 PH: ½ HP, 115 V; standard with plug, optional lengths have bare leads.	STOW – 14/3	9K385 - SJTOW	9K216*	9K161*	9K217*	0.9
1 PH: ⅓ & ½ HP, 208 & 230 V; standard with plug, opt. lengths have bare leads.	SJTOW – 16/3	9K164	9K214	9K215	N/A	0.5
1 PH: ¾ – 1½ HP, 208 & 230 V with bare leads.	STOW – 14/3	9K163	9K216	9K161	9K217	0.9
3 PH: ½ – 1½ HP, 200–230/460/575 V with bare leads.	STOW – 14/4	9K153	9K218	9K154	9K219	1.1
Item No. 455A, Sensor Cables						
Mechanical Seal Sensor - Standard for All Models	SJTOW – 16/2	9K189	9K220	9K221	9K222	0.5
Mechanical Seal/Heat Sensor - Optional for 3-Phase Models	SJTOW – 18/4	9K237	9K238	9K239	9K240	0.5

* Requires 5K111 Strain Relief Assembly and 1K208 Motor Cover.

MODEL 2ED (Dual Seal)

Item No.	Part Description	Material	Qty. Reqd.	Repair Parts Order Number					Max. Wt. (lbs.)
				1725 RPM	3450 RPM				
				⅓ HP	½ HP	¾ HP	1 HP	1½ HP	
100	Casing – "F" Model Only (8th Digit)	Cast Iron	1	1K171	N/A				13.0
	Casing – All Others			N/A	1K170				
101	Impeller – Standard	Cast Iron	1	2K158	2K220	2K219	2K218	2K217	4.0
	Model Number (8th Digit) = Diameter			E, F = 5⅜"	D = 3⁹⁄₁₆"	C = 4¹⁄₁₆"	B = 4⁷⁄₁₆"	A = 4⁹⁄₁₆"	
	Impeller – Standard	Bronze		2K271	2K272	2K273	2K274	2K275	2.5
	Model Number (8th Digit) = Diameter			E, F = 5⅜"	D = 3⁹⁄₁₆"	C = 4¹⁄₁₆"	B = 4⁷⁄₁₆"	A = 4⁹⁄₁₆"	
	Impeller – High Head	Cast Iron		N/A	2K225	N/A	N/A	2K221	3.5
	Model Number (8th Digit) = Diameter				H = 3⅜"			G = 5½"	
	Impeller – High Head	Bronze		N/A	2K276	N/A	N/A	2K277	4.0
	Model Number (8th Digit) = Diameter				H = 3⅜"			G = 5½"	
112A	Lower Ball Bearing	Steel	1	4K132					–
112B	Upper Ball Bearing	Steel	1	4K132					–
184	Seal Housing	Cast Iron	1	1K229					9.5
218	Insulating Oil – Gallons Required	Turbine Oil - ASTM150	–	4K432					7½ lbs./gal.
	Gallons Required in Seal Housing			0.10					
	Gallons Required in Motor Cover			1.0					
246	Seal Sensor – Plug and Rod	Nylon/Brass	1	9K191					–
304	Impeller Locknut - All	AISI 300 SS	1	13K286					–
338	Motor – 1 Phase, 115V	Stainless Steel Shaft	1	119-493R	119-4931R	N/A			13.0 to 24.0
	Motor – 1 Phase, 208V			119-49815R	119-4992R	119-4992R	119-4994R	119-4994R	
	Motor – 1 Phase, 230V			119-494R	119-4932R	119-4934R	119-4934R	119-4935R	
	Motor – 3 Phase, 200V			N/A	119-4971R	119-4973R	119-4973R	119-4974R	
	Motor – 3 Phase, 230/460V			N/A	119-4941R	119-4943R	119-4943R	119-4944R	
	Motor – 3 Phase, 575V			N/A	119-4951R	119-4954R	119-4954R	119-4954R	
340	Bearing Housing	Cast Iron	1	1K228					10.0
341	Motor Cover – 1 Phase	Cast Iron	1	1K230		1K231			23.0
	Motor Cover – 3 Phase			N/A	1K231				
351	Casing Gasket	Composite	1	5K170					–
	Shim Set - "High Head" Models Only	Plastic	1	5K169					–
352	Skt. Hd. Screw – Seal Housing to Motor Cover	AISI 300 SS	2	13K219					–
358	Plug – Seal Housing ¼" NPT	AISI 300 SS	1	6K168					–
358E	Plug – Motor Cover ⅜" NPT	AISI 300 SS	1	6K169					–
361	Retaining Ring	AISI 300 SS	1	4K375					–
361D	Seal Retainer	AISI 300 SS	1	4K379					–
371C	Skt. Hd. Screw – Bearing Housing to Motor Cover	AISI 300 SS	2	13K271					–
372D	Hex Cap Screw – Housing to Casing	AISI 300 SS	4	13K222					–
376	Capacitor (1 Phase Only) – Start	–	1	9K197					–
383	Mechanical Seal – Upper	Carbon/Ceramic	1	10K121 (Type 16)					–
387	Mechanical Seal – Lower (Standard)	Silicon Carbon	1	10K120 (Type 16)					–
	Mechanical Seal – Lower (Optional)	Tungsten Carbon	1	10K122 (Type 16)					–
412M	O-ring – Motor Cover	BUNA-N, AS 568A-166	1	4K252					–
412P	O-ring – Seal/Bearing Housing	BUNA-N, AS 568A-163	1	5K181					
457	Wire Nut – Power Cable - 1 Phase	Special Nylon Housing	N/A	None Required					–
	Wire Nut – Power Cable - 3 Phase		1 pkg.	N/A	9K145 (package of 8)				–
	Wire Nut – Seal/Heat Cable - Opt. 3 Phase Only		1 pkg.	9K145 (package of 8)					–
458	Handle Assembly	AISI 300 SS	1	4K243					–
484	Strain Relief Assembly, Sensor Cable	Varies	1	5K113					–
484B	Strain Relief Assembly (Power Cable) – 1 Phase	Varies	1	5K113		5K111			–
	Strain Relief Assembly (Power Cable) – 3 Phase		1	N/A	5K111				–
	Heat Sensor Kit (Optional)	–	1	9K261					–
	Seal Installation Tool	–	1	A02A013					–
	Loctite #271	–	1	AL27121					–

MODELS 3886, 3887 (WS_B, WS_BF, WS_BHF)



CAPACITOR DATA				
Capacitor/Switch Part No.	Date	Used On	MFD	VAC
9K197	All	WS, WT 1/3-1 HP 3450 RPM	161/193	110
9K351	All	WS, WT 2 HP Run	30	370
9K356	All	WS, WT 2 HP Switch	—	—
9K352	All	WS, WT 2 HP Start	200/240	220
9K353	before 7/1/07	WS, WT 1½ HP Start Cap	295/355	125
9K495	after 7/1/07	WS, WT 1½ HP Start Cap	275	125
9K355	before 7/1/07	WS, WT 1½ HP Switch	—	—
9K496	after 7/1/07	WS, WT 1½ HP Switch	—	—

Note: Model 3886 casing is threaded 2" NPT and therefore does not require some of the diagramed parts.

358E – Pipe Plug Not Shown
1750 RPM – Open Impeller
3500 RPM – Enclosed Impeller

MODEL 3886 (WS_B)

Item No.	Part Description		Material	Qty. Req.	Repair Parts Order Number 1725 RPM				Max. Wt. (lbs.)
					⅓ HP	½ HP	¾ HP	1 HP	
100	Casing		Cast Iron	1	1K168				16.5
101	Impeller		Cast Iron	1	2K268	2K239	2K240	2K241	3.0
	Impeller		Bronze	1	2K279	2K280	2K281	2K282	3.5
112A	Lower Ball Bearing		Steel	1	4K132				–
112B	Upper Ball Bearing		Steel	1	4K132				–
218	Insulating Turbine Oil		ASTM150	-	4K432 (1 gallon ⅓ - 1 HP)				7.5 lbs./gal.
304	Impeller Locknut - All		AISI 300 SS	1	13K286				–
338	Motor – 1 Phase, 115V		Motor with Stainless Steel Shaft	1	118-121R	118-123R	N/A	N/A	13.0 to 24.0
	Motor – 1 Phase, 208V				118-1215R	118-1215R	118-1217R	118-1217R	
	Motor – 1 Phase, 230V				118-122R	118-124R	118-1212R	118-1213R	
	Motor – 3 Phase, 200 V				N/A	118-1314R	118-1316R	118-1316R	
	Motor – 3 Phase, 230/460 V				N/A	118-132R	118-134R	118-134R	
	Motor – 3 Phase, 575 V				N/A	118-139R	118-1311R	118-1311R	
340	Seal / Bearing Housing		Cast Iron	1	1K167				10.0
341	Motor Cover – 1 Phase		Cast Iron	1	1K207				20.0
	Motor Cover – 3 Phase				1K208				
351	Casing Gasket		Composite	1	5K170				–
358E	Plug – Motor Cover ⅜" NPT		AISI 300 SS	1	6K169				–
371C	Skt. Hd. Screw – Housing to Motor Cover		AISI 300 SS	4	13K271				–
372D	Hex Cap Screw – Housing to Casing		AISI 300 SS	4	13K186				–
376	Capacitor (1 Phase only) Start		Varies	1	9K197		9K235		–
387	Mechanical Seal – Standard		Silicon Carbide	1	10K120				–
	Mechanical Seal – Optional		Tungsten Carbide	1	10K122				–
412M	O-ring – Motor Cover		BUNA-N, AS568A-166	1	4K252				–
457	Wire Nut (Power Cable)	1 Phase	Special Nylon Housing	-	N/A				–
		3 Phase		up to 6	N/A	9K145			–
458	Handle Assembly		AISI 300 SS	1	4K243				–
484B	Strain Relief Assembly (Power Cable)	1 Phase	Varies	1	5K113				–
		3 Phase			N/A	5K111			
	Loctite #271		–	1	AL27121				–

Item No. 456, Power Cables	Type and AWG Size	Standard length	Optional Lengths			Wt. (lbs./5 ft.)
		20'	30'	50'	100'	
1 PH: ⅓ HP, 115 V; standard with plug, optional length cords have bare leads.	SJTOW – 16/3	9K165	9K214	9K215	N/A	0.5
1 PH: ½ HP, 115 V; standard with plug, optional length cords have bare leads.	STOW – 14/3	9K385 - SJTOW	9K216*	9K161*	9K217*	0.9
1 PH: ⅓ and ½ HP, 208 & 230 V; standard with plug, opt. length cords have bare leads.	SJTOW – 16/3	9K164	9K214	9K215	N/A	0.5
1 PH: ¾ & 1 HP, 208 & 230 V; standard with plug, opt. length cords have bare leads.	STOW – 14/3	9K444 - SJTOW	9K216*	9K161*	9K217*	0.9
3 PH: ½ – 1 HP, 200-230/460/575 V with bare leads.	STOW – 14/4	9K153	9K218	9K154	9K219	1.1

* Requires 5K111 Strain Relief Assembly and 1K208 Motor Cover.

"P" option –9K445 1PH, 208/230 V, 14/3 SJTOW Cord with Plug, 30 ft.

MODEL 3887 (WS_BF)

Item No.	Part Description	Material	Qty. Req.	Repair Parts Order Number 1725 RPM				Max. Wt. (lbs.)
				⅓ HP	½ HP	¾ HP	1 HP	
100	Casing	Cast Iron	1	1K178				16.5
101	Impeller	Cast Iron	1	2K268	2K239	2K240	2K241	3.0
	Impeller	Bronze	1	2K279	2K280	2K281	2K282	3.5
112A	Lower Ball Bearing	Steel	1	4K132				–
112B	Upper Ball Bearing	Steel	1	4K132				–
195C	Discharge Flange (2" NPT STD.)	Cast Iron	1	6K76				1.5
	Discharge Flange (3" NPT OPT.)			A1-3				
218	Insulating Turbine Oil	ASTM150	1	4K432 (1.0 gallons, 1/3 - 1 HP)				7.5 lbs./gal.
304	Impeller Locknut - All	AISI 300 SS	1	13K286				–
338	Motor – 1 Phase, 115V	Motor with Stainless Steel Shaft	1	118-121R	118-123R	N/A	N/A	13.0 to 24.0
	Motor – 1 Phase, 208V			118-1215R	118-1215R	118-1217R	118-1217R	
	Motor – 1 Phase, 230V			118-122R	118-124R	118-1212R	118-1213R	
	Motor – 3 Phase, 200 V			N/A	118-1314R	118-1316R	118-1316R	
	Motor – 3 Phase, 230/460 V			N/A	118-132R	118-134R	118-134R	
	Motor – 3 Phase, 575 V			N/A	118-139R	118-1311R	118-1311R	
340	Seal / Bearing Housing	Cast Iron	1	1K167				10.0
341	Motor Cover – 1 Phase	Cast Iron	1	1K207				20.0
	Motor Cover – 3 Phase			1K208				
351	Casing Gasket	Composite	1	5K170				–
351A	Discharge Flange Gasket	Composite	1	5K150				–
357	Hex Nut – Discharge Flange	AISI 300 SS	2	13K99				
358E	Plug – Motor Cover ⅜" NPT	AISI 300 SS	1	6K169				–
371C	Skt. Hd. Screw – Housing to Motor Cover	AISI 300 SS	4	13K271				–
371H	Hex Cap Screw – Discharge Flange	AISI 300 SS	2	13K153				–
372D	Hex Screw – Housing to Casing	AISI 300 SS	4	13K186				–
376	Capacitor (1 Phase Only) Start	Varies	1	9K197		9K235		–
387	Mechanical Seal – Standard	Silicon Carbide	1	10K120				–
	Mechanical Seal – Optional	Tungsten Carbide	1	10K122				–
412M	O-Ring – Motor Cover	Buna-N, AS 568A-166	1	4K252				–
457	Wire Nut, Power Cable, 3 Phase	Special Nylon Housing	Up to 6	N/A		9K145		–
458	Handle Assembly	AISI 300 SS	1	4K243				–
484B	Strain Relief Assembly (Power Cable) 1 PH	Varies	1	5K113				–
	3 PH			N/A	5K111			
528	Washer – Discharge Flange	AISI 300 SS	2	13K82				–
	Loctite #271	–	1	AL27121				–

Item No. 456, Power Cables	Type and AWG Size	Standard length	Optional Lengths			Wt. (lbs./5 ft.)
		20'	30'	50'	100'	
1 PH: ⅓ HP, 115 V; standard with plug, optional length cords have bare leads.	SJTOW – 16/3	9K165	9K214	9K215	N/A	0.5
1 PH: ½ HP, 115 V; standard with plug, optional length cords have bare leads.	STOW – 14/3	9K385 - SJTOW	9K216*	9K161*	9K217*	0.9
1 PH: ⅓ & ½ HP, 208 & 230 V; standard with plug, optional length cords have bare leads.	SJTOW – 16/3	9K164	9K214	9K215	N/A	0.5
1 PH: ¾ & 1 HP, 208 & 230 V; standard with plug, optional length cords have bare leads.	STOW – 14/3	9K444 - SJTOW	9K216*	9K161*	9K217*	0.9
3 PH: ½ – 1 HP, 200-230/460/575 V with bare leads.	STOW – 14/4	9K153	9K218	9K154	9K219	1.1

* Requires 5K111 Strain Relief Assembly and 1K208 Motor Cover.

"P" option –9K445 1PH, 208/230 V, 14/3 SJTOW Cord with Plug, 30 ft.

MODEL 3887 (WS_BHF)

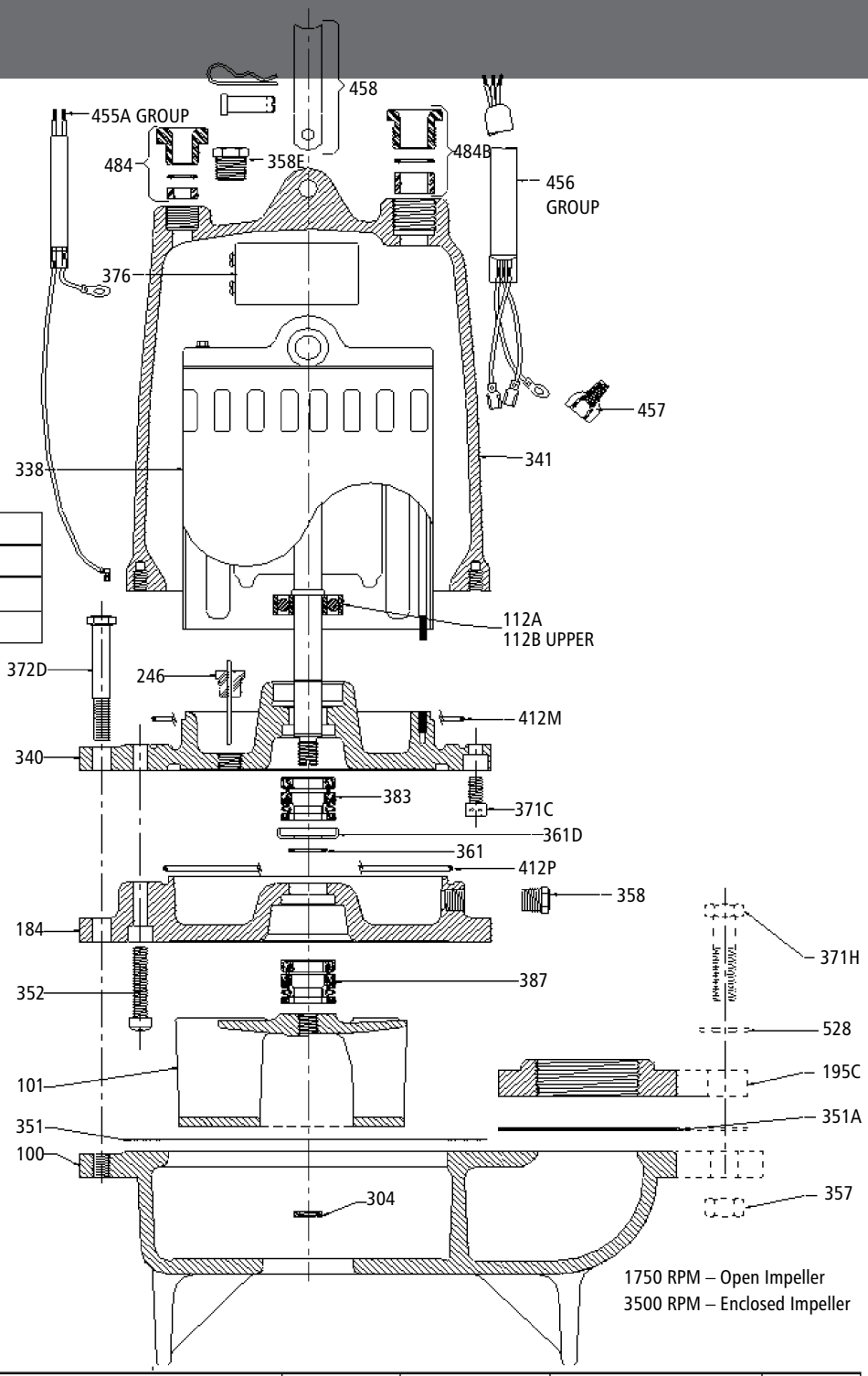
Item No.	Part Description		Material	Qty. Req.	Repair Parts Order Number 3450 RPM ⅓ HP	½ HP	¾ HP	1 HP	1½ HP	2 HP	Max. Wt. (lbs.)
100	Casing		Cast Iron	1	1K330						16.5
101	Impeller		Cast Iron	1	2K858	2K856	2K854	2K852	2K800	2K798	3.0
	Impeller		Bronze	1	2K859	2K857	2K855	2K853	2K801	2K799	3.5
112A	Lower Ball Bearing		Steel	1	4K132				4K384		–
112B	Upper Ball Bearing		Steel	1	4K132						–
195C	Discharge Flange (2" NPT STD.)		Cast Iron	1	6K76						1.5
	Discharge Flange (3" NPT OPT.)		Cast Iron	1	A1-3						1.5
218	Insulating Turbine Oil		ASTM150	-	4K432 (1 gallon ⅓-1 HP, .88 gallons 1½ and 2 HP)						7.5 lbs./gal.
304	Impeller Locknut - All		AISI 300 SS	1	13K286						–
338	Motor – 1 Phase, 115V		Stainless Steel Shaft	1	118-1222R	118-1222R	N/A	N/A	N/A	N/A	13.0 to 24.0
	Motor – 1 Phase, 208V				118-1236R	118-1236R	118-1236R	118-1238R	N/A	N/A	
	Motor – 1 Phase, 230V				118-1223R	118-1223R	118-1232R	118-1233R	120-844R	120-845R	
	Motor – 3 Phase, 200 V				N/A	118-1333R	118-1334R	118-1335R	120-8425R	120-8425R	
	Motor – 3 Phase, 230/460 V				N/A	118-1321R	118-1322R	118-1323R	120-8425R	120-8425R	
	Motor – 3 Phase, 575 V				N/A	118-1328R	118-1330R	118-1330R	120-8435R	120-8435R	
340	Seal / Bearing Housing		Cast Iron	1	1K167				1K332		10.0
341	Motor Cover – 1 Phase		Cast Iron	1	1K207				1K208		20.0
	Motor Cover – 3 Phase				1K208						
351	Casing Gasket		Composite	1	5K170						–
351A	Discharge Flange Gasket		Composite	1	5K150						–
357	Hex Nut – Discharge Flange		AISI 300 SS	2	13K99						
358E	Plug – Motor Cover ⅜" NPT		AISI 300 SS	1	6K169						–
371C	Skt. Hd. Screw – Housing to Motor Cover		AISI 300 SS	4	13K271						–
371H	Hex Cap Screw – Discharge Flange		AISI 300 SS	2	13K153						–
372D	Hex Cap Screw – Housing to Casing		AISI 300 SS	4	13K186						–
387	Mechanical Seal – Standard		Silicon Carbide	1	10K120				10K119		–
	Mechanical Seal – Optional		Tungsten Carbide	1	10K122				10K123		–
412M	O-Ring – Motor Cover		BUNA-N, AS568A-166	1	4K252						–
457	Wire Nut (Power Cable)	1 PH	Special Nylon Housing	2	N/A				9K145		–
		3 PH		up to 6	N/A	9K145					–
458	Handle Assembly		AISI 300 SS	1	4K243						–
484B	Strain Relief Assembly (Power Cable)	1 PH	Varies	1	5K113				5K111		–
		3 PH			N/A	5K111					
528	Washer – Discharge Flange		AISI 300 SS	2	13K82						–
	Loctite #271		–	1	AL27121						–

Item No. 456, Power Cables	Type and AWG Size	Standard length 20'	Optional Lengths 30'	50'	100'	Wt. (lbs./5 ft.)
1 PH: ⅓ HP, 115 V; standard with plug, optional lengths have bare leads.	SJTOW – 16/3	9K165	9K214	9K215	N/A	0.5
1 PH: ½ HP, 115 V; standard with plug, optional lengths have bare leads.	STOW – 14/3	9K385 - SJTOW	9K216*	9K161*	9K217*	0.9
1 PH: ⅓ and ½ HP, 208 & 230 V; standard with plug, optional lengths have bare leads.	SJTOW – 16/3	9K164	9K214	9K215	N/A	0.5
1 PH: ¾ – 1 HP, 208 & 230 V; standard with plug, optional lengths have bare leads.	STOW – 14/3	9K444 - SJTOW	9K216*	9K161*	9K217*	0.9
1 PH: 1½ and 2 HP, 230 V with bare leads.	STOW – 14/3	9K266	9K267	9K268	9K269	0.9
3 PH: ½ – 2 HP, 200-230/460/575 V with bare leads.	STOW – 14/4	9K153	9K218	9K154	9K219	1.1

* Requires 5K111 Strain Relief Assembly and 1K208 Motor Cover.

"P" option –9K445 1PH, 208/230 V, 14/3 SJTOW Cord with Plug, 30 ft.

MODEL 2WD/3WD



CAPACITOR DATA		
"K" no.	MFD	VAC
9K197	161/193	110
9K235	189/227	110

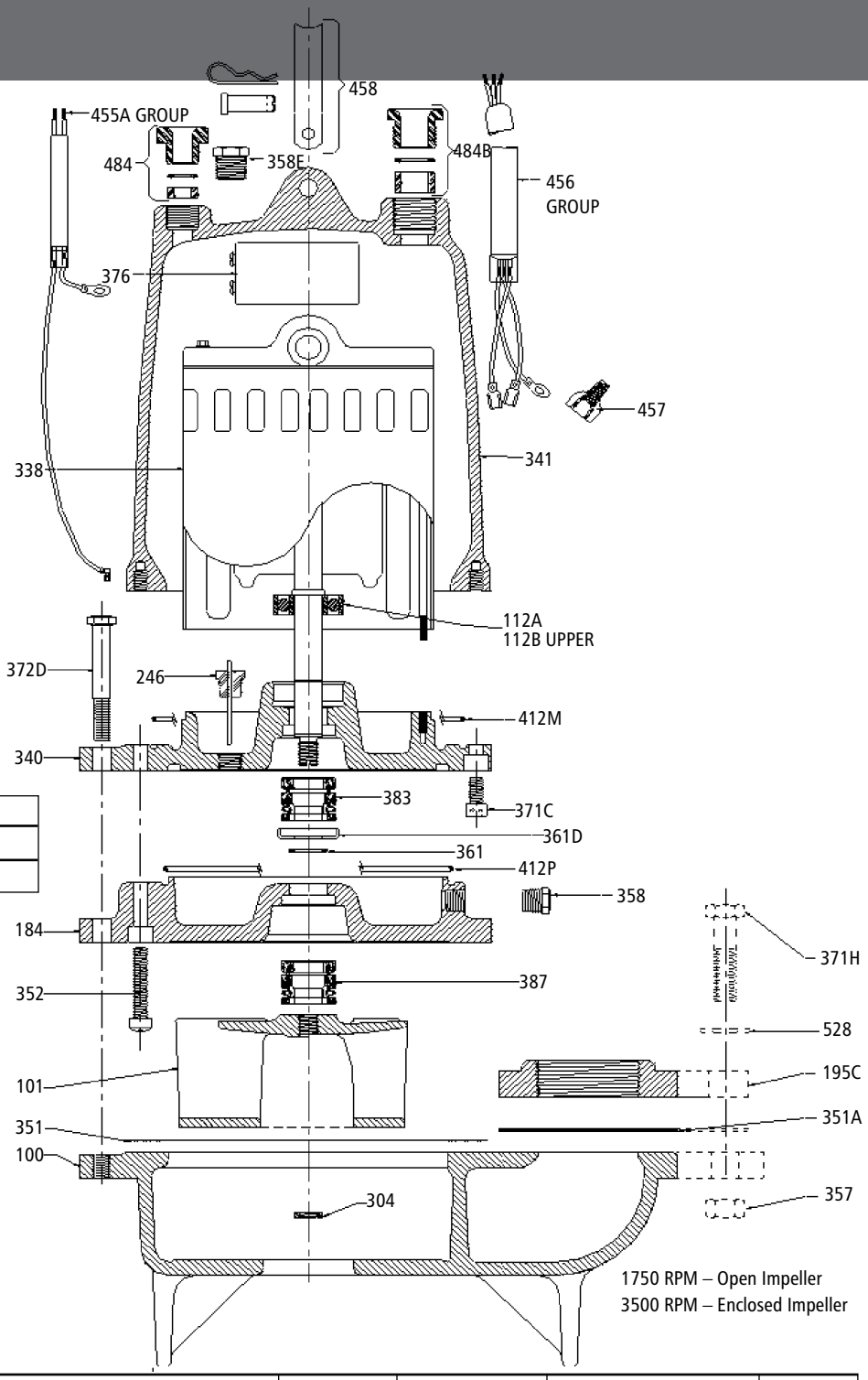
Item No. 456, Power Cables	Type and AWG Size	Standard length	Optional Lengths			Wt. (lbs./5 ft.)
		20'	30'	50'	100'	
1 PH: ⅓ HP, 115 V; standard with plug, optional lengths have bare leads.	SJTOW – 16/3	9K165	9K214	9K215	N/A	0.5
1 PH: ½ HP, 115 V; standard with plug, optional lengths have bare leads.	STOW – 14/3	9K385 - SJTOW	9K216*	9K161*	9K217*	0.9
1 PH: ⅓ & ½ HP, 208 & 230 V; standard with plug, opt. lengths have bare leads.	SJTOW – 16/3	9K164	9K214	9K215	N/A	0.5
1 PH: ¾ – 1 HP, 208 & 230 V with bare leads.	STOW – 14/3	9K163	9K216	9K161	9K217	0.9
3 PH: ½ – 1 HP, 200–230/460/575 V with bare leads.	STOW – 14/4	9K153	9K218	9K154	9K219	1.1
Item No. 455A, Sensor Cables						
Mechanical Seal Sensor - Standard for All Models	SJTOW – 16/2	9K189	9K220	9K221	9K222	0.5
Mechanical Seal/Heat Sensor - Optional for 3-Phase Models	SJTOW – 18/4	9K237	9K238	9K239	9K240	0.5

* Requires 5K111 Strain Relief Assembly and 1K208 Motor Cover.

MODEL 2WD/3WD (1725 RPM)

Item No.	Part Description	Material	Qty. Req.	Repair Parts Order Number 1725 RPM				Max. Wt. (lbs.)
				⅓ HP	½ HP	¾ HP	1 HP	
100	Casing	Cast Iron	1	1K178				16.5
101	Impeller	Cast Iron	1	2K268 E = 4 11/16"	2K239 D = 5"	2K240 C = 5 3/8"	2K241 B = 5 3/4"	3.0
	Impeller	Bronze	1	2K279 E = 4 11/16"	2K280 D = 5"	2K281 C = 5 3/8"	2K282 B = 5 3/4"	3.5
112A	Lower Ball Bearing	Steel	1	4K132				–
112B	Upper Ball Bearing	Steel	1	4K132				–
184	Seal Housing	Cast Iron	1	1K229				9.5
195C	Discharge Flange - Standard 2" NPT	Cast Iron	1	6K76				1.5
	Discharge Flange - Optional 3" NPT			A1-3				
218	Insulating Oil – Gallons Required	Turbine Oil - ASTM150	–	4K432				7.5 lbs./gal.
	Gallons Required in Seal Housing			0.10				
	Gallons Required in Motor Cover			1.0				
246	Seal Sensor - Plug and Rod	Nylon/Brass	1	9K198				–
304	Impeller Locknut – All	AISI 300 SS	1	13K286				–
338	Motor – 1 Phase, 115V	Stainless Steel Shaft	1	119-493R	119-493R	N/A	N/A	13.0 to 24.0
	Motor – 1 Phase, 208V			119-4981R	119-4981R	119-4983R	119-4983R	
	Motor – 1 Phase, 230V			119-494R	119-494R	119-496R	119-496R	
	Motor – 3 Phase, 200V			N/A	119-4961R	119-4963R	119-4963R	
	Motor – 3 Phase, 230/460V			N/A	119-4911R	119-4913R	119-4913R	
	Motor – 3 Phase, 575V			N/A	119-4921R	119-4923R	119-4923R	
340	Bearing Housing	Cast Iron	1	1K228				10.0
341	Motor Cover – 1 Phase	Cast Iron	1	1K230		1K231		20.0
	Motor Cover – 3 Phase			1K231				
351	Casing Gasket	Composite	1	5K170				–
351A	Discharge Flange Gasket	Composite	1	5K150				–
352	Skt. Hd. Screw - Seal Hsg. to Motor Cover	AISI 300 SS	2	13K219				–
357	Hex Nut – Discharge Flange	AISI 300 SS	2	13K99				–
358	Plug – Seal Housing ¼" NPT	AISI 300 SS	1	6K168				–
358E	Plug – Motor Cover ⅜" NPT	AISI 300 SS	1	6K169				–
361	Retaining Ring	AISI 300 SS	1	4K375				–
361D	Seal Retainer	AISI 300 SS	1	4K379				–
371C	Skt. Hd. Screw – Brg. Hsg. to Motor Cover	AISI 300 SS	2	13K271				–
371H	Hex Cap Screw – Discharge Flange	AISI 300 SS	2	13K153				–
372D	Hex Cap Screw – Housing to Casing	AISI 300 SS	4	13K222				–
376	Capacitor (1 Phase only) – Start	Varies	1	9K197		9K235		–
383	Mechanical Seal – Upper	Carbon/Ceramic	1	10K121 (Type 16)				–
387	Mechanical Seal – Lower (Standard)	Silicon Carbide	1	10K120 (Type 16)				–
	Mechanical Seal – Lower (Optional)	Tungsten Carbide	1	10K122 (Type 16)				–
412M	O-ring – Motor Cover	BUNA-N, AS568A-166	1	4K252				–
412P	O-ring – Seal/Bearing Housing	BUNA-N, AS568A-163	1	5K181				–
457	Wire Nut – Power Cable - 3 Ph., 460V	Special Nylon Housing	1 pkg.	N/A	9K145 (package of 8)			–
	Wire Nut – Seal/Heat Cable - Opt. 3 Ph. Only		1 pkg.	9K145 (package of 8)				–
458	Handle Assembly	AISI 300 SS	1	4K243				–
484	Strain Relief Assembly, Sensor Cable	Varies	1	5K113				–
484B	Strain Relief Assembly (Power Cable) – 1 Phase	Varies	1	5K113		5K111		–
	Strain Relief Assembly (Power Cable) – 3 Phase			N/A	5K111			
528	Washer – Discharge Flange	AISI 300 SS	2	13K82				–
–	Heat Sensor Kit (Optional)	–	1	9K261				–
–	Seal Installation Tool	–	1	A02A013				–
–	Loctite #271	–	1	AL27121				–

MODEL 2WD/3WD



CAPACITOR DATA		
"K" no.	MFD	VAC
9K197	161/193	110

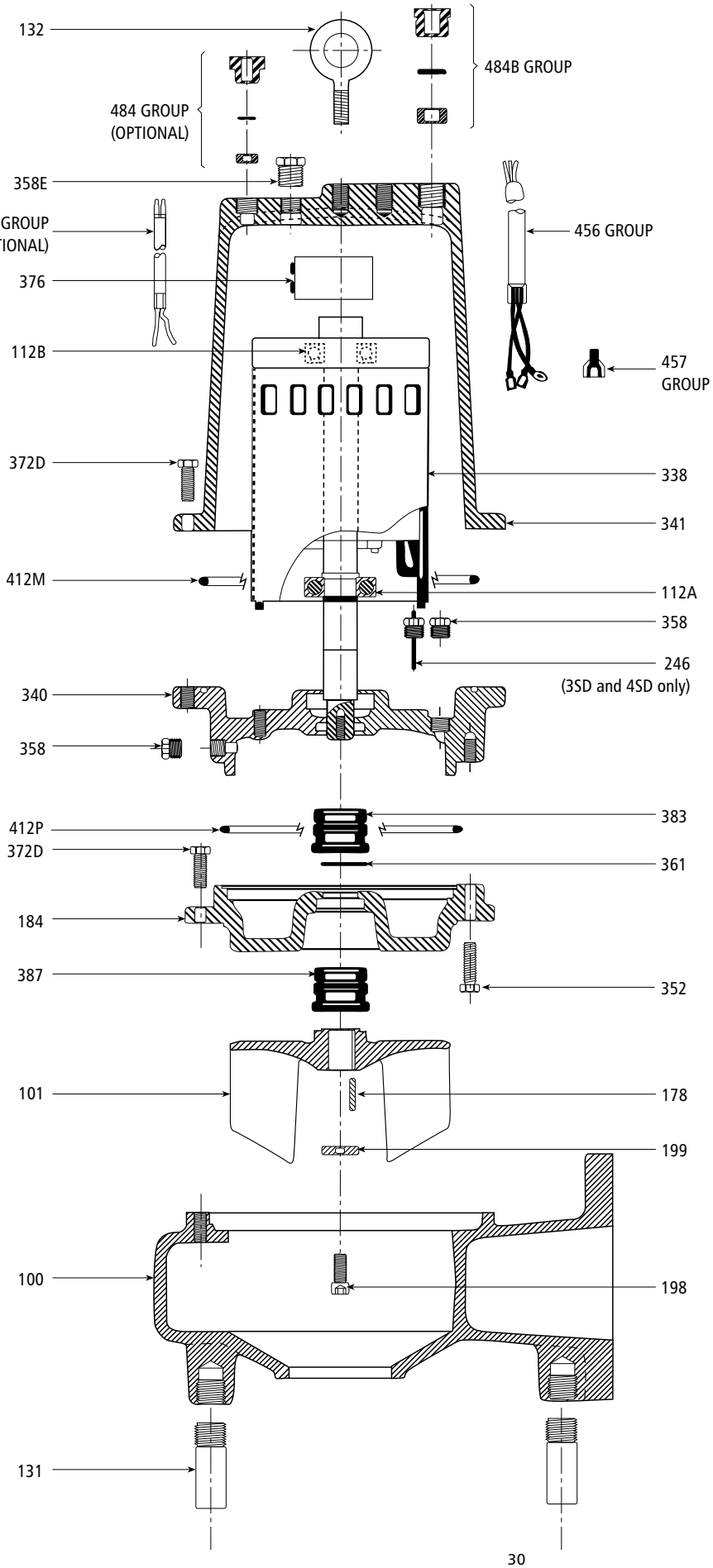
Item No. 456, Power Cables	Type and AWG Size	Standard length	Optional Lengths			Wt. (lbs./5 ft.)
		20'	30'	50'	100'	
1 PH: ⅓ HP, 115 V; standard with plug, optional lengths have bare leads.	SJTOW – 16/3	9K165	9K214	9K215	N/A	0.5
1 PH: ½ HP, 115 V; standard with plug, optional lengths have bare leads.	STOW – 14/3	9K385 - SJTOW	9K216*	9K161*	9K217*	0.9
1 PH: ⅓ & ½ HP, 208 & 230 V; standard with plug, opt. lengths have bare leads.	SJTOW – 16/3	9K164	9K214	9K215	N/A	0.5
1 PH: ¾ – 1 HP, 208 & 230 V with bare leads.	STOW – 14/3	9K163	9K216	9K161	9K217	0.9
3 PH: ½ – 1 HP, 200–230/460/575 V with bare leads.	STOW – 14/4	9K153	9K218	9K154	9K219	1.1
Item No. 455A, Sensor Cables						
Mechanical Seal Sensor - Standard for All Models	SJTOW – 16/2	9K189	9K220	9K221	9K222	0.5
Mechanical Seal/Heat Sensor - Optional for 3-Phase Models	SJTOW – 18/4	9K237	9K238	9K239	9K240	0.5

* Requires 5K111 Strain Relief Assembly and 1K208 Motor Cover.

MODEL 2WD/3WD (3500 RPM)

Item No.	Part Description	Material	Qty. Req.	Repair Parts Order Number 3450 RPM				Max. Wt. (lbs.)
				⅓ HP	½ HP	¾ HP	1 HP	
100	Casing	Cast Iron	1	1K330				16.5
101	Impeller	Cast Iron	1	2K858 K = $2^{15}/_{16}$"	2K856 J = $3^{3}/_{16}$"	2K854 H = $3^{7}/_{16}$"	2K852 A = 3¾"	3.0
	Impeller	Bronze	1	2K859 E = $2^{15}/_{16}$"	2K857 J = $3^{3}/_{16}$"	2K855 H = $3^{7}/_{16}$"	2K853 A = 3¾"	3.5
112A	Lower Ball Bearing	Steel	1	4K132				–
112B	Upper Ball Bearing	Steel	1	4K132				–
184	Seal Housing	Cast Iron	1	1K229				9.5
195C	Discharge Flange - Standard 2" NPT	Cast Iron	1	6K76				1.5
	Discharge Flange - Optional 3" NPT			A1-3				
218	Insulating Oil – Gallons Required	Turbine Oil - ASTM150	–	4K432				7.5 lbs./gal.
	Gallons Required in Seal Housing			0.10				
	Gallons Required in Motor Cover			1.0				
246	Seal Sensor - Plug and Rod	Nylon/Brass	1	9K191				–
304	Impeller Locknut – All	AISI 300 SS	1	13K286				–
338	Motor – 1 Phase, 115V	Stainless Steel Shaft	1	119-4931R	119-4931R	N/A	N/A	13.0 to 24.0
	Motor – 1 Phase, 208V			119-4992R	119-4992R	119-4992R	119-4994R	
	Motor – 1 Phase, 230V			119-4932R	119-4932R	119-4934R	119-4934R	
	Motor – 3 Phase, 200V			N/A	119-4971R	119-4973R	119-4973R	
	Motor – 3 Phase, 230/460V			N/A	119-4941R	119-4943R	119-4943R	
	Motor – 3 Phase, 575V			N/A	119-4951R	119-4954R	119-4954R	
340	Bearing Housing	Cast Iron	1	1K228				10.0
341	Motor Cover – 1 Phase	Cast Iron	1	1K230		1K231		20.0
	Motor Cover – 3 Phase			1K231				
351	Casing Gasket	Composite	1	5K170				–
351A	Discharge Flange Gasket	Composite	1	5K150				–
352	Skt. Hd. Screw - Seal Hsg. to Motor Cover	AISI 300 SS	2	13K219				–
357	Hex Nut – Discharge Flange	AISI 300 SS	2	13K99				–
358	Plug – Seal Housing ¼" NPT	AISI 300 SS	1	6K168				–
358E	Plug – Motor Cover ⅜" NPT	AISI 300SS	1	6K169				–
361	Retaining Ring	AISI 300 SS	1	4K375				–
361D	Seal Retainer	AISI 300 SS	1	4K379				–
371C	Skt. Hd. Screw – Brg. Hsg. to Motor Cover	AISI 300 SS	2	13K271				–
371H	Hex Cap Screw – Discharge Flange	AISI 300 SS	2	13K153				–
372D	Hex Cap Screw – Housing to Casing	AISI 300 SS	4	13K222				–
376	Capacitor (1 Phase only) – Start	Varies	1	9K197				–
383	Mechanical Seal – Upper	Carbon/Ceramic	1	10K121 (Type 16)				–
387	Mechanical Seal – Lower (Standard)	Silicon Carbide	1	10K120 (Type 16)				–
	Mechanical Seal – Lower (Optional)	Tungsten Carbide	1	10K122 (Type 16)				–
412M	O-ring – Motor Cover	BUNA-N, AS568A-166	1	4K252				–
412P	O-ring – Seal/Bearing Housing	BUNA-N, AS568A-163	1	5K181				–
457	Wire Nut – Power Cable - 3 Ph., 460V	Special Nylon Housing	1 pkg.	N/A	9K145 (package of 8)			–
	Wire Nut – Seal/Heat Cable - Opt. 3 Ph. Only		1 pkg.	9K145 (package of 8)				–
458	Handle Assembly	AISI 300 SS	1	4K243				–
484	Strain Relief Assembly, Sensor Cable	Varies	1	5K113				–
484B	Strain Relief Assembly (Power Cable) – 1 Phase	Varies	1	5K113		5K111		–
	Strain Relief Assembly (Power Cable) – 3 Phase			N/A	5K111			
528	Washer – Discharge Flange	AISI 300 SS	2	13K82				–
–	Heat Sensor Kit (Optional)	–	1	9K261				–
–	Seal Installation Tool	–	1	A02A013				–
–	Loctite #271	–	1	AL27121				–

MODELS 3888D3/3SD, 3888D4/4SD



CAPACITOR DATA			
"K" no.	MFD	VAC	Qty. Req.
9K144①	20	370	2
9K233②	30	370	2
9K262	50	370	2
9K332	60	370	See item 376
9K456③	40	370	2

① Used prior to March 1991.

② Replaced by (1) 9K332.

③ Used on new 11/2 & 2 HP motors after May 2006 – check capacitor ratings before ordering replacements.

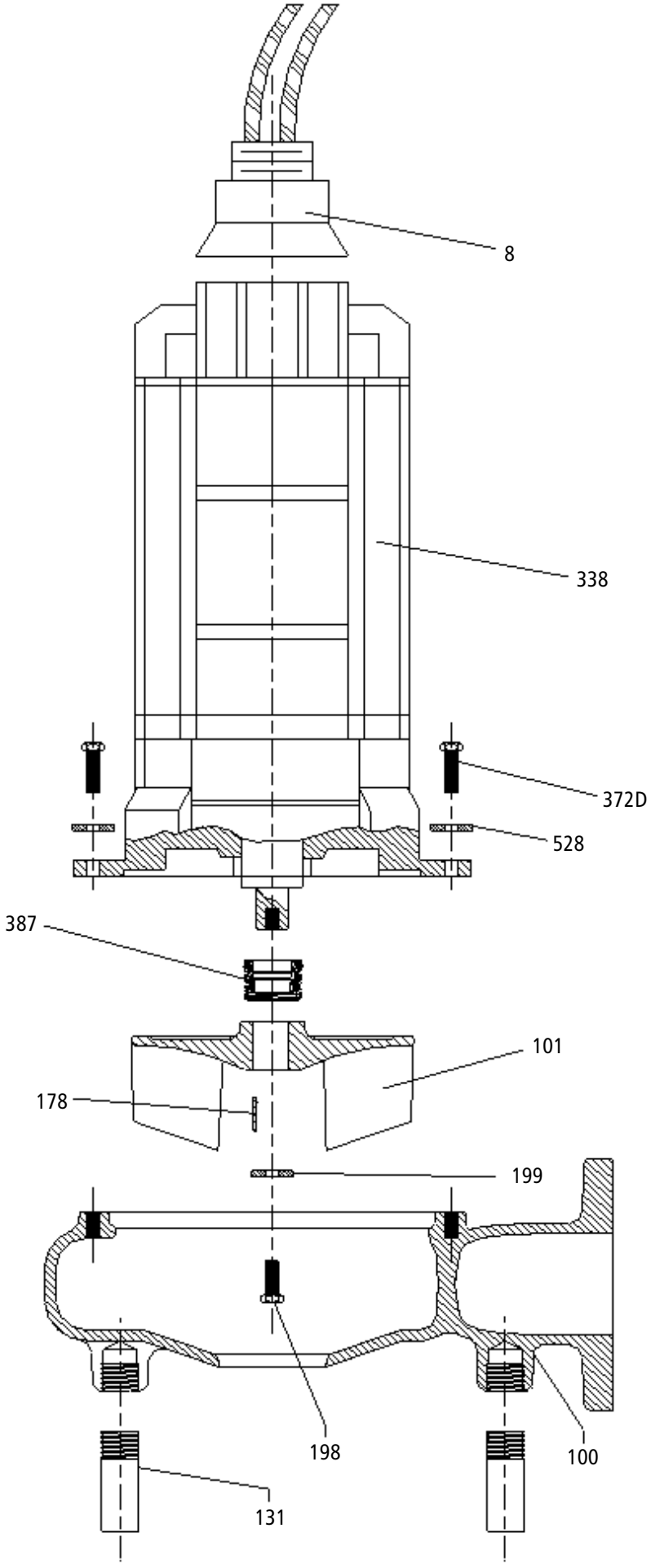
MODELS 3888D3/3SD, 3888D4/4SD

Item No.	Part Description	Material	Qty. Req.	Repair Parts Order Number – 1725 RPM						Max. Wt. (Lbs.)
				1½ HP M	1½ HP	2 HP	3 HP	5 HP	7½ HP	
100	Casing – 3888D3, 3SD	Cast Iron	1	1K190						42.0
	Casing – 3888D4, 4SD			1K219						52.0
101	Impeller – 3888D3, 3SD, Standard	Cast Iron	1	2K514 5¼"	2K24 6½"	2K25 7.0"	2K26 7¼"	2K27 8.0"	N/A	7.0
	Impeller – 3888D3, 3SD, Optional	Bronze		2K515 5¼"	2K284 6½"	2K285 7.0"	2K286 7¼"	2K287 8.0"	N/A	8.0
	Impeller – 3888D4, 4SD, Standard	Cast Iron		2K512 5⅝"	2K294 6¼"	2K295 6⅝"	2K296 7.0"	2K830 7¼"	2K532 $7^{1}/_{16}$"	7.5
	Impeller – 3888D4, 4SD, Optional	Bronze		2K513 5⅝"	2K329 6¼"	2K328 6⅝"	2K327 7.0"	2K326 7¼"	2K533 $7^{1}/_{16}$"	8.5
112A	Lower Ball Bearing	Steel	1	4K135					4K402	–
112B	Upper Ball Bearing	Steel	1	4K384						–
131	Pump Leg - Standard	Steel	3	4K42						–
	Pump Leg - Optional	Cast Iron	1	4K625						–
132	Eye Bolt	Galvanized Steel	1	13K193						–
178	Impeller Key	AISI 300 SS	1	4K11						–
184	Seal Housing – 3888D3, 3SD	Cast Iron	1	1K189					N/A	19.0
	Seal Housing – 3888D4, 4SD	Cast Iron	1	1K218						18.0
198	Impeller Bolt	17-4PH SS	1	13K48						–
199	Impeller Washer	AISI 300 SS	1	13L39						–
218	Insulating Turbine Oil	Turbine Oil - ASTM 150	–	4K432						7.5 lbs./gal.
	Gallons required in Seal Housing			3888D3, 3SD - .44 — 3888D4, 4SD - .38						
	Gallons required in Motor Cover			1.75					1.5	
246	Seal Sensor - Available Only on 3SD, 4SD	Nylon/Brass	1	9K191						–
338	Motor – 1 Phase, 208V	Stainless Steel Shaft	1	114-9210R	114-9210R	114-9210R	114-9210R	N/A	N/A	–
	Motor – 1 Phase, 230V			114-925R	114-925R	114-926R	114-927R	114-928R	N/A	
	Motor – 3 Phase, 200 V			114-9230R	114-9230R	114-9230R	114-9231R	114-9232R	N/A	
	Motor – 3 Phase, 230/460 V			114-9217R	114-9217R	114-9217R	114-9218R	114-9219R	119-961R	
	Motor – 3 Phase, 575 V			114-9227R	114-9227R	114-9227R	114-9228R	114-9229R	119-963R	
340	Bearing Housing	Cast Iron	1	1K176					1K303	28.0
341	Motor Cover– 3888D3, 3888D4	Cast Iron	1	1K177						39.0
	Motor Cover – 3SD, 4SD	Cast Iron	1	1K299						39.0
352	Hex Cap Screw-Seal Housing to Bearing Housing	AISI 300 SS	4	13K81						–
358	Plug – Seal Housing ¼" NPT	AISI 300 SS	2	6K168						–
358E	Plug – Motor Cover ½" NPT	AISI 300 SS	1*	6K170						–
361	Retaining Ring	AISI 300 SS	1	4K305						–
372D	Hex Screw – Bearing Housing to Motor Cover and Seal Housing to Casing	AISI 300 SS	8	13K186						–
376	Capacitor, Run - 1 Phase, 208 V	Varies	1	9K262 Qty. - 2	9K262 Qty. - 2	9K262 Qty. - 2	9K262 Qty. - 2	N/A		–
	Capacitor, Run - 1 Phase, 230 V - 9K332, pre D06 - 2 HP, pre F06 - 1.5 HP			9K332 Qty. - 1	9K332 Qty. - 1	9K332 Qty. - 1	9K262 Qty. - 2	9K332 Qty. - 2	N/A	–
	Capacitor, Run - 1 Phase, 230 V - 9K456, D06 - 2 HP, F06 - 1.5 HP			9K456 Qty. - 2	9K456 Qty. - 2	9K456 Qty. - 2	9K262 Qty. - 2	9K332 Qty. - 2	N/A	–
383	Mechanical Seal – Upper	Carbon/Ceramic	1	10K21 (Type 21)						–
387	Mechanical Seal – Lower (Standard)	Silicon Carbide	1	10K28 (Type 31)						–
	Mechanical Seal – Lower (Optional)	Tungsten Carbide	1	10K22 (Type 31)						–
412M	O-Ring – Bearing Housing to Motor Cover	BUNA-N, AS568A-374	1	4K242						–
412P	O-Ring – Bearing Housing to Seal Housing	BUNA-N, AS568A-265	1	5K74						–
457	Wire Nut (Power Cable) 1 Phase	Special Nylon Housing	2	9K145 (14/3 Cords), 9K252 (10/3 Cords)					N/A	–
	Wire Nut (Power Cable) 3 Phase		6	9K145 (14/4 Cords), 9K252 (10/4 Cords)						–
	Wire Nut (Power Cable) Sensor Cable		2	9K145						–
484	Strain Relief Assembly – Sensor Cable	Varies	1	5K113						–
484B	Strain Relief Assembly (Power Cable) 1 Phase	Varies	1	5K234 (14/3 Cords), 5K355 (10/3 Cords)					N/A	–
	Strain Relief Assembly (Power Cable) 3 Phase			5K226 (14/4 Cords), 5K227 (10/4 Cords)						–
	Seal Installation Tool – Guide	Delrin	1	A01A008						–
	Seal Installation Tool – Driver	Delrin	1	A02A017						–
	Loctite #271		1	AL27121						–

* 1 for 3SD/4SD and 2 for 3888D3/3888D4.

Power and Sensor Cables Description	Type and AWG Size	Standard Length	Optional Lengths			Wt. (lbs./5 ft.)
		20'	30'	50'	100'	
Item No. 456, Power Cables						
1 PH: 1½ and 2 HP, 230 V, standard with bare leads.	STOW – 14/3	9K266	9K267	9K268	9K269	0.9
1 PH: 2 HP, 3 HP and 5 HP, 208 V, standard with bare leads.	STOW – 10/3	9K289	9K290	9K291	9K293	1.6
3 PH: 1½, 2 HP, 3 HP (except 200 V) and 5 HP, 460 V, 575 V – bare leads.	STOW – 14/4	9K153	9K218	9K154	9K219	1.1
3 PH: 3 HP, 200 V, 5 HP 200/230 V and all 7½ HP – bare leads.	STOW – 10/4	9K251	9K247	9K248	9K250	1.6
Item No. 455A, Sensor Cables						
Mechanical Seal Sensor: Standard on 3SD and 4SD. (N/A on 3888D3 and 3888D4)	SJTOW – 16/2	9K189	9K220	9K221	9K222	0.5
Seal/Heat Sensor: Optional on 3SD and 4SD.	SJTOW – 18/4	9K237	9K238	9K239	9K240	0.5

MODELS 3SDX/4SDX



MODELS 3SDX/4SDX

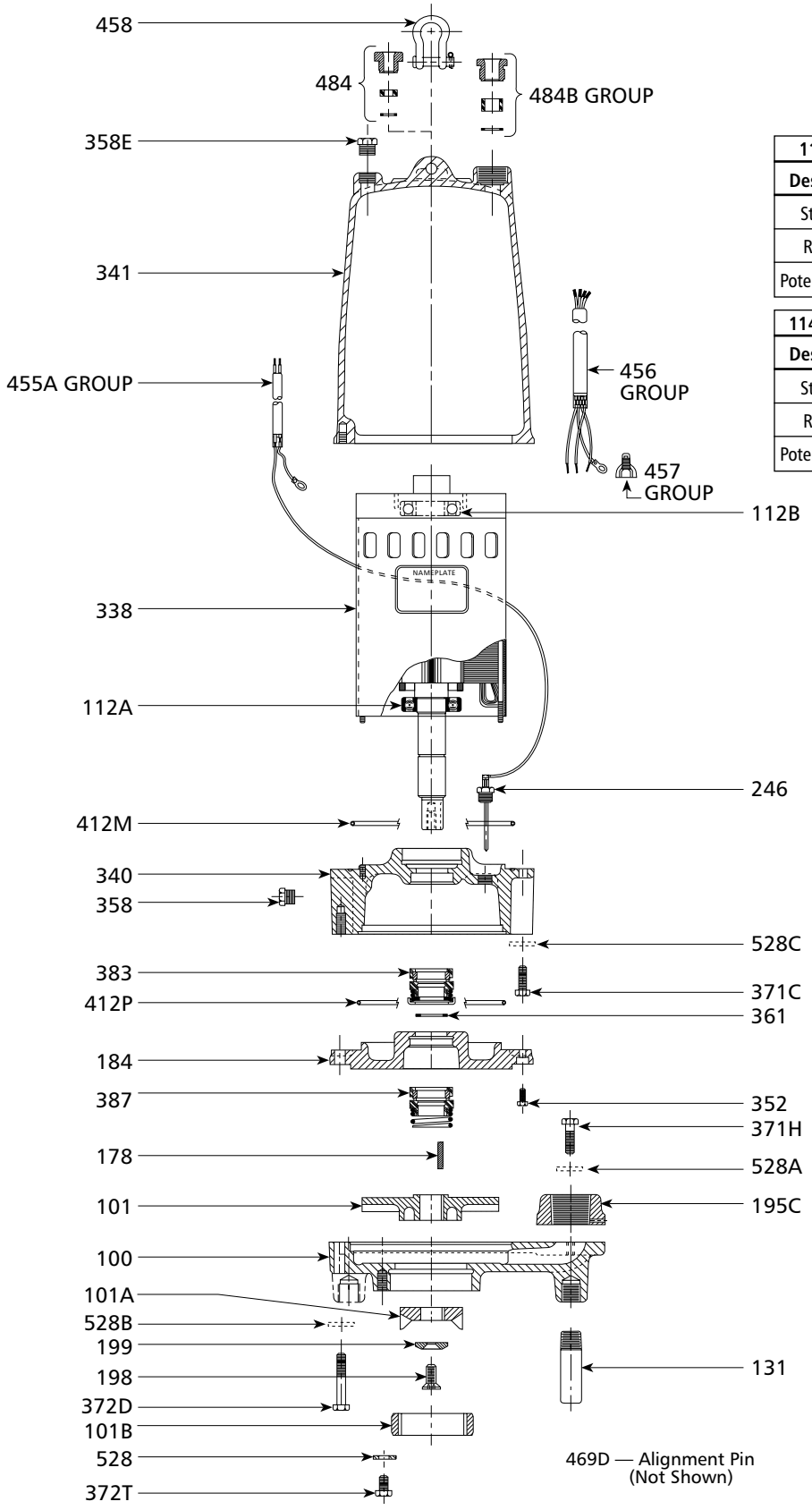
Item No.	Part Description		Material	Qty. Reqd.	Repair Parts Order Number					Max. Wt. (lbs.)
					1750 RPM					
					1½ HP	2 HP	3 HP	5 HP	7½ HP	
100	Casing – 3SDX		Cast Iron	1	1K429					35.0
	Casing – 4SDX				1K428					53.0
101	Impeller – 3SDX		Cast Iron	1	2K918 $5^{13}/_{16}$"	2K916 $6^{1}/_{8}$"	2K914 $6^{3}/_{4}$"	2K912 $7^{5}/_{8}$"	2K910 $8^{5}/_{16}$"	
	Impeller – 3SDX		Bronze		2K919 $5^{13}/_{16}$"	2K917 $6^{1}/_{8}$"	2K915 $6^{3}/_{4}$"	2K913 $7^{5}/_{8}$"	2K911 $8^{5}/_{16}$"	
	Impeller – 4SDX		Cast Iron		N/A	2K904 $5^{11}/_{16}$"	2K906 $6^{5}/_{16}$"	2K908 $7^{1}/_{8}$"	2K532 $7^{11}/_{16}$"	
	Impeller – 4SDX		Bronze			2K905 $5^{11}/_{16}$"	2K907 $6^{5}/_{16}$"	2K909 $7^{1}/_{8}$"	2K533 $7^{11}/_{16}$"	
131	Foot - Standard		Steel	3	4K42					–
	Foot - Optional		Cast Iron	1 Kit	4K625					–
178	Impeller Key		AISI 300 SS	1	4K11					–
198	Impeller Bolt		17-4 PH	1	13K48					–
199	Impeller Washer		AISI 300 SS	1	13L39					–
338	Motor	1 Phase, 230V	Stainless Steel	1	278-72 12	278-72 22	278-72 32	N/A	N/A	**180TY** 200 lbs. Air Filled
		3 Phase, 200V			278-72 13	278-72 23	278-72 33	278-72 43	278-72 53	
		3 Phase, 230V			278-72 14	278-72 24	278-72 34	278-72 44	278-72 54	
		3 Phase, 460V			278-72 15	278-72 25	278-72 35	278-72 45	278-72 55	
		3 Phase, 575V			278-72 16	278-72 26	278-72 36	278-72 46	278-72 56	
372D	Hex Cap Screw - Casing to Motor		AISI 300 SS	8	13K304					–
387 **NEW STYLE**	Mechanical Seal – Standard		Carbon/Ceramic	1	10K137 (180TY)					–
	Mechanical Seal – Optional		Silicon/Silicon	1	10K134 (180TY)					
	Mechanical Seal – Optional		Silicon/Tungsten	1	10K135 (180TY)					
387 **OLD STYLE**	Mechanical Seal – Standard		Carbon/Ceramic	1	10K136 (140TY)					–
	Mechanical Seal – Optional		Silicon/Silicon	1	10K132 (140TY)					
	Mechanical Seal – Optional		Silicon/Tungsten	1	10K133 (140TY)					
528	Lockwasher		AISI 300 SS	8	13K158					–

Reliance	Part Description	Material	Quantity	Repair No.	Motor Frame
Motor Repair Parts	Mechanical Seal Kit – Upper & Lower	Carbon/Ceramic	1 Set	10K183	180TY
	Bearing Kit – Upper & Lower	Steel	1 Set	4K700	
	O-Ring Kit	BUNA-N	1 Set	5K422	

Models 3SDX/4SDX, Power and Control Cap/Cables	Type and AWG Size	Standard length	Optional Lengths	Wt. (lbs./5 ft.)
		25'	50'	
1 PH: 1½ HP, 230V, 140TY	SOW, SOOW – 10/4	9K357	9K358	
1 PH: 1½, 2 and 3 HP, 230V, 180TY	SOW, SOOW – 8/4	9K359	9K360	
3 PH: 1½, 2 and 3 HP, 200-230/460/575V, 140TY	SOW, SOOW – 14/4	9K361	9K362	
3 PH: 5 HP, 200-230/460V, 180TY	SOW, SOOW – 12/4	9K365	9K366	
3 PH: 7½ HP, 200-230/460V, 180TY	SOW, SOOW – 10/4	9K367	9K368	
3 PH: 5 and 7½ HP, 575V, 180TY	SOW, SOOW – 14/4	9K363	9K364	
3 PH: 1½, 2 and 3 HP, 200, 230, 460, 575V, 180TY	SOW, SOOW – 14/4	9K363	9K364	

Control Cable is AWG Size 18/5 - SOW.

MODEL 1GD



114-92 New Capacitor Package – 10/05			
Description	**Repair**	**MFD**	**VAC**
Start Cap	CP1GDB	238	330
Run Cap		50	370
Potential Relay		155031 - 102 or 110	

114-92 Old Capacitor Package – Pre 10/05			
Description	**Repair**	**MFD**	**VAC**
Start Cap	CP-1B	594	125
Run Cap		30	370
Potential Relay		RB60 (155031 - 102)	

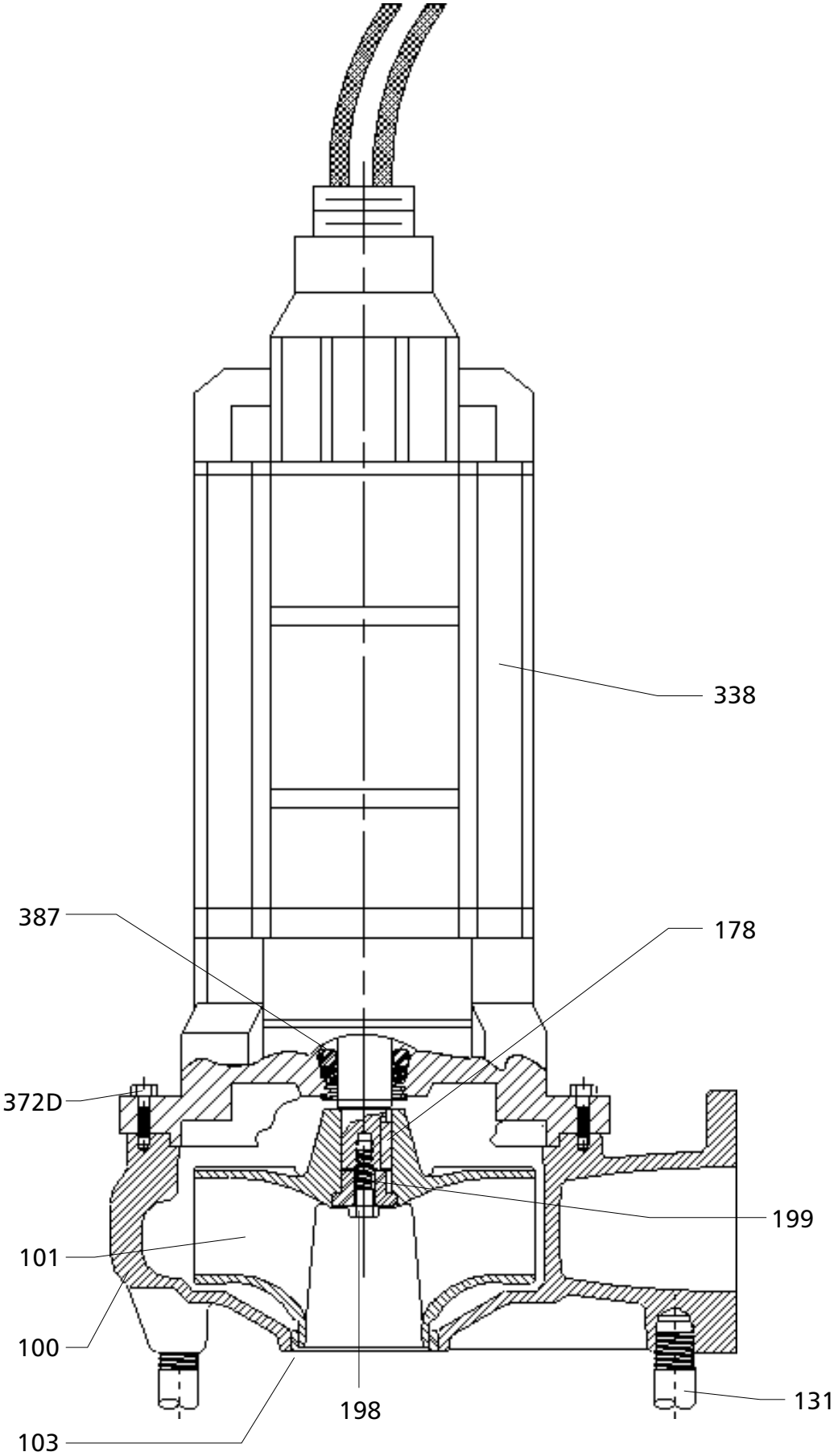
Item No. 456, Power Cables	**Type and AWG Size**	**Standard length**	**Optional Lengths**			**Wt.**
		20'	**30'**	**50'**	**100'**	**(lbs./5 ft.)**
1 and 3 PH: 2 HP, 200–230/460/575V with bare leads.	STOW – 14/4	9K153	9K218	9K154	9K219	1.1
Item No. 455A, Sensor Cables						
Mechanical Seal Sensor - Optional	SJTOW – 16/2	9K189	9K220	9K221	9K222	0.5
Heat Sensor - Standard 1 Phase, Optional 3 Phase.	SJTOW – 16/2	9K189	9K258	9K259	9K260	0.5
Mechanical Seal/Heat Sensor - Optional	SJTOW – 18/4	9K237	9K238	9K239	9K240	0.5

MODEL 1GD

Item No.	Part Description	Material	Quantity Required	Repair Parts Order Number	Weight (lbs.)
100	Casing	Cast Iron	1	1K174	10.5
101	Impeller – 8th Digit Model Designation and Diameter	Bronze	1	2K247 A = 5⅝"	3.0
				2K332 B = 5¼"	
				2K333 C = 4¾"	
				2K334 D = 4¼"	
101A	Cutter	AISI 440C SS	1	4K303	0.5
101B	Cutter Ring	AISI 440C SS	1	4K304	0.5
112A	Lower Ball Bearing	Steel	1	4K135	–
112B	Upper Ball Bearing	Steel	1	4K384	–
131	Foot – Standard	Steel	3	4K343	–
	Foot – Optional	Cast Iron	1 Kit	4K639	
178	Impeller Key	AISI 300 SS	1	4K11	–
184	Seal Housing	Cast Iron	1	1K226	8.5
195C	Discharge Flange	Cast Iron	1	4K313	1.0
198	Impeller Screw	AISI 300 SS	1	13K190	–
199	Impeller Washer	AISI 300 SS	1	13K191	–
218	Insulating Oil – Gallons Required	Turbine Oil - ASTM150	–	4K245	7.5 lbs./gal.
	Gallons Required in Seal Housing			0.98	
	Gallons Required in Motor Cover			0.23	
246	Seal Sensor - Plug and Rod (See Note)	Nylon/Brass	1	9K191	–
338	Motor – 1 Phase, 208V	Stainless Steel Shaft	1	114-921R	26.0 to 40.0
	Motor – 1 Phase, 230V			114-921R	
	Motor – 3 Phase, 200V			114-9220R	
	Motor – 3 Phase, 230/460V			114-9212R	
	Motor – 3 Phase, 575V			114-9292R	
340	Bearing Housing	Cast Iron	1	1K227	14.5
341	Motor Cover with Seal Sensor (See Note)	Cast Iron	1	1K197	23.0
	Motor Cover without Seal Sensor (See Note)			1K209	
352	Screw - Seal Housing to Bearing Housing	AISI 300 SS	2	13K347	–
358	Plug – Bearing Housing ¼" NPT	AISI 300 SS	1	6K168	–
358E	Plug – Motor Cover ⅜" NPT	AISI 300 SS	1	6K169	–
361	Retaining Ring	Steel	1	4K305	–
371C	Hex Cap Screw – Brg. Hsg. to Motor Cover	AISI 300 SS	4	13K78	–
371H	Hex Cap Screw – Discharge Flange to Casing	AISI 300 SS	2	13K186	–
372D	Hex Cap Screw – Casing to Bearing Housing	AISI 300 SS	4	13K52	–
372T	Hex Cap Screw – Cutter Ring Retainer	AISI 300 SS	3	13K218	–
383	Mechanical Seal – Upper	Carbon/Ceramic	1	10K21 (Type 21)	–
387	Mechanical Seal – Lower (Standard)	Silicon Carbon	1	10K28 (Type 31)	–
	Mechanical Seal – Lower (Optional)	Tungsten Carbon		10K22 (Type 31)	
412M	O-ring – Motor Cover	BUNA-N, AS568A-166	1	4K252	–
412P	O-ring – Seal/Bearing Housing	BUNA-N, AS568A-256	1	5K73	–
457	Wire Nut	Power Cable - 1 Ph., 230V	Nylon Housing	3	9K145	–
		Power Cable - 3 Ph., 200/230V		4		
		Power Cable - 3 Ph., 460V		6		
		Power Cable - 3 Ph., 575V		3		
		Seal/Heat Cable - See Note		2		
458	Lifting Handle	304 SS	1	4K494	–
469D	Alignment Roll Pin (Not Shown)	Steel	2	9K265	–
484	Strain Relief Assembly, Sensor Cable (See Note)	Varies	1	5K113	–
484B	Strain Relief Assembly, Power Cable	Varies	1	5K111	–
528	Washer –Cutter Ring Retainer	AISI 300 SS	3	13K212	–
528A	Lockwasher –Discharge Flange to Casing	AISI 300 SS	2	13K158	–
528B	Lockwasher –Casing to Bearing Housing	AISI 300 SS	4	13K158	–
528C	Lockwasher –Bearing Housing to Motor Cover	AISI 300 SS	4	13K117	–
–	Heat Sensor Kit (See Note)	–	1	9K261	–
–	Seal Installation Tool - Guide	Delrin®	1	A01A008	–
–	Seal Installation Tool - Driver	Delrin®	1	A02A017	–
–	Loctite® #271	–	1	AL27121	–

Notes: 1 phase (Old 114-92 #2 motor) has Heat Sensor (93711) supplied with motor, Goulds 3 phase is optional, Marlow 3 phase is standard.
New 1 Phase 114-92 #1 motor has in-line thermal protector
Old 1 Phase 114-92 #2 motor had pilot duty thermal protector

MODELS 4NS/4XD with Reliance Motors



MODELS 4NS/4XD with Reliance Motors

Item No.	Part Description		Material	Qty. Reqd.	Repair Parts Order Number									Max. Wt. (lbs.)
					1750 RPM							1150 RPM		
					7½ HP	10 HP	15 HP	20 HP	25 HP	30 HP	40 HP	7½ HP	10 HP	
100	Casing – with Wear Ring		Cast Iron	1	1K326									75.0
101	Impeller – 4NS/4XD		Cast Iron		2K781 7½"	2K779 8"	2K776 9"	2K774 9¾"	2K772 10⅜"	2K771 10¾"	2K770 11"	2K773 10⅛"	2K770 11"	21.5-28.0
	Impeller – 4NS/4XD		Bronze		2K795 7½"	2K793 8"	2K790 9"	2K788 9¾"	2K786 10⅜"	2K785 10¾"	2K784 11"	2K787 10⅛"	2K784 11"	25.0-32.5
103	Casing Wear Ring		Bronze	1	4K264									2.0
131	Foot - Standard		Steel	3	4K367 (Old), 4K42 (New)									2.0
	Foot - Optional		Cast Iron	1 Kit	4K625									–
178	Impeller Key		AISI 300 SS	1	4K392									–
198	Impeller Bolt		AISI 300 SS	1	13K275									–
199	Impeller Washer		AISI 300 SS	1	4K431									–
338	Motor	3 Phase, 200V	Replace 279-26 with 279-27 for UL listed Explosion Proof Motor. Index Suffixes are the same.	1	279-26 1 (210TY)	279-26 11 (210TY)	279-26 21 (210TY)	279-26 31 (210TY)	279-26 41 (250TYS)	279-26 51 (250TYS)	279-26 61 (250TYS)	279-26 71 (210TY)	279-26 81 (210TY)	**210TY** 315 lbs. Air Filled **250TYS** 750 lbs. Air Filled
		3 Phase, 230V			279-26 2 (210TY)	279-26 12 (210TY)	279-26 22 (210TY)	279-26 32 (210TY)	279-26 42 (250TYS)	279-26 52 (250TYS)	279-26 62 (250TYS)	279-26 72 (210TY)	279-26 82 (210TY)	
		3 Phase, 400V			279-26 3 (210TY)	279-26 13 (210TY)	279-26 23 (210TY)	279-26 33 (210TY)	279-26 43 (250TYS)	279-26 53 (250TYS)	279-26 63 (250TYS)	279-26 73 (210TY)	279-26 83 (210TY)	
		3 Phase, 460V			279-26 4 (210TY)	279-26 14 (210TY)	279-26 24 (210TY)	279-26 34 (210TY)	279-26 44 (250TYS)	279-26 54 (250TYS)	279-26 64 (250TYS)	279-26 74 (210TY)	279-26 84 (210TY)	
		3 Phase, 575V			279-26 5 (210TY)	279-26 15 (210TY)	279-26 25 (210TY)	279-26 35 (210TY)	279-26 45 (250TYS)	279-26 55 (250TYS)	279-26 65 (250TYS)	279-26 75 (210TY)	279-26 85 (210TY)	
372D	Hex Cap Screw - Casing to Motor		AISI 300 SS	8	13K45									–
387	Mechanical Seal – Standard		Carbon/Ceramic	1	10K157				10K160			10K157		–
	Mechanical Seal – Optional		Silicon/Silicon	1	10K158				10K161			10K158		
	Mechanical Seal – Optional		Silicon/Tungsten	1	10K159				10K162			10K159		

Power and Control Cap/Cables for Reliance Motors

Type and AWG Size	Standard length 25'	Optional Lengths 50'	Wt. (lbs./5 ft.)
SOW, SOOW 14/4	9K423	9K431	
SOW, SOOW 12/4	9K424	9K432	
SOW, SOOW 10/4	9K425	9K433	
SOW, SOOW 8/4	9K426	9K434	
SOW, SOOW 6/4	9K427	9K435	
SOW, SOOW 4/4	9K428	9K436	
SOW, SOOW 2/4	9K429	9K437	
SOW, SOOW 1/0/4	9K430	9K438	

Control Cable is AWG Size 18/5 - SOW-A, SO.

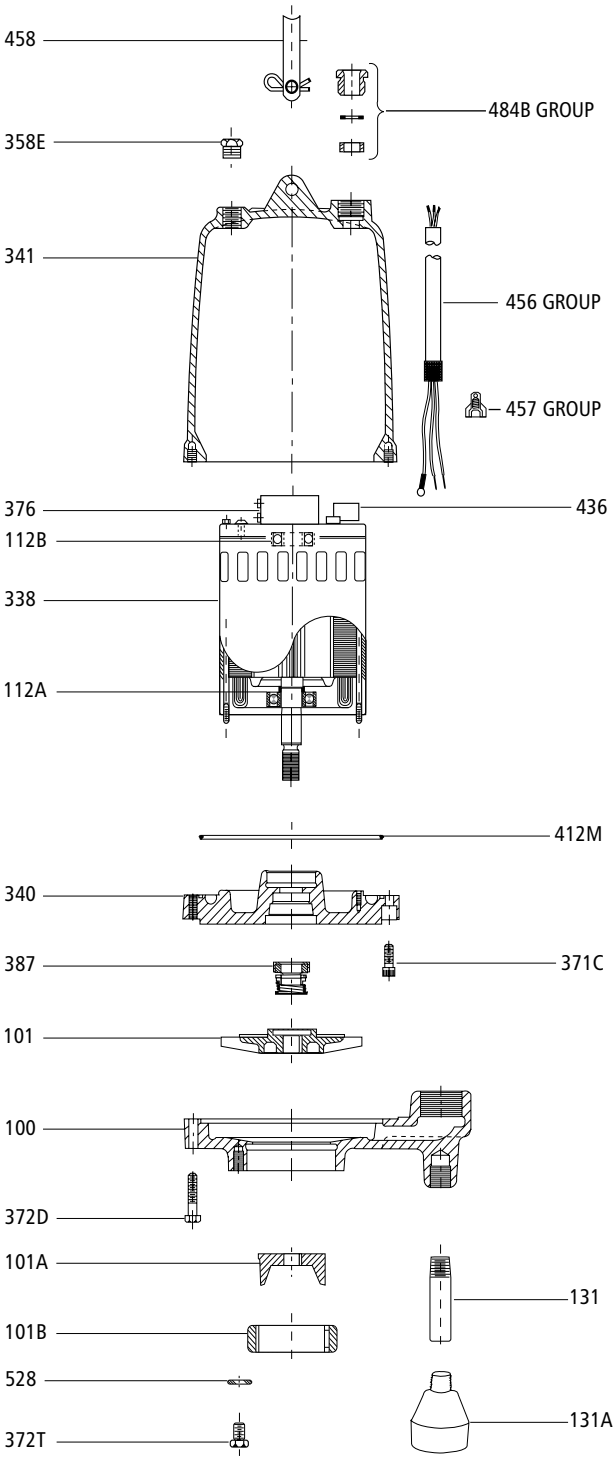
Parts for Pumps with USEM Motors							
372E	Hex Cap Screw - Bracket to Motor	AISI 300 SS	2	13K226	13K277	13K226	–
387	Mechanical Seal – Optional	Carbon/Ceramic	1	10K82	10K142	10K82	–
	Mechanical Seal – Optional	Silicon/Tungsten	1	10K83	10K85	10K83	
458	Lift Bracket	AISI 300 SS	1	4K433	4K434	4K433	3.5

Reliance	Part Description	Material	Quantity	Repair No.	Motor Frame	Repair No.	Motor Frame
Motor Repair Parts	Mechanical Seal Kit – Upper & Lower	Carbon/Ceramic	1 Set	10K181	210TY	10K182	250TY
	Bearing Kit – Upper & Lower	Steel	1 Set	4K698		4K699	
	O-Ring Kit	BUNA-N	1 Set	5K420		5K421	

Power and Control Cap/Cables for USEM Motors	Type and AWG Size	Standard Length 25'	Optional Lengths 50'
7½ – 15 HP, 200/230/380V; 7½ – 30 HP, 460/575V	SO – 8/4	9K279	9K280
20 – 25 HP, 200/230V	SO – 4/4	9K281	9K282
30 HP, 200/230V	SO – 2/4	9K283	9K284

Control Cable is AWG Size 18/5 - SOW-A, SO.

MODEL RGS2012



Item No.	Part Name	Material	Qty.	Repair Parts Order Number	Wt. (lbs.)
100	Casing	Cast iron	1	1K313	11
101	Impeller 5.69" dia.	Bronze	1	2K705	2.0
101A	Cutter with shims	AISI 440C SS	1	4K409	0.5
101B	Cutter ring	AISI 440C SS	1	4K304	0.5
112A	Lower ball bearing	Steel	1	4K384	–
112B	Upper ball bearing	Steel	1	4K132	–
131	Foot	Steel	3	4K343	–
131A	Optional Pump Legs	Steel	3	4K639	–
218	Insulating oil	Turbine Oil ASTM150	.98 gal	4K432 See Index Page	7.5 lbs/gal
338	Motor with Brg. Hsg. #340	–	–	120-212R	19
340	Bearing housing	Cast iron			
341	Motor cover – Use with cord with NEMA plug	Cast iron	1	1K207	18.5
	power cable without plug			1K208	
358E	Plug – motor cover 3/8" NPT	AISI 300 SS	1	6K169	–
371C	Screw – bearing housing to motor cover	AISI 300 SS	4	13K271	–
372D	Screw – casing to bearing housing	AISI 300 SS	4	13K336	–
372T	Screw – cutter ring retainer	AISI 300 SS	3	13K218	–
376	Capacitor (start)	–	1	9K353	–
387	Mechanical seal (standard)	Silicon Carbide	1	10K119	–
	Mechanical seal (optional)	Tungsten Carbide		10K123	–
412M	O-ring – motor cover	BUNA-N	1	4K252	–
436	Solid state switch	–	1	9K395	–
456	Power cable	–	1	See power cable chart	–
457	Wire nut	Nylon	2	9K145	–
458	Handle assembly	AISI 300 SS	1	4K243	–
484B	Strain relief assembly – power cable with plug	Varies	1	5K113	–
	power cable without plug			5K111	
528	Washer – cutter ring retainer	AISI 300 SS	3	13K212	–

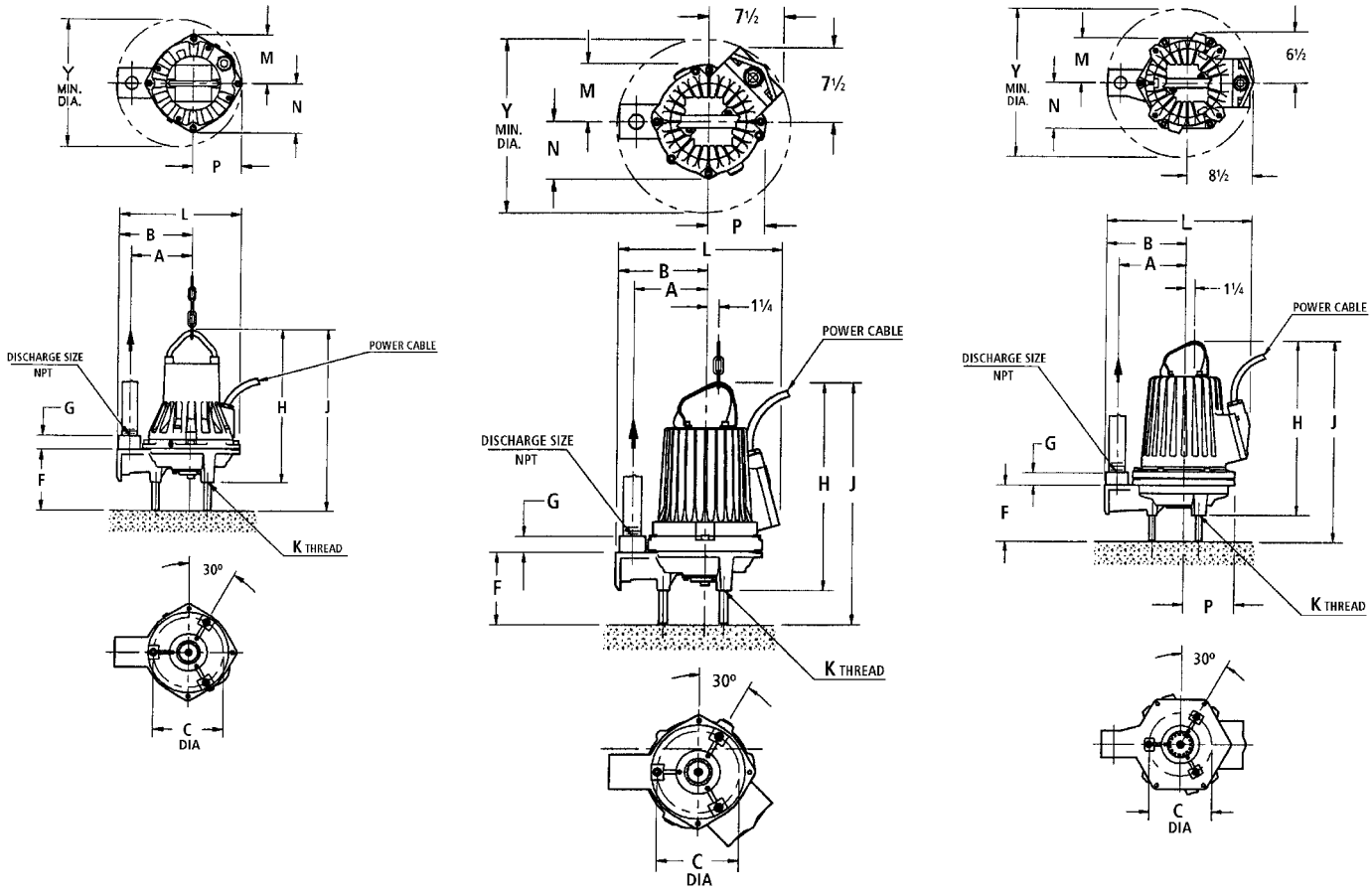
RESIDENTIAL GRINDER POWER CABLES

Residential Grinder Power Cables	Standard length	Optional Lengths			Wt. (lbs./5 ft)
	20'	30'	50'	100'*	
1 Phase, 2 HP, 230V - STOW - 14/3 with bare leads	9K266	9K267	9K268	9K269	0.9
1 Phase, 2 HP, 230V - SJTOW - 14/3 with Nema plug	9K393	9K394	N/A	N/A	0.9

* Maximum allowable cord length. ** Includes 230V NEMA plug.

9K353 capacitor is a 295/355 MFD, 125 VAC start capacitor with resistor.

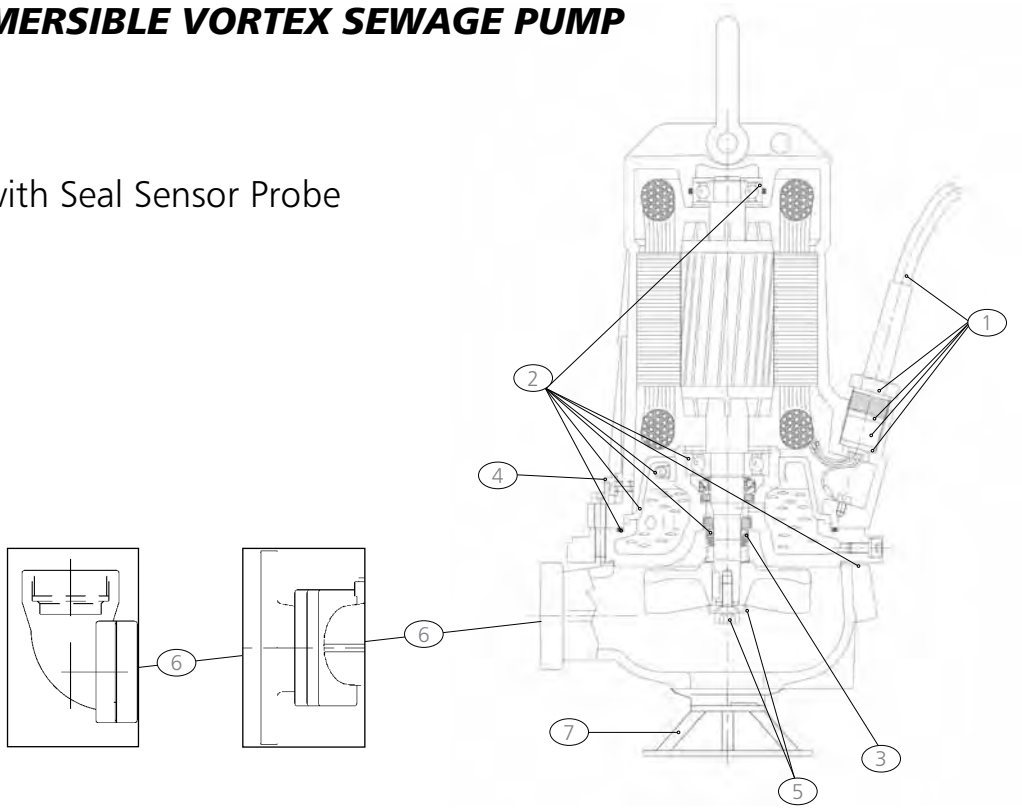
MODELS 1GA/2GA



Please contact Customer Service for part information.
Phone (315) 568-7123 or Fax (888) 3222-5877 (toll free)

ROBOT – SUBMERSIBLE VORTEX SEWAGE PUMP

Dual Seal with Seal Sensor Probe



Goulds Part No.	Item No.	Robot Pump	Description	Included
9K502	1	Up to and including 5.4 HP	14/7 cable with accessories and connections	Cable, cable entry gland, clamp, sleeve, cable connectors crimps and hardware
9K503		Up to and including 16.5 HP	12/7 cable with accessories and connections	Cable, cable entry gland, clamp, sleeve, cable connectors crimps and hardware
5K459	2	Up to and including 6.2 HP	Repair Kit	Bearings, both mechanical seals, o-rings and gaskets
10K193	3	Up to 6.2 HP	Lower Mechanical Seal	Lower Mechanical Seal
5K463	4	Up to 6.2 HP	Dobo Ring	Dobo ring
4K789	5	Up to 6.2 HP	Impeller Hardware	Key, cap, screw
1K588	6	2" Discharge kit	2" discharge Kit	2" Discharge Elbow, NPT
1K589		3" Discharge Kit	3" Discharge Kit	3" Discharge Flanged
1K590		4" Discharge Kit	4" Discharge Kit	4" Discharge Flanged
1K591	7	2" - 2.5" Suction Pump Stand**	See suction size on bulletin	Pump Stand
1K592		2.88" Suction Pump Stand**		
1K593		3" Suction Pump Stand**		
1K594		4" Suction Pump Stand**		

* Higher HP accessories will be special ordered. ** Note: These are rated on SUCTION size NOT discharge.

CONTROL PANEL REPAIR PARTS

RB Number	Description	SES Control Panel	"A" Series Control Panel	Manufacturing Number
RB-1	Single phase contactor, 2 pole	D10020, D10020N1, D10027, D10036	A6-0511, A6-1012, A-2012, A6-3012, A-5012, G6-2012	Furnas 41NB20AFP
RB-3	Pump circuit breaker		A6-2012 (After 11/98)	Square D – QOU225
RB-4	Pump circuit breaker		A6-3012	Square D – QOU230
RB-5	Pump circuit breaker		A6-5012	Square D – QOU240
RB-6	Pump circuit breaker		G6-2012 / A6-1012	Square D – QOU220
RB-15	Duplex alternator		A6-0511, A6-1012, A6-2012, A6-5032, A6-5034, A5-1 (Before 11/98)	Potter and Brumfield S89R5ABD1-120
RB-29	Same as RB-6		A6-1012	Same as RB-6
RB-30	Control circuit breaker		A6-1012, A6-2012, A6-0511	Square D – QOU110
RB-31	Seal sensor relay		A4-3, A4-4	Boulay BFI-SFR-120
RB-32*	Single phase contactor, 2 pole with auxiliary contact	S10020, S10020N1, S10027, S10036 with relays	A3-2012, A3-3012, A3-5012,G3-2012	Furnas 41NB20AFPM6R used on panels with relays
RB-33	Three phase motor starter		A3-5034, A6-5032, A6-5034	Furnas 15DF32AF81
RB-34	Control circuit transformer	All three phase SES controls	A3-5034, A6-5032, A6-5034	Square D – XF75
RB-35	Time delay relay		A6-0511, A6-1012, A6-2012, A6-5032, A6-5034, A5-1 (Before 11/98)	SSAC, TSD 74115
RB-36	Control relay	All SES simplex controls	A6-0511, A6-1012, A6-2012, A6-5032, A6-5034, A5-1, A4-1, A4-1N4 (Before 11/98)	Potter and Brumfield KUP14A15-120
RB-37	Pump circuit breaker		A6-0511	Square D – QOU115
RB-38	Pump circuit breaker		A6-2012 (Before 11/98)	Square D – QOU215
RB-39	Control circuit breaker		A6-5032	Square D – QOU210
RB-40	Pump circuit breaker		A6-5032	Square D – QOU330
RB-41	Control circuit breaker		A6-5034	Airpax 219-2-1-63-7-2-10
RB-42	Pump circuit breaker		A6-5034	Airpax 219-3-1-63-7-2-15
RB-43	Control circuit breaker	D10020, D10020N1, S10020, S10020N1	(Before 11/98)	Potter and Brumfield W28-XQTA-3
RB-44	Same as RB-43		A4-1	Same as RB-43
RB-45	Control module – OBSOLETE		A6-0511, A6-1012, A6-2012, A6-5032, A6-5034 (Before 11/98)	Boulay BFI-8630 – no longer available
RB-46	Three phase contactor, 3 pole with auxiliary	S31625-S32025		Furnas 41NB30AFPM6R
RB-47	Three phase contactor, 3 pole	D31625-D32025		Furnas 41NB30AFP
RB-48	Latching relay board alternating relay	All SES duplex panels	(Before 11/98)	Boulay BFI2-002-120
RB-49	Relay interface board	All SES duplex panels	(Before 11/98)	Boulay BFI3-003-120

** Panels with plug-in relays. Units with printed circuit boards use RB-81.*

Continued on next page.

CONTROL PANEL REPAIR PARTS (continued)

RB Number	Description	SES Control Panel	"A" Series Control Panel	Manufacturing Number
RB-50	Alarm horn	All SES controls		Floyd MW-09-201-QC
RB-51	Control relay	All SES duplex controls	A4-1, A4-1N4 (After 11/98)	Potter and Brumfield KHUA-11A11-120
RB-52	Motor circuit protector	S31625, D31625		Cutler Hammer A-302 GN
RB-53	Motor circuit protector	S32540, D32540		Cutler Hammer A-302 HN
RB-54	Motor circuit protector	S34063, D34063		Cutler Hammer A-302 JN
RB-55	Motor circuit protector	S36310, D36310		Cutler Hammer A-302 KN
RB-56	Motor circuit protector	S31016, D31016		Cutler Hammer A-302 LN
RB-57	Motor circuit protector	S31620, D31620		Cutler Hammer A-302 MN
RB-58	Motor circuit protector	S32025, D32025		Cutler Hammer A-302 NN
RB-59	Overload relay		A3-5012, A3-3012, A6-3012, A6-5012, G3-2012, G6-2012	Furnas 48DA18AA4
RB-60	Motor start relay		G3-2012, G6-2012	Franklin Electric 155031102
RB-61	Motor start capacitor		G3-2012, G6-2012	Mallory 580UF
RB-62	Motor run capacitor		G3-2012, G6-2012	30UFC370VAC
RB-63	Flashing red alarm light	All SES simplex panels (before 11/98)		BL4-30
RB-64	Flashing red alarm light	All SES duplex panels (before 11/98)		BL4-40
RB-70	Flashing red alarm light (after 11/98)	All S31625-S32025 D10020, D10020N1, S10020, S10020N1		Ingram MX-15
RB-71	Flashing red alarm light (after 11/98)	All D31625-D32025 D10027, D10036		Ingram LRX-40
RB-72	Pump run light assembly	All SES panels except S10020, D10020N1		BACO, C20SA20
RB-73	Alarm test button assembly	All SES panels except S10020N1, D10020N1		BACO, C21AA01
RB-74	Alarm reset button assembly	D10020, D10027, D10036 D31625-D32025		BACO, C21AA02
RB-75	Duplex logic control board	All SES duplex panels	A6-2012, G6-2012, A6-5032, A6-5034, A6-3012, A6-5012 (after 11/98)	Boulay BFI-LLC-120
RB-76	Alarm silence button assembly	All SES panels except D10020N1, S10020N1		BACO, C21AA01
RB-77	Replacement light bulbs for run lights (quantity 5)	All SES panels except D10020N1, S10020N1		BACO, WDL-120
RB-78	Circuit Breaker	D10020N1, D10020		QOU-225
RB-79	Replacement light bulb (1)	All SES panels except D10020N1, S10020N1		Sq. D ZB5AV033
RB-80	Simplex logic board	All simplex panels		BFI-SIMLLC-120
RB-81	Contactor 1Ø	Used on 1Ø panels with printed circuit boards		ABB DP30C2P–1/B

SUMP, EFFLUENT AND SEWAGE REPAIR PARTS OIL VOLUMES

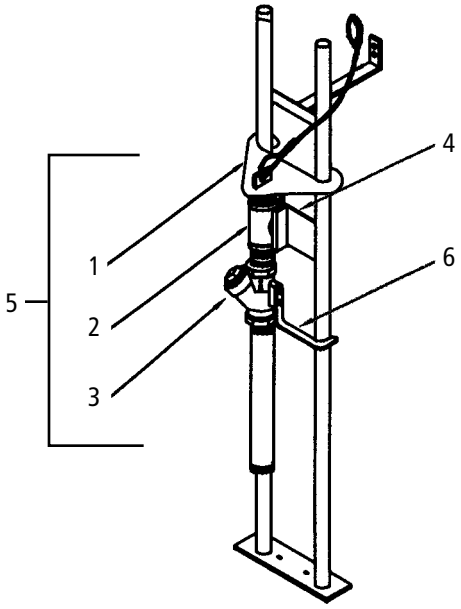
Model	Oil Volume - Motor Housing	Oil Volume - Seal Housing
	Quarts	Quarts
ST 31	1.32	N/A
PE31	1.32	N/A
PE41	1.32	N/A
PE51	1.32	N/A
PS41	1.70	N/A
PS51, PV51	1.70	N/A
3871 (EP's - .4 hp)	1.00	N/A
3871 (EP's - .5 hp)	0.85	N/A
3872 (WW's)	0.85	N/A
3885 (WE's) - A.O. Smith	3.90	N/A
3885 (WE's) - Franklin	3.50	N/A
2ED's - A.O. Smith	3.90	0.40
3886 (WS__B)	3.90	N/A
3887BF (WS__BF)	3.90	N/A
3887BHF (WS_BHF) - A.O. Smith	3.90	N/A
3887BHF (WS_BHF) - Franklin	3.50	N/A
2/3WD's - A.O. Smith	3.90	0.40
3888D3 (WS____D3)	7.00	1.70
3SD's	7.00	1.70
3888D4 (WS____D4)	7.00	1.50
4SD's	7.00	1.50
3888D4 (WS____D4) - 7½ HP	6.00	1.50
4SD's - 7½ HP	6.00	1.50
RGS2012	3.90	N/A
1GD - Single Phase	3.55	0.90
1GD - Three Phase	3.90	0.90

Noco T-32 oil is standard.

Note: Normally a minimum of a 1" air gap at the top of the motor/seal housing should be maintained due to thermal expansion of the oil.

A10-12, A10-2015 and A10-20

Item No.	Description	A10-12	A10-20 and A2015
1	Upper Guide Bracket	4K800	4K801
2	Brass Qick Disconnect	4K802	4K803
3	CI Ball Check Valve	4K804	4K805
4	O-Ring Disconnect	4K806	4K807
5	Movable Side	4K808	4K809
6	Lower Stand Off	4K810	4K811



GOULDS PUMPS

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Signet 2551 Magmeter

English

3-2551.090 Rev. F 02/07 English

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Description

The Signet 2551 Magmeter is an insertion style magnetic flow sensor that features no moving parts. The patented sensor design is available in corrosion-resistant materials to provide long-term reliability with minimal maintenance costs. Material options include PP with stainless steel, PVDF with stainless steel, PVDF with Hastelloy-C, or PVDF with Titanium. Utilizing the comprehensive line of Signet installation fittings, sensor alignment and insertion depth is automatic, delivering accurate flow measurement in pipe sizes ranging from DN15 to DN300 (½ to 12 inches).

Signet 2551 Magmeters offer many output options of frequency/digital (S^3L) or 4 to 20 mA. The frequency or digital (S^3L) sensor output can be used with Signet's extensive line of flow instruments while the 4 to 20mA output can be used for a direct input to PLCs, chart recorders, etc. Both the 4 to 20 mA output and digital (S^3L) sensor interface is available for long distance signal transmission of up to 1,000 ft. An additional benefit is the empty pipe detection which features a zero flow output when the sensors are not completely wetted. Also, the frequency output is bi-directional while the 4 to 20mA output can be set for uni- or bi-directional flow using the RS232 set-up tool which connects to PCs for programming capabilities.

1. Quick Start Guide

This manual contains the general installation, wiring and calibration data for the Signet 2551-XX-11 Magmeter with Frequency or Serial data output, and for the Signet 2551-XX-12 Magmeter with Currrent output. The basic steps are outlined on this page. See each referenced section for detailed information.

1. Configure the Hardware
2551-XX-11 ONLY: Position this Jumper to select digital (S^3L) output or Frequency output. (Not used for Current output version) Sec. 8 Pg. 6

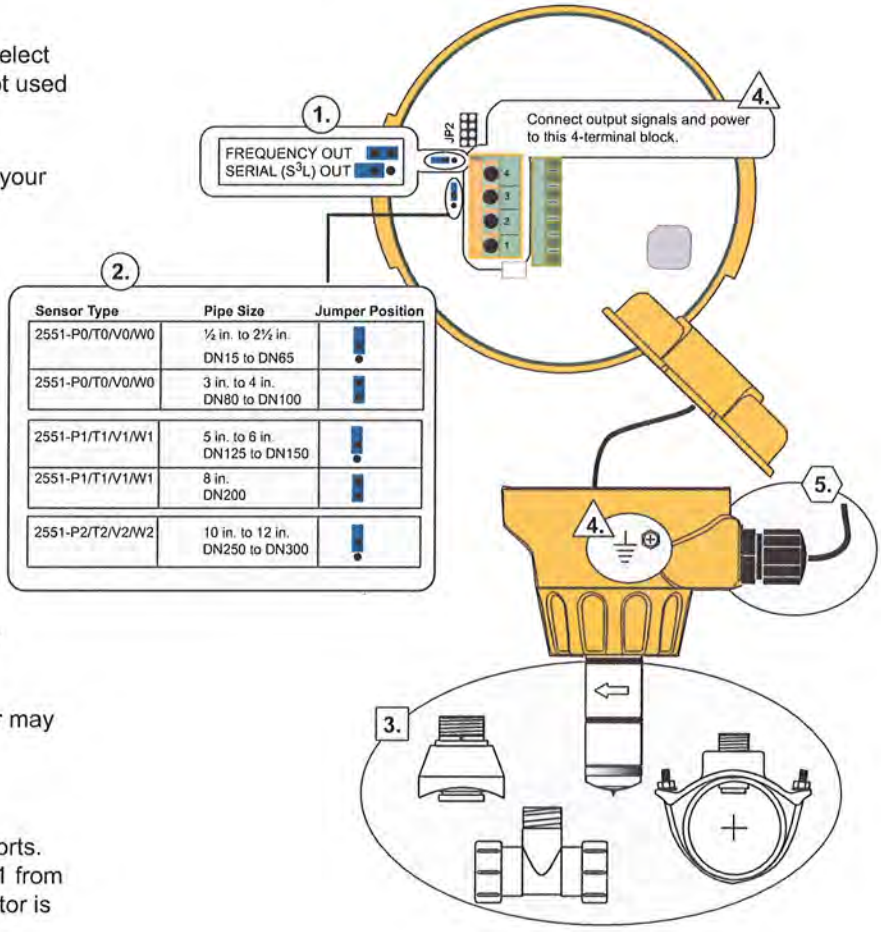
2. Position the PIPE SIZE Jumper according to your pipe size. Sec. 5 Pg. 4

3. Install the Magmeter into the pipe.
Use Signet installation fittings ONLY.
The installation fitting is critical to Magmeter performance. Sec. 3-4, Pg. 3

4. Connect POWER and OUTPUT wiring.
2551-XX-11 Frequency out: Sec. 8.1 Pg. 6
2551-XX-11 Serial data out: Sec. 8.2 Pg. 9
2551-XX-12 Current out wiring: Sec. 7 Pg. 5

GROUNDING
Without a good Earth Ground, the Magmeter may not operate efficiently. Sec. 6 Pg. 5

5. Route the wiring out through the two cable ports.
Use appropriate hardware to secure the 2551 from moisture intrusion. One Liquid Tight Connector is included. Sec. 5-6 Pg 4-5



SAFETY INSTRUCTIONS
1. Depressurize and vent system prior to installation or removal.
2. Confirm chemical compatibility before use.
3. Do not exceed maximum temperature/pressure specifications.
4. Wear safety goggles or face shield during installation/service.
5. Do not alter product construction.
6. Disconnect power before attempting any service or wiring.

2. Specifications

General
Pipe size range: DN15 to DN 300 (0.5 in. to 12 in.)
Flow Range
- Minimum: 0.05 m/s (0.15 ft/s)
- Maximum: 10 m/s (33 ft/s)

Linearity: ±1% reading plus 0.01m/s (0.033 ft/s)
Repeatability: ±0.5% of reading @ 25°C (77°F)
Minimum Conductivity: 20 µS/cm

Wetted Materials:
- Sensor body and Electrodes and Grounding ring:
  - -P0, -P1, -P2: Polypropylene and 316L SS
  - -T0, -T1, -T2: PVDF and Titanium
  - -V0, -V1,-V2: PVDF and Hastelloy-C
  - -W0, -W1, -W2: PVDF and 316L SS
  - O-rings: FPM (standard) EPDM, Kalrez® (optional)

The user is responsible for determining the chemical suitability of these materials for a specific application.

- Case: PBT
- Display window: Polyamide

Electrical
Power Requirements
- 4 to 20 mA: 21.6 to 26.4 VDC, 22.1 mA max.
- Frequency: 5 to 26.4 VDC, 15 mA max.
- Digital (S³L): 5 to 6.5 VDC, 15 mA max.

Reverse polarity and short circuit protected

Current output (4 to 20 mA):
- Loop Accuracy: 32 µA max. error (25°C @ 24 VDC)
- Isolation: Low voltage < 48 VAC/DC from electrodes and auxilary power
- Maximum cable: 300 m (1000 ft.)
- Error condition: 22.1 mA
- Max. Loop Resistance: 300 Ω
- Compatible with PLC, PC or similar equipment

Frequency output:
- Max. Pull-up Voltage: 30 VDC
- Compatible with Signet 5075, 5500, 5600, 8550, 8900

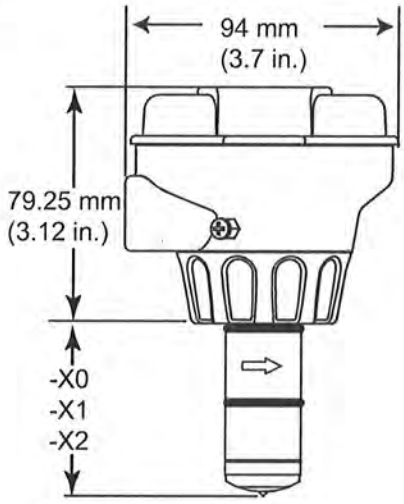
Digital (S³L) Output:
- Serial ASCII, TTL level 9600 bps
- Compatible with Signet 8900

Environmental Requirements
Storage Temperature: -20° to 70°C (-4° to 158°F)
Relative Humidity: 0 to 95% (non-condensing)
Operating Temperature:
- Ambient: -10° to 70°C (14° to 158°F)
- Media: 0° to 85°C (32° to 185°F)

Max. operating pressure:
- 10.3 bar @ 25°C (150 psi @ 77°F)
- 1.4 bar @ 85°C (20 psi @ 185°F)

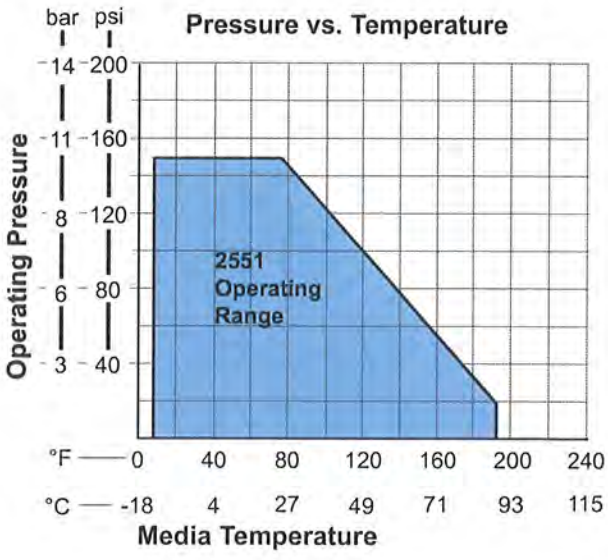
Standards and Approvals
CE
NEMA 4X / IP65 Enclosure (with cap installed)
EMC: EN55011: 1998 +A1:99+A2:02 Class B Emissions
EN61326: 1997 +A1:98+A2:01
EN61000-6-2:2001
Safety: EN61010-1:2001
U.S. Patent No. 7,055,396 B1

Dimensions



Pipe Range
1/2 to 4 in. -X0 = 58 mm (2.3 in.)
5 to 8 in. -X1 = 91 mm (3.6 in.)
10 to 12 in. -X2 = 167 mm (6.6 in.)

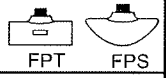
X = Sensor Body P, T, V, or W



3. Installation: Pipe fittings

George Fischer Signet offers a wide selection of installation fittings that control the position of the Magmeter electrodes in relation to the dimensions of the pipe. You will find a complete list of order numbers for installation fittings in the Calibration tables on pages 10-13.

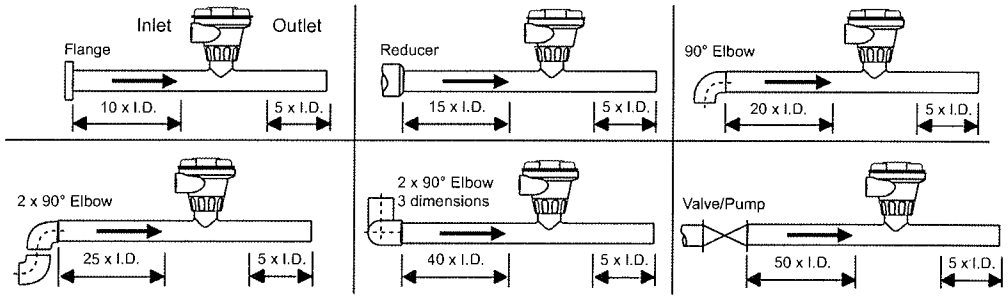
Type	Description
Plastic tees	• 0.5 to 4 inch versions • PVC or CPVC
PVC Glue-on Saddles	• Available in 10 and 12 inch sizes only • Cut 2-1/2 inch hole in pipe • Weld in place using solvent cement
PVC Saddles	• 2 to 4 inch, cut 1-7/16 inch hole in pipe • 6 to 8 inch, cut 2-1/8 inch hole in pipe
PP Clamp-on Saddles	• Available in 10 and 12 inch sizes only • Cut 2-1/8 inch hole in pipe
Iron Strap-on saddles	• 2 to 4 inch, cut 1-7/16 inch hole in pipe • Over 4 inch, cut 2-1/8 inch hole in pipe

Type	Description
Iron, Carbon Steel, 316 SS Threaded tees	• 0.5 to 2 in. versions • Mounts on threaded pipe ends
Carbon steel & stainless steel Weld-on Weldolets	• 2 to 4 inch, cut 1-7/16 inch hole in pipe • Over 4 inch, cut 2-1/8 inch hole in pipe
Fiberglass tees & saddles:  FPT FPS	• 1.5 in. to 8 in. PVDF insert • > 8 in. PVC insert
Metric Union tees	• For pipes from DN 15 to 50 mm • PP or PVDF

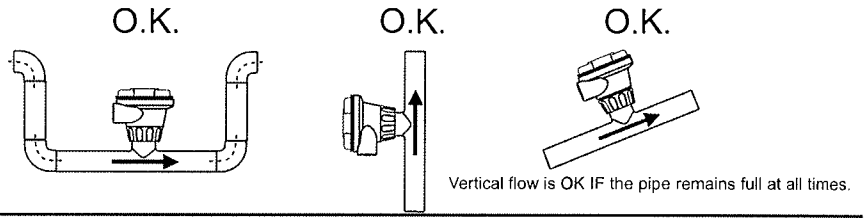
4. Selecting a Location

- The 2551 requires a full pipe and a fully developed turbulent flow profile for accurate measurement.
- If the piping system harbors air pockets or bubbles, take steps to locate the sensor so the air pockets will not contact the electrodes.
- In vertical installations, assemble the 2551 so the conduit ports are facing downward. This prevents condensation inside the conduit from being directed into the 2551 electronics housing.

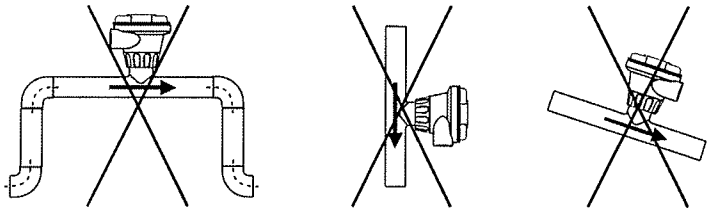
Select a location with sufficient distance of straight pipe immediately upstream of the sensor.



Locating the sensor in a trap or where the flow is upward helps to protect the sensor from exposure to air bubbles when the system is in operation.

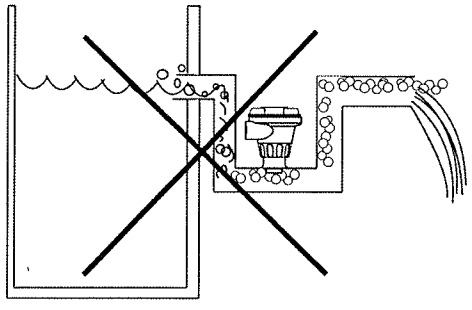


These configurations are not recommended because it is difficult to keep the pipe full.



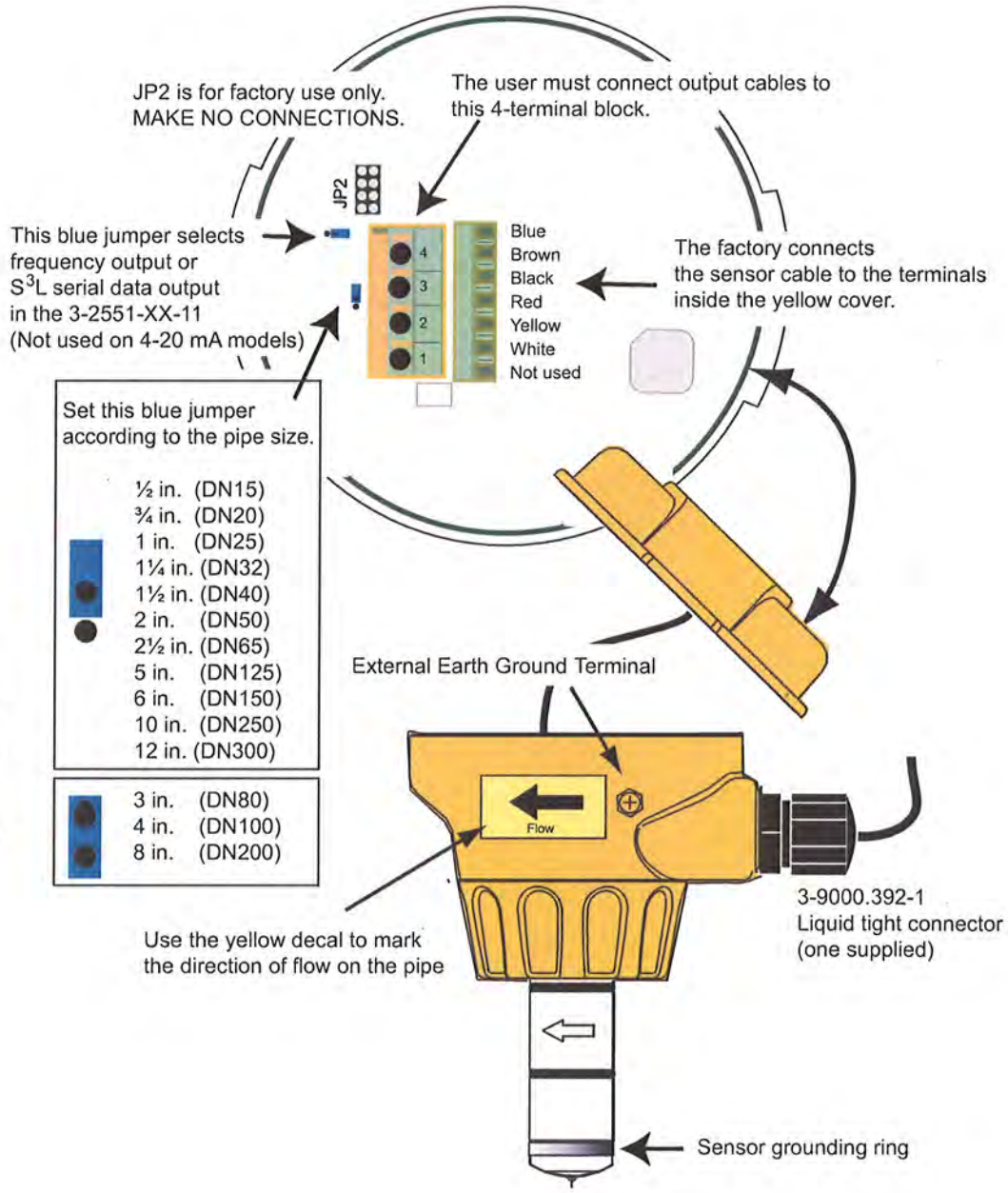
In a gravity-flow system, the tank must be designed so the level does not drop below the outlet.

This causes the pipe to draw air in from the tank.
If air bubbles pass across the Magmeter electrodes, the output will become erratic.



5. 2551 Magmeter Configuration

Whether using the 2551-XX-11 (frequency or digital S^3L output) or the 2551-XX-12 (with 4-20 mA output), the wiring terminals located on the inside of the yellow cover are identical. All of the connections from the Magmeter to external equipment (PLC, Datalogger, Chart Recorder, Flow meter, etc.) are made at the large 4-position terminal connector.
When the cover is removed the wiring from the sensor can be seen connected to the smaller terminal block. These connections should always remain connected to prevent inadvertent damage or miswiring.
The terminals on the 2551 Magmeter are designed for conductors from 16 AWG to 22 AWG.



WARNING!
If the second conduit port is used, carefully drill the opening. (The plastic is too strong to be punched out.)

- Secure the Magmeter in a vise to prevent damage or injury.
- The plastic inside the port is very thin. Do not allow the drill to penetrate too deeply and damage the Magmeter wiring.

Important:

- The directional arrow on the body of the sensor must be pointed DOWNSTREAM.
- The FLOW arrow decal can be placed directly on the pipe to identify the direction of flow.
- Use a cable gland or a liquid tight connector to seal the cable ports from water intrusion.
- The yellow housing may be reversed to align the conduit ports as required.
- If the Magmeter is installed on a vertical pipe, the conduit ports should be turned to point downward. This will prevent condensation from being channeled into the enclosure.
- Use plumber's tape or a suitable sealant on cable ports.

6. General Installation and Grounding Tips

Sensor conditioning

The Magmeter output signal may be unstable immediately after installation. Allowing the sensor to soak in a full pipe (or in any container of water) for 24 hours will stabilize the performance.

- Very low conductivity fluids may require a longer conditioning period. (The Magmeter may not operate properly in fluids where the conductivity is less than 20 µS/cm.)

Grounding

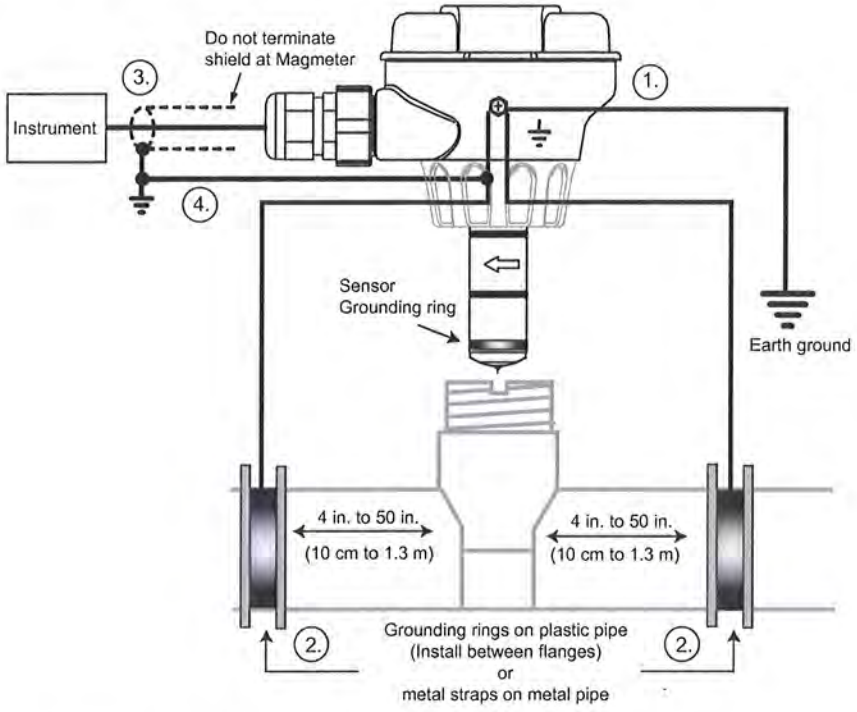
The 2551 Magmeter is unaffected by moderate levels of electrical noise. However, in some applications it may be necessary to ground portions of the system to eliminate electrical interference. The grounding requirements will vary with each installation.

One or more of the following steps may be applied if the 2551 Magmeter is affected by electrical noise:

① The ground terminal on the outside of the yellow housing is connected internally to the grounding ring at the tip of the sensor. Connect a wire (14 AWG/2.08 mm² recommended) from this terminal directly to a local Earth ground.

② Install fluid grounding devices immediately upstream and downstream of the Magmeter. Connect the fluid grounds to the Earth ground terminal on the 2551.
Use flanged grounding rings or metal electrodes on plastic pipes, or metal clamps on metal pipes.
Fluid grounds must be in direct contact with the fluid, and as near to the Magmeter as possible.

③ The shield from the output cable must be terminated at the remote instrument ONLY. This shield must not be connected at both ends!

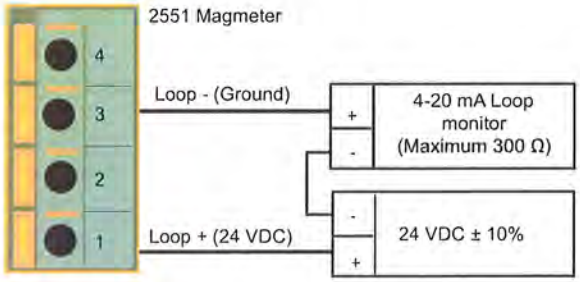


④ Connect an additional wire (minimum AWG 14/2.08 mm²) from the remote instrument ground to the Magmeter ground terminal.

7. Wiring the 2551-XX-12 Magmeter with 4-20 mA Loop Output

The 2551-XX-12 Magmeter is a traditional 2-wire passive 4-20 mA loop transmitter.

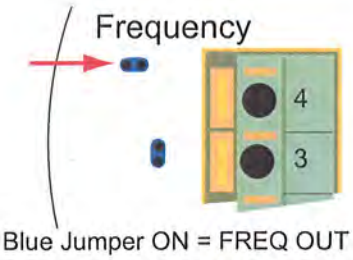
- External loop power (24 VDC ±10%) is required. See Ordering Information for power supplies.
- **The maximum loop resistance the Magmeter can accomodate is 300 Ω.**
- All 2551-XX-12 Magmeters are shipped from the factory with the 4-20 mA output scaled for 0 to 5 m/s (0 to 16.4 ft/s). If this operating range is suitable, no adjustments are necessary. The Calibration charts on pages 10-14 list the 20 mA setpoint for each installation fitting. Use this information to program the 4-20 mA range of the loop device (PLC, Datalogger, recorder, etc.)



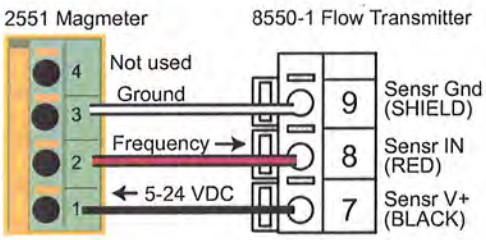
8. Wiring the 3-2551-11 with Frequency or Digital (S^3L) output

8.1 Wiring: Frequency output (Compatible with all POWERED Signet Flow instruments.)

- When the blue jumper illustrated here is placed over both pins, the 2551-XX-11 outputs an open collector frequency signal that can be connected to any powered Signet flow meter. (Models 5075, 5500, 5600, 8550, 8900.)
- 5 VDC power is provided to the 2551 Magmeter by all Signet flow instruments. No additional power is required.
- If connecting the 2551 Magmeter to a flow instrument from another manufacturer, 5 to 24 VDC power must be provided to the 2551. A 10 KΩ pull up resistor must also be connected between terminals 1 and 2.
- The frequency output will be displayed as positive flow regardless of the flow direction.

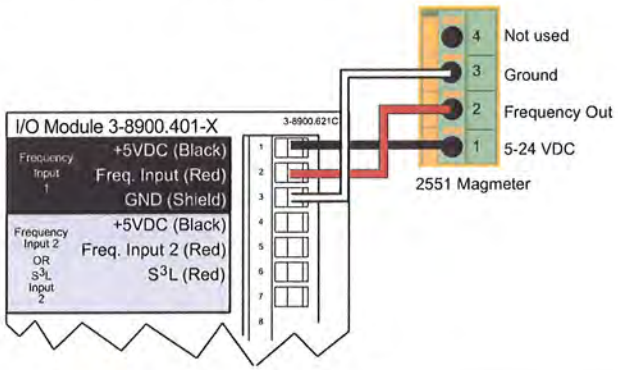


2551 Frequency Out to Signet 8550-1

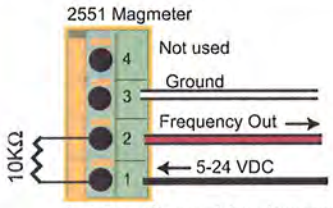


AUX power MUST be connected on the 8550 to provide power to the 2551.

2551 Frequency Out to Signet 8900



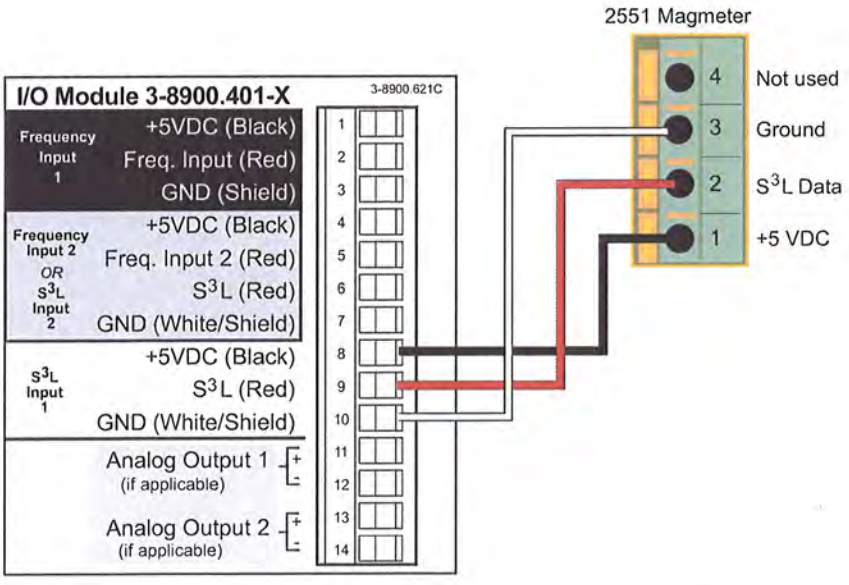
2551 Frequency Out to other Manufacturer's equipment

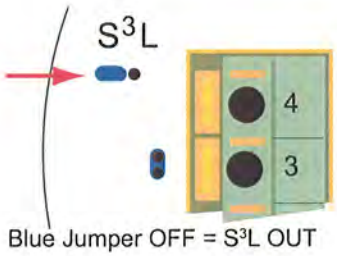


Install a pull-up resistor when connecting the 2551 Magmeter to other manufacturer's flowmeters.

8.2 Wiring: S^3L output (Compatible with 8900 Multi-Parameter Controller only)

- When the blue jumper illustrated here is removed (or placed over one pin for storage) the 2551-XX-11 outputs a digital (S^3L) signal compatible with the Signet 8900.
- The 2551 receives 5 VDC power from the 8900. No additional power is required.
- The 8900 will display 0 (Zero) flow rate during periods of reverse flow.





NOTE:
The maximum cable length from the 2551 to the 8900 depends on the 8900 configuration. Refer to the 8900 manual for complete information.

9. Custom System Span and Setup

- The 3-0232 Setup tool enables the user to configure the 2551 Magmeter to suit the application.
- The Setup tool connects the 2551 to a computer by converting the serial data output into standard RS232 format.
- The computer operating system must be Windows 98, 2000, 2000 Pro, XP, XP Pro ONLY.
- The 3-0232 Setup tool is not compatible with any other operating system.
- Managed and network systems may have security measures enabled that interfere with the installation of this program. See the network administrator or IT staff if the program cannot be installed.

9.1 Collect the Equipment and information that will be required:

- 3-0232 Setup Tool (Includes one RS232 Converter and one CD-ROM with software)
- 24 VDC ISOLATED power source.
- Personal computer with:
  Intel Pentium or Higher or AMD 1800 or Higher
  Windows 98, 2000, 2000 Pro, XP, XP Pro operating system
  CD ROM Reader capable of reading ISO 9660 Format
  Free Disk Space Of 400 KB
- DB9 serial-to-USB converter cable
  (required only for computers that do not have a DB9 serial port available.)
- Pipe data (id, K-factor from Sec. 12, Pg 10-14)
- Measurement Preferences (engineering units, timebase)

9.2 Install the software onto the computer:

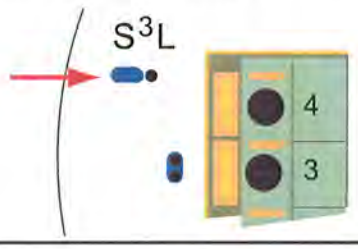
1. Insert the CD-ROM into a computer that is running on Win98, Win2000, or Win XP.
2. Click the START button, then Run. Click the BROWSE button and navigate to the CD drive and select the Setup.exe file. Click Open, then click OK.
3. If unable to install the program, contact the system administrator for assistance.

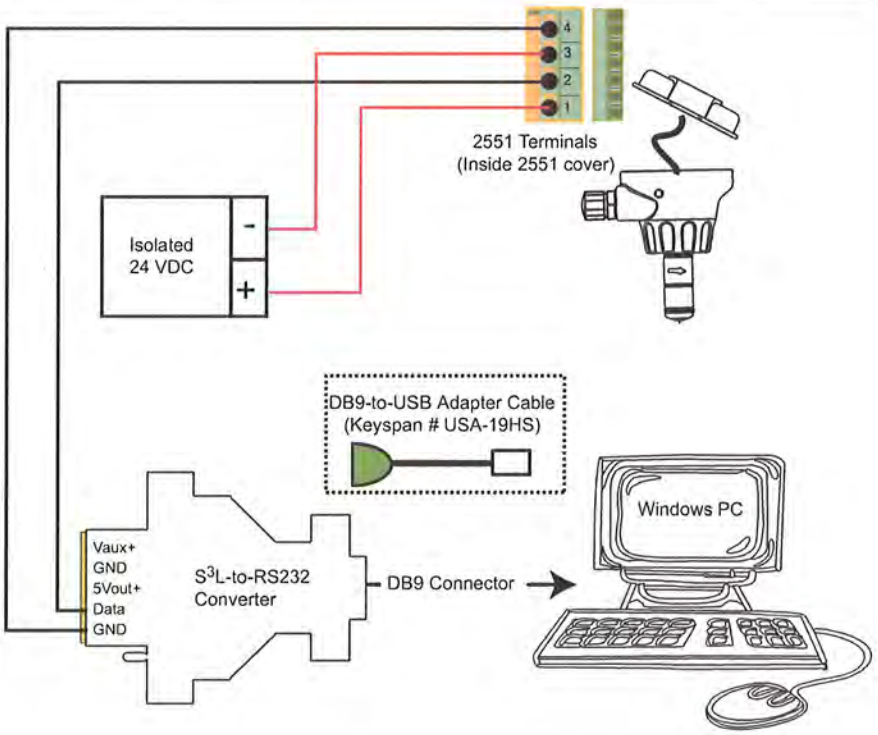
9.3 Connect the Magmeter to the computer:

1. Remove the cover from the Magmeter.
2. Connect the 2551 output terminals 2 and 4 to the input terminals of the RS232 Interface.
3. Connect the isolated 24 VDC power source to the 2551, terminals 1 and 3.
4. For 2551-11 version, configure the blue jumper for S³L operation. Remember to return it to the frequency position if necessary. (section 8.2, Pg 6.)
5. Connect the DB9 serial output connector from the RS232 Interface to the computer.
   Note: If the computer does not have an available DB9 serial port, use a serial-to-USB converter cable. Signet recommends cable model USA-19HS by Keyspan. (www.keyspan.com)

CAUTION!
TURN 24 VDC POWER OFF WHEN WIRING THE MAGMETER.

For 2551-11 version, configure the blue jumper for S³L operation. Remember to return it to the frequency position if necessary.





The following page outlines each step in the 2551 Magmeter Setup Tool software.

10. Using the 3-0232 i-Go S³L to RS232 Converter and Setup Tool to customize the 3-2551 Magmeter

Procedure:

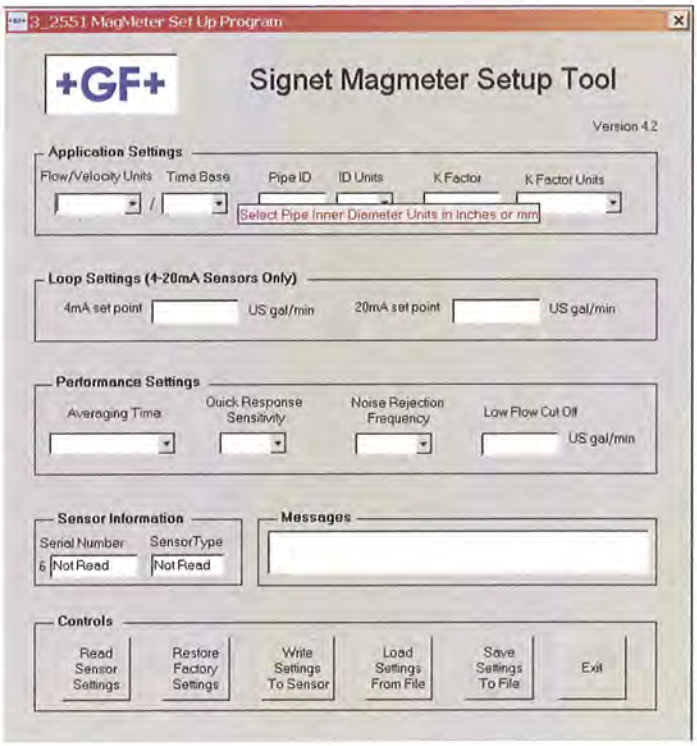
1. **Set the general information about the pipe and application preferences in the Application Settings fields.**
   Note: Press the "Restore Factory Settings" button while all fields are blank to load the setup program with factory settings. After a value is entered into any field, the "Restore Factory Settings" button will not change them.
   Flow/Velocity Units (factory set: Meters)
   - Select the engineering units from the list: meters, feet, cubic meters, liters, cu. ft., U.S. gallons, Imp. gallons.

   Timebase (factory set: Seconds)
   - Set the timebase preference: seconds, minutes, hours, days

   Pipe ID (Inside Diameter) (factory set: 44.0)
   - Enter the inside diameter of the pipe.

   ID Units: (factory set: millimeters)
   - Select inches or mm for the dimensions of the pipe.

   NOTE: Check all associated settings after changing the units. This program does not convert values automatically.
   K-Factor (factory set: 65.7665)
   - K-factors are published in the Magmeter manual as "pulses per gallon" and "pulses per liter".



2. **Set the 4-20 mA span (4-20 mA output models only)**
   - Enter the flow rate at 4 mA. (Factory set: 0 m/s)
   - Enter the flow rate at 20 mA. (Factory set: 5 m/s)
   - When the RESTORE FACTORY SETTINGS button is pressed, the 20 mA setpoint will be restored to the equivalent of 5 m/s, in terms of the Flow units and Timebase selected above.

3. **Set the Performance Settings to best accomodate the unique conditions in the pipe.**
   Averaging Time in Seconds (Factory set: 14 seconds)**
   - Select the time the Magmeter will use as the averaging period.
     Example: With averaging at 14 seconds, each display is an average of the previous 14 seconds input.
     Use higher averaging times to smooth the display and current output where the flow in the pipe is erratic.

   Quick Response Sensitivity (Factory set: 25% of Max Range, or 2.5 m/s)**
   - Set the percentage of change in the flow rate required to allow the Magmeter to override the AVERAGING and jump to a new flow rate immediately.
     (2551 maximum range is 10 m/s)
     A detailed explanation of **averaging** and **sensitivity** functions is provided on the following page.

   Noise Rejection Frequency (Factory set: 60 Hz)**
   - Select 50 Hz or 60 Hz according to local AC power specifications.

   Low Flow Cut-off (Factory set: 0.05 m/s)
   - Set the flow rate where all Magmeter outputs will be forced to zero. (When the flow rate drops below this value, the frequency output will be 0 Hz. and the current output will be 4 mA.)

Note: If a Low flow Cutoff or a 4-20 mA field turns RED, the value entered is outside of the allowable range. The maximum allowable value will be automatically loaded.

** SELECT FROM PULL-DOWN MENU ONLY. Direct text input will not be accepted. Error message will appear: "Cannot write all settings to sensor."

4. **Click "Write Settings to Sensor" at the bottom of the display to download the new settings to the Magmeter.**
   - To repeat the same settings in another Magmeter, remove 24 VDC Power to the magmeter and connect the second Magmeter.
   - Click "Write Settings to Sensor" again.
   - Click "Read Sensor Settings" to validate the new settings.
     Note: All settings are lost when you exit the program.

Sensor Information

Serial Number, Sensor Type:
- Information for these fields is read from the Magmeter when you press the "Read Sensor Settings" button.

Messages
- Displays messages related to the current selection. Error messages and procedure instructions appear here.

Controls
- **Read sensor settings:** Read information and setup values from the Magmeter into this setup display.
- **Restore factory settings:** Restores Loop and Performance settings to original factory values. Press this button before entering any data into the program if you want to load all factory settings.
- **Write settings to sensor:** Copies all of the settings in this setup display into the Magmeter.
- **Load settings from file:** Load a saved meter setup file into the Magmeter Setup Tool.
- **Save settings to file:** Save a meter setup file on your local hard drive to be used again.

11. 2551 Magmeter Averaging and Sensitivity Settings

Because ideal flow conditions are often impossible to achieve, the flow rate is often erratic, which causes any control features (ie; relays, 4-20 mA loops, etc.) that are associated with the flow rate to also be erratic.

The best solution to these problems is to correct the piping deficiencies that cause the instability. This may involve longer straight runs upstream, reducing the pipe size to maintain a full pipe at all times, and other installation changes. But in many situations these measures are simply not possible.

The 2551 Magmeter provides several tools that are designed to "work around" these deficiencies. They are called "Performance Settings" and can be modified only through the i-Go S^3L to RS232 Converter and the 2551 Magmeter Setup Tool. The noise rejection and the Low Flow Cutoff settings are self-explanatory. The Averaging and the Sensitivity features should be studied before making adjustments.

Averaging Time in Seconds (Factory set: 14 seconds)

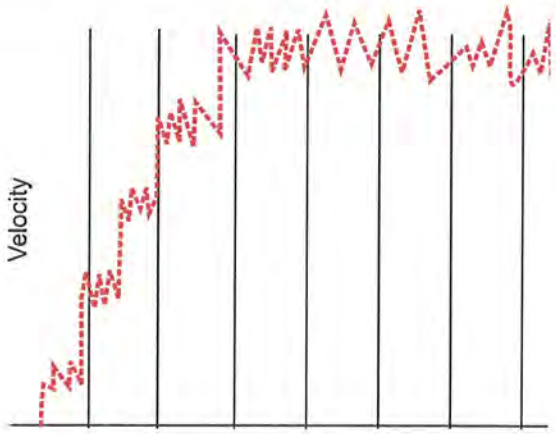
- Set the time the Magmeter will use as the averaging period.
  With averaging at 14 seconds, each display is an average of the previous 14 seconds input.
  Use higher averaging times to smooth the display and current output where the flow in the pipe is erratic.

Quick Response Sensitivity (Factory set: 25% of Maximum Range, or 2.5 m/s)

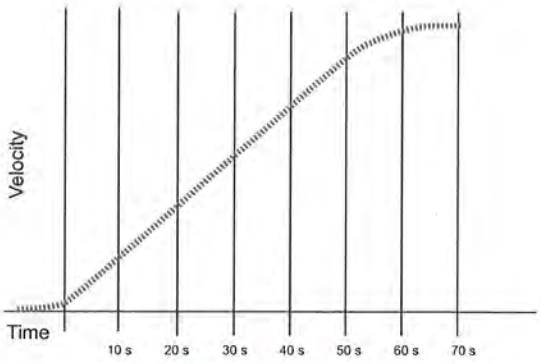
- Set the percentage of change in the flow rate required to allow the Magmeter to override the AVERAGING and jump to a new flow rate immediately. (2551 maximum range is 10 m/s)

The pictures below illustrate the effect of these settings.

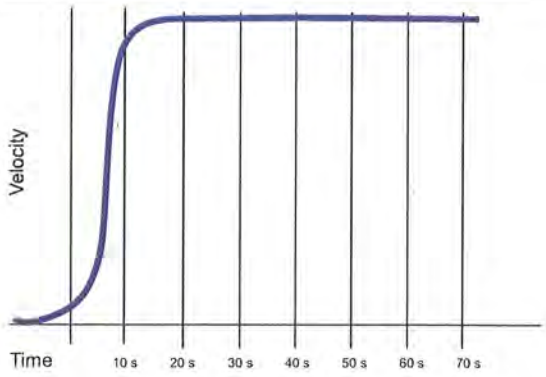
No AVERAGING, no SENSITIVITY
With AVERAGING set to 0 (zero) the SENSITIVITY is ineffective, and the flow rate may be very unstable. This will cause the output signals to respond erratically.



AVERAGING Only
With AVERAGING set to 60 seconds and SENSITIVITY set to 100%, the flow rate is stabilized, but a sharp change in flow rate is not represented for 60 seconds or longer. This can cause system problems if one of the operating setpoints falls within this range.

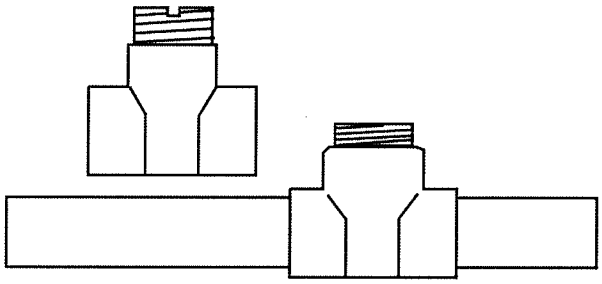


AVERAGING and SENSITIVITY
With AVERAGING at 60 seconds and SENSITIVITY set to 25%, the flow rate is stabilized, but the sudden shift in flow is reflected very quickly.



12. Calibration Data: K-factors and Full Scale Current Values

Plastic Installation Fittings: PVC Tees and Saddles

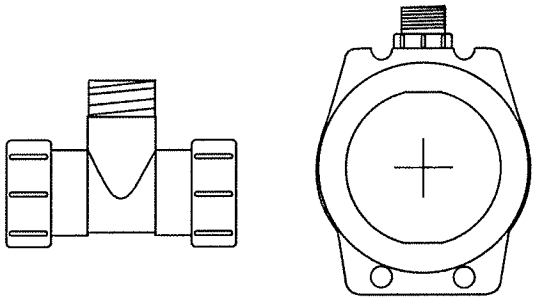


PIPE SIZE (IN.)	FITTING TYPE	K-Factor Gallons	K-Factor Liters*	20 mA= in GPM	20 mA= in LPM
SCH 80 PVC TEES FOR SCH 80 PVC PIPE					
½	PV8T005	2289.37	604.85	13.1	49.6
¾	PV8T007	1430.41	377.92	20.97	79.38
1	PV8T010	876.86	231.67	34.21	129.5
1¼	PV8T012	447.06	118.11	67.1	253.99
1½	PV8T015	324.19	85.65	92.54	350.25
2	PV8T020	206.69	54.61	145.15	549.38
2½	PV8T025	131.46	34.73	228.2	863.74
3	PV8T030	82.52	21.80	363.55	1376.04
4	PV8T040	44.78	11.83	669.88	2535.49
SCH 80 PVC TEES FOR SCH 80 CPVC PIPE					
½	CPV8T005	2496.03	659.45	12.02	45.49
¾	CPV8T007	1381.48	364.99	21.72	82.19
1	CPV8T010	857.98	226.68	34.97	132.34
1¼	CPV8T012	445.17	117.61	67.39	255.07
1½	CPV8T015	325.56	86.01	92.15	348.78
SCH 80 PVC SADDLES FOR SCH 80 PVC PIPE					
2	PV8S020	193.83	51.21	154.77	585.81
2½	PV8S025	138.01	36.46	217.38	822.78
3	PV8S030	83.89	22.16	357.62	1353.60
4	PV8S040	40.88	10.80	733.88	2777.74
6	PV8S060	22.53	5.95	1331.85	5041.06
8	PV8S080	12.52	3.31	2395.41	9066.64
10	PV8S100	7.94	2.10	3778.75	14302.57
12	PV8S120	5.71	1.51	5256.69	19896.57
SCH 80 PVC SADDLES FOR SCH 40 PVC PIPE					
2	PV8S020	180.01	47.56	166.66	630.81
2½	PV8S025	123.72	32.69	242.49	917.82
3	PV8S030	75.81	20.03	395.71	1497.76
4	PV8S040	41.87	11.06	716.56	2712.19
6	PV8S060	19.71	5.21	1521.92	5760.46
8	PV8S080	11.73	3.10	2558.12	9682.50
10	PV8S100	7.43	1.96	4037.60	15282.3
12	PV8S120	5.23	1.38	5734.87	21706.48
POLYPROPYLENE CLAMP-ON SADDLES ON SCH 80 PP PIPE					
10	PPS100	7.94	2.10	3778.75	14302.57
12	PPS120	5.71	1.51	5256.69	19896.57
POLYPROPYLENE CLAMP-ON SADDLES ON SCH 40 PP PIPE					
10	PPS100	7.43	1.96	4037.60	15282.3
12	PPS120	5.23	1.38	5734.87	21706.48

12. Calibration Data: K-factors and Full Scale Current Values

Plastic Installation Fittings for Metric Pipes:

Polypropylene True Union Tees and Wafers
PVDF True Union Tees and Wafers
PVC True Union Tees and Wafers

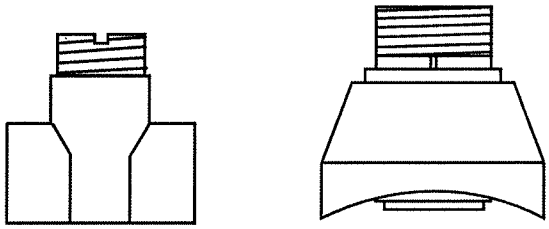


PIPE SIZE (Metric)	FITTING TYPE	K-Factor Gallons	K-Factor Liters*	20 mA= in GPM	20 mA= in LPM
POLYPROPYLENE FITTINGS (DIN/ISO ,BS, ANSI)					
DN15	PPMT005	2192.73	579.32	13.68	51.78
DN20	PPMT007	1327.81	350.81	22.59	85.52
DN25	PPMT010	737.16	194.76	40.70	154.04
DN32	PPMT012	453.46	119.81	66.16	250.41
DN40	PPMT015	275.03	72.66	109.08	412.86
DN50	PPMT020	164.17	43.35	182.74	691.66
DN65	PPMT025	112.02	29.59	267.82	1013.70
DN80	PPMT030	77.40	20.45	387.60	1467.06
DN100	PPMT040	51.76	13.68	579.58	2193.70
DN125	PPMT050	40.14	10.61	747.36	2828.74
DN150	PPMT060	24.51	6.47	1224.17	4633.48
DN200	PPMT080	15.66	4.14	1915.10	7248.67
PVDF FITTINGS (DIN/ISO ,BS, ANSI)					
DN15	SFMT005	1946.49	514.26	15.41	58.34
DN20	SFMT007	1158.05	305.96	25.91	98.05
DN25	SFMT010	749.09	197.91	40.05	151.58
DN32	SFMT012	439.51	116.12	68.26	258.36
DN40	SFMT015	248.93	65.77	120.52	456.16
DN50	SFMT020	146.85	38.80	204.30	773.26
DN65	SFMT025	104.84	27.70	286.16	1083.10
DN80	SFMT030	72.01	19.02	416.64	1576.97
DN100	SFMT040	46.82	12.37	640.69	2425.00
DN125	SFMT050	31.93	8.44	939.63	3556.51
DN150	SFMT060	18.78	4.96	1597.70	6047.30
DN200	SFMT080	11.86	3.13	2529.84	9575.44
PVC FITTINGS (DIN/ISO ,BS, ANSI)					
DN15	PVMT005	2067.76	546.30	14.51	54.91
DN20	PVMT007	1136.61	300.29	26.39	99.90
DN25	PVMT010	716.52	189.31	41.87	158.47
DN32	PVMT012	446.07	117.85	67.25	254.56
DN40	PVMT015	278.83	73.67	107.59	407.23
DN50	PVMT020	159.36	42.10	188.26	712.55
DN65	PVMT025	110.11	29.09	272.46	1031.26
DN80	PVMT030	73.92	19.53	405.84	1536.12
DN100	PVMT040	47.86	12.64	626.87	2372.70
DN125	PVMT050	36.18	9.56	829.10	3138.16
DN150	PVMT060	21.56	5.70	1391.30	5266.07
DN200	PVMT080	13.81	3.65	2172.63	8223.4

12. Calibration Data: K-factors and Full Scale Current Values

Metal Installation Fittings:

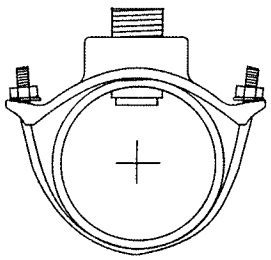
Carbon Steel Tees and Weld-o-Lets
Stainless Steel Tees and Weld-o-Lets
Galvanized Iron Tees



PIPE SIZE (IN.)	FITTING TYPE	K-Factor Gallons	K-Factor Liters*	20 mA= in GPM	20 mA= in LPM
CARBON STEEL TEES ON SCH 40 PIPE					
½	CS4T005	1572.66	415.50	19.08	72.20
¾	CS4T007	1086.73	287.11	27.61	104.49
1	CS4T010	582.34	153.86	51.52	194.99
1¼	CS4T012	377.48	99.73	79.48	300.81
1½	CS4T015	267.79	70.75	112.03	424.02
2	CS4T020	167.85	44.35	178.73	676.48
STAINLESS STEEL TEES ON SCH 40 PIPE					
½	CR4T005	1601.26	423.05	18.74	70.91
¾	CR4T007	937.78	247.76	31.99	121.08
1	CR4T010	606.18	160.15	49.49	187.32
1¼	CR4T012	279.68	73.89	107.26	405.99
1½	CR4T015	147.65	39.01	203.19	769.06
2	CR4T020	111.90	29.56	268.09	1014.73
STAINLESS STEEL WELDOLETS ON SCH 40 PIPE					
2½	CR4W025	106.31	28.09	282.19	1068.10
3	CR4W030	72.27	19.09	415.12	1571.25
4	CR4W040	36.84	9.73	814.34	3082.28
5	CR4W050	29.28	7.73	1024.70	3878.50
6	CR4W060	20.29	5.36	1478.26	5595.21
8	CR4W080	11.73	3.10	2557.72	9680.96
10	CR4W100	7.45	1.97	4028.83	15249.13
12	CR4W120	5.24	1.39	5722.73	21660.53
CARBON STEEL WELDOLETS ON SCH 40 PIPE					
2½	CS4W025	105.70	27.93	283.82	1074.27
3	CS4W030	70.68	18.67	424.45	1606.56
4	CS4W040	36.38	9.61	824.65	3121.30
5	CS4W050	29.28	7.73	1024.70	3878.50
6	CS4W060	20.29	5.36	1478.26	5595.21
8	CS4W080	11.73	3.10	2557.72	9680.96
10	CS4W100	7.45	1.97	4028.83	15249.13
12	CS4W120	5.24	1.39	5722.73	21660.53
GALVANIZED IRON TEES ON SCH 40 PIPE					
1	IR4T010	558.50	147.56	53.71	203.31
1¼	IR4T012	334.45	88.36	89.70	339.51
1½	IR4T015	248.97	65.78	120.49	456.07
2	IR4T020	146.00	38.57	205.48	777.76

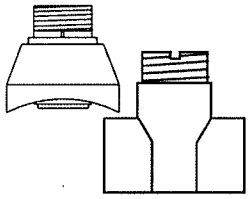
12. Calibration Data: K-factors and Full Scale Current Values

Metal Installation Fittings
Iron Saddles



PIPE SIZE (IN.)	FITTING TYPE	K-Factor Gallons	K-Factor Liters	20 mA= in GPM	20 mA= in LPM
SCH 80 IRON SADDLE ON SCH 80 PIPE					
2	IR8S020	194.85	51.48	153.96	582.75
2½	IR8S025	142.28	37.59	210.86	798.10
3	IR8S030	87.53	23.13	342.72	1297.20
4	IR8S040	40.62	10.73	738.58	2795.54
5	IR8S050	29.28	7.74	1024.43	3877.48
6	IR8S060	22.30	5.89	1345.58	5093.03
8	IR8S080	12.52	3.31	2395.41	9066.64
10	IR8S100	7.94	2.10	3778.75	14302.57
12	IR8S120	5.65	1.49	5311.45	20103.83
SCH 80 IRON SADDLE ON SCH 40 PIPE					
2	IR8S020	185.35	48.97	161.85	612.61
2½	IR8S025	127.47	33.68	235.36	890.83
3	IR8S030	76.62	20.24	391.54	1481.99
4	IR8S040	40.23	10.63	745.72	2822.57
5	IR8S050	27.32	7.22	1098.24	4156.83
6	IR8S060	19.71	5.21	1521.92	5760.46
8	IR8S080	11.61	3.07	2584.23	9781.30
10	IR8S100	7.36	1.94	4078.8	15438.2
12	IR8S120	5.18	1.37	5793.39	21927.98

Metal Installation Fittings:
Bronze and Copper Tees and Brazolets



PIPE SIZE (IN.)	FITTING TYPE	K-Factor Gallons	K-Factor Liters	20 mA= in GPM	20 mA= in LPM
BRONZE TEES ON SCH 40 PIPE					
1	BR4T010	582.34	153.86	51.52	194.99
1¼	BR4T012	330.54	87.33	90.76	343.53
1½	BR4T015	254.76	67.31	117.76	445.71
2	BR4T020	157.36	41.58	190.64	721.58
COPPER TEES FITTING ON COPPER PIPE SCH K					
½	CUKT005	2459.19	649.72	12.20	46.17
¾	CUKT007	1108.02	292.74	27.08	102.48
1	CUKT010	649.87	171.70	46.16	174.73
1¼	CUKT012	422.03	111.50	71.09	269.06
1½	CUKT015	281.43	74.35	106.60	403.47
2	CUKT020	136.02	35.94	220.55	834.78
COPPER TEES FITTING ON COPPER PIPE SCH L					
½	CUKT005	2406.30	635.75	12.47	47.19
¾	CUKT007	1174.77	310.37	25.54	96.66
1	CUKT010	672.28	177.62	44.62	168.90
1¼	CUKT012	402.84	106.43	74.47	281.87
1½	CUKT015	294.99	77.94	101.70	384.92
2	CUKT020	149.63	39.53	200.50	758.89
COPPER/BRONZE BRAZOLET ON SCH 40 PIPE					
2½	BR4B025	117.31	30.99	255.74	967.96
3	BR4B030	78.62	20.77	381.58	1444.28
4	BR4B040	45.13	11.92	664.77	2516.15
5	BR4B050	32.79	8.66	914.91	3462.95
6	BR4B060	22.73	6.01	1319.87	4995.72
8	BR4B080	13.14	3.47	2283.68	8643.71
10	BR4B100	8.34	2.20	3597.17	13615.29
12	BR4B120	5.87	1.55	5109.58	19339.76

13. Maintenance

The 2551 Magmeter requires very little maintenance. There are no user-serviceable components in the Magmeter.

- If the fluid contains deposits and solids that may coat the electrodes, a regular cleaning schedule is recommended.
- Do not use abrasive materials on the metal electrodes. Clean with soft cloth and mild detergent only.
- Use a cotton swab and mild detergent to remove deposits on the metal electrodes at the tip of the sensor.

13.1. Environmental Recommendations:

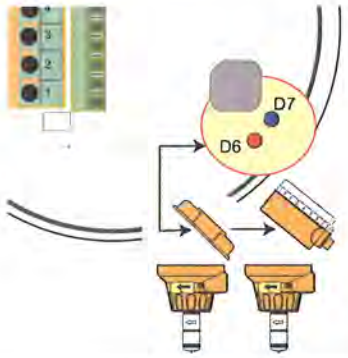
- When used properly, this product presents no inherent danger to the environment.
- Please follow local ordinance when disposing of this or any product with electronic components.

13.2 Troubleshooting

Symptom	Possible Cause	Possible Solution
• Frequency, Digital or Current output is erratic.	• Magmeter installed too close to upstream obstruction. • Magmeter electrodes are coated with solids. • Magmeter electrodes exposed to air bubbles/pockets. • Electrical noise is interfering with the measurement. • New sensor, metal surface not properly conditioned.	• Move the Magmeter upstream at least 10 pipe diameters from obstruction. • Clean the electrodes with soft cloth. Do not use abrasives. • Eliminate air bubbles in the pipe. • Remove the Magmeter and reinstall with the flow direction arrow on the sensor body pointed DOWNSTREAM. • Modify grounding as required to protect the Magmeter from interference. • Soak sensor overnight in fluid.
• Output is not 0 when flow is stopped.	• Electrode not adequately conditioned. • Electrical noise is interfering with the measurement. • Vibration or other movement in pipe causes magmeter to detect flow. • Defective Magmeter	• Soak sensor overnight in fluid. • Modify grounding as required to protect the Magmeter from interference. • Set low flow cutoff higher. • Return to factory for service.
• 4-20 mA output is incorrect.	• 4-20 mA is not scaled same as Loop device. • Loop device is not scaled same as Magmeter. • Range Jumper not placed correctly. • Defective Magmeter	• Use 3-0232 Span and Setup tool to set output range. • Respan Loop device to match Magmeter. • Set Range Jumper correctly. • Return to factory for service.
• Frequency output is inoperative • Digital (S^3L) output is inoperative. • Loop output is inperative.	• 2551 is wrong model. • Blue jumper not in correct position. • Wiring is not correct. • Frequency input to other manufacturer's flow instrument does not have pull-up resistor.	• Frequency model is 3-2551-11. • Place blue jumper correctly. (Sec. 5 pg. 9) • Check wiring, make corrections. • Install 10kΩ resistor. Sec 8.1, pg. 6)
• Output is 22.1 mA.	• Conductivity is less than 20 µS/cm. • Electronic component failure.	• Unsuitable application for Magmeter. • Return to factory for service.

Troubleshooting with the RED and BLUE lights

No Lights:	The power is off or the sensor is not connected
Solid Blue:	The power is on but there is no flow in the pipe.
Blinking Blue:	Normal operation, blink rate is proportional to the flow rate.
Alternating Red-Blue:	Empty pipe indication (electrodes are not wet.)
Blinking Red:	System errors (Electrical noise interference)
Solid Red:	Instrument error (defective electronics component)



Reverse flow:
- Frequency out cannot distinguish reverse flow from forward flow. The output will be the absolute value.
- Digital (S^3L) output: Reverse flow results in 0 flow rate displayed on 8900
- 4-20 mA output can be spanned into negative flow range using the custom setup tool. (example: 4-20 mA = -100 to +100 GPM)

Empty Pipe Detection
- Frequency output will be locked to 0 Hz if electrodes are not wet.
- Digital (S^3L) output will be locked to 0 if electrodes are not wet.
- 4-20 mA will be locked to 4 mA if electrodes are not wet.
- Blue and Red LED indicators on the magmeter circuit will blink alternately if the electrodes are not wet.

Accessories and Replacement Parts

O-Rings

Mfr. Part No.	Code	Description
1220-0021	198 801 186	O-ring, FPM (Viton®)
1224-0021	198 820 006	O-ring, EPDM
1228-0021	198 820 007	O-ring, FFPM (Kalrez®)

Replacement Transducers

Mfr. Part No.	Code	Description
3-2551-P0	159 001 211	PP/316L SS, DN15 to DN100 (½ to 4 in.) pipe
3-2551-P1	159 001 212	PP/316L SS, DN125 to DN200 (5 to 8 in.) pipe
3-2551-P2	159 001 444	PP/316L SS, DN250 to DN300 (10 to 12 in.) pipe
3-2551-T0	159 001 213	PVDF/Titanium, DN15 to DN100 (½ to 4 in.) pipe
3-2551-T1	159 001 214	PVDF/Titanium, DN125 to DN200 (5 to 8 in.) pipe
3-2551-T2	159 000 445	PVDF/Titanium, DN250 to DN300 (10 to 12 in.) pipe
3-2551-V0	159 001 376	PVDF/Hastelloy-C, DN15 to DN100 (0.5 to 4 in.) pipe
3-2551-V1	159 001 377	PVDF/Hastelloy-C, DN125 to DN200 (5 to 8 in.) pipe
3-2551-V2	159 000 446	PVDF/Hastelloy-C, DN250 to DN300 (10 to 12 in.) pipe
3-2551-W0	159 001 234	PVDF/316L SS, DN15 to DN100 (0.5 to 4 in.) pipe
3-2551-W1	159 001 235	PVDF/316L SS, DN125 to DN200 (5 to 8 in.) pipe
3-2551-W2	159 001 447	PVDF/316L SS, DN250 to DN300 (10 to 12 in.) pipe

Replacement Electronics Module

Mfr. Part No.	Code	Description
3-2551-11	159 001 215	Magmeter electronics, no display, frequency or digital (S^3L) output
3-2551-12	159 001 216	Magmeter electronics, no display, 4 to 20 mA output

Miscellaneous

Mfr. Part No.	Code	Description
7300-7524	159 000 687	24 VDC Power supply 7.5 W, 300 mA
7300-1524	159 000 688	24 VDC Power supply 15 W, 600 mA
7300-3024	159 000 689	24 VDC Power supply 30 W, 1.3 A
7300-5024	159 000 690	24 VDC Power supply 50 W, 2.1 A
7300-1024	159 000 691	24 VDC Power supply 100 W, 4.2 A
3-8551.521	159 001 378	Clear plastic cap for display
3-0232	159 000 865	4 to 20 mA spanning CD with RS232 Converter

Ordering Information

Sensor Part No.					
3-2551					
	Sensor Body (Transducer) and electrodes/grounding ring materials - Choose one				
	-P	Polypropylene and 316L SS			
	-T	PVDF and Titanium			
	-V	PVDF and Hastelloy C			
	-W	PVDF and 316L SS			
		Pipe size - Choose one			
		0	DN15 to DN100 (1/2 to 4 in.)		
		1	DN125 to DN200 (5 to 8 in.)		
		2	DN250 to DN300 (10 to 12 in.)		
			Display Options - Choose One		
			-1	No Display	
				Output options - Choose One	
				1	Frequency, Digital (S^3L)
				2	4 to 20 mA output
3-2551	-P	0	-1	2	Example Part Number

Part Number	Code
3-2551-P0-11	159 001 105
3-2551-P0-12	159 001 110
3-2551-P1-11	159 001 106
3-2551-P1-12	159 001 111
3-2551-P2-11	159 001 107
3-2551-P2-12	159 001 112
3-2551-T0-11	159 001 108
3-2551-T0-12	159 001 113
3-2551-T1-11	159 001 109
3-2551-T1-12	159 001 114
3-2551-T2-11	159 001 448
3-2551-T2-12	159 001 449

Part Number	Code
3-2551-V0-11	159 001 257
3-2551-V0-12	159 001 259
3-2551-V1-11	159 001 258
3-2551-V1-12	159 001 260
3-2551-V2-11	159 001 450
3-2551-V2-12	159 001 451
3-2551-W0-11	150 001 230
3-2551-W0-12	159 001 231
3-2551-W1-11	159 001 232
3-2551-W1-12	159 001 233
3-2551-W2-11	159 001 452
3-2551-W2-12	159 001 453

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1/4″ to 6″ PVC, Corzan® CPVC, PPL

Backflow Prevention

Hayward True Union Ball Check Valves prevent reversal of flow in piping systems. They are ideal where backflow could potentially cause damage to pumps, filters, or process equipment.

Automatic Operation

Hayward True Union Ball Check Valves operate without the need for any adjustments or settings. Line pressure moves the solid plastic ball off the elastomer seat, opening the valve. When the inlet flow stops, back pressure moves the ball back onto the seat – stopping the flow. Additionally, this valve features a unique square-cut elastomer seat to seal at low back pressures.

True Union Design

Sizes 1/2″ to 6″ feature a true union design. This allows for easy removal from a piping system without breaking down piping connections. Just unscrew the two assembly nuts and lift the valve body out of the line. A Trim Check design is used for the 1/4″ and 3/8″ sizes. While not true union, the valves are fully repairable, unlike some other smaller check valves.

No Corrosion Failures

Because of their all-plastic construction, these valves will never jam or stick as a result of rust or corrosion. Also they will not contaminate sensitive fluids that come into contact with them.

Features

- Full Port Design to 4″
- True Union Design
- Easy Maintenance
- FPM or EPDM Seals
- Unique Square Cut Seat
- Works in Any Position Except Downflow

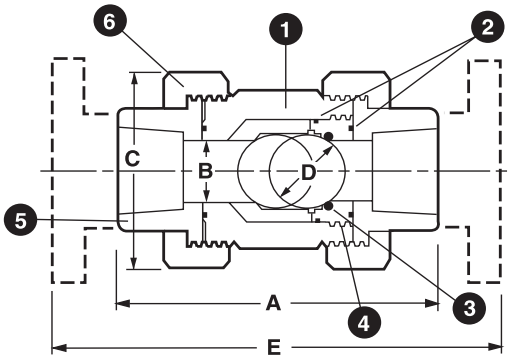
Options

- Foot Valve Screens

Corzan® is a registered trademark of Noveon, Inc.

Technical Information

True Check with foot valve screen installed



Parts List
True Union Ball Check Valves

1. Body
2. O-Ring Seals
3. Square Cut O-Ring Seat
4. Seal Retainer
5. End Connector
6. Union Nut

Dimensions - Inches / Millimeters

Size	A	B	C	D	E	F	G	Weight - (lb / kg) Socket/ Threaded	Weight - (lb / kg) Flanged
1/4″	3.06 / 78	0.31 / 8	1.38 / 35	0.50 / 13	N/A	N/A	N/A	0.13 / .06	N/A
3/8″	3.06 / 78	0.31 / 8	1.38 / 35	0.50 / 13	N/A	N/A	N/A	0.13 / .06	N/A
1/2″ / 20*	4.63 / 118	0.50 / 13	2.25 / 57	0.75 / 19	6.75 / 171	4.88 / 124	2.32 / 59	0.75 / .34	1.00 / .45
3/4″ / 25*	4.75 / 121	0.75 / 19	2.63 / 67	1.0 / 25	7.13 / 181	5.00 / 127	2.60 / 66	0.75 / .34	1.38 / .63
1″ / 32*	5.25 / 133	1.00 / 25	3.00 / 76	1.25 / 32	7.75 / 197	5.88 / 14	2.88 / 73	1.25 / .57	2.13 / .97
1-1/4″ / 40*	6.30 / 160	1.25 / 32	4.00 / 102	1.75 / 44	9.19 / 233	6.94 / 17	3.75 / 95	2.00 / .90	3.75 / 1.70
1-1/2″ / 50*	6.75 / 171	1.50 / 38	4.00 / 102	1.75 / 44	9.75 / 248	7.06 / 17	3.75 / 95	2.00 / .90	3.75 / 1.70
2″ / 63*	8.00 / 203	1.94 / 49	4.75 / 121	2.25 / 57	11.25 / 286	8.56 / 217	4.50 / 114	3.75 / 1.70	5.75 / 2.60
2-1/2″	10.68 / 271	2.88 / 73	6.56 / 167	3.25 / 83	14.38 / 365	11.25 / 286	2.50 / 64	10.00 / 4.54	14.00 / 6.36
3″ / 90*	10.56 / 268	2.88 / 73	6.56 / 167	3.25 / 83	14.38 / 365	11.25 / 286	2.50 / 64	10.00 / 4.54	14.00 / 6.36
4″ / 110*	12.94 / 329	4.00 / 102	8.56 / 217	4.25 / 108	17.00 / 432	14.63 / 372	4.25 / 108	17.00 / 7.72	25.00 / 11.36
6″	N/A	4.00 / 102	N/A	4.25 / 108	19.19 / 487	N/A	N/A	N/A	30.20 / 13.73

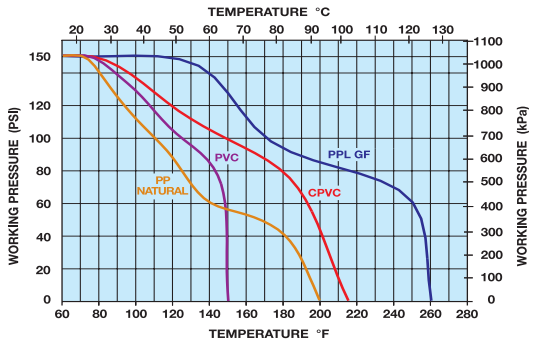
*** Metric End Connections Available in:** BSP – Straight Thread, BSP TR – Tapered Thread and Metric Socket

Selection Chart

Size	Material	End. Conn.	Seals	Pressure Rating
1/4″ - 3/8″*	PVC	Socket or Threaded	FPM	150 PSI @70°F Non-Shock
1/2″ - 4″	PVC or CPVC	Socket, Threaded, or Flanged	FPM or EPDM	
1/2″ - 2″	NAT. PPL***	Threaded	FPM	
6″**	PVC or CPVC	Flanged		

*Trim Check Design
** 4″ Valve Venturied to 6″
*** 2″ Rated at 100 PSI

Operating Temperature/Pressure



Pressure Loss Calculation Formula

$$\Delta P = \left[\frac{Q}{Cv}\right]^2$$

ΔP = Pressure Drop
Q = Flow in GPM
Cv = Flow Coefficient

Cv Factors

Size	Factor	Size	Factor
1/4″	1.0	1-1/2″	45
3/8″	3.0	2″	130
1/2″	4.8	2-1/2″	170
3/4″	7.7	3″	250
1″	11	4″	400
1-1/4″	25	6″	340

FILTRASORB® 816
Granular Activated Carbon for Municipal Specifications

CALGON CARBON CORPORATION

Description

FILTRASORB® 816 is a granular activated carbon developed by Calgon Carbon Corporation for the removal of taste and odor compounds, disinfection by-product precursors, and other dissolved organic compounds from potable water. This activated carbon is manufactured from selected grades of bituminous coal to produce a high-activity, durable, granular product capable of withstanding the abrasion associated with repeated backwashing, air scouring, and hydraulic transport. Activation is carefully controlled to produce an equal blend of both low energy pores as measured by iodine number and high energy pores as measured by trace capacity number for effective adsorption of a broad range of high and low molecular weight organic contaminants. The product is also designed to comply with all the applicable provisions of the AWWA Standard for Granular Activated Carbon edition B604-05, the stringent extractable metals requirements of ANSI/NSF Standard 61, and Food Chemicals Codex.

Applications

FILTRASORB® 816 is used primarily to treat surface water sources for the production of drinking water. This carbon is a coarser mesh media and is generally used in deep bed filters where pressure drop may be a concern. FILTRASORB® 816 functions as a dual purpose media providing both filtration and adsorption.

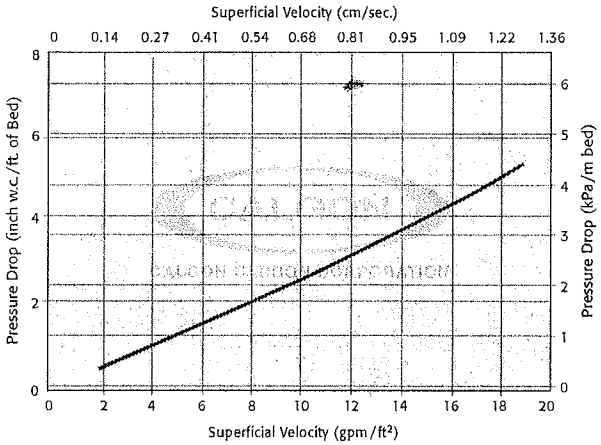
Specifications	Value
Iodine Number.	900 mg/g (min)
Moisture by weight	2% (max)
Effective size	1.3 - 1.5 mm
Uniformity Coefficient	1.4 (max)
Abrasion No.	75 (min)
Trace Capacity Number	9 mg/cc (min)
Screen Size by weight, US Sieve Series	
On 8 mesh	15% (max)
Through 16 mesh	5% (max)

Typical Property	Value
Apparent Density	0.55 g/cc
Ash by weight	8%

Features	Benefits
Bituminous-based raw material	Provides higher hardness relative to other raw materials reducing the generation of fines and product losses during backwashing.
Coal is pulverized and reagglomerated with suitable binder	Pore structure provides an equal blend of low and high energy pores for effective removal of a broad range of high and low molecular weight organic compounds. Wets readily and does not float, thus minimizing loss during backwash operations. Creates optimal transport paths for faster adsorption.

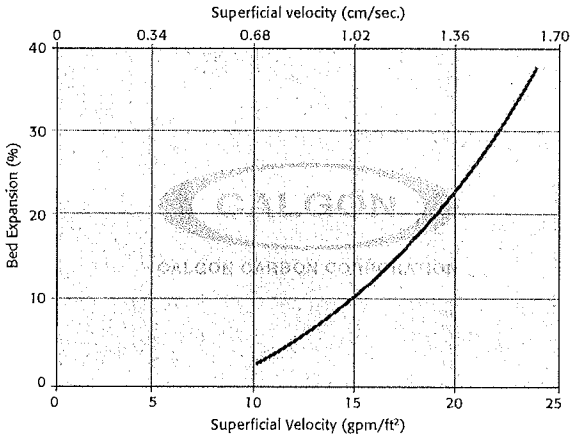
Pressure Drop

Down Flow Pressure Drop at 55°F
Based on Backwashed and Segregated Bed



Bed Expansion

Bed Expansion During Backwash at 55°F
Based on Backwashed and Segregated Bed



FILTRASORB® 816
Granular Activated Carbon for Municipal Specifications

CALGON CARBON CORPORATION

Design Considerations

As a replacement for existing filter media, the conversion to FILTRASORB® 816 activated carbon imposes no major changes to a plant's normal filtration operations. If more contact time is required, the height of the backwash troughs can be increased. Calgon Carbon Corporation can also provide complete modular adsorption systems as an add-on treatment stage if required.

Packaging

55 lb. (25 kg) poly bag

1,000 lb. (454 kg) super sack

Bulk trucks

Safety Message

Wet activated carbon preferentially removes oxygen from air. In closed or partially closed containers and vessels, oxygen depletion may reach hazardous levels. If workers are to enter a vessel containing carbon, appropriate sampling and work procedures for potentially low oxygen spaces should be followed including all applicable Federal and State requirements.

CALGON
CALGON CARBON CORPORATION

Making Water and Air Safer and Cleaner

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Appendix E

HCC Treatment System Control Logic Report

SECTION 16290

CONTROL LOGIC REPORT

PART 1 - GENERAL

1.01 SUMMARY

A. This specification provides a summary of process control requirements for the Pump and Treat Groundwater Remediation System (PTGRS) to be installed for Burlington Northern Santa Fe Railway Company (BNSF) at the Former Maintenance and Fueling Facility located within the town of Skykomish, Washington. The report provides an overview of system operations and a more detailed summary of each control instrument and how the system will respond when the instrument is engaged. This is a supplement to the instrumentation and electrical equipment specification, and is to be used for design of control logic, operator interface, and control hardware enclosures.

B. System operations and related controls can essentially be grouped into seven major sub-systems. These are:

1. **Groundwater Recovery Operation** - Groundwater Recovery Well Pumps (P-01A through P-01H), with cooling shrouds (CS-01A through CS-01H), controlled by Pezoimeter Level Transducers (PZ-1, PZ-2N & S – PZ-7N & S, and PZ-8);

2. **LNAPL Recovery Operations** - Oil Belt Skimmer (SK-01A through SK-0H) with Oil Storage Tank (T-01A through T-01H);

3. **Primary Treatment Process** - Oil Water Separation (OWS-01) with Recovered Oil Tank (T-02), Influent Equalization Tank (T-03) and Influent Equalization Transfer Pump (P-02A and P-02B);

4. **Particulate Removal Process** - Particulate removal via a Sand Filter Package (F-01A and F-01B), backwash operation and Backwash Pump (P-05), and Backwash Tank (T-04);

5. **Secondary Groundwater Treatment Process** - Groundwater treatment via liquid phase Granular Activated Carbon Package (F-02A and F-02B);

6. **Treated Water Discharge Operations** - Effluent Equalization Tank (T-05) and Treated Water NPDES Discharge Pump (P-03) and Injection Pump (P-04); and

7. **Sump Pump Operations** - Northern and Southern Utility Vault Sumps (S-01A,B and Pumps P-07A,B) and Building Sump (S-02 and Pump P-06)

C. System operations will involve a variety of analog and digital instruments and complex control loops. Control logic will be managed via a custom control enclosure (PLC Panel) which will house a programmable logic controller and an auto-dialer for remote alarm notification. A separate desk-top PC-based man-machine-interface (MMI) will be used for operator interface, data acquisition, data logging to Excel files, setpoint adjustments, etc. The system will also be equipped to allow for remote monitoring, control and data acquisition through an internet based connection.

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D. Individual system motors will be controlled by either Variable Frequency Drives (VFDs) or motor starters which will be mounted and wired in a separate Motor Control Cabinet (MCC) which will be located in the treatment system building. Power supplies for all individual VFDs and starters will be pre-wired within the MCC to a common power supply buss so that a single 3 phase power supply to the MCC enclosure can be made by the field electrician. There will be a series of discrete and analog signals that will also be field-wired between the PLC and MCC enclosures. These I/O will be pre-wired within the PLC and MCC cabinets to labeled terminal strips to facilitate field connections.

1.02 GROUNDWATER RECOVERY OPERATION

A. Eight recovery wells (RW-01 through RW-08) will provide hydraulic control along the HCC. Groundwater will be pumped from recovery wells along the HCC to create a gradient from the northern (down-gradient) to southern (up-gradient) side of the HCC. Each groundwater pump will have a 5 Hp variable frequency drive (VFD), sine wave filter, and auxiliary overload relay to operate and protect the 1 Hp down well submersible pump. The down well pumps will be controlled by level transducers located in a network of North-South piezometer pairs (PZ-1, PZ-2S & N through PZ7S & 7N, and PZ-8) on both sided of the HCC, and PZ-1/PZ-8 on the eastern and western ends. Level transducers (LT-101 & LT-102, LT-103A,B through LT108A,B) located in the fourteen (14) piezometers will provide analog inputs to the systems PLC. The operator shall be able to input which piezometer pair will be used as a basis for controlling each individual pump's speed. The differential level setpoints for each pair will also be adjustable by the operator. The down well submersible pumps operation, and groundwater pumping rate, will be automatically adjusted to maintain the desired differential level set point thus maintaining a targeted gradient and hydraulic control at the HCC. Two additional level transducers (LT-109 and LT-110) will be installed in RW-02 and RW-05 as a backup level control mechanism to prevent down well submersible pumps from running dry from excess localized drawdown. Each of the down well submersible pumping rates will be monitored by flow transducers (FIT-112A through FIT-122-H), that will provide an analog input to the system's PLC, and allow the total gallons recovered and pumping rate to be monitored.

1.03 LNAPL RECOVERY OPERATION

A. All eight of the recovery wells (RW-01 through 08) will be set up to allow for the installation of LNAPL belt skimming systems (Engineer Provided), but only five belts skimming systems will be installed initially. LNAPL will be recovered from recovery wells via belt skimmers (SK-01A through SK-01H). Each skimmer system will be controlled by a locally mounted control panel that will have a timer to control belt skimming operations, and an integral heater to decrease the viscosity of recovered product. Collected oils will flow to and be stored within a skimmer package tank (T-01A through T-01H) which shall be installed within each of the recovery well vaults. Each tank shall be fitted with a level gauge and a single high-high level switch (LSH-111A through LSH-111H) that will trigger an alarm when the storage tank level is too high for the belt Skimmer to continue to operate. The locally mounted control panel will have a dry contact to allow this high level tank signal to be shared with the main PLC control panel.

1.04 PRIMARY TREATMENT PROCESS

A. The recovered groundwater may have trace amounts of LNAPL present. It will be pumped to the treatment building into an Oil/Water Separator (OWS-01). A flow transducer will

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monitor (FIT-115)), will provide an analog input to the system's PLC, and allow the total gallons recovered and pumping rate to be monitored. LNAPL accumulating in the OWS will gravity drain into the Recovered Oil Storage Tank, a 55-gallon drum (T-02) stored in a 95 gallon over-pack drum, equipped with a High-High Level Alarm shut down (float switch LSH-116) which will provide an input to the PLC. OWS-01 will be equipped with a High-High Level Alarm shut down (float switch LSH-117). Recovered Groundwater will then gravity drain from the OWS into a 1,500 gallon Influent Equalization Tank (T-03).

B. Floating oil will be collected in a slotted pipe at the fluid surface of OWS-01, and this material drains to T-02. Collected oil will be removed from T-02 by licensed waste disposal contractors on an as needed basis, based on the operator's observations and recommendations.

C. Equalization Tank (T-03) will be fitted with a high level switch (LSHH-201) which will shut down the system and alert the operator in the event that a high level is reached. T-03 shall also be fitted with a level transducer (LT-202) that will provide an analog input to the system's PLC. The PLC will provide outputs to separate VFD's which will control two Influent Equalization Transfer Pumps (P-02A and P-02B). The system programming will control the VFD's to P-02A and P-02B such that one pump is running continuously in order to maintain a user programmable level setpoint in T-03. The PLC will also use the level transmitter's (LT-202) signal to generate programmed low and high level alarms.

D. The system design dictates that each pump P-02A and P-02B shall be capable of discharging the system design flow rate of 100 gpm. The system's control logic shall include programming such that pumps P-02A and P-02B will alternate operation on a daily basis.

1.05 PARTICULATE REMOVAL PROCESS

A. Water will be pumped from T-03 through sand filters which will perform particulate removal. The Sand Filter Package (F-01A and F-01B) will be configured to run in parallel during normal operations.

B. The sand filters will be backwashed based on a differential pressure switch (DPS-204) which will monitor the differential pressure across the filter skid. A high differential pressure as indicated by this pressure switch will trigger automatic backwash of the vessels in a lead-lag fashion. While backwash is occurring on the lead vessel, system influent water will continue to be processed through the lag vessel. Backwashing will occur for a user programmable period of time. Then the sequence is reversed such that influent flows through the lead vessel while the lag is backwashed. When both vessels have been flushed, the system will return to it's normal operating state (parallel flow).

C. The units will be backwashed with treated groundwater from the Effluent Equalization Tank (T-05) by a Backwash Pump (P-05). Particulate laden backwash water will be directed to the Backwash Tank (T-04). The Backwash Tank will allow sediments to settle out, and clarified water will be gravity decanted back to T-03. Accumulated sediments in T-04 will be cleaned out manually as needed by the operator.

D. Backwash Tank (T-04) will be fitted with a level transducer (LT-213) that will provide an analog input to the system's PLC. The PLC will provide outputs to a motor operated valve (MOV-214) which will allow the backwash tank to gravity feed into T-03 as required. The

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PLC will also use the level transmitter's (LT-213) signal to generate a programmed high level alarm.

E. Digital outputs from the PLC shall be utilized to control a series of eight motor operated valves located on the influent and effluent lines of each sand filter. The PLC shall control these valves as necessary to allow automatic backwashing and system water treatment to occur as described above without the need for manual operations by the system operator.

1.06 SECONDARY TREATMENT PROCESS

A. After passing through the sand filters, the groundwater will be treated for residual organics by a liquid phase Granular Activated Carbon Package (F-02A,B) which will be configured in series initially, but could be operated in parallel if desired.

B. The operating pressure of the LGACs will be monitored by a differential pressure switch (DPS-301) which will issue a discrete input to the PLC. The PLC will be programmed to shut the system down and alert the operator in the event that a high pressure is reached.

1.07 TREATED WATER DISCHARGE OPERATIONS

A. Treated groundwater will be collected in the Effluent Equalization Tank (T-05) which will supply water for backwashing and re-injection, while the remainder of the treated groundwater will be discharged to the NPDES outfall.

B. Tank T-05 will be fitted with a high-high level switch (LSHH-303) which will shut down the system and alert the operator in the event that a high-high level is reached. T-05 shall also be fitted with a level transducer (LT-304) that will provide an analog input to the system's PLC. The PLC will provide outputs to a VFD which will control the NPDES discharge pump (P-03). Flow to the NPDES outfall will be measured by flow transducer (FIT-307), that will provide an analog input to the system's PLC, and allow the total gallons recovered and pumping rate to be monitored. The system programming will control the VFD to P-03 such the pump will run continuously in order to maintain a user programmable set point in T-03. The PLC will also use the level transmitter's (LT-304) signal to generate programmed low and high level alarms.

C. The Treated Water Injection Pump (P-04) will run continuously at a flow rate of approximately 5-10 gpm. Treated water discharge from P-04 will be directed to the injection well manifold where it will be directed to the two injection wells at approximately 5 gpm to each well. Flow control to the injection wells will be measured by transducers (FIT-310A and B), that will provide analog inputs to the system's PLC, and allow the total gallons recovered and pumping rate to be monitored. The discharge from the Injection Pump will supply each injection well by using valves that will be manually adjusted to control the injection rate (5-10 gpm per point). The manifold legs for each injection well will be fitted with solenoid valves (SV-309 A and B) and each injection well will be fitted with a high level conductivity probe (LSH-311A and B). In the event that the groundwater level in either injection well reaches a high level the corresponding solenoid will be closed and the operator will be alerted.

1.08 SUMP PUMP OPERATIONS

A. Sump pumps (P-07A and B) located in the northern and southern utility vaults will pump water that accumulates in the vaults into the groundwater header pipe. Each sump (S-01A,B)

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will be have a high level switch (LSH-114A and B). This water is directed OWS-01 where it is sent through the treatment pant.

B. The building sump pump (P-06) will pump any water accumulating in the building drain/sump into the Influent Equalization Tank (T-03) and/or the Backwash Tank (T-04), depending on the position of hand valves. Sump (S-02) will be have a high level witch (LSH-215). The water is then sent through the treatment plant.

C. All sump pumps will operate based on level control systems that are integral to these pumps (signals not managed by PLC). Power supply for these pumps will, however, be interlocked via the PLC such that they will not be permitted to operate if there is a related alarm condition in the treatment plant. Separate high-high level switches provided at each of these locations will be wired to the PLC. These signals will be used to alert the operator that the sump pump operation cannot keep up with water accumulation rates.

1.09 DATA ACQUISITION, DATA LOGGING, AND ALARMS

A. A desk-top PC will function as the MMI for this project. A series of custom screens will be developed which will display operating status of equipment, present real-time operating data, and provide a format for the operator to monitor and adjust control parameters such as level setpoints, timer settings, and other parameters as described in detail below. The screens will also include graphical trending for a limited set of key operating parameters over a limited timeframe (propose one week), and maintain a log of recent alarm conditions (propose 20 most recent events).

B. The PC-based MMI will provide data logging for a wide range of operating data and conditions. Data will be stored in tabular format in Excel files, and each file will manage one calendar month worth of logged data. Snapshots of real-time data will be logged at timed intervals that are set by the operator on an MMI screen. A separate Excel file will be generated to log system alarm conditions as they occur. Each logged entry will be date/time stamped.

C. The PLC, MMI, and auto-dialer will be programmed to notify the operator of a range of alarm conditions that may occur in the field or in the treatment building. Alarm notifications will be displayed on the MMI, logged on the PC, trigger a dial-out to notify the operator, or a combination of these based on the nature/severity of the alarm condition. The dialer will be programmed such that the operator can locally or remotely acknowledge an active alarm so that repeated dial-outs for the same alarm condition can be avoided/minimized. It will be necessary for the operator to be physically present and address the situation that created the alarm, then reset the acknowledged alarm at the MMI, before affected portions of the collection and treatment system will be allowed to re-start or return to normal operations. The alarm log will differentiate between “active”

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alarms that must be addressed/reset by the operator, and historic alarms that have already been addressed.

D. The MMI will allow the system operator to engage "START PROCESS" and "STOP PROCESS" switches. When system is started, PLC control logic will sequence startup of collection and treatment system motors to avoid initial amperage surge. Sequence will start with treated water pump P-03 and work backwards through the plant and finish with groundwater pumps P-01 A-H. A ramp sequence will be implemented such that all variable speed motors will commence at a minimum setting (% scale, Hz) and ramp up to the appropriate control setting determined by PLC logic. All system operations will follow the control logic as described below after "START PROCESS" is engaged and ramp sequence is completed. "STOP PROCESS" shuts down all operations that are under automatic control. Operations may still run in "Hand" mode when the process has been stopped where configured to do so.

1.10 CONTROL DESCRIPTIONS

A. Instrument #: HS-100

1. Panel: PLC

2. P&ID #: P-101

3. Purpose: Panic button to shut down all system operations

4. Initial Setpoint: N/A.

5. MMI Display: Screen displays "Emergency Stop". Indicator remains until operator acknowledges/clears/resets alarm.

Note: MMI displays 20 most recent alarm conditions (event ID, date, time).

6. Control Logic:

When any E-Stop button is actuated, all system operations will stop. Components will not re-start until operator acknowledges/clears/resets alarm. System auto-dials (Group 3) for remote alarm notification.

7. Data Logging: Log each event (event ID, date, time) in separate "Alarm" Excel file. Separate files saved for each month worth of entries. Excel files available locally and remotely via Internet.

B. Instrument #: LT-101, LI-101

1. Panel: PLC

2. P&ID #: P-101

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3. Purpose: Monitor groundwater level in piezometer PZ-1 at eastern end of HCC barrier.

4. Initial Setpoint: NA

5. MMI Display: Screen allows operator entry and display of following parameters:

- Well Rim Elevation: "XXX.XX ft MSL"
- Transmitter Depth: "XXX.XX ft"
- Transmitter Range: "X ft/ mA" (need instrument response parameter in case we change transmitters at a later time)

Based on transmitter response and above parameters, screen displays level as "XXX.XX ft MSL". One-week graphical trending of this parameter on MMI screen. Worst case groundwater level range for all piezometer transducers is 910 to 935 ft MSL (trending graphic range).

6. Control Logic: Groundwater level display calculated as: Rim Elevation – Transmitter Depth + Height of Water over transmitter (based on transmitter's 4-20 mA signal).

7. Data Logging: Log data in Excel file based on operator set interval.

C. Instrument #: LT-102, LI-102

See details for LT-101 described above. Device is mounted in PZ-8 on western end of HCC barrier. LT-101 and 102 are for monitoring purposes only.

D. Instrument#: LT-103A&B through LT-108A&B, DLAH-109A - H

1. Panel: PLC

2. P&ID #: P-101

3. Purpose: Monitor groundwater levels on upgradient and downgradient piezometer pairs along HCC barrier. Provide basis for differential level control of pumping rates for groundwater pumps.

4. Initial Setpoint: Adjustable ("- X.XX to + X.XX" ft)

5. Display:

MMI screen allows operator entry of transducer installation parameters and instrument response and displays groundwater elevation for each of the (12) transmitters as described for LT-101 (above).

Screen allows operator to individually establish for each groundwater pump (P-01A – H) which of the (6) piezometer pairs will be used as a basis for differential level control to adjust the speed/output of that pump, and what the differential level setpoint for the selected piezometer pair/pump will be. Pump differential level

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setpoint units will be: "X.XX ft" (range 0 – 9.99 ft). Screen will also display current (real-time) differential level for each piezometer pair.

Screen allows operator to set a single dL high alarm setting to represent all piezometer pairs. MMI will display alarm notification for any piezometer pair whose dL is less than this programmed setting. Common alarm light on PLC panel illuminates.

One-week graphical trending of the (12) piezometers readings will be provided on the MMI screen.

Screen allows operator input of VFD governor settings (SCH-113A-H) (Hz or % scale) for each groundwater pump to limit maximum pump output when dL significantly exceeds dL setpoint (initial startup and following alarm responses).

6. Control Logic:

Groundwater levels to be calculated and displayed as described above for LT-101.

Differential level values are to be calculated as: North piezometer (A) value – South piezometer (B) value = "+/-X.XX ft" for each pair.

Logic will include programmed Proportional, Integral, and Differential (PID) response parameters for pump speed controls. PLC analog outputs will be issued to each pump's VFD based on deviation between actual dL and setpoint dL for the piezomter pairs selected to control individual pumps. Output to VFD's will be limited by governor setting (SCH-113 A-H) entered at the MMI.

PLC will trigger an auto-dialer notification (Group 1) and illuminate the shared alarm light on the PLC panel when any piezometer pair differential level is less than the dL alarm limit, set by the operator at the MMI, for 15 minutes. Alarm notification display will remain until operator acknowledges/resets the alarm at the MMI.

7. Data Logging: Log current level data for all (12) transmitters in Excel file based on operator set interval. Log dL alarm events in a separate Excel file with date/time/event ID.

E. Instrument#: LT-109, LAL-109

1. Panel: PLC

2. P&ID #: P-101

3. Purpose: Monitor groundwater levels within RW-02. Provide a backup level control mechanism to prevent P-01 X, Y, Z from running dry.

4. Initial Setpoint: Adjustable (~2 ft above pump intake elevation)

5. Display:

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MMI screen allows operator entry of transducer installation parameters and instrument response (see LT-101) and displays groundwater elevation for RW-02.

Screen allows operator entry of Low Level Alarm setting: "XXX.XX" ft MSL.

Screen indicates Low Level Alarm when measured groundwater level drops below operator set Low Level Alarm setting. Common alarm light on PLC panel illuminates.

6. Control Logic:

Groundwater levels to be calculated and displayed as described above for LT-101.

When Low Level Alarm (LAL-109) is triggered, P-01 X, Y, Z will not be permitted to operate until the measured groundwater level is consistently above the Low Level Alarm setting for at least 10 minutes.

PLC will trigger an auto-dialer notification (Group 1), generate MMI alarm notification, and illuminate the shared alarm light on the PLC panel when LAL-109 is triggered. Alarm notification display will remain until operator acknowledges/resets the alarm at the MMI.

7. Data Logging: Log current level in Excel file based on operator set interval. Log alarm events in a separate Excel file with date/time/event ID.

F. Instrument#: LT-110, LAL-110

1. Panel: PLC

2. P&ID #: P-101

3. Purpose: Monitor groundwater levels within RW-05. Provide a backup level control mechanism to prevent P-01 X, Y, Z from running dry.

4. Initial Setpoint: Adjustable (~2 ft above pump intake elevation)

5. Display:

MMI screen allows operator entry of transducer installation parameters and instrument response (see LT-101) and displays groundwater elevation for RW-05.

MMI screen allows operator entry of Low Level Alarm setting: "XXX.XX" ft MSL.

MMI screen indicates Low Level Alarm when measured groundwater level drops below operator set Low Level Alarm setting. Common alarm light on PLC panel illuminates.

6. Control Logic:

Groundwater levels to be calculated and displayed as described above for LT-101.

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When Low Level Alarm (LAL-110) is triggered, P-01 X, Y, Z will not be permitted to operate until the measured groundwater level is consistently above the Low Level Alarm setting for at least 10 minutes.

PLC will trigger an auto-dialer notification (Group 1) and illuminate the shared alarm light on the PLC panel when LAL-110 is triggered. Alarm notification display will remain until operator acknowledges/resets the alarm at the MMI.

7. Data Logging: Log current level data in Excel file based on operator set interval. Log alarm events in a separate Excel file with date/time/event ID.

G. Instrument#: HSS-111 A-H (not wired to PLC)

Skimmers operate independently of PLC logic. HSS allows manual and auto operating modes. Units are factory wired to shut down in Auto when tank (T-01) reaches high level (LSH-11).

H. Instrument#: LSH-111 A-H, LAH-111 A-H

1. Panel: PLC

2. P&ID #: P-101

3. Purpose: Provide PLC input that oil skimmer Recovered Oil Storage Tanks (T-01 A-H) are at a high level, the skimmers have shut down, and operator attention is required to empty the vessels.

4. Initial Setpoint: N/A

5. Display:

MMI screen displays “T-01 (A-H) Level Normal” when LSH-111 (A-H) is open.

MMI screen overwrites “Level Normal” with “T-01 (A-H) High Level” when LSH-111 (A-H) closes.

Common red alarm light (push to test) on PLC panel will illuminate when any skimmer tank High Level switch is engaged.

6. Control Logic:

PLC will trigger an auto-dialer notification (Group 1) and illuminate the shared alarm light on the PLC panel when LSH-111 (A-H) is triggered. Alarm notification on the MMI and common alarm light on the PLC panel will continue to display until operator acknowledges/resets the alarm at the MMI.

7. Data Logging: Log alarm events in Excel file with date/time/event ID.

I. Instrument #: HSS-113 (A-H)

1. Panel: PLC

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2. P&ID #: P-101

3. Purpose: Select control mode for recovery well pumps P-01A through P-01H. Select "Hand," "Off," or "Auto" position at the PLC control panel. Separate local lockable disconnect switch (HS-113 A-H) located on power supply to each pump in the field vaults.

4. Initial Setpoint: N/A

5. Display:

MMI screen displays run status for each pump based on ZSC-113 A-H. MMI also displays controlled speed of P-01 A-H (% scale or Hz) when in Auto mode.

Green run light on PLC panel (ZI-113 A-H) (push to test) displays run status of P-01A-H based on ZSC-113 A-H.

6. Control Logic:

In "Hand" mode, P-01 A-H will be permitted to operate independently of PLC control logic. Speed control will be set manually at the individual VFDs (SC-113 A-H).

In "Auto" mode, the PLC will issue permissive signals to individual groundwater pump's VFDs (SC-113 A-H) based on conditions in the recovery network and treatment system. Speed control signals will be issued by the PLC (SIC-113 A-H) to individual pump's VFDs based on comparison of measured dL for the piezometer pair controlling each well and the dL setpoint for the pair set at the MMI by the operator (LT-103 A,B – LT-108A,B). Maximum speed is governed by SCH-113 A-H set at MMI.

In "Off" position, pumps P-01 A-H will not operate.

7. Data Logging: Log current speed control signal (Hz or % scale) in Excel file based on operator set interval.

J. Instrument #: ZSC-113 A-H, ZI-113 A-H

1. Panel: MCC & PLC

2. P&ID #: P-101

3. Purpose: Run confirm for P-01 A-H

4. Initial Setpoint: NA

5. Display:

MMI screen indicates ON/OFF status for each groundwater pump (ZI-113 A-H). Screen also displays controlled speed of P-01 A-H (SIC-113 A-H) (% scale or Hz) when in Auto mode.

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Green run light (ZI-113 A-H) on PLC panel (push to test) displays run status of P-01A-H based on ZSC-113 A-H.

MMI screen displays "P-01 A-H Alarm" (ZA-113 A-H) and common red alarm light on PLC illuminates when P-01 A – H should logically be operating but run confirm based on ZSC-113 A-H is not present.

6. Control Logic:

PLC generates "Pump Failure" alarm (ZA-113 A-H) when any of P-01 A-H should logically be operating but a run confirm from ZSC-113 A-H is not present. PLC will trigger an auto-dialer notification (Group 1) and illuminate the shared alarm light on the PLC panel. Alarm notification on the MMI and common alarm light on the PLC panel will continue to display until operator acknowledges/resets the alarm at the MMI.

7. Data Logging: Log alarm events in Excel file with date/time/event ID.

K. Instrument #: FE/FIT-112 A-H, FI-112 A-H, FQI-112 A-H

1. Panel: PLC

2. P&ID #: P-101

3. Purpose: Measurement of flow from each recovery well (RW-01 through RW-08)

4. Initial Setpoint: NA

5. Display: MMI screen displays instantaneous flow rate (gpm), totalized flow (gallons) for each well pump (P-01 A-H).

6. Control Logic: PLC to convert paddle wheel output reading (4 -20 mA) to " XX.X GPM" and totalized "XXXXXX KGAL" (gal x 1000).

7. Data Logging: Instantaneous and totalized flow to be logged in Excel file based on operator set interval.

L. Instrument #: CR-114 A,B

Northern and southern utility vault sump pumps have built-in level control systems to automate ON-OFF cycles. The vaults are fitted with separate high-high levels switches (LSHH-114 A,B) which tie to the PLC. The PLC will control the power supply to these sump pumps based on monitored conditions in the recovery network and treatment plant.

M. Instrument #: LSHH-114 A,B, LAHH-114 A,B

1. Panel: PLC

2. P&ID #: P-101

3. Purpose: Indicates high-high level in the northern and southern utility vaults (S-01A, and S-01B).

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4. Initial Setpoint: Field set.

5. Display:

MMI screen displays "North" or "South Vault High High Level Alarm" when LSHH-114 A or B is engaged. Common red alarm light on PLC panel illuminates. MMI screen reads "North/South Vault OK" when there is no active level alarm.

6. Control Logic:

PLC will trigger an auto-dialer notification (Group 1) and illuminate the shared alarm light on the PLC panel. Alarm notification on the MMI and common alarm light on the PLC panel will continue to display until operator acknowledges/resets the alarm at the MMI.

7. Data Logging: Log alarm events in Excel file with date/time/event ID.

N. Instrument #: FE/FIT-115, FI-115, FQI-115

1. Panel: PLC

2. P&ID #: P-101

3. Purpose: Measurement of total system influent from recovery wells (RW-01 through RW-08) and northern/southern utility vault sump pumps.

4. Initial Setpoint: NA

5. Display:

MMI screen displays instantaneous flow rate (gpm), totalized flow (gallons). One week graphical trending of this parameter displayed on MMI.

6. Control Logic: PLC to convert paddle wheel output reading (4 -20 mA) to " XX.X GPM" and totalized "XXXXXX KGAL" (gal x 1000).

7. Data Logging: Instantaneous and totalized flow to be logged in Excel file based on operator set interval.

O. Instrument #: LSH-116, LAH-116

1. Panel: PLC

2. P&ID #: P-101

3. Purpose: Indicate high-high level in T-02

4. Initial Setpoint: Approximately 90% full.

5. Display:

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MMI screen displays “T-02 High Alarm”. A common alarm light on the PLC panel will illuminate. MMI displays “T-02 Level OK” when not in high level alarm.

6. Control Logic:

PLC will terminate all water collection and treatment system operations when LSH-116 is engaged. Air sparging compressor (C-01) may continue to operate. System water components will remain off until the operator addresses the alarm condition and acknowledges/reset the alarm.

PLC will trigger an auto-dialer notification (Group 2) and illuminate the shared alarm light on the PLC panel. Alarm notification on the MMI and common alarm light on the PLC panel will continue to display until operator acknowledges/resets the alarm at the MMI.

7. Data Logging: Log alarm events in Excel file with date/time/event ID.

P. Instrument #: LSH-117, LAH-117

1. Panel: PLC

2. P&ID #: P-101

3. Purpose: Indicate high level in OWS-01

4. Initial Setpoint: Approximately 90% full.

5. Display:

MMI screen displays “OWS-01 High Alarm”. Common alarm light on PLC panel will illuminate. Display indicates “OWS-01 OK” when not in a high level.

6. Control Logic:

PLC will terminate all water collection and treatment system operations when LSH-117 is engaged. Air sparging compressor (C-01) may continue to operate. System water components will remain off until the operator addresses the alarm condition and acknowledges/reset the alarm.

PLC will trigger an auto-dialer notification (Group 2) and illuminate the shared alarm light on the PLC panel. Alarm notification on the MMI and common alarm light on the PLC panel will continue to display until operator acknowledges/resets the alarm at the MMI.

7. Data Logging: Log alarm events in Excel file with date/time/event ID.

Q. Instrument #: LSHH-201, LAH-201

1. Panel: PLC

2. P&ID #: P-102

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3. Purpose: Indicates high-high level in T-03

4. Initial Setpoint: Approximately 90% full.

5. Display:

MMI screen displays "T-03 High-High Alarm". Display remains until operator acknowledges/clears/resets alarm. A common alarm light on the PLC panel will illuminate.

6. Control Logic:

PLC will terminate all water collection and treatment system operations when LSHH-201 is engaged. Air sparging compressor (C-01) may continue to operate. System water components will remain off until the operator addresses the alarm condition and acknowledges/reset the alarm.

PLC will trigger an auto-dialer notification (Group 2) and illuminate the shared alarm light on the PLC panel. Alarm notification on the MMI and common alarm light on the PLC panel will continue to display until operator acknowledges/resets the alarm at the MMI.

7. Data Logging: Log alarm events in Excel file with date/time/event ID.

R. Instrument #: LE/LT-202, LAL-202, LAH-202

1. Panel: PLC and MCC

2. P&ID #: P-102

3. Purpose: Water level measurement in T-03, and control of pump P-02A and P-02B

4. Initial Setpoint: Operator set at MMI.

5. Display:

MMI screen allows operator to adjust level control setpoint for the P-02 A,B and T-03, and set low level alarm (LAL-202) and high level alarm settings (LAH-202). Level setpoint, alarm levels, and current reading units will be: "X.XX ft" (range 0 – 9.99 ft).

MMI screen will display current (real-time) level for T-03 (LI-202).

MMI screen will display "T-03 High Level Alarm" when level in T-03 exceeds operator set alarm level (LAH-202). A common alarm light on the PLC panel will illuminate.

MMI screen will display "T-03 Low Level Alarm" when level in T-03 drops below operator set alarm level (LAL-202). A common alarm light on the PLC panel will illuminate.

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MMI screen will allows operator input of VFD governor settings (SCH-203 A,B) (Hz or % scale) for P-02A,B to limit maximum pump output when current is significantly above the level control.

6. Control Logic:

PLC converts 4-20 mA signal from LT-202 to "X.X Ft" of water for display purposes.

Logic will include programmed Proportional, Integral, and Differential (PID) response parameters for pump speed controls. PLC analog outputs will be issued to each pump's VFD based on deviation between actual level in T-03 and setpoint level for LT-202 set by the operator at the MMI. Output to VFD's will be limited by governor setting (SCH-202 A,B) entered at the MMI.

PLC will toggle between P-02 A and B such that one pump or the other will operate for any 24 hour period.

When measured levels in T-03 exceed the operator set high alarm level (LAH-202), the PLC will shut down P-01 A-H, P-07-A,B, and P-06, until the measured level reaches the level control setpoint for T-03. Air sparging compressor (C-01) may continue to operate. PLC will trigger an auto-dialer notification (Group 2), display "T-03 High Level Alarm", or "T-03 Low Level Alarm", and illuminate the shared alarm light on the PLC panel when either a low level or high level. Alarm notification display will remain until operator acknowledges/resets the alarm at the MMI.

When measured levels in T-03 drops below the operator set low alarm level (LAL-202), the PLC will shut down P-02 A, B until the measured level reaches the level control setpoint for T-03. PLC will trigger an auto-dialer notification (Group 2), display "T-03 Low Level Alarm", and illuminate the shared alarm light on the PLC panel when either a low level or high level. Alarm notification display will remain until operator acknowledges/resets the alarm at the MMI.

7. Data Logging: Log current level data in Excel file based on operator set interval. Log alarm events in a separate Excel file with date/time/event ID.

S. Instrument #: HSS-203 A,B

1. Panel: PLC

2. P&ID #: P-102

3. Purpose: Select control mode for pumps P-02A and B. Select "Hand," "Off," or "Auto" position at the PLC control panel. Separate local lockable disconnect switches (HS-203 A,B) are located on power supply to each pump on the pump skid.

4. Initial Setpoint: N/A

5. Display:

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MMI screen displays run status for each pump based on ZSC-203 A,B. MMI also displays controlled speed of P-02 A,B (% scale or Hz) when in Auto mode.

Green run light on PLC panel (ZI-203 A,B) (push to test) displays run status of P-02 A,B on ZSC-203 A,B.

6. Control Logic:

With either pump in "Hand" mode, P-02 A,B will operate independently of PLC control logic. Speed control will be set manually at the individual VFDs (SC-203 A,B).

With both pumps in "Auto" mode, the PLC will alternate operation of these two pumps such that one pump or the other will operate for every 24 hour period. When only one pump is in "Auto" mode, that pump alone will be selected to operate. The PLC will issue permissive signals to individual groundwater pump's VFDs (SC-203A,B) based on which pump is active, and based on monitored conditions in the recovery network and treatment system. Speed control signals will be issued by the PLC (SIC-203 A,B) to individual pump's VFDs based on comparison of measured level in T-03 and the level setpoint for T-03 set at the MMI by the operator (LT-202). Maximum speed is governed by SCH-203 A,B set at MMI.

In "Off" position, pumps P-01 A-H will not operate.

7. Data Logging: NA

T. Instrument #: ZSC-203 A,B, ZI-203 A,B

1. Panel: MCC & PLC

2. P&ID #: P-102

3. Purpose: Run confirm for P-02 A,B

4. Initial Setpoint: NA

5. Display:

MMI screen indicates ON/OFF status for P-02 A,B (ZI-203A,B). Screen also displays controlled speed of P-02 A,B (SIC-203 A,B) (% scale or Hz) when in Auto mode.

Green run light (ZI-203 A,B) on PLC panel (push to test) displays run status of P-02 A,B.

MMI screen displays "P-02 A,B Alarm" (ZA-203 A,B) and common red alarm light on PLC illuminates when P-02 A,B should logically be operating but run confirm based on ZSC-203 A,B is not present.

6. Control Logic:

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PLC generates "Pump Failure" alarm (ZA-203 A,B) when P-02 A,B should logically be operating but a run confirm from ZSC-203 A,B is not present. PLC will trigger an auto-dialer notification (Group 2) and illuminate the shared alarm light on the PLC panel. Alarm notification on the MMI and common alarm light on the PLC panel will continue to display until operator acknowledges/resets the alarm at the MMI.

7. Data Logging: Log alarm events in Excel file with date/time/event ID.

U. Instrument #: CR-215

The treatment building sump pump (P-06) has a built-in level control systems to automate ON-OFF cycles. The vault is fitted with a separate high-high levels switches (LSHH-215) that ties to the PLC. The PLC will control the power supply to the sump pump based on monitored conditions in the recovery network and treatment plant.

V. Instrument #: LSHH-215, LAHH-215

1. Panel: PLC

2. P&ID #: P-102

3. Purpose: Indicates high-high level in the building sump (S-02).

4. Initial Setpoint: Field set.

5. Display:

MMI screen displays "Building Sump High High Level Alarm" when LSHH-215 is engaged. Common red alarm light on PLC panel illuminates. MMI screen reads "Building Sump Level OK" when there is no active level alarm.

6. Control Logic:

PLC will terminate all water collection and treatment system operations and air sparging compressor (C-01) when LSHH-201 is engaged. System water components will remain off until the operator addresses the alarm condition and acknowledges/reset the alarm.

PLC will trigger an auto-dialer notification (Group 2) and illuminate the shared alarm light on the PLC panel. Alarm notification on the MMI and common alarm light on the PLC panel will continue to display until operator acknowledges/resets the alarm at the MMI.

7. Data Logging: Log alarm events in Excel file with date/time/event ID.

W. Instrument #: DPSH-204, DPAH-204, KIC-204

1. Panel: PLC

2. P&ID #: P-102

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3. Purpose: High differential pressure indicator for initiation of sand filter system backwash.

4. Initial Setpoint: NA

5. Display:

MMI screen will allow operator to enter backwash timer settings (KIC-204) (XX minutes) for both vessels.

MMI screen will allow operator to enter speed setting (% scale or Hz) for P-05 which will be used to set backwash flowrate for F-01 A,B.

MMI screen allows operator to manually initiate backwashing operations by placing screen-based selector switch (HSS-205A) in "Hand" mode. In "Auto" mode, the units will follow the backwash sequence described below based on DPSH-204. In "Off" position, all valves will remain in their current position.

With HSS-205A in "Off" position, MMI screen allows the operator to force all sand filter MOVs open or closed for testing purposes by actuating a separate screen-based selector switch (HSS-205B).

MMI screen displays "F-01A or B Backwashing". Screen shall indicate which vessel is actively filtering and which vessel is actively backwashing. Screen will display current timer reading while vessels are being backwashed. MMI screen displays "F-01A,B Normal" when units are operating normally in parallel.

6. Control Logic:

DPSH-204 must remain continuously engaged for a minimum of 5 seconds before it is acted upon. When this switch is sufficiently engaged, T-04 is <u>not</u> in "High Level Alarm" (LAH-213), and T-05 is not in "Low Level Alarm" (LAL-304), PLC will;

- Issue permissive to CR-205B, CR-208B, CR-209B, and CR-212B to close MOV-205, MOV-208, MOV-209, and MOV-212. Permissive will be issued for X seconds (set during startup) to provide sufficient time for all valves to close.

- When permissive to close the above valves times out, P-05 will be permitted to operate when in Auto mode at speed setting establish by operator until both filter units are backwashed.

- When backwash cycle times out for lead vessel, PLC issues permissives to CR-205A, CR-208A, CR-209A, and CR-212A to open MOV-205, MOV-208, MOV-209, and MOV-212. Simultaneously PLC issues permissives to CR-206B, CR-207B, CR-210B, and CR-211B to close MOV-206, MOV-207, MOV-210 and MOV-211. Permissives will be issued for X seconds (set during startup) to provide sufficient time for all valves to be in their proper position.

- When backwash cycle times out for lag vessel, PLC issues permissives to CR-206A, CR-207A, CR-210A, and CR-211A to re-open MOV-206,

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MOV-207, MOV-210 and MOV-211 and discontinue permissive for P-05. This completes backwash cycle.

If DPSH-204 engages while T-04 is at High Level (LAH-213), PLC must automate sufficient drainage of T-04 (via MOV-214) to reach Low Level (LAL-213) before backwash operations described above can commence. Backwash operations may continue even if LAH-213 is re-engaged during the backwash cycle.

The automated backwash sequence listed above will also be followed when the operator manually initiates a backwash cycle by engaging HSS-205A at the MMI screen.

7. Data Logging: Log each automated backwash event in alarm-based Excel file with date/time/event ID.

X. Instrument #: HSS-205 through HSS-212

1. Panel: PLC

2. P&ID #: P-102

3. Purpose: Select control mode for motor operated valves (MOV-205 through MOV-212). Select "Open," "Closed," or "Auto" position at the PLC control panel.

4. Initial Setpoint: N/A

5. Display:

MMI screen displays current valve position (Open or Closed).

6. Control Logic:

In "Open" position, the PLC will energize the MOV. In "Close" position, the PLC will de-energize the MOV. In the "Auto" position, the PLC will determine whether the MOV should open, close, or remain in current position based on system operation mode (i.e. backwash or normal operation (parallel)).

7. Data Logging: Log each automated backwash event in alarm-based Excel file with date/time/event ID.

Y. Instrument #: ZSC-205 through ZSC-212, ZI-205 through ZI-212

1. Panel: MCC & PLC

2. P&ID #: P-102

3. Purpose: Closed position confirm of the MOVs (MOV-205 through MOV-212)

4. Initial Setpoint: NA

5. Display:

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MMI screen indicates current position of MOV

MMI screen displays “MOV-205 through MOV-212 Closed Failure Alarm”, (ZA-205 through ZA-212) and common red alarm light on PLC illuminates when MOV-205 through MOV-212 should logically be closed but limit switch is not made.

6. Control Logic:

PLC generates “Closed Failure Alarm” alarm (ZA-205 through ZA-212) when MOV-205 through MOV-212 should logically be closed but a confirm from ZSC-205 through ZSC-212 is not present. PLC will terminate all water collection and treatment system operations but the air sparge compressor (C-01) will continue to operate. The PLC will also trigger an auto-dialer notification (Group 2) and illuminate the shared alarm light on the PLC panel. Alarm notification on the MMI and common alarm light on the PLC panel will continue to display until operator acknowledges/resets the alarm at the MMI.

7. Data Logging: Log alarm events in Excel file with date/time/event ID.

Z. Instrument #: ZSO-205 through ZSO-212, ZI-205 through ZI-212

1. Panel: MCC & PLC

2. P&ID #: P-102

3. Purpose: Open position confirm of the MOVs (MOV-205 through MOV-212)

4. Initial Setpoint: NA

5. Display:

MMI screen indicates current position of MOV

MMI screen displays “MOV-205 through MOV-212 Open Failure Alarm”, (ZA-205 through ZA-212) and common red alarm light on PLC illuminates when MOV-205 through MOV-212 should logically be open but limit switch is not made.

6. Control Logic:

PLC generates “Open Failure Alarm” alarm (ZA-205 through ZA-212) when MOV-205 through MOV-212 should logically be open but a confirm from ZSC-205 through ZSC-212 is not present. PLC will terminate all water collection and treatment system operations but the air sparge compressor (C-01) will continue to operate. The PLC will also trigger an auto-dialer notification (Group 2) and illuminate the shared alarm light on the PLC panel. Alarm notification on the MMI and common alarm light on the PLC panel will continue to display until operator acknowledges/resets the alarm at the MMI.

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7. Data Logging: Log alarm events in Excel file with date/time/event ID.

AA. Instrument #: LE/LT-213, LAL-213, LAH-213

1. Panel: PLC

2. P&ID #: P-102

3. Purpose: Water level measurement in T-04, and control of system backwash cycles.

4. Initial Setpoint: TBD

5. Display:

MMI screen allows operator adjustment of programmed "Low Level Alarm" (LAL-213) and "High Level Alarm" (LAH-213) settings.

Screen displays current level in T-04 (XX.X Ft). Screen also indicates if T-04 is at or above "T-04 High Level" or at/below "T-04 Low Level". A common alarm light on the PLC will illuminate when LAH-213 or LAL-213 is reached. There is no dial-out required for these alarm condition.

MMI screen allows operator to manually drain T-04 via MOV-214 by placing screen-based selector switch (HSS-214) in "Hand" mode which forces the valve open. In "Auto" mode, the valve will actuate based on the backwash control logic for the sand filters. In "Off" position, MOV-214 will be forced closed.

MMI screen displays "T-04 Draining" when T-04 is being <u>automatically</u> drained.

6. Control Logic:

PLC will convert depth-to-water signal (4-20 mA) to height of water in T-04 for display/control purposes (XX.X ft).

PLC indicates high level alarm condition at the MMI and illuminates the common alarm light on the PLC panel when the operator set limit for LAH-213 is exceeded in -04. The auto-dialer will <u>not</u> be engaged for this alarm condition. The MMI indication and alarm light will remain "on" until the operator acknowledges/resets the alarm at the MMI.

PLC will automate drainage of T-04 via MOV-214 if;

- Backwash operations are pending based on DPSH-204, or if
- Backwashing is initiated manually by the operator (HSS-205A), and if
- HSS-214 is in the "Auto" position.

PLC indicates low level alarm condition at the MMI and illuminates the common alarm light on the PLC panel when T-04 level drops below the operator set limit for LAL-213. The auto-dialer will <u>not</u> be engaged for this alarm condition. The MMI

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indication and alarm light will remain "on" until the operator acknowledges/resets the alarm at the MMI.

7. Data Logging: Instantaneous level data for T-04 is to be logged in Excel file based on operator set interval. Log high/low alarm events in separate Excel file with date/time/event ID.

BB. Instrument #: HSS-214

1. Panel: PLC

2. P&ID #: P-102

3. Purpose: Select control mode for motor operated valves (MOV-214). Select "Open," "Closed," or "Auto" position at the PLC control panel.

4. Initial Setpoint: N/A

5. Display:

MMI screen displays current valve position (Open or Closed).

6. Control Logic:

In "Open" position, the PLC will energize the MOV. In "Close" position, the PLC will de-energize the MOV. In the "Auto" position, the PLC will determine whether the MOV should open, close, or remain in current position based on the current water level in T-04 as indicated by LT-213, as discussed above.

7. Data Logging: Log each automated MOV event in alarm-based Excel file with date/time/event ID.

CC. Instrument #: ZSC-214, ZI-214

1. Panel: MCC & PLC

2. P&ID #: P-102

3. Purpose: Closed position confirm of the MOVs (MOV-214)

4. Initial Setpoint: NA

5. Display:

MMI screen indicates current position of MOV

MMI screen displays "MOV-214 Closed Failure Alarm", (ZA-214) and common red alarm light on PLC illuminates when MOV-214 should logically be closed but limit switch is not made.

6. Control Logic:

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PLC generates "Closed Failure Alarm" alarm (ZA-214) when MOV-214 through MOV-214 should logically be closed but a confirm from ZSC-214 is not present. PLC will not trigger an auto-dialer notification but will illuminate the shared alarm light on the PLC panel. Alarm notification on the MMI and common alarm light on the PLC panel will continue to display until operator acknowledges/resets the alarm at the MMI.

7. Data Logging: Log alarm events in Excel file with date/time/event ID.

DD. Instrument #: ZSO-214, ZI-214

1. Panel: MCC & PLC

2. P&ID #: P-102

3. Purpose: Open position confirm of the MOVs (MOV-205 through MOV-212)

4. Initial Setpoint: NA

5. Display:

MMI screen indicates current position of MOV

MMI screen displays "MOV-214 Open Failure Alarm", (ZA-214) and common red alarm light on PLC illuminates when MOV-214 should logically be open but limit switch is not made.

6. Control Logic:

PLC generates "Open Failure Alarm" alarm (ZA-214) when MOV-214 should logically be open but a confirm from ZSC-214 is not present. PLC will not trigger an auto-dialer notification (Group 2) but will illuminate the shared alarm light on the PLC panel. Alarm notification on the MMI and common alarm light on the PLC panel will continue to display until operator acknowledges/resets the alarm at the MMI.

7. Data Logging: Log alarm events in Excel file with date/time/event ID.

EE. Instrument #: DPSH-301, DPAH-301

1. Panel: PLC

2. P&ID #: P-103

3. Purpose: High differential pressure switch to monitor backpressure at F-02A and F-02B

4. Initial Setpoint: TBD

5. Display:

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MMI screen displays “High Pressure F-02A, B”. The common alarm light on the PLC panel will be illuminated.

6. Control Logic:

DPSH-301 must remain continuously engaged for a minimum of 5 seconds before it is acted upon. When sufficiently engage, the PLC will shut down the entire groundwater collection and treatment system. The Sparge Air Compressor (C-01) may continue to operate.

PLC will trigger an auto-dialer notification (Group 2) and illuminate the shared alarm light on the PLC panel. The operator will be required to clear/acknowledge/reset the alarm condition before the groundwater system components will be allowed to restart.

Backwashing of F-02 A,B is to be performed manually by the operator.

7. Data Logging: Log alarm events in Excel file with date/time/event ID.

FF. Instrument #: HSS-305

1. Panel: PLC

2. P&ID #: P-103

3. Purpose: Control for backwash pump P-05. Selects “Hand,” “Off,“ or “Auto” position at PLC panel.

4. Initial Setpoint: N/A

5. Display:

MMI screen to display “P-05 ON” based on run confirm (ZSC-305). Green “Run” light (push-to-test) for P-05 will illuminate on the PLC panel. Display shall read “P-05 On” when running, and “P-05 Off” when not running.

6. Control Logic:

As described above, P-05 will be permitted to operate by the PLC if;

- HSS-305 is in the “Auto” position,
- Sand Filter backwashing operations are pending,
- T-04 is not in High Level Alarm (LAH-213), and
- T-05 is not in Low Level Alarm (LAL-304)

Speed settings for P-05 for sand filter backwashing operations with HSS-302 in “Auto” position will be based on rate set by operator at the MMI as described for DPSH-204.

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In "Hand" mode, P-05 will operate independently of PLC logic. Speed control for P-05 in this mode will be adjusted locally at the P-05 VFD. This mode of operation will be used to backwash GAC vessels F-02A,B. Operator must ensure there is adequate supply of water in T-05 and adequate space in T-04 before initiating manual backwashing of F-02A,B.

7. Data Logging: NA.

GG. Instrument #: ZSC-305, ZI-305

1. Panel: MCC & PLC

2. P&ID #: P-103

3. Purpose: Run confirm for P-05

4. Initial Setpoint: NA

5. Display:

MMI screen indicates ON/OFF status for P-05 (ZI-305). Screen also displays controlled speed of P-05 (SIC-305) (% scale or Hz) when in Auto mode.

Green run light (ZI-305) on PLC panel (push to test) displays run status of P-05 based on ZSC-305.

MMI screen displays "P-05 Alarm" (ZA-305) and common red alarm light on PLC illuminates when P-05 should logically be operating but run confirm based on ZSC-305 is not present.

6. Control Logic:

PLC generates "Pump Failure" alarm (ZA-305) when P-05 should logically be operating but a run confirm from ZSC-305 is not present. PLC will trigger an auto-dialer notification (Group 2) and illuminate the shared alarm light on the PLC panel. Alarm notification on the MMI and common alarm light on the PLC panel will continue to display until operator acknowledges/resets the alarm at the MMI.

7. Data Logging: Log alarm events in Excel file with date/time/event ID.

HH. Instrument #: LSHH-303, LAHH-303

1. Panel: PLC

2. P&ID #: P-103

3. Purpose: Indicate high-high level in T-05

4. Initial Setpoint: Approximately 90% full.

5. Display:

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MMI screen displays "T-05 High-High Alarm". A common alarm light will be illuminated at the PLC panel.

6. Control Logic:

PLC will terminate all water collection and treatment system operations when LSHH-303 is engaged. Air sparging compressor (C-01) may continue to operate. System water components will remain off until the operator addresses the alarm condition and acknowledges/reset the alarm.

PLC will trigger an auto-dialer notification (Group 2) and illuminate the shared alarm light on the PLC panel. Alarm notification on the MMI and common alarm light on the PLC panel will continue to display until operator acknowledges/resets the alarm at the MMI.

7. Data Logging: Log alarm events in Excel file with date/time/event ID.

II. Instrument #: LE/LT-304, LAL-304, LAH-304

1. Panel: PLC

2. P&ID #: P-103

3. Purpose: Water level measurement in T-05, and control of pumps P-03, P-04, and P-05

4. Initial Setpoint: TBD

5. Display:

MMI screen allows operator to adjust level control setpoint for the P-03 and T-05, and set low level alarm (LAL-304) and high level alarm settings (LAH-304). Level setpoint, alarm levels, and current reading units will be: "XX.X ft" (range 0 – 11.0 ft).

MMI screen will display current (real-time) level for T-05 (LI-304).

MMI screen will display "T-04 High Level Alarm" when level in T-05 exceeds operator set alarm level (LAH-304). A common alarm light on the PLC panel will illuminate.

MMI screen will display "T-05 Low Level Alarm" when level in T-05 drops below operator set alarm level (LAL-304). A common alarm light on the PLC panel will illuminate.

MMI screen will allows operator input of VFD governor settings (SCH-306) (Hz or % scale) for P-03 to limit maximum pump output.

6. Control Logic:

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PLC converts 4-20 mA signal from LT-304 to "XX.X Ft" of water for display purposes.

Logic will include programmed Proportional, Integral, and Differential (PID) response parameters for pump P-03 speed controls. PLC analog outputs will be issued to P-03's VFD based on deviation between actual level in T-05 and setpoint level for LT-304 set by the operator at the MMI. Output to VFD will be limited by governor setting (SCH-306) entered at the MMI.

When measured levels in T-05 exceed the operator set high alarm level (LAH-304), the PLC will shut down P-02A,B, P-01 A-H, and P-06, and P-07 A,B until the measured level reaches the level control setpoint for T-05. PLC will trigger an auto-dialer notification (Group 2), display "T-05 High Level Alarm", and illuminate the shared alarm light on the PLC panel when either a low level or high level. Alarm notification display will remain until operator acknowledges/resets the alarm at the MMI.

When measured levels in T-05 drops below the operator set low alarm level (LAL-304), the PLC will shut down P-03, P-04, and P-05 until the measured level reaches the level control setpoint for T-05. PLC will trigger an auto-dialer notification (Group 2), display "T-05 Low Level Alarm", and illuminate the shared alarm light on the PLC panel when either a low level or high level. Alarm notification display will remain until operator acknowledges/resets the alarm at the MMI.

7. Data Logging: Instantaneous and totalized flow to be logged in Excel file based on operator set interval. Log alarm events in separate Excel file with date/time/event ID.

JJ. Instrument #: HSS-306

1. Panel: PLC

2. P&ID #: P-103

3. Purpose: Control for T-05 Pump (P-03). Selects "Hand," "Off," or "Auto" position at main control panel..

4. Initial Setpoint: N/A

5. Display:

MMI screen displays "P-03 ON" when running, and "P-03 OFF" when not running based on ZSC-306. Green "Run" light (push-to-test) for P-03 to be illuminated on PLC panel when pump is running. Panel shall also indicate the speed control signal for P-03 (Hz or % scale).

6. Control Logic:

With P-03 in "Hand" mode, P-03 will operate independently of PLC control logic. Speed control will be set manually at the pump's VFDs.

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With pump in "Auto" mode the PLC will issue permissive signals to P-03 based on monitored conditions in the recovery network and treatment system. Speed control signals will be issued by the PLC (SIC-306) to P-03's VFD based on comparison of measured level in T-05 and the level setpoint for T-05 set at the MMI by the operator (LT-304). Maximum speed is governed by SCH-306 set at MMI.

In "Off" position, pumps P-03 will not operate.

7. Data Logging: NA

KK. Instrument #: ZSC-306, ZI-306

1. Panel: MCC & PLC

2. P&ID #: P-103

3. Purpose: Run confirm for P-03

4. Initial Setpoint: NA

5. Display:

MMI screen indicates ON/OFF status for P-03 (ZI-306). Screen also displays controlled speed of P-03 (SIC-306) (% scale or Hz) when in Auto mode.

Green run light (ZI-306) on PLC panel (push to test) displays run status of P-03 based on ZSC-306.

MMI screen displays "P-03 A-H Alarm" (ZA-306) and common red alarm light on PLC illuminates when P-03should logically be operating but run confirm based on ZSC-306 is not present.

6. Control Logic:

PLC generates "Pump Failure" alarm (ZA-306) when P-03 should logically be operating but a run confirm from ZSC-306 is not present. PLC will trigger an auto-dialer notification (Group 2) and illuminate the shared alarm light on the PLC panel. Alarm notification on the MMI and common alarm light on the PLC panel will continue to display until operator acknowledges/resets the alarm at the MMI.

7. Data Logging: Log alarm events in Excel file with date/time/event ID.

LL. Instrument #: FE/FIT-307, FI-307, FQI-307

1. Panel: PLC

2. P&ID #: P-103

3. Purpose: Measurement of flow to NPDES outfall.

4. Initial Setpoint: NA

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5. Display:

MMI screen displays instantaneous flow rate "XXX.X gpm"and totalized flow "XXXXXX KGAL". One week graphical trending of this parameter displayed on MMI.

6. Control Logic:

PLC to convert paddle wheel output reading (4 – 20 mA) to gpm and KGAL for display purposes.

7. Data Logging: Instantaneous and totalized flow to be logged in Excel file based on operator set interval.

MM. Instrument #: HSS-308

1. Panel: PLC

2. P&ID #: P-103

3. Purpose: Control for injection pump P-04. Selects "Hand," "Off," or "Auto" position at main control panel.

4. Initial Setpoint: N/A

5. Display:

MMI screen displays "P-04 ON" when running, and "P-04 OFF" when not running based on ZSC-308. Green "Run" light (push-to-test) for P-05 to illuminate on PLC panel.

6. Control Logic:

With P-04 in "Hand" mode, P-04 will operate independently of PLC control logic.

With pump in "Auto" mode the PLC will issue permissive signals to P-04 based on monitored conditions in the recovery network and treatment system.

P-04 will <u>not</u> be permitted to run in Auto unless;

- Either HSS-309A or B are also in auto position, and
- At least one solenoid valves is Open, and
- At least on of the injection wells is <u>not</u> in High Level Alarm (LAHH-311A,B)

In "Off" position, pumps P-03 will not operate.

7. Data Logging: NA.

NN. Instrument #: ZSC-308, ZI-308

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1. Panel: MCC & PLC

2. P&ID #: P-103

3. Purpose: Run confirm for P-04

4. Initial Setpoint: NA

5. Display:

MMI screen indicates ON/OFF status of P-04 (ZI-308).

Green run light (ZI-308) on PLC panel (push to test) displays run status of P-04 based on ZSC-308.

MMI screen displays "P-04 Alarm" (ZA-308) and common red alarm light on PLC illuminates when P-04 should logically be operating but run confirm based on ZSC-308 is not present.

6. Control Logic:

PLC generates "Pump Failure" alarm (ZA-308) when any of P-04 should logically be operating but a run confirm from ZSC-308 is not present. PLC will trigger an auto-dialer notification (Group 2) and illuminate the shared alarm light on the PLC panel. Alarm notification on the MMI and common alarm light on the PLC panel will continue to display until operator acknowledges/resets the alarm at the MMI.

7. Data Logging: Log alarm events in Excel file with date/time/event ID.

OO. Instrument #: HSS-309A, B

1. Panel: PLC

2. P&ID #: P-103

3. Purpose: Control for injection well solenoid valves SV-308A and B. Selects "Hand," "Off," or "Auto" position at main control panel.

4. Initial Setpoint: N/A

5. Display:

MMI screen display "Open" or "Closed" status of each status of each solenoid. Green "Open" light (push-to-test) for SV-301A and SV-301B will illuminate on PLC panel.

6. Control Logic:

In "Hand" position, the specified solenoid valve (SV-301A or SV-301B) will open independently of PLC logic. In "Off" position, the specified solenoid will remain closed. When placed in "Auto" position, the specified solenoid will remain open unless LSHH-311A of LSHH-311B are engaged indicating a high level condition in

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the injection well. A high level in LSHH-311A will result in closing of SV-301A, and a high level in LSHH-311B will result in closing of SV-301B when HSS-308A or HSS-308B are in the Auto position. As noted above, P-04 will not be permitted to operate in Auto if neither HSS-309A or B are in the Auto position, and both LAHH-311A and B are engaged.

7. Data Logging: NA

PP. Instrument #: FE/FIT-310 A and B, FI-310A,B, FQI-310A,B

1. Panel: PLC

2. P&ID #: P-103

3. Purpose: Measurement of flow to each injection well.

4. Initial Setpoint: NA

5. Display:

MMI screen display instantaneous flow rate "XX.X gpm", totalized flow "XXXXX KGAL".

6. Control Logic: PLC to convert paddle wheel output reading to gallons for display purposes.

7. Data Logging: Instantaneous and totalized flow to be logged in Excel file based on operator set interval.

QQ. Instrument #: LSHH-311A and B, LAHH-311 A,B

1. Panel: PLC

2. P&ID #: P-103

3. Purpose: Indicate high-high level in the specified injection well

4. Initial Setpoint: Approximately 90% full.

5. Display:

MMI screen displays "IW-1 or IW-2 High Level". Common alarm light will illuminate on PLC panel. Display reads "OK" when not in high level.

6. Control Logic:

The corresponding solenoid valve (SV-309A for LSHH-311A, and SV-309B for LSHH-311B) shall be "Closed" if a high level is reached in the corresponding injection well. The solenoid valve(s) will remain closed and related displays will remain until the operator clears/acknowledges/resets the alarm condition. System will auto-dial for remote alarm notification (Group 2).

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As noted above, P-04 must not be permitted to operate in Auto mode if neitherHSS-309A or B is in auto mode, and if both inject wells are in High Alarm.

7. Data Logging: Log alarm events in separate Excel file with date/time/event ID.

RR. Instrument #: HSS-401

1. Panel: PLC

2. P&ID #: P-104

3. Purpose: Control for Air Sparge Compressor (C-01). Selects "Hand," "Off," or "Auto" position at main control panel..

4. Initial Setpoint: TBD

5. Display:

MMI screen display shall read "C-01 ON" when running, and "C-01 OFF" when not running based on ZSC-401. Green "Run" light (push-to-test) for C-01 will illuminate on PLC panel.

6. Control Logic:

In "Auto" mode the compressor will run continuously based on setpoint flow control signal and permissives will be issued based on monitored conditions in the treatment plant. In "Hand" mode the compressor shall run independently of PLC logic with speed control adjusted locally at C-01's VFD. In "Off" mode the compressor will not run.

7. Data Logging: NA

SS. Instrument #: ZSC-401, ZI-401

1. Panel: MCC & PLC

2. P&ID #: P-104

3. Purpose: Run confirm for C-01

4. Initial Setpoint: NA

5. Display:

MMI screen indicates ON/OFF status for each air sparge compressor (ZI-401). Screen also displays controlled speed of C-01 (SIC-401) (% scale or Hz) when in Auto mode.

Green run light (ZI-401) on PLC panel (push to test) displays run status of C-01 based on ZSC-401.

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MMI screen displays "C-01 Alarm" (ZA-401) and common red alarm light on PLC illuminates when C-01 should logically be operating but run confirm based on ZSC-401 is not present.

6. Control Logic:

PLC generates "Compressor Failure" alarm (ZA-401) when any of C-01 should logically be operating but a run confirm from ZSC-401 is not present. PLC will trigger an auto-dialer notification (Group 4) and illuminate the shared alarm light on the PLC panel. Alarm notification on the MMI and common alarm light on the PLC panel will continue to display until operator acknowledges/resets the alarm at the MMI.

7. Data Logging: Log alarm events in Excel file with date/time/event ID.

TT. Instrument #: DP-402, FIC-402, FAL-402, FAH-402

1. Panel 1

2. P&ID #: P-104

3. Purpose: Measurement and flow control for Sparge Air Compressor (C-01).

4. Initial Setpoint: TBD

5. MMI Display:

MMI screen allows operator to adjust flow rate setpoint for C-01 (FIC-402), and set low flow alarm (FAL-402) and high flow alarm (FAH-402). Flowrate setpoint, alarm levels, and current reading units will be displayed on MMI screen as: "XXX.X CFM".

MMI screen will display "C-01 Low Flow Alarm" when measured flow drops below operator set alarm level (FAL-402). A common alarm light on the PLC panel will illuminate.

MMI screen will display "C-01 High Flow Alarm" when measured flow rises above the operator set alarm level (FAH-402). A common alarm light on the PLC panel will illuminate.

MMI screen will allow operator input of VFD governor settings (SCH-402) (Hz or % scale) for C-01 to limit maximum compressor output.

6. Control Logic:

PLC to convert differential pressure reading from DPT-402 to CFM for monitoring and control purposes. PLC will modulate speed signal to C-01 VFD based on measured deviation between actual measured flowrate and flow control setpoint set by the operator at the MMI.

7. Data Logging: Instantaneous flow to be logged in Excel file based on operator set interval. Log alarm events in separate Excel file with date/time/event ID.

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UU. Instrument #: TE/TT-403, TAH-403

1. Panel: PLC

2. P&ID #: P-103

3. Purpose: Air Sparge air temperature measurement

4. Initial Setpoint: 120 deg F

5. Display:

MMI screen allows operator entry of High Temperature Alarm (TAH-403) setting. Screen displays current temperature in "XXX.X F" for TT-403". Screen indicates "High Temp Alarm" when measured temperature exceeds alarm level set by the operator at the MMI. Share alarm light will illuminate for alarm condition at PLC panel.

6. Control Logic:

PLC converts TT-403 signal (4-20 mA) to temperature in degrees F for display and control purposes.

When TAH-403 is engaged, C-01 will shut down and the alarm displays will remain until the operator acknowledges/clears/resets alarm. System will auto-dial for remote alarm notification (Group 2).

7. Data Logging: Instantaneous temperature to be logged in Excel file based on operator set interval. Log alarm events in separate Excel file with date/time/event ID.

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1.11 MOTOR SUMMARY

A. All vendor provided motors and controls are to be rated electrically for 480V/3 Phase, and general purpose locations. Below is a table detailing system controlled devices:

PART 2 - PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION

Appendix F

HCC Treatment System NPDES Permit

Permit No. WA-003212-3
Issuance Date: May 4, 2006
Effective Date: June 1, 2006
Expiration Date: May 4, 2011
1st Modification Date: August 15, 2006
2nd Modification Date: June 30, 2008

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM
WASTE DISCHARGE PERMIT No. WA-003212-3

State of Washington
DEPARTMENT OF ECOLOGY
Northwest Regional Office
3190 – 160th Avenue SE
Bellevue, WA 98008-5452

In compliance with the provisions of
The State of Washington Water Pollution Control Law
Chapter 90.48 Revised Code of Washington
and
The Federal Water Pollution Control Act
(The Clean Water Act)
Title 33 United States Code, Section 1251 et seq.

BNSF RAILWAY COMPANY

2454 Occidental Avenue South, Suite 1A

Seattle, WA 98134

Facility Location: BNSF Skykomish Cleanup Site South Fork of the Skykomish River Skykomish, WA	Receiving Water: South Fork of the Skykomish River
Water Body I.D. No.: 1215779478143	Discharge Location: Outfall 002: Latitude: 47° 42' 35" N Longitude: 121° 21' 49" W
Industry Type: Contaminated Soil Remediation	Outfall 003: Latitude: 47° 42' 37" N Longitude: 121° 21' 31" W

is authorized to discharge in accordance with the Special and General Conditions which follow.

Bob Warren
Toxics Cleanup Section Manager
Northwest Regional Office
Washington State Department of Ecology

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SUMMARY OF PERMIT REPORT SUBMITTALS

Refer to the Special and General Conditions of this permit for additional submittal requirements.

Permit Section	Submittal	Frequency	First Submittal Date
S3.A	Discharge Monitoring Report	Monthly	August 15, 2006
S3.E	Noncompliance Notification	As necessary	
S4.A	Operations and Maintenance Manual	1/permit cycle	
S4.A	Operations and Maintenance Manual Update or Review Confirmation Letter	Annually	
S4.A	Treatment System Operating Plan		
S4.A	Treatment System Operating Plan Updates	As necessary	30 days prior to implementation
S4.B	Reporting Bypasses	As necessary	
S10.	Application for Permit Renewal	1/permit cycle	November 4, 2010
S6.C	Solid Waste Control Plan	1/permit cycle, updates submitted as necessary	July 15, 2006
S7.	Spill Plan	1/permit cycle, updates submitted as necessary	30 days prior to construction or discharge
S9.	Stormwater Pollution Prevention Plan	1/permit cycle	30 days prior to construction or discharge
S9.	Stormwater Pollution Prevention Plan Modifications or updates	As necessary	30 days prior to construction or discharge
S9.C2	Notification of Unpermitted Non-stormwater to *Stormwater Drainage System*	As necessary	
G1.	Notice of Change in Authorization	As necessary	
G4.	Permit Application for Substantive Changes to the Discharge	As necessary	
G5.	Engineering Report for Construction or Modification Activities	As necessary	
G8.	Notice of Permit Transfer	As necessary	
G21.	Reporting Anticipated Noncompliance	As necessary	
G22.	Reporting Other Information	As necessary	

SPECIAL CONDITIONS

S1. DISCHARGE LIMITATIONS

A. Authorized Discharges

This permit authorizes the discharge of treated stormwater and dewatering water associated with cleanup activities, to the South Fork of the Skykomish River from the BNSF Railway Company soil remediation project.

B. Discharge Prohibitions

Discharges of industrial stormwater and dewatering water including stormwater runoff from sand and gravel stockpiles, leachate from stockpiles of contaminated soils, and any water resulting from soil remediation activities, to the former and existing Maloney Creek, are prohibited.

Discharge of process wastewater, and domestic wastewater to surface water and ground water is prohibited. Prohibited process wastewater discharges include, but are not limited to: truck wash water, tire bath waste water, wheel wash water, and equipment wash water, and chemical wastes.

Visible track-out on public roads is prohibited.

This permit does not authorize illicit discharges, including spills of oils or hazardous substances, nor does it relieve entities from obligations under state and federal laws and regulations pertaining to those discharges.

C. Industrial Stormwater and Construction Dewatering Discharges Associated With All Cleanup Zones (Figure 3 of the fact sheet)

All discharges and activities authorized by this permit shall be consistent with the terms and conditions of this permit.

The discharge of any of the following pollutants more frequently than, or at a level in excess of, that identified and authorized by this permit shall constitute a violation of the terms and conditions of this permit.

Beginning on the effective date of this permit and lasting through the expiration date, the Permittee is authorized to discharge excavation dewatering water and industrial stormwater resulting from contaminated soil and sediment remediation to the South Fork of the Skykomish River, subject to complying with the following limitations.

In addition, beginning on the issuance date of the second permit modification of this permit and lasting through the expiration date, the Permittee is authorized to discharge treated water to groundwater through injection wells IW1 and IW2 (see Figure B-2), subject to complying with the following limitations:

EFFLUENT LIMITATIONS FOR ALL CLEANUP ZONES: OUTFALLS # 002[e] and 003[e]	
Parameter	**Maximum Daily[a]**
Flow (002) summer[g], river level <922.5 feet	673 gpm
Flow (002) winter[g], river level <922.5 feet	269 gpm
Flow (003) summer[g] and winter[g], river level <928.56 feet	100 gpm
Temperature (September 15 to July 1)	13°C or 55.4°F
Temperature (July 2 to September 14)	12°C or 53.6°F
Chitosan Acetate[c]	0.1 mg/L
pH (s.u.)	Between 6.5 and 8.5 standard units
Dissolved Oxygen	Minimum 8 mg/L
Turbidity	5 NTU above background[d]
Oily Sheen	No visible sheen
Benzene	1.2 µg/L
BTEX	100 µg/L
Total Petroleum Hydrocarbon (TPH)	208 µg/L
Lead[h]	17.5 µg/L (TR)/ 15 µg/L (T)
Arsenic[i]	360 µg/L (TR)/ 7.42 µg/L (T)
Anthracene	2,400 µg/L
Fluorene	640 µg/L
Naphthalene	160 µg/L
Pyrene	480 µg/L
Benzo(a)anthracene[b]	0.0028 µg/L (0.01 µg/L)
Benzo(b)fluoranthene[b]	0.0028 µg/L (0.01 µg/L)
Benzo(k)fluoranthene[b]	0.0028 µg/L (0.01 µg/L)
Benzo(a)pyrene[b]	0.0002 µg/L (0.01 µg/L)
Chrysene[b]	0.0028 µg/L (0.01 µg/L)
Dibenzo(a,h)anthracene[b]	0.0028 µg/L (0.01 µg/L)
Indeno(1,2,3-cd)pyrene[b]	0.0028 µg/L (0.01 µg/L)
Acenaphthene	643 µg/L
Fluoranthene	90.2 µg/L

Outfall 002: The Permittee must cease discharge to the Skykomish River when the river level exceeds 922.5 feet.

Outfall 003: The Permittee must cease discharge to the Skykomish River when the river level exceeds 928.56 feet.

[a] The maximum daily effluent limitation is defined as the highest allowable daily discharge. The daily discharge means the discharge of a pollutant measured during a calendar day.

[b] The method detection level (MDL) for these PAH compounds is above the effluent limits using the approved analytical test method EPA 8270C-HVI. The reporting level (RL) for these compounds has been reported as 0.01µg/L. Therefore, these RLs will be used for assessment of compliance with these effluent limits. These RLs will be referred to as enforcement limits in this permit.

[c] The turbidity of the influent to the second tank (T-2A) shall not be greater than 600 NTU. The Permittee shall adhere to the Chitosan dosage rates and requirements set forth in Special Condition S5 of the permit.

[d] Turbidity shall not exceed 5 NTU over background turbidity when the background turbidity is 50 NTU or less, or have more than a 10 percent increase in turbidity when the background turbidity is more than 50 NTU.

[e] Outfall 002 is located on West River Road, and is connected to the city storm sewer along 6th Street. Outfall 003 is connected to the city storm sewer located along 3rd Street.

[f] Since the treatment system for the hydraulic control and containment system is designed for 100 gpm, the summer flow limit is set at 100 gpm. The maximum capacity available in the 3rd Street storm sewer during a 2-year, 24-hour storm event is 377 gpm. Should the Permittee upgrade the treatment system to handle a higher flow, the Permittee may discharge up to that flow rate upon written approval from the Department.
[g] The summer period is from June 1 through September 30. The winter period is from October 1 through May 30.
[h] The effluent limit for lead for surface water discharge is 17.5 µg/L based on total recoverable (TR) metals. The effluent limit for groundwater discharge by means of injection wells is 15 µg/L based on total (T) metals.
[i] The effluent limit for arsenic for surface water discharge is 360 µg/L based on total recoverable (TR) metals. The effluent limit for groundwater discharge by means of injection wells is 7.42 µg/L based on total (T) metals.

D. Contaminated Water Within the Temporary River Exclusion Wall (Cofferdam)

The Permittee shall maintain a negative hydraulic gradient between the interior of the cofferdam and the river. If an oily sheen is observed beyond the inner cofferdam, corrective measures must be implemented immediately to remedy the problem before excavation is to be continued. There shall be no oily sheen beyond the boom containment area.

E. Untreated Overflow

There shall be no untreated overflow or runoff from any excavation pits or any containment tanks on-site to surface waters of the state. When the water in an excavation pit or a containment tank reaches 90 percent storage capacity, the Permittee is required to implement a contingency plan to prevent overflow from occurring.

F. Untreated Stormwater Discharge

There shall be no untreated stormwater discharge from the excavation area to surface waters of the state.

G. Outfall Location

The Permittee shall not discharge to a dry river bed area. The discharge outfall consisting of the discharge pipe and the energy dissipation structure shall be positioned in the river such that the river flow rate is greater than the discharge flow rate.

H. Industrial Stormwater Discharges Associated With Rail Yard Operations

Industrial stormwater discharges associated with railyard operations (not related to cleanup activities) are regulated under the General Stormwater NPDES Permit No. S03003658 except for those cases in which contaminated water from railyard operations passes through the cleanup site.

I. Compliance With Standards

The Permittee shall comply with State of Washington Surface Water Quality Standards (Chapter 173-201A WAC), Sediment Management Standards (Chapter 173-204 WAC), Ground Water Quality Standards (Chapter 173-200 WAC), and human health-based criteria in the National Toxics Rule (Federal Register, Vol. 57, No. 246, December 22, 1992, pages 60848-60923).

When not in compliance with these standards, the Permittee shall take immediate action(s) to achieve compliance by implementing additional best management practices (BMPs), and/or improved compliance with existing BMPs, and file a noncompliance notification, as required under Condition S3.E.

Facilities that discharge either directly or indirectly by means of a stormwater conveyance system to waters listed as impaired by the State under Section 303(d) of the Clean Water Act must comply with the State's Surface Water Quality Standards.

S2. MONITORING REQUIREMENTS

The Permittee shall monitor in accordance with the following schedule:

A. Monitoring Schedule for All Cleanup Zones (shown on Figure 3)

Samples shall be collected after Granular Activated Carbon treatment from each treatment train (pertaining to outfalls 002 and 003) and prior to discharge to surface water and to groundwater.

Parameter	Units	Minimum Sampling Frequency	Sample Type	Test Method
Flow (002) summer	gpm	Daily	Metered	N/A
Flow (002) winter	gpm	Daily	Metered	N/A
Flow (003) summer	gpm	Daily	Metered	N/A
Flow (003) winter	gpm	Daily	Metered	N/A
Injection Rate[c], Wells IW1 and IW2	gpm	Continuous	Metered	N/A
Chitosan Acetate	mg/L	Daily	Grab	Chitosan Field Screening Test
Temperature[e]	°F	Daily	Grab	Thermometer or equivalent
Oily Sheen	N/A	Daily	Observed	Visual
pH (s.u.)	Standard Units	Weekly	Grab	EPA 150.1
Dissolved Oxygen	mg/L	Weekly (for a period of five weeks)	Grab	Field Metering
Turbidity	NTU	Weekly	Grab	EPA 180.1 or equivalent
Benzene	µg/L	Monthly	Grab	SW8260B
BTEX	µg/L	Monthly	Grab	SW8260B
Total Petroleum Hydrocarbon (TPH)[a]	µg/L	Weekly (Two samples: One before and one after GAC treatment)	Grab	NWTPH-D_x (no silica gel filtration)
Lead (TR, and T)[d]	µg/L	Weekly	Grab	EPA 200.8
Arsenic (TR, and T)[d]	µg/L	Weekly	Grab	EPA 200.8
Anthracene[b]	µg/L	Monthly	Grab	SW8270-SIM
Fluorene[b]	µg/L	Monthly	Grab	SW8270-SIM
Naphthalene[b]	µg/L	Monthly	Grab	SW8270-SIM
Pyrene[b]	µg/L	Monthly	Grab	SW8270-SIM
Benzo(a)anthracene[b]	µg/L	Monthly	Grab	EPA 8270C-HVI
Benzo(b)fluoranthene[b]	µg/L	Monthly	Grab	EPA 8270C-HVI

Parameter	Units	Minimum Sampling Frequency	Sample Type	Test Method
Benzo(k)fluoranthene[b]	µg/L	Monthly	Grab	EPA 8270C-HVI
Benzo(a)pyrene[b]	µg/L	Monthly	Grab	EPA 8270C-HVI
Chrysene[b]	µg/L	Monthly	Grab	EPA 8270C-HVI
Dibenzo(a,h)anthracene[b]	µg/L	Monthly	Grab	EPA 8270C-HVI
Indeno(1,2,3-cd)pyrene[b]	µg/L	Monthly	Grab	EPA 8270C-HVI
Acenaphthene[b]	µg/L	Monthly	Grab	SW8270-SIM
Fluoranthene[b]	µg/L	Monthly	Grab	SW8270-SIM

[a] For each sampling event, the Permittee shall collect one sample before and after the first Granular Activated Carbon (GAC) column for TPH analysis. Results from samples collected before the GAC treatment will be used to evaluate the performance and removal efficiency of the GAC columns (See S4, O&M of the permit for details). The Permittee shall change out the GAC column as often as necessary to ensure compliance with the effluent limits.

[b] The sampling frequency for the PAH compounds will be reduced from weekly to monthly, if the monitoring data collected during the first phase of remediation (i.e. levee remediation) clearly support TPH as a surrogate for PAH.

[c] The Permittee shall monitor the injection rate for wells IW1 and IW2. Should the Permittee choose to inject at a flow rate exceeding 5 gpm, the Permittee must seek written approval from the Department prior to discharging at that rate.

[d] For surface water discharge, the Permittee shall perform total recoverable metals analyses for arsenic and lead. For groundwater discharge, the Permittee shall perform total metals analyses for arsenic and lead.

[e] The Permittee is required to monitor effluent temperature only when the Permittee is discharging wastewater resulting from the thermal groundwater remediation pilot testing.

B. Sampling and Analytical Procedures

Samples and measurements taken to meet the requirements of this permit shall be representative of the volume and nature of the monitored parameters, including representative sampling of any unusual discharge or discharge condition, including bypasses, upsets, and maintenance-related conditions affecting effluent quality.

The detection limits achieved for those analytical test methods specified in S2.A shall be lower than the effluent limits (or enforcement limits for PAH compounds) listed in S1.C of the permit.

C. Flow Measurement

Appropriate flow measurement devices and methods consistent with accepted scientific practices shall be selected and used to ensure the accuracy and reliability of measurements of the quantity of monitored flows. The devices shall be installed, calibrated, and maintained to ensure the accuracy of the measurements is consistent with the accepted industry standard for that type of device. Frequency of calibration shall be in conformance with manufacturer's recommendations and at a minimum frequency of at least one calibration per year. Calibration records shall be maintained for at least three years.

D. Laboratory Accreditation

All monitoring data required by the Department shall be prepared by a laboratory registered or accredited under the provisions of *Accreditation of Environmental Laboratories*, Chapter 173-50 WAC. Flow, pH, turbidity, and internal process control parameters are exempt from this requirement.

S3. REPORTING AND RECORD KEEPING REQUIREMENTS

The Permittee shall monitor and report in accordance with the following conditions. The falsification of information submitted to the Department shall constitute a violation of the terms and conditions of this permit.

A. Reporting

The first monitoring period begins on the effective date of the permit. Monitoring results shall be submitted monthly. Monitoring data obtained during each monitoring period shall be summarized, reported, and submitted on a Discharge Monitoring Report (DMR) form provided, or otherwise approved, by the Department. DMR forms shall be postmarked or received no later than the 15th day of the month following the completed monitoring period, unless otherwise specified in this permit. The report(s) shall be sent to the Department of Ecology Water Quality Program, 3190 - 160th Avenue SE, Bellevue, WA 98008-5452.

All laboratory reports providing data for organic and metal parameters shall include the following information: sampling date, sample location, date of analysis, parameter name, CAS number, analytical method/number, method detection limit (MDL), laboratory practical quantitation limit (PQL), reporting units, and concentration detected. Analytical results from samples sent to a contract laboratory must have information on the chain of custody, the analytical method, QA/QC results, and documentation of accreditation for the parameter.

Discharge Monitoring Report forms must be submitted monthly whether or not the facility was discharging. If there was no discharge during a given monitoring period, the Permittee is required to submit the form as required with the words "no discharge" entered in place of the monitoring results.

If there was no discharge during a given monitoring period, the Permittee is required to submit the form applicable to that period as required with the words “no discharge” entered in the place of the monitoring results.

B. Records Retention

The Permittee shall retain records of all monitoring information for a minimum of three years. Such information shall include all calibration and maintenance records and all original recordings for continuous monitoring instrumentation, copies of all reports required by this permit, and records of all data used to complete the application for this permit. This period of retention shall be extended during the course of any unresolved litigation regarding the discharge of pollutants by the Permittee or when requested by the Director.

C. Recording of Results

For each measurement or sample taken, the Permittee shall record the following information: (1) the date, exact place, method, and time of sampling or measurement; (2) the individual who performed the sampling or measurement; (3) the dates the analyses were performed; (4) the individual who performed the analyses; (5) the analytical techniques or methods used; and (6) the results of all analyses.

D. Additional Monitoring by the Permittee

If the Permittee monitors any pollutant more frequently than required by this permit using test procedures specified by Condition S2 of this permit, then the results of this monitoring shall be included in the calculation and reporting of the data submitted in the Permittee's DMR.

E. Noncompliance Notification

In the event the Permittee is unable to comply with any of the terms and conditions of this permit due to any cause, the Permittee shall:

1. Immediately take action to stop, contain, and clean up unauthorized discharges or otherwise stop the noncompliance, correct the problem and, if applicable, repeat sampling and analysis of any non-complying discharges immediately and submit the results to the Department within five (5) days after becoming aware of the violation.

2. Immediately notify the Department of the failure to comply.

3. Submit a detailed, written report to the Department within five (5) days. The report shall contain a description of the noncompliance, including exact dates and times, and if the noncompliance has not been corrected, the anticipated time it is expected to continue; and the steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance.

Compliance with these requirements does not relieve the Permittee from responsibility to maintain continuous compliance with the terms and conditions of this permit or any resulting liability for failure to comply.

F. Other Noncompliance Reporting

The Permittee must report all instances of noncompliance, not required to be reported within 24 hours, at the time that monitoring reports for S3.A ("Reporting") are submitted. The reports must contain the information listed in paragraph E, above, (“Twenty-four Hour Notice of Noncompliance Reporting”). Compliance with these requirements does not relieve the Permittee from responsibility to maintain continuous compliance with the terms and conditions of this permit or the resulting liability for failure to comply.

G. Maintaining a Copy of This Permit

A copy of this permit must be kept at the facility and be made available upon request to Department of Ecology inspectors.

S4. OPERATIONS AND MAINTENANCE

The Permittee shall, at all times, properly operate and maintain all systems of treatment and control (and related appurtenances) which are installed to achieve compliance with the terms and conditions of this permit. Proper operation and maintenance also includes adequate laboratory controls and appropriate quality assurance procedures. This provision requires the operation of backup or auxiliary facilities or similar systems, which are installed by a Permittee only when the operation is necessary to achieve compliance with the conditions of this permit.

A. Operations and Maintenance Manual

An Operations and Maintenance (O&M) Manual shall be prepared by the Permittee in accordance with WAC 173-240-150 and be submitted to the Department for approval within thirty (30) days after permit issuance date. The Permittee shall periodically review and update the O&M Manual as necessary, in order to maintain compliance with the conditions in this permit. At a minimum, the O&M Manual shall be reviewed annually, and the Permittee shall confirm this review by letter to the Department. Updates to the O&M Manual shall be submitted to the Department for approval prior to implementation.

The approved Operations and Maintenance Manual shall be kept available at the permitted facility, and all operators shall follow the instructions and procedures of this manual.

In addition to the requirements of WAC 173-240-150(1) and (2), the O&M Manual shall include:

1. Emergency procedures for plant shutdown and cleanup in event of wastewater system upset or failure.
2. Wastewater system maintenance procedures that contribute to the generation of process wastewater.
3. Any directions to maintenance staff when cleaning, or maintaining other equipment or performing other tasks which are necessary to protect the operation of the wastewater system (for example, defining maximum allowable discharge rate for draining a tank, blocking all floor drains before beginning the overhaul of a stationary engine).
4. The treatment plant process control monitoring schedule.
5. The change-out frequency of the Granular Activated Carbon columns shall be based on internal process control results.
6. The automatic shutoff of the discharge pump(s) when back wash or the sand filtration units are not working.
7. The contingency plan for unanticipated failure of the sand filtration units (for example, backwash, etc.).
8. The contingency treatment plan to treat the wastewater to meet the turbidity limit if Chitosan treatment failed.

The following information shall be summarized in the initial chapter of the O&M Manual. This chapter shall be entitled the "Treatment System Operating Plan." For the purposes of this NPDES permit, a Treatment System Operating Plan (TSOP) is a concise summary of specifically defined elements of the O&M Manual. The TSOP shall not conflict with the O&M Manual and shall include the following information:

1. A baseline operating condition, which describes the operating parameters and procedures, used to meet the effluent limitations of S1 at the production levels used in developing these limitations.

2. In the event of production rates, which are below the baseline levels used to establish these limitations, the plan shall describe the operating procedures and conditions needed to maintain design treatment efficiency. The monitoring and reporting shall be described in the plan.

3. In the event of an upset, due to plant maintenance activities, severe stormwater events, start ups or shut downs, or other causes, the plan shall describe the operating procedures and conditions employed to mitigate the upset. The monitoring and reporting shall be described in the plan.

4. A description of any regularly scheduled maintenance or repair activities at the facility which would affect the volume or character of the wastes discharged to the wastewater treatment system and a plan for monitoring and treating/controlling the discharge of maintenance-related materials (such as cleaners, degreasers, solvents, etc.).

5. A description of operating procedures to be employed for treatment of turbidity if Chitosan treatment failed.

B. Bypass Procedures

Bypass, which is the intentional diversion of waste streams from any portion of a treatment facility, is prohibited, and the Department may take enforcement action against a Permittee for bypass unless one of the following circumstances (1, 2, or 3) is applicable.

1. Bypass for Essential Maintenance Without the Potential to Cause Violation of Permit Limits or Conditions.

   Bypass is authorized if it is for essential maintenance and does not have the potential to cause violations of limitations or other conditions of this permit, or adversely impact public health as determined by the Department prior to the bypass. The Permittee shall submit prior notice, if possible, at least ten days before the date of the bypass.

2. Bypass Which is Unavoidable, Unanticipated, and Results in Noncompliance of this Permit.

   This bypass is permitted only if:

   a. Bypass is unavoidable to prevent loss of life, personal injury, or severe property damage. "Severe property damage" means substantial physical damage to property, damage to the treatment facilities which would cause them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the absence of a bypass.

   b. There are no feasible alternatives to the bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, stopping production, maintenance during normal periods of equipment downtime (but not if adequate backup equipment should have been installed in the exercise of reasonable engineering judgment to prevent a bypass which occurred during normal periods of equipment downtime or preventative maintenance), or transport of untreated wastes to another treatment facility.

c. The Department is properly notified of the bypass as required in Condition S3.E of this permit.

3. Bypass which is Anticipated and has the Potential to Result in Noncompliance of this Permit.

The Permittee shall notify the Department at least thirty (30) days before the planned date of bypass. The notice shall contain: (1) a description of the bypass and its cause; (2) an analysis of all known alternatives which would eliminate, reduce, or mitigate the need for bypassing; (3) a cost-effectiveness analysis of alternatives including comparative resource damage assessment; (4) the minimum and maximum duration of bypass under each alternative; (5) a recommendation as to the preferred alternative for conducting the bypass; (6) the projected date of bypass initiation; (7) a statement of compliance with SEPA; (8) a request for modification of water quality standards as provided for in WAC 173-201A-110, if an exceedance of any water quality standard is anticipated; and (9) steps taken or planned to reduce, eliminate, and prevent reoccurrence of the bypass.

For probable construction bypasses, the need to bypass is to be identified as early in the planning process as possible. The analysis required above shall be considered during preparation of the engineering report or facilities plan and plans and specifications and shall be included to the extent practical. In cases where the probable need to bypass is determined early, continued analysis is necessary up to and including the construction period in an effort to minimize or eliminate the bypass.

The Department will consider the following prior to issuing an administrative order for this type of bypass:

a. If the bypass is necessary to perform construction or maintenance-related activities essential to meet the requirements of this permit.

b. If there are feasible alternatives to bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, stopping production, maintenance during normal periods of equipment down time, or transport of untreated wastes to another treatment facility.

c. If the bypass is planned and scheduled to minimize adverse effects on the public and the environment.

After consideration of the above and the adverse effects of the proposed bypass and any other relevant factors, the Department will approve or deny the request. The public shall be notified and given an opportunity to comment on bypass incidents of significant duration, to the extent feasible. Approval of a request to bypass will be by administrative order issued by the Department under RCW 90.48.120.

C. Duty to Mitigate

The Permittee is required to take all reasonable steps to minimize or prevent any discharge or sludge use or disposal in violation of this permit that has a reasonable likelihood of adversely affecting human health or the environment.

S5. CHITOSAN DOSAGE RATE AND OPERATION

The Department has approved two chemical flocculant products: Liqui-Floc chitosan enhanced sand filtration produced by Natural Site Solutions, and Floc-Clear chitosan enhanced sand filtration produced by Clear Creek Systems, Inc. The Permittee is required to follow the Maintenance of Safety Margin (dosage rate) and Safety Margin Checklist as listed in Appendix I and II of the permit, for whichever approved product the Permittee chooses to use.

Both products contain different weight percentages of chitosan acetate. The dosage rate and the safety margin checklists for each product as referenced-above are not the same. Chitosan acetate can be employed to effectively treat stormwater turbidity up to 600 NTU without using chitosan acetate concentrations above 1.06 mg/L. Application at concentrations in excess of this level may result in toxicity in the effluent.

S6. SOLID WASTE DISPOSAL

A. Solid Waste Handling

The Permittee shall handle and dispose of all solid waste material in such a manner as to prevent its entry into state ground or surface water.

B. Leachate

The Permittee shall not allow leachate from its solid waste material to enter state waters without providing all known available and reasonable methods of treatment, nor allow such leachate to cause violations of the state surface water quality standards, Chapter 173-201A WAC, or the state ground water quality standards, Chapter 173-200 WAC. The Permittee shall apply for a permit or permit modification as may be required for such discharges to state ground or surface waters.

C. Solid Waste Control Plan

The Permittee shall submit a solid waste control plan to the Department no later than July 15, 2006. This plan shall include all solid wastes with the exception of those solid wastes regulated by Chapter 173-303 WAC (Dangerous Waste Regulations). The plan shall include, at a minimum, a description, source, generation rate, and disposal methods of these solid wastes. This plan shall not be at variance with any approved local solid waste management plan. Any proposed revision or modification of the solid waste handling plan must be submitted to the Department within fourteen (14) days of adoption. The Permittee shall comply with the plan and any modifications thereof. The Permittee shall submit an update of the solid waste control plan with the application for permit renewal one hundred eighty (180) days prior to the expiration date of the permit.

S7. SPILL PLAN

At least thirty (30) days prior to the start of construction or discharge, the Permittee shall submit to the Department a spill control plan for the prevention, containment, and control of spills or unplanned discharges of: 1) oil and petroleum products, 2) materials, which when spilled, or otherwise released into the environment, are designated dangerous waste (DW) or extremely hazardous waste (EHW) by the procedures set forth in WAC 173-303-070, or 3) other materials which may become pollutants or cause pollution upon reaching state's waters. The Permittee shall review and update the spill plan, as needed, at least annually. Changes to the plan shall be sent to the Department within fourteen (14) days of adoption. The plan and any supplements shall be followed throughout the term of the permit.

The updated spill control plan shall include the following:

- A description of the reporting system, which will be used to alert responsible managers and legal authorities (including Snohomish County Public Works) in the event of a spill.

  Candice Soine, Environmental Review Coordinator
  Snohomish County Public Works
  2930 Wetmore, 4th Floor
  Everett, WA 98201
  (425) 388-3488 Ext. 4259
  Candice.soine@co.snohomish.wa.us

- A description of preventive measures and facilities (including an overall facility plot showing drainage patterns) which prevent, contain, or treat spills of these materials.

- A list of all oil and chemicals used, processed, or stored at the facility which may be spilled into state waters.

For the purpose of meeting this requirement, plans and manuals, or portions thereof, required by 33 CFR 154, 40 CFR 109, 40 CFR 110, 40 CFR Part 112, the Federal Oil Pollution Act of 1990, Chapter 173-181, and contingency plans required by Chapter 173-303 WAC may be submitted.

S8. BEST MANAGEMENT PRACTICES

1. The oil/water separators shall be inspected on a weekly basis at minimum and maintained as needed to ensure satisfactory performance. Oil sludges shall be disposed of in a manner that will not cause water quality degradation to state waters. A record of inspection, maintenance, and disposal shall be kept on file and available for review by the Department's inspector(s).

2. In the event of an accidental discharge of oil, chemicals, toxic, or hazardous materials into waters of the state or onto land with a potential for entry into state waters, including ground water, representatives of the Northwest Regional Office Spill Response Team shall be notified immediately (within 24 hours) at (425) 649-7000. A written spill report shall

be submitted to the Department of Ecology, Water Quality Program, within five (5) days of the time the Permittee becomes aware of the circumstances, unless the Department waives or extends this requirement on a case-by-case basis.

3. Sludges, scales, and sediments from tanks shall be disposed of in an approved manner other than to waters of the state, and other than to the sanitary sewer system.

4. All barrels, drums, or similar containers containing toxic or deleterious materials, including, but not limited to petroleum products, organic solvents, strong acids and bases, shall be stored in an upright position, in a bermed, covered area sufficient to prevent discharge into state ground or surface waters in the event of leakage or rupture.

5. Empty barrels shall be stored with all openings plugged, in an upright position, and at least 20 feet from storm drains.

6. The Permittee shall inspect the outfall line including the energy dissipation structure to document its integrity and continued function, daily during the operational period. If conditions allow for a photographic verification, it shall be included in the report. The report shall be made available to the Department's inspector(s) on-site.

S9. STORMWATER POLLUTION PREVENTION PLAN (SWPPP) FOR INDIVIDUAL CLEANUP ZONE CONSTRUCTION ACTIVITIES (Each Zone is Listed Under Background Information in the Fact Sheet)

A SWPPP for construction activity, including construction dewatering, shall be prepared, implemented, and updated to reflect current stage of construction activity. The Permittee shall submit the SWPPP to the Department at least thirty (30) days prior to the start of construction. The SWPPP for each new phase of construction shall be kept current, updated as necessary, and submitted to the Department. At a minimum, the SWPPP shall be submitted to the Department annually. The SWPPP will cover the current and next year's anticipated activities. The phased construction activities include clearing, grading, filling, earth work, excavation, and hauling activities.

A. <u>General Requirements</u>

1. The SWPPP and all of its modifications shall be signed in accordance with General Condition G.1.B. In addition, the SWPPP shall be stamped by a Professional Engineer certified by the State of Washington.

2. The SWPPP shall be retained on-site or within reasonable access to the site and be made available upon request.

3. The Permittee shall be responsible for the implementation of the SWPPP. The Erosion and Sediment Control Plan shall be attached to bid packages when seeking contractors to allow the contractor sufficient time and resources to plan implementation. At construction sites for which a lease, easement, or other use agreement has been obtained by the Permittee, the Permittee shall be responsible for the implementation of the SWPPP.

4. The Permittee shall implement procedures for reviewing the SWPPP with contractors and subcontractors prior to initiating construction activities. The Permittee shall implement procedures for addressing changes in plans and construction activities and resolving disagreements on the interpretation of the SWPPP.

5. The Permittee shall designate a contact person who will be available 24 hours a day to respond to emergencies, and to inquiries or directives from the Department. The contact person shall have authority over the SWPPP implementation. A qualified construction pollution control officer, as approved by Ecology, shall be established to advise on and determine compliance with the SWPPP and the applicable water quality standards. The name of the pollution control officer shall be listed in the SWPPP. While the Permittee is ultimately responsible for the implementation of the SWPPP, both the Permittee and the contractor/subcontractor may be held liable for violations of the permit conditions and/or the water quality standards.

6. The Permittee shall retain the SWPPP and copies of inspection reports and all other reports required by this permit for at least three (3) years after the date of final stabilization of the construction site. The Permittee shall make these documents available upon request.

7. Reports on incidents, such as discharge of spills and other noncompliance notification, shall be included in the records.

8. A rain gauge shall be installed and maintained at the project with rainfall data logged daily.

9. Modifications:

    a. The Department may notify the Permittee when the SWPPP does not meet one or more of the requirements of this special condition. Upon notification by the Department, the Permittee shall take appropriate action(s) to come into compliance with this special condition. These SWPPP modifications shall be submitted to the Department for review, within thirty (30) days.

    b. The Permittee shall implement SWPPP and BMP modifications as directed by the Department if compliance with State of Washington Surface Water Quality Standards (Chapter 173-201A WAC), Sediment Management Standards (Chapter 173-204 WAC), Ground Water Quality Standards (Chapter 173-200 WAC), and human health-based criteria in the National Toxics Rule (Federal Register, Vol. 57, No. 246, Dec. 22, 1992, pages 60848-60923) is not being achieved.

    c. The Permittee shall modify the SWPPP whenever there is a change in design, construction, operation, or maintenance of any BMP which cause(s) the SWPPP to be less effective in controlling pollutants.

d. Whenever a self-inspection reveals that the description of pollutant sources or the BMPs identified in the SWPPP are inadequate due to the actual discharge of, or potential to discharge, a significant amount of any pollutant, the SWPPP shall be modified as appropriate. The Permittee shall provide for implementation of any modifications to the SWPPP within fourteen (14) days.

10. BMPs shall be selected from Ecology's August 2001 *Stormwater Management Manual for Western Washington* (*SWMM*) or equivalent.

11. The Permittee may request in writing that the Department approve the use of an experimental BMP. The request shall be submitted to the Department at least thirty (30) days prior to the proposed use of the experimental BMP. The request shall include, but need not be limited to, a description of:

    a. The experimental BMP.

    b. Why the experimental BMP is being requested.

    c. Why the BMPs in the *SWMM* are not adequate.

    d. Applicable construction techniques.

    e. The characteristics of the site or sites at which use of the experimental BMP is proposed.

    f. Design criteria for the experimental BMP and the expected results.

    g. Maintenance procedures.

    h. Cost estimates.

    i. Monitoring procedures and duration.

    j. If appropriate, an approved BMP that could be used if the experimental BMP fails.

12. Chemical Treatment

    a. Chemical treatment of stormwater, other than by means of treatment with chitosan solution as authorized in this permit, must be approved in writing by Ecology.

    b. Chemicals may only be used to stabilize soils if the storm water from the chemical application area is routed to and treated by a stormwater detention pond. In addition, chemical treatment/soil stabilization shall be consistent with Ecology's Stormwater Management Manuals.

    c. Spill prevention, control, and contingencies in the SWPPP should include specifics for all chemicals used.

B. SWPPP Contents and Requirements

The SWPPP shall consist of and include provisions for the following:

1. An Erosion and Sediment Control Plan:

The Erosion and Sediment Control Plan shall describe stabilization and structural practices, both of which shall be implemented to minimize erosion and the transport of sediments.

a. Stabilization Practices

The Erosion and Sediment Control Plan shall include a description of stabilization BMPs, including site-specific scheduling of the implementation of the practices. Stabilization practices may include: temporary seeding, permanent seeding, mulching, geotextiles, sod stabilization, vegetative buffer strips, protection of trees, preservation of mature vegetation, commercially available soil stabilization products, and other appropriate measures. A record of the dates when major grading activities occur, when construction activities temporarily or permanently cease on a portion of the site, and when stabilization measures are initiated shall be included in the plan. Stabilization measures shall be initiated as soon as practicable in portions of the site where construction activities have temporarily or permanently ceased.

The plan shall ensure that the following requirements are satisfied:

i) All exposed and unworked soils shall be stabilized by suitable and timely application of BMPs.

From October 1 to April 30:	No soils shall remain unstabilized for more than two (2) days.
From May 1 to September 30:	No soils shall remain unstabilized for more than seven (7) days.

ii) Existing vegetation should be preserved whenever possible. Areas which are not to be disturbed, including setbacks, sensitive/critical areas and their buffers, trees and drainage courses, shall be fenced or flagged on-site before construction activities are initiated. These areas should not be harmed when measures under the SWPPP and/or construction activities are undertaken.

iii) Cut and fill slopes shall be designed and constructed in a manner that will minimize erosion. Slopes shall be stabilized in accordance with the requirements of this subsection.

iv) Stabilization adequate to prevent erosion of outlets and adjacent stream banks shall be provided at the outlets of all conveyance systems.

v) All storm drain inlets made operable during construction shall be provided with adequate inlet protection and be properly maintained.

vi) Any and all use of polyacrylamides (PAM) for soil erosion protection shall be consistent with BMP C126 in Chapter 4, Volume II, of Ecology's *SWMM*.

vii) Wherever construction vehicle access routes intersect paved roads, provisions must be made to minimize the transport of sediment (mud) onto the paved road. If sediment is transported onto a road surface, the roads adjacent to the construction site shall be cleaned on a regular basis. Street washing shall be allowed only after other methods to prevent the transport or removal of the sediments are unsuccessful. Street wash water may not be discharged to surface waters.

b. Structural Practices

In addition to stabilization practices, the Erosion and Sediment Control Plan shall include a description of structural BMPs to divert flows from exposed soils, store flows, or otherwise limit runoff and the discharge of pollutants from exposed areas of the site. Such practices may include silt fences, earth dikes, drainage swales, sediment traps, check dams, subsurface drains, pipe slope drains, level spreaders, storm drain inlet protection, rock outlet protection, reinforced soil retaining systems, gabions, and sediment basins. Structural practices should be placed on upland soils to the degree attainable. The installation of these devices may be subject to Section 404 of the Federal Clean Water Act.

The plan shall ensure that the following requirements are satisfied:

i) Prior to leaving the site, stormwater runoff shall pass through a sediment pond or sediment trap, or other appropriate BMPs.

ii) Properties adjacent to the project site shall be protected from sediment deposition.

iii) Sediment ponds and traps, perimeter dikes, sediment barriers, and other BMPs intended to trap sediment on-site shall be constructed as a first step in grading. These BMPs shall be functional before other land disturbing activities take place. Earthen structures used for sediment control such as dams, dikes, and diversions shall be stabilized as soon as possible.

iv) Properties and waterways downstream from the construction site shall be protected from erosion due to increases in volume, velocity, and peak flow of stormwater runoff from the project site. The stormwater discharge rate for the area affected by construction shall not exceed 50 percent of the predevelopment peak flow rate for the two-year, 24-hour storm.

v) All temporary erosion and sediment control BMPs shall be removed within thirty (30) days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on-site. Disturbed soil areas resulting from removal shall be permanently stabilized.

c. Inspection and Maintenance

All BMPs shall be inspected, maintained, and repaired as needed to assure continued performance of their intended function. All on-site erosion and sediment control measures shall be inspected daily when construction is occurring and within 24 hours after any storm event of greater than 0.25 inches of rain per 24-hour period.

d. Record Keeping

Reports summarizing the scope of inspections, the personnel conducting the inspection, the date(s) of the inspection, major observations relating to the implementation of the SWPPP, and actions taken as a result of these inspections shall be prepared and retained as part of the SWPPP.

e. Format

The Erosion and Sediment Control Plan shall consist of two parts: a narrative and a set of site plans. The Permittee may refer to Chapter 3, Volume II, of Ecology's *SWMM* for guidance on the content and format.

2. Control of Pollutants Other Than Sediment on Construction Sites

All pollutants that occur on-site during construction shall be handled and disposed of in a manner that does not cause contamination of storm water or ground water. A Spill Prevention and Emergency Cleanup Plan shall be included as a section in the SWPPP. BMPs for Spills of Oil and Hazardous Substances in Chapter 2 of Volume IV of Ecology's *SWMM* shall be used for guidance in developing this plan.

Solid chemicals, chemical solutions, paints, petroleum products, solvents, acids, caustic solutions and waste materials, including used batteries, shall be stored in a manner which will prevent the inadvertent entry of these materials into waters of the state, including ground water. Storage shall be in a manner that will prevent spills due to overfilling, tipping, or rupture. In addition, the following practices shall be used:

a. All liquid products and wastes shall be stored on durable impervious surfaces and within bermed containment capable of containing 110 percent of the largest single container in the storage area. Reasonable steps shall be taken to prevent releases of liquid products from malicious tampering or vandalism.

b. All waste shall be stored under cover, such as tarpaulins or roofed structures. All waste storage areas, whether for waste oil or hazardous waste, shall be clearly designated as such and kept segregated from new product storage.

4. Coordination with Local Requirements

This permit does not relieve the Permittee of compliance with any more stringent requirements of local government.

S10. APPLICATION FOR PERMIT RENEWAL

The Permittee shall submit an application for renewal of this permit by November 4, 2010, to the Department of Ecology for permit renewal.

GENERAL CONDITIONS

G1. SIGNATORY REQUIREMENTS

All applications, reports, or information submitted to the Department shall be signed and certified.

A. All permit applications shall be signed by either a responsible corporate officer of at least the level of vice president of a corporation, a general partner of a partnership, or the proprietor of a sole proprietorship.

B. All reports required by this permit and other information requested by the Department shall be signed by a person described above or by a duly authorized representative of that person. A person is a duly authorized representative only if:

1. The authorization is made in writing by a person described above and submitted to the Department.

2. The authorization specifies either an individual or a position having responsibility for the overall operation of the regulated facility, such as the position of plant manager, superintendent, position of equivalent responsibility, or an individual or position having overall responsibility for environmental matters. (A duly authorized representative may thus be either a named individual or any individual occupying a named position.)

C. Changes to authorization. If an authorization under paragraph B.2, above, is no longer accurate because a different individual or position has responsibility for the overall operation of the facility, a new authorization satisfying the requirements of paragraph B.2, above, must be submitted to the Department prior to or together with any reports, information, or applications to be signed by an authorized representative.

D. Certification. Any person signing a document under this section shall make the following certification:

> *"I certify under penalty of law, that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."*

G2. RIGHT OF INSPECTION AND ENTRY

The Permittee shall allow an authorized representative of the Department, upon the presentation of credentials and such other documents as may be required by law:

A. To enter upon the premises where a discharge is located or where any records must be kept under the terms and conditions of this permit.

B. To have access to and copy - at reasonable times and at reasonable cost - any records required to be kept under the terms and conditions of this permit.

C. To inspect - at reasonable times - any facilities, equipment (including monitoring and control equipment), practices, methods, or operations regulated or required under this permit.

D. To sample or monitor - at reasonable times - any substances or parameters at any location for purposes of assuring permit compliance or as otherwise authorized by the Clean Water Act.

G3. PERMIT ACTIONS

This permit may be modified, revoked and reissued, or terminated either at the request of any interested person (including the Permittee) or upon the Department's initiative. However, the permit may only be modified, revoked and reissued, or terminated for the reasons specified in 40 CFR 122.62, 122.64 or WAC 173-220-150 according to the procedures of 40 CFR 124.5.

A. The following are causes for terminating this permit during its term, or for denying a permit renewal application:

1. Violation of any permit term or condition.

2. Obtaining a permit by misrepresentation or failure to disclose all relevant facts.

3. A material change in quantity or type of waste disposal.

4. A determination that the permitted activity endangers human health or the environment or contributes to water quality standards violations and can only be regulated to acceptable levels by permit modification or termination [40 CFR Part 122.64(3)].

5. A change in any condition that requires either a temporary or permanent reduction or elimination of any discharge or sludge use or disposal practice controlled by the permit [40 CFR Part 122.64(4)].

6. Nonpayment of fees assessed pursuant to RCW 90.48.465.

7. Failure or refusal of the Permittee to allow entry as required in RCW 90.48.090.

B. The following are causes for modification but not revocation and reissuance except when the Permittee requests or agrees:

1. A material change in the condition of the waters of the state.

2. New information not available at the time of permit issuance that would have justified the application of different permit conditions.

3. Material and substantial alterations or additions to the permitted facility or activities which occurred after this permit issuance.

4. Promulgation of new or amended standards or regulations having a direct bearing upon permit conditions, or requiring permit revision.

5. The Permittee has requested a modification based on other rationale meeting the criteria of 40 CFR Part 122.62.

6. The Department has determined that good cause exists for modification of a compliance schedule, and the modification will not violate statutory deadlines.

7. Incorporation of an approved local pretreatment program into a municipality's permit.

C. The following are causes for modification or alternatively revocation and reissuance:

1. Cause exists for termination for reasons listed in A1 through A7, of this section, and the Department determines that modification or revocation and reissuance is appropriate.

2. The Department has received notification of a proposed transfer of the permit. A permit may also be modified to reflect a transfer after the effective date of an automatic transfer (General Condition G8) but will not be revoked and reissued after the effective date of the transfer except upon the request of the new Permittee.

G4. REPORTING PLANNED CHANGES

The Permittee shall, as soon as possible, but no later than sixty (60) days prior to the proposed changes, give notice to the Department of planned physical alterations or additions to the permitted facility, production increases, or process modification which will result in: 1) the permitted facility being determined to be a new source pursuant to 40 CFR 122.29(b); 2) a significant change in the nature or an increase in quantity of pollutants discharged; or 3) a significant change in the Permittee's sludge use or disposal practices. Following such notice, and the submittal of a new application or supplement to the existing application, along with required engineering plans and reports, this permit may be modified, or revoked and reissued pursuant to 40 CFR 122.62(a) to specify and limit any pollutants not previously limited. Until such modification is effective, any new or increased discharge in excess of permit limits or not specifically authorized by this permit constitutes a violation.

G5. PLAN REVIEW REQUIRED

Prior to constructing or modifying any wastewater control facilities, an engineering report and detailed plans and specifications shall be submitted to the Department for approval in accordance with Chapter 173-240 WAC. Engineering reports, plans, and specifications shall be submitted at least one hundred eighty (180) days prior to the planned start of construction unless a shorter time is approved by Ecology. Facilities shall be constructed and operated in accordance with the approved plans.

G6. COMPLIANCE WITH OTHER LAWS AND STATUTES

Nothing in this permit shall be construed as excusing the Permittee from compliance with any applicable federal, state, or local statutes, ordinances, or regulations.

G7. TRANSFER OF THIS PERMIT

In the event of any change in control or ownership of facilities from which the authorized discharge emanate, the Permittee shall notify the succeeding owner or controller of the existence of this permit by letter, a copy of which shall be forwarded to the Department.

A. Transfers by Modification

Except as provided in paragraph B, below, this permit may be transferred by the Permittee to a new owner or operator only if this permit has been modified or revoked and reissued under 40 CFR 122.62(b)(2), or a minor modification made under 40 CFR 122.63(d), to identify the new Permittee and incorporate such other requirements as may be necessary under the Clean Water Act.

B. Automatic Transfers

This permit may be automatically transferred to a new Permittee if:

1. The Permittee notifies the Department at least thirty (30) days in advance of the proposed transfer date.

2. The notice includes a written agreement between the existing and new Permittee's containing a specific date transfer of permit responsibility, coverage, and liability between them.

3. The Department does not notify the existing Permittee and the proposed new Permittee of its intent to modify or revoke and reissue this permit. A modification under the subparagraph may also be minor modification under 40 CFR 122.63. If this notice is not received, the transfer is effective on the date specified in the written agreement.

G8. REDUCED PRODUCTION FOR COMPLIANCE

The Permittee, in order to maintain compliance with its permit, shall control production and/or all discharges upon reduction, loss, failure, or bypass of the treatment facility until the facility is restored or an alternative method of treatment is provided. This requirement applies in the situation where, among other things, the primary source of power of the treatment facility is reduced, lost, or fails.

G9. REMOVED SUBSTANCES

Collected screenings, grit, solids, sludges, filter backwash, or other pollutants removed in the course of treatment or control of wastewaters shall not be resuspended or reintroduced to the final effluent stream for discharge to state waters.

G10. DUTY TO PROVIDE INFORMATION

The Permittee shall submit to the Department, within a reasonable time, all information which the Department may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit or to determine compliance with this permit. The Permittee shall also submit to the Department upon request, copies of records required to be kept by this permit.

G11. OTHER REQUIREMENTS OF 40 CFR

All other requirements of 40 CFR 122.41 and 122.42 are incorporated in this permit by reference.

G12. ADDITIONAL MONITORING

The Department may establish specific monitoring requirements in addition to those contained in this permit by administrative order or permit modification.

G13. PAYMENT OF FEES

The Permittee shall submit payment of fees associated with this permit as assessed by the Department.

G14. PENALTIES FOR VIOLATING PERMIT CONDITIONS

Any person who is found guilty of willfully violating the terms and conditions of this permit shall be deemed guilty of a crime, and upon conviction thereof shall be punished by a fine of up to ten thousand dollars ($10,000) and costs of prosecution, or by imprisonment in the discretion of the court. Each day upon which a willful violation occurs may be deemed a separate and additional violation.

Any person who violates the terms and conditions of a waste discharge permit shall incur, in addition to any other penalty as provided by law, a civil penalty in the amount of up to ten thousand dollars ($10,000) for every such violation. Each and every such violation shall be a separate and distinct offense, and in case of a continuing violation, every day's continuance shall be deemed to be a separate and distinct violation.

G15. UPSET

Definition – "Upset" means an exceptional incident in which there is unintentional and temporary noncompliance with technology-based permit effluent limitations because of factors beyond the reasonable control of the Permittee. An upset does not include noncompliance to the extent caused by operational error, improperly designed treatment facilities, inadequate treatment facilities, lack of preventive maintenance, or careless or improper operation.

An upset constitutes an affirmative defense to an action brought for noncompliance with such technology-based permit effluent limitations if the requirements of the following paragraph are met.

A Permittee who wishes to establish the affirmative defense of upset shall demonstrate, through properly signed, contemporaneous operating logs or other relevant evidence that:
1) an upset occurred and that the Permittee can identify the cause(s) of the upset;
2) the permitted facility was being properly operated at the time of the upset;
3) the Permittee submitted notice of the upset as required in Condition S3.E; and
4) the Permittee complied with any remedial measures required under S4.C of this permit.

In any enforcement proceedings the Permittee seeking to establish the occurrence of an upset has the burden of proof.

G16. PROPERTY RIGHTS

This permit does not convey any property rights of any sort, or any exclusive privilege.

G17. DUTY TO COMPLY

The Permittee shall comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the Clean Water Act and is grounds for enforcement action; for permit termination, revocation and reissuance, or modification; or denial of a permit renewal application.

G18. TOXIC POLLUTANTS

The Permittee shall comply with effluent standards or prohibitions established under Section 307(a) of the Clean Water Act for toxic pollutants within the time provided in the regulations that establish those standards or prohibitions, even if this permit has not yet been modified to incorporate the requirement.

G19. PENALTIES FOR TAMPERING

The Clean Water Act provides that any person who falsifies, tampers with, or knowingly renders inaccurate any monitoring device or method required to be maintained under this permit shall, upon conviction, be punished by a fine of not more than $10,000 per violation, or by imprisonment for not more than two (2) years per violation, or by both. If a conviction of a person is for a violation committed after a first conviction of such person under this Condition, punishment shall be a fine of not more than $20,000 per day of violation, or by imprisonment of not more than four (4) years, or by both.

G20. REPORTING ANTICIPATED NONCOMPLIANCE

The Permittee shall give advance notice to the Department by submission of a new application or supplement thereto at least one hundred eighty (180) days prior to commencement of such discharges, of any facility expansions, production increases, or other planned changes, such as process modifications, in the permitted facility or activity which may result in noncompliance with permit limits or conditions. Any maintenance of facilities, which might necessitate unavoidable interruption of operation and degradation of effluent quality, shall be scheduled during noncritical water quality periods and carried out in a manner approved by the Department.

G21. REPORTING OTHER INFORMATION

Where the Permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application or in any report to the Department, it shall promptly submit such facts or information.

G22. REPORTING REQUIREMENTS APPLICABLE TO EXISTING MANUFACTURING, COMMERCIAL, MINING, AND SILVICULTURAL DISCHARGERS

The Permittee belonging to the categories of existing manufacturing, commercial, mining, or silviculture must notify the Department as soon as they know or have reason to believe:

A. That any activity has occurred or will occur which would result in the discharge, on a routine or frequent basis, of any toxic pollutant which is not limited in this permit, if that discharge will exceed the highest of the following "notification levels":

1. One hundred micrograms per liter (100 μg/L).

2. Two hundred micrograms per liter (200 μg/L) for acrolein and acrylonitrile; five hundred micrograms per liter (500 μg/L) for 2,4-dinitrophenol and for 2-methyl-4,6-dinitrophenol; and one milligram per liter (1 mg/L) for antimony.

3. Five times the maximum concentration value reported for that pollutant in the permit application in accordance with 40 CFR 122.21(g)(7).

4. The level established by the Director in accordance with 40 CFR 122.44(f).

B. That any activity has occurred or will occur which would result in any discharge, on a nonroutine or infrequent basis, of a toxic pollutant which is not limited in this permit, if that discharge will exceed the highest of the following "notification levels":

1. Five hundred micrograms per liter (500 μg/L).

2. One milligram per liter (1 mg/L) for antimony.

3. Ten times the maximum concentration value reported for that pollutant in the permit application in accordance with 40 CFR 122.21(g)(7).

4. The level established by the Director in accordance with 40 CFR 122.44(f).

G23. COMPLIANCE SCHEDULES

Reports of compliance or noncompliance with, or any progress reports on, interim and final requirements contained in any compliance schedule of this permit shall be submitted no later than fourteen (14) days following each schedule date.

APPENDIX I

LIQUID-FLOC CHITOSAN ENHANCED SAND FILTRATION (Natural Site Solutions)

Maintenance of Safety Margin

Chitosan acetate can effectively treat stormwater turbidity up to 600 NTU without using a concentration above 1.06 mg/L. 1.06 mg/L chitosan is below its toxic threshold of 1.21 mg/L in clear water. In addition, chitosan will be removed from solution by binding to solids and by being withheld in the sand filter. The safety margin will certainly be maintained if the treatment concentration is kept to 1.06 mg/L or below. Any mechanical failure of the positive displacement metering pump will immediately cause a reduction in Liqui-Floc dosing, so pump failure is only a problem for treatment effectiveness and not safety margin maintenance.

The following dose rate table shall be used to ensure both treatment plant effectiveness and a chitosan concentration below 1.06 mg/L prior to sand filtration.

Dose Rate Table for Liqui-Floc (1% Chitosan Acetate) Based on Flow and Turbidity

Turbidity	Stormwater Flow Rate	Liqui-Floc Dose Rate	Chitosan Concentration
50 - 200 NTU	200 gpm	20 ml/min or 0.32 gph	0.26 mg/L
	300 gpm	30 ml/min or 0.48 gph	
	400 gpm	40 ml/min or 0.64 gph	
	500 gpm	50 ml/min or 0.8 gph	
	600 gpm	60 ml/min or 0.96 gph	
	700 gpm	70 ml/min or 1.11 gph	
200 - 400 NTU	200 gpm	40 ml/min or 0.64 gph	0.53 mg/L
	300 gpm	60 ml/min or 0.96 gph	
	400 gpm	80 ml/min or 1.27 gph	
	500 gpm	100 ml/min or 1.6 gph	
	600 gpm	120 ml/min or 1.91 gph	
	700 gpm	140 ml/min or 2.23 gph	
400 - 600 NTU	200 gpm	80 ml/min or 1.27 gph	1.06 mg/L
	300 gpm	120 ml/min or 1.91 gph	
	400 gpm	160 ml/min or 2.54 gph	
	500 gpm	200 ml/min or 3.17 gph	
	600 gpm	240 ml/min or 3.81 gph	
	700 gpm	280 ml/min or 4.45 gph	

Checking formula:
chitosan concentration in mg/L = (ml/min Liqui-Floc x 0.01 x 1 g/ml x 1000 mg/g)/system flow rate in liters/min
liters/min = gpm x 3.78 liters/gal

Safety Margin Checklist

- Only Storm Klear Liqui-Floc™ containing 1 percent chitosan acetate shall be used.
- The metering pump shall be calibrated using a calibration cylinder at startup and every time that the Liqui-Floc dose rate needs changed. The calibration shall be recorded in the log. The stroke frequency shall be set as high as possible, and the stroke length adjusted to provide the correct dosing.

- The system flow rate and the turbidity of both influent and effluent shall be measured hourly and recorded in the log.
- No chitosan-treated water shall be discharged to surface water without first being sand-filtered.
- Secondary containment for the Liqui-Floc storage container and the metering pump shall be at least equal to the volume of the storage container.
- Spill adsorbent material shall be readily available to immobilize any spill of Liqui-Floc during handling.
- If the treatment system is located less than 50 feet from surface water, a 1-foot high earthen berm shall be constructed and maintained down-gradient as additional spill containment.
- Only discharges to streams are allowed at this time.
- The occasional use of the Residual Chitosan Field Screening Test to confirm a discharge concentration below 0.1 is encouraged in order to further build confidence in CESF system safety.

APPENDIX II

FLOC-CLEAR CHITOSAN ENHANCED SAND FILTRATION
(Clear Creek Systems, Inc.)

Maintenance of Safety Margin

Chitosan acetate can effectively treat storm water up to 600 NTU without using a concentration above 1.06 mg/L. 1.06 mg/L chitosan from FlocClear™ is below its toxic threshold of 2.5 mg/L in clear water. The chitosan concentration will decrease after dosing due to binding to solids and the sand filter. If the metering pump fails, the anti-siphon valve will prevent FlocClear™ from being siphoned into the system. If the metering pump is incorrectly calibrated and the storm water is overdosed, treated water will not coagulate well enough to be clarified and the turbidimeter will trigger the return of effluent to the detention structure instead of discharge.

The following dose rate table shall be used to ensure both treatment plant effectiveness and a chitosan concentration below 1.06 mg/L prior to sand filtration.

Influent Turbidity (NTU)	Influent Flow Rate (gpm)	FlocClear™ 2% Solution Dose Rate		chitosan (mg/L)	Influent Turbidity (NTU)	Influent Flow Rate (gpm)	FlocClear™ 2% Solution Dose Rate		chitosan (mg/L)
		ml/min	gph				ml/min	gph	
50 - 150	100	5	0.08	***0.265***	**150 - 300**	100	10	0.16	***0.529***
	200	10	0.16			200	20	0.32	
	300	15	0.24			300	30	0.48	
	400	20	0.32			400	40	0.63	
	500	25	0.40			500	50	0.79	
	600	30	0.48			600	60	0.95	
	700	35	0.56			700	70	1.11	
	800	40	0.64			800	80	1.27	
	900	45	0.72			900	90	1.43	
	1000	50	0.79			1000	100	1.59	
300 - 450	100	15	0.24	***0.794***	**450 - 600**	100	20	0.32	***1.058***
	200	30	0.48			200	40	0.63	
	300	45	0.71			300	60	0.95	
	400	60	0.95			400	80	1.27	
	500	75	1.19			500	100	1.59	
	600	90	1.43			600	120	1.90	
	700	105	1.67			700	140	2.22	
	800	120	1.91			800	160	2.54	
	900	135	2.14			900	180	2.86	
	1000	150	2.38			1000	200	3.17	

Checking formula:
chitosan concentration in mg/L = (ml/min FlocClear™ x 0.02 x 1 g/ml x 1000 mg/g)/system flow rate in liters/min
liters/min = gpm x 3.78 liters/gal

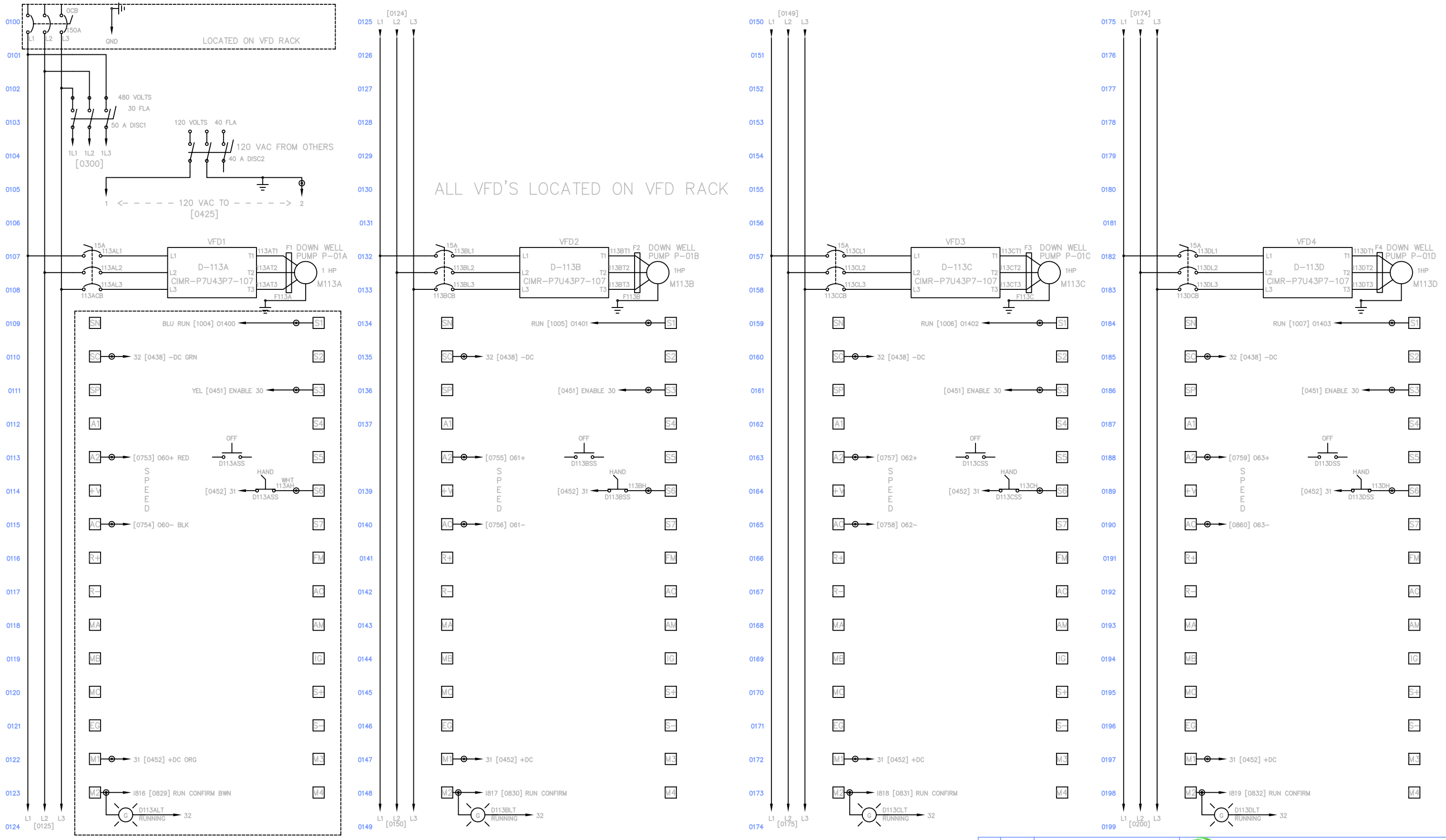
Safety Margin Checklist

- Only FlocClear™ containing 2 percent chitosan acetate shall be used and discharges shall only be to streams.
- No chitosan-treated water shall be discharged without first receiving sand-filtration.

- Secondary containment for the FlocClear™ tote and metering pump shall be at least equal to the tote volume.
- FlocClear™ shall be stored at least 50 feet away from all natural drainages, conveyances, and storm drain inlets or a 1-foot high earthen berm shall be constructed and maintained down-gradient as additional containment.
- Spill absorbent material shall be readily available to immobilize any spill during handling.
- The FlocClear™ metering pump shall be positive displacement and provided with an anti-siphon valve which shall be inspected and the inspection recorded at the beginning of each treatment shift.
- The metering pump shall be calibrated using a calibration cylinder at the beginning of each treatment shift and every time that the FlocClear™ dose rate changes. The calibration shall be recorded in the log. The stroke frequency shall be set as high as possible, and the stroke length/speed adjusted to provide correct dosing.
- Flow rate, turbidity, and pH of influent and effluent shall be recorded at startup and every 2 hours thereafter.
- Bench/jar testing shall be done at startup and when influent turbidity changes more than 50 NTU. If the results of the jar tests indicate that the dose needs to be adjusted, the jar testing results and the indicated dose rate change shall be documented in the daily operating log.
- The volume of chitosan in the tote shall be recorded at the beginning and end of the treatment period. The volume used shall be determined and compared to the volume of water treated to further validate dose rate.
- The Residual Chitosan Field Screening Test shall be used twice per day during CESF operation at 1 hour and 2 hours after startup to confirm a discharge concentration below 0.1. If any chitosan is detected in the discharge, the operator shall shut down the CESF until the malfunction has been found and fixed.
- All inspections, calibrations, tests, measurements, dose rate changes, and equipment adjustments shall be recorded in a daily operating log which must be kept available for at least the duration of the treatment project.

Appendix G

HCC Treatment System Electrical Schematic



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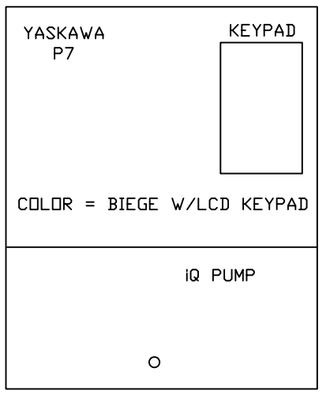
DRAWN BY: JJG	SCALE: N/A	APPROVED:	DATE:
DATE: 10/26/08	JOB#: JOB#		
SUBJECT: 480 VAC DISTRIBUTION			SHEET
LOCATION: Skykomish, WA		DWG NO: DWG01	

VFD EXTERIOR



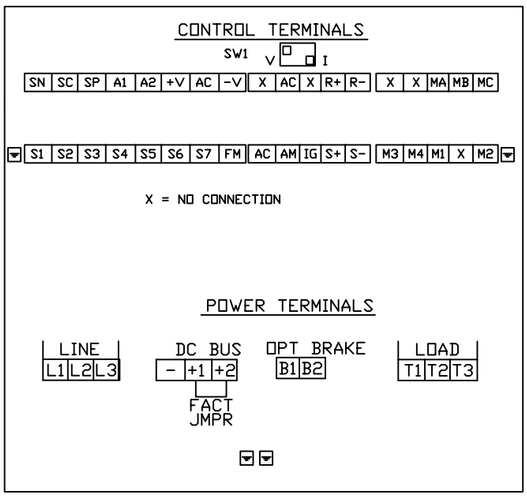
MODBUS PORT BENNEATH UPPER COVER

TO OPEN (LOWER HALF ONLY):
LOOSEN PHILLIPS SCREW AND SLIDE COVER DOWN. PULL OFF.

TO CLEAR FAULTS
1. CORRECT CONDITION CAUSING FAULT.
2. PRESS "RESET" OR CYCLE POWER.
3. CYCLE STOP/RUN CONTACT (AUTO TO OFF THEN BACK TO AUTO)

VFD INTERIOR

WIRING AREA ONLY



VFD PARAMETER SETTINGS

AS ADJUSTED/PROGRAMMED BY NES

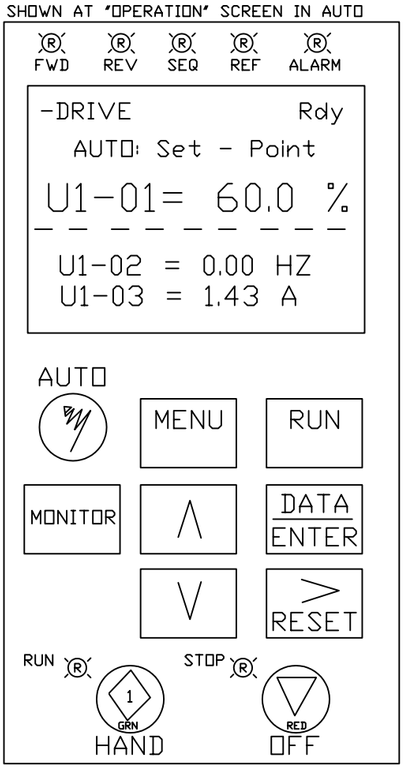
MANUAL PAGE #	MENU	PARAM #	DESCRIPTION	SETTINGS BY NES VFD1-8	11	VFD9,10	VFD12,13	DESCRIP. OR UNIT
			MOTOR HP'S	1	5	15	10	
166	PROG.	b1-01	SPEED REF 1 (SET VIA S5 OFF)	1		1	1	A2=4-20
166	PROG.	b1-02	RUN COMMAND	1		1	1	TERM.
166	PROG.	b1-03	STOP CONTROL	1		1	1	COAST
166	PROG.	b1-07	EXTERNAL RUN AFTER HAND POS	1		1	1	NO CYCL
167	PROG.	b5-01	CONTROL MODE (PID,ETC)	0		0	0	PID OFF
168	PROG.	C1-01	ACCELERATION TIME	10	3	3	10	SEC
169	PROG.	C6-02	CARRIER FREQ. (SET LOW FOR FILT)	1		1	1	2 KHZ
170	PROG.	d1-02	SPEED REF 2 (DR SET VIA S5 ON)	100		100	100	%
171	PROG.	E2-01	MOTOR FULL LOAD CURRENT (SF*)	2.4	7.0	21	13.3	AMPS
171	PROG.	E2-03	MOTOR NO-LOAD CURRENT	0.6		0.6	0.6	AMPS
172	PROG.	H1-01	INPUT S3 (ON = DRIVE ENABLE)	6A		6A	6A	ENABL
172	PROG.	H1-03	INPUT S5 (MULTI-STEP SPEED REF)	3		3	3	P172
175	PROG.	H2-01	SETS RELAY OUTPUT 2 (M1,M2)	0		0	0	RUN
176	PROG.	H3-09	SELECTS FUNCTION OF A2	0		0	0	BIAS
176	PROG.	H3-11	SETS A2 BIAS (MIN VALUE CLAMP)	50		50	50	%
176	PROG.	H3-13	SETS A2 (AN IN 2) AS SPEED REF 1	1		1	1	A2=REF
183	PROG.	P1-02	SYSTEM UNITS	12		12	12	%
183	PROG.	P1-03	FEEDBACK DEVICE SCALE	11000		11000	11000	XXX.X
184	PROG.	P1-12	LOSS OF PRIME	0		0	0	OFF
189	PROG.	P5-01	HAND MODE SPEED REFERENCE	1		1	1	IN DR
189	PROG.	P5-02	SETS FREQ. WHEN DRIVE IN HAND	45		45	45	HZ
189	PROG.	P5-04	DISABLES HAND BUTTON ON KEYPAD	0		0	0	DISABL
170	PROG.	d2-01	MINIMUM FREQ. (ALL REF'S)	50		50	50	%

01 (OF U1-01) FLASHES DURING NORM. OPERATION

FWD (RUNNING FORWARD)
REV (RUNNING REVERSE)
SEQ (AUTO RUN CMD FROM TERM)
REF (AUTO FREQ REF. FROM TERM)
ALARM (ON FOR FAULTS, FLASHES FOR ALARMS)

VFD KEYPAD

SHOWN AT "OPERATION" SCREEN IN AUTO



INPUT SIGNAL (50-100%) (4-20mA)

OUTPUT FREQ. (30-60 Hz)

OUTPUT AMPS (0-5A)

LOCAL HAND BUTTON (ON KEYPAD) DISABLED
USE SEL. SW. ON MAIN PANEL

NOTES FOR BENCH TESTING: NOT NECESSARY TO DISABLE L8-05,07 (IN/OUT PHASE LOSS), DUE TO NEED FOR LOAD AND METHOD OF DETECTION USED (RIPPLE MEASURED).

NOTES FOR ABOVE TABLE
1. ALL PARAMETERS NOT LISTED ABOVE REMAIN AT FACTORY DEFAULT SETTINGS.
2. SEE DRAWINGS FOR VFD AND MOTOR SIZES.

FOR MANUAL ADJUSTMENT OF MOTOR SPEED (VFD FREQUENCY)
1. SET AT PC SCREEN (CHOOSE MANUAL SPEED CONTROL).
2. ENTER SETPOINT IN d1-02 AND APPLY JUMPER (SEE DWG).
3. FOR HAND MODE SPEED ONLY CHANGE P5-02 TO DESIRED VALUE.

TO MONITOR VFD ITEMS:

U1-06 = OUTPUT AC VOLTAGE
U1-07 = DC BUS VOLTAGE
U1-10 = INPUT STATUS S1-S7 (R TO L, 8TH BIT IS NOT USED)
U1-11 = OUTPUT STATUS M1,M2;M3,M4, 3 NOT USED, MA,MB LAST (R TO L, 4-6TH BITS NOT USED)
U1-13 = RUN TIME
U1-16 = A2 ANALOG INPUT LEVEL (IN %)

FOR NES REFERENCE ONLY (UNITS HAVE ALREADY BEEN PROGRAMMED).

TO PROGRAM VFD
1. PRESS MENU UNTIL "PROGRAMMING" APPEARS. (MENUS: OPERATION, PUMP QUICK SETUP, PROGRAMMING, MODIFIED CONST.)
2. PRESS ENTER. THEN USE UP/DOWN ARROWS TO GET TO CORRECT LETTER PREFIX (A,b1,b2,C1,C6, ETC).
3. THEN USE RIGHT ARROW AND UP/DOWN ARROWS TO GET TO CORRECT NUMBER(-01,-02).
4. PRESS ENTER. THEN USE UP/DOWN ARROWS TO GET TO DESIRED VALUE.
5. PRESS ENTER WHEN DESIRED VALUE APPEARS. DISPLAY SHOULD SHOW "ENTRY ACCEPTED".
6. PRESS MONITOR TO GET TO MAIN (OPERATION) DISPLAY.
7. ALTERNATIVELY GO TO MODIFIED CONSTANTS TO ADJUST VALUES IF ALREADY DIFFERENT FORM FACT. DEF. SETTINGS.
8. USE COPY FUNCTION IF DESIRED: (03-02=(1) ENABLE, 03-01=1 (READ), OR 2 (WRITE).

NOTE: SEE YASKAWA iQPUMP MANUALS (USER,PROGRAMMING) FOR ADDITIONAL INFORMATION IF NECESSARY. PAGE REFERENCES REFER TO THE USER MANUAL (REV: 08-06).

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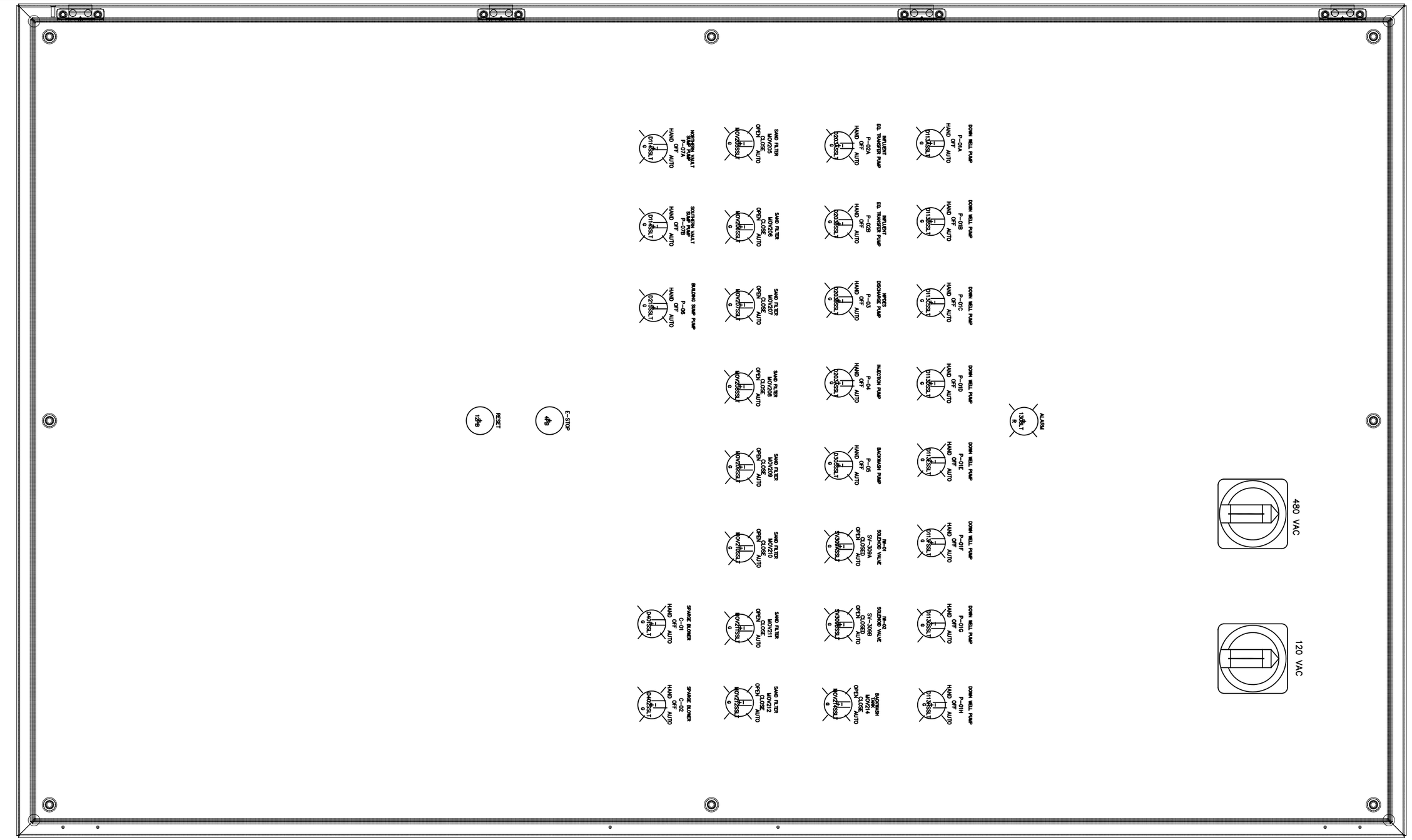
TITLE			
VFD INTERIOR,EXT, LCD DISPLAY			
ENSR AECOM SKYKOMISH, WA			JOB NO. 08-208
SCALE NTS	SIZE	DWG NO. DWG13	SHEET DWG13 / REV



REV	DATE	DESCRIPTION
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DRAWN BY: JJG	SCALE: 1/4	APPROVED: DATE:
DATE: 11/18/08	JOB#: JOB#	
SUBJECT: PANEL LAYOUT		SHEET
LOCATION: Skykomish, WA		DWG NO: DWG12

480 VAC FEED FROM VFD RACK

120 VAC FEED FROM BUILDING DIST

MCP114A | MCP114B | MCP215 | MCP305 | MCP308

114AM | 114BM | 215M | 305M | 308M

DISC1 480 VAC

DISC# 120 VAC

PLEXIGLASS COVER WITH BARRIER

TO MOTORS

E STOPS

MOV'S

CR205 CR206 CR207 CR208 CR209 CR210 CR211 CR212 CR214

COMPACT LOGIX PLC (CPU & I/O CARDS)

COMPACT LOGIX PLC (I/O CARDS)

FIELDINPUTS 120 VAC

SENSAPHONE

DRP-240-24

WARWICK CONTROLER

WARWICK CONTROLER

FIELDINPUTS 24 VDC

FIELDINPUTS ANALOG

LINE

ISLATROL IC+105

LOAD

MCR

CR1311 CR1310 CR1309 CR1308 CR1307

31CB 30CB 26CB 25CB 21CB 20CB 23CB 18CB 3CB

2A 5A 5A 15A 2A 5A 15A 20A 2A

VFD CONTROL/MONITOR

UPS

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DRAWN BY: JJG | SCALE: 1/4 | APPROVED: | DATE:

DATE: 10/26/08 | JOB#: JOB# | SHEET

SUBJECT: PANEL LAYOUT

LOCATION: Skykomish, WA | DWG NO: DWG11

REV	DATE	DESCRIPTION
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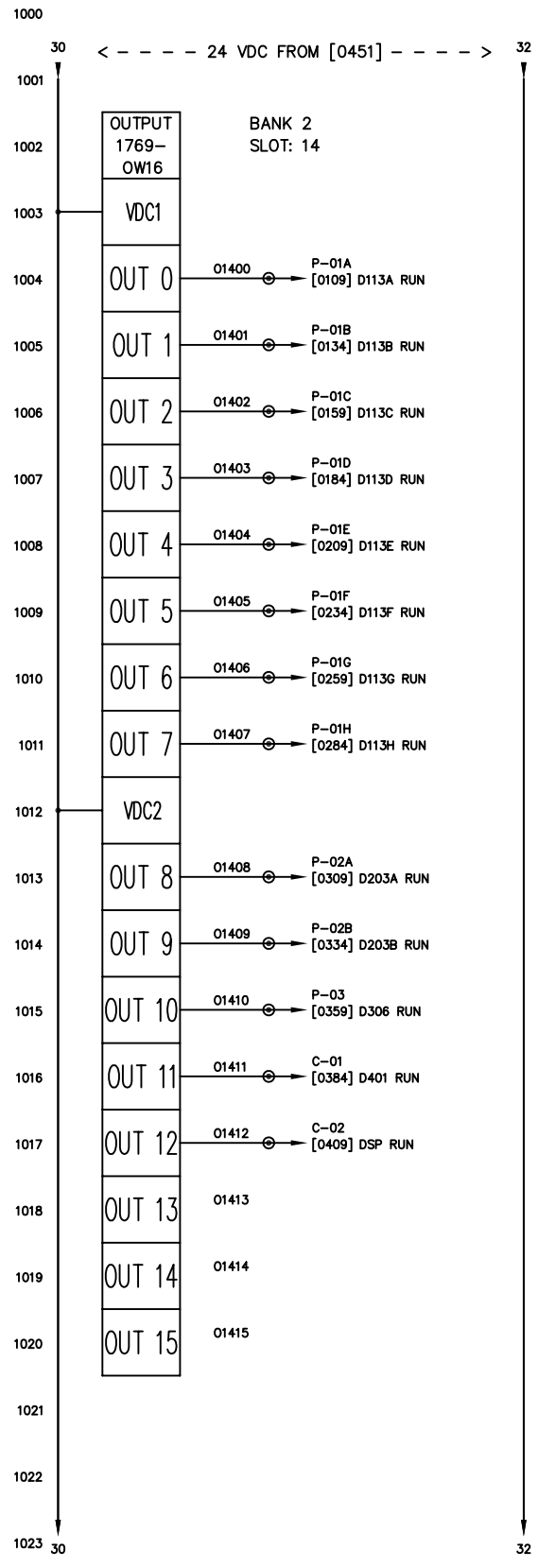

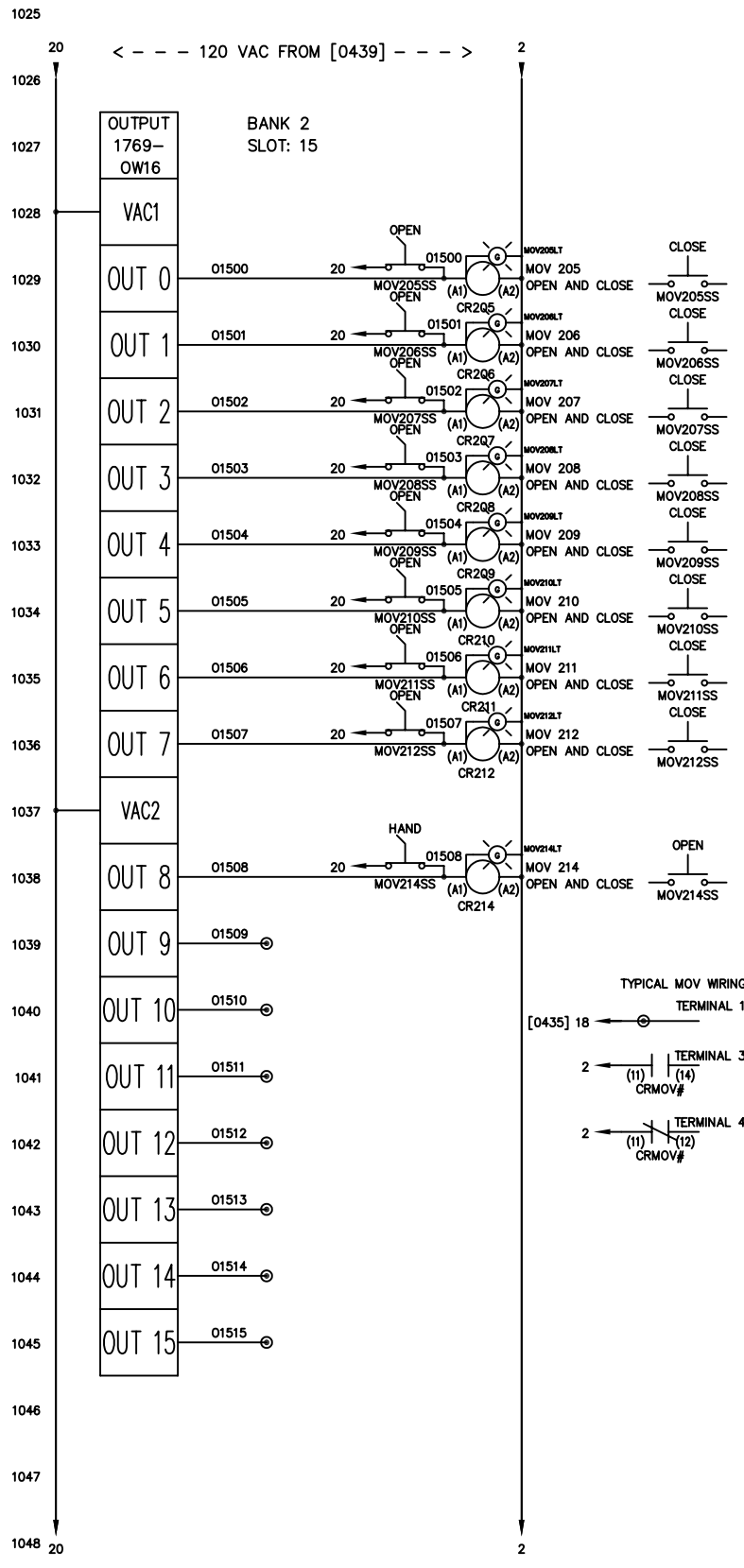

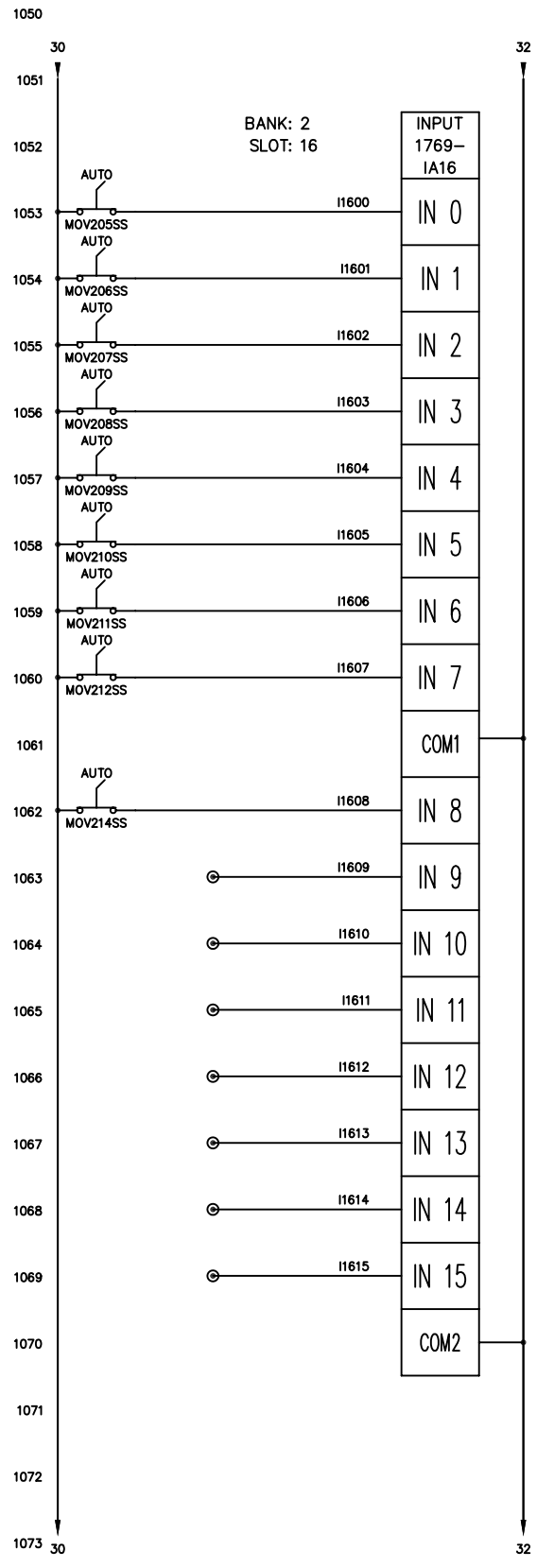

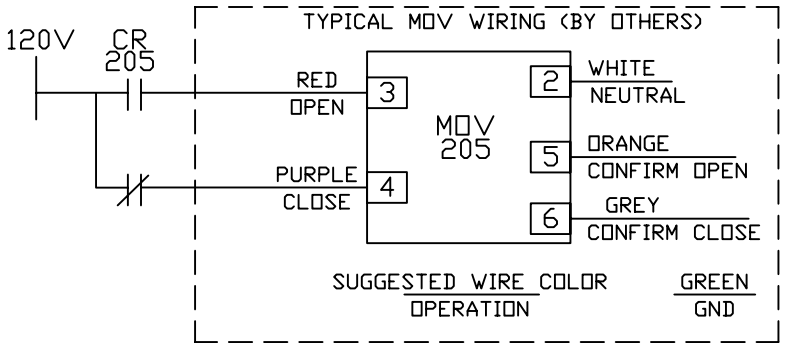

HAYWARD EVS SERIES ACTUATOR (NEMA 4/7)
CONFIRM ABOVE WIRING WITH UNIT IN FIELD,
PRIOR TO ENERGIZING.

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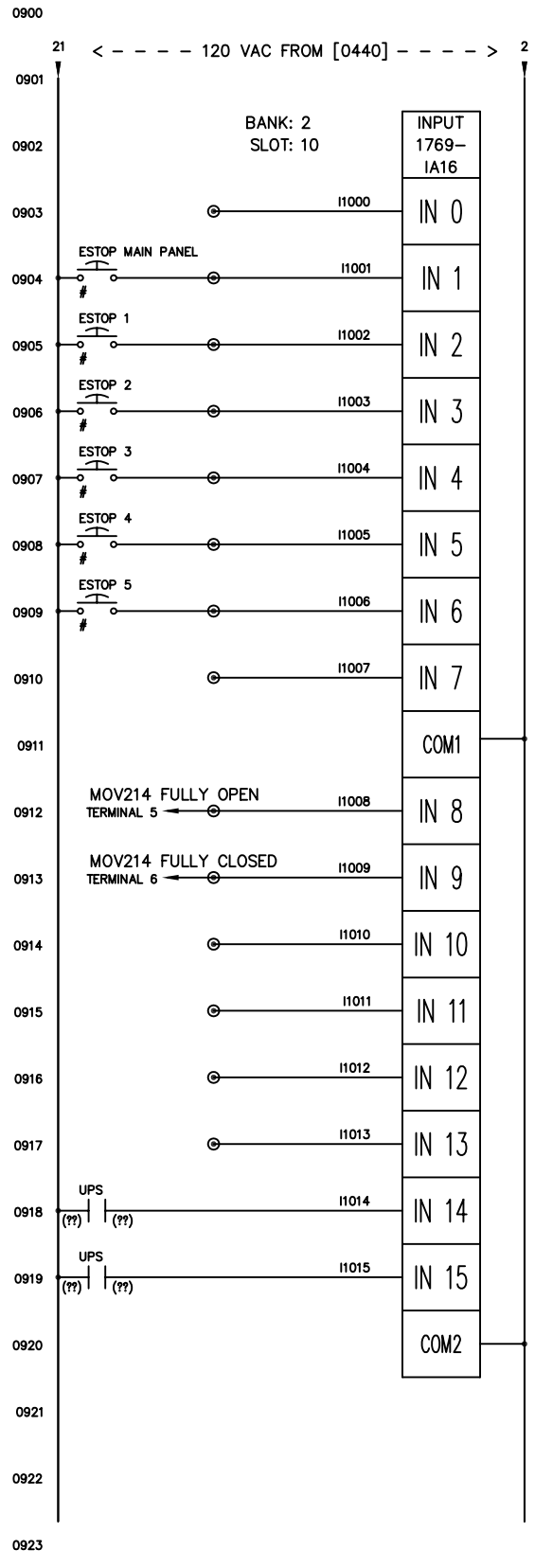
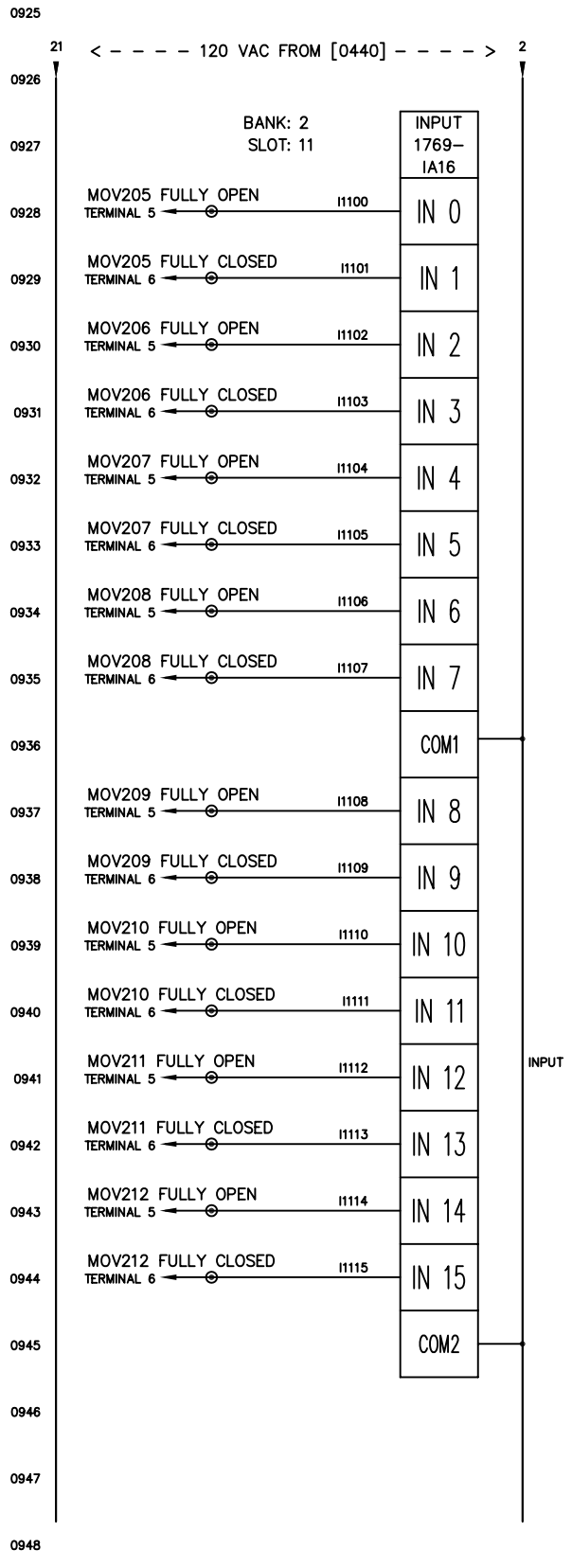
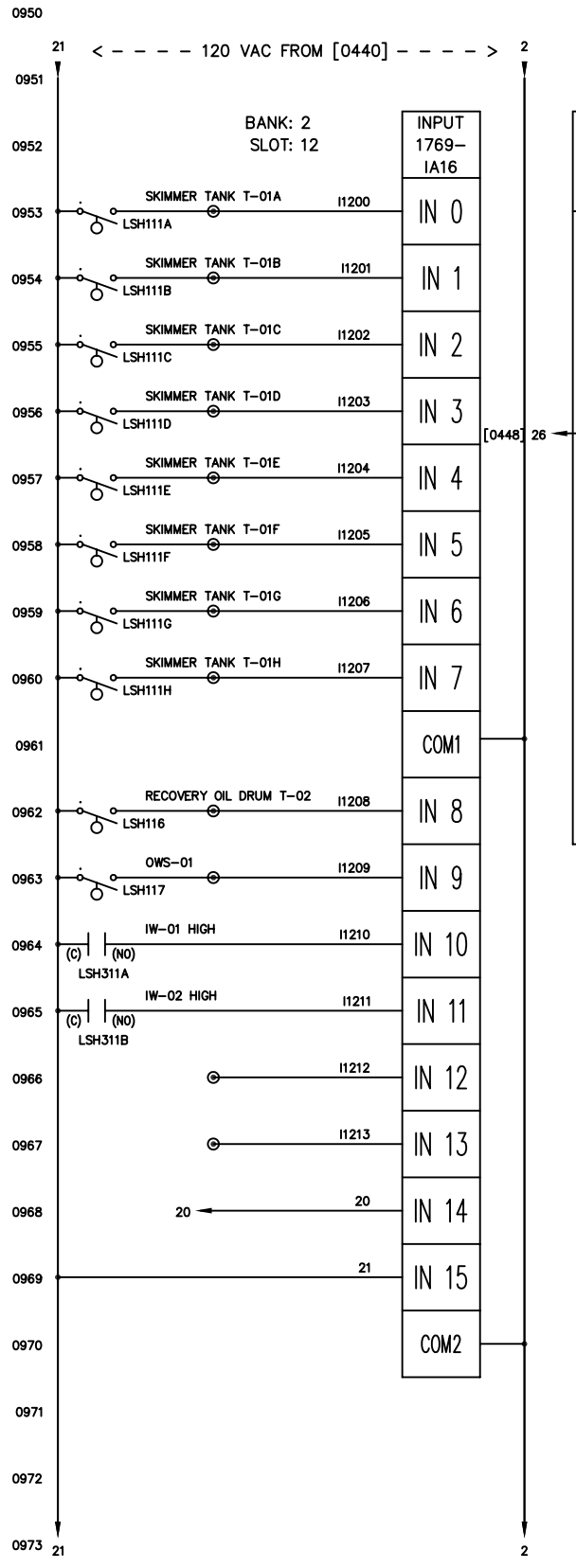
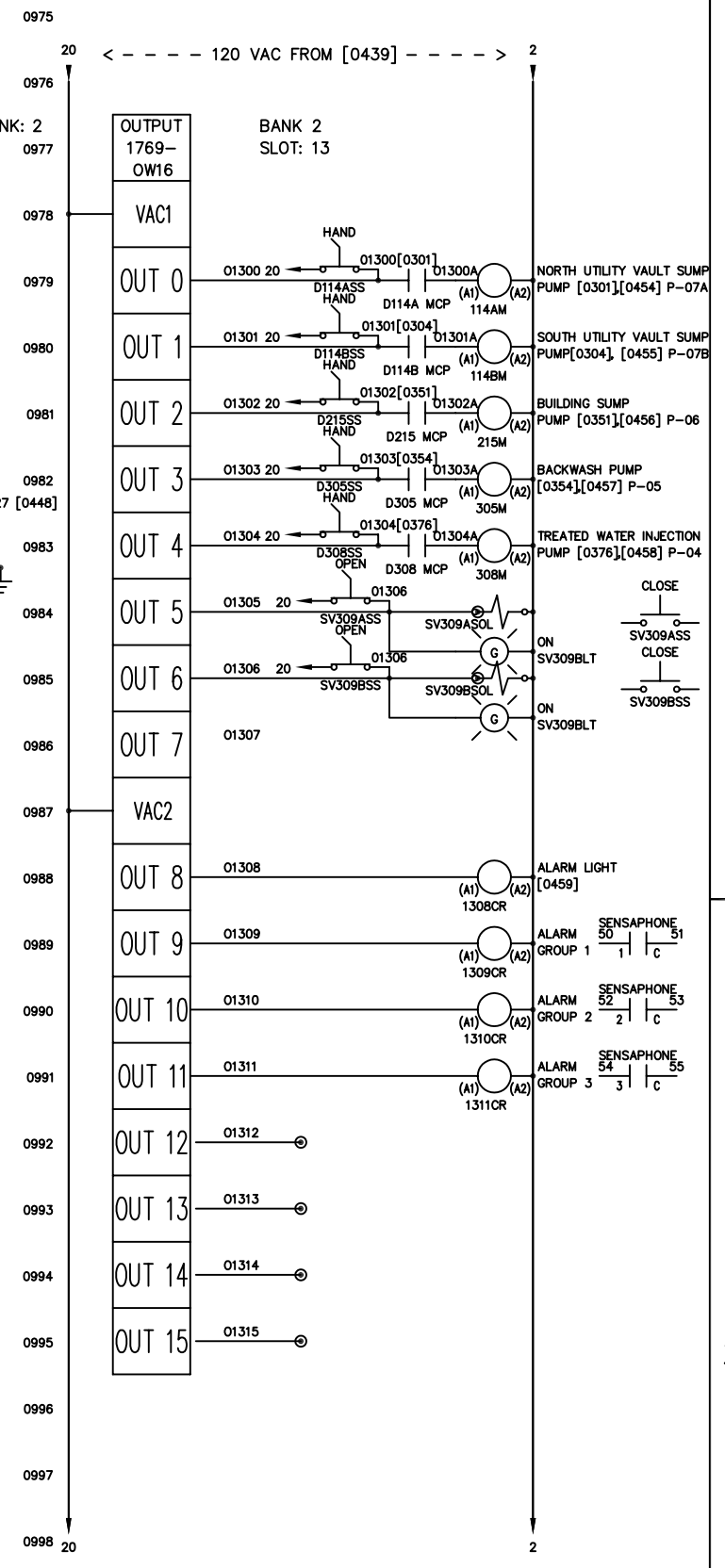
DRAWN BY: JJG	SCALE: N/A	APPROVED:	DATE:
DATE: 10/26/08	JOB#: JOB#		
SUBJECT: PLC BANK 2 SLOTS 14-15			SHEET
LOCATION: Skykomish, WA		DWG NO: DWG10	









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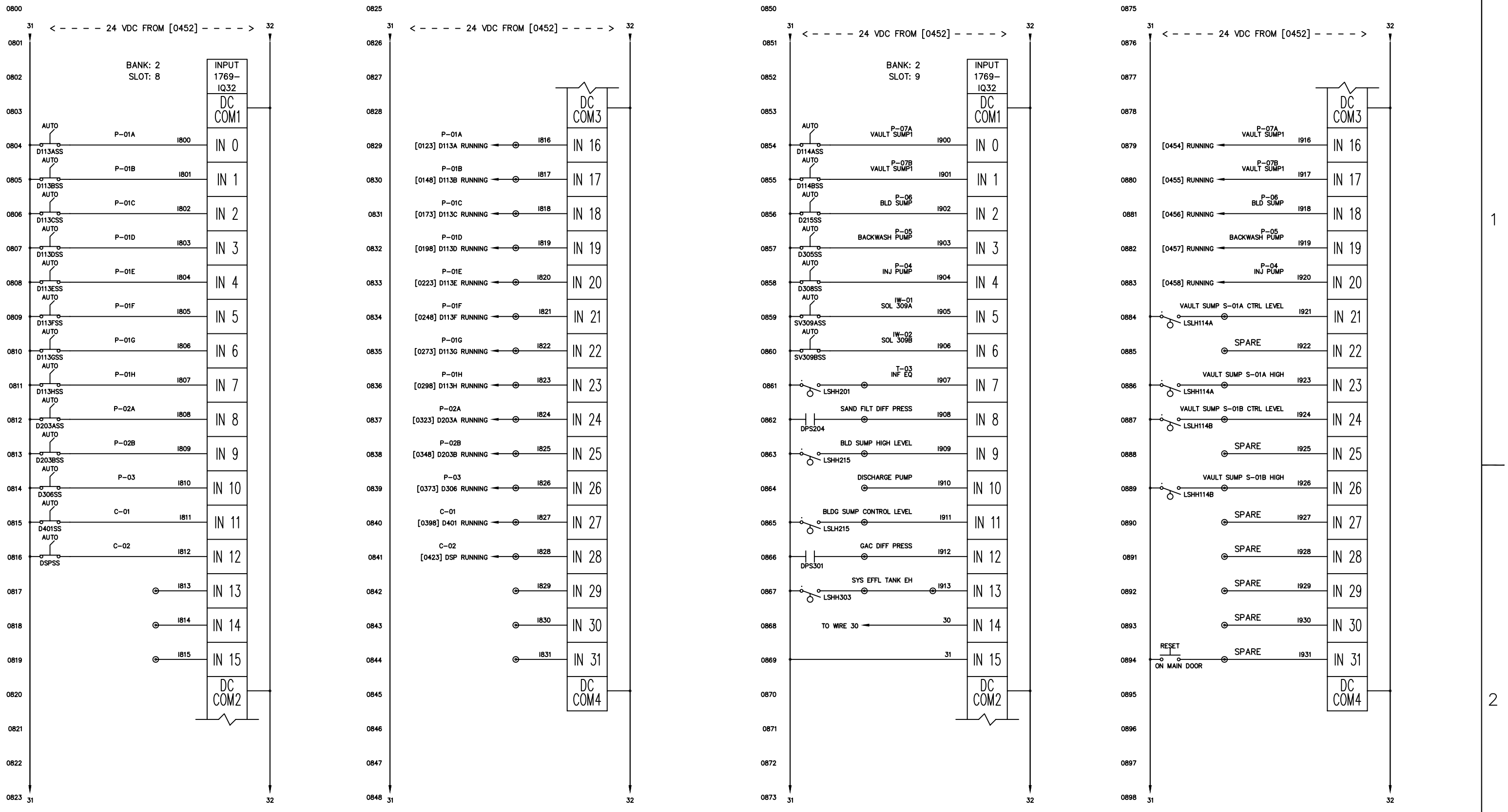
DRAWN BY: JJG	SCALE: N/A	APPROVED:	DATE:
DATE: 10/26/08	JOB#: JOB#		
SUBJECT: PLC BANK 2 SLOTS 10-11			SHEET
LOCATION: Skykomish, WA		DWG NO: DWG09	



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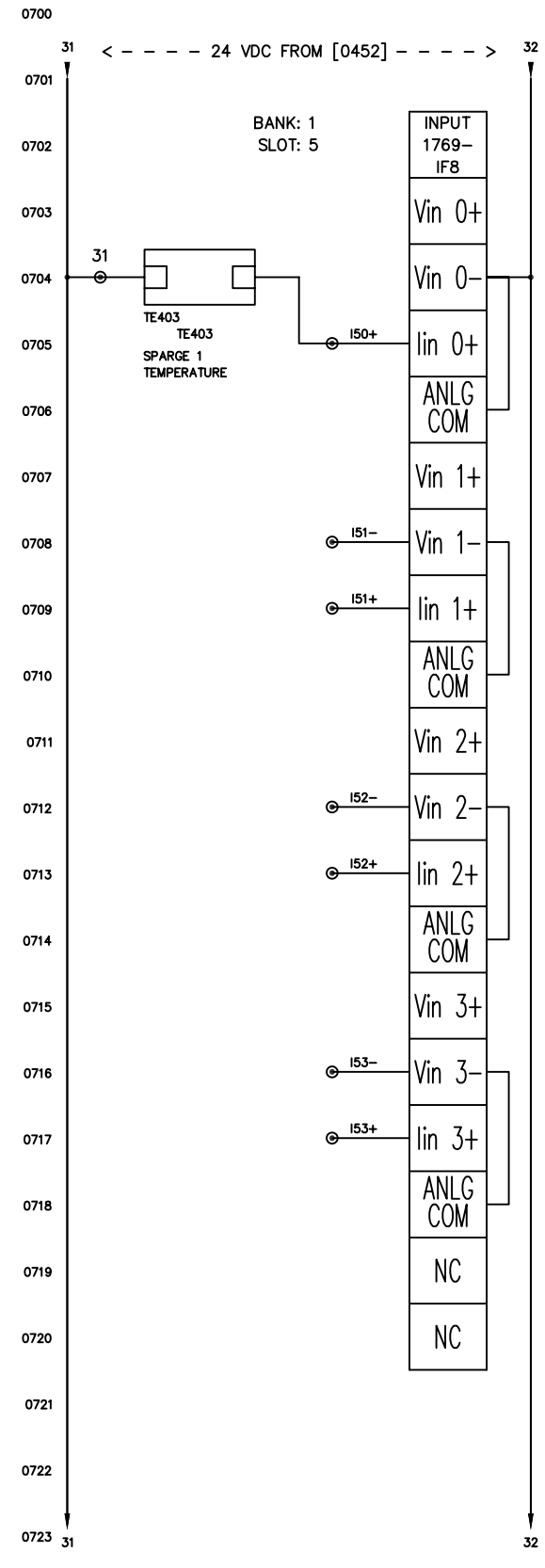
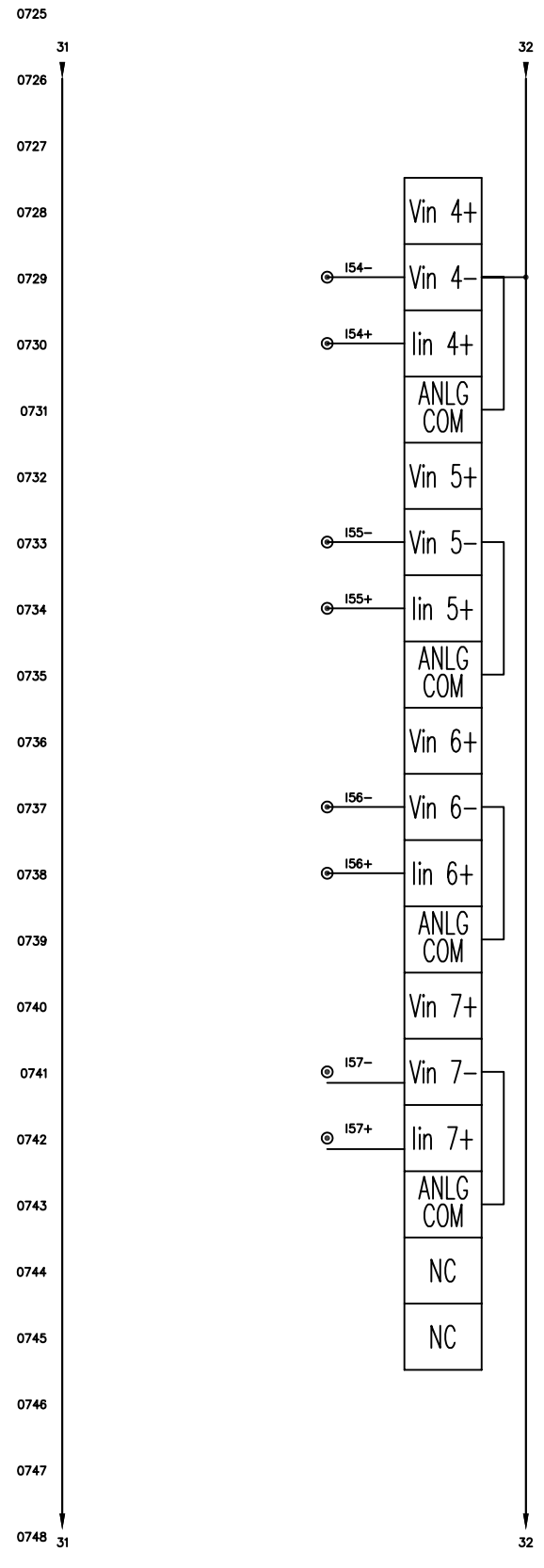
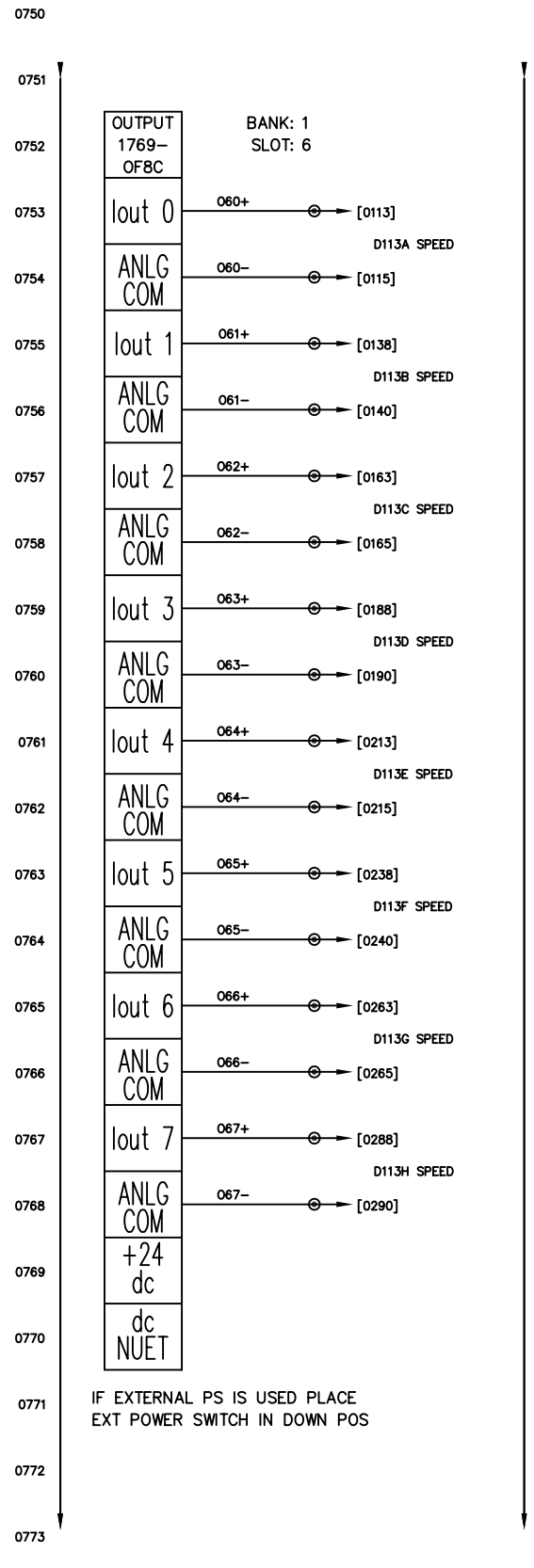
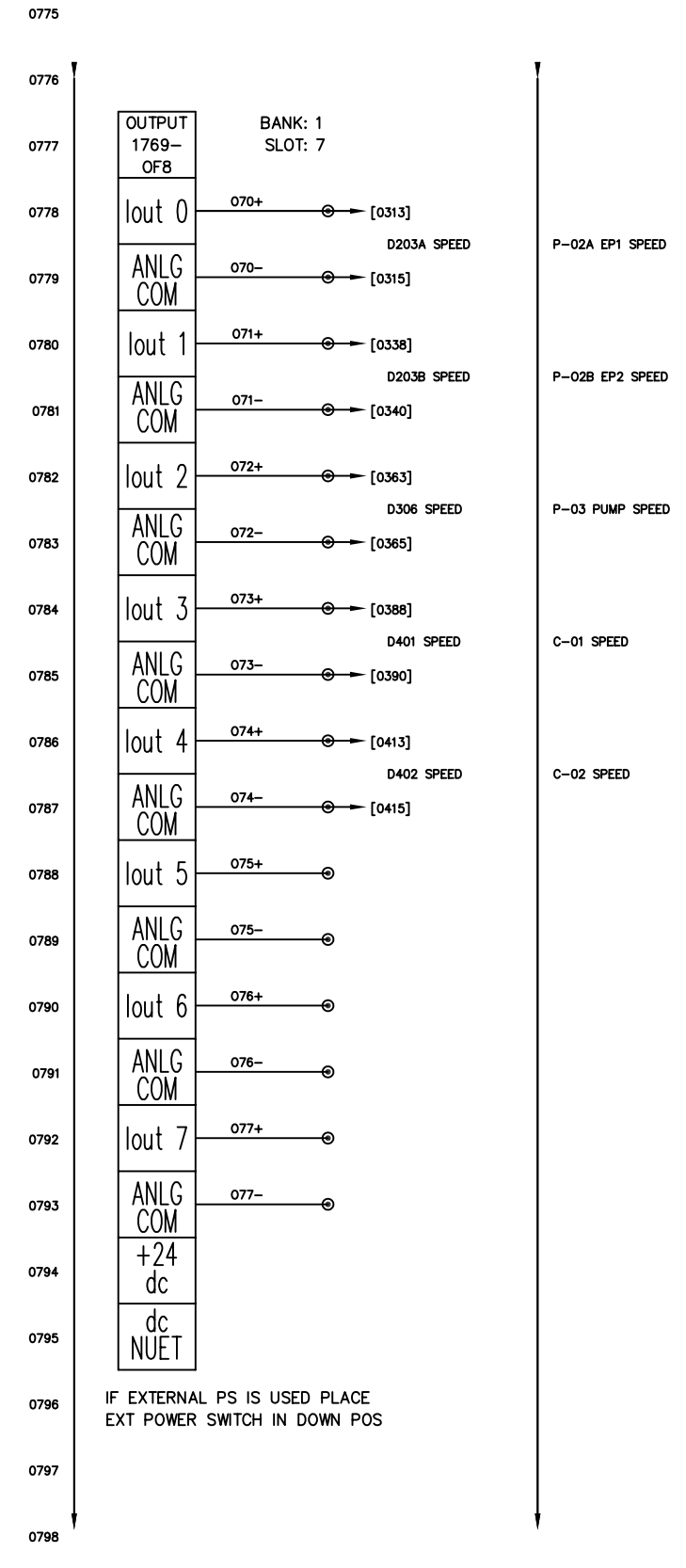
DRAWN BY: JJG	SCALE: N/A	APPROVED:	DATE:
DATE: 10/26/08	JOB#: JOB#		
SUBJECT: PLC BANK 1 & 2 SLOTS 7-9			SHEET
LOCATION: Skykomish, WA			DWG NO: DWG08









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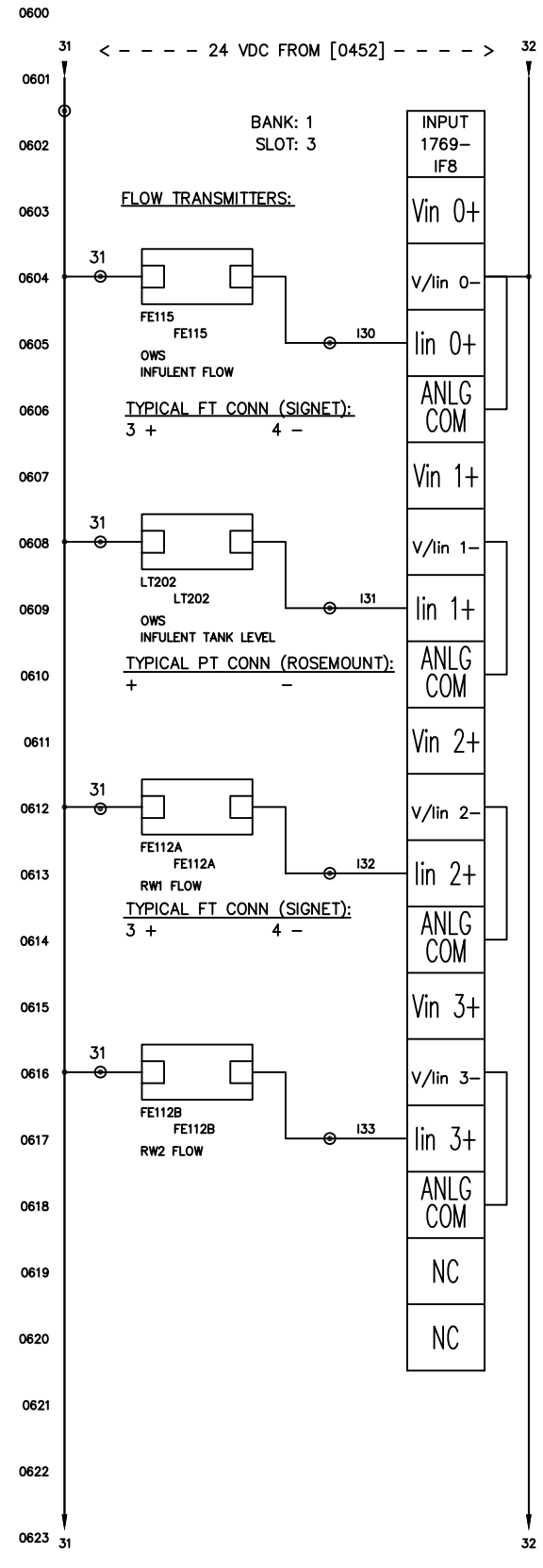
DRAWN BY: JJG | SCALE: N/A | APPROVED: | DATE:
DATE: 10/26/08 | JOB#: JOB#
SUBJECT: PLC BANK 1 SLOTS 5-7 | SHEET
LOCATION: Skykomish, WA | DWG NO: DWG07



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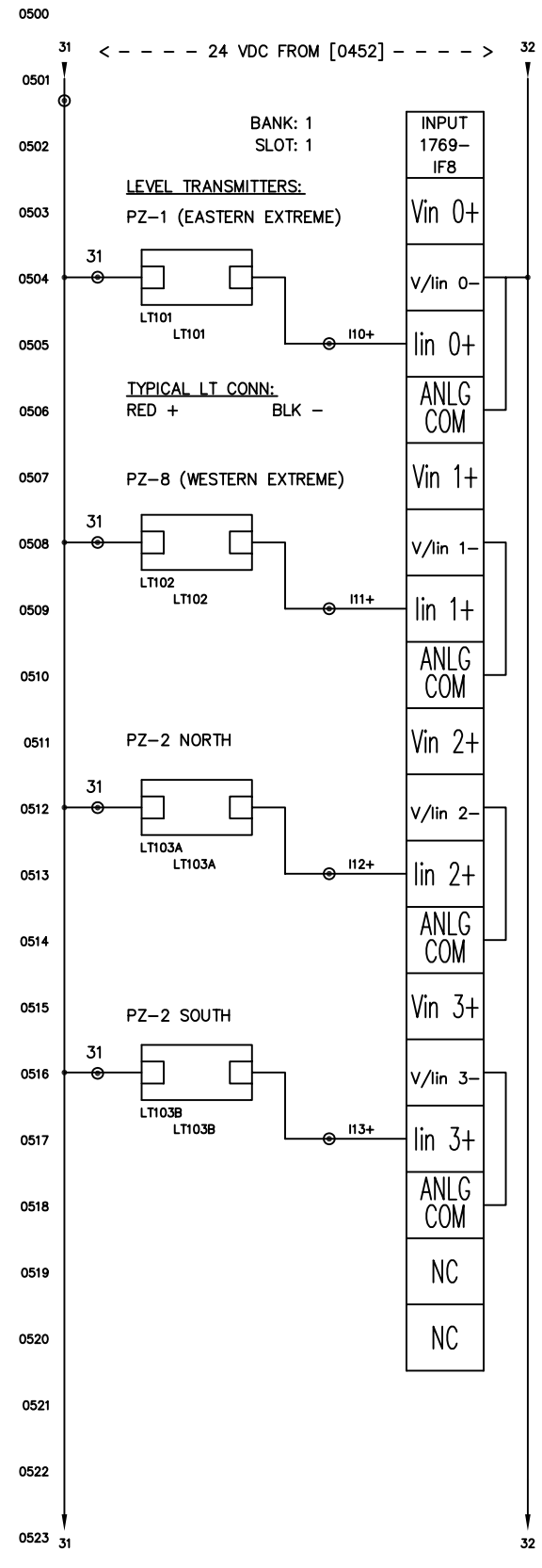
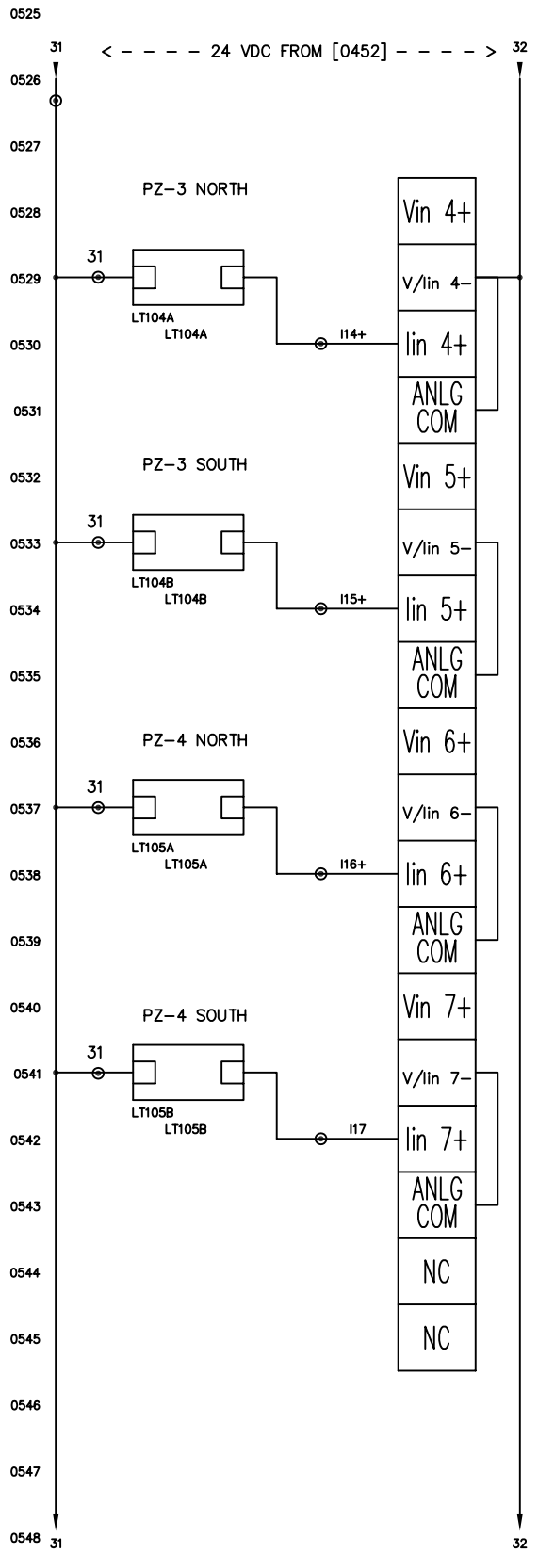
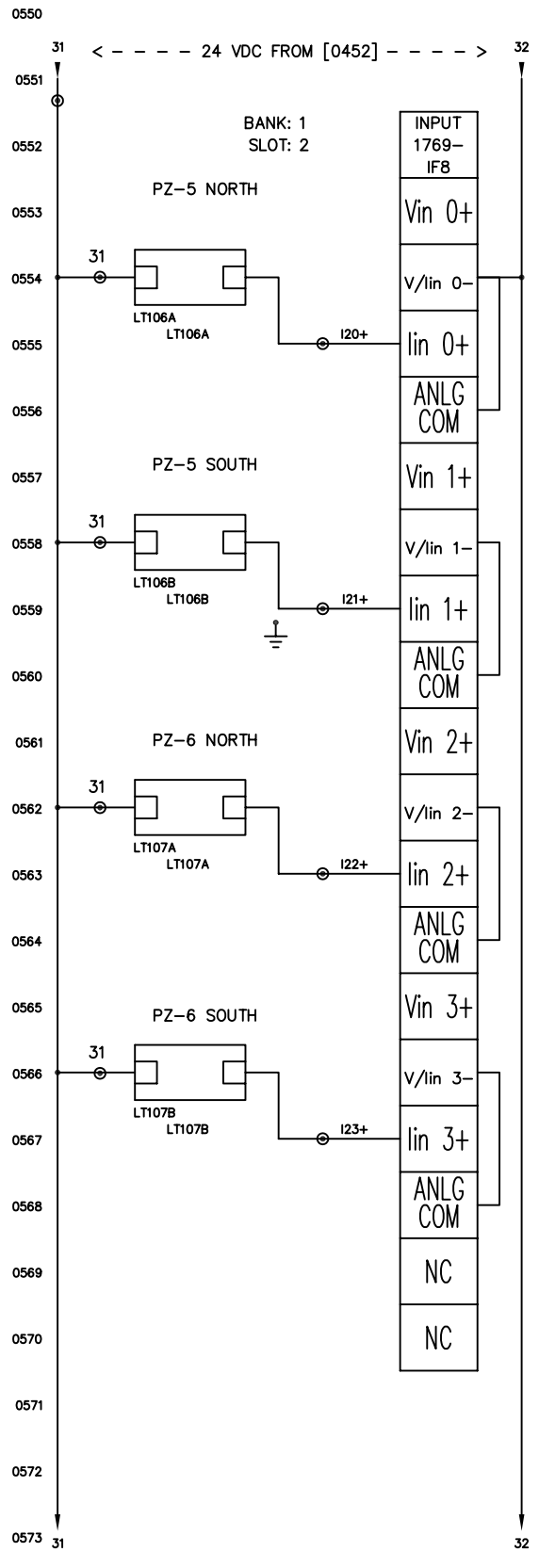
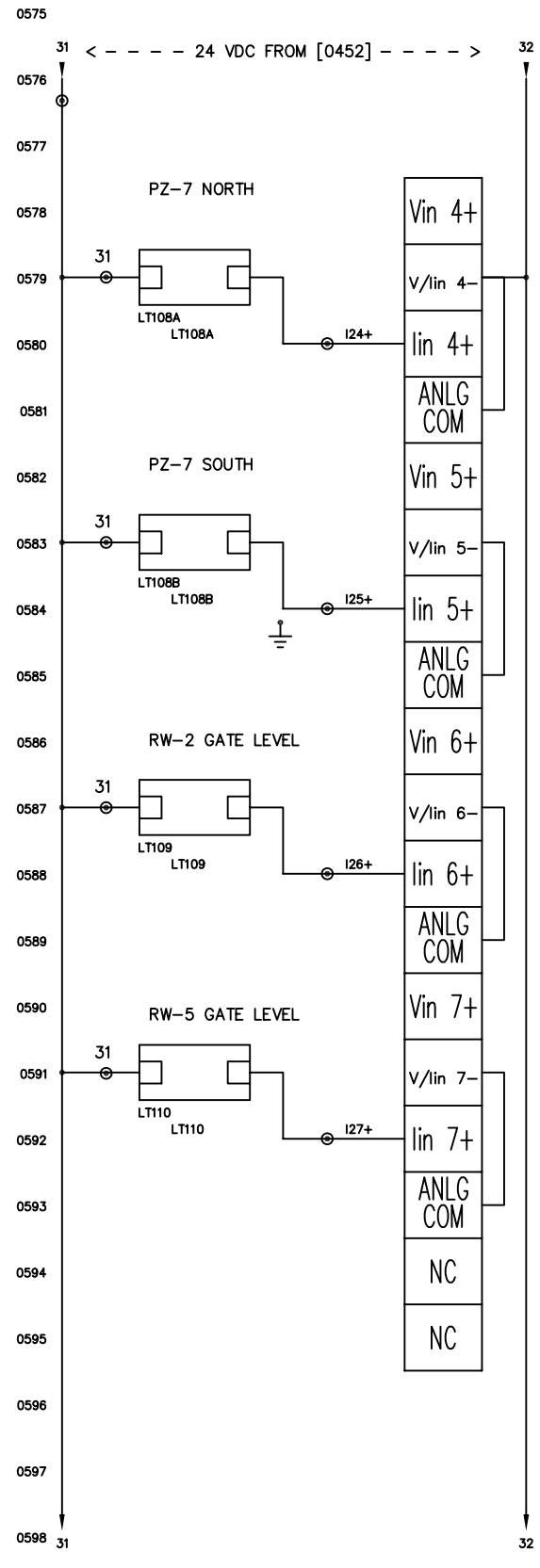
DRAWN BY: JJG | SCALE: N/A | APPROVED: | DATE:
DATE: 10/26/08 | JOB#: JOB#
SUBJECT: PLC BANK 1 SLOTS 3-4 | SHEET
LOCATION: Skykomish, WA | DWG NO: DWG06









z

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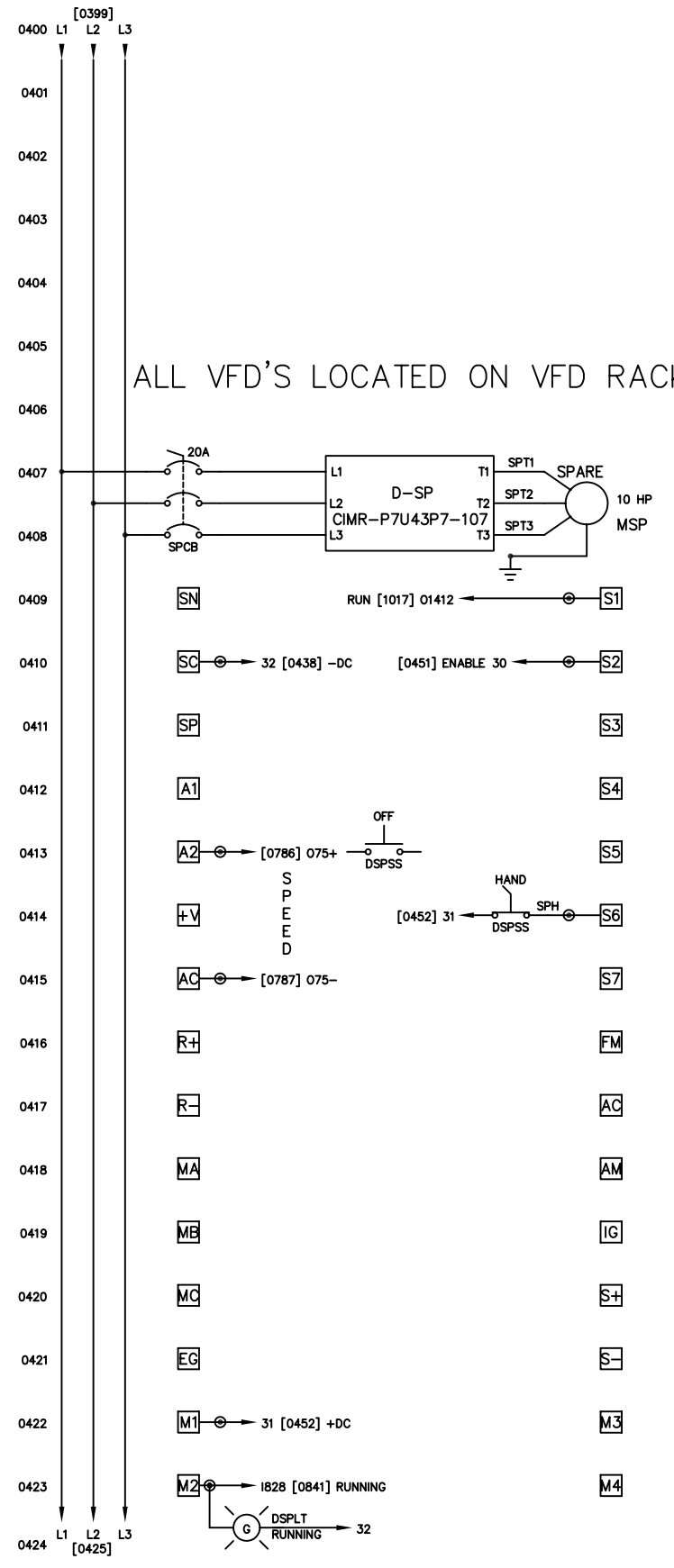
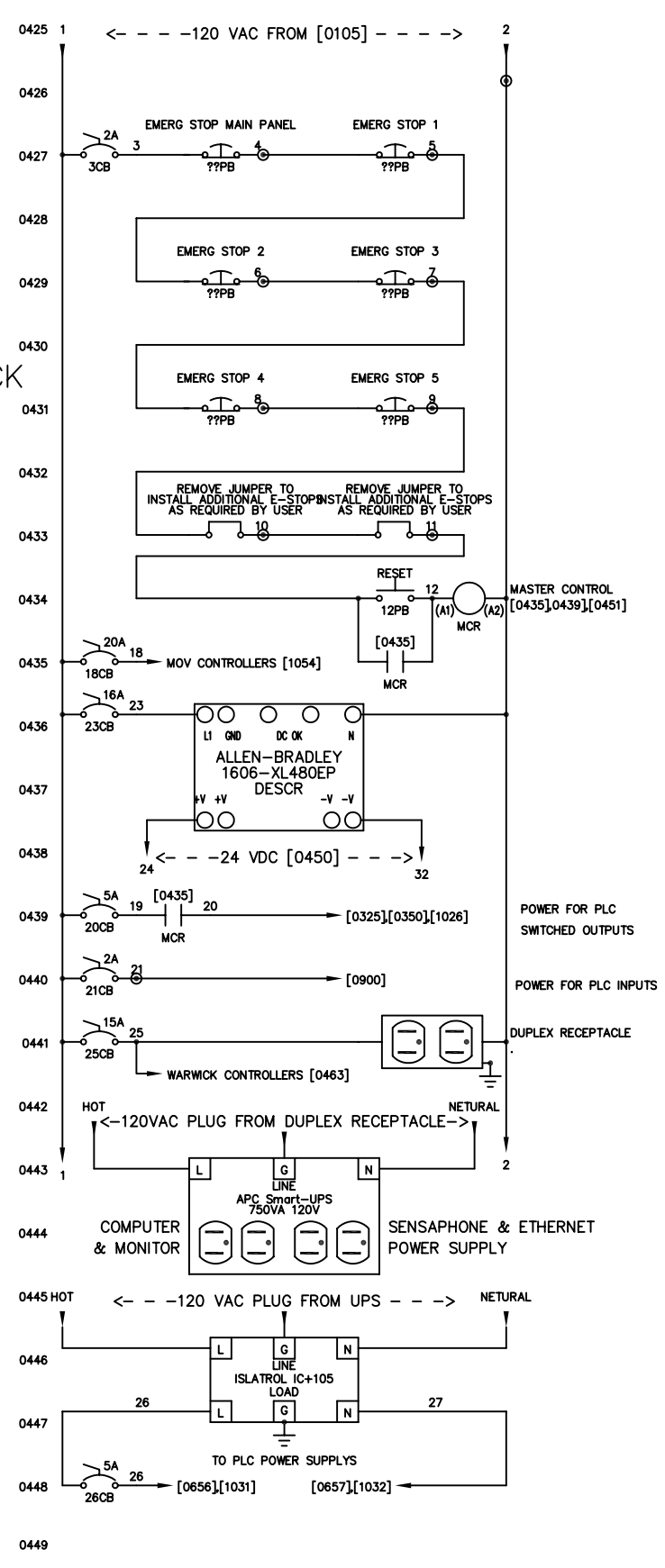
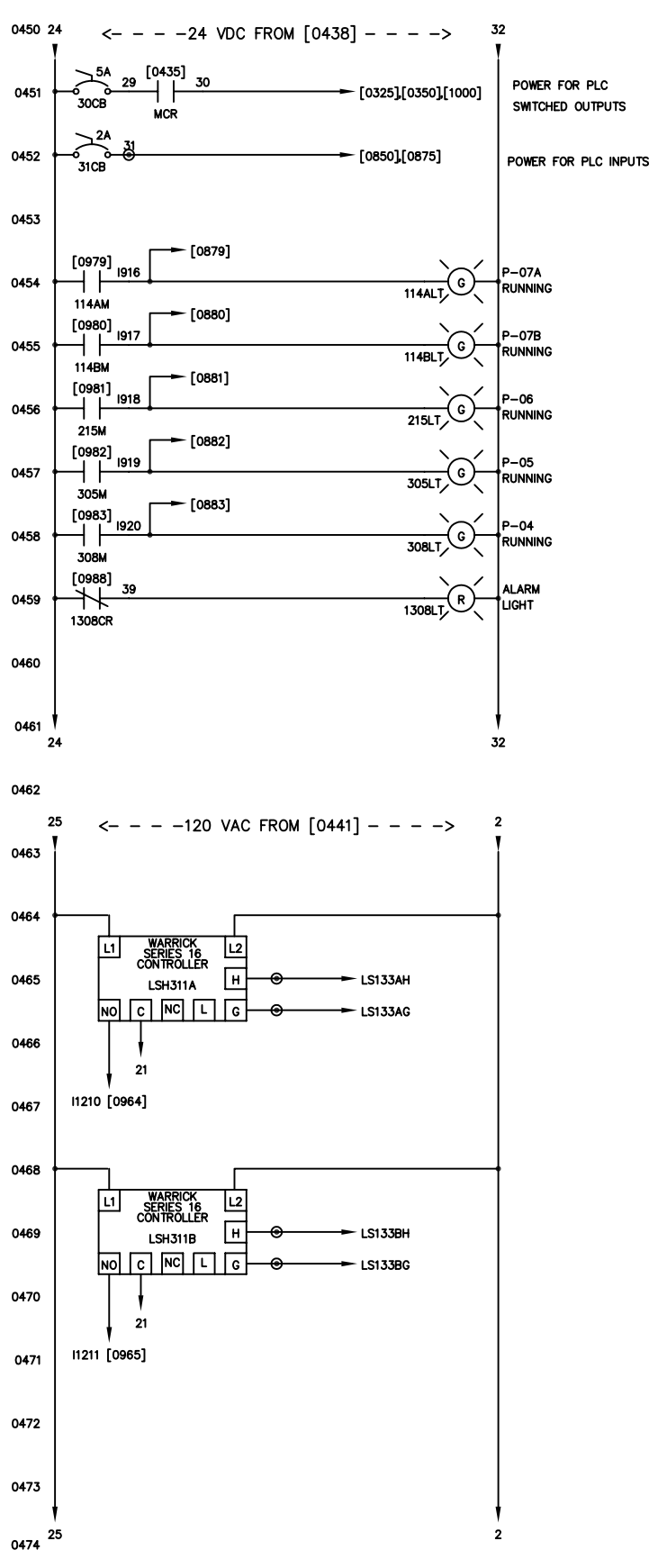
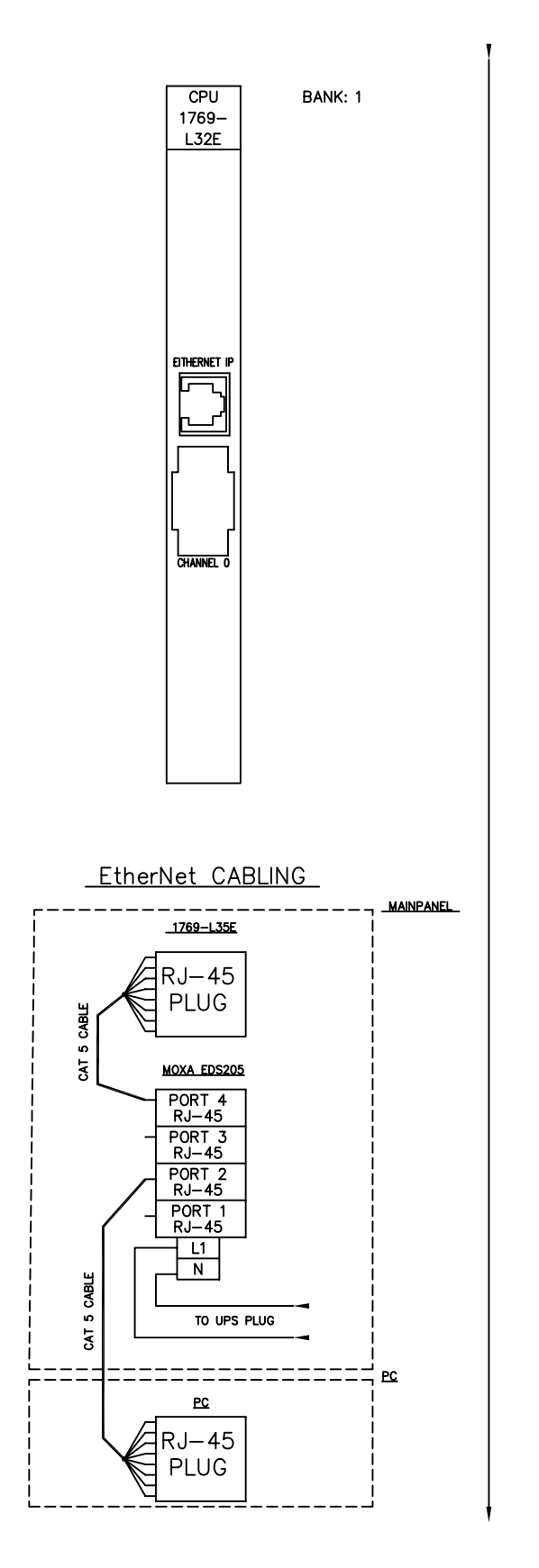
DRAWN BY: JJG | SCALE: N/A | APPROVED: | DATE:
DATE: 10/26/08 | JOB#: JOB#
SUBJECT: PLC BANK 1 SLOTS 1-2 | SHEET
LOCATION: Skykomish, WA | DWG NO: DWG05









REV	DATE	DESCRIPTION
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DRAWN BY: JJG	SCALE: N/A	APPROVED:	DATE:
DATE: 10/26/08	JOB#: JOB#		
SUBJECT: 480 & 120 VAC DISTRIBUTION 24 VDC DISTRIBUTION PLC CPU			SHEET
LOCATION: Skykomish, WA		DWG NO: DWG04	

A | B | C | D

1

2

[0104] L1 L2 L3

MCP114A — [0979] — 114AT1 / 114AT2 / 114AT3 — 114AM — 1.0–1.6 [0879]

NORTH UTILITY VAULT SUMP PUMP — 1/2 HP — D114A P-07A

MCP114B — [0980] — 114BT1 / 114BT2 / 114BT3 — 114BM — 1.0–1.6 [0880]

SOUTH UTILITY VAULT SUMP PUMP — 1/2 HP — D114B P-07B

[0350] L1 L2 L3

[0299] L1 L2 L3

40A — 203AL1 / 203AL2 / 203AL3 — 203ACB

D-203A — CIMR-P7U49P0-107 — L1 L2 L3 — T1 T2 T3 — 203AT1 / 203AT2 / 203AT3

INFLUENT EQU XFER PUMP P-02A — 15 HP — M203A

SN — RUN [1063] O1408 — S1

SC — 32 [0438] –DC — S2

SP — [0451] ENABLE 30 — S3

A1 — S4

A2 — [0828] O70+ — S5

OFF — D203ASS — HAND — [0452] 31 — 203AH — D203ASS — S6

SPEED

+V — S6

AC — [0829] O70– — S7

R+ — FM

R– — AC

MA — AM

MB — IG

MC — S+

EG — S–

M1 — 31 [0452] +DC — M3

M2 — I824 [0887] RUNNING — D203ALT RUNNING — 32 — M4

L1 L2 L3 [0325]

[0324] L1 L2 L3

ALL VFD'S LOCATED ON VFD RACK

40A — 203BL1 / 203BL2 / 203BL3 — 203BCB

D-203B — CIMR-P7U49P0-107 — L1 L2 L3 — T1 T2 T3 — 203BT1 / 203BT2 / 203BT3

INFLUENT EQU XFER PUMP P-02B — 15 HP — M203B

SN — RUN [1064] O1409 — S1

SC — 32 [0438] –DC — S2

SP — [0830] — [0451] ENABLE 30 — S3

A1 — S4

A2 — [0830] O71+ — S5

OFF — D203BSS — HAND — [0452] 31 — 203BH — D203BSS — S6

SPEED

+V — S6

AC — [0831] O71– — S7

R+ — FM

R– — AC

MA — AM

MB — IG

MC — S+

EG — S–

M1 — 31 [0452] +DC — M3

M2 — I825 [0888] RUNNING — D203BLT RUNNING — 32 — M4

L1 L2 L3 [0356]

[0305] L1 L2 L3

MCP215 — [0981] — 215T1 / 215T2 / 215T3 — D215M — 1.0–1.6 [0881]

BUILDING SUMP PUMP — 1/2 HP — D215 P-06

MCP305 — [0982] — 305T1 / 305T2 / 305T3 — D305M — 10–16 [0882]

BACKWASH PUMP — 10 HP — D305 P-05

[0375] L1 L2 L3

[0349] L1 L2 L3

20A — 306L1 / 306L2 / 306L3 — 306CB

D-306 — CIMR-P7U43P7-107 — L1 L2 L3 — T1 T2 T3 — 306T1 / 306T2 / 306T3

TREATED WATER NEPDES DISCHARGE PUMP P-03 — 5 HP — M306

SN — RUN [1065] O1410 — S1

SC — 32 [0438] –DC — S2

SP — [0451] ENABLE 30 — S3

A1 — S4

A2 — [0832] O72+ — S5

OFF — D306SS — HAND — [0452] 31 — 306H — D306SS — S6

SPEED

+V — S6

AC — [0833] O72– — S7

R+ — FM

R– — AC

MA — AM

MB — IG

MC — S+

EG — S–

M1 — 31 [0452] +DC — M3

M2 — I826 [0889] RUNNING — D306LT RUNNING — 32 — M4

L1 L2 L3 [0381]

0355 L1 L2 L3

MCP308 — [0983] — 308T1 / 308T2 / 308T3 — D308M — 1.0–1.6 [0883]

TREATED WATER INJECTION PUMP — 1/2 HP — D308 P-04

[0374] L1 L2 L3

20A — 401L1 / 401L2 / 401L3 — 401CB

D-401 — CIMR-P7U43P7-107 — L1 L2 L3 — T1 T2 T3 — 401T1 / 401T2 / 401T3

SPARGE AIR COMPRESSOR C-01 — 5 HP — M401

SN — RUN [1066] O1411 — S1

SC — 32 [0438] –DC — S2

SP — [0451] ENABLE 30 — S3

A1 — S4

A2 — [0834] O74+ — S5

OFF — D401SS — HAND — [0452] 31 — 401H — D401SS — S6

SPEED

+V — S6

AC — [0835] O74– — S7

R+ — FM

R– — AC

MA — AM

MB — IG

MC — S+

EG — S–

M1 — 31 [0452] +DC — M3

M2 — I827 [0890] RUNNING — D401LT RUNNING — 32 — M4

L1 L2 L3 [0400]

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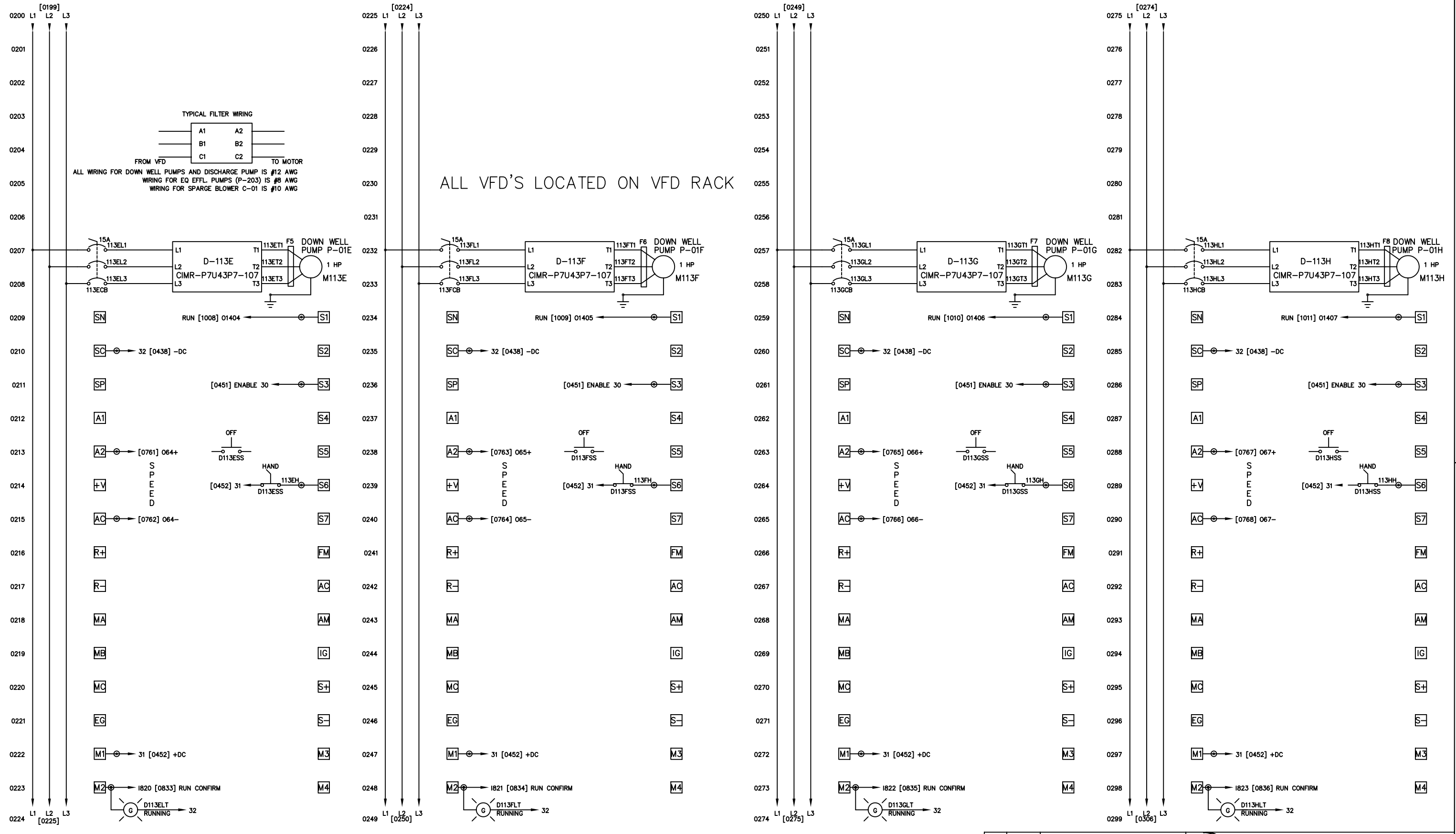
DRAWN BY: JJG | SCALE: N/A | APPROVED: | DATE:

DATE: 10/26/08 | JOB#: JOB#

SUBJECT: 480 VAC DISTRIBUTION | SHEET

LOCATION: Skykomish, WA | DWG NO: DWG03



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REV	DATE	DESCRIPTION
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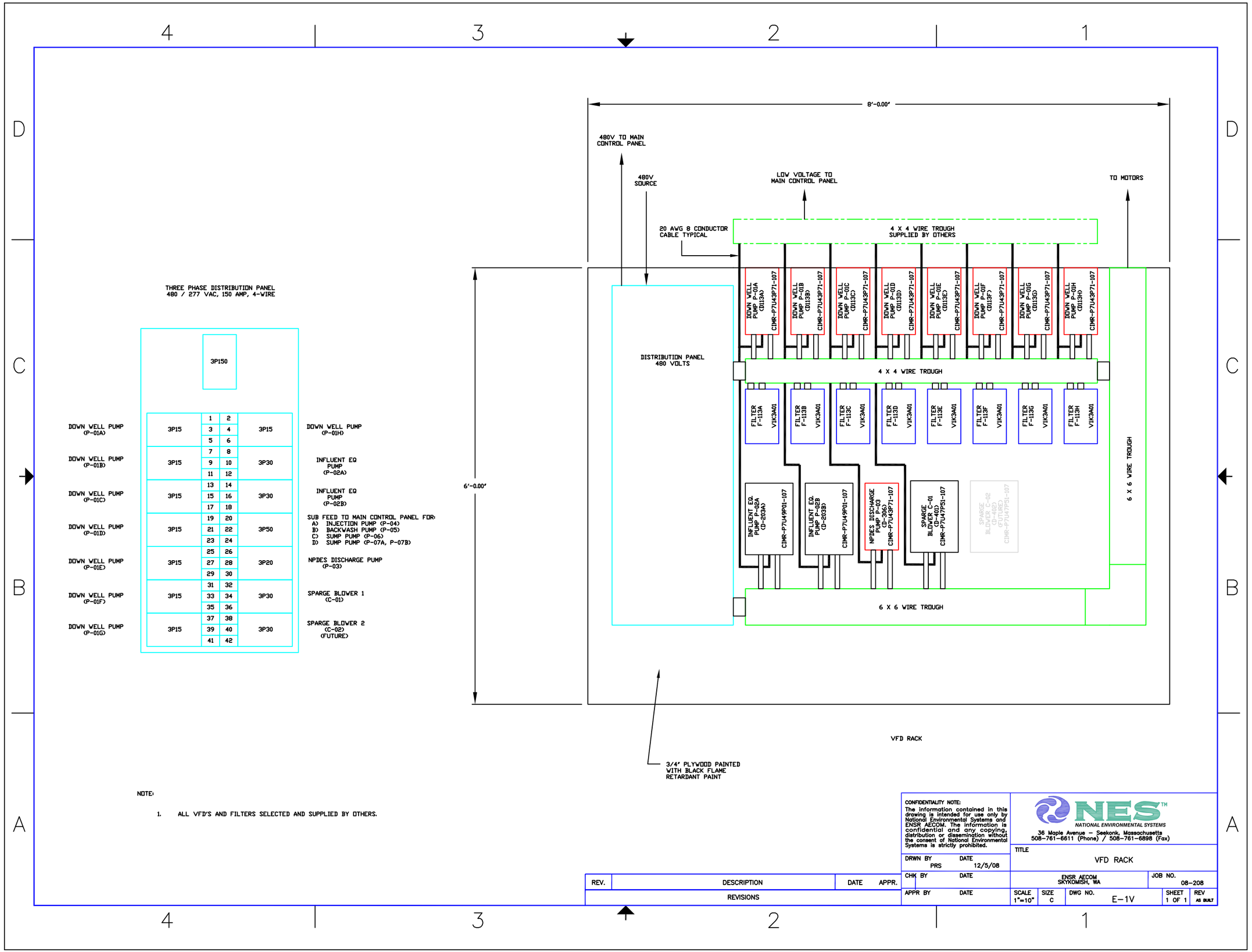
DRAWN BY: JJG | SCALE: N/A | APPROVED: | DATE:
DATE: 10/26/08 | JOB#: JOB#
SUBJECT: 480 VAC DISTRIBUTION | SHEET
LOCATION: Skykomish, WA | DWG NO: DWG02



THREE PHASE DISTRIBUTION PANEL
480 / 277 VAC, 150 AMP, 4-WIRE

3P150

DOWN WELL PUMP (P-01A)	3P15	1 2 / 3 4 / 5 6	3P15	DOWN WELL PUMP (P-01H)
DOWN WELL PUMP (P-01B)	3P15	7 8 / 9 10 / 11 12	3P30	INFLUENT EQ PUMP (P-02A)
DOWN WELL PUMP (P-01C)	3P15	13 14 / 15 16 / 17 18	3P30	INFLUENT EQ PUMP (P-02B)
DOWN WELL PUMP (P-01D)	3P15	19 20 / 21 22 / 23 24	3P50	SUB FEED TO MAIN CONTROL PANEL FOR: A) INJECTION PUMP (P-04) B) BACKWASH PUMP (P-05) C) SUMP PUMP (P-06) D) SUMP PUMP (P-07A, P-07B)
DOWN WELL PUMP (P-01E)	3P15	25 26 / 27 28 / 29 30	3P20	NPDES DISCHARGE PUMP (P-03)
DOWN WELL PUMP (P-01F)	3P15	31 32 / 33 34 / 35 36	3P30	SPARGE BLOWER 1 (C-01)
DOWN WELL PUMP (P-01G)	3P15	37 38 / 39 40 / 41 42	3P30	SPARGE BLOWER 2 (C-02) (FUTURE)

NOTE:

1. ALL VFD'S AND FILTERS SELECTED AND SUPPLIED BY OTHERS.

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REV.	DESCRIPTION	DATE	APPR.
	REVISIONS		

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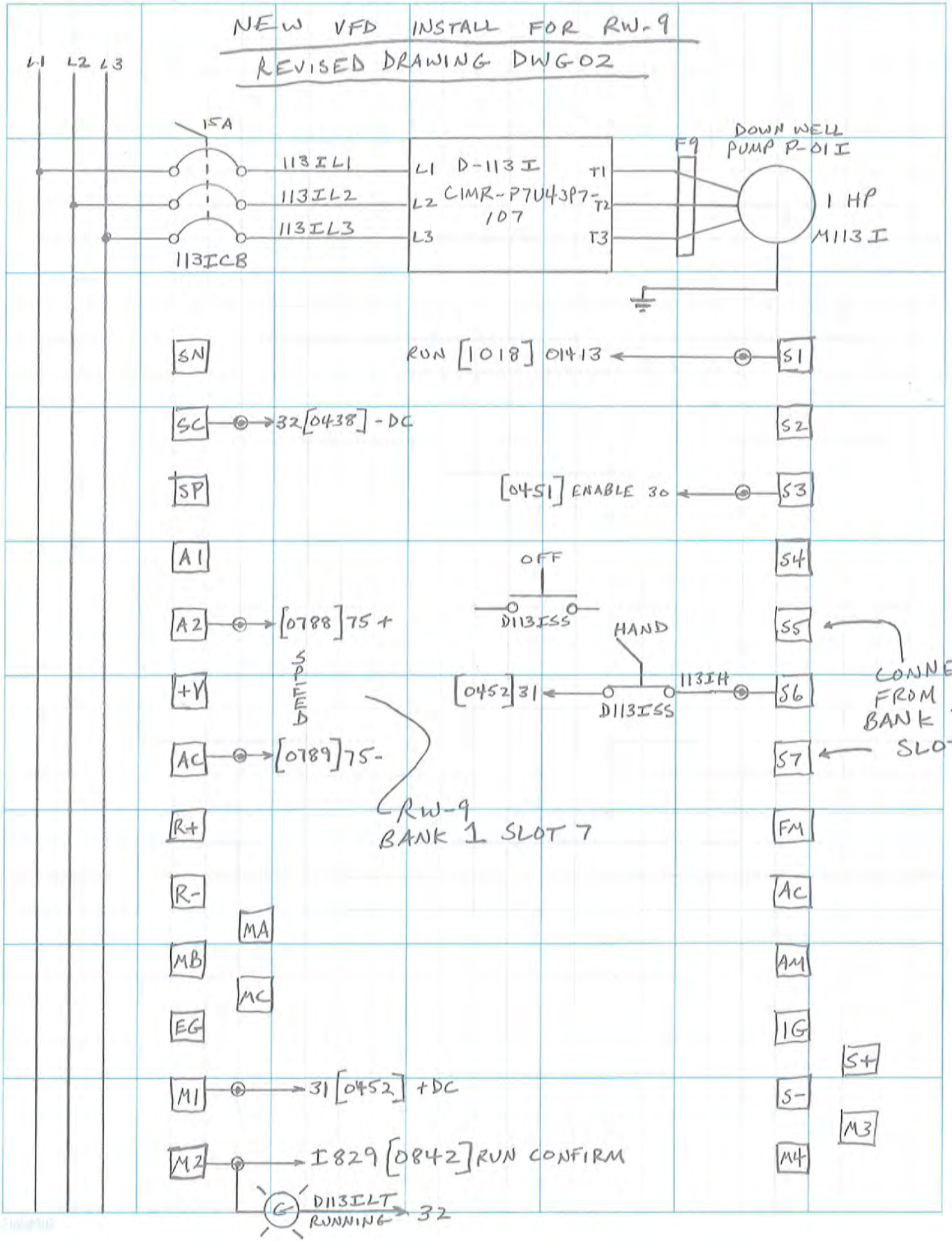
DRWN BY	PRS
DATE	12/5/08
CHK BY	
DATE	
APPR BY	
DATE	
TITLE	VFD RACK
ENSR AECOM SKYKOMISH, WA	JOB NO. 08-208
SCALE 1"=10"	SIZE C
DWG NO.	E-1V
SHEET	1 OF 1
REV	AS BUILT

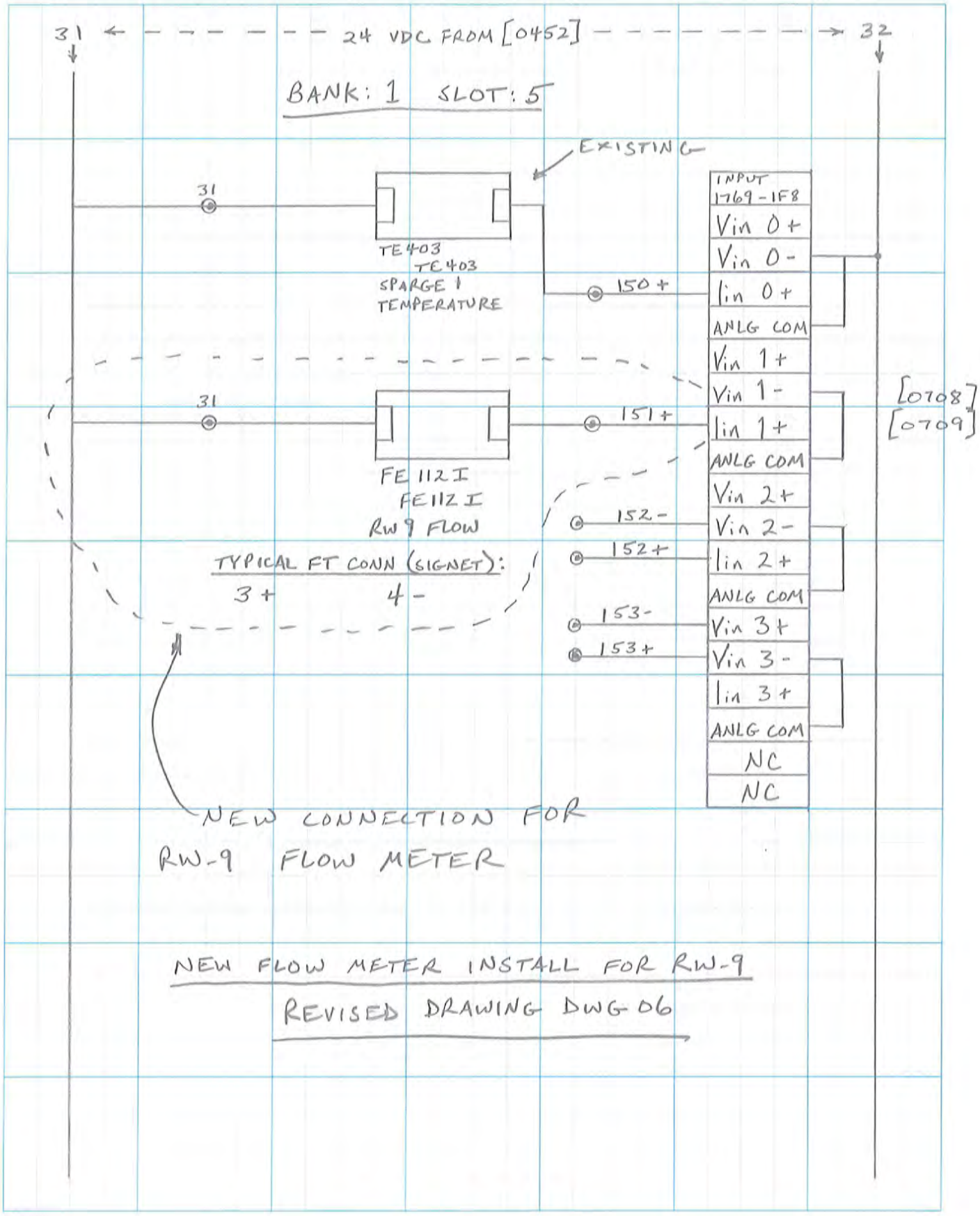
Project #		Page	1 of 6
Client	BNSF	Date	9/29/2010
Site	SKYKOMISH	By	PVB
Subject	RW-9 WIRING	App.	

ENSR | AECOM



Project # _____ Page 2 of 6
Client BNSF Date 9/30/2010
Site SKYKOMISH By PVB
Subject RW-9 WIRING App. _____

ENSR | AECOM



ENSR | AECOM

31 ↓ 32 ↓

BANK: 1, SLOT: 7

OUTPUT 1769-OF8			
Iout 0	[0313]	D203A SPEED	P-02A EP1 SPEED
ANLG COM	[0315]		
Iout 1	[0338]	D203B SPEED	P-02B EP2 SPEED
ANLG COM	[0340]		
Iout 2	[0363]	D306 SPEED	P-03 PUMP SPEED
ANLG COM	[0365]		
Iout 3	[0388]	D401 SPEED	C-01 SPEED
ANLG COM	[0390]		
Iout 4	[0413]	D402 SPEED	C-02 SPEED
ANLG COM	[0415]		
Iout 5	[55]	D113I SPEED	P-01I SPEED
ANLG COM	[57]		
Iout 6			
ANLG COM			
Iout 7			
ANLG COM			
+24 dc			
dc NUET			

[0788]
[0789]

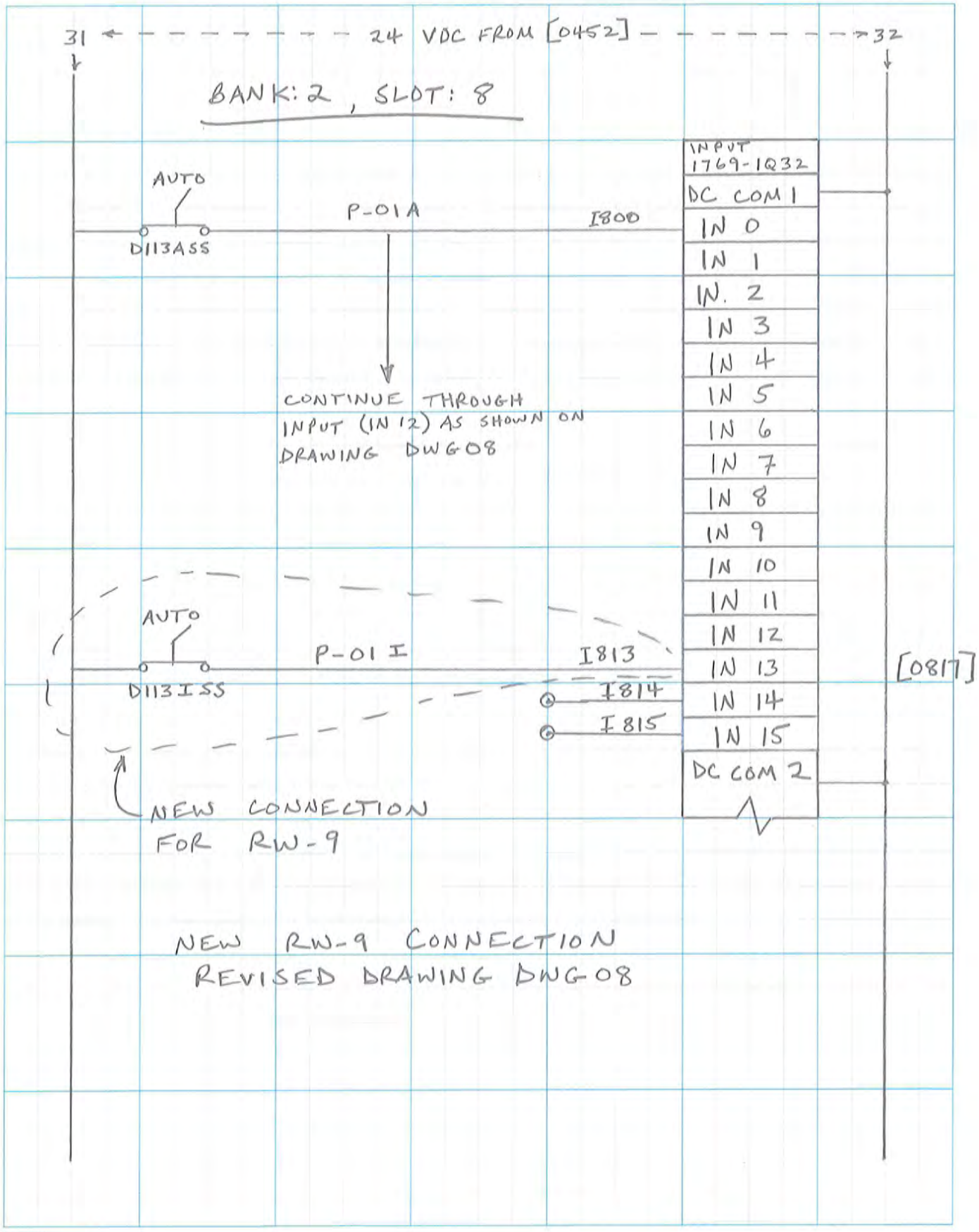
↳ CONNECT ON VFD FOR RW-9

NEW CONNECTION FOR RW-9 VFD SPEED

IF EXTERNAL PS IS USED PLACE EXT POWER SWITCH IN DOWN POS

NEW SPEED CONTROL OUTPUT FOR RW-9
REVISED DRAWING DWG 07

ENSR | AECOM


31
24 VDC FROM [0452]
32
BANK: 2 , SLOT: 8
INPUT 1769-IQ32
DC COM 1
IN 0
IN 1
IN 2
IN 3
IN 4
IN 5
IN 6
IN 7
IN 8
IN 9
IN 10
IN 11
IN 12
IN 13
IN 14
IN 15
DC COM 2
AUTO
P-01A
I800
D113ASS
CONTINUE THROUGH INPUT (IN 12) AS SHOWN ON DRAWING DWG08
AUTO
P-01 I
I813
I814
I815
D113ISS
[0817]
NEW CONNECTION FOR RW-9
NEW RW-9 CONNECTION
REVISED DRAWING DWG08

ENSR | AECOM

31 ← 24 VDC FROM [0452] → 32

BANK: 2, SLOT: 8 (CONTINUED)

			DC COM 3
P-01A [0123]	D113A RUNNING	I 816	IN 16
P-01B [0148]	D113B RUNNING	I 817	IN 17
P-01C [0173]	D113C RUNNING	I 818	IN 18
P-01D [0198]	D113D RUNNING	I 819	IN 19
P-01E [0223]	D113E RUNNING	I 820	IN 20
P-01F [0248]	D113F RUNNING	I 821	IN 21
P-01G [0273]	D113G RUNNING	I 822	IN 22
P-10H [0298]	D113H RUNNING	I 823	IN 23
P-02A [0323]	D203A RUNNING	I 824	IN 24
P-02B [0348]	D203B RUNNING	I 825	IN 25
P-03 [0373]	D306 RUNNING	I 826	IN 26
C-01 [0398]	D401 RUNNING	I 827	IN 27
C-02 [0423]	DSP RUNNING	I 828	IN 28
P-01I [ ]	D113I RUNNING	I 829	IN 29
		I 830	IN 30
		I 831	IN 31
			DC COM 4

[0842]

FROM PAGE 1 OF REVISION DRAWINGS
M2 ON VFD

NEW CONNECTION FOR RW-9
REVISED DRAWING DWG 08

ENSR | AECOM

30 ← — — — — — — — — 24 VDC FROM [0451] — — — — — — — → 32

BANK: 2, SLOT 14

OUTPUT 1769-OW16		
VDC 1		
OUT 0	01400	→ P-01A [0109] D113A RUN
OUT 1	01401	→ P-01B [0134] D113B RUN
OUT 2	01402	→ P-01C [0159] D113C RUN
OUT 3	01403	→ P-01D [0184] D113D RUN
OUT 4	01404	→ P-01E [0209] D113E RUN
OUT 5	01405	→ P-01F [0234] D113F RUN
OUT 6	01406	→ P-01G [0259] D113G RUN
OUT 7	01407	→ P-01H [0284] D113H RUN
VDC 2		
OUT 8	01408	→ P-02A [0309] D203A RUN
OUT 9	01409	→ P-02B [0334] D203B RUN
OUT 10	01410	→ P-03 [0359] D306 RUN
OUT 11	01411	→ C-01 [0384] D401 RUN
OUT 12	01412	→ C-02 [0409] DSP RUN
OUT 13	01413	→ P-01I [ ] D113I RUN
OUT 14	01414	
OUT 15	01415	

[1018]

NEW CONNECTION FOR RW-9

FROM PAGE 1 OF REVISION DRAWINGS

51 ON VFD

NEW CONNECTION FOR RW-9
REVISED DRAWING DWG 10

Appendix H

Electric Motor Load Table

FULL LOAD CALCULATION & BALANCED LOAD CONFIGURATION

Date:	September 8, 2008
Calculation Done By:	David Macone, P.E.
ENSR Project Number:	01140-222-0210
Site Address:	BNSF Railroad
	Former Fuel/Maintenance
	Skykomish, Washington

SERVICE REQUIRED:

Service Type:	4 wire wye
Amps:	225
volt	277/480
Phase	3

Service Requirement Calculations:

NEC Article 220.18A - Motor-Operated and Combination Loads - Where a circuit supplies only motor-operated loads, Article 430 shall apply. Where a circuit supplies only air-conditioning equipment, refrigerating equipment, or both, Article 440 Shall apply. For circuits supplying loads consisting of motor-operated utilization equipment that is fastened in place and has a motor larger than 1/8 hp in combination with other loads, the total calculated load shall be based on 125 percent of the largest motor load plus the sum of the other loads.

SERVICE REQUIREMENTS

SYSTEM POWER REQUIREMENTS TO SIZE ELECTRICAL SERVICE						Power	BALANCED LOAD			NOTES
ITEM	DEVICE	HP	PHASE	VOLTS	FLA	KW	A	B	C	
1*	**Air Sparge Compressor (C-01)**	**10**	**3**	**480**	**34.8**	**36.1**	34.8	34.8	34.8	**VFD**
2	Air Sparge Compressor (C-02 Spare)	10	3	480	27.8	23.1	27.8	27.8	27.8	VFD
3	Down Well Pump (P-01-1)	1	3	480	2.4	2.0	2.4	2.4	2.4	VFD
4	Down Well Pump (P-01-2)	1	3	480	2.4	2.0	2.4	2.4	2.4	VFD
5	Down Well Pump (P-01-3)	1	3	480	2.4	2.0	2.4	2.4	2.4	VFD
6	Down Well Pump (P-01-4)	1	3	480	2.4	2.0	2.4	2.4	2.4	VFD
7	Down Well Pump (P-01-5)	1	3	480	2.4	2.0	2.4	2.4	2.4	VFD
8	Down Well Pump (P-01-6)	1	3	480	2.4	2.0	2.4	2.4	2.4	VFD
9	Down Well Pump (P-01-7)	1	3	480	2.4	2.0	2.4	2.4	2.4	VFD
10	Down Well Pump (P-01-8)	1	3	480	2.4	2.0	2.4	2.4	2.4	VFD
11	Inf. EQ. Tank Transfer Pump (P-02A)	***15***	***3***	***480***	***21***	***17.5***	***17.5***	***17.5***	***17.5***	VFD
12	Inf. EQ. Tank Transfer Pump (P-02B)	***15***	***3***	***480***	***21***	***17.5***	***17.5***	***17.5***	***17.5***	VFD
13	Storm Water Discharge Pump (P-03)	5	3	480	7.6	6.3	7.6	7.6	7.6	VFD
14	Injection Water Pump (P-04)	1/2	3	480	1	0.8	1	1	1	VFD
15	Backwash Pump (P-05)	***10***	***3***	***480***	***14***	***11.6***	***14***	***14***	***14***	operated as needed
16	Building Transformer	---	3	480	65.0	54.0	65	65	65	208/120 V
17	Skimmer Transformers (1 of 8)	---	1	480	2	0.96	2	---	---	
18	Skimmer Transformers (2 of 8)	---	1	480	2	0.96	---	2	---	
19	Skimmer Transformers (3 of 8)	---	1	480	2	0.96	---	---	2	
20	Skimmer Transformers (4 of 8)	---	1	480	2	0.96	2	---	---	
21	Skimmer Transformers (5 of 8)	---	1	480	2	0.96	---	2	---	
22	Skimmer Transformers (6 of 8)	---	1	480	2	0.96	---	---	2	For future expansion
23	Skimmer Transformers (7 of 8)	---	1	480	2	0.96	2	---	---	For future expansion
24	Skimmer Transformers (8 of 8)	---	1	480	2	0.96	---	2	---	For future expansion
					Totals:	**190.6**	**210.4**	**210.4**	**208.4**	

* Largest motor

BUILDING TRANSFORMER LOAD REQUIREMENT:

SYSTEM POWER REQUIREMENTS TO SIZE ELECTRICAL SERVICE						Power	BALANCED LOAD			NOTES
ITEM	DEVICE	HP	PHASE	VOLTS	FLA	KW	A	B	C	
1*	**Building Sump Pump (P-06)**	**1/2**	**1**	**120**	**6.0**	**0.9**	**6.0**	**---**	**---**	**operated as needed**
2	GFI's (4 circuits, each with 2 receptacles) - RW's	NA	1	120	30.0	3.6	---	15	15	
3	N. Utility Vault Sump Pumps (P-07-1)	1/2	1	120	4.8	0.6	---	4.8	---	operated as needed
4	S. Utility Vault Sump Pumps (P-07-2)	1/2	1	120	4.8	0.6	---	---	4.8	operated as needed
5	Control Panel	NA	1	120	5.0	0.6	---	---	5	
6	Lights (3 circuits for 12 200W fixtures)	NA	1	120	7.0	0.8	7	---	---	
7	Lights (3 circuits for 12 200W fixtures)	NA	1	120	7.0	0.8	---	7	---	
8	Lights (3 circuits for 12 200W fixtures)	NA	1	120	7.0	0.8	---	---	7	
9	Exhaust Fans 1/4 Hp	1/4	1	120	6.0	0.7	---	---	6	
10	Exhaust Fans 1/4 Hp	1/4	1	120	6.0	0.7	---	6	---	
11	Exhaust Fans 1/4 Hp	1/4	1	120	6.0	0.7	---	---	6	
12	Exhaust Fans 1/4 Hp	1/4	1	120	6.0	0.7	---	6	---	
13	Exhaust Fans 1/4 Hp	1/4	1	120	6.0	0.7	---	---	6	
14	Heater 5KW	NA	1	208	24.0	5.0	24	24	---	
15	Heater 5KW	NA	1	208	24.0	5.0	---	24	24	
16	Heater 5KW	NA	1	208	24.0	5.0	24	---	24	
17	Heater 5KW	NA	1	208	24.0	5.0	24	24	---	
18	Heater 1.5KW	NA	1	208	7.2	1.5	7.2	---	7.2	
19	GFI's (3 circuits, each with 3 receptacles)	NA	1	120	45.0	5.4	15	15	15	
20	Heat Trace (5 W per LFT - 15 LFT per well - 1)	NA	1	120	0.63	0.1	0.6	---	---	For future expansion
21	Heat Trace (5 W per LFT - 15 LFT per well - 1)	NA	1	120	0.63	0.1	0.6	---	---	For future expansion
22	Heat Trace (5 W per LFT - 15 LFT per well - 1)	NA	1	120	0.63	0.1	---	---	0.6	For future expansion
23	Heat Trace (5 W per LFT - 15 LFT per well - 1)	NA	1	120	0.63	0.1	---	---	0.6	For future expansion
24	Heat Trace (5 W per LFT - 15 LFT per well - 1)	NA	1	120	0.63	0.1	---	---	0.6	For future expansion
25	Heat Trace (5 W per LFT - 15 LFT per well - 1)	NA	1	120	0.63	0.1	0.6	---	---	For future expansion
26	Heat Trace (5 W per LFT - 15 LFT per well - 1)	NA	1	120	0.63	0.1	0.6	---	---	For future expansion
27	Heat Trace (5 W per LFT - 15 LFT per well - 1)	NA	1	120	0.63	0.1	0.6	---	---	For future expansion
					Totals:	**32.8**	**97.2**	**106**	**97**	

Three Phase Transformer:

Calculated Minimum Requirement for Secondary Side of Transformer:

106 Amps (based on highest leg)
208 V
38.2 KW

Calculated Minimum Requirement for Primary Side of Each Transformer:

45.9 Amps
480.0 V
38.2 KW

Therefore, for future expansion:

Transformer:

480/120-208 V Three Phase Transformer
75 KW
65 amps

Secondary Side of Transformer:

150 Amps
208 V
54.0 KW

Primary Side of Each Transformer:

65.0 Amps
480.0 V
54.0 KW

SKIMMER TRANSFORMER LOAD REQUIREMENT:

SYSTEM POWER REQUIREMENTS TO SIZE ELECTRICAL SERVICE						Power	BALANCED LOAD			NOTES
ITEM	DEVICE	HP	PHASE	VOLTS	FLA	KW	A	B	C	
1	Skimmers (T-01- 1of 8)	NA	1	120	8	1.2	8	---		3 for future expansion
					Totals:	1.2	8	0	0	

Signal Phase Transformer: Typical of all 8 Skimmers (3 for future expansion)

Secondary Side of Transformer:

8 Amps
120 V
0.96 KW

Primary Side of Each Transformer:

2 Amps
480.0 V
0.96 KW

Governing Equations:

Signal Phase Power Equation:

$Power_{Singal\ Phase}\ (KW) = E_{volts} \times I_{amps} / 1000$

Three Phase Power Equation:

$Power_{Three\ Phase}\ (KW) =$ Volts x Load Amperes x $3^{\wedge 1/2}$ / 1000

Load information that has been updated from the May 19, 2008 Full Load Cal..

Appendix I

Electrical Permit

PUGET SOUND ENERGY
The Energy To Do Great Things

APPLICATION FOR ELECTRIC SERVICE

NON-RESIDENTIAL PROJECT

OFFICE USE ONLY
NOTIFICATION NO.

NEW SERVICE ADDRESS		CITY	STATE	ZIP CODE
418 East Old Cascade Highway		Skykomish	WA	98288
PARCEL NO.	PROJECT NAME			
2626119017	Skykomish Remediation Building			
OWNER NAME			SOCIAL SECURITY/TAX ID NO.	
Burlington Northern Santa Fe				
ADDRESS		CITY	STATE	ZIP CODE
2425 Occidental Ave. South	Suite 1A	Seattle	WA	98134
CONTACT	PHONE	CELL PHONE	EMAIL ADDRESS	
Bruce Sheppard	206-625-6035			
CONTRACTOR/DEVELOPER			SOCIAL SECURITY/TAX ID NO.	
The ENSR Corporation			06-0852759	
ADDRESS		CITY	STATE	ZIP CODE
1011 SW Klickitat Way, Suite 207		Seattle	WA	98134
CONTACT	PHONE	CELL PHONE	EMAIL ADDRESS	
Paul Bianco	206-624-9349		pbianco@ensr.aecom.com	
ELECTRICAL CONTRACTOR			SOCIAL SECURITY/TAX ID NO.	
McCandlish Electric				
ADDRESS		CITY	STATE	ZIP CODE
3014 G.S. Center Road, Suite D		Wenatchee	WA	98801
CONTACT	PHONE	CELL PHONE	EMAIL ADDRESS	
Greg Twombly	(509) 662-3508	(509) 421-2658	gt49@nwi.net	
ARCHITECT				
CONTACT	PHONE	CELL PHONE	EMAIL ADDRESS	
ONSITE COORDINATOR		EMAIL ADDRESS	PHONE	
Greg Chase		gchase@ensr.aecom.com	206 4620373	

BILLING INFORMATION

TEMPORARY POWER

The party responsible for payment of utility construction costs for temporary service

NAME	ADDRESS	ZIP CODE

The party responsible for payment of energy usage for temporary service

NAME	ADDRESS	ZIP CODE

PERMANENT POWER

The party responsible for payment of utility construction costs for permanent service

NAME	ADDRESS	ZIP CODE
Bruce Sheppard	BNSF Railway Company 2454 Occidental Ave., S, Suite 1ASeattle, WA	98134

The party responsible for payment of energy usage for permanent service

NAME	ADDRESS	ZIP CODE
Bruce Sheppard	BNSF Railway Company 2454 Occidental Ave., S, Suite 1ASeattle, WA	98134

SERVICE ADDRESS	OWNER
418 East Old Cascade Highway	BNSF

TYPE OF SERVICE DESIRED

☐ Temporary Overhead ☒ Permanent Overhead

☐ Temporary Underground ☐ Permanent Underground

EXISTING DISTRIBUTION TYPE	BUILDING TYPE & USE	TOTAL SQUARE FOOTAGE
☒ Overhead ☐ Underground	Mechanical Building	1500

SECONDARY VOLTAGE REQUIRED	NUMBER WIRES PER RUN
☐ 120 / 240 ☐ 120 / 208 ☒ 277 / 480	4

PHASE REQUIRED	UNDERGROUND SECONDARY CONDUCTOR SIZE	NEUTRAL SIZE	NO. OF RUNS
☒ Single Phase ☒ Three Phase			1

GENERATORS

Are you installing back-up or emergency generation?

☒ YES ☐ NO

Generator output (KW, MW)

Will this generator operate full time?

☐ YES ☒ NO

Will this generator operate in parallel with PSE's distribution system?

☐ YES ☐ NO

MOVING EXISTING FACILITIES

Will existing power facilities require relocation? (Mark on site plan)

☐ YES ☒ NO

DESCRIBE

	ELECTRICAL LOAD IN kW		PANEL SIZES (AMPS) AND NO. OF METERS PER PANEL	
	1 PHASE	3 PHASE	PANEL SIZES	NO. METERS
Lighting	2.4			
Heating	21.5			
Cooling	3.5			
Refrigeration				
Elevators				
Other Motors	3.3	109.6		
Water Heating				
Cooking				
Miscellaneous	18.08	54		
Existing Load	0	0		
Total Conn Load				1
Est. Total Demand	47.58	163.6	Main Panel Size	Amps

STREET LIGHTS

Will street lights be required? ☐ YES ☒ NO

OPERATING HOURS PER WEEK	DAYS PER WEEK
168	7

Billing agency

DATES SERVICE NEEDED

Construction Start Date: 9/17/08

Date Temporary Service Required

Date Permanent Service Required: 10/31/08

MOTOR DETAILS

	HP	PHASE	NEMA CODE	LRC
Construction Start Date				
Date Temporary Service Required				
Date Permanent Service Required				

SPECIAL INSTRUCTIONS

I affirm that the above information is correct to the best of my knowledge, and that I have been provided with a construction information sheet. I understand that any changes I make in the above information or drawings will increase the time required for Puget Sound Energy to provide service to my project and that I might be liable for additional engineering and construction costs.

SIGNATURE OF OWNER/REPRESENTATIVE	PRINT NAME	DATE
	Paul Bianco	

Appendix B

2014 O&M Manual Update

FARALLON CONSULTING

Washington
Issaquah | Bellingham | Seattle

Oregon
Portland

California
Oakland | Sacramento

2014 ADDENDUM TO THE OPERATION AND MAINTENANCE MANUAL FOR THE HYDRAULIC CONTROL AND CONTAINMENT SYSTEM

BNSF FORMER MAINTENANCE AND FUELING FACILITY
SKYKOMISH, WASHINGTON
CONSENT DECREE NO. 07-2-33672-9 SEA

Submitted by:
Farallon Consulting, L.L.C.
975 5th Avenue Northwest
Issaquah, Washington 98027

Farallon PN: 683-043

For:
BNSF Railway Company
2454 Occidental Avenue South, Suite 1A
Seattle, Washington 98134

September 10, 2014

Prepared by:

Richard W. McManus, P.E.
Principal Engineer

Reviewed by:

Gerald J. Portele
Principal

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REVISED FIGURES

Figure 4-1a *Process and Instrumentation Diagram, Remediation System Process Flow Diagram*
Figure 4-1b *Process and Instrumentation Diagram, Pump and Treat System Recovery and Oil Water Separation*

1.0 REVISIONS TO OPERATIONS AND MAINTENANCE MANUAL

This 2014 Addendum to the 2011 Operation and Maintenance Manual for the Hydraulic Control and Containment System, Former Maintenance and Fueling Facility, Skykomish, Washington dated April 8, 2011, prepared by AECOM Environment, has been prepared on behalf of BNSF Railway Company. This Addendum has been prepared to document the addition of a disinfection system to the influent line to the Hydraulic Control and Containment (HCC) system to control the presence of iron-fouling bacteria in the treatment system. This Addendum has been prepared in accordance with the provisions of Consent Decree No. 07-2-33672-9 SEA between BNSF and the Washington State Department of Ecology.

1.1 REVISIONS TO SECTION 1.0, INTRODUCTION

The last paragraph of Section 1.0, Introduction reads:

> The HCC treatment system is designed to treat the extracted groundwater to achieve the required effluent limits described in the National Pollutant Discharge Elimination System (NPDES) Discharge Permit No. WA-003212-3 issued on May 4, 2006 and modified on August 15, 2006, June 30, 2008, and June 23, 2010. This O&M Manual has been prepared pursuant to the NPDES permit and meets the requirements of WAC-173-240-150(1) and (2). This manual also meets the requirements of the CD for systems installed in calendar year 2008, 2009, and 2010.

This is to be changed to read:

> The HCC treatment system is designed to treat the extracted groundwater to achieve the required effluent limits described in the National Pollutant Discharge Elimination System (NPDES) Discharge Permit No. WA-003212-3 issued on May 4, 2006 and modified on August 15, 2006, June 30, 2008, June 23, 2010, and February 11, 2014. This O&M Manual has been prepared pursuant to the NPDES permit and meets the requirements of WAC-173-240-150(1) and (2). This manual also meets the requirements of the CD for systems installed in calendar years 2008, 2009, 2010, and 2013.

1.2 REVISIONS TO SECTION 2.0, TREATMENT SYSTEM OPERATING PLAN

The description of the treatment system in Section 2.0 Treatment System Operating Plan currently reads:

> System operations and related controls can essentially be grouped into ten major sub-systems. These are:
>
> - Barrier Wall and Passive Gates
> - Groundwater Recovery Operation
> - NAPL Recovery Operations
> - Primary Treatment Process

- Particulate Removal Process
- Secondary Treatment Process
- Effluent Aeration
- pH Adjustment
- Treated Water Discharge Operations
- Sump Pump Operations.

For a more complete description of each system refer to Section 4.0 of this manual.

This is to be changed to read:

System operations and related controls can essentially be grouped into 11 major sub-systems. These are:

- Barrier Wall and Passive Gates
- Groundwater Recovery Operation
- NAPL Recovery Operations
- Primary Treatment Process
- Particulate Removal Process
- Secondary Treatment Process
- Effluent Aeration
- pH Adjustment
- Treated Water Discharge Operations
- Sump Pump Operations
- Disinfection.

For a more complete description of each system refer to Section 4.0 of this manual.

1.2.1 Revisions to Section 2.1, Baseline Operating Procedures and Parameters

The following paragraphs are to be added to Section 2.1, Baseline Operating Procedures and Parameters as new Section 2.1.11, Disinfection.

2.1.11 Disinfection

Recovered groundwater from HCC System operations was determined to contain iron bacteria that fouled the treatment equipment and reduced operational efficiency. A disinfection process was added to the treatment system to reduce/eliminate the impact of the iron-fouling bacteria on treatment facility operations. Disinfection is accomplished by injection of hydrogen peroxide solution before the oil-water separator in the treatment building. A metering pump (P-08) discharges 34 percent hydrogen peroxide solution into the oil-water separator inlet pipe. The metering pump sits atop a 55-gallon hydrogen peroxide storage drum (T-07) which is set on a spill containment pallet. The injection metering pump is capable of injecting hydrogen peroxide solution to create an in-line concentration ranging from 1 to 200 milligrams/liter (mg/l). The system is currently

operating at an injection concentration of 10 mg/l. At an influent concentration of 10 mg/l the presence of iron-fouling bacteria has diminished substantively within the treatment system and the system is operating at greater efficiency.

1.2.2 Revisions to Section 2.5, HCC System Responsible Individuals and Contacts

Replace the existing contact table with the following:

	Name	Company	Telephone Number	Cell Number
1	Mr. David Johnson, E.I.T.	Farallon Consulting	(425) 295-0800	(425) 463-6022
2	Mr. Gerald Portele	Farallon Consulting	(425) 295-0800	(425) 785-7425
3	Mr. Thayne Wastman	Glacier Environmental	(425) 355-2826	(206) 793-3713
4	Mr. Richard McManus, P.E.	Farallon Consulting	(425) 295-0800	(425) 466-1032

1.3 REVISIONS TO SECTION 4.0, HCC TREATMENT SYSTEM DETAILS

1.3.1 Revisions to Section 4.1, Organization of System Operations

Revise the first sentence of Section 4.1, Organization of System Operations, to read:

> System operations and related controls can essentially be grouped into 11 major sub-systems.

Add the following paragraph to the list in Section 4.1, Organization of System Operations:

> 11. **Disinfection** – The hydrogen peroxide injection system is required to minimize the impact of iron-fouling bacteria on treatment system operations. Injection of the hydrogen peroxide solution occurs before the inlet to the OWS.

Add the following section to existing Section 4.1, Organization of System Operations and revise the numbering of current Section 4.1.10 to 4.1.11:

> **4.1.10 Disinfection System Operations**
>
> The hydrogen peroxide metering pump is control interlocked to the influent flow meter (FIT 115), and is activated when any of the recovery wells are turned on and incoming flow to the HCC building is registered by the meter. The injection rate is manually set on the metering pump to achieve a minimum influent hydrogen peroxide concentration before the influent enters the OWS.

Section 4.1.11, HCC System Typical Operating Parameters currently reads:

> Based on the design criteria and operations of the system during 2010, a list of operational baseline parameters is presented in Table 4.1 to assist an operator in setting up the system in the event of a shutdown or data loss. This list is not intended to supersede the operators' experience and knowledge to changing operating parameters nor will it necessarily be correct in the event that site conditions change significantly.

Section 4.1.11, HCC System Typical Operating Parameters should be changed to read:

> Based on the design criteria and operations of the system during 2013, a list of operational baseline parameters is presented in Table 4-2 to assist an operator in setting up the system in the event of a shutdown or data loss. This list is not intended to supersede the operators' experience and knowledge to changing operating parameters nor will it necessarily be correct in the event that site conditions change significantly.

1.3.2 Revisions to New Section 4.1.11, HCC System Typical Operating Parameters

Table 4-2, Typical Operating Parameters of the HCC System, currently reads:

Table 4-2 Typical Operating Parameters of the HCC System

Parameter	Typical Reading or Measurement	Typical System Setting	Notes
Inlet Flow	30 to 70 gpm	Inlet valve completely open	Influent typically greater in winter and spring and less in summer and fall
Influent Equalization Tank Level	2.00 ~ 2.25 Feet	2.00 ~ 2.25 feet input on Main MMI screen	Keep above influent transfer pump inlet to keep pumps primed
Sand Filter Inlet Pressure	~20 PSI	Influent transfer pump valves open 4 turns on discharge side of pump.	Inlet pressure above 40 PSI usually indicates backwash needed
Sand Filter Discharge Pressure	~5 to 10 PSI	All valves completely open; backwash valve ½ open.	Discharge pressure of sand filters equals inlet pressure of primary LPGAC adsorber
LPGAC Discharge Pressure	~5 to 10 PSI	All valves marked in field with proper open/closed setting	
Effluent Tank Level	4.5 Feet	4.5 feet input on Equalization or Pump Setup screen	Effluent tank must retain enough water to backwash either LPGAC or sand filters
NPDES Discharge Flow	30 to 70 gpm	Discharge valve completely open	Effluent typically greater in winter and spring and less in summer and fall
East Gate Discharge Flow	~17 to 20 gpm	Discharge flow controlled by ball valve	Pump discharge valve fully open
Data Logging Time Interval	4 Hours	Interval input on Pump Setup screen	Must be collected twice per day minimum (minimum setting is 12 hours)
Operating Hertz (Hz) of Influent Transfer Pump	~20 to 30 Hz	Operating Hz dependent on flow rate	If operating Hz above 40, sometimes trips sand filter backwash when not needed

Parameter	Typical Reading or Measurement	Typical System Setting	Notes
Operating Hertz (Hz) of Effluent NPDES Transfer Pump	~20 to 30 Hz	Operating Hz dependent on flow rate	
Backwash Level	1.75 Feet	1.75 feet input on Backwash screen	Must have enough capacity to retain water from backwashing of LPGAC or sand filters

Table 4-2, Typical Operating Parameters of the HCC System, should be changed to read:

Table 4-2 Typical Operating Parameters of the HCC System

Parameter	Typical Reading or Measurement	Typical System Setting	Notes
Inlet Flow	30 to 70 gpm	Inlet valve completely open	Influent typically greater in winter and spring and less in summer and fall
Influent Equalization Tank Level	2.00 ~ 2.25 Feet	2.00 ~ 2.25 feet input on Main MMI screen	Keep above influent transfer pump inlet to keep pumps primed
Sand Filter Inlet Pressure	~20 PSI	Influent transfer pump valves open 4 turns on discharge side of pump.	Inlet pressure above 40 PSI usually indicates backwash needed
Sand Filter Discharge Pressure	~5 to 10 PSI	All valves completely open; backwash valve ½ open.	Discharge pressure of sand filters equals inlet pressure of primary LPGAC adsorber
LPGAC Discharge Pressure	~5 to 10 PSI	All valves marked in field with proper open/closed setting	
Effluent Tank Level	4.5 Feet	4.5 feet input on Equalization or Pump Setup screen	Effluent tank must retain enough water to backwash either LPGAC or sand filters
NPDES Discharge Flow	30 to 70 gpm	Discharge valve completely open	Effluent typically greater in winter and spring and less in summer and fall
East Gate Discharge Flow	~17 to 20 gpm	Discharge flow controlled by ball valve	Pump discharge valve fully open
Data Logging Time Interval	4 Hours	Interval input on Pump Setup screen	Must be collected twice per day minimum (minimum setting is 12 hours)
Operating Hertz (Hz) of Influent Transfer Pump	~20 to 30 Hz	Operating Hz dependent on flow rate	If operating Hz above 40, sometimes trips sand filter backwash when not needed

Parameter	Typical Reading or Measurement	Typical System Setting	Notes
Operating Hertz (Hz) of Effluent NPDES Transfer Pump	~20 to 30 Hz	Operating Hz dependent on flow rate	
Backwash Level	1.75 Feet	1.75 feet input on Backwash screen	Must have enough capacity to retain water from backwashing of LPGAC or sand filters
Disinfection	1 to 200 mg/l	10-30 mg/l	Can be adjusted to control iron-fouling bacteria accumulation in sand filters and granular activated carbon filters

1.3.3 Revisions to Section 7.1, Normal Startup

Section 7.1, Normal Startup currently reads:

> Operations of the system should be performed utilizing the MMI and PLC. Normal startup of the system is performed as follows.
>
> 1. Check to ensure all Hand/Off/Auto (HOA) switches on the control panel are in the "Auto" position.
>
> 2. Check to ensure the valves on the LPGAC skid are correctly positioned to operate in series configuration.
>
> 3. Check to ensure Tank T-03 is set at the set point level.
>
> 4. Check to ensure the ball valve for the system influent line is in the fully open position.
>
> 5. At the MMI on the MAIN screen (Figure 5.1), right click on the "System Stopped Push to Start" button in the lower left hand corner of the Main screen.
>
> 6. Check to ensure influent flow is occurring and continue to monitor T-03 and T-05 levels for a few minutes.

Section 7.1, Normal Startup should be changed to read:

> Operations of the system should be performed utilizing the MMI and PLC. Normal startup of the system is performed as follows.
>
> 1. Check to ensure all Hand/Off/Auto (HOA) switches on the control panel are in the "Auto" position.
>
> 2. Check to ensure the valves on the LPGAC skid are correctly positioned to operate in series configuration.
>
> 3. Check to ensure Tank T-03 is set at the set point level.

4. Check to ensure the ball valve for the system influent line is in the fully open position.

5. At the MMI on the MAIN screen (Figure 5.1), right click on the "System Stopped Push to Start" button in the lower left hand corner of the Main screen.

6. Check to ensure influent flow is occurring and continue to monitor T-03 and T-05 levels for a few minutes.

7. Check the hydrogen peroxide metering pump to assure flow of hydrogen peroxide solution in to the influent pipe. This can be determined by visually observing small bubbles moving through the metering pump tubing.

1.3.4 Revisions to Figures

Figure 4-1a, Process and Instrumentation Diagram, Remediation System Process Flow Diagram has been revised to reflect the inclusion of the hydrogen peroxide injection system to the influent line to the OWS.

Figure 4-1b, Process and Instrumentation Diagram, Pump and Treat System, Recovery and Oil Water Separation has been revised to reflect the inclusion of the hydrogen peroxide injection system to the influent line to the OWS.

REVISED FIGURES

2014 ADDENDUM TO THE
OPERATION AND MAINTENANCE MANUAL FOR THE HYDRAULIC CONTROL AND CONTAINMENT SYSTEM
BNSF Former Maintenance and Fueling Facility
Skykomish, Washington
Farallon PN: 683-043

P-01 (A-H)	CS-01 (A-H)	SK-01 (A-H)	T-01 (A-H)	OWS-01	T-02	T-03	P-02A,B	F-01A,B	F-02A,B	T-05	T-04	P-03	P-04	P-05	P-06	P-07A,B	S-01A,B	S-02	C-01	T-06	M-01	P-06
DOWN WELL SUBMERSIBLE PUMP	COOLING SHROUD DOWN WELL SUBMERSIBLE PUMP	OIL RECOVERY BELT SKIMMER PACKAGE	RECOVERED OIL STORGE TANK & OVERPACK	OIL/WATER SEPARATOR	RECOVERED OIL STORAGE TANK & OVERPACK	INFLUENT EQUALIZATION TANK	INFLUENT EQUALIZATION TANK TRANSFER PUMP	SAND FILTER PACKAGE	GRANULAR ACTIVATED CARBON PACKAGE	EFFLUENT EQUALIZATION TANK	BACKWASH TANK	TREATED WATER NPDES DISCHARGE PUMP	TREATED WATER INJECTION PUMP	BACKWASH PUMP	BUILDING SUMP PUMP	UTILITY VAULT SUMP PUMP	UTILITY VAULT SUMP	BUILDING FLOOR SUMP	AIR SPARGE BLOWER	NaOH STORAGE TANK	STATIC MIXER	NaOH METERING PUMP

P-08
METERING PUMP
0.5 GPH, 250psi
115V

T-07
HYDROGEN PEROXIDE SOLUTION TANK
55-GALLONS

Ⓐ

TREATMENT BUILDING

VENT
OIL DISPOSAL
T-02
VENT
T-04
AMBIENT AIR
C-01
AIR SPARGE SYSTEM
T-06
P-06
VENT
IW-1 AND IW-2
NPDES
M-01
P-04
P-03
T-05
OWS-01
P-08
P-02A,B
T-03
F-01A,B
F-02A,B
P-05
T-07
TO OWS-1
S-01A,B
P-07A,B
TO T-03
S-02
P-06

GSE
GSE
T-01 (A-H)
ENDS OF HCC
NORTH SIDE OF HCC
SOUTH SIDE OF HCC
SK-01 (A-H)
SHEETPILE BARRIER
CS-01 (A-H)
P-01 (A-H)

Ⓐ 2014 OPERATION AND MAINTENANCE MANUAL FOR HYDRAULIC CONTROL AND CONTAINMENT SYSTEM ADDENDUM
CLOUDED CHANGES BY FARALLON CONSULTING LLC, AUGUST 15, 2014

REVISIONS

NO.:	DESCRIPTION:	DATE:	BY:
1	ISSUED FOR BID	4/08	SAC
2	ISSUED FOR CONSTRUCTION	6/08	SAC
3	ISSUED FOR CONSTRUCTION-REV 1	7/08	SAC
4	FOR ELECTRICAL BID	9/08	RCW
5	ISSUED FOR CONSTRUCTION-REV2	10/08	RCW/BMP

DESIGNED BY:
DRAWN BY:
CHECKED BY:
APPROVED BY:

ENSR | AECOM

ENSR CORPORATION
SEATTLE, WASHINGTON 98134
PHONE: (206) 624-9349
FAX: (206) 624-2839
WEB: HTTP://WWW.ENSR.AECOM.COM

2009 HCC O&M MANUAL

PROCESS AND INSRUMENTATION DIAGRAM
REMEDIATION SYSTEM
PROCESS FLOW DIAGRAM
THE BNSF RAILWAY COMPANY
SKYKOMISH, WAHINGTON

SCALE: NTS
DATE: 11/20/08
PROJECT NUMBER: 01140-222-0210

FIGURE NUMBER: 4-1a

DRAWING NUMBER: 1

File: F:\PROJECTS\BNSF Skykomish\10209 HCC O&M Manual-2009-11\ACAD\Skykomish-PM&R-Construction_12-16-08_Black.dwg Layout: P-103 User: BlancoP Plotted: Dec 12, 2009 - 11:08am XrefDe

P-01 (A-H)
DOWN WELL SUBMERSIBLE PUMP
1 HP VFD
460 VAC, 3ø, 0-60 Hz

CS-01 (A-H)
COOLING SHROUD DOWN WELL SUBMERSIBLE PUMP

SK-01 (A-H)
OIL RECOVERY BELT SKIMMER PACKAGE
460 VAC SUPPLY
INTEGRAL 460/120 TRANSFORMER
120 VAC, 1ø, 7 AMPS

T-01 (A-H)
RECOVERED OIL STORAGE TANK & OVERPACK

OWS-01
OIL/WATER SEPARATOR
100 GPM

T-02
RECOVERED OIL STORAGE TANK & OVERPACK
55-GALLON w/95-GALLON OVERPACK

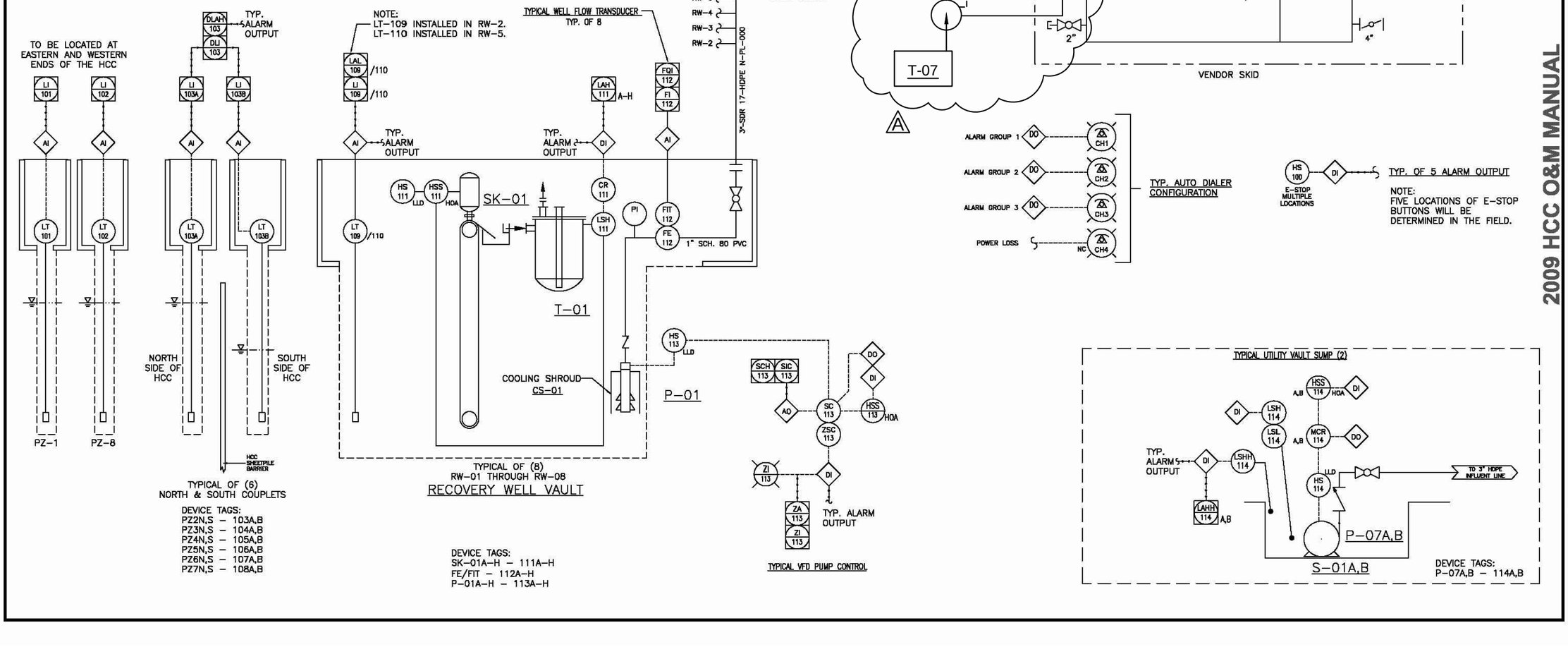
P-07A,B
UTILITY VAULT SUMP PUMP
53 GPM @ 15 FT TDH
1/2 HP, 1ø, 115 VAC

S-01A,B
UTILITY VAULT SUMP

LEGEND

- SKIDS SHIPPED FROM ENCOTECH
- EQUIPMENT SHIPPED LOOSE AND SUPPLIED BY OTHERS
- FIELD PIPING (MATERIAL AND LABOR PROVIDED BY CONTRACTOR

A 2014 OPERATION AND MAINTENANCE MANUAL FOR HYDRAULIC CONTROL AND CONTAINMENT SYSTEM ADDENDUM
CLOUDED CHANGES BY FARALLON CONSULTING LLC, AUGUST 15, 2014



REVISIONS			
NO.:	DESCRIPTION:	DATE:	BY:
1	ISSUED FOR PIPING BID	09/24/08	RCW
2	ISSUED FOR CONSTRUCTION-REV2	10/08	RCW/BeV
3	ISSUED FOR CONSTRUCTION-REV3	11/05/08	RCW/BeV
4	ISSUED FOR CONSTRUCTION-REV4		BeV

DESIGNED BY: SAC
DRAWN BY: RCW
CHECKED BY: DM
APPROVED BY: SM

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2009 HCC O&M MANUAL

PROCESS AND INSRUMENTATION DIAGRAM
PUMP AND TREAT SYSTEM
RECOVERY AND OIL WATER SEPARATION
THE BNSF RAILWAY COMPANY
SKYKOMISH, WAHINGTON

SCALE: NTS
DATE: 11/20/08
PROJECT NUMBER: 01140-222-0210

FIGURE NUMBER: 4-1b

DRAWING NUMBER:

File: F:\PROJECTS\BNSF Skykomish\2009 HCC O&M Manual-2009-11\HCC O&M Figures\HCC O&M Manual-2009-11-Figures-Table\HCC-Construction_12-16-08_Block.dwg Layout: P-101 User: BlancoP Plotted: Dec 17, 2009 - 11:08am XrefS:

Appendix C

Health and Safety Plan

Site Specific Health and Safety Plan

Revision 19 b

Project Name:	BNSF Former Maintenance and Fueling Facility 105 6th Street North Skykomish, Washington 98288
Project Number:	30144053
Client Name:	BNSF
Date:	1/17/2023
HASP Expires	1/17/2024
Revision:	1 (updated from 8/30/2022)

Approvals:

HASP Developer: Dawn Monico

Project Manager: Kyle Haslam

HASP Reviewer: Nicholas Monico

HASP Reviewer Name Typed

HASP Reviewer Signature (handwritten or digital signature)

Arcadis Culture of Caring

Arcadis is committed to a Culture of Caring that ensures each Arcadis employee, part time as needed employee (PTAN), temporary agency employee under Arcadis day to day control, Inexperienced Workers and contractor (cumulatively referred to here as "field staff") goes home at the end of the day free from injury or illness. I certify that the following has been performed with all Arcadis field staff on this project either in person or virtually through Teams:

☐ Reviewed the HASP including a discussion of hazard identification and controls.

- ☐ If conducting activities deemed by Arcadis to be "High Risk", frontline management has reviewed applicable H&S standards (Job Safety Analysis [JSA] when authorized by H&S) for these activities with field staff.
- ☐ If permit to work is required, frontline management has reviewed the permit(s) with field staff.

☐ Reviewed proactive H&S engagement expectations/injury prevention actions.
☐ Reviewed Stop Work Authority.
☐ Reviewed the incident reporting process and expectations including when WorkCare should be contacted by staff (WorkCare incident intervention for all minor, non-emergency injuries) and that the WorkCare phone number is programmed into field team cell phone.
☐ For Inexperienced Workers, a mentor has been assigned for the new task being performed.

For short service employees (SSEs), PTANS* and temporary agency employees* :

☐ Provided coaching and mentoring on Arcadis H&S expectations during project work. Reviewed in detail specific hazards and controls and provided a resource who can be contacted if individual has questions regarding planned or unplanned work tasks.

Mentor/Resource # _____ _____
Name Phone Number

Signed:

_____ Project Manager

* Upon hiring/contracting for the first time.

Emergency Information

Site Address: BNSF Former Maintenance and Fueling Facility
105 6th Street North
Skykomish, WA 98288

Emergency Phone Numbers:

Emergency (fire, police, ambulance)		911
Emergency (facility specific, if applicable):		
King County Fire District #50		360-677-2686
Town of Skykomish Police		206-296-3311
Emergency Other (specify):		
Primary Client Contact:	Scott MacDonald	360-621-6419
WorkCare (non-life-threatening injury/illness):		1-888-449-7787
Project H&S:	Emily Zikmund	206-413-6534
Task Manager:	Joe Sepiol	
Project Manager:	Kyle Haslam	206-719-6991
H&S Specialist:	Zach Mongan	240-476-1315
Area H&S Director:	Andrew McDonald	410-200-3752

Hospital Name and Address: EvergreenHealth Monroe Medical Center
14701 179th Ave SE
Monroe, WA 98272

Hospital Phone Number: 360-794-1402

Supplemental Client Contact Information:

Other Important Phone Numbers:

Poison Control Center	1-800-222-1222
Nat. Response Ctr. (spills in reportable quantities)	1-800-424-8802
U.S. Coast Guard (spills to water)	1-800-424-8802

Incident Reporting Protocol Within Arcadis

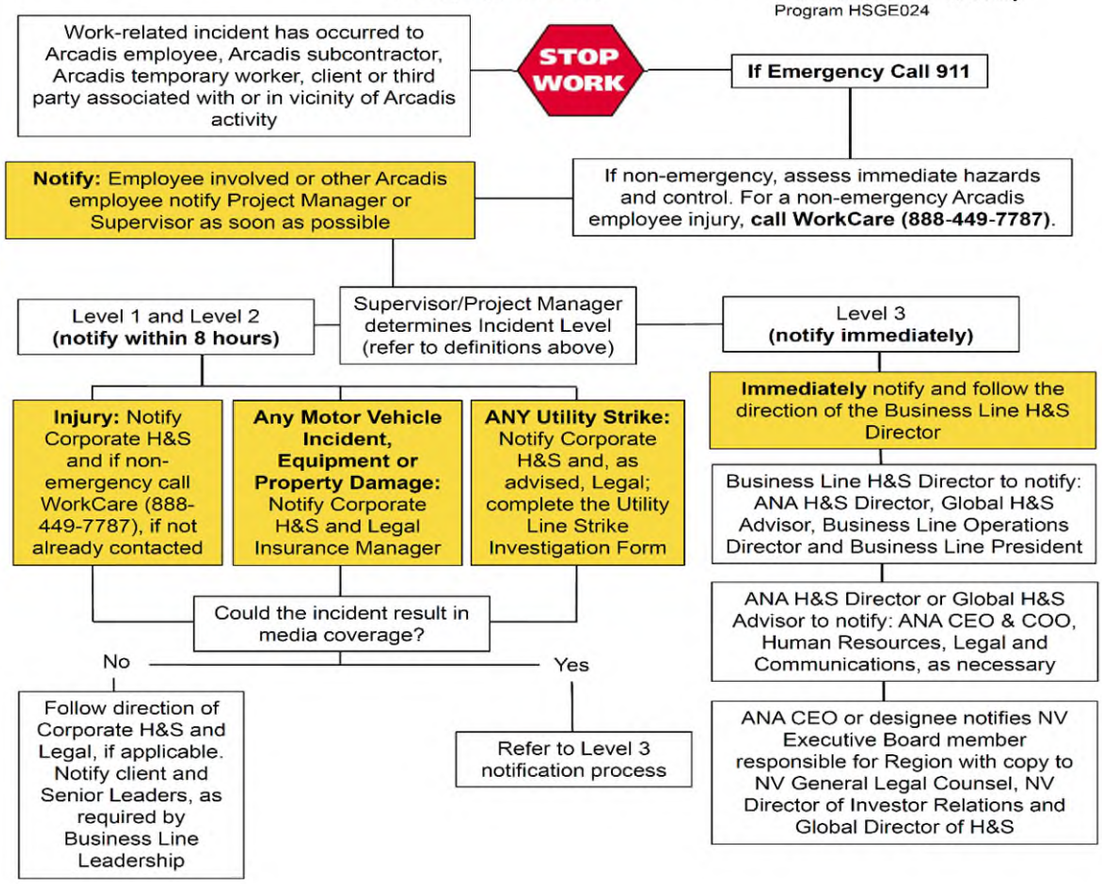
Incident Levels

Level 1: First aid/self-treated, work-related injury (contact WorkCare as soon as possible); minor property or equipment damage (less than or equal to $100); vehicle loss event* (no injuries, no third-party involvement or other vehicle involvement).

Level 2: Professional Medical Treatment (if non-emergency injury or illness, employee must contact WorkCare as soon as possible); moderate property or equipment damage (greater than $100 but less than or equal to $5,000); ANY utility strike incident, any motor vehicle accident* (including injury or third-party involvement).

Level 3: Immediately report fatality, severe or catastrophic injury and/or overnight hospitalization required; significant property or equipment damage (greater than $5,000); missing person or incident that generates media coverage.

* Refer to Motor Vehicle Safety Program HSGE024



Client Incident Reporting Protocol

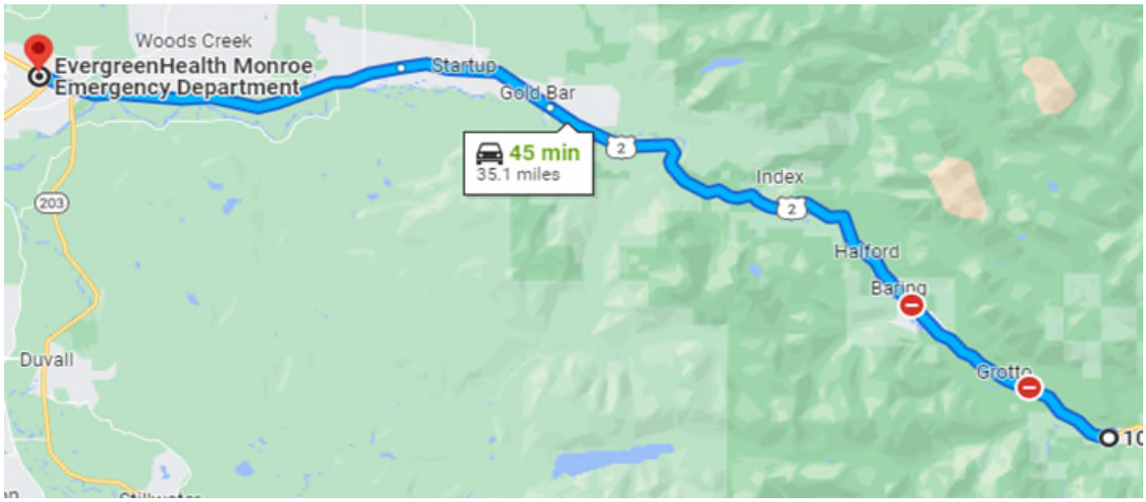
Alert the project team below for any incidents, starting with the associate project manager and project manager as listed below.

1. Dial 911/Facility Emergency Number/WorkCare as applicable
2. Contact PM/Supervisor - Kyle Haslam (cell: 206-719-6991)
3. Contact Corporate H&S - Eve Crudup (cell: 713-953-4862)
4. Contact Client - Scott MacDonald (cell: 360-621-6419)

Route to the Hospital

EvergreenHealth Monroe Medical Center
14701 179th Ave SE
Monroe, WA 98272

Phone: 360-794-1402



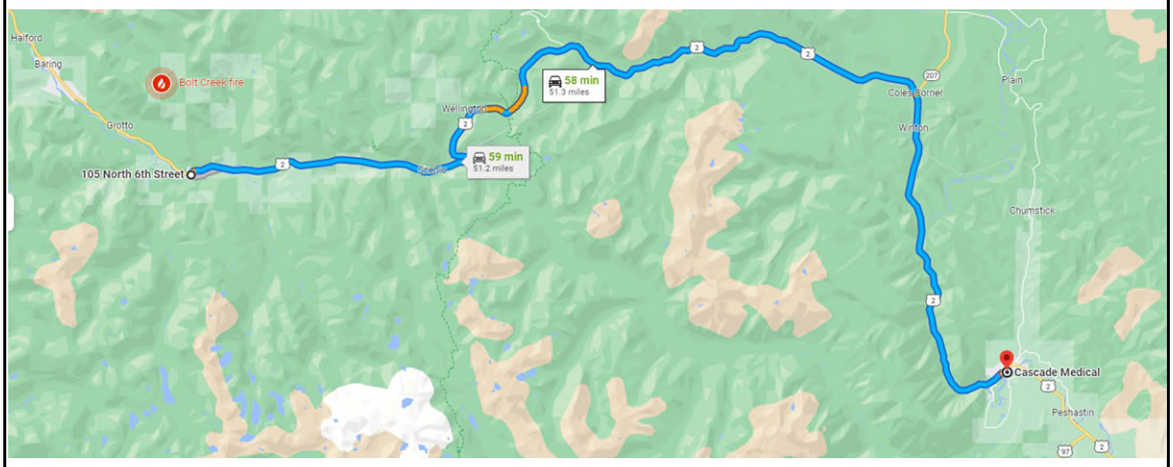
Directions:
1. Head north on N 6th St toward W Riverside Dr. (travel 210 ft)
2. Turn right onto W Riverside Dr. (travel 469 ft)
3. Sharp left onto 5th St N (travel 0.1 mi)
4. Turn left onto U.S. Rte 2 W (travel 20.0 mi) Parts of this road may be closed at certain times or days (see next page for backup hospital route)
5. Continue straight onto Croft Ave (travel 69 ft)
6. Continue straight onto U.S. Rte 2 W (travel 194 ft)
7. Continue straight to stay on U.S. Rte 2 W (travel 4.4 mi)
8. At the traffic circle, take the 2nd exit onto U.S. Rte 2 (pass by Burger King) (travel 10.3 mi)
9. Turn left onto 179th Ave SE (travel 423 ft)
10. Turn left (destination will be on the rigth (travel 161 ft)

Travel Summary:
Travel Distance = 35.1 mi
Travel Time = 45 min

Route to the Hospital (Backup if Highway 2 Westbound is closed)

Hospital Name: Cascade Medical
Hospital Address: 817 Commercial St, Leavenworth, WA 98826
Hospital Phone Number: 509-548-5815

Site Address: 105 6th Street North, Skykomish, WA 98288



105 N 6th St
Skykomish, WA 98288

1. Head north on N 6th St toward W Riverside Dr
210 ft
2. Turn right onto W Riverside Dr
469 ft
3. Sharp left onto 5th St N
0.1 mi
4. Turn right onto US-2 E/US Hwy 2
⚠ Parts of this road may be closed at certain times or days
50.8 mi
5. Turn right onto Front St
0.2 mi
6. Turn right onto 8th St
302 ft
7. Turn left onto Commercial St
ⓘ Destination will be on the right
161 ft

Cascade Medical
817 Commercial St, Leavenworth, WA 98826

Site Type

The project site is an active facility with the following attributes:

Parking Lot/Private Drive (NON ROW)	
Railroad	
Residential	

For class I railroads, work within 25 ft of the rails is prohibited unless FRA On-Track Safety and railroad specific trained. For other railroads (i.e. short line railorads), the project or task manager will specify any special training needs. For all rail related work, field staff will have access to the Arcadis Railroad Safety Handbook and/or client rail safety handbook.Work in parking lots will require preparation of a Non-ROW Traffic Safety Plan.

Surrounding Land Use and Topography

The site includes BNSF property and public and private properties in the town of Skykomish in King County, WA, and emcompasses approximately 40 acres. The site is bounded by the Skykomish River to the north, the town city limits to the east, Old Cascade Highway to the south, and Maloney Creek to the west. The site topography is located within a river basin and is generally flat, with surrounding raised wooded elevation to the north and south of the site.

Simultaneous Operations (SimOps)

SimOps is expected or will be conducted in proximity to Arcadis work activities on the project site. SimOps creates unique hazards that could affect Arcadis employees and subcontractors and SimOps hazards identified on site will be addressed in the JSA or similar governing document (i.e. permit) for affected Arcadis work tasks. If the SimOps work activities create a high hazard to Arcadis staff or subcontractors, Arcadis will utilize stop work until the SimOps activity is complete or will coordinate work activities with SimOps workers and/or client to ensure SimOps work hazards are mitigated.

Site Background

Historical activities have occurred at this site since the last 1890s at the BNSF railyard. These activities include refueling and maintaining trains, and operating an electrical substation. BNSF stored Bunker C and diesel fuel at BNSF railyard in above ground storage tanks and underground storage tanks until 1974 when fueling operations ceased. These historic operations resulted in the release of petroleum hydrocarbons. Soil has been excavated off site, and an air sparging system is in operation. There are also recovery wells, a hydraulic control and containment system, and HWF system in operation. COCs on site consist of TPH, and LNAPL is commonly encountered and sampled at the site.

Project Tasks

The following tasks are identified for this project:

1	Driving - Motor vehicles
2	Mobilization - Loading and unloading vehicles
3	Oversight - Oversight of contractors (Sys O&M incl GAC Changeout)
4	Sampling - Free product - all media and all manual methods
5	Sampling - Well sampling using peristaltic pumps
6	Monitor well - Well sounding, water level or product measurements using probes, tapes or downhole water parameter measurements
7	Waste - Containment of IDW in small containment devices greater than 10 gallons but less than or equal to 119 gallons capacity
8	Decontamination - Small or hand-held objects using manual methods
9	Utilities - Clearance
10	Monitor well - Well installation, development, or purging contractor oversight
11	Construction - Contractor oversight of system installation
12	Excavation - Contractor oversight of trenching/piping

The following documents and/or plans associated with the above task(s) are required and attached:
- Client specific H&S information.
- Subcontractor provided H&S information.
- Washington Heat Illness Prevention Plan (HIPP).
- Silica Exposure Control Plan

[X] Required Checklists/Work Forms

- *Tailgate Safety Briefing Form*
- *Vehicle Inspection Checklist*
- *Utility and Structures Checklist*

[ ] Required Permits

- *Not Applicable*

[X] Required H&S Standards

- *Heat Stress Prevention_ARC HSIH013*
- *Cold Stress Prevention_ARC HSIH014*
- *First Aid/CPR_ARC HSGE004*
- *Utility Location Procedures_ARC HSFS019*

Short Service Employees (SSEs), Part Time As Needed Employees (PTANs) and Temporary Agency Employees

SSEs (employees who are employed with Arcadis for less than 1 year or are Inexperienced Workers) have the potential to work on this project. If SSEs are utilized, the project team working in conjunction with the SSE's administrative supervisor will ensure requirements of ARC HSGE019 "Short Service Employees" are completed. SSE's will be identified on the project Tailgate Safety Meeting Form.

Roles and Responsibilities

	Name	Role	Short Service Employee
1	Kyle Haslam	Project Manager (PM)	No
2	Lauren Selleck	Associate Project Manager (APM)	No
3	Joe Sepiol	Task Manager	No
4	Elizabeth Scheller	Field Technical Lead	No
5	Elizabeth Scheller	Site Safety Officer (SSO) (HAZWOPER)	No
6	Daniela Galeano	Field Staff	No
7	Savannah Green	Field Staff	No
8	Trevor Bryant	System Tech	No
9			
10			

Training

All Arcadis employees are required to have the following training to be on site:

Defensive Driving - Smith On-Line
HAZCOM GHS/EAP (non-certificate)
PPE (non-certificate)
Hazwoper 40-Hour
Hazwoper 8-Hour Annual Refresher
H&S Program Orientation (non-certificat
Fire Extinguisher (non-certificate)
Heat Stress
First Aid/CPR
Railroad - eRAILSAFE (non-CSX)
Silica General Awareness
None
None
Client specific:
BNSF contractor training
Other:
Railroad Worker Protection

Selected Arcadis employees are required to have the following additional training:

	Names or Numbers from above
BBP (Bloodborne Pathogens)	4, 5
DOT HazMat #1	4, 5
None	
None	
None	
None	
None	
None	
None	
None	
None	
None	
None	
None	
None	
Other:	

The Arcadis Fundamental H&S Principles

Staff working on any of the task(s) listed above must utilize the six Arcadis Fundamental H&S Principles to ensure work is conducted safely. These principles include: 1) Use of TRACK, 2) H&S Planning, 3) Stop Work Authority, 4) "If Not Me Then Who", 5) Stewardship, and 6) Incident Reporting. Every project team member plays an important role in project health and safety. This is more than just having a HASP, training, or PPE. Proactive staff engagement with these principles is critical to a safe work environment.

General Task Hazard Assessment and Risk Control (HARC)

General:	Site-Wide

The 12 hazard category HARC ratings are not available in this General THA. The mitigated and unmitigated ratings for the hazards presented are based on the Risk Assessment Matrix below. Modify hazards and ratings as necessary to meet project needs.

Risk Assessment Matrix		Likelihood Ratings			
Consequences Ratings		A	B	C	D
People	Property	0 Almost Impossible	1 Possible but Unlikely	2 Likely to Happen	3 Almost Certain to Happen
1-Slight or No Health Effect	Slight or No Damage	0-Low	1-Low	2-Low	3-Low
2-Minor Health Effect	Minor Damage	0-Low	2-Low	4-Medium	6-Medium
3-Major Health Effect	Local Damage	0-Low	3-Low	6-Medium	9-High
4-Fatalities	Major Damage	0-Low	4-Medium	8-High	12-High

Hazard #1

Driving - On road - Injury or vehicle damage from motor vehicle accident or incident

Suggested FHSHB Ref:	3.4	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	HIGH	Smith System (on line)
Mitigated Risk:	MEDIUM	JSAs
Comments:	Use Smith System "5-Keys" when driving. See Driving JSA for details.	

Hazard #2

Driving - Driver - Injury, death or property damage due to driver distraction, fatigue, etc.

Suggested FHSHB Ref:	3.4, 3.21	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	HIGH	Smith System (on line)
Mitigated Risk:	LOW	Driver awareness and use of stop work authority
Comments:	Use route planning. Keep eyes moving while driving. See Driving JSA.	

Hazard #3

Biological - skin/eye irritation or damage from poisonous plants

Suggested FHSHB Ref:	3.17.11	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	LOW	See HASP Tick/Poisonous Plant Section
Mitigated Risk:	LOW	Job Briefing/Site Awareness
Comments:	Use skin pre-treatment lotions when available.	

Hazard #4

Biological - bites or stings from exposure to insects or arachnids

Suggested FHSHB Ref:	3.17: 2,3,7,8,9,10	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	LOW	PPE (see HASP "PPE" section)
Mitigated Risk:	LOW	Job Briefing/Site Awareness
Comments:	Do body check daily. For ticks see also HASP Tick/Poisonous Plant section	

Hazard #5

Biological - cuts, scrapes, skin/eye puncture from exposure to physically damaging plants

Suggested FHSHB Ref:	3.17.11	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Job Briefing/Site Awareness
Mitigated Risk:	LOW	PPE (see HASP "PPE" section)
Comments:		

General Task HARC (continued)

Hazard #6		
Environmental - Thermal stress - Injury or illness from heat or cold		
Suggested FHSHB Ref:	3.16	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Field H&S Handbook (see ref. above)
Mitigated Risk:	LOW	JSAs
Comments:	Use job rotation or rest breaks. Stay hydrated and eat regularly.	
Hazard #7		
Environmental - Inclement weather -Injury or equipment damage from inclement weather		
Suggested FHSHB Ref:	3.12	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Weather Monitoring
Mitigated Risk:	LOW	Cont./Emerg. Planning
Comments:	Use 30/30 rule for lightning. See FHSHB for details.	
Hazard #8		
Motion - Musculoskeletal - Injury from lifting, twisting , stooping, or awkward body positions		
Suggested FHSHB Ref:	3.29.1	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Engineering Controls (specify in comments)
Mitigated Risk:	LOW	Admin. Controls (specify in comments)
Comments:	Use proper lifting techniques. Use job rotation when applicable. See FHSHB for details.	
Hazard #9		
Motion - Musculoskeletal - Injury from repeated work activity or body motion		
Suggested FHSHB Ref:	3.29.2	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Engineering Controls (specify in comments)
Mitigated Risk:	LOW	Admin. Controls (specify in comments)
Comments:	Use proper lifting techniques. Use job rotation when applicable. See FHSHB for details.	
Hazard #10		
Gravity - Falls - Injury due to slips and trips		
Suggested FHSHB Ref:	3.26.4, 4.11	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Site Awareness
Mitigated Risk:	LOW	Housekeeping
Comments:	Use footwear appropriate for site conditions, plan routes and do not hurry while walking.	

Task Specific HARC

Task 1:	Driving - Motor vehicles

HARC Unmitigated Hazard Types (H-High, M-Medium, L-Low): FHSHB Ref: 3.4

Biological*	-	Chemical	-	Driving*	H	Electrical	-
Environmental*	-	Gravity*	-	Mechanical	-	Motion*	-
Personal Safety	L	Pressure	-	Radiation	-	Sound	L

* *Hazard rating, if present, excludes General THA hazards in this category.*

Hazard #1

Personal safety - Fatigue - Injury or illness caused while working when fatigued

Suggested FHSHB Ref:	3.21	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Job Briefing/Site Awareness
Mitigated Risk:	LOW	Job Rotation
Comments:	Make sure to get adequate rest before driving and take rest breaks as needed.	

Hazard #2

Mechanical - Pinch point - Injury by pinching of body part in mechanical process

Suggested FHSHB Ref:	3.27.4	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Site Awareness
Mitigated Risk:	LOW	PPE (see HASP "PPE" section)
Comments:	Verify show of hands when closing doors or hood.	

Hazard #3

Driving - Off road - Injury or vehicle damage from object impact/vehicle rollover/improper load securement

Suggested FHSHB Ref:	3.4.2.1	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	HIGH	JSAs
Mitigated Risk:	LOW	Smith System (on line)
Comments:	Ensure all equipment is properly secured on Arcadis vehicles and subcontractor's.	

Hazard #4

Motion - Struck by - Bodily injury from impact with moving object

Suggested FHSHB Ref:	2.5, 3.22	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	JSAs
Mitigated Risk:	LOW	Site Awareness
Comments:	Be very aware of surroundings when operating a vehicle and constantly search for changing environment to avoid accidents.	

Task Specific HARC (continued)

Task 2:	Mobilization - Loading and unloading vehicles

HARC Unmitigated Hazard Types (H-High, M-Medium, L-Low): FHSHB Ref: 3.9

Biological*	-	Chemical	L	Driving*	-	Electrical	L
Environmental*	L	Gravity*	M	Mechanical	L	Motion*	M
Personal Safety	L	Pressure	L	Radiation	L	Sound	L

Hazard #1

Gravity - Struck by - Injury from falling object

Suggested FHSHB Ref:	3.26.2	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	PPE (see HASP "PPE" section)
Mitigated Risk:	LOW	Job Briefing/Site Awareness
Comments:	Items may have shifted during transport - be cautious when opening vehicle after movement. Wear work gloves and a hard hat if moving equipment from heights.	

Hazard #2

Mechanical - Pinch point - Injury by pinching of body part in mechanical process

Suggested FHSHB Ref:	3.27.4	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Site Awareness
Mitigated Risk:	LOW	PPE (see HASP "PPE" section)
Comments:	Keep hands/fingers away from pinch points when closing vehicle doors and equipment cases. Wear work gloves when moving equipment around.	

Hazard #3

Motion - Cuts and scrapes - Injury from moving object impacting skin or eye

Suggested FHSHB Ref:	2.5, 3.22	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Site Awareness
Mitigated Risk:	LOW	PPE (see HASP "PPE" section)
Comments:	Wear safety glasses, long sleeves, and long pant to avoid injury.	

Task Specific HARC (continued)

Task 3:	Oversight - Oversight of contractors (Sys O&M incl GAC Changeout)

HARC Unmitigated Hazard Types (H-High, M-Medium, L-Low): FHSHB Ref: 3.9

Biological*	L	Chemical	L	Driving*	-	Electrical	L
Environmental*	L	Gravity*	L	Mechanical	L	Motion*	L
Personal Safety	L	Pressure	L	Radiation	L	Sound	M

Hazard #1

Chemical - liquids - injury or illness from vapor inhalation

Suggested FHSHB Ref:	3.2, 3.22, 3.30, 3.33	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	HASP
Mitigated Risk:	LOW	See HASP "Monitoring" section
Comments:	Air monitoring will be conducted during pumping activities with a properly calibrated air monitor and trained personnel. STOP WORK if action levels are reached.	

Hazard #2

Motion - Struck by - Bodily injury from impact with moving object

Suggested FHSHB Ref:	2.5, 3.22	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Engineering Controls (specify in comments)
Mitigated Risk:	LOW	H&S Standards
Comments:	Work area shall be established per task specific TSP. Site workers shall don Class 2 reflective clothing while onsite during daylight hours, or Class 3 if onsite during nighttime hours. The temporary fence panels shall be equipped with reflective tape or lights to alert nearby personnel of work zone.	

Hazard #3

Motion - Cuts and scrapes - Injury from moving object impacting skin or eye

Suggested FHSHB Ref:	2.5, 3.22	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	JSAs
Mitigated Risk:	LOW	Site Awareness
Comments:	Ensure subcontractors are using the right tools for the job when changing carbon vessels. Conduct a safety meeting each day to keep safety at the forefront of everyone on site's mind when working.	

Hazard #4

Electrical - Housekeeping - Injury or property damage due to frayed wiring, improperly mounted wiring, missing or damaged warning labels, etc.

Suggested FHSHB Ref:	3.25	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Inspections
Mitigated Risk:	LOW	Housekeeping
Comments:	Conduct an inspection on all equipment before use, and check that the system is in proper working order.	

Task Specific HARC (continued)

Task 4:	Sampling - Free product - all media and all manual methods

HARC Unmitigated Hazard Types (H-High, M-Medium, L-Low): FHSHB Ref: 3.9

Biological*	L	Chemical	M	Driving*	-	Electrical	L
Environmental*	L	Gravity*	L	Mechanical	L	Motion*	L
Personal Safety	L	Pressure	L	Radiation	-	Sound	L

Hazard #1

Chemical - liquids - injury or illness from vapor inhalation

Suggested FHSHB Ref:	3.2, 3.22, 3.30, 3.33	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	See HASP "Monitoring" section
Mitigated Risk:	LOW	Job Briefing/Site Awareness
Comments:	Conduct air monitoring according to the HASP when working near monitoring wells with product.	

Hazard #3

Motion - Struck by - Bodily injury from impact with moving object

Suggested FHSHB Ref:	2.5, 3.22	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	H&S Standards
Mitigated Risk:	LOW	Job Briefing/Site Awareness
Comments:	Set up traffic control barricades according to TSP, Use Spotters, Wear High Vis PPE.	

Hazard #4

Motion - Cuts and scrapes - Injury from moving object impacting skin or eye

Suggested FHSHB Ref:	2.5, 3.22	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	PPE (see HASP "PPE" section)
Mitigated Risk:	LOW	Job Briefing/Site Awareness
Comments:	Do not overtighten lids on glass bottleware as it may cause breakage. Wear gloves and safety glasses to protect yourself.	

Hazard #4

Chemical - liquids, skin or eye irritation/damage/allergy

Suggested FHSHB Ref:	3.9, 3.22, 3.30, 3.33	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	PPE (see HASP "PPE" section)
Mitigated Risk:	LOW	JSAs
Comments:	Wear safety glasses and nitrile gloves when working with groundwater with free product. If product touches skin, immediately rinse with DI water.	

Hazard #5

Chemical - gasses - injury due to inhalation, asphyxiation, skin/eye contact

Suggested FHSHB Ref:	3.30, 3.32	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Job Briefing/Site Awareness
Mitigated Risk:	LOW	JSAs
Comments:	Stand upwind when sampling a monitoring well with free product to avoid inhaling vapors.	

Task Specific HARC (continued)

Task 5:	Sampling - Well sampling using peristaltic pumps

HARC Unmitigated Hazard Types (H-High, M-Medium, L-Low): FHSHB Ref: 3.9

Biological*	L	Chemical	M	Driving*	-	Electrical	L
Environmental*	L	Gravity*	L	Mechanical	-	Motion*	L
Personal Safety	L	Pressure	L	Radiation	-	Sound	L

Hazard #1

Electrical - Housekeeping - Injury or property damage due to frayed wiring, improperly mounted wiring, missing

Suggested FHSHB Ref:	3.25	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Housekeeping
Mitigated Risk:	LOW	Inspections
Comments:	Inspect equipment before each use, make sure to check that all wires are covered and not exposed.	

Hazard #2

Chemical - liquids - injury or illness from vapor inhalation

Suggested FHSHB Ref:	3.2, 3.22, 3.30, 3.33	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	See HASP "Monitoring" section
Mitigated Risk:	LOW	Job Briefing/Site Awareness
Comments:	Conduct air monitoring according to the HASP when working near monitoring wells.	

Hazard #3

Motion - Struck by - Bodily injury from impact with moving object

Suggested FHSHB Ref:	2.5, 3.22	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	H&S Standards
Mitigated Risk:	LOW	Job Briefing/Site Awareness
Comments:	Set up traffic control barricades according to TSP, Use Spotters, Wear High Vis PPE.	

Hazard #4

Motion - Cuts and scrapes - Injury from moving object impacting skin or eye

Suggested FHSHB Ref:	2.5, 3.22	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	PPE (see HASP "PPE" section)
Mitigated Risk:	LOW	Job Briefing/Site Awareness
Comments:	Do not overtighten lids on glass bottleware as it may cause breakage. Wear gloves and safety glasses to protect yourself.	

Hazard #5

Chemical - liquids, skin or eye irritation/damage/allergy

Suggested FHSHB Ref:	3.9, 3.22, 3.30, 3.33	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	PPE (see HASP "PPE" section)
Mitigated Risk:	LOW	JSAs
Comments:	Wear safety glasses and nitrile gloves when working with groundwater. If water touches skin, rinse with DI water.	

Task Specific HARC (continued)

Task 6:	Monitor well - Well sounding, water level or product measurements using probes, tapes or downhole water parameter measurements

HARC Unmitigated Hazard Types (H-High, M-Medium, L-Low): FHSHB Ref: 3.9

Biological*	L	Chemical	L	Driving*	-	Electrical	-
Environmental*	L	Gravity*	M	Mechanical	-	Motion*	L
Personal Safety	-	Pressure	L	Radiation	-	Sound	L

Hazard #1

Chemical - liquids, skin or eye irritation/damage/allergy

Suggested FHSHB Ref:	3.9, 3.22, 3.30, 3.33	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	JSAs
Mitigated Risk:	LOW	PPE (see HASP "PPE" section)
Comments:	Be aware of site contaminants; wear Nitrile gloves and safety glasses.	

Hazard #2

Chemical - gasses - injury due to inhalation, asphyxiation, skin/eye contact

Suggested FHSHB Ref:	3.30, 3.32	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	JSAs
Mitigated Risk:	LOW	Job Briefing/Site Awareness
Comments:	Stand up wind when opening monitoring well caps and when gauging the well. Avoid contacting liquids and if contact occurs - rinse immediately with DI water.	

Hazard #3

Chemical - liquids - injury or illness from vapor inhalation

Suggested FHSHB Ref:	3.2, 3.22, 3.30, 3.33	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Field H&S Handbook (see ref. above)
Mitigated Risk:	LOW	See HASP "Monitoring" section
Comments:	Stand up wind when opening monitoring well caps and when gauging the well. Wear safety glasses and nitrile gloves.	

Hazard #4

Mechanical - Pinch point - Injury by pinching of body part in mechanical process

Suggested FHSHB Ref:	3.27.4	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	PPE (see HASP "PPE" section)
Mitigated Risk:	LOW	Site Awareness
Comments:	Use caution when opening rusty or overtightened well/vault lids; use hand tools in the manner intended by the manufacturer; wear work gloves and safety glasses.	

Hazard #5

Mechanical - Pinch point - Injury by pinching of body part in mechanical process

Suggested FHSHB Ref:	3.27.4	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	PPE (see HASP "PPE" section)
Mitigated Risk:	LOW	Machine Guarding
Comments:	Keep fingers clear of well plates and wear gloves. Use the appropriate tools when opening lids.	

Task Specific HARC (continued)

Task 7:	Waste - Containment of IDW in small containment devices greater than 10 gallons but less than or equal to 119 gallons capacity

HARC Unmitigated Hazard Types (H-High, M-Medium, L-Low): FHSHB Ref: 3.3

Biological*	L	Chemical	M	Driving*	-	Electrical	-
Environmental*	M	Gravity*	M	Mechanical	L	Motion*	M
Personal Safety	L	Pressure	L	Radiation	-	Sound	L

Hazard #1

Motion - Struck by - Bodily injury from impact with moving object

Suggested FHSHB Ref:	2.5, 3.22	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Housekeeping
Mitigated Risk:	LOW	JSAs
Comments:	Struck by drum when handling waste, have solid stance and place drums on flat ground. Refer to Traffic Safety Plan in HASP when staging at site. Place drum in designated drum storage area for Arcadis use.	

Hazard #2

Chemical- solids/particulates - injury or illness from skin absorption

Suggested FHSHB Ref:	3.9, 3.22, 3.30, 3.33	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	HASP
Mitigated Risk:	LOW	JSAs
Comments:	Use nitrile gloves when handling any waste and immediately rinse with DI water if it contacts skin.	

Hazard #3

Mechanical - Pinch point - Injury by pinching of body part in mechanical process

Suggested FHSHB Ref:	3.27.4	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	PPE (see HASP "PPE" section)
Mitigated Risk:	LOW	Site Awareness
Comments:	Watch hands and fingers when closing lids to drums. Wear work gloves when handling drums.	

Hazard #4

Chemical - liquids, skin or eye irritation/damage/allergy

Suggested FHSHB Ref:	3.9, 3.22, 3.30, 3.33	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	PPE (see HASP "PPE" section)
Mitigated Risk:	LOW	JSAs
Comments:	Wear nitrile/work gloves and safety glasses when handling waste or drums. If waste contacts skin rinse with DI water.	

Hazard #5

Chemical - solids/particulates, skin or eye irritation/damage/allergy

Suggested FHSHB Ref:	3.9, 3.22, 3.30, 3.33	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	PPE (see HASP "PPE" section)
Mitigated Risk:	LOW	JSAs
Comments:	Wear nitrile/work gloves and safety glasses when handling waste or drums. If waste contacts skin rinse with DI water.	

Hazard #6

Motion - Cuts and scrapes - Injury from moving object impacting skin or eye

Suggested FHSHB Ref:	2.5, 3.22	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	PPE (see HASP "PPE" section)
Mitigated Risk:	LOW	JSAs

Comments:	All personnel shall wear PPE in accordance with HASP and JSA. Use long handled tools when opening and closing drums. Be aware of the potential for sharp edges on the drum lid. Wear work gloves when handling drums.

Task Specific HARC (continued)

Task 8:	Decontamination - Small or hand-held objects using manual methods

HARC Unmitigated Hazard Types (H-High, M-Medium, L-Low): FHSHB Ref: 3.10.4

Biological*	L	Chemical	M	Driving*	-	Electrical	-
Environmental*	L	Gravity*	L	Mechanical	-	Motion*	L
Personal Safety	L	Pressure	L	Radiation	-	Sound	L

Hazard #1

Chemical - liquids, skin or eye irritation/damage/allergy

Suggested FHSHB Ref: 3.9, 3.22, 3.30, 3.33
Overall Unmitigated Risk: MEDIUM
Mitigated Risk: LOW
Comments: Be aware of site contaminants and cleaning agent; wear Nitrile gloves and safety glasses

To mitigate this hazard, use TRACK and the following:
JSAs
PPE (see HASP "PPE" section)

Hazard #2

Chemical - solids/particulates, skin or eye irritation/damage/allergy

Suggested FHSHB Ref: 3.9, 3.22, 3.30, 3.33
Overall Unmitigated Risk: MEDIUM
Mitigated Risk: LOW
Comments: Be aware of site contaminants and cleaning agent; wear Nitrile gloves and safety glasses

To mitigate this hazard, use TRACK and the following:
JSAs
PPE (see HASP "PPE" section)

Hazard #3

Chemical- solids/particulates - injury or illness from skin absorption

Suggested FHSHB Ref: 3.9, 3.22, 3.30, 3.33
Overall Unmitigated Risk: MEDIUM
Mitigated Risk: LOW
Comments: Be aware of site contaminants and cleaning agent; wear Nitrile gloves and safety glasses

To mitigate this hazard, use TRACK and the following:
PPE (see HASP "PPE" section)
JSAs

Hazard #4

Chemical - liquids - injury or illness from vapor inhalation

Suggested FHSHB Ref: 3.2, 3.22, 3.30, 3.33
Overall Unmitigated Risk: MEDIUM
Mitigated Risk: LOW
Comments: Be aware of site contaminants and cleaning agent; wear Nitrile gloves and safety glasses.

To mitigate this hazard, use TRACK and the following:
PPE (see HASP "PPE" section)
JSAs

Task Specific HARC (continued)

Task 11:	Construction - Contractor oversight of system installation

HARC Unmitigated Hazard Types (H-High, M-Medium, L-Low): FHSHB Ref: 4

Biological*	L	Chemical	L	Driving*	-	Electrical	M
Environmental*	L	Gravity*	M	Mechanical	M	Motion*	M
Personal Safety	-	Pressure	L	Radiation	-	Sound	M

Hazard #1

Motion - Cuts and scrapes - Injury from moving object impacting skin or eye

Suggested FHSHB Ref: 2.5, 3.22

Overall Unmitigated Risk: MEDIUM

Mitigated Risk: LOW

To mitigate this hazard, use TRACK and the following:

Site Awareness

PPE (see HASP "PPE" section)

Comments: Understand system installation process; make eye contact with contractor prior to entering the exclusion zone; keep safe distance from work zone; wear safety vest, hard hat, and safety glasses.

Task Specific HARC (continued)

Task 12:	Excavation - Contractor oversight of trenching/piping

HARC Unmitigated Hazard Types (H-High, M-Medium, L-Low): FHSHB Ref: 4.4

Biological*	L	Chemical	L	Driving*	-	Electrical	M
Environmental*	L	Gravity*	L	Mechanical	M	Motion*	M
Personal Safety	-	Pressure	L	Radiation	-	Sound	M

Hazard #1

Motion - Struck by - Bodily injury from impact with moving object

Suggested FHSHB Ref:	2.5, 3.22	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Site Awareness
Mitigated Risk:	LOW	JSAs
Comments:	Stay out of exclusion zone when possible; make eye contact with contractors when needing to approach work area; wear safety vest, hard hat, and safety glasses.	

Hazard #2

Motion - Cuts and scrapes - Injury from moving object impacting skin or eye

Suggested FHSHB Ref:	2.5, 3.22	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Site Awareness
Mitigated Risk:	LOW	PPE (see HASP "PPE" section)
Comments:	Stay out of exclusion zone when possible; make eye contact with contractors when needing to approach work area; wear safety vest, hard hat, and safety glasses.	

Hazard #3

Chemical - solids/particulates, skin or eye irritation/damage/allergy

Suggested FHSHB Ref:	3.9, 3.22, 3.30, 3.33	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Job Briefing/Site Awareness
Mitigated Risk:	LOW	PPE (see HASP "PPE" section)
Comments:	Be aware of site contaminants; wear nitrile gloves and safety glasses.	

Hazard Communication (HAZCOM)/Global Harmonization System (GHS)

[ ] HAZCOM/GHS for this project is managed by the client or general contractor

List the chemicals anticipated to be used by Arcadis on this project per HAZCOM/GHS requirements.
(Modify quantities as needed)

	Preservatives	Qty
[ ]	Not applicable	
[X]	Hydrochloric acid	<500 ml
[ ]	Nitric acid	<500 ml
[X]	Sulfuric acid	<500 ml
[ ]	Sodium hydroxide	<500 ml
[ ]	Zinc acetate	<500 ml
[ ]	Ascorbic acid	<500 ml
[ ]	Acetic acid	<500 ml
[ ]	Isopropyl alcohol	< 4 gal.
[ ]	Formalin (<10%)	< 4 gal.
[ ]	Methanol	<500 ml
[ ]	Sodium bisulfate	<500 ml

	Decontamination	Qty
[ ]	Not applicable	
[X]	Alconox	≤ 5 lbs
[X]	Liquinox	≤ 1 gal
[ ]	Acetone	≤ 1 gal
[ ]	Methanol	≤ 1 gal
[ ]	Hexane	≤ 1 gal
[ ]	Isopropyl alcohol	≤ 4 gal
[ ]	Nitric acid	≤ 1 L
[ ]	Other:	

	Calibration	Qty.
[ ]	Not applicable	
[X]	Isobutylene/air	1 cyl
[ ]	Methane/air	1 cyl
[ ]	Pentane/air	1 cyl
[ ]	Hydrogen/air	1 cyl
[ ]	Propane/air	1 cyl
[ ]	Hydrogen sulfide/air	1 cyl
[ ]	Carbon monoxide/air	1 cyl
[X]	pH standards (4,7,10)	≤ 1 gal
[X]	Conductivity standards	≤ 1 gal
[X]	Other:	
	ORP Standard	≤ 1 gal
	Multi-Gas Cal Gas	1 cyl

	Fuels	Qty.
[ ]	Not applicable	
[X]	Gasoline	≤ 5 gal
[ ]	Diesel	≤ 5 gal
[ ]	Kerosene	≤ 5 gal
[ ]	Propane	1 cyl
[ ]	Other:	

	Kits	Qty.
[X]	Not applicable	
[ ]	Hach (specify):	1 kit
[ ]	DTECH (specify):	1 kit
[ ]	Other:	1 kit

	Remediation	Qty.
[ ]	Not applicable	
[X]	Carbon	
[ ]		
[ ]		
[ ]		
[ ]		

	Other:	Qty.
[ ]	Not applicable	
[X]	Spray paint	≤ 6 cans
[X]	WD-40	≤ 1 can
[ ]	Pipe cement	≤ 1 can
[ ]	Pipe primer	≤ 1 can
[ ]	Mineral spirits	≤ 1 gal

	DOT(1):	Qty.
[ ]	MOT eligible soils	
[ ]	MOT eligible water	
[ ]	MOT eligible solids	
[ ]	MOT eligible liquids	
[ ]		
[ ]		
[ ]		

(1) Attach applicable Materials of Trade (MOT) Quick Form to shipping determination or this HASP. SDS not generally applicable to this category.

SDSs for this project will be available in printed form in the company vehicle. All project workers will be notified of the SDS location in their initial safety briefing.

Contractor SDSs will be submitted to Arcadis in advance of work and will be filed with Arcadis SDSs as indicated above.

This project will not be utilizing materials subject to the HAZCOM Standard in bulk storage. In this HASP, bulk storage means any material stored on the project site in a bulk packaging >119 gallons (> 450 L) liquid capacity or a palletized quantity of a material in packagings ≤119 gallons (≤450 L) liquid capacity.

Air Monitoring

☐ There are no atmospheric chemical, radiological, or particulate hazards on this project requiring air monitoring.
☐ Air monitoring is the responsibility of the client or subcontractor.

Constituents of Interest:

Time Weighted Averages (TWAs) are ACGIH 8-Hr Threshold Limit Values (TLVs) unless noted.

Gasoline			
TWA	30 ppm, Arcadis administrative limit	LEL/UEL (%):	1.4/7.6
STEL	500 ppm	VD (Air = 1):	NA
IDLH	NA	VP (mmHg):	38-300

Diesel		Anticipated Breathing Zone Concentration <=	3	mg/m3
TWA	100 mg/m3, skin, (15 ppm Arcadis limit-see PID warning)	LEL/UEL (%):	NA	
STEL	NA	VD (Air = 1):	NA	
IDLH	NA	VP (mmHg):	NA	

TWA - Time Weighted Average (ACGIH TLV unless noted)
STEL - Short Term Exposure Limit
IDLH - Immediately Dangerous to Life and Health
LEL/UEL - Lower /Upper Explosive Limit
RGD - Relative Gas Density
VP - Vapor Pressure

Notes:
One or more constituents above is listed with a skin notation. Avoid conditions where dusts, mists, or aerosols are created. Avoid skin contact with impacted media. Air monitoring is not required during site visits or non-intrusive work.

Required Monitoring Instruments, Action Levels and Monitoring Frequency

Gray fields below are not automated. Make necessary selections from drop down menus.

Photoionization Detector — Select Lamp: 10.6 eV

Diesel/Fuel Oil: The 15 ppm Arcadis recommended exposure limit for diesel/fuel oil is not included in the computation below. Manual action level adjustment may be required. The PID may provide a slow response to diesel fuel/fuel oil.

Computed action levels (PID units) (1):			Computed action levels have been manually adjusted.
<	16.7		Continue working
	16.7 -	33.3	Levels sustained > 5 minutes, monitor continuously and review engineering controls and PPE. Proceed with caution.
>	33.3000		Stop work and contact SSO

(1) Computed action levels are for PIDs which have not been programmed to correct TLVs for specific constituents or mixtures.

Particulate/aerosol monitoring is not required. Re-evaluate if visible dusts or aerosols cannot be controlled.

Action levels are in mg/m3			Computed action levels have been manually adjusted.
<	NA		Continue working
	NA		Levels sustained > 5 minutes, monitor continuously and review engineering controls and PPE. Proceed with caution.
>	NA		Stop work and contact SSO

Breathing zone air monitoring using the above instruments will be performed at the following frequency:

Hourly

If manually logging air monitoring results, all results must be documented, including non-detects.

Multigas (including LEL/O2 and Hg vapor) monitoring is not required.

LEL/O2 Meter	0-5% LEL	Continue work
LEL/O2 Monitoring Not Required	>5-10% LEL	Continually monitor, review engineering controls, proceed with caution
	>10% LEL	Stop work, evacuate, contact SSO
	19.5%-23.5% O2	Normal, continue work
	<19.5% O2	O2 deficient, stop work, evacuate, contact SSO
	>23.5% O2	O2 enriched, stop work, evacuate, contact SSO

Additional Gas/Vapor Monitoring is Not Required

		1/2 TLV	Stop Work Action Level	Comments
☐	Ammonia	12.5 ppm	25 ppm	
☐	Carbon dioxide	2500 ppm	5000 ppm	
☐	Carbon monoxide	12.5 ppm	25 ppm	
☐	Chlorine	0.05 ppm	0.1 ppm	
☐	Hydrogen cyanide	2.35 ppm (skin)	4.7 ppm* (skin)	
☐	Hydrogen sulfide	0.5 ppm	1 ppm	
☐	Methane	Simple Asphyxiant		
☐	Nitrogen dioxide	0.1 ppm	0.2 ppm	
☐	Phosphine	0.025 ppm	0.05 ppm	
☐	Sulfur dioxide	0.125 ppm	0.25* ppm	
☐	Mercury vapor	0.0125 mg/m3	0.025 mg/m3	

* Ceiling or STEL value

All air-monitoring instruments must be calibration checked daily, if used, per manufacturer's instructions. Calibration checks, including calibration gases used, must be documented.

Compound specific monitoring using indicator tubes or chips is not required.

Indicator:		≤TWA	Continue work
☐ Tube	☐ Chip	>TWA	Stop work, review engineering controls and PPE, contact SSO
Compound(s):			

Indicator tube/chip monitoring frequency: Not applicable

Tick and Poisonous Plant Hazards

For all projects with outdoor work, biological hazards must be addressed in the tailgate safety meeting each day. The following controls must be used to mitigate biological hazards while working and must also be discussed in the tailgate safety meeting. For low risk situations, the discussion must include exposure to weeds/vegetation near fences, buildings, etc.

Controlling Tick Hazards

Risk Guide for Ticks:

Low	Paved areas; parking lots; well manicured lawns and fields; no work taking place within 15 feet of vegetated areas; work in REGIONS with no tick populations; sub-freezing temperatures, snow or ice cover on ground.*
Medium	Brush hogged fields, wetlands, and grasslands; forested areas with little undergrowth; weeds less than knee height; moderately dense foliage; sporadic or moderately vegetated shaded areas; average leaf accumulation and decaying material on the ground; work taking place in fields after application of insecticide; work in REGIONS with a recognized moderate tick populations; outdoor work during spring, summer and fall months.*
High	Uncut fields, wetlands, forested areas, and grasslands; weeds taller than knee height; heavy dense foliage; heavily vegetated shaded areas; excessive accumulations of leaves and decaying material on the ground; work in REGIONS with recognized heavy tick populations; areas with posted tick hazard warnings; outdoor work during spring, summer and fall months.*

*Cold weather does not eliminate risk of exposure to deer ticks as they may be active all year in areas that experience subfreezing temperatures.

Ticks are ranked as a **Low** risk for this project

Care should be taken to avoid walking through or working in tall grasses, overgrown or bushy vegetation to the extent reasonable and practical. No single control is effective against ticks.

Select required controls below:

Engineering Controls

- [ ] Mowing of work area
- [ ] Clearing overgrown vegetation
- [ ] Pesticide application
- [X] Other: Not applicable

Administrative Controls

- [ ] Complete tick check morning/evening
- [ ] Scheduled tick check: _____
- [X] Inspect backpacks, equipment cases, etc. daily
- [X] Vehicle cab - maintain good housekeeping
- [ ] Other: _____

Personal Protective Equipment

- [ ] Light colored clothing
- [ ] Light colored hat/hardhat
- [ ] Pants tucked in boots
- [ ] Shirt tucked into pants
- [X] Long sleeved shirt and long pants
- [ ] White Tyvek pants
- [ ] White coveralls/Tyvek
- [ ] Taped cuffs/pant legs
- [ ] Tick gators
- [ ] Double sided tape/duct tape sticky side out
- [ ] Insect mesh/netting for face/head or whole body suit
- [ ] Other: _____

Heat stress signs/symptoms and controls to also be addressed in tailgate safety meeting if temperatures >80°F

Repellents

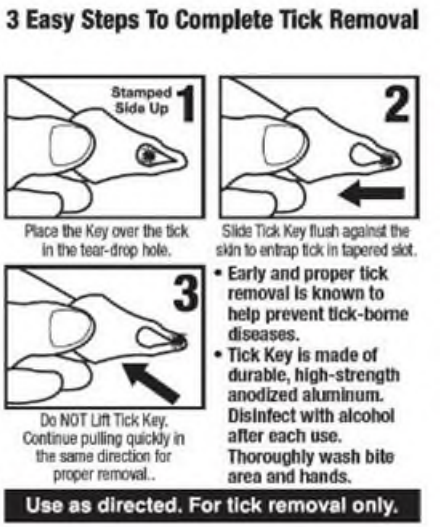
- [X] Repellents will not be used
- [ ] Permethrin impregnated clothing (purchased)
- [ ] Permethrin (0.5% self applied/treated to clothing)
- [ ] Deet 20-40% applied to skin
- [ ] Other: _____

If repellents are not used, additional PPE controls must be considered.

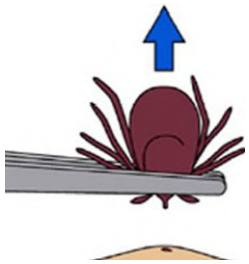
Tick Removal and First Aid

Ticks removed within 24 hours of embedment represent a very low risk for adverse outcomes. Perform tick checks as directed above. To properly remove a tick:

Using a Tick Removal Tool



Using Tweezers



1) Use point tip tweezers, if available, to reduce potential of crushing the ticks body
2) Grasp the tick as close to skin as possible
3) Pull upward with even pressure.

Do not crush tick with fingers

After removal, wash affected area with alcohol or iodine. Wash hands thoroughly after removal.
Document date/time of the removal in field notes, field form or H&S app.
If rash or fever develops, call WorkCare

Poisonous Plants (Poison Ivy, Poison Oak, Poison Sumac)

All work outdoors, regardless of time of year, must address poisonous plant hazards and controls in the tailgate safety meeting. For low risk projects, the discussion should consider potential vegetation exposure near fences, buildings, work near trees, etc.

Controlling Exposure to Poisonous Plants

Poisonous Plants are ranked as a **Low** risk on this project

Select required controls below:

Engineering Controls

- [X] Not applicable
- [ ] Mowing of work area
- [ ] Clearing overgrown vegetation
- [ ] Herbicide application
- [ ] Other: _____

Administrative Controls

- [ ] Identify and avoid (see ID Quick Guide below)
- [ ] Watch for signs or symptoms of exposure
- [X] Vehicle cab - maintain good housekeeping
- [ ] Other: _____

Personal Protective Equipment

- [ ] Gloves
- [ ] Hat/hardhat/head covering
- [ ] Pants tucked in boots
- [ ] Shirt tucked into pants
- [X] Long sleeved shirt and long pants
- [ ] White coveralls/Tyvek
- [ ] Taped cuffs/pant legs
- [ ] Dust mask (during burning activities, etc.)
- [ ] Other: _____

Heat stress signs/symptoms and controls to also be addressed in tailgate safety meeting if temperatures >80°F

Repellents

X	Repellents will not be used
	Barrier creams
	Other: _____

Skin Decontamination

	Wash with post-exposure soap and water
	Wash with soap and water (use hot water if available)
X	Hot shower at end of day
	Other: _____

Equipment Decontamination

Due to the low risk associated with poisonous plants on this project, portable equipment and tools may still have a potential to be contaminated with urushiol (the oil that causes allergic reactions and dermatitis in poisonous plants covered by this plan). It is recommend to decontaminate handles, grips, and hand holds of tools and equipment with post-exposure soap and water or alcohol spray (if safe to do so for the equipment/tool being decontaminated) as a best practice.

Clothing Decontamination

Wash work clothing in hot water separate from other clothing. Even though there is a low risk for poisonous plants on this project, work boots should be considered potentially contaminated with urushiol. Decontaminate with post-exposure soap and water or hot soap and water. If safe for the boot, consider spraying with alcohol spray of post exposure soap is not available.

First Aid

If skin irritation or other signs of allergic reaction develops contact WorkCare for assistance. Document date and time of exposure, if known, in field notes, field form or H&S app.

Identification Quick Guide

Ticks:

American Dog Tick

Blacklegged (Deer) Tick

Brown Dog Tick

Groundhog Tick

Gulf Coast Tick

Lone Star Tick

Rocky Mountain Wood Tick

Soft Tick

Poison Ivy:

Poison Oak:

Poison Sumac:

For other biological hazards, address the hazards and controls in the JSA for the work task.

Personal Protective Equipment (PPE)

See JSA or Permit for the task being performed for required PPE. If work is not conducted under a JSA or Permit, refer to the governing document for PPE requirements. At a minimum, the following checked PPE is required for all tasks during field work (outside of field office trailers and vehicles) not covered by a JSA or Permit on this project:

Minimum PPE required to be worn by all staff on project:						Specify Type:
X	Hard hat		Snake chaps/guards		Coveralls:	
X	Safety glasses		Briar chaps		Apron:	
	Safety goggles		Chainsaw chaps		Chem. resistant gloves:	
	Face shield		Sturdy boot		Gloves other:	
	Hearing protection	X	Steel or comp. toe boot		Chemical boot:	
	Rain suit		Metatarsal boot		Boot other:	
X	Other:			X	Traffic vest, shirt or coat:	Class II
	Long Sleeves				Life vest:	

Task specific PPE: Nitrile Gloves and Work Gloves
Comments:

Task specific PPE - worn when applicable hazards are present as described in the corresponding JSA.

Medical Surveillance

All Arcadis employees and subcontractors performing field work will be required to be current in HAZWOPER medical surveillance.

Client and DOT mandated drug and alcohol testing is not required for this project and will not be performed.

Hazardous Materials Shipping and Transportation

A shipping determination package has been prepared, reviewed and provided to Arcadis field staff for this project.

Traffic Safety and Traffic Safety Plans (TSPs)

All or portions of the project work will be conducted in a parking lot and/or private roadway. A Non-ROW TSP addressing this work is attached to this HASP.

Arcadis Commercial Motor Vehicles (CMVs)

CMVs operated by Arcadis employees on public roadways will not be utilized on this project. Arcadis defines a CMV as any single vehicle with a gross vehicle weight rating (GVWR) ≥10,001 pounds or a truck and trailer combination with a combined GVWR ≥10,001 pounds (GVWR of truck + GVWR of trailer = ≥10,001 pounds).

Site Control

Site control requirements are addressed in the applicable task JSA for this project. JSAs requiring site control are attached to this HASP.

Decontamination

Decontamination protocols are addressed in the applicable task JSA(s) for this project. The applicable JSAs are attached to this HASP.

Sanitation

The project scope is a mobile work operation. The project field team will have reasonable access to restroom facilities within 10 minutes of the work area where the mobile work activity is actively taking place. Potable water will be carried by the field team in the vehicle used for the project. Unless alternate requirements are stipulated in a plan supplement (i.e. Heat Injury and Illness Prevention Plan), permit or JSA, bottled or water coolers with potable water will be provided to project workers at 1 gallon/worker/day.

Safety Briefings

Arcadis will lead all safety briefings on this project and will document the safety briefing on a Tailgate Safety Briefing form or logbook. Safety briefings will be conducted once at the beginning of each work day unless the Site Safety Officer deems more frequent safety briefings will be required based on work being conducted. All project workers, including Arcadis subcontractors, will be required to attend the safety briefing. Site visitors and project workers not on duty during the morning safety briefing will receive the safety briefing upon their arrival onto the project site for the day.

Employee Health and Safety Engagement

The CPM or APM is responsible for reviewing and establishing H&S engagement goals for the project. These goals are summarized below.

Hazard Observations (via H&S App or TIP) required at the following frequency on this project:

1 per event

Close Call reporting (via H&S app) goals for this project:

1 per event or as observed

Other (specify):

Safety Equipment and Supplies

Safety equipment/supply requirements are addressed in the JSA or Permit for the task being performed. If work is not performed under a JSA or Permit, the following safety equipment is required to be present on site in good condition unless otherwise noted (Check all that apply):

X	First aid kit		Insect repellent:
	Bloodborne pathogens kit	X	Sunscreen
X	Fire extinguisher		Air horn
	Eyewash (ANSI compliant)	X	Traffic cones
X	Eyewash (bottle)		2-way radios
X	Drinking water		Heat stress monitor
	Other:		See Tick and Poisonous Plant Hazards section for addtional equipment/supply information.

International Travel

International travel is not required for this project.

Spill Control and Containment

Spill control and containment protocols, including required equipment and supplies, are located in a JSA prepared by Arcadis. Implementation of the JSA requirements are the responsiblity of Arcadis.

Use of Electronic Devices in Areas of Increased Safety Risk

The intent of this section is to ensure use of standard computer tablets, laptops, or cell phones (collectively referred to in this HASP as a digital device) is performed in a manner that is effective in preventing or mitigating injury to the user of the digital device.

Use of electronic devices within 25 ft of a railroad track requires approval of the railroad owning or operating on the track. Railroad On-Track Safety rules for use of electronic devices must be followed without exception even if not under contract to the railroad (Arcadis policy). Refer to the Arcadis Railroad Safety Handbook for more information.

Use of electronic devices in an active parking lot must be addressed in the Non-ROW TSP. Use of Non-ROW short-term traffic controls in situations where digital data collection or documentation is conducted should be avoided unless spotter options are utilized. When practical, use project vehicle as shield in parking lots.

Electronic device use and distractions to be discussed and documented in the job briefing/safety briefing.

Signatures

I have read, understand and agree to abide by the requirements presented in this health and safety plan. I understand that I have the absolute right to stop work if I recognize an unsafe condition affecting my work until corrected.

Printed Name	Signature	Date

Add additional sheets if necessary

You have an absolute right to STOP WORK if unsafe conditions exist!

Attachment A
JSAs

Job Safety Analysis

General

JSA ID	HASP 1	**Status**	Complete
Job Name	General Industry-Driving - passenger vehicles	**Created Date**	12/27/2022
Task Description	Driving a car, van, or truck on public roadways.	**Completed Date**	12/27/2022

Client / Project

Client	BNSF
Project Number	30144053
Project Name	BNSF Former Maintenance and Fueling Facility
Project Manager	Kyle Haslam

User Roles

Role	Employee	Due Date	Completed Date
Developer	Dawn Monico	12/27/2022	12/27/2022
HASP Reviewer	Monico, Nicholas - Wexford PA	12/27/2022	12/27/2022
Quality Reviewer			

Job Steps

Job Step No.	Job Step Description		Potential Hazard	Critical Action	H&S Reference
1	Pre-Trip Inspection	1	Failing to perform pre-trip inspections may cause mechanical failure, accident or injury.	Perform walk around of vehicle with particular attention to tire inflation and condition. Check lights, wipers, seatbelts for proper operating condition. Properly adjust seat and mirrors prior to vehicle operation. Use or review vehicle inspection checklist as required under the MVSP.	ARC HSGE024 Motor Vehicle Safety Standard (MVSP)
		2	Scrapes, cuts, burns to hand if inspecting engine fluids and/or tires. Eye splash hazard if inspecting engine fluids. Pinch or crush hazards when opening or closing hood, trunk, or tailgate.	Wear protective gloves and safety glasses as described below when checking under hood or tires. Use TRACK and keep hands clear when opening/closing hood, trunk, or tailgate to avoid crush or pinch hazard.	
		3	Struck by other vehicles while walking around vehicle performing inspections.	Wear high visibility vest, shirt, or coat while performing inspections in parking lots or other areas with a traffic hazard. Remain vigilant of moving vehicles or equipment in area, face oncoming vehicles to extent practical.	
		4	Improperly secured cargo may dislodge creating injury, property damage, or road hazard.	Ensure all cargo is properly secured to prevent movement while the vehicle is in operation. This includes cargo in the cab of the vehicle.	
2	Driving a motor vehicle on public streets	1	Failing to observe traffic flow ahead increases risk of hard braking resulting in potential impact of vehicle ahead, being struck by another vehicle from behind, and decreases decision making time.	Use Smith System Key #1, "Aim High in Steering". **Look ahead (15 seconds if possible) to observe traffic flow and traffic signals.** Adjust speed accordingly to keep vehicle moving and avoid frequent braking. Select lane of least traffic and adjust speed based on observed signal timing when possible. Avoid following directly behind large vehicles that obscure view ahead.	Smith System "5-Keys" is a registered trademark of Smith System Driver Improvement Institute, Inc.

		2	Failing to observe vehicles, pedestrians, bicyclists, and other relevant objects in vicinity of your vehicle increases risk of side swipes, rear ending, and third party injury.	Use Smith System Key #2, "Get the Big Picture". **Maintain 360 degrees of awareness around vehicle.** Check a mirror every 6-8 seconds, maintain space around the vehicle, choose a lane that avoids being boxed in. Look for pedestrian activity ahead in crosswalks or sidewalks. Watch for construction zone approach signs and act early by executing lane changes and reducing speed.	
		3	Failing to keep your eyes moving increases risk of not seeing relevant vehicles, pedestrians, and objects in your vicinity that may impair your ability to make timely and appropriate driving decisions and also increases risk of accident.	Use Smith System Key #3, "Keep Your Eyes Moving". **Move your eyes every 2 seconds and avoid staring while evaluating relevant objects.** Scan major and minor intersections prior to entering them. Check mirrors.	
		4	Failing to maintain space around and in front of your vehicle increases risk of striking another vehicle or being struck by another vehicle. Insufficient space shortens time for effective driving decision making resulting in increased accident risk.	Use Smith System #4, "Leave Yourself an Out". **Use 4 second rule when following a vehicle.** Avoid driving in vehicle clusters by adjusting speed and using lanes that permit maximum space and visibility. When stopped, keep one car length space in front of vehicle ahead or white line.	
		5	Failing to communicate with other drivers and pedestrians increases risk of striking vehicles, pedestrians, or being struck by other vehicles, especially from the rear.	Use Smith System Key #5, "Make Sure They See You". **Brake early and gradually when stopping to reduce potential of being rear ended.** Keep foot on brake while stopped. Use turn signals and horn effectively. Establish eye contact with other drivers and pedestrians to extent practical. Use vehicle positioning that promotes being seen.	
		6	Distractions within the vehicle takes focus off driving, increases risk of accident decreases time for making effective driving decisions.	**Cell phone use (any type or configuration) is prohibited while the vehicle is in motion.** Familiarize yourself with vehicle layout and controls (radio, temperature controls, etc.) prior to operating unfamiliar vehicles. Set controls prior to operating vehicle. Use GPS in unfamiliar areas to avoid use of paper maps/directions while driving. Set GPS prior to vehicle operation. Pull over and stop to modify GPS functions. Avoid consuming food or drink while driving.	
3	Parking	1	Parking vehicle in areas of clustered parked vehicles or near facility entrance may impair visibility to oncoming traffic in lot and increase exposure to pedestrian traffic.	**Use pull through parking or back into parking space when permitted or practical.** When practical and safe to do so, park away from other vehicles and avoid parking near the facility entrance or loading docks. If available, use a spotter to aid in backing activity. Back no further than necessary and back slowly. Get out and look (GOAL) if uncertain of immediate surroundings. Tap horn prior to backing.	

PPE Personal Protective Equipment

Type	Personal Protective Equipment	Description	Required
Eye Protection	safety glasses	While checking engine or tires	Required
Hand Protection	work gloves (specify type)	Leather or equivalent checking engine or tires	Required

Supplies

Type	Supply	Description	Required
Communication Devices	mobile phone		Required
	other	Vehicle kit (applies to company trucks)	Required
Miscellaneous	fire extinguisher	Applies to company trucks	Required
	first aid kit	Applies to company trucks	Required

Job Safety Analysis

ARCADIS Design & Consultancy for natural and built assets

JSA Description: General Oversight	**Date of JSA Development: 8/31/21**
Project Name: BNSF Skykomish	**PMCoW: 30144053**
Site Address: 105 6th Street North, Skykomish, WA 98288	**Project No:**

Development Team (Include employer & email if not employed by Arcadis.)		
Zack Mason		
Reviewed By (Include employer & email if not employed by Arcadis.)	**Position/Title:**	**Review Date** (MM/DD/YYYY)

Permits/Plans Required (general, Specialized, etc.):	
Specialized tools/equipment:	

MINIMUM REQUIRED PERSONAL PROTECTIVE EQUIPMENT

- ☑ ANSI/ISEA 107-2010 Class 2 or 3 vest or ANSI/ISEA 107-2015 Type R, Class 1 or 2 vest
- ☑ Long pants
- ☑ Long-sleeved shirts
- ☑ Safety glasses, wraparound or with side shields labeled with ANSI Z87.1 rating, or a certification card for lenses and frames
- ☑ Safety footwear meeting ASTM F2413-05 standard with chemical or oil resistant soles
- ☑ High visibility work gloves (when high visibility glove options exist for a particular glove type)
- ☑ Hard hat that complies with ANSI Z89.1

TASK SPECIFIC: Personal Protective Equipment (PPE) Determination*

Eye Protection

Must comply with ANSI Z87.1

- ☐ Impact Goggles
- ☐ Flexible goggles
- ☐ Welding goggles/helmet or face shield. Tinted lenses required
- ☐ Laser safety glasses

Head Protection

- ☐ Type E Hardhat (Electrical)
- ☐ Hardhat with chin strap, miner's helmet with chin strap or mountaineering helmet with chin strap

Hazardous Atmosphere

- ☐ Photoionization Detector (PID)
- ☐ Flame Ionization Detector (FID)
- ☐ Dust Monitor
- ☐ LEL / O_2 Meter
- ☐ H_2S Meter

Hearing Protection

- ☐ Ear Plugs (noise 80 db)
- ☐ Ear Muffs with Ear Plugs (noise 105 db)

Body Protection

- ☐ Chemical resistant cloting recommended on SDS
- ☐ Chain saw chaps
- ☐ Snake chaps or boots marketed as "snake proof"[3]
- ☐ ANSI/ISEA 107-2010 Class 3 vest or ANSI/ISEA 107-2015 Type R, Class 2 vest if low light conditions or traffic flow at 50 mph or more
- ☐ ANSI/ISEA 107-2010 Class 2 or 3 *BREAKAWAY* vest or ANSI/ISEA 107-2015 Type R, Class 1 or 2 vest
- ☐ Sunscreen lotion >= SPF30
- ☐ Insect repellant (DEET: flying insects)
- ☐ Insecticide (Permethrin: ticks)
- ☐ US Coast Guard approved personal flotation device (PFD) – Type I, II or III

Face Protection

- ☐ Chemical protective goggles that comply with ANSI Z87.1
- ☐ Face Shield over safety glasses

Respiratory Protection

- ☐ Half-face Air Purifying Respirator
- ☐ Full-face Air Purifying respirator
- ☐ SCBA or Supplied Air

Fall Protection

- ☐ Personal fall arrest system designed or approved by a qualified person OR other means of fall protection determined by qualified person

Hand Protection

- ☐ Chemical resistant gloves per SDS
- ☐ Cut-resistant gloves or liners
- ☐ Leather/Work gloves
- ☐ Welding gloves
- ☐ Leather gloves, insulated
- ☐ Nitrile gloves
- ☐ Impact resistant gloves

Foot Protection

- ☐ Safety shoes or boots with metatarsal guards
- ☐ Safety boots with puncture-resistant midsoles or that have built-in puncture resistance (PR rated)
- ☐ Safety boots with electric hazard (EH) protection (standard in most footwear)
- ☐ Rubber-sole boots or grips
- ☐ Chemical resistant boot covers
- ☐ Lace-up safety boots conforming to ASTM F2413-05 or equivalent in non-US jurisdictions

Heat, Flame, Flash Fire or Arc Hazard

- ☐ Cooling vest
- ☐ Fire retardant clothing (FRC)

***If an item is checked, it is relevant for all job steps. If an item is specific to a particular job step it must be noted in the Critical Action(s) column in the JSA.**

Job Safety Analysis

ARCADIS Design & Consultancy for natural and built assets

JSA Description: General Oversight	Site ID:

BIOLOGICAL
CHEMICAL
ELECTRICAL
GRAVITY
HUMAN PERFORMANCE
MECHANICAL
MOTION
PRESSURE
RADIATION
SOUND
TEMPERATURE

Job Steps (Avoid listing too many job steps for a task. Consider multiple JSAs instead.)	Potential Hazard(s) (Avoid being too general- i.e. "slip, trip, fall" or "fire". Example of better wording: "tripping on silt fence" or "fire due to static discharge in hose".)	Critical Action(s) (Avoid using generic words (i.e. use "proper" PPE or "proper" lifting techniques). Consider "wear Level A2 cut resistant gloves under nitrile gloves" or "lift with the legs and not the back, get assistance when carrying over 50 pounds or bulky loads".)	Responsible Person(s) – Initials
1. Site access and work area walk	MOTION - Broken bones, sprains, lacerations, or death from being struck by motor vehicle	1. Observe vehicle traffic and pedestrian traffic in or around potential work zones. When setting up cones and barricades scan work zone and surrounding area for traffic. Make eye contact with drivers and give right-of-way to all motor vehicles present. 2. Establish traffic control for exclusion zone per requirements; use 42.0" high-visibility delineator post with flags; and park vehicle as barrier, if feasible. 3. Wear DOT Class II or higher hi-visibility traffic vests to make personnel more visible to on and off site traffic	
	MECHANICAL - Lacerations, abrasions to hands when carrying A-frame barricades	1. Identify pinch points with tape or highly visible marking ink to increase awareness. 2. Wear Level 2 cut-resistant gloves prevent soft tissue injuries	
	MOTION - Nails or other sharp objects piercing the bottoms of boot and feet	1. Perform a site walks to clear area of nails and other sharp objects on the ground using broom to push the objects out of the work area 2. Wearing puncture resistant boots or steel sole inserts to prevent sharp objects from piercing the bottom of boots	
2. Observing General Oversight	MOTION – Broken bones, lacerations or sprains when walking in inclement weather conditions.	1. Watch for black ice. 2. Use caution when walking. 3. Rain/Mud: Plan walking path to avoid muddy areas when available; avoid flooded areas. 4. Fog: Stay alert for equipment and hard-to-see hazards.	
	BIOLOGICAL – Bites or stings from ticks/ mosquitoes and poison oak/ivy/sumac, etc.	1. Have insect spray available to kill wasps/bees. 2. Inspect work area for inspects and avoid if observed. 3. Inspect clothing for ticks after being onsite. 4. Wear gloves, long sleeves, and pants to prevent insect bites.	

Job Safety Analysis

ARCADIS Design & Consultancy for natural and built assets

JSA Description: General Oversight	Site ID:

BIOLOGICAL

CHEMICAL

ELECTRICAL

GRAVITY

HUMAN PERFORMANCE

MECHANICAL

MOTION

PRESSURE

RADIATION

SOUND

TEMPERATURE

Job Steps (Avoid listing too many job steps for a task. Consider multiple JSAs instead.)	Potential Hazard(s) (Avoid being too general- i.e. "slip, trip, fall" or "fire". Example of better wording: "tripping on silt fence" or "fire due to static discharge in hose".)	Critical Action(s) (Avoid using generic words (i.e. use "proper" PPE or "proper" lifting techniques). Consider "wear Level A2 cut resistant gloves under nitrile gloves" or "lift with the legs and not the back, get assistance when carrying over 50 pounds or bulky loads".)	Responsible Person(s) – Initials
		5. Wear light colored clothing to prevent attracting insects.	
	MOTION – Serious injury or death from contact with heavy equipment or truck traffic.	1. Keep 20 feet from reach of equipment and out of the swing radius or line of fire. 2. Do not approach heavy equipment until it has been de-energized and communication has been established with the equipment operator.	
	CHEMICAL – Skin or respiratory irritation from exposure to contaminants of concern [Benzene; Ethyl benzene; Ammonia; Chlorobenzene; Coal Tar Pitch; and Lead].	1. Monitor DUST onsite with CAMP monitoring. 2. Don respiratory protection or stop work if necessary. 3. Maintain safe distance from open excavation 4. Wear nitrile gloves if handling potentially impacted soil. Decon any boots and equipment that may have come in contact of impacted materials.	
	TEMPERATURE – Heat Stroke or heat stress from high temperatures and level of work load.	1. Take shelter in vehicle/trailer to keep cool or in shaded area as necessary. 2. Drink water to stay hydrated and cool. 3. Wear appropriate clothing for weather conditions. 4. Watch coworkers for signs of heat stroke. Temperature (°F) / Maximum Allowable Work Time / Minimum Mandatory Rest Time 95+ / 8 minutes / 15 minutes 85-95 / 13 minutes / 10 minutes 75-85 / 20 minutes / 10 minutes	
	SOUND – Hearing damage from equipment noise	1. Stay out of the exclusion zone to maintain a safe distance to limit noise exposure. 2. Wear hearing protection when necessary. Generally when you need to raise your voice to converse with a person standing next to you.	

Job Safety Analysis

JSA Description: General Oversight	Site ID:

BIOLOGICAL

CHEMICAL

ELECTRICAL

GRAVITY

HUMAN PERFORMANCE

MECHANICAL

MOTION

PRESSURE

RADIATION

SOUND

TEMPERATURE

Job Steps (Avoid listing too many job steps for a task. Consider multiple JSAs instead.)	**Potential Hazard(s)** (Avoid being too general- i.e. "slip, trip, fall" or "fire". Example of better wording: "tripping on silt fence" or "fire due to static discharge in hose".)	**Critical Action(s)** (Avoid using generic words (i.e. use "proper" PPE or "proper" lifting techniques). Consider "wear Level A2 cut resistant gloves under nitrile gloves" or "lift with the legs and not the back, get assistance when carrying over 50 pounds or bulky loads".)	**Responsible Person(s) – Initials**
	MOTION – Broken bones, lacerations or sprains from tripping over debris while taking photographs	1. Take photographs and field notes from a stationary position. Do not walk and talk while in the work area and on the phone. 2. Plan route before walking. Conduct TRACK all of the time.	

Sound Pressure Level (dBA)	Source of Noise
40	Whisper
50	Average residence
60	Large store or office
70	Inside a luxury car at 60 mph
80	Inside a sports car at 60 mph
120	Jet taking off

JSA Acknowledgement

"I have read this JSA, and I understand the hazards and safe work practices associated with the task.
If conditions change or an additional hazard is recognized, I will Stop Work and notify the Site H&S Officer immediately:"

This JSA must be acknowledged by affected workers every shift.

Name	Signature	Initials Used on Form	Date	Date	Date
PMCoW:					

Verification of Critical Actions – Undersigned verifies that critical actions are in place, or have been evaluated based on availability, effectiveness and understood by the crew prior to work starting.

Name of Verifier	Signature	Date	Date	Date

End of Day Lookback – Use this section to log changes made to the JSA throughout the day and note any recommendations for Task JSA.

Brief description Lookback	Lookback Leader Name	Date

Job Safety Analysis

JSA Description: Groundwater Monitoring	**Date of JSA Development: 02/01/2022**
Project Name: BNSF Skykomish	**PMCoW:**
Site Address: 105 6th Street North, Skykomish, WA 98288	**Project No: 30144053**

Development Team (Include employer & email if not employed by Arcadis.)		
Reviewed By (Include employer & email if not employed by Arcadis.)	**Position/Title:**	**Review Date** (MM/DD/YYYY)

Permits/Plans Required (general, Specialized, etc.):	General PTW if inside OERB.
Specialized tools/equipment:	PID, Pumps, Tubing, Buckets, Water Quality Meter, Sampling Equipment

MINIMUM REQUIRED PERSONAL PROTECTIVE EQUIPMENT

- ☑ ANSI/ISEA 107-2010 Class 2 or 3 vest or ANSI/ISEA 107-2015 Type R, Class 1 or 2 vest
- ☑ Long pants
- ☑ Long-sleeved shirts
- ☑ Safety glasses, wraparound or with side shields labeled with ANSI Z87.1 rating, or a certification card for lenses and frames
- ☑ Safety footwear meeting ASTM F2413-05 standard with chemical or oil resistant soles
- ☑ High visibility work gloves (when high visibility glove options exist for a particular glove type)
- ☑ Hard hat that complies with ANSI Z89.1

TASK SPECIFIC: Personal Protective Equipment (PPE) Determination*

Eye Protection

Must comply with ANSI Z87.1

- ☐ Impact Goggles
- ☐ Flexible goggles
- ☐ Welding goggles/helmet or face shield. Tinted lenses required
- ☐ Laser safety glasses

Head Protection

- ☐ Type E Hardhat (Electrical)
- ☐ Hardhat with chin strap, miner's helmet with chin strap or mountaineering helmet with chin strap

Hazardous Atmosphere

- ☒ Photoionization Detector (PID)
- ☐ Flame Ionization Detector (FID)
- ☐ Dust Monitor
- ☐ LEL / O_2 Meter
- ☐ H_2S Meter

Hearing Protection

- ☐ Ear Plugs (noise 80 db)
- ☐ Ear Muffs with Ear Plugs (noise 105 db)

Body Protection

- ☐ Chemical resistant clothing recommended on SDS
- ☐ Chain saw chaps
- ☐ Snake chaps or boots marketed as "snake proof"[3]
- ☐ ANSI/ISEA 107-2010 Class 3 vest or ANSI/ISEA 107-2015 Type R, Class 2 vest if low light conditions or traffic flow at 50 mph or more
- ☐ ANSI/ISEA 107-2010 Class 2 or 3 *BREAKAWAY* vest or ANSI/ISEA 107-2015 Type R, Class 1 or 2 vest
- ☒ Sunscreen lotion >= SPF30
- ☒ Flying insect control: DEET (primary), permethrin (secondary)
- ☒ Tick control: Permethrin (primary), DEET (secondary)
- ☐ US Coast Guard approved personal flotation device (PFD) – Type I, II or III

Face Protection

- ☐ Chemical protective goggles that comply with ANSI Z87.1
- ☐ Face Shield over safety glasses

Respiratory Protection

- ☐ Half-face Air Purifying Respirator
- ☐ Full-face Air Purifying respirator
- ☐ SCBA or Supplied Air

Fall Protection

- ☐ Personal fall arrest system designed or approved by a qualified person OR other means of fall protection determined by qualified person

Hand Protection

- ☐ Chemical resistant gloves per SDS
- ☒ Cut-resistant gloves or liners
- ☐ Leather/Work gloves
- ☐ Welding gloves
- ☐ Leather gloves, insulated
- ☒ Nitrile gloves
- ☐ Impact resistant gloves

Foot Protection

- ☐ Safety shoes or boots with metatarsal guards
- ☒ Safety boots with puncture-resistant midsoles or that have built-in puncture resistance (PR rated)
- ☐ Safety boots with electric hazard (EH) protection (standard in most footwear)
- ☐ Rubber-sole boots or grips
- ☐ Chemical resistant boot covers
- ☐ Lace-up safety boots conforming to ASTM F2413-05 or equivalent in non-US jurisdictions

Heat, Flame, Flash Fire or Arc Hazard

- ☐ Cooling vest
- ☐ Flame resistant clothing (FRC)

***If an item is checked, it is relevant for all job steps. If an item is specific to a particular job step it must be noted in the Critical Action(s) column in the JSA.**

Job Safety Analysis

ARCADIS

JSA Description: Groundwater Monitoring	Site ID:

BIOLOGICAL

CHEMICAL

ELECTRICAL

GRAVITY

HUMAN PERFORMANCE

MECHANICAL

MOTION

PRESSURE

RADIATION

SOUND

TEMPERATURE

Job Steps (Avoid listing too many job steps for a task. Consider multiple JSAs instead.)	**Potential Hazard(s)** (Avoid being too general- i.e. "slip, trip, fall" or "fire". Example of better wording: "tripping on silt fence" or "fire due to static discharge in hose".)	**Critical Action(s)** (Avoid using generic words (i.e. use "proper" PPE or "proper" lifting techniques). Consider "wear Level A2 cut resistant gloves under nitrile gloves" or "lift with the legs and not the back, get assistance when carrying over 50 pounds or bulky loads".)	**Responsible Person(s) – Initials**
1. Evaluate Human and Operational Performance (HOP)	HUMAN PERFORMANCE – Error-likely situations that may lead to serious injury and fatality	• Refer to Arcadis Human Performance Reference Guide • Use observable cues (physical, verbal, etc.) to identify potential error traps that could increase the probability of error: o Organizational o Individual o Task Demands o Work Environment • Use HOP tools to reduce likelihood of error: o Stop & Get Help o Speak, Point, & Check o Step-by-Step Placekeeping • 3-Way Communication	
2. Establish work zone cones and/or barricades at proposed well locations	Motion - Broken bones, sprains, lacerations, or death from being struck by motor vehicle	• Observe vehicle traffic and pedestrian traffic in and/or around potential work zones. When setting up cones and barricades scan work zone and surrounding area for traffic. Make eye contact with drivers and give right-of-way to all motor vehicles present. • Wear DOT Class II or higher hi-visibility traffic vests to make personnel more visible to on and off site traffic.	
	Mechanical - Lacerations, abrasions to hands when carrying A-frame barricades or delineators	• Identify pinch points with tape or highly visible marking ink to increase awareness. • Set up delineators around work area and stage vehicle to provide buffer from traffic if feasible. • Wear Level 2 cut-resistant gloves to prevent soft tissue injuries.	
	Motion - Nails or other sharp objects piercing the bottoms of boot and feet	• Perform a site walk to clear area of nails and other sharp objects on the ground using broom to push the objects out of the work area. • Wear puncture resistant boots or steel sole inserts to prevent sharp objects from piercing the bottom of boots.	

Job Safety Analysis

ARCADIS

JSA Description: Groundwater Monitoring	Site ID:

BIOLOGICAL

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Job Steps (Avoid listing too many job steps for a task. Consider multiple JSAs instead.)	**Potential Hazard(s)** (Avoid being too general- i.e. "slip, trip, fall" or "fire". Example of better wording: "tripping on silt fence" or "fire due to static discharge in hose".)	**Critical Action(s)** (Avoid using generic words (i.e. use "proper" PPE or "proper" lifting techniques). Consider "wear Level A2 cut resistant gloves under nitrile gloves" or "lift with the legs and not the back, get assistance when carrying over 50 pounds or bulky loads".)	**Responsible Person(s) – Initials**
3. Open wells for monitoring	Gravity - Slip/Trips/Falls over sampling equipment resulting in broken bones, sprains, or lacerations	• Visually check and remove trip hazards in the work area prior to starting work at each well. Mark all identified fix hazards with cones or high-visibility tape. • Stage equipment in one central location to minimize trip hazards.	
	Motion - Pinch points from leading edge of well housing and well cap resulting in lacerations, abrasions to hands	• Do not grab well cap around edge to prevent entering line of fire of well cap and well housing and contact with sharp edges. • Use well/vault key to open wells to keep hands from being pinched/crushed by well cap and/or well housing. Do not place hands under lid when removing. • Utilize team lift for opening heavy vault lids. Establish plan prior to opening and maintain good communication while executing. • Use socket wrench to remove bolts and pry bar to remove lid to prevent having to touch sharp edges. • Keep hands free of lid when removing well cap to keep hands out of line of fire of well lid and well housing. • Wear Level 2 resistant gloves to prevent lacerations to hands from sharp well caps or pinched hands.	
	Biological - Bites/stings from insects or snakes inside or near well housing resulting in allergic reactions or skin irritation	• Visually check for insects and snakes prior to opening the well. If feasible, clear potential biting/stringing insects prior to reaching inside well vault/lid. If unable to perform safely, STOP WORK and contact project team. • Wear gloves, long sleeves and full-length pants to prevent insect bites to skin.	
	Pressure - Lacerations or abrasions by flying well cap due to pressurized well	• Open well cap slowly to depressurize well. • Stay out of the line of fire above well cap. Keep face clear of well head while opening. • Wear hard hat to prevent head injury from a well cap that becomes airborne. Wear safety glasses to prevent debris from inside well contacting eyes.	

Job Safety Analysis

ARCADIS

JSA Description: Groundwater Monitoring	Site ID:

BIOLOGICAL

CHEMICAL

ELECTRICAL

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HUMAN PERFORMANCE

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SOUND

TEMPERATURE

Job Steps (Avoid listing too many job steps for a task. Consider multiple JSAs instead.)	**Potential Hazard(s)** (Avoid being too general- i.e. "slip, trip, fall" or "fire". Example of better wording: "tripping on silt fence" or "fire due to static discharge in hose".)	**Critical Action(s)** (Avoid using generic words (i.e. use "proper" PPE or "proper" lifting techniques). Consider "wear Level A2 cut resistant gloves under nitrile gloves" or "lift with the legs and not the back, get assistance when carrying over 50 pounds or bulky loads".)	**Responsible Person(s) – Initials**
	Chemical - Chemical exposure from vapor/gas inhalation resulting in irritation or asphyxiation	• Work upwind of well head. • **STOP WORK** and inform project team of any readings exceeding action level identified in the HASP. • Air monitoring with a calibrated photo-ionization (PID) detector (fitted with a 10.6 eV bulb) must be utilized to determine concentrations of petroleum vapors in breathing zone.	
	Motion - Being struck by motor vehicle resulting in broken bones, lacerations, abrasions, sprains, or death	• Scan work zone and surrounding area for vehicle and pedestrian traffic. If vehicle parks directly beside work zone **STOP WORK** and observe vehicle and driver for movement, make eye contact with driver. • Wear DOT Class II or higher hi-visibility traffic vest to increase visibility to on and off site traffic.	
4. Set up of sampling equipment	Motion - Lacerations from sharp edges of well head resulting in hand lacerations or abrasions	• Do not grab edge of well head. Visually identify and verbalize sharp edges and pinch points with site workers. • Wear Level 2 cut resistant gloves while handling equipment/debris to prevent hand lacerations.	
	Gravity - Slip/Trips/Falls over sampling equipment resulting in broken bones, sprains, or lacerations	• Use route planning and visually check for and remove trip hazards prior to setup of sampling equipment. • Stage equipment in one central location to minimize trip hazards.	
	Motion - Struck by vehicle resulting in broken bones, lacerations, abrasions, sprains or death	• Scan work zone and surrounding area for vehicle traffic. If vehicle approaches work zone or parks beside work zone **STOP WORK**, make eye contact with driver and wait for vehicle to stop and driver to exit vehicle leaving work zone prior to resuming activities. • Wear DOT Class II or higher hi-visibility traffic vests to make personnel more visible to on and off site traffic.	

Job Safety Analysis

ARCADIS

JSA Description: Groundwater Monitoring	Site ID:

BIOLOGICAL

CHEMICAL

ELECTRICAL

GRAVITY

HUMAN PERFORMANCE

MECHANICAL

MOTION

PRESSURE

RADIATION

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Job Steps (Avoid listing too many job steps for a task. Consider multiple JSAs instead.)	**Potential Hazard(s)** (Avoid being too general- i.e. "slip, trip, fall" or "fire". Example of better wording: "tripping on silt fence" or "fire due to static discharge in hose".)	**Critical Action(s)** (Avoid using generic words (i.e. use "proper" PPE or "proper" lifting techniques). Consider "wear Level A2 cut resistant gloves under nitrile gloves" or "lift with the legs and not the back, get assistance when carrying over 50 pounds or bulky loads".)	**Responsible Person(s) – Initials**
	Motion - Nails or other sharp objects piercing the bottoms of boot and feet	• Perform a site walk to clear area of nails and other sharp objects on the ground using broom to push the objects out of the work area. • Wear puncture resistant boots or steel sole inserts to prevent sharp objects from piercing the bottom of boots.	
	CHEMICAL – Eye or dermal irritation from damaged pump battery	• Inspect the GeoPump Battery for cracks/leaks • Pack baking soda to cleanup/neutralize any spills of battery acid.	
5. Monitor groundwater level with probe	Gravity - Slip/Trip/Falls on measuring tape resulting in broken bones, sprains, or lacerations	• Always deploy and retrieve measuring tape with a spool. • Do not allow tape to drag the ground when walking between well locations to minimize trip hazard.	
		•	
	Chemical - Chemical exposure from skin or eye contact with groundwater	• Lower and retract tape slowly to reduce the potential for splashing. • Wear nitrile gloves and safety glasses while using measuring tape over Level 2 cut resistant gloves to prevent chemical exposure to skin and eyes.	
	Motion - Lacerations, back strain, or bruises to knees while gauging well volume	• Inspect ground surface for sharp objects or stones which may cause lacerations of bruising. Removed objects from around well head. • Kneel on soft surfaces or pads instead of bending over at the waist or squatting to prevent knee and back injuries.	
6. Purge groundwater monitoring well	Gravity - Slip, trip and fall hazards over loose bailer twine, twine bucket, bailers, pump cables or associated tubing resulting in broken bones, sprains, or lacerations	• Keep loose twine, tubing, and pump cables off of the ground (utilize vehicle trunk/bed if available). When pulling twine or tubing from bucket or spool determine amount needed to match depth of well to be purged and wind twine into a loop which can be easily carried. Do not place twine buckets, tubing, or pump controllers in walking path in or around work zone.	

Job Safety Analysis

ARCADIS

JSA Description: Groundwater Monitoring	Site ID:

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Job Steps (Avoid listing too many job steps for a task. Consider multiple JSAs instead.)	**Potential Hazard(s)** (Avoid being too general- i.e. "slip, trip, fall" or "fire". Example of better wording: "tripping on silt fence" or "fire due to static discharge in hose".)	**Critical Action(s)** (Avoid using generic words (i.e. use "proper" PPE or "proper" lifting techniques). Consider "wear Level A2 cut resistant gloves under nitrile gloves" or "lift with the legs and not the back, get assistance when carrying over 50 pounds or bulky loads".)	**Responsible Person(s) – Initials**
		• Keep bailers in bailer box on support truck when not in use.	
	Motion - Cutting twine or pump tubing resulting in hand lacerations	• Use scissors or tubing cutters to cut twine or tubing. • Do not use fixed open blades. . • Wear Level 2 cut-resistant gloves when using scissors or tube cutters to prevent cuts to hands and fingers.	
	Motion - Sprains and strains to arms and back while deploying and retrieving bailer or pump in groundwater monitoring well	• Do not bend over at waist when deploying or retrieving bailers or pumps in wells. Stand upright with back straight. Do not lift arms over head when retrieving bailer or pump from well. Use both hands when dropping or pulling twine attached to bailer or tubing attached to pumps. Deploy and retrieve bailers and pumps slowly. • Use pump to purge wells with high purge volumes to reduce sprains and strains.	
	GRAVITY - Slips and falls due to wet surfaces created by discharging purge water into bucket resulting in broken bones, sprains, or lacerations	• Pour contents of bailer into purge buckets slowly keeping spout of bailer directly over top of bucket. Keep effluent end of tubing inside bucket opening and fixed to the side of the bucket using clips or ties to mitigate splash hazards. • When pouring purge water from bailer into bucket keep effluent end of bailer approximately 1 foot or less from opening of bucket to avoid spilling purge water onto ground creating slippery surface. Pour slowly to mitigate splashing.	
	Temperature - Dermal burns or abrasions to hands while deploying bailer or pump to well	• Do not allow twine, cables or tubing to slide though hands or fingers. Use hand-over-hand technique to deploy and retrieve twine, cables, or tubing. • Wear Level 2 cut-resistant glove with nitrile liners or nitriles over Level 2 cut-resistant gloves when handling twine, bailers, pumps, tubing and cables to prevent abrasions and lacerations to hands from bailer twine.	

Job Safety Analysis

ARCADIS

JSA Description: Groundwater Monitoring	Site ID:

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	Motion - Abrasions and lacerations to hands by entan gled bailer twine or pump cable	• Do not allow twine or pump cables to entangle hands or fingers creating loops which can potentially cause pinch points, abrasions, and/or lacerations to hands. • Wear Level 2 cut-resistant glove with nitrile liners or nitriles over Level 2 cut-resistant gloves when handling twine, bailers, pumps, tubing and cables to prevent abrasions and lacerations to hands from bailer twine.	
	ELECTRICAL – electric shock, short circuiting or flame from incorrectly connecting pump to power source	• Inspect all cords and connections for frays, cuts or other damage; take out of service and replace if damaged. • Keep all cords and connections away from water and keep battery connections covered with lid until used.	
7. Collection of sample	Motion - Back strain from opening well/bailing water/collecting sample/lifting and carrying 5 gallon bucket of water to remediation system or drum.	• Only fill buckets ½ - ¾ full to prevent awkward loads and splashing. • Kneel instead of bending over at the waist or squatting when working around well. Lift with legs not back or shoulders. Do not twist at waist to avoid back strains/sprains. • Use knee pads to prevent knee lacerations from kneeling on ground.	
	Chemical - Dermal exposure to groundwater and/or sample preservation fluids while filling VOA/sampling media resulting in allergic reactions, skin irritation, or dermal burns	• Fill sample bottles slowly to avoid splashing/spillage. • Wear nitrile gloves over Level 2 cut-resistant gloves and safety glasses with side shields to prevent chemical exposure to skin. • Pack baking soda to cleanup/neutralize any spills of sample preservation acid.	
	Motion - Lacerations to hands from glass sample bottle breakage	• Never over tighten caps on glass VOA vials to avoid possible breakage. • Place VOA/sampling media in bubble wrap as soon as possible once sample has been taken.	

Job Safety Analysis

ARCADIS

JSA Description: Groundwater Monitoring	Site ID:

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		• Wear nitrile gloves over level 2 cut-resistant gloves to prevent hand lacerations and dermal exposure due to bottle breakage and preservative contact.	
	Chemical - Chemical exposure from vapor/gas inhalation resulting in irritation or asphyxiation	• Keep face a minimum of 1 ft. away from top of well head and work upwind of well head to prevent chemical exposure. • Conduct air monitoring with a calibrated photo-ionization (PID) detector (fitted with a 10.6 eV bulb) must be utilized to determine concentrations of petroleum vapors in breathing zone. • **STOP WORK** and inform project team of any readings exceeding action level identified in the HASP.	
8. Close Well	Motion - Strain to back and arms when closing well	• Do not bend at waist to replace well cap and lid. Do not over extend arms or back when reaching for cap, lid or tools. Keep cap, lid and tools within arm's reach when closing well.	
	Motion - Lacerations or bruises to knees while kneeling	• Avoid placing knee on ground or hard surface when replacing cap and lid. • Use knee pads if necessary to place knee on ground to avoid lacerations, abrasions, and busies	
	Motion - Lacerations or abrasions to fingers or hands when handling and placing well lid	• Keep hands away from leading edges on well lids. Do not place fingers between or under rim of well and edge of well lid. • Use Level 2 cut-resistant gloves when handling well lids to prevent lacerations or abrasions to hands and fingers.	
9. Take down sampling equipment	Motion - Back/muscle strain from loading equipment	• Do not lift awkward loads or weight >50 lbs. • Lift with legs and not the back. Keep all loads close to body. Reposition body using feet, do not twist at waist.	
	Motion - Lacerations to hands from sharp edges of equipment	• Use handles on equipment to avoid grabbing sharp edges.	

Job Safety Analysis

ARCADIS

JSA Description: Groundwater Monitoring	Site ID:

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		• Avoid grabbing/holding sharp edges/points and wear Level 2 cut-resistant gloves while handling equipment.	
	Gravity - Slip/Trips/Falls on equipment resulting in broken bones, sprains, or lacerations	• Use route planning and visually check for and remove trip hazards in work area. • Stage equipment in one central location to minimize trip hazards.	
10. Transfer purge water into waste drum	MOTION - Back/muscle strain from loading equipment	• Do not lift akward loads or weight >50 lbs without using buddy system. • Lift with legs and not the back and keep all loads close to your body. Reposition body using feet, do not twist at waist.	
	CHEMICAL – Eye or dermal exposure to ground/purge water during transfer process	• Do not fill temporary storage containers over ¾ capacity to avoid spillage and heavy loads. • Cover container with a lid if transporting in a vehicle to transfer location. • If transferring to a drum, use pump or funnel to minimize potential for spills. • Pour in a slow controlled manner to avoid splashing. 1. Wear nitrile gloves and eye-protection to avoid contact with ground/purge water.	

JSA Acknowledgement

"I have read this JSA, and I understand the hazards and safe work practices associated with the task.
If conditions change or an additional hazard is recognized, I will Stop Work and notify the Site H&S Officer immediately:"

This JSA must be acknowledged by affected workers every shift.

Name	Signature	Initials Used on Form	Date	Date	Date	Date	Date	Date

Verification of Critical Actions – Undersigned verifies that critical actions are in place, or have been evaluated based on availability, effectiveness and understood by the crew prior to work starting.

Name of Verifier	Signature	Date	Date	Date

End of Day Lookback – Use this section to log changes made to the JSA throughout the day and note any recommendations for Task JSA.

Brief description Lookback	Lookback Leader Name	Date
Did anything come up during this task worthy of further updates, revisions, or conducting a Learning Team?		

Job Safety Analysis

ARCADIS

JSA Description: Sample Packing and Cooler Handling	**Date of JSA Development: 2/2/2022**
Project Name: BNSF Skykomish	**PMCoW:**
Site Address: 105 6th Street North, Skykomish, WA 98288	**Project No: 30144053**

Development Team (Include employer & email if not employed by Arcadis.)		
Minda Moe		
Reviewed By (Include employer & email if not employed by Arcadis.)	**Position/Title:**	**Review Date** (MM/DD/YYYY)

Permits/Plans Required (general, Specialized, etc.):	General PTW if working inside OERB.
Specialized tools/equipment:	Coolers, sample bottles

MINIMUM REQUIRED PERSONAL PROTECTIVE EQUIPMENT

- ☑ ANSI/ISEA 107-2010 Class 2 or 3 vest or ANSI/ISEA 107-2015 Type R, Class 1 or 2 vest
- ☑ Long pants
- ☑ Long-sleeved shirts
- ☑ Safety glasses, wraparound or with side shields labeled with ANSI Z87.1 rating, or a certification card for lenses and frames
- ☑ Safety footwear meeting ASTM F2413-05 standard with chemical or oil resistant soles
- ☑ High visibility work gloves (when high visibility glove options exist for a particular glove type)
- ☑ Hard hat that complies with ANSI Z89.1

TASK SPECIFIC: Personal Protective Equipment (PPE) Determination*

Eye Protection

Must comply with ANSI Z87.1

- ☐ Impact Goggles
- ☐ Flexible goggles
- ☐ Welding goggles/helmet or face shield. Tinted lenses required
- ☐ Laser safety glasses

Head Protection

- ☐ Type E Hardhat (Electrical)
- ☐ Hardhat with chin strap, miner's helmet with chin strap or mountaineering helmet with chin strap

Hazardous Atmosphere

- ☐ Photoionization Detector (PID)
- ☐ Flame Ionization Detector (FID)
- ☐ Dust Monitor
- ☐ LEL / O_2 Meter
- ☐ H_2S Meter

Hearing Protection

- ☐ Ear Plugs (noise 80 db)
- ☐ Ear Muffs with Ear Plugs (noise 105 db)

Body Protection

- ☐ Chemical resistant clothing recommended on SDS
- ☐ Chain saw chaps
- ☐ Snake chaps or boots marketed as "snake proof"[3]
- ☐ ANSI/ISEA 107-2010 Class 3 vest or ANSI/ISEA 107-2015 Type R, Class 2 vest if low light conditions or traffic flow at 50 mph or more
- ☐ ANSI/ISEA 107-2010 Class 2 or 3 *BREAKAWAY* vest or ANSI/ISEA 107-2015 Type R, Class 1 or 2 vest
- ☒ Sunscreen lotion >= SPF30
- ☐ Flying insect control: DEET (primary), permethrin (secondary)
- ☐ Tick control: Permethrin (primary), DEET (secondary)
- ☐ US Coast Guard approved personal flotation device (PFD) – Type I, II or III

Face Protection

- ☐ Chemical protective goggles that comply with ANSI Z87.1
- ☐ Face Shield over safety glasses

Respiratory Protection

- ☐ Half-face Air Purifying Respirator
- ☐ Full-face Air Purifying respirator
- ☐ SCBA or Supplied Air

Fall Protection

- ☐ Personal fall arrest system designed or approved by a qualified person OR other means of fall protection determined by qualified person

Hand Protection

- ☐ Chemical resistant gloves per SDS
- ☐ Cut-resistant gloves or liners
- ☒ Leather/Work gloves
- ☐ Welding gloves
- ☐ Leather gloves, insulated
- ☒ Nitrile gloves
- ☐ Impact resistant gloves

Foot Protection

- ☐ Safety shoes or boots with metatarsal guards
- ☐ Safety boots with puncture-resistant midsoles or that have built-in puncture resistance (PR rated)
- ☐ Safety boots with electric hazard (EH) protection (standard in most footwear)
- ☐ Rubber-sole boots or grips
- ☐ Chemical resistant boot covers
- ☐ Lace-up safety boots conforming to ASTM F2413-05 or equivalent in non-US jurisdictions

Heat, Flame, Flash Fire or Arc Hazard

- ☐ Cooling vest
- ☐ Flame resistant clothing (FRC)

***If an item is checked, it is relevant for all job steps. If an item is specific to a particular job step it must be noted in the Critical Action(s) column in the JSA.**

Job Safety Analysis

ARCADIS

JSA Description:	Site ID:

BIOLOGICAL

CHEMICAL

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GRAVITY

HUMAN PERFORMANCE

MECHANICAL

MOTION

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Job Steps (Avoid listing too many job steps for a task. Consider multiple JSAs instead.)	**Potential Hazard(s)** (Avoid being too general- i.e. "slip, trip, fall" or "fire". Example of better wording: "tripping on silt fence" or "fire due to static discharge in hose".)	**Critical Action(s)** (Avoid using generic words (i.e. use "proper" PPE or "proper" lifting techniques). Consider "wear Level A2 cut resistant gloves under nitrile gloves" or "lift with the legs and not the back, get assistance when carrying over 50 pounds or bulky loads".)	**Responsible Person(s) – Initials**
1. Evaluate Human and Operational Performance (HOP)	HUMAN PERFORMANCE – Error-likely situations that may lead to serious injury and fatality	• Refer to Arcadis Human Performance Reference Guide • Use observable cues (physical, verbal, etc.) to identify potential error traps that could increase the probability of error: o Organizational o Individual o Task Demands o Work Environment • Use HOP tools to reduce likelihood of error: o Stop & Get Help o Speak, Point, & Check o Step-by-Step Placekeeping o 3-Way Communication	
2. Set up sample processing area and unpack equipment.	MOTION – Struck by vehicles due to lack of traffic controls or poor visibility	• Locate non-traffic or low traffic areas to setup work station. • Park support vehicle away from active traffic or between work area and active traffic to protect workers from traffic. • Scan area for moving vehicles and hazards before opening door. • Place cones around vehicle to alert drivers of upcoming work and to demarcate work area. • Wear reflective vest to increase visibility to drivers and reduce struck by hazard.	
	GRAVITY – Personal injury from tripping over debris or equipment on the ground	• Visually check area to identify and remove trip hazards (equipment, debris). If hazards cannot be removed (uneven ground, roots, rocks) mark with cones, high visibility tape, or flagging and notify others working in area. • Designate equipment storage area within work area to prevent clutter and reduce trip hazards. • Do not place any equipment in walking path.	

Job Safety Analysis

ARCADIS

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	MOTION – Back strain from lifting coolers using improper lifting techniques	• Do not lift loads heavier than 50 pounds without assistance from another person. • Get a firm grip, lift using legs, and keep back straight. Do not bend or twist at waist. • If possible, use portable field table, or secure work surface at table height to prepare packages. • Stage field vehicle as close as possible to cooler packing/staging area to minimize distance that coolers must be carried during loading.	
	GRAVITY – Dropping equipment on self or others causing injury	• Lift coolers using designated handles and confirm they are securely attached prior to lifting. • Plan route and verify clear before starting lift.	
	MECHANICAL – Lacerations/injuries from pinch points on equipment while setting up work area	• Identify pinch points on equipment and cases such as hinges, and keep hands 6 inches from identified pinch areas. • Use only closed-blade or self-retracting cutting tools to cut tape when opening taped coolers and wear cut resistant gloves. • Maintain a 4-foot radius from others when using cutting tools and always cut away from body.	
	CHEMICAL – Chemical burns from broken/leaking sample bottles containing preservatives	• Use wet paper towel to carefully remove leaking preservative from the outside of other sample containers and the cooler. • Do not touch broken sample bottles; discard bottles in accordance with Site waste disposal practices. • Do not touch glass or preservatives with bare hands, wear at least nitrile gloves and add work gloves if handling broken glass. • If chemicals contact clothes, removed soiled clothing and wash contacted area on body.	

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		• Wear safety glasses at all times to protect eyes from contact with chemicals.	
3. Packing samples	CHEMICAL – Contact with contaminated soils on outside of sample bottles	• Visually inspect bottles and wipe off any soil observed on outside of container before placing into bubble wrap and cooler. • Wear nitrile gloves when handling sample containers to avoid contact with soils or groundwater.	
	MOTION – Lacerations from broken sample containers or when taping coolers for shipment	• Place glass containers in bubble wrap before placing in cooler. • Handle full bottles with 2 hands and dry outside with paper towels to avoid dropping. • Use minimal hand pressure necessary to remove or tighten bottle lids/caps. • Once lids/caps on VOA vials are placed on containers and tightened to where there is no leakage, do not over-tighten to prevent breakage of glass and potential lacerations to hands. • Pack sample bottles tightly in cooler and use bubble wrap to reduce excess space/potential for breakage. • Use only closed-blade cutting tools to cut tape when preparing coolers for shipment to prevent potential lacerations to hands.	
	GRAVITY – Exertion or muscle strain from lifting heavy coolers to place in vehicle	• Bend at knees and keep back straight, do not twist or bend at waist. • Limit weight of each cooler when packing and use two-man lift if carrying loads heavier than 50 pounds. • Use countdown of 3 and keep continuous conversation if using 2 people to lift and carry coolers. • Use cooler handles when lifting coolers, verify that handles are not broken prior to lifting.	

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		• Plan route and have clear path of travel, secure equipment in vehicle once loaded. 	

JSA Acknowledgement

"I have read this JSA, and I understand the hazards and safe work practices associated with the task.
If conditions change or an additional hazard is recognized, I will Stop Work and notify the Site H&S Officer immediately:"

This JSA must be acknowledged by affected workers every shift.

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Name of Verifier	Signature	Date	Date	Date

End of Day Lookback – Use this section to log changes made to the JSA throughout the day and note any recommendations for Task JSA.

Brief description Lookback	Lookback Leader Name	Date
Did anything come up during this task worthy of further updates, revisions, or conducting a Learning Team?		

Job Safety Analysis

ARCADIS

JSA Description: Drum Handling	**Date of JSA Development: 1/24/2022**
Project Name: BNSF Skykomish	**PMCoW:**
Site Address: 105 6th Street North, Skykomish, WA 98288	**Project No: 30144053**

Development Team (Include employer & email if not employed by Arcadis.)		
Minda Moe		
Reviewed By (Include employer & email if not employed by Arcadis.)	**Position/Title:**	**Review Date** (MM/DD/YYYY)

Permits/Plans Required (general, Specialized, etc.):	General PTW if inside OERB.
Specialized tools/equipment:	Drum dolly, truck with liftgate, drum labels

MINIMUM REQUIRED PERSONAL PROTECTIVE EQUIPMENT

- ☑ ANSI/ISEA 107-2010 Class 2 or 3 vest or ANSI/ISEA 107-2015 Type R, Class 1 or 2 vest
- ☑ Long pants
- ☑ Long-sleeved shirts
- ☑ Safety glasses, wraparound or with side shields labeled with ANSI Z87.1 rating, or a certification card for lenses and frames
- ☑ Safety footwear meeting ASTM F2413-05 standard with chemical or oil resistant soles
- ☑ High visibility work gloves (when high visibility glove options exist for a particular glove type)
- ☑ Hard hat that complies with ANSI Z89.1

TASK SPECIFIC: Personal Protective Equipment (PPE) Determination*

Eye Protection

Must comply with ANSI Z87.1

- ☐ Impact Goggles
- ☐ Flexible goggles
- ☐ Welding goggles/helmet or face shield. Tinted lenses required
- ☐ Laser safety glasses

Head Protection

- ☐ Type E Hardhat (Electrical)
- ☐ Hardhat with chin strap, miner's helmet with chin strap or mountaineering helmet with chin strap

Hazardous Atmosphere

- ☐ Photoionization Detector (PID)
- ☐ Flame Ionization Detector (FID)
- ☐ Dust Monitor
- ☐ LEL / O_2 Meter
- ☐ H_2S Meter

Hearing Protection

- ☐ Ear Plugs (noise 80 db)
- ☐ Ear Muffs with Ear Plugs (noise 105 db)

Body Protection

- ☐ Chemical resistant clothing recommended on SDS
- ☐ Chain saw chaps
- ☐ Snake chaps or boots marketed as "snake proof"[3]
- ☐ ANSI/ISEA 107-2010 Class 3 vest or ANSI/ISEA 107-2015 Type R, Class 2 vest if low light conditions or traffic flow at 50 mph or more
- ☐ ANSI/ISEA 107-2010 Class 2 or 3 *BREAKAWAY* vest or ANSI/ISEA 107-2015 Type R, Class 1 or 2 vest
- ☐ Sunscreen lotion >= SPF30
- ☐ Flying insect control: DEET (primary), permethrin (secondary)
- ☐ Tick control: Permethrin (primary), DEET (secondary)
- ☐ US Coast Guard approved personal flotation device (PFD) – Type I, II or III

Face Protection

- ☐ Chemical protective goggles that comply with ANSI Z87.1
- ☐ Face Shield over safety glasses

Respiratory Protection

- ☐ Half-face Air Purifying Respirator
- ☐ Full-face Air Purifying respirator
- ☐ SCBA or Supplied Air

Fall Protection

- ☐ Personal fall arrest system designed or approved by a qualified person OR other means of fall protection determined by qualified person

Hand Protection

- ☐ Chemical resistant gloves per SDS
- ☐ Cut-resistant gloves or liners
- ☒ Leather/Work gloves
- ☐ Welding gloves
- ☐ Leather gloves, insulated
- ☐ Nitrile gloves
- ☐ Impact resistant gloves

Foot Protection

- ☐ Safety shoes or boots with metatarsal guards
- ☐ Safety boots with puncture-resistant midsoles or that have built-in puncture resistance (PR rated)
- ☐ Safety boots with electric hazard (EH) protection (standard in most footwear)
- ☐ Rubber-sole boots or grips
- ☐ Chemical resistant boot covers
- ☐ Lace-up safety boots conforming to ASTM F2413-05 or equivalent in non-US jurisdictions

Heat, Flame, Flash Fire or Arc Hazard

- ☐ Cooling vest
- ☐ Flame resistant clothing (FRC)

***If an item is checked, it is relevant for all job steps. If an item is specific to a particular job step it must be noted in the Critical Action(s) column in the JSA.**

Job Safety Analysis

ARCADIS

JSA Description:	Site ID:

BIOLOGICAL

CHEMICAL

ELECTRICAL

GRAVITY

HUMAN PERFORMANCE

MECHANICAL

MOTION

PRESSURE

RADIATION

SOUND

TEMPERATURE

Job Steps (Avoid listing too many job steps for a task. Consider multiple JSAs instead.)	Potential Hazard(s) (Avoid being too general- i.e. "slip, trip, fall" or "fire". Example of better wording: "tripping on silt fence" or "fire due to static discharge in hose".)	Critical Action(s) (Avoid using generic words (i.e. use "proper" PPE or "proper" lifting techniques). Consider "wear Level A2 cut resistant gloves under nitrile gloves" or "lift with the legs and not the back, get assistance when carrying over 50 pounds or bulky loads".)	Responsible Person(s) – Initials
1. Evaluate Human and Operational Performance (HOP)	Error-likely situations that may lead to serious injury and fatality	• Refer to Arcadis Human Performance Reference Guide • Evaluate which performance mode(s) apply to each task in this JSA to help reduce the likelihood of error: o Knowledge-based o Rule-based o Skill based • Use observable cues (physical, verbal, etc.) to identify potential error traps that could increase the probability of error: o Organizational o Individual o Task Demands o Work Environment • Use HOP tools to reduce likelihood of error: o Stop & Get Help o Speak, Point, & Check o Step-by-Step Placekeeping o 3-Way Communication	All Staff
2. Establish work zone with cones and/or barricades at proposed drum location	MOTION - Injury or death from being struck by motor vehicle	• Utilize buddy system. One person must focus on establishing work zone while the second person must focus on establishing eye contact with approaching motor vehicle drivers and alerting other workers to potential imminent hazards. • Wear DOT Class II or higher hi-visibility traffic vests to make personnel more visible to on and off site traffic.	
	MECHANICAL - Pinch and cuts to hands when carrying A-frame barricades	• Identify pinch points with tape or highly visible marking ink to increase awareness. • Wear minimum class II cut-resistant gloves to reduce potential for soft tissue injuries	

Job Safety Analysis

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Job Steps (Avoid listing too many job steps for a task. Consider multiple JSAs instead.)	Potential Hazard(s) (Avoid being too general- i.e. "slip, trip, fall" or "fire". Example of better wording: "tripping on silt fence" or "fire due to static discharge in hose".)	Critical Action(s) (Avoid using generic words (i.e. use "proper" PPE or "proper" lifting techniques). Consider "wear Level A2 cut resistant gloves under nitrile gloves" or "lift with the legs and not the back, get assistance when carrying over 50 pounds or bulky loads".)	Responsible Person(s) – Initials
	MOTION - Nails or other sharp objects piercing the bottoms of boot and feet	• Perform a site walk to visually confirm that area is clear of nails and other sharp objects on the ground. Use a broom to push any debris or sharp objects out of the work area. • If puncture hazards are present at the site (debris, rebar, demolition waste) puncture resistant boots or steel sole inserts should be worn to prevent sharp objects from piercing the bottom of boots.	
3. Moving of Drums from work area to staging area and staging area to load out area	GRAVITY - Injury due to slips trips and falls from blocked vision while moving drums	• Plan path of travel and visually inspect ground for trip hazards, choose path to avoid uneven, wet or slippery surfaces • Do not step over objects, maintain a clear pathway before transporting or moving drums	
	MECHANICAL - Personal injury associated with pinch points and potential lacerations or amputations of fingers.	• Do not place hands below the edge of the drum before setting them down. The ring and lid may have sharp edges – do not place your hands here. • Wear leather / cut resistant gloves while opening and closing drum lids and working with drum rings	
	CHEMICAL - Leaks and spills as a result of drums tipping over, incorrectly sealed drum, punctures, pinholes, impacted sides, top or bottom, rust, weathered conditions, knock drum over resulting in a release or exposure to worker.	• Verify SDS and review SDS for chemicals contained in drums. Review hazards and emergency procedures for all chemicals contained in drums on site prior to handling • Verify drums and drum lids are completely sealed around all edges by inspecting rim and ring of drum and lid. Do not move drums without closing them first. • All drums must be labeled or otherwise identified with their contents. • Drums containing liquid waste should be staged on secondary containment (drum liners, containment pallet, berm.) The containment structure must be capable of storing 110% of the contents of all containers stored on it. • Inspect all drums before use – do not use drums that show evidence of rusting/perforation and may leak.	

Job Safety Analysis

ARCADIS

JSA Description:	Site ID:

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Job Steps (Avoid listing too many job steps for a task. Consider multiple JSAs instead.)	**Potential Hazard(s)** (Avoid being too general- i.e. "slip, trip, fall" or "fire". Example of better wording: "tripping on silt fence" or "fire due to static discharge in hose".)	**Critical Action(s)** (Avoid using generic words (i.e. use "proper" PPE or "proper" lifting techniques). Consider "wear Level A2 cut resistant gloves under nitrile gloves" or "lift with the legs and not the back, get assistance when carrying over 50 pounds or bulky loads".)	**Responsible Person(s) – Initials**
		• Wear nitrile chemical resistant gloves or glove liners while handling drums containing product	
3. Load out of Drums for disposal	MOTION - Back strain from lifting and pushing/pulling drums to staging and load out areas, Contact with chemical resulting in exposure	• Stage drums on hard, level and clean surface. • Only empty drums may be lifted manually, and only if workers are comfortable with the lift. • Bend at knees. Do not over assert back, legs or arms – use team lift if necessary. • Use drum dolly or mechanical means to lift or move drums that contain any materials. Full soil drums can weigh over 800lbs. •	
	MECHANICAL - Personal injury, lacerations or amputations associated with Pinch points identified on lift gates, tailgates, between drum rims and stationary objects	• Visually identify all pinch points on equipment and vehicles prior to beginning work • Use TRACK to determine body position in order to be able to move freely around drum and do not place body in-between drum and stationary objects. • Do not place fingers between rim of drum and stationary objects when moving drum • Wear leather and/or cut resistant gloves when handling or moving drums. • Do not attempt to to roll full drums – they can tip and crush extremities.	

Job Safety Analysis

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Job Steps (Avoid listing too many job steps for a task. Consider multiple JSAs instead.)	**Potential Hazard(s)** (Avoid being too general- i.e. "slip, trip, fall" or "fire". Example of better wording: "tripping on silt fence" or "fire due to static discharge in hose".)	**Critical Action(s)** (Avoid using generic words (i.e. use "proper" PPE or "proper" lifting techniques). Consider "wear Level A2 cut resistant gloves under nitrile gloves" or "lift with the legs and not the back, get assistance when carrying over 50 pounds or bulky loads".)	**Responsible Person(s) – Initials**
	MOTION - Back, arm and shoulder strains from lifting drums for disposal	• Only empty drums should be moved manually – full soil drums can weigh over 800 lbs. • Lift with knees. Do not apply pressure to the arms, legs or back when moving drums to the extent that you feel discomfort or pain in muscles. Have a personal understanding of your own capabilities and limitations. • Use Buddy System to move drums when additional workers are available • Use Drum Dolly or other mechanical means to lift/move drums when available. If not available, do not attempt to move drums full of soil or water. Do not roll drums on their edge. • Use Drum Dolly or mechanical means to place drums directly into Box Truck or onto Lift Gate	
	GRAVITY - Slips, Trips and fall while walking, moving drums, operating a drum dolly or moving drum onto lift gate resulting in personal injury.	• Identify a path clear of obstacles, uneven surface, slippery surfaces and debris prior to moving drum. Remove any obstacles or debris when possible • Visually observe surrounding including vehicle and pedestrian traffic in order to better understand potential traffic and pedestrian hazards in and around work area.	
	MOTION - Struck by vehicle resulting in personal injury or death.	• An exclusion zone must be established where required by the HASP and Traffic Safety plan. • Stage drum storage area away from traffic and in a protected location. • If heavy equipment is used to move drums, remain outside of the work area/travel path of the equipment. • Equipment spotters must complete the struck by/crushed by checklist and discuss hand signals before beginning. • Keep body out of line of fire when working with swinging lift arms attached to trucks when used to move drums and lift drums into storage area of truck	

Job Safety Analysis

JSA Description:	Site ID:

BIOLOGICAL

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SOUND

TEMPERATURE

Job Steps (Avoid listing too many job steps for a task. Consider multiple JSAs instead.)	**Potential Hazard(s)** (Avoid being too general- i.e. "slip, trip, fall" or "fire". Example of better wording: "tripping on silt fence" or "fire due to static discharge in hose".)	**Critical Action(s)** (Avoid using generic words (i.e. use "proper" PPE or "proper" lifting techniques). Consider "wear Level A2 cut resistant gloves under nitrile gloves" or "lift with the legs and not the back, get assistance when carrying over 50 pounds or bulky loads".)	**Responsible Person(s) – Initials**
		• Do not walk directly behind Skid Steers or loading equipment without making contact with operator prior to moving • Wear DOT Class II or higher hi-visibility traffic vests to make personnel more visible to on and off site traffic.	

JSA Acknowledgement

"I have read this JSA, and I understand the hazards and safe work practices associated with the task.
If conditions change or an additional hazard is recognized, I will Stop Work and notify the Site H&S Officer immediately:"

This JSA must be acknowledged by affected workers every shift.

Name	Signature	Initials Used on Form	Date	Date	Date	Date	Date	Date

Verification of Critical Actions – Undersigned verifies that critical actions are in place, or have been evaluated based on availability, effectiveness and understood by the crew prior to work starting.

Name of Verifier	Signature	Date	Date	Date

End of Day Lookback – Use this section to log changes made to the JSA throughout the day and note any recommendations for Task JSA.

Brief description Lookback	Lookback Leader Name	Date
Did anything come up during this task worthy of further updates, revisions, or conducting a Learning Team?		

Attachment B
Field Forms

Task Improvement Process

General

Observed Company:

Observation Type:

TIP Form: H&S Field Multi-Task (General)

Task Observed:

Observee Name:

Observer Name:

Observation Date:

Project Number: 30144053

Project Name: BNSF Former Maintenance and Fueling Facility105 6th Street NorthSkykomish, Washin

Supervisor:

Equipment On Site:

Pertinent Information:

Observation

Task	Correct	Questionable	Comments
General			
PPE worn according to HASP/JLA specifications and inspected before use?			
STOP work authority used where appropriate?			
Body Use/Positioning			
Proper lifting/pushing/pulling techniques used (no awkward positions/posture; no twisting or excessive reaching; no straining; no excessive weight; load under control/stable; etc.)?			
Body parts away from pinch points (clear or protected from being caught between objects/equipment or from contacting sharp objects/edges, etc.)?			
Body parts not in the Line of Fire (protected from being struck by traffic, equipment, falling/flying objects, etc.)?			
Work Procedures/Environment			
Correct type and number of barricades/warning devices/cones?			

Communication with others when necessary (hand signals, flags, etc.)?			
Right tools and equipment selected for the job and inspected before use?			
Tools and equipment used properly?			
Housekeeping performed (work areas and pathways clear of hazards, uneven surfaces addressed, etc.)?			
Slip/trip/fall hazards addressed (path selected and cleared, eyes on path, speed footing, etc.)?			
Proper energy control (electrical systems grounded, lock out/tag out performed, isolated, cords/fixtures in good condition, GFCI inspected and utilized when appropriate and used properly, etc.)?			
Protected from overhead/underground utilities (proper clearance, properly marked, spotters as necessary, etc.)?			
Safe work on/near water (appropriate flotation device, appropriate boat for body of water and operation of boat, etc.)?			
Chemical/Radiation protection (decontamination zones set up properly, air monitoring, completed, and logged, etc.)?			
Fall from elevated height prevention (maintains 3-points of contact, appropriate ladder, mounting/dismounting vehicle/equipment, fall arrest system, etc.)?			
Any additional safety issues identified:			

Tip Summary **Enter details of the TIP and follow up discussion provide details on how any questionable items were resolved.**

Discussion following the TIP led by: _____

Date of follow-up discussion: _____

Positive Comments:

Discussion Summary Completed:

- ☐ Supervisor Led
- ☐ Peer to Peer
- ☐ Arcadis Employee to Subcontractor

Summary of Questionable Items

Action Items (Optional) Assign appropriate action items based on the observations made. You can add more than one action item if needed.

Item #	Action Item	Responsible Person	Due Date	Comp. Date
1				
2				
3				

Standard Review

Reviews to be performed after entry of this TIP into 4-Sight.

Quality Review

Quality Reviews to be performed after entry of this TIP into 4-Sight.

Field Validation and Verification

Use the 4-Sight generated copy of this TIP to perform field V&V activities.

Air Monitoring Documentation Form

PID Model: _____ Monitor Frequency: _____

LEL/O_2 Model: _____

CIT Model: _____

Dust Mon. Model: _____

Air Monitoring Results

Date	Time	PID (units)	O_2 (%)	LEL (% LEL)	CIT (ppm)	Dusts (mg/m^3)	Location

CIT = Colorimetric Indicator Tube
LEL = Lower Explosive Limit
mg/m3 = Milligram per cubic meter
O2 = Oxygen
ppm = Part per million
% = Percent
PID = Photoionization Detector

LEL/O_2 Calibration Log

ARCADIS

Calibration Gas Source: _____ Instrument Type: _____
Lot Number/Expiration Date: _____ Serial Number: _____
Concentration: _____ Instrument Type: _____
Other: _____ Serial Number: _____
Other: _____ _____

PAGE ____ of ____

Instrument Number	Date	Time		Alarms OK? (Y/N)	Oxygen Reading	Zero Cal. OK? (Y/N)	Span Reading	Calibration OK? (Y/N)	User Initials

Arcadis Visitor Acknowledgement and Acceptance of HASP Signature Form

By signing below, I waive, release, and discharge the owner of the site and Arcadis and their employees from any future claims for bodily and personal injuries which may result from my presence at, entering, or leaving the site and in any way arising from or related to any and all known and unknown conditions on the site.

Printed Name	Signature	Company	Date/Time On Site	Date/Time Off Site

Arcadis Weekly Vehicle Inspection Form

Vehicle # / License Plate # | **Lease Plan # / Last 6 of Vin #**

Inspection Date												
Odometer reading												
Driver / Inspector Name												
Check the appropriate box and enter repair date for identified repairs:	OK	Needs Repair	Repair Date	OK	Needs Repair	Repair Date	OK	Needs Repair	Repair Date	OK	Needs Repair	Repair Date
Interior	Horn operational												
	Door Locks operational												
	Seat Belts in good repair												
	Seats and Seating Controls												
	Steering Wheel - No Excessive Play												
	Interior Lights and Light Controls												
	Instrument Panel/Gauges												
	Wiper Controls operational												
	Heat/Defrost/Air Conditioning working												
	Rear View Mirror present												
	Backup Camera/Sensors working												
	Jack and Lug Wrench present												
Exterior[1]	Lights and Signals operational												
	Tires properly inflated/good tread depth												
	Spare Tire properly inflated												
	Doors operational												
	Windows Not Cracked/Damaged												
	Side View Mirrors												
	Body Panels and Bumpers												
Engine & Brakes	Engine Start & Running Smoothly												
	Fluid Levels, No Noticeable Leaks												
	Belts tight, no cracks												
	Brakes operational, no squeaking												
Emergency Equipment[2]	First Aid Kit, inspected weekly												
	Fire Extinguisher properly secured												
	Fire Extinguisher inspected weekly												
	Orange/Yellow emergency warning light												
	Roadside Assistance Information												
	Recommend spotter cones available												
Cargo	Cargo Secure and Properly Distributed												
	Securing Devices in Good Condition												
Registration	License Plate /Tags												
	Registration and Insurance												
	City/State Inspection Decal												
	Lease Plan information/Fuel Card												

[1] **Note all damages to the vehicle on the back of this page**

[2] **Emergency Equipment required per Motor Vehicle Standard ARC HSGE024**

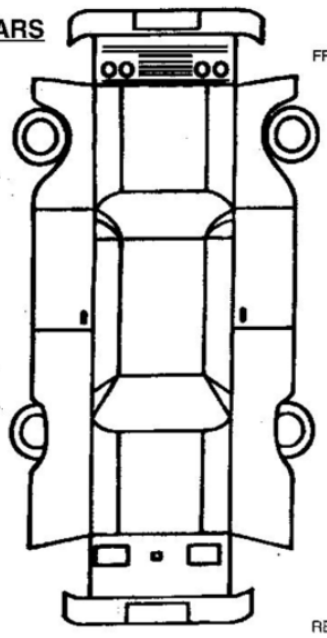
Note All Vehicle Damage Below

All Vehicle Damage must be reported to Sue Berndt (Corporate Legal), Andrew McDonald (Corporate H&S), and Roger Elliot (Corporate Fleet Manger)

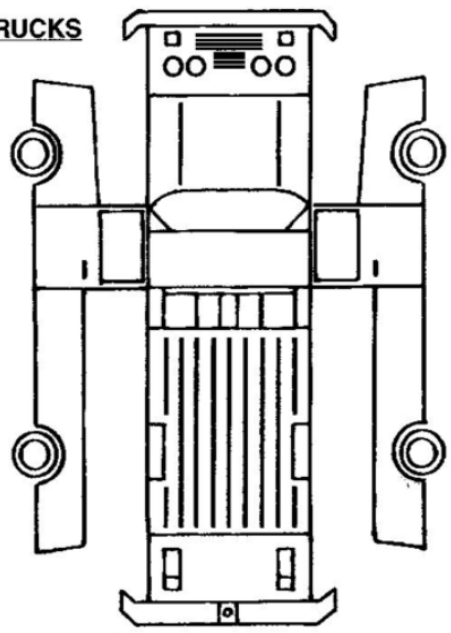
CODES:

B-BENT
BR-BROKEN
BU-BULGE
C-CHAFED
CH-CHIPPED
CPM-COVERED WITH PROTECTIVE MATERIAL-UNABLE TO DETERMINE DEFECTS IF ANY
CSA-CHAFED AND SCRATCHED ALL OVER
CR-CRACKED
D-DENTED
DMC-DUST AND MUD COVERED UNABLE TO DETERMINE OTHER DEFECTS IF ANY
G-GOUGED OR CUT
GC-GLASS CRACKED
HS-HAIRLINE SCRATCH
M-MISSING
P-PUNCTURED
R-RUSTY
S-SCRATCHED
SC-SCRAPED
SM-SMASHED
ST-STAINED AND/OR SOILED
T-TORN

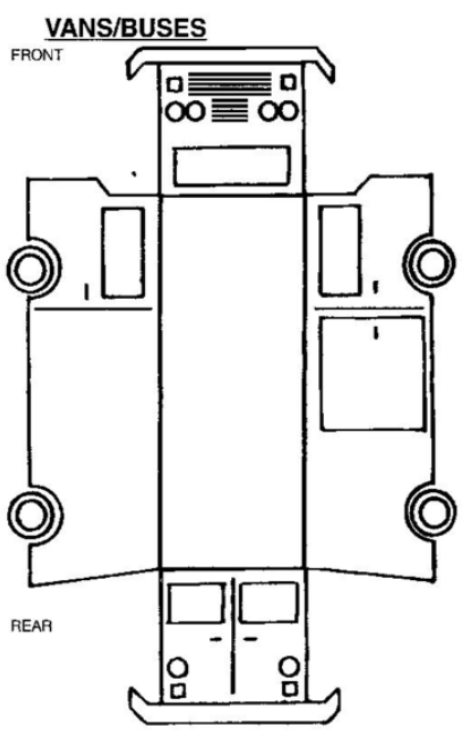
CARS



TRUCKS



VANS/BUSES



-INDICATE ON DIAGRAM-
-GIVE DIMENSIONS-
-CIRCLE WHERE APPLICABLE-

Notes:

Tread guide: If a tread gauge is not available coins may be used to determine remaining tread. 2/32” is the minimum by law in most states (top of Lincoln’s head on penny), 4/32” is minimum recommended for wet surfaces (top of Washington’s head on quarter), 6/32” is minimum recommended for snowy surfaces (top of Lincoln Memorial on penny).Vehicle tires should be replaced if the tread depth is less than 6/32”.

2/32” remaining 4/32” remaining 6/32” remaining

Reference JSA 10907 For Weekly Vehicle Inspection

PID Calibration Log

Zero Gas Source: _____ Instrument Type: _____ PAGE ____ of ____

Lot Number/Expiration Date: _____ Serial Number: _____

Calibration Gas Source: _____ Instrument Type: _____

Lot Number/Expiration Date: _____ Serial Number: _____

Concentration: _____ _____

Instrument Number	Date	Time	Zero Cal. OK (Y/N)	Calibration Gas Reading	Comments	Calibration w/in 2% (Y/N)?	Alarms Set (Yes/No)?	User Initials

Control Number: TSM- 30144053

TSM + project number plus date as follows: xxxxxxxx.xxxx.xxxxx - dd/mm/year

TAILGATE HEALTH & SAFETY MEETING FORM

Project Name:			**Project Location:**
Date:	**Time:**	**Conducted by:**	**Signature/Title:**

Issues or concerns from previous day's activities:

Task anticipated to be performed today:

☐ Additional permits/checklists attached

USE TRACK! Evaluate the hazards (h) for the tasks being performed today and rank as Low (L), Medium (M) or High (H). Use relevant JSAs, FHSHB, permit or other work standard to communicate controls (c) to be used to eliminate or mitigate identified hazards.

☐ Gravity (i.e., ladder, trips) (L M H) h: c:	☐ Motion (i.e., traffic, machinery) (L M H) h: c:	☐ Mechanical (i.e., augers, motors) (L M H) h: c:
☐ Electrical (i.e., utilities) (L M H) h: c:	☐ Pressure (i.e., gas cyl., wells) (L M H) h: c:	☐ Environment (i.e., heat, cold) (L M H) h: c:
☐ Chemical (i.e., fuel, acid, paint) (L M H) h: c:	☐ Biological (i.e., ticks, poison ivy) (L M H) h: c:	☐ Radiation (i.e., alpha, sun, laser) (L M H) h: c:
☐ Sound (i.e., machinery) (L M H) h: c:	☐ Personal (i.e. alone, night) (L M H) h: c:	☐ Driving (i.e. car, ATV, boat) (L M H) h: c:

☐ Refer to the attached Hazard Analysis Sheet(s) or JSA

Comments:

Signature and Certification: I have read and understand the project specific HASP for this project.

Non-Life Threatening Injury or Illness
Call WorkCare 1-888-449-7787

SSE Employee*	Printed Name/Signature/Company	Sign In Time	Sign Out Time

***Short Service Employee (SSE) working for Arcadis <1 year.**

I will STOP the job any time anyone is concerned or uncertain about health & safety or if anyone identifies a hazard or additional mitigation not recorded in the site, project, job or task hazard assessment.

I will be alert to any changes in personnel, conditions at the work site or hazards not covered by the original hazard assessments.

If it is necessary to **STOP THE JOB,** I will perform **TRACK**; and then amend the hazard assessments or the HASP as needed.

I will not assist a subcontractor or other party with their work unless it is absolutely necessary and then only after I have done TRACK and I have thoroughly controlled the hazard.

All site staff should arrive fit for work. If not, they should report to the supervisor any restrictions or concerns.

In the event of an injury, employees will call **WorkCare at 1.888.449-7787** and then notify the field supervisor.

Utility strike, motor vehicle accident or 3rd party property damage - field supervisor will immediately notify the Project or Task Manager

January 17, 2023

To whom it may concern:

Arcadis and its affiliates (“Arcadis”) is a firm with experienced professionals and staff who support projects, activities, infrastructure and businesses essential to maintaining the public's health, safety and welfare.

Arcadis has been authorized by BNSF to complete the following activities:

Arcadis personnel will be identifiable by:

- [X] Branded hard hat and/or safety vest
- [ ] Branded vehicle
- [ ] Buisness card or ID badge
- [ ] Other: _____

If you have any questions related to the work being completed or Arcadis’ presence at this location, please contact the following:

Kyle Haslam	Arcadis Project Manager	at	206-719-6991
Scott MacDonald	BNSF	at	360-621-6419

Attachment C
Safety Plans

Traffic Safety Plan (TSP)

1.0 General

Plan type	Non-Right of Way (Non-ROW)
Project Name:	BNSF Skykomish
Project Number:	30144053
Developer Name:	Laura Jones
Duration of Project (in hours or days):	1 week
Time Restrictions (Y/N, if Y describe below):	N
Not Applicable	
Not Applicable	
Not Applicable	NA
Not Applicable	
Not Applicable	NA
	Working on multiple roads?

Comments:

2.0 Work Description

Provide a brief description of scope of work:

Work will be conducted in an an active parking lot. Scope of work includes groundwater sampling and monitoring, and contactor oversight. Equipment included in the delineation: subcontractor field truck and Arcadis field truck.

3.0 Type and Duration

Work locations on this project will be: Intermediate work (1-8 hours per location)

Non-ROW work will be performed in: Active parking lot

Special traffic conditions may include (select most prevalent): Not applicable

4.0 Traffic Control Layout, Number of Devices Required, and Phasing

The following Non-ROW requirements in the Traffic Safety Handbook applies:

Section 7.3 Intermediate Duration Work in Parking Areas (1 to 8 Hours) (DOT Facts-302b)

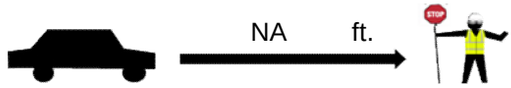
The menu below will be blank and is not applicable.

The menu below will be blank and is not applicable.

Non-ROW configuration:
An example non-ROW traffic control configuration for this project is illustrated below. The actual type and number of devices required are specified below. Don't leave vehicle doors open. Don't establish controls within 25 ft of the front or rear of parked large vehicles/rolling equipment without coordinating with the vehicle/equipment operator.

Intermediate Term (1-8 Hours)
Channelizing Cones with Caution Tape

Short to Long Term
Truck as Barrier to Traffic Exposure

ROW minimum sign spacing distances for "A", "B" and "C" (as applicable) in referenced DOT Facts.	ROW oncoming traffic minimum site distance required to see Flagger and properly decelerate and stop.
A NA ft. B NA ft. C NA ft.	 NA ft.

ROW Cone Calculation (Values are default. Light grey fields may be modified based on actual road conditions)

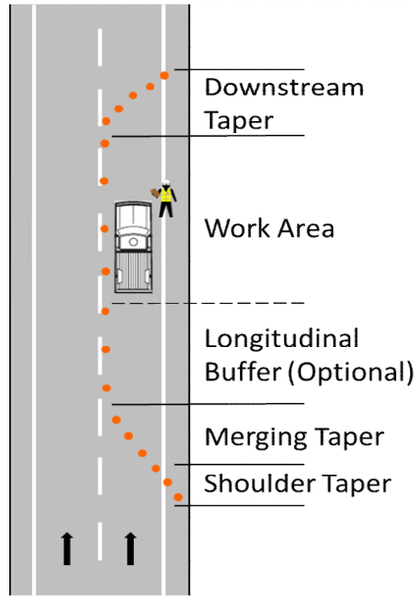
	Active work area length (feet)	
☐	Apply Optional Longitudinal Buffer (ft)?	
	Lane width of offset (feet)	
	Shoulder width of offset (feet)	
	Posted speed limit	NA

☐ **Shoulder Taper**

Taper Length (feet)	NA
Cones Required	NA
Cones Spacing (max., ft)	NA

☐ **Merging Taper**

Taper Length (feet)	NA
Cones Required	NA
Cones Spacing (max., ft)	NA



☐ **Work Area**

Cone Spacing (max., ft)	NA
Cones Required	NA

☐ **Downstream Taper**

Taper Length (feet)	NA
Cones Required	NA
Cone Spacing (max., ft)	NA

Cones Required (minimum) NA

Note: Review taper configuration and cone spacing after ROW implementation to ensure traffic is moving efficiently without motorist confusion in the RWZ.

Select the traffic control devices to be used and enter number each required:

Check all that apply:		*Wording or Pictogram*	*Number:*
☐	Warning signs		
☐	Warning signs		
☐	Warning signs		
☐	Stop/Slow paddle		
☐	Red flag		
☐	Drums		
X	Channelizer cone (42 inch height, 10 lb base)		7
☐	Channelizer cone (42 inch height, 30 lb base)		
☐	Traffic cones (≥ 18 inches tall)		NA
☐	Barricade:		
☐	Flags for cones		
☐	Lights (for night work)		
☐	Plastic fencing (rolls)		
X	Caution tape (rolls)		1
☐	Other (specify):		

Non-ROW Phasing:

1) Position truck as shield, if practical

2) Deploy traffic control devices

3) Affix flags, caution tape or fencing

4) Unload project equipment

5) Commence work

6) SSO to maintain controls

7) Remove controls in reverse order

Electronic Device Use Safety

Electronic devices (tablets, laptops and cell phones) used to collect data or document activities in active parking lots must be used in a manner that does not interfere with the user's ability to see and react to vehicle movements in the work area. If this requirement cannot maintained, a spotter must be used. When possible position vehicle to act as a shield. Short-term traffic control scenarios provided by this TSP are not authorized if a spotter is not used.

Reviewed By:

HASP Reviewer: Nicholas Monico

Smoke Respiratory Protection Plan

Project Name: BNSF Former Maintenance and Fueling Facility105 6th Street NorthSkykomish, Was
Project Number: 30144053
Date: 12/27/2022

Introduction:

This Smoke Respiratory Protection Plan (Plan) has been prepared for use by employees working on projects or project sites in wildfire smoke impacted areas where there is known, forecasted or anticipated smoke concentrations in the breathing zone greater than or equal to a current Air Quality Index (AQI) of 151 for PM2.5 (See definitions below). This plan is designed to meet Cal OSHA regulatory requirements but may be used outside of California as a best practice on project sites with breathing zone smoke issues.

Task Description:

The scope of work includes system installation, well isntallation, groundwater monitoring, and contractor oversight of system maintenance.

Definitions:

Current Air Quality Index (AQI). The method used by the U.S. Environmental Protection Agency (U.S. EPA) to report air quality on a real-time basis. Current AQI is also referred to as the "NowCast," and represents data collected over time periods of varying length in order to reflect present conditions as accurately as possible. The AQI data can be used to assess conditions at the work site if site specific data is unavailable.

PM2.5. Solid particles and liquid droplets suspended in air, known as particulate matter, with an aerodynamic diameter of 2.5 micrometers or smaller

Filtering facepiece respirator (FFR). An FFR is an N95 or similar type respirator AKA as "dust ask". Unlike FFRs, reusable respirators described as "tight-fitting facepieces" or "elastomeric respirators" even when used in a "voluntary use" capacity still have requirements which at a minuimum includes a medical evaluation.

The current AQI is divided into six categories as shown in the table below, adapted from Table 2 of Title 40 Code of Federal Regulations, Part 58, Appendix G.

Air Quality Index (AQI) Categories for PM2.5	PM2.5 in Microgram per Cubic Meter (µg/m3)	Levels of Health Concern
0 to 50	0 to 12	Good
51 to 100	12.1 to 35.4	Moderate
101 to 150	35.5 to 55.4	Unhealthy for Sensitive Groups
151 to 200	55.5 to 150.4	Unhealthy
201 to 300	150.5 to 250.4	Very Unhealthy
301 to 500	**250.4 to 500.4**	**Hazardous**

If Site Specific Air Monitoring Equipment is Used:

[X] Project team will rely on AQI data from AirNow.gov instead of using air monitoring devices.

When using a direct-reading particulate monitor to determine PM2.5 levels described above:
(1) Must not underestimate employee exposures to wildfire smoke; or
(2) May underestimate wildfire smoke exposures, but the project team has obtained information on the possible error of the monitor from the manufacturer or other published literature and has accounted for the error of the monitor when determining exposures to PM2.5 to ensure that employee exposure levels are not underestimated.

The monitor selected shall be designed and manufactured to measure the concentration of airborne particle sizes ranging from an aerodynamic diameter of 0.1 micrometers up to and including 2.5 micrometers. If the monitor measures a particle size range beyond these limits, the project team must treat the results as the PM2.5 levels.

The project team shall ensure that the monitor used is calibrated, maintained, and used, including the use of necessary accessories, in accordance with the manufacturer's instructions for accurately

measuring PM2.5 concentrations.

Smoke Inhalation Hazard Controls:
Consistent with Arcadis policy, engineering controls will first be considered and implemented to the extent practical to control PM2.5 levels of smoke in the atmosphere. These controls include, but are not limited to performing work such as preparing paperwork, calibrating instruments, preparing equipment, etc. inside buildings or vehicles with filtered air ventilation systems to the extent possible.

If engineering controls fail to mitigate smoke to less than current AQI 151 for PM2.5 levels in the breathing zone, administrative controls will be considered. These controls may include, but are not limited to, adjusting work schedules for affected employees, use of job rotation, implementing work/rest periods, etc. to mitigate the exposure.

If engineering and administrative controls fail to mitigate a current AQI151 for PM2.5 exposure, personal protective equipment in the form of respiratory protection will be provided as follows:

a) Where the current AQI for PM2.5 is equal to or greater than 151, but does not exceed 500, respirators will be provided to all employees for voluntary use and employees are encouraged to use the respirators provided. Respirators selected shall be NIOSH-approved and effectively protect the wearers from inhalation of PM2.5, such as N95 filtering facepiece respirators. Respirators shall be cleaned, stored, maintained, and replaced so that they do not present a health hazard to users. Additionally:

1) The project team shall provide each respirator wearer a copy of Attachment A to this Plan as training in the proper voluntary use of respirators on the project.
2) Since the filtering facepiece respirator use is voluntary, regulatory and Arcadis requirements regarding fit testing and medical evaluations are not mandatory.

b) Where the current AQI for PM2.5 exceeds 500, respirator use is required in accordance with all requirements in the Arcadis Respiratory Protection Health and Safety Standard. The assigned protection factor for the respirator used will ensure the PM2.5 levels inside the respirator correspond to an AQI less than 151. If wildfire smoke is the only respiratory hazard of concern on the project, preparation of the Arcadis Level C Supplement is not required if meeting the requirements of this

Site Specific Controls:
The project team will monitor the AQI before field staff mobilize to the site. If AQI levels are poor, engineering and administrative controls will be used to mitigate smoke inhalation. Engineering controls will include performing as much work inside a vehicle. Administrative controls will include rescheduling work shifts, implementing a work/rest period, or rescheduling the event. If engineering and administrative controls cannot mitigate smoke inhalation, please reference the Smoke Inhalation Hazard Controls section for AQI exceedances and respirator use.

Respirator Change Out:
In most situations, the NIOSH approved N-95 respirator to be issued for voluntary use will be in the form of a "dust mask". When used in voluntary situations, the dust mask will be replaced:

a) At the end of each work shift; or
b) When visibly soiled or discolored from smoke, dirt or debris; or
c) When breathing becomes difficult or labored while wearing the dust mask.

Voluntary use of other types of respirators meeting NIOSH N-95 protection, such as tight-fitting half-facepiece or full facepiece air purifying respirators equipped with particulate cartridges, the cartridges will be changed out using the same criteria above for dust masks or will be changed out in accordance with manufacturer's end of service life (ESLI) recommendations.

Respirator Decontamination and Disinfection:
Disposable dust masks will not be decontaminated or disinfected and will be disposed after use. For other types of respirators, the following cleaning and disinfecting procedure will be used:

1) Remove cartridges/canisters/filters. Disassemble facepiece by removing speaking diaphragm, demand and pressure-demand valve assemblies, hoses, or any components recommended by the manufacturer.
2) Wash components with warm (<110° F) water with a mild detergent or with a cleaner approved by the manufacturer. A soft, non-wire bristle brush may be used to facilitate dirt removal.
3) Rinse with warm (<110° F) clean water, preferably running water.
4) If the cleaner used does not contain a disinfecting agent, respirator components should be immersed in one of the following for two minutes:

a) Hypochlorite solution (50 ppm chlorine) made by adding approximately 1 milliliter of laundry bleach to 1 liter of water at 110° F; or
b) Aqueous solution of iodine (50 ppm iodine) made by adding approximately 0.8 milliliters of tincture of iodine [6-8 grams ammonium and/or potassium iodide/100 cubic centimeters (cc) of 45 percent alcohol] to one liter of water at 110° F; or
c) Other commercially available cleansers of equivalent disinfectant quality, when used as directed by the manufacturer, and are approved for use by the respirator manufacturer.

5) Thoroughly rinse the respirator components in clean, warm, (<110° F) running water.
6) Components should be hand dried with a soft lint free cloth or allowed to air dry.
7) Reassemble the facepiece and restore cartridges/canisters/filters as necessary.
8) Test the respirator for proper working condition.

Communications:
The Site Safety Officer will update employees on current AQI for PM2.5 verbally during safety briefings and throughout the day by:

- [ ] Two-way radio communications
- [X] Cell or satellite phone via voice or text
- [ ] Other method: _____

Utilization of WorkCare for Smoke Inhalation Questions or Concerns:
Employees experiencing diffculty breathing due to wildfire smoke exposure (regardless of the AQI) or through voluntary use of a respirator are expected, as a matter of Arcadis policy, to contact WorkCare (1-888-449-7787) for medical evaluation and guidance.

Signatures:

Prepared by: Dawn Monico Date: 8/29/2022

Reviewed by: Nicholas Monico Date: 12/27/2022

Attachment A

Protection from Wildfire Smoke Information to Be Provided to Employees (California Mandatory per Appendix B to Title 8 Section 5141.1. All Other States Distribution Recommended)

(a) The health effects of wildfire smoke.
Although there are many hazardous chemicals in wildfire smoke, the main harmful pollutant for people who are not very close to the fire is "particulate matter," the tiny particles suspended in the air. Particulate matter can irritate the lungs and cause persistent coughing, phlegm, wheezing, or difficulty breathing. Particulate matter can also cause more serious problems, such as reduced lung function, bronchitis, worsening of asthma, heart failure, and early death. People over 65 and people who already have heart and lung problems are the most likely to suffer from serious health effects. The smallest-and usually the most harmful-particulate matter is called PM2.5 because it has a diameter of 2.5 micrometers or smaller.

(b) The right to obtain medical treatment without fear of reprisal.
Employers shall allow employees who show signs of injury or illness due to wildfire smoke exposure to seek medical treatment, and may not punish affected employees for seeking such treatment. Employers shall also have effective provisions made in advance for prompt medical treatment of employees in the event of serious injury or illness caused by wildfire smoke exposure.

(c) How employees can obtain the current Air Quality Index (AQI) for PM2.5.
Various government agencies monitor the air at locations throughout California and report the current AQI for those places. The AQI is a measurement of how polluted the air is. An AQI over 100 is unhealthy for sensitive people and an AQI over 150 is unhealthy for everyone. Although there are AQIs for several pollutants, Title 8, section 5141.1 about wildfire smoke only uses the AQI for PM2.5.

The easiest way to find the current and forecasted AQI for PM2.5 is to go to www.AirNow.gov and enter the zip code of the location where you will be working. The current AQI is also available from the U.S. Forest Service at https://tools.airfire.orgl or a local air district, which can be located at www:arb.ca.gov/capcoa/dismap.htm. Employees who do not have access to the internet can contact their employer for the current AQL. The EPA website www.enviroflash.info can transmit daily and forecasted AQIs by text or email for particular cities or zip codes.

(d) The requirements in Title 8, section 5141.1 about wildfire smoke.
If employees may be exposed to wildfire smoke, then the employer is required to find out the current AQI applicable to the worksite. If the current AQI for PM2.5 is 151 or more, the employer is required to:
(1) Check the current AQI before and periodically during each shift.
(2) Provide training to employees.
(3) Lower employee exposures.
(4) Provide respirators and encourage their use.

(e) The employer's two-way communication system.
Employers shall alert employees when the air quality is harmful and what protective measures are available to employees. Employers shall encourage employees to inform their employers if they notice the air quality is getting worse, or if they are suffering from any symptoms due to the air
The employer communication system is:
The Site Safety Officer will update employees on current AQI for PM2.5 verbally during safety briefings and throughout the day by:

- [ ] Two-way radio communications
- [X] Cell or satellite phone via voice or text
- [ ] Other metho NA

f) The employer's methods to protect employees from wildfire smoke.
Employers shall take action to protect employees from PM2.5 when the current AQI for PM2.5 is 151 or greater. Examples of protective methods include:
(1) Locating work in enclosed structures or vehicles where the air is filtered.
(2) Changing procedures such as moving workers to a place with a lower current AQI for PM2.5.
(3) Reducing work time in areas with unfiltered air.
(4) Increasing rest time and frequency, and providing a rest area with filtered air.
(5) Reducing the physical intensity of the work to help lower the breathing and heart rates.

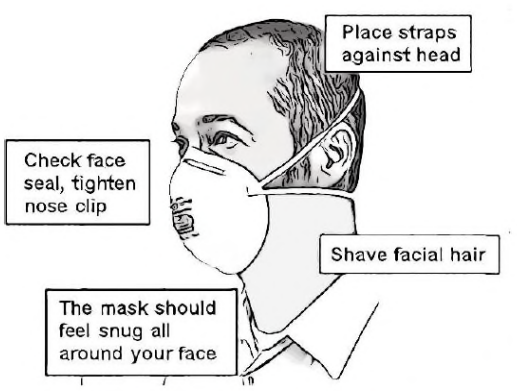
The employer's control system at this worksite is:
The project team will monitor the AQI before field staff mobilize to the site. If AQI levels are poor, engineering and administrative controls will be used to mitigate smoke inhalation. Engineering controls will include performing as much work inside a vehicle. Administrative controls will include rescheduling work shifts, implementing a work/rest period, or rescheduling the event. If engineering and administrative controls cannot mitigate smoke inhalation, please reference the Smoke Inhalation

(g) The importance, limitations, and benefits of using a respirator when exposed to wildfire smoke.
Respirators can be an effective way to protect employee health by reducing exposure to wildfire smoke, when they are properly selected and worn. Respirator use can be beneficial even when the AQI for PM2.5 is less than 151, to provide additional protection.·
When the current AQI for PM2.5 is151 or greater, employers shall provide their workers with proper respirators for voluntary use. If the current AQI is greater than 500, respirator use is required in accoradance with all applicable regulatory and Arcadis Respiratory Protection Program requirements.

A respirator should be used properly and kept clean. The following precautions shall be taken:
(1) Employers shall select respirators certified for protection against the specific air contaminants at the workplace. NIOSH, the National Institute for Occupational Safety and Health of the U.S. Center for Disease Control and Prevention, certifies respirators. A label or statement of certification should appear on the respirator or respirator packaging. It will list what the respirator is designed for (particulates, for example). Surgical masks or items worn over the nose and mouth such as scarves, T-shirts, and · bandannas will not provide protection against wildfire smoke. An N95 filtering facepiece respirator, shown in the image below, is the minimum level of protection for wildfire smoke.
(2) Read and follow the manufacturer's instructions on the respirator's use, maintenance, cleaning and care, along with any warnings regarding the respirator's limitations. The manufacturer's instructions for medical evaluations, fit testing, and shaving should also be followed, although doing so is not required by Title 8, section 5141.1 for voluntary use of filtering facepiece respirators.
(3) Do not wear respirators in areas where the air contains contaminants for which the respirator is not designed. A respirator designed to filter particles will not protect employees against gases or vapors, and it will not supply oxygen.

(4) Employees should keep track of their respirator so that they do not mistakenly use someone else's respirator.
(5) Employees who have a heart or lung problem should ask their doctor before using a respirator.

(h) How to properly put on, use, and maintain the respirators provided by the employer.
To get the most protection from a respirator, there must be a tight seal around the face. A respirator will provide much less protection if facial hair interferes with the seal. Loose-fitting powered air purifying respirators may be worn by people with facial hair since they do not have seals that are affected by facial hair.
The proper way to put on a respirator depends on the type and model of the respirator. For those who use an N95 or other filtering facepiece respirator mask that is made of filter material:
(1) Place the mask over the nose and under the chin, with one strap placed below the ears and one strap above.
(2) Pinch the metal part (if there is one) of the respirator over the top of the nose so it fits securely.



Drawing Showing Proper Fitting of a Filtering Facepiece Respirator (shaving is not required for voluntary respirator use)

For a respirator that relies on a tight seal to the face, check how well it seals to the face by following the manufacturer's instructions for user seal checks. Adjust the respirator if air leaks between the seal and the face. The more air leaks under the seal, the less protection the user receives.

Respirator filters should be replaced if they get damaged, deformed, dirty, or difficult to breathe through. Filtering facepiece respirators are disposable respirators that cannot be cleaned or disinfected. A best practice is to replace filtering facepiece respirators at the beginning of each shift. If you have symptoms such as difficulty breathing, dizziness, or nausea, go to an area with cleaner air, take off the respirator, and get medical help.

NOTE: Authority cited: Section 142.3, Labor Code. Reference: Sections 142.3 and 144.6, Labor Code.

Purpose and Scope **Date Completed** 12/27/2022

The purpose of this document is to serve as a planning tool and implementation guide to assist the project team, onsite personnel, and the Site Safety Officer (SSO) or other designated responsible party to comply with the requirements set forth by **Cal/OSHA Title 8 CCR 3395 Heat Illness Prevention Standard** and the **Washington State Outdoor Heat Exposure Regulations 296-62-09510 thru 09560**.

NOTE: This HASP Supplement is required to be used in California and Washington states. The Arcadis Health and Safety Standards ARC HSIH013 Heat Stress Prevention, and ARC HSGE008 Injury and Illness Prevention Program (IIPP) must accompany this HASP Supplement. To completely address the regulatory requirements for work in CA and WA states these standards are required to be used in association with the project-specific HASP and this supplement.

The scope of this HIPP applies to Arcadis projects which include, but are not limited to: outdoor operations such as contractor oversight, construction, refining, oil and gas extraction, asbestos removal, and hazardous waste site activities and interior work particularly tasks which require employees to wear PPE which can increase the risk for heat stress for the wearer. This HIPP provides guidance to prevent or reduce the risk of work-related heat illness. This HASP Supplement provides site specific instructions for actions to be completed at the project site.

Project sites in other states and provinces are expected to use this HASP Supplement as a Best Management Practice to prevent heat related illness injuries.

Project Site Name	BNSF Skykomish

Authority and Implementation

The following designated individuals have authority and responsibility for implementing the provisions of this program at the project work site indicated above.

Project Manager	Kyle Haslam
Site Safety Officer (SSO)	Emily Zikmund
SSO Designated Alternate	Elizabeth Scheller

Acclimatization of Personnel for Heat Stress Prevention

The degree to which personnel have been able to physiologically adjust or acclimatize to working under hot conditions affects ability to safely do work. Acclimatized individuals generally have lower heart rates and body temperatures than unacclimated individuals, and sweat sooner and more profusely. This enables them to maintain lower skin and body temperatures at a given level of environmental heat and work loads than unacclimated workers. Acclimatization can occur after a few days of exposure to the hot work environment. OSHA/NIOSH suggests an acclimatization period of 2-3 days for fit personnel. One the 1st day personnel should spend 50% of the day exposed to / working in the hot environment and increasing the amount of work 10-20% based on personnel response to the hot environment and work load.

Procedures for Provisions for Potable Water

The SSO or designee will be responsible for implementing the following when conditions at the site are anticipated to exceed 80 degrees (°) Fahrenheit (F) / 26.6° Celsius (C)

1. Proper hydration is critical to preventing heat related illness and injury. Project sites will maintain an adequate supply of suitably cool, fresh and pure potable water on site/readily accessible to allow each employee to consume 1 quart (1 L) of water per hour, ideally at a rate of four 8-oz (250 mL) cups per hour.
NOTE: Fresh and pure water is defined as being "odor free and suitably cool". Where suitably cool means water being cooler than the ambient temperature but not so cold as to cause discomfort or prevent drinking.
NOTE: Electrolyte replacement drinks or “Sports Drinks” should be used to replace essential minerals lost during sweating. Sports drinks should supplement water intake e.g. one “sport drink” to every three bottles of water (3 waters : 1 sport drink)

2. During the Tailgate Safety Meeting and site briefings identify and communicate the type and location of the water source. The water source must provide suitably cool, fresh, and pure water in sufficient quantity for all employees at the site. Water shall be provided free of charge or expenses will be reimbursed for employees. If the source is potable plumbed water do not complete Item 6 of this Section.

3. Communicate to staff whether all water for the day will be provided at the start of the shift (e.g., 2 gallons / 8 L per employee for an 8-hour shift), or how and when water will be replenished.

NOTE: A sufficient quantity of water must always be present and readily accessible to allow every employee to consume at least 1 quart (1L) of water per hour. It is suggested to have a minimum of three hours supply of water per employee on hand.

4. Water supplies must be positioned as close as reasonable possible to site workers. Placing water only in shaded areas or by toilet facilities is not sufficient, particularly at large work sites or at multi-story construction sites. Drinking water sources need to be close enough to workers to allow for routine consumption per the rate noted above.

5. Inspect the coolers / water dispensers for cleanliness and replenishment of water and cooling ice routinely based on temperatures and staff size. Cooling ice will be stored in clean coolers if added directly to water dispensers.
NOTE: If the site temperature exceeds 90° F / 32° C the frequency of the cooler inspection will increase to verify water remains cool and the water supply is maintained.

6. Oversee the daily inspection and maintenance of coolers to ensure they are kept clean and in good condition.

Potable Water Source & Location

☐	Potable plumbed source	Location:	
X	Bottled water in chilled cooler	Location:	In Arcadis field vehicle
☐	Drinking water dispenser & cups	Location:	

Procedures for Provisions for Potable Water Continued

Check which applies. Must check at least one box, or provide additional detail.

X	Ice will be purchased at the start of each day.
	Ice will be provided by an onsite source or vendor service. Ice to be potable
	Alternative potable ice source:
	Food safe cleaning product for water cooler.
	Sufficient amount of drinking water cups for each employee per dispenser.
	Other items needed:

Access to Shade

The SSO or designee is responsible for implementing the following for how shade will be coordinated and provided **when temperatures exceed 80° F / 26° C**.

1. Access to shade must be allowed at all times. Before the start of work, the location of the shade areas, the importance of taking shade breaks, recognizing the signs and symptoms of heat illness, the schedule of shade breaks, and the location of shade break locations (if not portable) will be addressed during each Tailgate Safety Meeting and site briefing.

NOTE: Where required by regulation, shade breaks will be taken at a minimum rate of 10 minutes of shade for every two hour work period. As temperature increases shade breaks will increase in frequency. See the Heat Index table below for Heat Index specific Action Levels defining shade break frequency and duration.

2. The amount of shaded area must be able to accommodate all employees taking a recovery or rest break including employees on meal breaks. The shaded area(s) don't need to provide shade to accommodate **all employees** on a site or working a shift at the same time. An example includes rotating routine breaks among employees. Also, additional portable shade structures can be erected on an “as-needed” basis.
Employees must have enough shaded space so they can sit in a normal posture fully in the shade with enough space to allow for sitting without being in physical contact with each other. Employees who desire access to shade must not be deprived of it due to lack of space.

3. Employees who take a preventative cool-down rest;
(1) shall be monitored and asked if they are experiencing symptoms of heat related illness. (2) shall be encouraged to remain in the shade. (3) shall not be ordered back to work until signs or symptoms of heat illness have abated, but in no event less than 5 minutes in addition to the time needed to access the shade. If an employee exhibits signs or symptoms of heat illness while taking a preventative cool-down rest the SSO will provide appropriate support (e.g. additional hydration and/or call to WorkCare) or emergency response support as needed based on symptoms.

4. Shade structures will be relocated to follow the crew for moving tasks. Shade structures will be placed within 50 feet of the work area, if practical. Shade structures must be no further than a short walk away (e.g. 2-3 minutes) from the work area. This consideration becomes more critical as the temperature rises above 80° F (26 C).

Access to Shade Continued

5. In situations where it is not safe or feasible to provide shade, the SSO will document in the HASP Supplement the unsafe or unfeasible conditions, and include the steps taken to provide alternative cooling measures equivalent to shade.

Unsafe/unfeasible conditions: _____

Alternative Cooling Measures Implemented:

X	Provide vehicles with working air conditioner to all employees for rest breaks / recovery breaks / meal breaks.
	Provide temporary or mobile shade structure(s) that are either ventilated or open to air movement (Secure against wind.)
	Provide a building / permanent structure(s) in close proximity to the work area with a cooling environment via mechanical ventilation or open to air movement which will be used for shade. (Job trailer, pavilion, manufacturing building, etc.)
	Other:

Monitoring of Weather and Heat Index Table

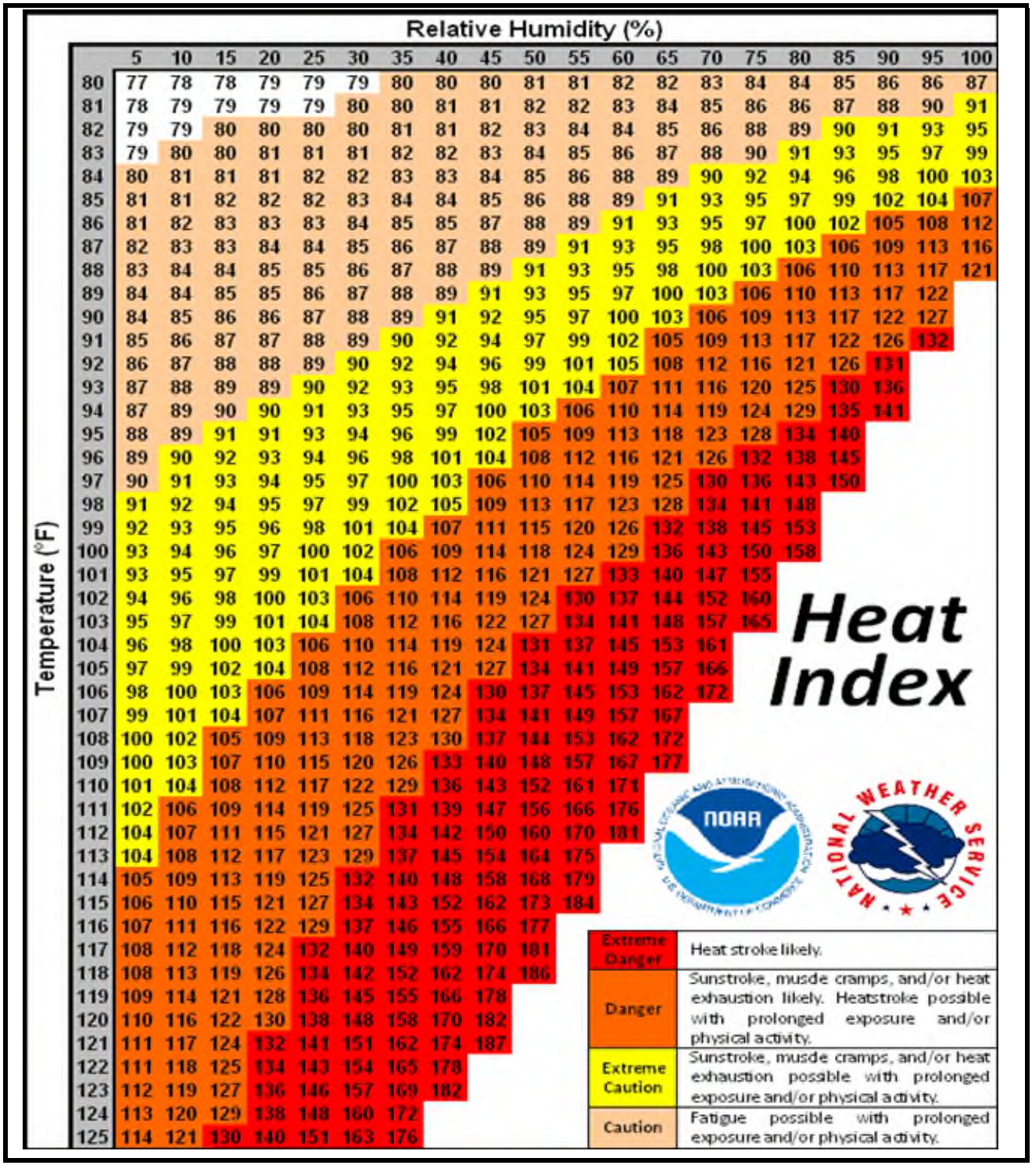
1. The SSO or designee must check the extended weather forecast in advance of the upcoming work on a weekly basis. Work schedules will be adjusted in advance, taking into consideration whether high temperatures or a heat wave is expected.
Accepted weather forecasting resources include webpages "NOAA.gov" or "weather.com" or see the NIOSH Heat Tool (formerly the OSHA Heat Tool app)

https://www.cdc.gov/niosh/topics/heatstress/heatapp.html

2. Before work starts for the day or shift, the SSO will review the forecasted temperature and humidity for the (exterior) work site and compare conditions against the National Weather Service Heat Index (below) to evaluate the risk level for heat illness. Determination will be made of whether or not workers will be exposed to a combination of temperature and humidity characterized as "Caution", “Extreme Caution”, "Danger" or “Extreme Danger” for heat illnesses.
NOTE: It is important to know the temperature at which these warnings occur. When working outdoors see the Heat Index Table in this supplement for Action Level specific instructions for hazard controls.

3. Where state regulations indicate a thermometer or similar on-site monitoring device will be used at the job site to monitor for sudden increases in temperature. The SSO will be responsible for obtaining a thermometer/weather station prior to the start of work and make it readily visible / accessible where it can easily be monitored throughout the course of the day.
NOTE: If the temperature is **> 80°F (26 C)** shade structures will be opened and made available to workers. If temperature is **≥ 95° F (35 C)** additional preventive measures will be implemented.

Monitoring of Weather and Heat Index Table Continued



Temp (°F)	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
80	77	78	78	79	79	79	80	80	80	81	81	82	82	83	84	84	85	86	86	87
81	78	79	79	79	79	80	80	81	81	82	82	83	84	85	86	86	87	88	90	91
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88	83	84	84	85	85	86	87	88	89	91	93	95	98	100	103	106	110	113	117	121
89	84	84	85	85	86	87	88	89	91	93	95	97	100	103	106	110	113	117	122	
90	84	85	86	86	87	88	89	91	92	95	97	100	103	106	109	113	117	122	127	
91	85	86	87	87	88	89	90	92	94	97	99	102	105	109	113	117	122	126	132	
92	86	87	88	88	89	90	92	94	96	99	101	105	108	112	116	121	126	131		
93	87	88	89	89	90	92	93	95	98	101	104	107	111	116	120	125	130	136		
94	87	89	90	90	91	93	95	97	100	103	106	110	114	119	124	129	135	141		
95	88	89	91	91	93	94	96	99	102	105	109	113	118	123	128	134	140			
96	89	90	92	93	94	96	98	101	104	108	112	116	121	126	132	138	145			
97	90	91	93	94	95	97	100	103	106	110	114	119	125	130	136	143	150			
98	91	92	94	95	97	99	102	105	109	113	117	123	128	134	141	148				
99	92	93	95	96	98	101	104	107	111	115	120	126	132	138	145	153				
100	93	94	96	97	100	102	106	109	114	118	124	129	136	143	150	158				
101	93	95	97	99	101	104	108	112	116	121	127	133	140	147	155					
102	94	96	98	100	103	106	110	114	119	124	130	137	144	152	160					
103	95	97	99	101	104	108	112	116	122	127	134	141	148	157	165					
104	96	98	100	103	106	110	114	119	124	131	137	145	153	161						
105	97	99	102	104	108	112	116	121	127	134	141	149	157	166						
106	98	100	103	106	109	114	119	124	130	137	145	153	162	172						
107	99	101	104	107	111	116	121	127	134	141	149	157	167							
108	100	102	105	109	113	118	123	130	137	144	153	162	172							
109	100	103	107	110	115	120	126	133	140	148	157	167	177							
110	101	104	108	112	117	122	129	136	143	152	161	171								
111	102	106	109	114	119	125	131	139	147	156	166	176								
112	104	107	111	115	121	127	134	142	150	160	170	181								
113	104	108	112	117	123	129	137	145	154	164	175									
114	105	109	113	119	125	132	140	148	158	168	179									
115	106	110	115	121	127	134	143	152	162	173	184									
116	107	111	116	122	129	137	146	155	166	177										
117	108	112	118	124	132	140	149	159	170	181										
118	108	113	119	126	134	142	152	162	174	186										
119	109	114	121	128	136	145	155	166	178											
120	110	116	122	130	138	148	158	170	182											
121	111	117	124	132	141	151	162	174	187											
122	111	118	125	134	143	154	165	178												
123	112	119	127	136	146	157	169	182												
124	113	120	129	138	148	160	172													
125	114	121	130	140	151	163	176													

Note: The Heat Index table was developed with an expectation of partial shade & light wind conditions present. Work conducted in direct / full sunlight (e.g. no partial shade) and no wind adds up to 15° F (8° C) to the Heat Index evaluation.

Monitoring of Weather and Heat Index Table Continued

Heat Index Action Levels. Below are recommended additional controls. Each level of additional controls is additive as the temperature increases.

CAUTION 80° - 90° F (26° - 32° C). Implement one or more of the following measures: Provide and direct hydration, schedule breaks, ensure lightweight clothing is worn, provide break areas with shade / ventilation / air conditioning.

EXTREME CAUTION 90° - 105° F (32° - 40.5° C). Implement all the previous and add one or more of the following: Provide light duty PPE, cooled break areas, shaded work areas.
NOTE: "Light Duty PPE" includes hard hat sun shades, sun hats, dry or wet evaporative cooling vests, microfiber cooling towels / scarves / headbands / hard hat suspension inserts or sweatbands, hard hat neck shades.

DANGER 105 ° - 130 ° F (40.5° - 54.4° C). Implement all the previous and add one or more of the following: cooled work areas, modified work schedule, heavy duty PPE, and personnel physiological monitoring.
NOTE: "Heavy Duty PPE" phase-change cooling vests, gel pack or ice pack equipped cooling vests. Consider engineering controls such as forced ventilation.

EXTREME DANGER ≥ 130° F (≥ 54.4° C). If working at this temperature or greater Stop Work until conditions change or hazards are effectively controlled via the items listed above. At this range of temperatures it is critical to implement personnel vital sign monitoring for determining the appropriate frequency and duration of Work / Rest cycles.

Work / Rest Cycle Duration and Frequency Process

All workers, regardless if they are wearing permeable or impermeable clothing, should be monitored when conditions warrant e.g., when temperatures exceed 80°F / 26.6°C. If impermeable clothing is worn (e.g., not standard cotton/synthetic work clothes), it is a best practice to begin monitoring workers when temps are > 70°F in the work area. Prioritize workers completing strenuous tasks. Prioritization should also apply to work conducted indoors, for strenuous tasks, and/or if additional PPE is worn (such as Level C respiratory protection or(CPC). If impermeable clothing, Level C, or CPC is not worn, follow the Heat Index table instructions and evaluate personnel monitoring as part of the high heat measures. Details provided below for appropriate work/rest cycle development with the default rest cycle being a 15-minute interval for every hour when temperatures exceed 90°F.

NOTE: *Warning signs include: When a person's sustained (e.g., several minutes) heart rate exceeds 180 beats per minute (bpm) minus their age (e.g., 180 - age = X) for individuals with normal cardiac performance per their physician; or a body core temperature exceeds 101.3°F / 38.5°C for acclimatized workers or 100°F / 38°C for unacclimated workers; a recovery heart rate at 1 minute after a peak work effort is greater than 120 bpm; or there are symptoms of sudden and severe fatigue, nausea, dizziness, or lightheadedness.*

Suggested Frequency and Duration of Work / Rest Cycles Applying Physiological Monitoring of Acclimatized Personnel

Adjusted Temp. (1)	Permeable PPE (2)	Impermeable PPE (3)
≥ 90° F / 32° C	After ea. 45 mins. of work	After ea. 15 mins. working
87.5-90° F / 30.8-32.2° C	After ea. 60 mins. of work	After ea. 30 mins. Working
82.5-87.5° F / 28.1-30.8° C	After ea. 90 mins. of work	After ea. 60 mins. Working
77.5-82.5° F / 25.3-28.1° C	After ea.120 mins. of work	After ea. 90 mins. Working
72.5-77.5° F / 22.5-25.3° C	After ea.150 mins. of work	After ea. 120 mins. Working

NOTES:

(1) Adjusted air temp (ta adj) calculation: ta adj F = ta F + (13 x % sunshine). Measure the air temperature (ta) with a thermometer (shielded from radiant heat). Estimate the percent sunshine by judging what percent time the sun is not covered by clouds
that are thick enough to produce a shadow. (100 percent sunshine = no cloud cover and a sharp, distinct shadow; 0 percent sunshine = no shadows.)

(2) Permeable PPE consists of cotton clothing with long sleeves and pants or breathable coveralls.

(3) Add 1.8 °F for Tyvek coveralls; add 5.4 °F for heavy clothing; add 19.8 °F for impermeable/semi-impermeable PPE - Level A/B suits)

Heart Rate Monitoring

When conducting heart rate monitoring, first record a resting heart rate to establish the individuals daily baseline heart rate. Count the radial pulse (located on the inside of the wrist below the thumb) during a 30 second interval before the start of work to establish a baseline heart rate. During rest cycles count the heart rate as early as possible at the beginning of the rest cycle and again 3-5 minutes later. The heart rate should fall and soon approach the individuals baseline heart rate.

- If the heart rate exceeds 110 beats per minute at the beginning of the rest period, shorten the next work cycle by one-third and keep the rest period the same.
- If the heart rate still exceeds 110 beats per minute at the next rest period, shorten the following work cycle by one-third.

Body Temperature Monitoring

Use an oral, inner ear, or an infrared type thermometer to measure the body temperature at the end of the work period (If using an oral thermometer record temperature before drinking liquids).

- If oral temperature exceeds 99.6°F (37.6°C), shorten the next work cycle by one-third without changing the rest period.
- If oral temperature still exceeds 99.6°F (37.6°C) at the beginning of the next rest period, shorten the following work cycle by one-third.
- Do not permit a worker to wear a semi-permeable or impermeable garment when his/her oral temperature exceeds 100.6 °F (38.1 °C).

Procedures for High Heat Conditions and Heat Waves

These procedures are additional preventative measures to be implemented when the temperature is > 95° F (35° C). The SSO or designee is responsible for ensuring effective observation and monitoring of employees during periods of high heat by implementing one or more of the following procedures:

1. SSO or designee will supervise 20 or fewer employees.
2. The “Buddy System” is mandatory. Conduct routine checks for early signs of Heat Illness. Set and verify routine consumption of water & sports drinks in a 3:1 ratio.

3. Maintain regular communication between Project Manager or SSO / designee and field staff (e.g. via mobile phone, radio or another effective means) for observation of early signs of heat illness.

4. Designate one or more employees as authorized to contact emergency medical services and communicating that if no designate is identified and the SSO is unavailable that any employee can call for emergency medical assistance.

5. Modify work schedule to avoid hottest parts of the day (e.g. start work earlier in the AM, stop work for the hottest hours of the day, conduct work during the evening).

Additionally, tailgate Safety Meetings will include a review the high heat procedures, encourage employees to drink plenty of water, and remind employees of the importance to take a preventative or recovery cool-down rest when necessary.

Employees will be observed for alertness and signs and symptoms of heat illness at regular intervals to be documented in the field book or field log.

The “Buddy System” must be implemented. Particular attention needs to be paid to new employees or employees who have yet to acclimate to high heat conditions. Additionally, frequent communication will be maintained with employees working by themselves (via cell phone or two-way radio), to evaluate early warning signs and symptoms of heat illness.

When the SSO is not available, an alternate responsible person must be assigned to look for signs and symptoms of heat illness. Such a designated observer will be trained and know what steps to take if heat illness occurs.

"Heat Wave" Procedures

A “heat wave” as defined by NOAA, is a period of abnormally and uncomfortably hot and unusually humid weather.” Typically, a heat wave lasts 2 or more days. A "Heat Wave" as defined for the purposes of this Standard is when temperatures are sustained above 80° F / 26° C.
During a heat wave or if site conditions indicate the potential for “Extreme Caution”, "Danger" or “Extreme Danger” per the NOAA Heat Index Table the following steps will be taken:

Work schedules will be modified to protect workers from heat illnesses. The SSO or designee in coordination with the project team, will use their Stop Work Authority and evaluate the following actions and document the action in the daily field log

1. Modify work hours to exclude the hottest parts of the day.

2. Reschedule work or specific tasks that require strenuous exertion or Stop Work.

If schedule modifications are not possible, the Heat Illness Prevention Plan will be reviewed before work resumes. At a minimum, procedures for heat illness prevention, the provisions of the high heat procedures, the weather forecast and emergency response protocols will be reviewed.

Employees will be provided with additional water and rest breaks and will be observed more frequently. During work activities and rest breaks, employees will be observed for signs and symptoms of heat illness.

All employees will maintain frequent communication with the SSO or designee, who will be monitoring workers for possible symptoms of heat illness. In the event of large project sites where the SSO may be unable to be near the workers (to directly observe or communicate with them), then communication via a cell phone or radio may be used for this purpose provided reception in the area is reliable.

Procedure for Emergency Response

Emergency procedures include recognizing the symptoms of heat related illness. A critical step also involves ensuring that effective communication is established either through voice, direct observation or electronic means such as via mobile phones or 2-way radios. In an emergency situation it is critical that employees understand the process and contact information for requesting emergency medical support. The reception coverage for the site must be evaluated and understood to ensure adequate communication is in place across the project site. During a heat wave or hot temperatures, workers will be reminded and encouraged to immediately report to the SSO any signs or symptoms of the onset of heat stress they are experiencing.

Procedure for Emergency Response Continued

The SSO or designee is responsible for implementing the following procedures for emergency response. These procedures include, but are not limited to, the following:

1. Prior to assigning staff to a particular work site, during the Tailgate H&S Safety Meeting all site workers will review the HASP along with the identified Hospital precise directions (such as streets or road names, distinguishing features, and distances to major roads), to avoid a delay of emergency medical services.

2. Prior to work, efforts will be made to ensure that a qualified, appropriately trained and equipped personnel are consistently available to render first aid.

3. Prior to the morning Tailgate Safety Meeting, an evaluation of whether or not a language barrier is present at the site for understanding the necessary preventative measures and emergency notifications procedures can be completed. Necessary steps will be taken (such as assigning the responsibility to call emergency medical services to the SSO or an English speaking worker) to ensure that emergency medical services can be immediately called in the event of an emergency.

4. All SSOs and supervisors will carry cell phones or other means of communication to ensure that emergency medical services can be called. Routine checks will be made to ensure the devices are allowed on site, have adequate reception across the site, and are functional prior to each shift.

5. When an employee reports symptoms, or displaying symptoms of possible heat illness, steps will be taken immediately to keep the affected employee cool and comfortable. Evaluate whether 1st aid is to be administered or emergency services are to be contacted or the employee is to be taken to an emergency facility for care.

Procedure for Handling a Sick Employee

Signs of Heat Stress: Excessive fatigue, heavy sweating, headaches, abdominal and/or upper thigh cramps, mild dizziness, elevated pulse.
Signs of Heat Exhaustion: Cool, moist, pale or flushed skin, nausea or vomiting, disorientation or confusion.
Signs of Heat Stroke: Hot, red skin which can feel dry to the touch, or moist from overexertion, changes in consciousness, rapid or weak pulse, shallow rapid breathing.

The SSO or designee is responsible for implementing the following procedures for evaluating and providing care for a sick employee:

1. When an employee displays signs or symptoms consistent with the heat related illness, the SSO or designee will check the sick employee and determine whether resting in the shade and drinking cool water will suffice or if emergency service providers will need to be called.

Procedure for Handling a Sick Employee Continued

If determined to be **a non-emergency** (e.g. heat cramps or heat stress) the SSO will contact **WorkCare Injury Assistance Hotline 1-888-449-7787** for 1st aid medical assistance. In the event of the injury being an emergency, or potentially (e.g. Heat Exhaustion or Heat Stroke) contact emergency support services.

2. When an employee displays possible signs or symptoms of heat illness and no trained first aid worker or supervisor is available at the site, emergency service providers will be called.

3. Emergency service providers will be called immediately if an employee displays signs or symptoms of advanced stage heat related illness like Heat Exhaustion or Heat Stroke (loss of consciousness, incoherent speech, convulsions, red and hot face) or does not get better after drinking cool water in intervals of 8 ounces every 15 minutes and resting in the shade. While the ambulance is in route, assign a person to care for the injured, first aid will be administered (cool the worker by placing them in the shade, remove excess layers of clothing, place ice pack in the armpits and groin area and fan the person). A worker determined to be suffering an advanced stage of heat related illness will not be allowed to leave the site except under medical care, or as directed by a medical professional.

4. If an employee displays signs or symptoms of advanced stage heat related illness (loss of consciousness, incoherent speech, convulsions, red and hot face), and the work site is located more than 20 minutes away from a hospital, call emergency service providers, communicate the signs and symptoms of the victim, and request an Air Ambulance if necessary.

Revisions, notes, amendments, and clarifications specific to this plan will be detailed in the space below:

Arcadis Lone Worker or Remote Location Communication Plan

(For international travel/work, use the Travel Safety and Security Plan template in lieu of this template)

Project Name:	BNSF Black Tank
Project Number:	30093684
Date:	2/28/2022
Revision:	

General Information (select all that apply):

- [X] Worker will be alone
- [ ] Buddy system will be used
- [X] Area is within cell phone service range
- [ ] Cell phone service is limited or out of range
- [ ] Worker will be performing high risk activity (Lone Worker is not permitted)
- [X] Work will be performed outside normal operating hours (nights or weekends)
- [ ] Wilderness work
- [ ] Site is not accessible to standard emergency services
- [ ] Other unique site conditions that may hinder employee's ability to get help, if required.

Explain:

Communication Plan

Frequency of Communication: HOURLY

Planned Start Time: 7:30:00 AM Planned End Time: 7:30:00 PM

Contact Information:	Steven Dixon/Betty Walter
Field Worker Name:	Steven Dixon/Betty Walter
Field Worker Phone Number:	315 729 5305/406 402 7167
Vehicle Make/Model/ Plate:	Rental vehicle will be used
Office Contact Name:	Kyle Haslam
Office Contact Phone Number:	206-719-6991

Method of Communication:

- [X] Cell Phone (including text notification)
- [ ] Landline
- [ ] 2-way Radio
- [ ] Satellite Phone
- [ ] GPS
- [ ] Transponder
- [ ] App:
- [ ] Other:

Contingency Plan (if the Field Worker cannot be reached, describe actions the Office Contact will take)

If field worker cannot be reached, reach out to Kyle Haslam (206-719-6991). If Kyle Haslam cannot be reached, please reach out to Lauren Selleck (206 413 6620)

Notification Log

Time	Field Worker Notification	Office Receipt of Notification
7:30:00 AM		
8:30:00 AM		
9:30:00 AM		
11:30:00 AM		
12:30:00 PM		
1:30:00 PM		
2:30:00 PM		
3:30:00 PM		
4:30:00 PM		
5:30:00 PM		
6:30:00 PM		
7:30:00 PM		

Attachment D
H&S Standards

Implementation Date	ARCADIS HS Standard Name	ARCADIS Design & Consultancy for natural and built assets
10 January 2008	First Aid/CPR/AED	
Revision Date	ARCADIS HS Standard No.	Revision Number
04 February 2019	ARC HSGE004	10

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QUICK SHEET

Applicability

The First Aid/Cardiopulmonary Resuscitation (CPR)/Automated External Defibrillator (AED) standard applies to all Arcadis offices or job sites that designate or expect employee(s) to act as First Aid Responders. Employees who are not designated or expected to act as a First Aid Responder may render first aid voluntarily if they are trained in first aid, but their actions are not covered under the OSHA standard.

Need To Know

If the office or job site is in near proximity (within 3-4 minutes) to medical services, employees do not need to be designated or expect to act as First Aid Responders unless required to do so by a particular OSHA standard or client requirement. However, if the job site is not in near proximity to medical services and serious accidents are possible, an employee or employees will be designated and trained as a First Aid Responder.

> **Note:** OSHA has long interpreted the term "near proximity" to mean that emergency care must be available within no more than 3-4 minutes from the workplace. Accordingly, in workplaces where serious accidents such as those involving falls, suffocation, electrocution, or amputation are possible, emergency medical services must be available within 3-4 minutes, if there is no employee on the site who is trained to render first aid. OSHA exercises discretion in enforcing the first aid requirements in particular cases. OSHA recognizes that a somewhat longer response time of up to 15 minutes may be reasonable in workplaces, such as offices, where the possibility of such serious work-related injuries is more remote.

The Project Manager (PM), Location Leader, and/or Office Health & Safety (H&S) Coordinator determines if they are required to designate First Aid Responders at the office location and/or at any particular job site. The types of accidents/injuries that could occur, location/availability of medical facilities, and the response time of emergency services are considered in making this determination.

In the absence of an infirmary, clinic or hospital in near proximity to the workplace, an employee(s) will be trained to render First Aid/CPR/AED. This may also be necessary if required to do so by another standard (i.e. more stringent Arcadis standard or State OSHA standard) or client requirements. First aid supplies are readily available if an employee is designated as a First Aid Responder.

Training

First Aid/CPR/AED/Bloodborne Pathogens (BBP) training occurs prior to assignment as a First Aid Responder. First Aid/CPR/AED training is certified by the American Heart Association (AHA) or the Red Cross and is required at a minimum on a bi-annual (every two years) basis. BBP training is required annually.

Equipment

Employees designated or expected to act as First Aid Responders must have first aid supplies readily available. The type of work being done, job site and office sites are considered when

determining the contents of a first aid kit. If exposure to the weather is possible, the contents of the first aid kit must be protected.

Permits or Forms Required

Offices and project locations may opt to evaluate whether an AED is necessary at their location. The AED Evaluation form must be completed prior to AED request.

1. POLICY

It is the policy of Arcadis to comply with OSHA's Medical Services and First Aid Standard as it relates to the work we do. According to OSHA, the employer will ensure the "ready availability of medical personnel", but how this is implemented is dependent on the circumstances of each place of work.

2. PURPOSE AND SCOPE

2.1 Purpose

This Health & Safety Standard (HSS) assists Arcadis employees in determining if the OSHA standard applies to their job sites, and assists in evaluating appropriate training needs for employees.

2.2 Scope

The First Aid/CPR/AED HSS applies to all Arcadis offices that designate or expect employee(s) to act as First Aid Responders at the office location and/or a job site. Employees who are not designated or expected to act as a First Aid Responder may render first aid voluntarily if they are trained in first aid, but their actions are not covered under the OSHA standard.

If the office or job site is in near proximity to medical services, employees do not need to be designated or expect to act as First Aid Responders unless required to do so by a particular OSHA standard or client requirement. However, if the office or job site is not in near proximity to medical services, an employee or employees will be designated and trained as a First Aid Responder.

3. DEFINITIONS

There are a number of definitions associated with this standard. These definitions are presented in Exhibit 1 of this document. A list of acronyms and abbreviations used in this HSS is provided in Exhibit 2.

4. RESPONSIBILITIES

4.1 Project Management

Project Management will:

Project Management determines if a First Aid Responder is required for their job site, and ensures that employees working on their job sites have the proper training as required by this HSS.

4.2 Location Leader and Office H&S Coordinator

The Location Leader and Office H&S Coordinator determines if a First Aid Responder is required for their office location, and ensures that employees working in those locations have the proper training as required by this HSS.

If the office is enrolled in the Cintas® US National First Aid and Safety Cintas First Aid and Safety Program (Cintas® First Aid and Safety Program), H&S Coordinators are responsible for ensuring Cintas has completed and documented all of the required inspections. In offices not enrolled in the Cintas® First Aid and Safety Program, the H&S Coordinator is responsible for ensuring first aid kits are inspected at a minimum of monthly, maintained, and restocked after use.

4.3 Employees

If designated as a First Aid Responder, employees ensure their training is up to date as required by this HSS.

For job sites not enrolled in the Cintas® First Aid and Safety Program, employees are responsible for ensuring first aid kits are inspected at a minimum of monthly, maintained, and restocked after use.

4.4 Cintas

Cintas® will be responsible for restocking, inspecting and maintaining at locations that have a Cintas® issued first aid kit and/or leased AED.

5. PROCEDURE

5.1 Designation of First Responders

The PM, Location Leader and/or Office H&S Coordinator determines if a designated First Aid Responder is required at the office location and/or at any particular job site. The types of accidents/injuries that could occur, location/availability of medical facilities, and the response time of emergency services are considered in making this determination.

In the absence of an infirmary, clinic or hospital in near proximity to the workplace, an employee(s) will be trained to render First Aid/CPR. This may also be necessary if required to do so by another standard (i.e. more stringent Arcadis standard or State OSHA standard) or client requirements. First aid supplies will be readily available if an employee is designated as a First Aid Responder.

If the office and/or job site is in near proximity of emergency medical services (within 3-4 minutes), and if not required to do so by some other standard or client, there is no requirement to designate First Aid Responders. However, if the decision is made to designate First Aid Responders, all requirements of this HSS apply.

This HSS does not apply to employees who voluntarily obtain First Aid/CPR/AED/BBP certification for their own personal benefit, and were not designated by Arcadis as a First Aid Responder.ection title]

5.2 Injury/Illness Reporting and Notification

Where the illness/injury is acute or serious (life threating) it is generally best that Emergency Medical Services (EMS) is contacted by dialing 911.

WorkCare must be contacted for every non-emergency, work-related injury or illness to an Arcadis employee via their reporting hotline number (888-449-7787) to ensure proper medical

management of the injury. Additional information regarding incident reporting requirements can be found in Incident Reporting and Investigation Standard (ARC HSMS010).

5.3 Transport to Medical Facility

When EMS is contacted, a designated First Aid Responder, if possible, should stay with the injured/ill employee until professional EMS has arrived to transport the employee to the hospital.

Where the injury or illness is minor or where waiting for ambulatory services is impractical, an injured or ill employee may be driven to a medical facility. The injured or ill person should be accompanied by at least one other employee, preferably a designated First Aid Responder, in addition to the operator of the vehicle.

5.4 First Aid Supplies/Kits

Employees designated or expected to act as First Aid Responders must have first aid supplies readily available. The type of work being done, job site and office sites are considered when determining the contents of a first aid kit. If exposure to the weather is possible, the contents of the first aid kit must be protected.

The OSHA standard does not specify what should be in a kit, but does reference the recommendations by American National Standards Institute (ANSI) in their Z308.1-1998 publication, “Minimum Requirements for Workplace First Aid Kits” which provides types of kits and basic and optional contents. Since the OSHA regulation was published, the ANSI Z308.1 publication was last updated in 2014. Please note that some state OSHA programs require additional contents within first aid kits. Additional recommendations from WorkCare in regards to the contents of a first aid kit for the State of California are included in Exhibit 5. Employees are responsible for verifying and complying with state-specific requirements. The first aid kit will also contain appropriate personal protective equipment (PPE) and waste disposal supplies as required in OSHA’s BBP standard described in the Arcadis BBP HSS (ARC HSGE005). First aid kits will not contain medications that have potential to cause drowsiness or contain prescription medications.

5.4.1 Types of First Aid Kits

ANSI Z308.1 designates two classes of first aid kits (Class A & B) and four types (Type I, II, III, IV). **Class A** first aid kits are intended to provide a basic range of products to deal with most common types of injuries encountered in the workplace including: major wounds, minor wounds (cuts and abrasions), minor burns and eye injuries. First aid kits designated as Class A shall contain the assortment of compliant supplies in the quantities specified in Exhibit 3.

Class B kits are intended to provide broader range and quantity of supplies to deal with injuries encountered in more populated, complex and/or high risk workplace environments. First aid kits designated as Class B shall contain the assortment of compliant supplies in the quantities specified in Exhibit 3.

Type I first aid kits are intended for use in stationary, indoor settings where the potential for damage of kit supplies due to environmental factors and rough handling is minimal. Type I first aid kits shall have a means for mounting in a fixed position and are generally not intended to be portable.

Note: Typical applications for Type I first aid kits may include, but are not limited to, the following: general indoor use, an office setting or a manufacturing facility. First aid cabinets would generally fall into the Type I classification. Class B Type I first aid kits are recommend for Arcadis Offices and job site trailers.

Type II first aid kits are intended for portable use in indoor settings where the potential for damage of kit supplies due to environmental factors and rough handling is minimal.

Note: Typical applications for Type II first aid kits may include, but are not limited to, the following: general indoor use, an office setting or a manufacturing facility.

Type III first aid kits are intended for portable use in mobile, indoor and/or outdoor settings where the potential for damage of kit supplies due to environmental factors is not probable. Type III kits shall have a means to be mounted in a fixed position and shall have a water resistant seal.

Note: Typical applications for Type III first aid kits may include general indoor use and sheltered outdoor use. Class B Type III first aid kits are recommend for Arcadis fleet/rental vehicles and job site.

Type IV first aid kits are intended for portable use in the mobile industries and/or outdoor settings where the potential for damage to kit supplies due to environmental factors and rough handling is significant. Type IV kits shall have a means to be mounted in a fixed position and shall meet specific performance requirements.

Note: Typical applications for Type IV first aid kits may include, but are not limited to, the following: the transportation industry, the utility industry, the construction industry, and the armed forces.

5.5 Office First Aid Kit Program

Arcadis offices with five or more staff will be enrolled in the Cintas® First Aid and Safety Program. Cintas® will provide the Arcadis office with at a minimum one Class B, Type I first aid cabinet. Additional first aid cabinets may be needed based on office configuration or warehouse or shop spaces. Offices located in Puerto Rico are not currently eligible for the Cintas® First Aid and Safety Program.

Arcadis job sites are also eligible to enroll in the Cintas® US National First Aid and Safety Cintas First Aid and Safety Program. To begin the enrollment process, please contact 4-Sight-Support@Arcadis-us.com.

5.6 First Aid Kit Inspections

For offices enrolled in the Cintas® First Aid and Safety Program, Cintas® will conduct the required monthly inspections, restocking and any maintenance associated with the office first aid cabinets. Warehouse/shop spaces must be readily accessible during regular business hours.

Offices and job sites not enrolled in the Cintas® First Aid and Safety Program must complete and document routine inventory of all first aid kits. For job site first aid kits, the inventory is checked when it is initially taken to the job site, weekly thereafter, and anytime first aid is rendered. For office first aid kits, the inventory is checked monthly and anytime first aid is rendered. An example of an inventory form is included in Exhibit 4.

5.7 Emergency Eyewash and Body Wash Equipment

Where the eyes or body of an employee may be exposed to injurious corrosive materials, suitable facilities for emergency drenching/flushing of the eyes and body will be provided within the "immediate" work area.

5.8 Automated External Defibrillator

5.8.1 Optional AED Leasing

Arcadis offices and job sites with 5 or more people may opt to evaluate whether an AED is necessary at their location. The office or job site must first complete the AED Evaluation shown in Exhibit 6. Once the evaluation is complete, it must be submitted to Corporate H&S and Procurement at 4-Sight-Support@Arcadis-us.com for review. Upon review of the AED Evaluation, offices or job sites may be enrolled in the Cintas® AED lease program, which will provide the location a minimum of one AED. Additional AEDs may be needed based on office/job site configuration or warehouse/shop space location. The AED lease program includes Medical Direction, Written Plan, Replacement of Pads & Batteries, an AED wall cabinet, signage and on-going monthly checks to ensure regulatory compliance.

Staff must be trained in the use of an AED and be current in First Aid/CPR/AED/BBP training. Offices or job sites requesting an AED must ensure that staff are properly trained as per Section 6 and have at a minimum one staff member trained and designated as First Aid Responder present during normal business/working hours. Additionally, it is recommended that offices or job sites with an AED have at a minimum 10 percent of the staff properly training on the use of an AED and designated as First Aid Responders.

Offices with a building provided AED that is readily available and accessible to the tenants should be provided instructions from building management on how to access and use the building AED. These instructions shall be included in the office's emergency action plan. This process may include but is not limited to a direct line to security, security elevator override to access the floor quickly, and emergency service direction. It is recommended that staff with a building provided AED be trained in the use of an AED and be current in First Aid/CPR/AED/BBP training.

All costs associated with leasing and maintaining AEDs will be covered by office overhead or the project budget. Arcadis prohibits the overhead purchasing of AED units for Arcadis office use.

5.8.2 Project AED

The Cintas® AED lease program is the preferred method to provide an AED at a project site. When the Cintas AED Cintas® AED lease program is not feasible an AED unit may be purchased for Arcadis project use when the cost is applied directly to a project. Arcadis owned AED units are prohibited from being used in an Arcadis office.

Prior to purchasing an Arcadis project owned AED unit the AED Evaluation shown in Exhibit 6 must be completed and submitted to 4-Sight-Support@Arcadis-us.com. Project teams are required to register, maintain, and inspected the AED unit in accordance with state and federal regulations.

5.9 Hepatitis B Vaccination Series

The Hepatitis B vaccination series will be made available to all employees who are designated or expected to act as First Aid Responders. If an employee declines the vaccination, the declination form will be signed by the employee.

Additional information along with the declination form regarding the Hepatitis B vaccination series can be found in the Arcadis BBP HSS (ARC HSIH005).

6. TRAINING

First Aid/CPR/AED training occurs prior to assignment as a First Aid Responder. Training is certified by the AHA or Red Cross. Exceptions to using the AHA or Red Cross certified training needs to be approved by the Arcadis Corporate Training Team (HRSolutionsCenter.ANA@arcadis.com) before proceeding with training.

First Aid/CPR/AED recertification is provided at a minimum on a bi-annual (every two year) basis. BBP training is required annually per OSHA's BBP standard described in Arcadis BBP HSS (ARC HSIH005).

7. REFERENCES

CFR 1910.151, "Medical Surveillance and First Aid"

CFR 1926.50, "Medical Services and First Aid"

OSHA Technical Links, "Medical and First Aid

OSHA Best Practices Guide: Fundamentals of a Workplace First-Aid Program

OSHA January 16, 2007 – OSHA Interpretation Letter Compliance for "in near proximity" and "serious injury"

ANSI Z308.1-1998 publication, "Minimum Requirements for Workplace First Aid Kits"

ANSI/ISEA Z308.1-2014 American National Standard - Minimum Requirements for Workplace First Aid Kits and Supplies

Arcadis Bloodborne Pathogens Standard (ARC HSIH005)

Arcadis Incident Reporting and Investigation Standard (ARC HSMS010)

8. RECORDS

Upon completion of the AHA or Red Cross First Aid/CPR/AED and BBP course, certification cards are issued. Employees must send copies of the certification cards to the Arcadis Corporate Training Team (HRSolutionsCenter.ANA@arcadis.com).

9. APPROVALS AND HISTORY OF CHANGE

Julie Santaniello, CSP – Corporate H&S Manager of Technical Programs

History of Change

Revision Date	Revision Number	Standard Developed/Reviewed By or Revised By	Reason for change
10 January 2008	01	Mija Coppola	Original document
28 April 2010	02	Cindy Larweth	Add clarification of "near proximity" in section 5.1
3 April 2012	03	Camille Carollo/Tony Tremblay	Executive Summary added; Health and Safety Procedure revised to Health and Safety Standard; Serious Injury definition added as Section 3.4; Section 5.1 reference to near proximity changed to 3-4 minutes; OSHA "in near proximity" reference document in Section 8 updated; first aid kit content must comply with state OSHA reference added to Exhibit 1
19 November 2012	04	Pat Vollertsen/Tony Tremblay	Addition of information and exhibit related to Hepatitis B vaccination series
12 February 2013	05	Pat Vollertsen/Tony Tremblay	Section 3 Definitions moved to Exhibit 1; Added Section 5.2 Transport to Medical Facility (information about transport of injured personnel to medical facilities) and renumbered other Section 5 subsections

Revision Date	Revision Number	Standard Developed/Reviewed By or Revised By	Reason for change
24 June 2014	06	Pat Vollertsen and Amanda Tine/ Tony Tremblay	Revised Executive summary and section 6 to include Red Cross training; revised section 8 to include Red Cross and revise where records are to be sent; Revised Section 5.3 ANSI Z308.1-2009 Minimum requirements for workplace first aid kit; updated header/footer format; Updated Exhibit 2 First Aid kit contents; Exhibit 5 licensed physician letter for first aid kit content
05 April 2016	07	Andrew McDonald/Tony Tremblay/Julie Santaniello	Updated and renumbered Section 5 to included new Section 5.2 Injury/Illness Reporting and Notification, Section 5.4 First Aid Supplies/Kits compliant with ANSI Z308.1-2014, Section 5.5 Office First Aid Kit Program (Cintas® First Aid and Safety Program), Section 5.8 Optional AED Leasing. Renumbered Exhibits. Removal of Exhibit 4 – Hepatitis B Declination Form. New Exhibit 5 AED Evaluation Form.
01 December 2016	08	Andrew McDonald/Julie Santaniello	Updated Exhibit 5 AED Evaluation form to include overhead code / project number. Updated Section 5.8 Optional AED Leasing to clarify the requirement that Office/Project Site must designated at a minimum 1 First Aid Responder and recommend the designation of 10% of the staff at the location.

Implementation Date	ARCADIS HS Standard Name	ARCADIS Design & Consultancy for natural and built assets
10 January 2008	First Aid/CPR/AED	
Revision Date	ARCADIS HS Standard No.	Revision Number
04 February 2019	ARC HSGE004	10

Revision Date	Revision Number	Standard Developed/Reviewed By or Revised By	Reason for change
16 August 2018	09	Andrew McDonald/Julie Santaniello	Updated Exhibit 5 AED Evaluation form to include AED lease duration and pricing. Updated Section 4.4 Cintas responsibilities. Clarified enrollment requirements in Section 5.8. Updated hyperlinks.
4 February 2019	10	Andrew McDonald/Julie Santaniello	Updated Section 5.8 for optional office AED leasing and project AED purchasing. Updated standard template.

EXHIBIT 1 - DEFINITIONS

First Aid Responder – An employee designated by Arcadis to receive First Aid/CPR/AED/Bloodborne Pathogen training so that he/she can respond to emergency situations and administer First Aid/CPR/AED until medical attention can be administered by medical professionals.

Near Proximity – The ability to respond and start to administer first aid within 3 to 4 minutes.

> **Note:** OSHA has long interpreted the term "near proximity" to mean that emergency care must be available within no more than 3-4 minutes from the workplace. Medical literature establishes that, for serious injuries such as those involving stopped breathing, cardiac arrest, or uncontrolled bleeding, first aid treatment must be provided within the first few minutes to avoid permanent medical impairment or death. Accordingly, in workplaces where serious accidents such as those involving falls, suffocation, electrocution, or amputation are possible, emergency medical services must be available within 3-4 minutes, if there is no employee on the site who is trained to render first aid. OSHA exercises discretion in enforcing the first aid requirements in particular cases. OSHA recognizes that a somewhat longer response time of up to 15 minutes may be reasonable in workplaces, such as offices, where the possibility of such serious work-related injuries is more remote.

Serious Injury – Injuries such as those involving stopped breathing, cardiac arrest, or uncontrolled bleeding where first aid treatment must be provided within the first few minutes to avoid permanent medical impairment or death.

EXHIBIT 2 - ACRONYMS AND ABBREVIATIONS

AED	Automated External Defibrillator
AHA	American Heart Association
ANA	Arcadis North America
Arcadis	Arcadis U.S. Inc.
BBP	Bloodborne Pathogens
CPR	Cardiopulmonary Resuscitation
EMS	Emergency Medical Services
HS	Health and Safety
H&S	Health and Safety
HSS	Health and Safety Standard
OSHA	Occupational Safety and Health Administration

EXHIBIT 3 - BASIC FIRST AID KIT CONTENTS (CLASS A/B Type I/II/III/IV)

(ANSI Publication Z308.1-2014 and Arcadis Best Practice)

First Aid Supply	Minimum Quantity		Minimum Size or Volume	
	Class A Kits	Class B Kits	(US)	(metric)
Adhesive Bandage	16	50	1 x 3 in.	2.5 x 7.5 cm
Adhesive Tape	1	2	2.5 yd (total)	2.3 m
Antibiotic Application	10	25	0.14 fl oz	0.5 g
Antiseptic	10	50	0.14 fl oz	0.5 g
Breathing Barrier	1	1	--	--
Burn Dressing (gel soaked)	1	2	4 x 4 in.	10 x 10 cm
Burn Treatment	10	25	1/32 oz	0.9 g
Cold Pack	1	2	4 x 5 in.	10 x 12.5 cm
Eye Covering, with means of attachment	2	2	2.9 sq. in.	19 sq. cm
Eye/Skin Wash				
	1fl. oz total	--	--	29.6 ml
	--	4 fl. oz total	--	118.3 ml
First Aid Guide	1	1	NA	N/A
Hand Sanitizer	6	10	1/32 oz	0.9 g
Medical Exam Gloves	2 pair	4 pair	N/A	N/A
Roller Bandage				
2 inch 4 inch	1 0	2 1	2 in. x 4 yd 4 in. x 4 yd	5 cm x 3.66 m 10 cm x 6.66 m
Scissors	1	1	N/A	N/A
Splint	0	1	4.5 x 24 in.	11.4 x 61 cm
Sterile pad	2	4	3 x 3 in.	7.5 x 7.5 cm
Tourniquet	0	1	1 in. (width)	2.5 cm (width)
Trauma pad	2	4	5 x 9 in.	12.7 x 22.9 cm
Triangular Bandage	1	2	40 x 40 x 56 in.	101x101x142cm

Note: Optional items and sizes may be added to the basic contents listed above to augment a first-aid kit, based on the specific hazards existing in a particular work environment.

Exhibit 3 – Basic First Aid Kit Contents (Class A/B Type I/II/III/IV) Continued

Characteristics of Types of First Aid Kits					
Use	**Portable**	**Mountable**	**Water Resistant**	**Waterproof**	**Performance**
Indoor		X			
Indoor	X				
Indoor/ Outdoor	X	X	X		
Indoor/ Outdoor	X	X		X	ANSI Z308.1-2014

EXHIBIT 4 - SAMPLE FIRST AID KIT INSPECTION FORM

MONTHLY CHECK OF FIRST AID CABINET

If any items appear missing, **(responsible Arcadis party name or vendor name)** will be contacted that same day so that replacement supplies can be ordered. **(Responsible Arcadis party name vendor name)** will also inspect, replace and remove and replace outdated items every **(#)** days.

Year _____

Date Checked	Checked By	Date Checked	Checked By

Checked by:

1._____

2._____

3._____

Replacement: Place an asterisk (*) beside the date a missing item(s) was noted and when the vendor was called; note below when replacement was delivered. Include any other pertinent comments.

_____

_____

_____

_____

_____

EXHIBIT 5 - WORKCARE RECOMMENDATIONS FOR FIRST AID KITS IN CALIFORNIA

WorkCare™ Making Health Count

November 4, 2013

Brian Kundert
US Director of H&S
ARCADIS
2000 Powell Street, Suite 700
Emeryville CA 94608

Re: First Aid Kits in California

Pat,

WorkCare is providing the following recommendation with regards to First Aid Kits, specifically those in California:

First aid for employees who become sick or injured on the job comes under the OSHA regulations in section 1910.151 of Subpart K. Such first aid may consist of attention to simple problems that require no further treatment or emergency help for the severely injured until professional medical personnel can take over.

First aid supplies should be stored in a water proof container, located in a visible location with ready access in event of an injury or emergency. Kits should have a periodic schedule to be restocked. Kits should be accessible on each floor. Contents should be specifically selected to deal with events in specific or specialized occupations.

Contents should include:

- Gauze roller bandages 3" (i.e., Kerlix) -- 6
- Adhesive bandages (Band-Aids) (various sizes)- box
- Triangular bandage with safety pins- 3
- Antiseptic applicators or swabs) 10ea
- Alcohol 70% swabs (box) 1
- Eye pads 10
- Wire or thin board splints (SAM splint) 2
- Forceps (tweezers) 1
- Neosporin ointment 1 tube or packets
- Gloves- medium & large sizes plastic or latex 5 pairs ea
- Germicidal hand cleansing solution (Purcell, Vivonex, etc) 1 btl
- Tape 1" adhesive (Micropore, Transpore) 1 roll ea

300 S. Harbor Blvd., Suite 600 • Anaheim, CA 92805 • (714) 978-7488 • Fax (714) 456-2154
1320 Harbor Bay Parkway, Suite 115 • Alameda, CA 94502-6556 • (510) 748-6900 • Fax (510) 748-6915
email: info@workcare.com • website: www.workcare.com

- Burn Cream – Water-Jel or equivalent.
- Tylenol or generic – Purchased/stored in single dose, tamper evident packaging
- Ibruprofen tablets 200mg (generic) for inflammation/pain - Purchased/stored in single dose, tamper evident packaging
- Chemical cold packs 4 pks
- Sterile eye irrigation solution 4oz/8oz bottle 2 btl
- Bloodborne Pathogen clean up kit (gloves, eye shield/goggles, apron or protective garment, Chlorox solution, red bag for disposal) 1ea
- Hydrocortisone ointment 1% for itching, rashes 1ea
- Antihistimine – Moore Brand Phenylephrine (or equivalent **NON Drowsy Formula**) (OTC) for allergic reactions, insect bites, bee stings. Purchased/stored in single dose, tamper evident packaging.
- Betadine solution (8oz bottle) to soak lacerations/cuts 1 btl
- CPR mouth shield 1 ea
- Paramedic scissors 1 ea
- Gauze pads (3x3s) & (4x4s) sterile 1 bx of 50 ea size
- Compression bandage or ABD pads 10 ea
- Reference book on first aid 1 ea
- Ace bandages 3", 4" 2 ea
- Emergency blanket 1 ea
- Penlight flashlight 1 ea
- Sterile cotton tip applicators 1 bx of 50

Should you have any questions regarding this recommendation, please do not hesitate to contact me.

Sincerely,

Peter P. Greaney, MD
Medical Director
WorkCare

(800) 455-6155 • info@workcare.com • www.workcare.com

EXHIBIT 6 - AED EVALUATION

(Link to AED Evaluation)

AED EVALUATION

ARCADIS Design & Consultancy for natural and built assets

The AED Evaluation below must be completed in its entirety prior to being submitted to Corporate Health and Safety for review (4-Sight-Support@Arcadis-us.com). Incomplete evaluations will be returned to the requesting party, potentially delaying enrollment in the Cintas AED Lease Program. Please contact Corporate Health & Safety at the email address above with any questions.

Office / Job Site Evaluation

Location Information	Circle/highlight: Office Project Site Address:
Overhead Office Code / Project Number *Note: AED lease is for 36 months @ $99 a month plus applicable tax.*	
Current Location Leader / Project Manager	Name: Email or Phone Number:
Current Health and Safety Coordinator / Site Safety Officer	Name: Email or Phone Nu
Is an AED located in close proximity to the office/job site (i.e. in the building lobby or comm area) If yes, indicate where.	
Will the building or t provid AED at no cost?	
What the averag emergency respon time for E ergency Medical Service (EMS)? *Note: It is recommended contacting local EMS to help determine average response time*	
Total Head Count:	
Total number of Arcadis employees currently trained in First Aid/CPR/AED	
Total number of Arcadis employees designated as First Aid Responders, per the definition in First Aid/CPR/AED Standard (ARC HSGE004)?	
Total number of AED units requested	
Individual Submitting Request	Name: Email or Phone Number:

EXAMPLE

Implementation Date	ARCADIS HS Standard Name	ARCADIS Design & Consultancy for natural and built assets
31 August 2011	Heat Stress Prevention	
Revision Date	ARCADIS HS Standard No.	Revision Number
17 February 2020	ARC HSIH013	09

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QUICK SHEET

Applicability

Heat related illnesses (also referred to as “Heat Stress”) are caused by working in hot environments. The hazards associated with working in hot environments can be controlled and minimized by using safe work practices such as applying administrative controls, engineering controls, and providing the appropriate personal protective equipment (PPE).

Need To Know

Project personnel are responsible for understanding the conditions, signs, and symptoms that can lead to heat illness and adhering to the prescribed control and mitigation and methods.

Personal risk factors for heat illness include poor health, age, excessive weight, and pre-existing medical conditions; inadequate acclimation to working in the heat; and a previous episode of heat illness. Environmental risk factors include workload severity and duration, high temperature and humidity, direct sun exposure, and insufficient air movement. If left unchecked, heat illness will progress to the heat stroke stage, which is a life-threatening condition, and emergency personnel should be contacted immediately.

Preventive safe work practices involve avoidance of working in the heat when possible; taking regularly scheduled shade breaks; acclimatization; rotating personnel; avoiding beverages containing caffeine or sugar; staying appropriately nourished; maintaining hydration; and providing readily available fresh, pure, and suitably cool potable water access at all times.

Engineering controls that should be implemented include monitoring and measuring temperature and heat index factors, designing appropriate work/rest cycles, and choosing clothing that allows for wicking of perspiration.

Personnel will report any signs and symptoms of heat illness exhibited by themselves or by other personnel.

Training

Training for heat illness prevention will be provided to all supervisory employees before project assignment. Topics will include the importance of acclimatizing, risk factors, signs and symptoms of various heat illnesses, and procedures to follow in the event of an emergency. Staff working in California, Washington, or other states with specific heat illness standards must receive documented training before assignment. Other affected employees not working in these states must be familiar with this HSS and the information detailed in the Field Health & Safety Handbook. Corporate H&S recommends that all staff that might reasonably be anticipated to be exposed to the risk of heat illness complete the online heat illness training course.

Equipment

Equipment required for work in hot environments may include but is not limited to cooling devices, shade structures and weather monitoring devices. Refer to the Heat Plan H&S Plan Supplement for project or task specific equipment required.

Permits or Forms Required

The Heat Plan H&S Plan Supplement will be prepared during project planning to document and communicate the site-specific heat illness prevention provisions for projects in California and Washington State (best management practice [BMP] for other states).

1. POLICY

It is Arcadis policy that the project team and field staff will work together to protect on-site personnel from the hazards of heat illness when employees are required to work in hot, outdoor places of employment or in other areas where the environmental risk factors for heat illness are present.

Heat-related illnesses may be prevented by using safe work practices including administrative controls, engineering controls, and/or appropriate personal protective equipment (PPE).

2. PURPOSE AND SCOPE

2.1 Purpose

The purpose of this Health & Safety Standard (HSS) is to promote employee awareness regarding heat illness symptoms, direction on the controls and prevention of heat-related illnesses, and guidance on appropriate response actions if symptoms do occur.

2.2 Scope

This HSS applies to Arcadis projects that include, but are not limited to: indoor operations in hot environments or outdoor operations conducted in hot weather such as construction, refining, oil and gas extraction, asbestos removal, and hazardous waste site activities, especially those that require employees to wear semipermeable or impermeable chemical protective clothing (CPC) that are likely to cause heat illness among the exposed. California and Washington State enforce specific occupational heat illness prevention requirements, which are addressed in this HSS. Project teams are advised that, for all other states and U.S. territories, the information provided in this HSS will be used as best management practices (BMPs) for addressing heat-related illness prevention.

Project sites located in California and Washington State must comply with the requirements set forth in this HSS, which has been developed to comply with the California Occupational Safety and Health Administration (Cal/OSHA) Title 8 California Code of Regulations (CCR) 3395 Heat Illness Prevention Standard and the Washington State Outdoor Heat Exposure Regulations 296-62-09510 thru 09560. Project sites in California and Washington State must complete the HASP Supplement and include this HSS as an attachment to the field copy of the HASP, along with the completed HASP Supplement.

3. DEFINITIONS

There are a number of definitions associated with this standard. These definitions are presented in Exhibit 1 of this document. A list of acronyms and abbreviations used in this HSS is provided in Exhibit 2.

4. RESPONSIBILITIES

4.1 Project Managers, Associate Project Managers, and Task Managers

Project Managers (PMs), Associate Project Managers (APMs) and Task Managers (TMs) are responsible for ensuring that heat illness is considered and addressed in project task hazard analysis, risk assessment, and project planning.

Ensure that the project Health & Safety Plan (HASP) addresses the need for adequate water, provisions for shade are available at a job site, and that time is available for staff to eat when the environmental risk factors for heat illness are present.

Ensure that the HASP addresses the need for affected employees to receive applicable training on heat illness prevention and that staff are provided time to complete the training before starting work.

4.2 Supervisory Personnel

Supervisory personnel (e.g., Site Safety Officers [SSOs], PMs, APMs, and/or TMs who are supervising employees working on site and in the heat) must review this HSS and complete training in the prevention of heat related illnesses before supervising employees that work in the heat (risk of heat illness). Supervisory personnel will be trained in heat illness prevention methods and provided procedures in this HSS to follow when an employee exhibits symptoms consistent with possible heat illness including emergency response procedures. Supervisory personnel must ensure that personal risk factors that contribute to heat-related illness are considered before assigning a task where there is the possibility of a heat-related illness occurring (See Section 5.2 for risk factors) and plan for and implement preventive measures and controls when heat advisories are issued for those areas in which staff will be working.

Ensure that effective communication by voice, observation, or electronic means is maintained so that site employees can contact a supervisor, WorkCare, or emergency medical services when necessary. Devices, such as radios or mobile phones or satellite phones, may be used for this purpose only if reception in the area is reliable. If an electronic device does not provide reliable communication in the work area, the project team must ensure that a suitable means of summoning emergency medical services is available.

Ensure that affected employees working on site have received proper training on heat illness prevention.

Ensure that the requirements in this HSS are documented and followed.

Ensure that staff working in the heat have constant access to suitably cool, fresh, pure potable water; are provided routine breaks; and have access to shade.

4.3 Affected Employees

Employees are responsible for understanding the conditions, signs, and symptoms that can lead to heat illness and for using and adhering to the prescribed control and mitigation and methods. Personnel will report to the SSO and/or PM any signs and symptoms of heat illness exhibited by themselves or by other personnel on the project site.

If site personnel have not received heat illness training before conducting work, then site personnel will be educated on heat illness prevention by reviewing this HSS, reading the site HASP (including the site-specific Heat Illness Prevention Plan [HIPP] HASP Supplement as required for California and Washington States), and by attending the daily tailgate meeting.

Employees must review and comply with the provisions of this HSS.

Employees must ensure that they have suitably cool, fresh, pure (potable) water available at all times and that they eat before starting work and during the day when the environmental risk factors for heat illness are present.

Employees will ensure that they have constant access to a shaded area to prevent or recover from heat-related symptoms.

4.4 Corporate Health & Safety

Corporate H&S is responsible for keeping this HSS up to date with regulatory requirements and best work practices.

As requested, provide training to potentially impacted employees and their supervisors on the risks and prevention of heat illness, including how to recognize symptoms and how to respond when they appear.

5. PROCEDURE

5.1 Safe Work Practices

Arcadis staff will follow these general safe work practices when working in hot environments:

- Where determined by regulation, the project site will implement heat illness prevention measures when temperatures in the work area exceed an equivalent heat index temperature of 80 degrees (°) Fahrenheit (F) or 26.6° Celsius (C), accounting for ambient air temperature, humidity, use of semi-permeable and impermeable PPE, and the degree of exertion by the workers.
- Staff will avoid working during periods of high heat ($\geq$ 95°F / 35°C) when possible. This can be accomplished by avoiding scheduling work during the hottest parts of the day, working in cooled enclosures, or providing cooling units in the work area. Severe heat conditions can be cause for stopping or not starting work.
- Allow personnel to acclimatize and adapt to the heat; specifically, those employees new to the project, wearing semi-permeable/impermeable PPE, conducting strenuous tasks, or working in high heat areas.
- The SSO will be particularly watchful of the condition of new employees and stay alert to the onset of heat-related symptoms. New employees will be assigned a “buddy” or experienced co-worker for monitoring each other closely for symptoms of heat illness.
- Whenever possible, rotate personnel in/out of working conditions where heat is a hazard.
- Personnel will have constant access to suitably cool, fresh, pure (“fresh and pure” is defined as being free of odors) water. Where the supply of water is not plumbed or otherwise continuously supplied, water will be provided at no cost to the employee(s) (or employee will be reimbursed) in sufficient quantity at the beginning of the work shift and for the shift duration.

Note: *Thirst cannot be relied on as a guide for hydration. Employees need to drink cool, fresh water throughout the day (four 8 oz cups per hour) during hot weather. Electrolyte replacement drinks or "Sports Drinks" can be used to replace essential minerals lost during sweating. Generally, such drinks should supplement water intake such as one "sports drink" to every three bottles of water. One teaspoon of salt added to every gallon of water could also be used.*

Electrolyte replacement and "Sport Drinks" should not be used as the primary source of hydration or as a substitute for food or water.

- Employees will be notified of the location(s) of the closest drinking water supplies.
- Employees should be advised to choose non-carbonated water over sodas and other beverages containing caffeine or sugar.
- Employees should eat before work and then during the work rotation.
- Employees and the SSO must understand the individual, pre-disposing susceptibilities to heat illness (e.g., previous exposure to heat illness or when taking certain medications).
- Employees must understand the signs and symptoms of heat illness including discomfort, excessive sweating, headache, poor concentration, muscle pain, cramping, dizziness, fatigue, irritability, loss of coordination, vomiting, blurry vision, confusion, lack of sweating, fainting, and seizures.
- Employees must understand first aid and emergency response procedures associated with heat illness.
- If an emergency arises, it is critical that employees understand the process and contact information for requesting emergency medical support. The reception coverage for the site must be evaluated to ensure that adequate communication is in place across the project site and for contacting emergency responders.
- See Exhibit 3 for more safe work practices information.
- See Exhibit 4 for a link to the HASP Supplement, contained in the Standard Excel® HASP template.

5.2 Risk Factors for Heat-Related Illnesses

The personal and environmental risk factors for heat-related illnesses must be evaluated as part of the TRACK process before performing a task.

5.2.1 Personal Risk Factors

Risk factors applicable to the individual employee must be considered when evaluating a working environment for potential exposure to heat illness. The following risk factors should be considered for each individual employee, as these may vary among individuals.

- No recent exposure to high heat work areas is a risk factor because the individual's body is not acclimatized to working in the heat.
- Individual susceptibilities, such as age, weight, degree of physical fitness, use of medications, and certain medical conditions (such as hypertension and diabetes), all affect the potential to experience a heat-related illness.
- A person is at greater risk for heat illness when they are in poor health, are dehydrated, have not eaten, have not been acclimated to working in the heat, or have experienced previous heat illness.

- Working in a hot environment tends to lower the mental alertness and physical performance of an individual. Increased body temperature and physical discomfort promote irritability, anger, and other emotional states that have the potential to cause personnel to overlook safety procedures or to divert attention from hazardous tasks.
- Wearing PPE that increases the potential for the onset of heat illness symptoms is also considered a risk factor for the onset of heat illness.

5.2.2 Environmental Risk Factors

Some risk factors are considered environmental, and therefore apply to all individuals working in a specific area. These are additional to any personal risk factors identified for individual employees. The following risk factors should also be considered when determining the potential for the occurrence of heat illness.

- High temperature and humidity
- Working in direct sun
- No breeze or wind
- Radiant heat or heated air movement
- Conducting strenuous tasks and long duration work.

Working in the heat tends to increase the likelihood of accidents due to the slipperiness of sweaty palms, dizziness, or the fogging of safety glasses. The frequency of accidents, in general, appears to be higher in hot work environments (> 80°F/26.6°C) than in environments involving moderate temperatures.

5.3 Administrative and Engineering Controls

When feasible, Arcadis staff will implement the following administrative and engineering controls:

- Avoid scheduling work during the hottest parts of the day when possible. Alternatively, schedule more strenuous tasks or tasks that require use of semi-permeable or impermeable (e.g. non-breathable, non-venting) PPE early in the morning when conditions are typically cooler than midday or afternoon conditions.
- Monitor the temperature and humidity at the site. These comprise the heat index factors, which convey the magnitude of the heat hazard. Discussion during the daily safety briefings is critical to ensure that this hazard is understood by on-site personnel. Monitoring can be accomplished with on-site instrumentation, especially when working indoors or in enclosed spaces, or by monitoring outdoor weather conditions through the internet, radio, or local weather bureaus. See Section 5.3.4.
- Encourage personnel to wear appropriate clothing that allows for the wicking away of perspiration as a form of evaporative cooling to help cool the wearer.
- Develop and implement appropriate work/rest cycles to allow for adequate cool-down periods.
- Employees suffering from heat illness related symptoms must be allowed, and will be encouraged, to take a preventive cool-down rest in an area with shade that is either open to the air or provided with ventilation or cooling (e.g., cooling stations, misters, air-conditioned spaces). While taking a preventive rest, the employee will be monitored for heat illness symptoms by the SSO and encouraged to remain in the shade and not allowed to return to work until the symptoms are gone. Access to shade will always be permitted.

5.3.1 Procedure for Acclimatization

Supervisors, SSOs, and employees will be trained on the importance of acclimatization, how it is developed, and how to implement an acclimatization process consistent with applicable regulations and the guidelines set forth in this HSS. An employee is at risk of heat illness during a sudden increase in the ambient temperatures of the work environment if not given time to adjust to the changing conditions. Acclimatization (the physiological process of becoming accustomed to changing conditions) is necessary especially in conditions of high heat and for tasks requiring strenuous physical exertion. In addition to acclimatization, other factors can affect employees working at sites where high temperatures are anticipated, such as: poor general health, age, weight, pre-existing medical conditions, and having previously experienced heat illness. Employees are not required to share personal health information such as pre-existing medical conditions. However, including a discussion of how these factors can contribute to the onset of heat illness in the Tailgate Safety Meeting discussion raises individual awareness of the risks involved with heat illness.

A gradual acclimatization period will be implemented for new employees that have not been exposed to a work environment where high temperatures are present (e.g., employees not accustomed to the conditions of the work site will be given slower paced, less physically strenuous tasks during the hot parts of the day and given the more physically strenuous tasks during cooler parts of the day). New employees will be closely monitored during their acclimatization period, which can last up to 2 weeks. The steps taken to reduce the workload intensity for employees not yet acclimated to working in high heat conditions will be documented in the field copy of the HASP Supplement.

The SSO or designee is responsible for implementing the following procedures for acclimatization. These procedures include, but are not limited to, the following:

- Observing employees closely for signs of heat illness. Specific site conditions warranting close observation include, but are not limited to, any day when the temperature is 80°F/26.6°C or greater and is at least 10°F (6°C) higher than the average daily temperature for the preceding 5 days.
- Providing effective acclimatization procedures for employees during exposure to a sudden increase in temperature. The SSO will be aware of those employees who are not yet acclimatized to sudden changes in temperature and will attend to those employees to prevent heat illness.
- Monitoring weather daily. The SSO will be on the lookout for sudden heat wave(s) or increases in temperatures that employees haven't been exposed to for several weeks or longer per Section 5.3.4 Weather Monitoring Procedures, detailed in this HSS.
- Implementing specific Work/Rest Cycles based on monitoring vital signs of on-site personnel, see Section 5.4.3.

5.3.2 Provisions for Water at the Site

At the start of work, the importance of drinking water, the signs and symptoms of heat illness, the location(s) of the water/water coolers, and the schedule of water/rest breaks will be communicated to all staff during each Tailgate Safety Meeting. The SSO or the designated alternate will provide for distribution of suitably cool, fresh, clean potable (drinking) water at the project site. An adequate supply of suitably cool, fresh, clean potable water will always be maintained on site to allow each employee to consume 1 quart (1 liter [1 L]) of water per hour (i.e., 2 gallons [8 L] per employee for an 8-hour shift).

Where unlimited drinking water is not immediately available from a plumbed system or otherwise continuously supplied, water will be provided to staff via coolers containing bottled water or insulated drinking water dispensers (verify that coolers/dispensers are of a sufficient capacity to support the amount of field staff present) accompanied with disposable cups to maintain sanitary conditions for potable water consumption. When conditions are anticipated to exceed 80°F/26.6°C, SSOs and/or supervisors will encourage employees to drink water before they "feel" thirsty. Ideally, drinking 8 ounces of water every 15 minutes will allow the body to remain properly hydrated while working in high temperature conditions.

If the decision is made not to provide all site employees the full-shift quantity of drinking water at the start of a work shift (i.e., 2 gallons [8 L] per employee for an 8-hour shift), then effective procedure(s) must be documented and implemented to ensure drinking water replenishment to allow each employee to drink 1 quart (1 L) per hour. This means that a sufficient quantity of water must always be present and readily accessible to allow every employee to consume at least 1 quart of water per hour until the water supply has been replenished.

- Coolers containing bottled water or drinking water coolers should be maintained to provide for a minimum of 3 hours of water per employee (at least 1 quart [1 L] of water will be made available per employee per hour) to account for a sufficient quantity of water to always be present.
- Water supplies will be positioned as close as reasonably possible to site workers. Ideally, water supplies will be positioned within 50 feet of employee activity or in vehicles used by employees to gain access to individual work areas; however, coolers will be stationary when employees are essentially stationary. Placing water only in shaded areas or by toilet facilities is not sufficient, particularly at large work sites or at multi-story construction sites. Drinking water sources need to be close enough to workers to allow for routine consumption.
- Coolers will be inspected and replenished with water and ice for cooling periodically (e.g., every 30 minutes, or based on site temperature and number of employees present) by the SSO or designee.
- Ice will be added to the coolers, as necessary, during the required inspections.

  ***Note**: When the temperature exceeds 90°F (32°C), inspections will be increased in frequency and ice will be added as needed to keep water cool*.

- Ice will be distributed from a separate cooler or service and added to coolers to ensure that the drinking water remains potable and appropriately cool for employee consumption. Ice used to chill the water will be stored separately to remain sanitary. Sanitary ice storage can include storage of ice in bags when bottled water is used or use of separate storage coolers when using drinking water dispensers.
- Coolers will be inspected and cleaned after each work shift or before starting work each shift. The SSO will oversee cooler maintenance and provide appropriate cleaning supplies.
- The SSO or designee will document the weekly review of the HASP Supplement and make the necessary adjustments each week for weather changes or when new employees are introduced to the project. The reminder may include water ordering information if purchased in bulk from an appropriate supplier.

5.3.3 Access to Shade

The project team is responsible for making sure that the necessary equipment to provide shade is available at the project site. The temperature threshold for shade to be in place is when site temperatures exceed 80°F/26.6°C. The SSO or designee is responsible for directing how shade will be coordinated and placed. The term "shade," for the purposes of complying with applicable regulations, will be defined as "The blockage of sunlight to the extent that no shadow is cast while sitting in the designated area." Flecks of sunlight are acceptable as long as, overall, the shade provides substantially complete blockage of sunlight. Where trees or other vegetation are used to provide shade, the thickness and shape of the canopy must cast sufficient shadow, given the changing angles of the sun, to protect employees from the sun during the entire shift.

At the start of each shift, the importance of taking shade breaks, recognizing the signs and symptoms of heat illness, the duration of shade breaks (> 5 minutes per break), and the shade location will be addressed during each Tailgate Safety Meeting. Access to shade must be allowed at all times.

> ***Note**: Where required by regulation, shade breaks will be taken at a minimum rate of 15 minutes of shade for every 2-hour work period. As temperature increases shade breaks will increase in frequency. See the Heat Index table in Section 5.4 for Heat Index specific Action Levels defining shade break frequency and duration.*

Establishing adequate shaded areas for employees involves:

- If the temperature at the site exceeds 80°F, shade structures will be opened and made available to employees.
- Shaded areas must be able to accommodate all employees taking a recovery or rest break including those employees who are on meal breaks. This does not mean that the shaded area(s) must provide shade to accommodate all employees on a site or working a shift *at the same time.* An example includes rotating routine breaks among employees. Also, additional portable shade structures can be erected as needed.
- Employees must have enough shaded space to sit comfortably while fully shaded and to allow for sitting without being in physical contact with each other.

  > ***Note**: When establishing shade, it is important to ensure that employees who desire access to shade will not be deprived of it due to lack of space. One such procedure to address this point would be to rotate employees in and out of shaded areas to ensure that all have sufficient access for the 15-minute interval required. Another option would be to have additional shade structures on hand to deploy as needed.*

- Shade structures will be relocated to follow the crew for moving tasks.
- Shade structures will be placed within 50 feet of the work area if practical. A key consideration when placing a shade structure is that it is a short walk away (e.g., 2 to 3 minutes) from the work area. This consideration becomes critical as the temperature rises above 80°F/26.6°C.
- Where it is not safe or feasible to provide shade, notes will be made to the HASP Supplement of the unsafe or unfeasible conditions. The SSO will also document the steps taken to provide alternative cooling measures equivalent to providing shade, such as vehicles equipped with air conditioning or air-conditioned office trailers.
- An employee who takes a preventive cool-down rest:

- Will be monitored by the SSO and asked if they are experiencing symptoms of heat illness.
- Will be encouraged to remain in the shade.
- Will not be ordered back to work until any signs or symptoms of heat illness have abated.
- If an employee exhibits signs or symptoms of heat illness while taking a preventive cool-down rest, the SSO will provide appropriate first aid or emergency response.

5.3.4 Monitoring of Weather and Procedures for Heat Waves

The SSO or designee will be trained in consulting weather forecasting resources and is responsible for checking the extended weather forecast before work. Work schedules will be adjusted in advance, considering whether high temperatures or a heat wave is expected. The SSO will be responsible for obtaining thermometers before the start of the project and ensuring that they are readily accessible or posted on site for ease of monitoring throughout the workday. The following web pages are considered accurate and reliable sources for checking weather forecasts:

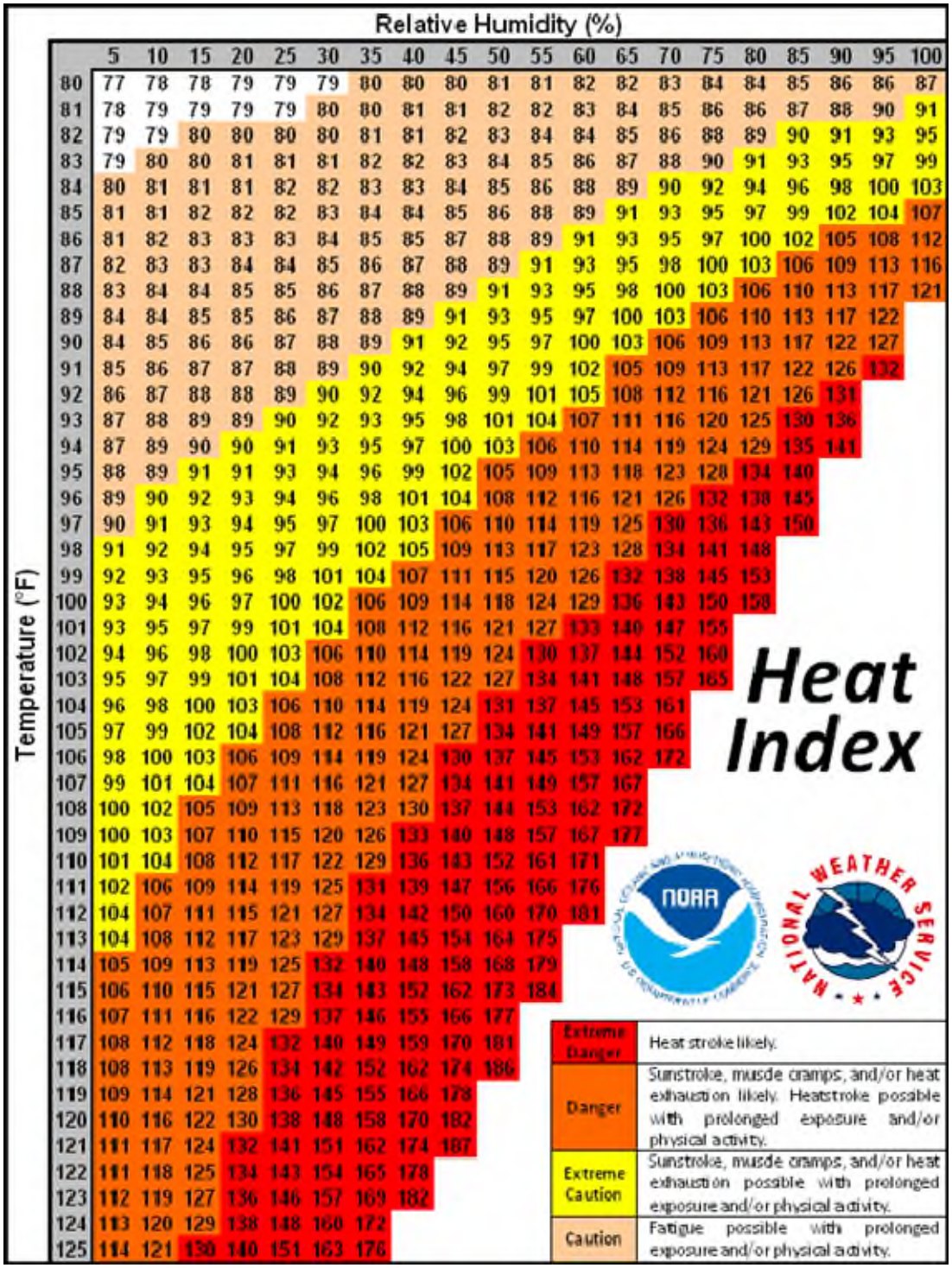
- http://www.noaa.gov/
- https://www.weather.gov/

Before starting each shift, the SSO or designee will review the forecasted temperature and humidity for the work site and compare conditions against the National Weather Service Heat Index (See Table 1) to evaluate the risk level for heat illness. A “heat wave,” as defined by the National Oceanic and Atmospheric Administration (NOAA), is a period of abnormally and uncomfortably hot and unusually humid weather.” Typically, a heat wave lasts 2 or more days.

5.4 Heat Index Table, Heat Index Action Levels, and Recommended Hazard Controls

The following action levels and controls information are intended to be used as recommended guidance by project teams for work conducted in all states except where heat-related illness hazard controls are required by regulation.

Table 1 – Heat Index Table



During the planning stages for future field work, develop a communications plan where field staff will contact the project team when conditions are expected that will trigger Heat Index Action Levels.

Use the information in Table 1 to determine if employees will be exposed to a combination of temperature and humidity that pose a risk for heat illness. If the site conditions are characterized as falling inside the ranges for “Extreme Caution,” "Danger," or “Extreme Danger” for heat illness, additional steps must be taken. It is important to note that the NOAA Heat Index was developed with an understanding that partial shade and light wind conditions are present. Work conducted in direct/full sunlight without light wind conditions (e.g., no partial shade or no breeze) adds up to 15°F (8°C) to the Heat Index value.

Each Heat Index level detailed below is additive.

- If the Heat Index indicates "CAUTION" 80° to 90°F (26° to 32°C), implement one or more of the following:
  - Provide and direct hydration, schedule rest breaks, ensure lightweight clothing is worn, provide break areas with shade / ventilation / air conditioning.
- If the Heat Index indicates "EXTREME CAUTION" 90° to 105°F (32° to 40.5°C), implement all the above and add one or more of the following:
  - Provide light-duty PPE, cooled break areas, and shaded work areas.

    Note: *“Light-duty PPE” includes items such as hard hat sunshades, sun hats, dry or wet evaporative cooling vests, microfiber cooling towels, scarves, headbands, hard hat neck shades, hard hat suspension inserts, and sweatbands.*

- If the Heat Index indicates "DANGER" 105° to 130°F (40.5° to 54.4°C.), implement all the above and add one or more of the following:
  - Provide cooled work areas, modify work schedule, provide heavy-duty PPE,and personnel physiological monitoring.

    Note: *“Heavy-duty PPE” includes phase-change cooling vests, and gel pack and ice pack equipped cooling vests. Ice pack vests generally offer the coldest option and should not be worn directly against the skin. Consider engineering controls such as forced ventilation.*

- If the Heat Index indicates "EXTREME DANGER" +130°F (+54.4°C) or greater, Stop Work until conditions change or hazards are effectively controlled using items listed above. At this range of temperatures it is critical to implement personnel vital sign monitoring for determining the appropriate frequency and duration of Work / Rest cycles.

5.4.1 Procedures for High Heat

High heat procedures will be implemented when the temperature rises above 95°/35°C. High heat procedures include:

- Hold a Tailgate Safety Meeting to review the high heat procedures, encourage employees to drink plenty of water, and remind employees of the importance of taking a preventive or recovery cool-down rest when necessary.
- Arcadis will ensure that effective employee observation and monitoring procedures are put in place including:

  - SSO or designee will supervise 20 or fewer employees.
  - The “Buddy System” is mandatory.
  - Regular communication with SSO or designee will be implemented via mobile phone or radio.
  - One or more employees will be designated as authorized to contact emergency medical services and communicating that, if no designate is identified and the SSO is unavailable, any employee can call for emergency medical assistance.
- Employees will be reminded throughout the shift to drink plenty of water.
- The “Buddy System” must be implemented for worker monitoring. Particular attention will be paid to new employees or employees who have yet to acclimate to high heat conditions. Additionally, frequent communication will be maintained with employees working by themselves (via cell phone or two-way radio), to be on the lookout for possible symptoms of heat illness.
- During high heat conditions, employees will be provided with a minimum 10-minute cool-down period every 2 hours.
- Employees will be regularly observed for alertness and signs and symptoms of heat illness to be documented in the field book or field log.
- When the SSO is not available, an alternate responsible person must be assigned to look for signs and symptoms of heat illness. Such a designated observer will be trained to know what steps to take if heat illness occurs.

5.4.2 Procedures for Heat Waves

A “heat wave,” as defined by NOAA, is a period of abnormally and uncomfortably hot and unusually humid weather. Typically, a heat wave lasts 2 or more days. A "heat wave," as defined for the purposes of this HSS, is when temperatures are sustained above 80°F (26°C), or if site conditions indicate the potential for “Extreme Caution,” "Danger," or “Extreme Danger” per Table 1, the following steps will be taken:

- The SSO or designee, in coordination with the project team, will use their Stop Work Authority; evaluate the following actions; and document the action in the daily field log:
  - Modify the work shift or cut the work day short (e.g., 12:00 pm).
  - Reschedule the work (e.g., conduct the remaining work during cooler times of the day) or suspend strenuous tasks.
  - Use Stop Work Authority to cease work for the day.
- If schedule modifications are not possible, the Heat Illness HASP Supplement will be reviewed before work resumes. At a minimum, procedures for heat illness prevention, the provisions for high heat procedures, the weather forecast, and emergency response protocols will be reviewed.
- Employees will be provided with additional water and rest breaks and will be observed more frequently. They will also be reminded throughout the shift to drink plenty of water.
- During work activities and rest breaks, employees will be observed for signs and symptoms of heat illness.
- All employees will maintain frequent communication with the SSO or designee, who will be monitoring employees for possible symptoms of heat illness.

***Note**: At large project sites where the SSO is unable to be near the employees (to directly observe or communicate with them), communication via a cell phone or radio may be used for this purpose if reception in the area is reliable.*

5.4.3 Work/Rest Cycle Duration and Frequency Procedures

The occurrence of heat illness depends on a variety of factors. All workers, regardless if they are wearing permeable or semi-permeable clothing, should be monitored when conditions warrant monitoring (e.g., when temperatures exceed 80°F/26.6°C). If semi-permeable clothing is worn (e.g., not standard cotton or synthetic work clothing), it is recommended to begin monitoring those workers when temperatures exceed 70°F in the work area and prioritize workers completing strenuous tasks. Personnel monitoring becomes particularly important when work is conducted indoors, includes strenuous tasks, and additional PPE is worn (such as Level C respiratory protection or CPC). If semi-permeable clothing, Level C PPE, or CPC is not worn, follow the Heat Index table instructions and prepare to implement monitoring as part of the high heat measures discussed in Section 5.4.1. Table 2 below details procedures to be followed to determine an appropriate work/rest cycle with the default rest cycle duration beginning with a 15-minute period every hour when working in temperatures exceeding 90°F.

***Note:** Warning signs include: When a person's sustained (e.g., several minutes) heart rate exceeds 180 beats per minute (bpm) minus their age (e.g., 180 - age = X) for individuals with normal cardiac performance per their physician; or a body core temperature exceeds 101.3°F/38.5°C for acclimatized workers or 100°F/38°C for unacclimated workers; a recovery heart rate at 1 minute after a peak work effort is greater than 120 bpm; or there are symptoms of sudden and severe fatigue, nausea, dizziness, or lightheadedness.*

Table 2 - Suggested Frequency and Duration of Work/Rest Cycles Applying Physiological Monitoring of Acclimatized Personnel

Adjusted Air Temp. [1]	Wearing Permeable PPE [2]	Wearing Impermeable PPE [3]
> 90°F/32°C	After ea. 45 mins. of work	After ea. 15 mins. working
87.5 to 90°F/30.8 to 32.2°C	After ea. 60 mins. of work	After ea. 30 mins. working
82.5 to 87.5°F/28.1 to 30.8°C	After ea. 90 mins. of work	After ea. 60 mins. working
77.5 to 82.5°F/25.3 to 28.1°C	After ea.120 mins. of work	After ea. 90 mins. working
72.5 to 77.5°F/22.5 to 25.3°C	After ea.150 mins. of work	After ea. 120 mins. working

Notes:

[1] - Adjusted air temp (ta adj) calculation: ta adj F = ta F + (13 x % sunshine). Measure the air temperature (ta) with a thermometer (shielded from radiant heat). Estimate the percent sunshine by judging what percent time the sun is not covered by clouds that are thick enough to produce a shadow. (100 percent sunshine = no cloud cover and a sharp, distinct shadow; 0 percent sunshine = no shadows.)

[2] - Permeable PPE consists of cotton clothing with long sleeves and pants or breathable coveralls.

[3] - Add 1.8 °F for Tyvek coveralls; add 5.4 °F for heavy clothing; add 19.8 °F for impermeable/semi-impermeable PPE - Level A/B suits)

5.4.4 Monitoring Personnel Vital Signs for Determining Work/Rest Cycles

To conduct heart rate monitoring, first collect and record a resting heart rate to establish the baseline value for each individual to be monitored. Count the heartbeats at the radial pulse (located on the inside of the wrist below the base of the thumb) during a 30-second interval. During rest cycles, count and record the heart rate as early as possible at the beginning of the rest cycle and again 3-5 minutes later. The pulse rate should fall rapidly and soon approach the individuals baseline heart rate level. The heart rate will remain elevated for a worker experiencing onset of heat illness.

- If the heart rate exceeds 110 beats per minute at the beginning of the rest period, shorten the next work cycle by one third and keep the rest period the same.
- If the heart rate still exceeds 110 beats per minute at the next rest period, shorten the following work cycle by one third.

Body temperature monitoring is used in conjunction with heart rate monitoring to evaluate an individual's condition and ability to sufficiently cool down during breaks when working in hot environments. Monitor and record body temperature orally using a clinical thermometer (3 minutes under the tongue and before drinking liquids) or using an infrared forehead swipe thermometer per manufacturer's directions. Take temperatures at the end of the work period before the rest cycle.

- If oral temperature exceeds 99.6°F (37.6°C), shorten the next work cycle by one third without changing the rest period.
- If oral temperature still exceeds 99.6°F (37.6°C) at the beginning of the next rest period, shorten the following work cycle by one third.
- Do not permit a worker to wear a semi-permeable or impermeable garment when the oral temperature exceeds 100.6°F (38.1°C).

5.5 Heat Exhaustion and Heat Stroke Symptoms, First Aid and Emergency Procedures

Emergency procedures include recognizing the more serious symptoms associated with the third and fourth stages of heat-related illness: heat exhaustion and heat stroke. A critical step to having effective emergency procedures involves ensuring that effective communication has been established and maintained to contact emergency responders.

5.5.1 Heat Exhaustion and Heat Stroke Symptoms

Signs of heat exhaustion include:

- Cool, moist, pale, or flushed skin
- Heavy sweating
- Headache
- Nausea, dizziness, and exhaustion
- Normal or below normal body temperature.

Signs of heat stroke include:

- Hot, red skin, which can be dry or moist from exercise
- Changes in consciousness
- Rapid, weak pulse

- Rapid, shallow breathing, vomiting
- A person experiencing heat stroke can have a very high body temperature—sometimes as high as 106°F (41°C).

5.5.2 First Aid Procedures for Heat Exhaustion

If an employee is determined to be suffering from heat exhaustion, perform the following steps:

1. Move the person to a cooler place.
2. Remove or loosen tight clothing and apply cool, wet cloths, such as towels or sheets soaked in water.
3. If the person is conscious, give him or her cool water to drink. Make sure the person drinks slowly. Give a half glass of cool water every 15 minutes.
4. Contact the employees' supervisor, the project manager, and Work Care 1-888-449-7787 (US & Canada).
5. Let the person rest in a comfortable position.
6. Watch carefully for changes in his or her condition.

Do not give liquids that contain alcohol or caffeine because they can cause further dehydration, making conditions worse.

5.5.3 First Aid and Emergency Procedures for Heat Stroke

Heat stroke is a life-threatening situation. If you suspect that someone is suffering from heat stroke, call 9-1-1 or the local emergency number immediately.

1. Move the person to a cool place.
2. Loosen tight clothing.
3. Remove perspiration-soaked clothing.
4. Apply cool, wet cloths to the skin.
5. Fan the person.
6. If conscious, give small amounts of cool water to drink.
7. Place the person on his or her side.
8. Contact the employees' supervisor, the project manager, and Work Care 1-888-449-7787 (US & Canada).
9. Continue to cool the person using ice or cold packs on the wrists, ankles, groin, and neck and in the armpits.
10. Continue to check breathing and circulation.

Do not give liquids that contain alcohol or caffeine because they can cause further dehydration, making conditions worse. Ensure that 911 or the local emergency number is called if the person refuses water, vomits, or starts to lose consciousness.

Emergency contact telephone numbers and hospital directions/map must be included in each site-specific HASP for employee reference.

6. TRAINING

The Arcadis Heat Illness Prevention online training offered through the Arcadis Learning Center is required to be completed before Supervisory Personnel and Affected Employees working in California or Washington States will be permitted to begin work. Project teams conducting work in

locations other than California or Washington States are expected to complete the training before conducting work as defined in the H&S training matrices specific to each Business Line. Completion of the training once is generally considered sufficient to satisfy the training requirement; however, the training may be required to be completed again as determined by Arcadis policy or management, or by client or specific state requirements. Refresher training is encouraged for all staff that infrequently conducts or supervises work where heat illness is a hazard.

6.1 Supervisory Personnel

Personnel supervising staff on a California or Washington State site who might reasonably be anticipated to be exposed to the risk of heat illness will be provided training in the following topics before assignment:

- The environmental and personal risk factors for heat illness
- The importance of frequent consumption of small quantities of water; consuming 8 fl. oz. every 15 minutes or 32 fl. oz. per hour, when the work environment temperature exceeds 80°F/26.6°C because employees are more likely to be sweating more than usual in the performance of their duties.
- The importance of staying appropriately nourished and hydrated
- The importance of acclimatizing before work
- The different types of heat illness and the common signs and symptoms
- The importance for employees to immediately report to the employer, directly or through the employee's supervisor, symptoms or signs of heat illness in themselves or in co-workers
- The procedures to follow for responding to symptoms of possible heat illness, including how emergency medical services will be provided should they become necessary
- The procedures for contacting emergency medical services, and if necessary, for transporting employees to a point where they can be reached by an emergency medical service provider
- The procedures for ensuring that, in the event of emergency, clear and precise directions to the work site can and will be provided as needed to emergency responders.

In addition, these supervisory personnel must review and understand:

- This Heat Illness Prevention HSS and the associated HASP Supplement
- How to implement the emergency response procedures detailed in the site-specific HASP when an employee exhibits symptoms consistent with possible heat illness
- Weather monitoring reports as detailed in the field Health & Safety Handbook
- How to monitor weather reports and how to plan for and respond to hot weather advisories.

This training will be documented within the Learning Center database along with details on the subject matter covered and date of training recorded.

6.2 Affected Employees

For those employees who work in California or Washington State, or when using this HSS as a BMP in any other state and might reasonably be anticipated to be exposed to the risk of heat illness, training in the following topics is required before assignment:

- The environmental and personal risk factors for heat illness
- The importance of frequent consumption of small quantities of water; 8 fl. oz. every 15 minutes or 32 fl. oz. per hour when the work environment temperature exceeds 80°F/26.6°C and employees are more likely to be sweating more than usual in the performance of their duties
- The importance of acclimatizing
- The different types of heat illness and the common signs and symptoms
- The importance for employees to immediately report to the employer, directly or through the employee's supervisor, symptoms or signs of heat illness in themselves or in co-workers
- The procedures for responding to symptoms of possible heat illness, including how emergency medical services will be provided should they become necessary
- The procedures for contacting emergency medical services, and if necessary, for transporting employees to a point where they can be reached by an emergency medical service provider
- The procedures for ensuring that, in the event of emergency, clear and precise directions to the work site can and will be provided as needed to emergency responders.

This training will be documented within the Learning Center database along with details on the subject matter covered and date of training recorded.

Note: *For those staff who are not working in California, Washington State, or other states that have specified heat illness training requirements, staff that might reasonably be anticipated to be exposed to the risk of heat illness will (at a minimum) review the information detailed in the Field Health & Safety Handbook and this HSS. Corporate H&S recommends that all staff that might be reasonably be anticipated to be exposed to the risk of heat illness complete the online heat illness training course through the Learning Center.*

7. REFERENCES

- Occupational Safety and Health Administration (OSHA) Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities Section 8 "Heat Stress and Other Physiological Factors" OSHA, National Institute for Occupational Safety and Health (NIOSH), United States Environmental Protection Agency (USEPA), U.S. Coast Guard (USCG). Chapter 8. 1985.
- OSHA Technical Manual – Section III Chapter 4
- National Institute of Occupational Safety and Health (NIOSH) Publication Number 86-112
- American Conference of Governmental Industrial Hygienists (ACGIH) "Guidelines for Limiting Heat Strain" 2018
- American Red Cross 2007
- Cal/OSHA Title 8 CCR 3395 Heat Illness Prevention Standard and Title 8 CCR 3202 Injury and Illness Prevention Program
- Washington State Outdoor Heat Exposure Regulations 296-62-09510 thru 09560
- See Exhibit 3 for links to additional regulatory resources.

8. RECORDS

Heat illness training records will be maintained by the Arcadis Training Team.

Heat Plan H&S Plan Supplement will be maintained with project files.

9. APPROVALS AND HISTORY OF CHANGE

Approved by: Julie Santaniello, CSP – Corporate H&S Manager of Technical Programs

History of Change

Revision Date	Revision Number	Standard Developed/Reviewed By or Revised By	Reason for change
31 August 2011	01	Tony Tremblay & Mija Coppola	Original document
13 March 2012	02	Tony Tremblay	Detailed Supervisory Personnel requirement to plan/detail preventive measures/controls when heat advisories are issued; clarified training requirements for staff and supervisory personnel; inserted heat advisory and excessive heat warning definitions
19 June 2012	03	Pat Vollertsen	Information added about nourishment
16 June 2014	04	Pat Vollertsen & Alec MacAdam/Tony Tremblay	Revised standard format and History of Change Section. Updated to include specific prescriptive language to address Cal OSHA and Washington State requirements. Inclusion of HASP supplement and preparation guidance. Clarification of the use of sports/electrolyte drinks
7 August 2014	05	Alec MacAdam	Update guidance for use of “Sports Drinks”

Revision Date	Revision Number	Standard Developed/Reviewed By or Revised By	Reason for change
6 April 2015	06	Alec MacAdam	Revise temperature threshold from 85° to 80°F, provisions for shade, guidance for preventative rest breaks, revised high heat procedures and clarification of acclimatization procedures
15 March 2017	07	Alec MacAdam & Denis Balcer/ Tony Tremblay & Julie Santaniello	Updated brand. Updated links to Exhibits 2 & 3, Revised Admin. Controls in Section 5.3, Additional regulatory detail in Sections 5.3.2 and 5.3.3. Added Section 5.4 Heat Index Action Levels and Recommended Hazard Controls. Revised the HIPP HASP Supplement to reflect changes in the HSS.
2 January 2020	08	Alec MacAdam	Updated format. Clarifications in Roles & Responsibilities § 4; Updated Safe Work Practices in § 5.1; Updated Administrative and Engineering Controls in § 5.3; Updated Heat Index Table 1 § 5.4; Added Work/Rest Cycle Guidance § 5.4.3; and Personnel Vital Signs Monitoring § 5.4.4; Revised Heat Exhaustion and Heat Stroke Emergency Procedures; Updated References; Updated HASP Supplement with above noted revisions on 6 May 2019.
17 February 2020	09	Julie Santaniello	Updated Heat Index ranges in Section 5.4 so text matches Table 1.

EXHIBIT 1 - DEFINITIONS

Acclimation – A process by which the body adjusts to increased heat exposure. The body needs time to adapt when working in hotter environments. Employees working in a hot environment are more likely to develop heat illness if not allowed or encouraged to allow their body to acclimate when a heat wave strikes or when starting a job that newly exposes them to heat. Acclimatization is fully achieved in most people within 4 to 14 days of regular work involving at least 2 hours per day in the heat.

Excessive Heat Warning - Extreme Heat Index making it feel very hot, typically above 110°F (43°C) for 3 hours or more during the day for two consecutive days or above 110°F (43°C) at any time. Specific criteria vary over different county warning areas.

Heat Advisory - Issued when the Heat Index is expected to exceed 105°F (40°C) during the day and 80°F (27°C) during the night for at least two consecutive days.

Heat Cramps – Normally caused by performing hard physical labor in a hot environment. These cramps have been attributed to an electrolyte imbalance caused by sweating. Salt tablets should not be taken.

Heat Collapse – Commonly known as “Heat Stress,” technically referred to as heat syncope. Heat collapse or syncope (fainting) is the condition where the brain does not receive enough oxygen because blood pools in the extremities. To prevent heat collapse, the employee should gradually acclimatize to the hot environment.

Heat Exhaustion – Less severe than heat stroke, but the victim must be treated as soon as possible. Symptoms include clammy and moist skin; pale or flushed complexion; sweating along with extreme weakness or fatigue, giddiness, nausea, or headache; and (in more serious cases) vomiting or loss of consciousness.

Heat Fatigue – The signs and symptoms of heat fatigue include impaired performance of skilled sensorimotor, mental, or vigilance jobs. There is no treatment for heat fatigue except to remove the person from the heat before a more serious heat-related condition develops.

Heat Index – an “apparent temperature” that is a measure of how hot it feels when relative humidity is added to the actual air temperature.

Heat Rashes – Also referred to as prickly heat, is the most common problem in hot work environments. Prickly heat is manifested as red papules and usually appears in areas where the clothing is restrictive.

Heat Stress – A physiological condition induced when high temperatures and humidity compromise the body’s ability to cool itself, resulting in heat-related illness.

Heat Stroke – The body's system of temperature regulation fails, and body temperature rises to critical levels. This condition is caused by a combination of highly variable factors, and its occurrence is difficult to predict. **Heat stroke is a medical emergency.** The primary signs and symptoms of heat stroke include confusion; irrational behavior; loss of consciousness; convulsions; a lack of sweating (usually); hot, dry skin; and an abnormally high body temperature.

Heat Wave - A “heat wave,” as defined by NOAA, is a period of abnormally and uncomfortably hot and unusually humid weather. Typically, a heat wave lasts 2 or more days. A "heat wave," as defined for the purposes of this HSS, is when temperatures are sustained above 80°F.

Provision of Water - Employees will have access to potable drinking water meeting the requirements of Section 5.3.2 of this HSS including but not limited to the requirements that it be fresh, pure (water must be potable and free of odors), suitably cool (the water must be cooler than the ambient temperature but not so cool as to cause discomfort), and provided to employees free of charge. The water will be located as close as practicable to the areas where employees are working. Where drinking water is not plumbed or otherwise continuously supplied, it will be provided in sufficient quantity at the beginning of the work shift to provide 1 quart per employee per hour for drinking for the entire shift. Employers may begin the shift with smaller quantities of water if they have effective procedures for replenishment during the shift as needed to allow employees to drink 1 quart or more per hour. The frequent drinking of water will be encouraged. The purpose of requiring that water is “fresh, pure, suitably cool, and provided to employees free of charge” and “located as close as practicable to the areas where employees are working” is to encourage workers to drink water often and avoid making the workers interrupt their work in order to do so. To ensure that water is fresh, pure, and suitably cool, Cal/OSHA advises that employers or supervisors visually examine the water and pour some on their skin.

Shade - The blockage of direct sunlight. Canopies, umbrellas, and other temporary structures or devices may be used to provide shade. One indicator that blockage is sufficient is when objects do not cast a shadow in the area of blocked sunlight. Shade is not adequate when heat in the area of shade defeats the purpose of shade, which is to allow the body to cool. For example, a car sitting in direct sunlight does not provide acceptable shade to a person inside it unless the car engine is operating with air conditioning on. Shade may be provided by any natural or artificial means that does not expose employees to unsafe or unhealthy conditions and that does not deter or discourage access or use.

Transient Heat Fatigue – The temporary state of discomfort and mental or psychological strain arising from prolonged heat exposure. Employees unaccustomed to the heat are particularly susceptible and can suffer, to varying degrees, a decline in task performance, coordination, alertness, and vigilance.

EXHIBIT 2 - ACRONYMS AND ABBREVIATIONS

ACGIH	American Conference of Governmental Industrial Hygienists
ANA	Arcadis North America
APM	Assistant Project Manager
Arcadis	Arcadis U.S. Inc.
BMP	Best Management Practice
BPM	Beats Per Minute
°C	Degrees Celsius
Cal/OSHA	California Occupational Safety and Health Administration
CCR	California Code of Regulations
CPC	Chemical Protective Clothing
°F	Degrees Fahrenheit
HASP	Health & Safety Plan
HIPP	Heat Illness Prevention Plan
HS	Health and Safety
H&S	Health and Safety
HSS	Health and Safety Standard
L	Liter
NIOSH	National Institute of Occupational Safety and Health
NOAA	National Oceanic and Atmospheric Administration
OSHA	Occupational Safety and Health Administration
Oz	Ounce
PM	Project Manager
PPE	Personal Protective Equipment
SSO	Site Safety Officer
TM	Task Manager

EXHIBIT 3 – Heat Illness Links

CDC / NIOSH Occupational Exposure to Heat and Hot Environments - 2016

Heat Illness Symptoms

Heat Illness Thermometer and PPE

OSHA Working Outdoors Fact Sheet

OSHA Worker Protection from Heat Stress

California Heat Illness Prevention Enforcement Q&A

Washington State Outdoor Heat Exposure Enforcement Procedures

EXHIBIT 4 – Heat Illness Prevention Plan HASP Supplement Template

The Heat Plan HASP Supplement is contained in the Standard Excel® HASP template. The most current version of the HASP template is located on the ANA H&S Intranet site on the "Forms and Templates" page.

Link to the H&S "Forms and Templates" page:
https://arcadiso365.sharepoint.com/sites/naintranet/en-us/HealthandSafety/FormsTemplates

The Heat Plan supplement can be accessed by right clicking on the lower toolbar of the excel HASP template and selecting "Unhide" and selecting the "Heat Illness Prevention Plan."

EXECUTIVE SUMMARY

The purpose of reporting and investigating incidents is to prevent similar or more serious incidents from recurring.

The types of incidents reported and investigated under the Arcadis H&S program include:

- Work-related injuries and illnesses
- Near misses
- Motor vehicle accidents
- Utility Strikes
- Environmental releases
- Equipment or property damage
- Regulatory violations
- Operational or system inefficiencies or losses

This standard is followed for any of the above-listed incidents incurred by Arcadis employees, Arcadis subcontractors, temporary agency workers contracted by Arcadis, clients or third parties associated with or in the vicinity of Arcadis activities, which would affect the health and safety of the Arcadis work area or activities. All employees receive Incident Reporting and Investigation training during Health & Safety Orientation training.

Immediately following an incident, **STOP** operations until it is determined that it is safe to resume. This assessment may be as simple as performing TRACK or as complex as a team assessment of practices and conditions.

The employee is responsible for reporting any near miss or incident, including reporting to the Supervisor/PM and/or the client as outlined in the project H&S Plan.

Every non-emergency, work-related injury or illness is required to be called into WorkCare via their reporting hotline number to ensure proper medical management of the injury.

All incidents are recorded and stored in the Health & Safety database and maintained per Arcadis recordkeeping requirements.

1. POLICY

An Incident is defined as “a sudden and unplanned event or chain of events, which has, or could have caused, injury or illness and/or damage to assets”.

It is Arcadis U.S. policy that:

- All incidents, including near misses, are reported.
- Reporting of incidents is every employee’s responsibility.

- Incidents involving non-emergency work-related injury are reported to WorkCare first to ensure proper medical care and management.
- All near misses and incidents are investigated (Exhibit A-2 and B-2).
- The level of investigation is based on the severity of the outcome or the potential outcomes of the incident or near miss.
- All investigations result in learning that is communicated to appropriate staff.

2. PURPOSE AND SCOPE

2.1 Purpose

The purpose of reporting and investigating near misses and incidents is to prevent similar or more serious incidents from recurring. This is completed by determining the contributing factors to the incident and/or the root causes of those factors using the Root Cause Analysis and Solution Development HSS (ARC HSMS011).

2.2 Scope

The types of incidents reported and investigated under the Arcadis H&S program include:

Work-related injuries and illnesses

- fatality/permanent disability
- lost time
- restricted duty
- medical treatment
- first aid

Near misses

Motor vehicle accidents

Utility strikes

Environmental releases

Equipment or property damage

Regulatory violations

Operational or system inefficiencies or losses

This standard is also followed for any of the above-listed incidents incurred by temporary agency workers contracted by Arcadis, clients or third parties associated with or in the vicinity of Arcadis activities, which would affect the health and safety of the Arcadis work area or activities.

The investigation team may include subcontractor workers and a subcontractor supervisor. Arcadis personnel will participate on the investigation team to provide

knowledge of the project site and to facilitate the proper use of the process.

Additional client-specific and contract requirements may also be required and implemented.

3. DEFINITIONS

Definitions can be found in Exhibit A of ARC HSMS000 – Arcadis US HS Management System.

4. RESPONSIBILITIES

All employees will refer to the Near Miss Reporting and Near Miss Investigation Process Flow or Incident Reporting and Incident Investigation Process Flow diagrams in Exhibit A and Exhibit B.

4.1 Employees and Arcadis Contracted Temporary Agency Workers

Employees are required to report all workplace near misses, incidents and any event that may generate media coverage that involves Arcadis employees and Arcadis subcontractors.

> **Note:** As the "host employer" of temporary staffing workers, Arcadis would be responsible for reporting incidents of temporary workers when Arcadis provides day-to-day supervision. For additional information, refer to Exhibit C.

4.2 Project Managers and Supervisors

Project Managers and Supervisors are required to be involved in the reporting and investigation process for incidents and near misses as defined in Exhibits A-1, A-2, B-1 and B-2. Ensure all near misses and incidents are recorded in the H&S Database.

4.3 Leadership

Leadership will be notified of certain near misses and incidents as presented in the Exhibit A-1 or B-1, respectively. Business Line Leadership may have specific reporting and investigation requirements that exceed the minimum requirements presented in the process flow diagrams.

Leadership may be involved in the reporting and investigation of significant near misses Level 2 and Level 3 incidents.

4.4 Corporate Services (Legal, Communications and Human Resources)

Depending on the Incident Level or significance of the near miss, Corporate Legal, Communications and Human Resources may be notified during the reporting process and included in the investigation process.

4.5 Corporate Health and Safety

Corporate H&S Staff have the responsibility for:

- Communicating the policy and standard requirements in this HSS to Arcadis staff;

- Notifying Leadership, other Corporate Services or Global Health & Safety, as appropriate, and keeping them informed;
- Participating in Near Miss and Incident Investigations as required or as requested; and
- Reviewing, evaluating and maintaining this HSS on a routine basis.

5. PROCEDURE

The reporting and investigation procedures discussed in this section are broken down into the following components:

- Stop Work
- Reporting and Notification
- WorkCare Intervention and Case Management
- Investigation Team
- Incident Investigation Process
- Description of Incident
- Determine Contributing Factor(s)
- Determine Root Cause(s) of Key Contributing Factor(s)
- Develop Solution(s)
- Review Process
- Validation and Verification

5.1 Stop Work

It is Arcadis policy that during the conduct of their work, Arcadis, and subcontractor employees and temporary workers have the authority and responsibility to Stop Work immediately in any situation when the Health, Safety, Security and Environment hazards and risks associated with the work being performed is not clearly established or controlled.

Immediately following a near miss or incident, STOP Work until it is determined that it is safe to resume. Refer to the Stop Work Authority HSS (ARC HSGE009).

If a person sustains a major injury, or if the incident is classified as a significant near miss, the operation must be stopped and the investigation initiated immediately.

5.2 Reporting and Notification

The Arcadis employee, subcontractor employee and/or temporary workers is responsible for reporting any near miss and incident including reporting to the Supervisor/PM and/or the client as outlined in Exhibit A-1, Exhibit B-1 and the project H&S Plan. Incidents and near misses will be categorized as follows:

- Level 1 - First aid/self-treated, work-related injury (contact WorkCare as soon as possible); minor property or equipment damage (less than or equal to $100); vehicle loss event (no injuries, no third-party involvement or other vehicle involvement – refer to Motor Vehicle Safety Program HSGE024).

- Level 2 - Professional Medical Treatment (if non-emergency injury or illness, employee must contact WorkCare as soon as possible); moderate property or equipment damage (greater than $100 but less than or equal to $5,000); ANY utility strike incident, any motor vehicle accident (including injury or third-party involvement – refer to Motor Vehicle Safety Program HSGE024).

- Level 3 - Immediately report fatality, severe or catastrophic injury and/or overnight hospitalization required; significant property or equipment damage (greater than $5,000); missing person or incident that generates media coverage.

- Near Miss - Potential for an incident that could have resulted in illness, injury or damage to assets, but did not.

- Significant Near Miss - Potential for severe injury or damage of greater than $5,000.

Reporting and notification times vary depending on the Incident Level, but all should be done as soon as possible and no later than as outlined in the Incident Reporting and Investigation Process flowchart in Exhibit B-1. This reporting will be completed via telephone to the appropriate person.

> **Note:** Some California OSHA (CalOSHA) Districts are requiring that employers report any serious injury or fatality that occurs at the workplace regardless of whether it is work-related or not. CalOSHA defines a serious injury as any incident requiring inpatient hospitalization in excess of 24 hours (for other than medical observation) or in which an employee suffers a body part loss or serious degree of permanent disfigurement. Therefore, staff in California must report to Corporate H&S any serious injury or fatality that occurs at a California workplace.

As necessary, an Arcadis employee that is present on a site where an injury occurred is authorized to and may accompany the employee to the treating facility.

5.2.1 OSHA Notification Requirements

The ANA HS Director will notify OSHA in the event of the following:

- Work-related fatality;

- Work-related inpatient/overnight hospitalizations;
- Amputations; or
- Loss of an eye.

All notifications to OSHA or state agencies will be completed by the ANA H&S Director or his/her designee.

A fatality must be reported to OSHA within 8 hours.

An in-patient/overnight hospitalization, amputation, or eye loss must be reported to OSHA within 24 hours.

5.3 WorkCare Intervention and Case Management

WorkCare must be contacted for every non-emergency, work-related injury or illness to an Arcadis employee via their reporting hotline number (888-449-7787) to ensure proper medical management of the injury. WorkCare will manage the case along with the Arcadis Workers Compensation manager to ensure the appropriate and effective care is provided to the employee. A flowchart of the WorkCare Intervention process is shown in Exhibit D.

5.4 Investigation Team

Team composition varies depending on the type of near miss or Incident Level. The recommended members of the investigation team are listed in the Near Miss Investigation Process flowchart (Exhibit A-2) or Incident Investigation Process flowchart (Exhibit B-2).

5.5 Near Miss and Incident Investigation Process

5.5.1 Initiating the Investigation

Information or conditions that may change with time must be captured immediately. This may include taking pictures of damage before it is repaired and of the site before conditions change, and getting names of witnesses before they leave the area. The longer the delay in examining the incident scene and interviewing witnesses the greater the possibility of obtaining erroneous or incomplete information.

The severity or potential severity of the incident will determine when the formal investigation should be initiated.

5.5.2 Fact Gathering

It is essential that proper information and data gathering take place at all times during the investigation. The accuracy and thoroughness with which the investigators obtain and record information and data largely determines the quality of the final report and the effectiveness of corrective actions.

For minor incidents, the information may be gathered by the supervisor or other involved personnel immediately following the incident. Based on the complexity of the situation, this information may be all that is necessary to enable the investigation team to analyze the

incident, determine the root cause, and develop solutions. More complex situations may require the investigation team to revisit the incident site or re-interview key witnesses to obtain answers to questions that may arise during the investigation process.

For damaged equipment or property incidents, photographs or videos of the scene should be taken from all sides and from various distances. Sketches or drawings could also be pertinent to the investigation. This is especially important when the investigation team is not able to visit the incident scene.

5.5.3 Starting an Investigation

The Project Manager or Supervisor, as it relates to the activity being conducted at the time of the incident, is responsible for initiating the investigation process. Depending on severity, the Business Line Corporate H&S Director will initiate the investigation process at their discretion. The incident investigation is initiated once the area is secure, injured people have received appropriate medical attention, and appropriate notifications have been made.

5.5.4 Investigation Documentation

Near Miss and incident investigations are maintained in the H&S database. Prior to entry in the H&S database, utility strikes and 3rd Party incidents will be discussed with Corporate H&S and other Corporate Services.

5.6 Description of Incident

It is critical to accurately describe what happened. Do not speculate on causes, state “just the facts.” The description should be clear and concise. For example:

> “Mechanics opened the flange on transfer line Number 2 from Tank 101 and 50 gallons of diesel fuel was released. No injuries occurred. Spill was contained in the area drainage system”.

5.7 Determining Contributing Factor(s)

Contributing factors are things, events, circumstances, actions that led up to the incident. Facts can be contributing factors.

Once all contributing factors have been identified, determine which contributing factor(s) were primary in the event occurring (key contributing factor). Contributing factors are not root causes.

5.8 Determining the Root Cause(s) of the Key Contributing Factor(s)

For each key contributing factor, follow the Root Cause Process Flow presented in the Root Cause Analysis and Solution Development HSS (ARC HSMS011).

Any near miss or incident may have one or more root causes that will be categorized based on the Arcadis Root Cause Categories presented in Exhibit 3 of ARC HSMS011.

5.9 Development of Solution(s)

Each root cause must be addressed by a solution, with a responsible person identified and notified for solution implementation. The investigation team cannot identify a root cause and then make no recommendation to address it. Furthermore, there must be a "match" between the root cause and the solution. Refer to the Solutions Actions Table in Exhibit 4 of ARC HSMS011.

5.10 Review Process

The roles and responsibilities of the investigation and review processes are outlined in the Near Miss Investigation Process and Incident Investigation Process flowcharts presented in Exhibit A-2 and B-2, respectively. Review and follow-up on incident investigations is important to verify the effectiveness of the process.

Quality reviews of incident investigations offer an opportunity to provide positive feedback or constructive advice for continued improvement.

5.11 Validation and Verification

Employees have the opportunity to follow-up on near miss and incident investigations by verifying that the solutions have been implemented and validating that the solutions have adequately addressed the root cause(s) of the incident.

6. TRAINING

All employees receive Incident Reporting and Investigation training during Health & Safety Orientation training.

7. REFERENCES (regulation citation, technical links, publications, etc.)

ARC HSMS000 – Health & Safety Management System

ARC HSMS011 – Root Cause Analysis and Solution Development

ARC HSGE009 - Stop Work Authority

8. RECORDS - DATA RECORDING AND MANAGEMENT

Near Misses and Incidents are recorded and stored in the H&S database and maintained per Arcadis recordkeeping requirements.

9. APPROVALS AND HISTORY OF CHANGE

Julie Santaniello, CSP – Corporate Health & Safety, Manager of Technical Programs

History of Change

Revision Date	Revision Number	Standard Developed/Reviewed By or Revised By	Reason for change
22 October 2007	01	Pat Vollertsen/Mike Thomas	Original document
9 June 2009	02	Pat Vollertsen	Revision and update to include WorkCare intervention which has been implemented since 2006 but documented in separate document. Also update new LPS terminology
26 June 2009	03	Pat Vollertsen	Revision includes language that, when necessary, an injured employee will be accompanied to medical care by authorized employee
6 October 2010	04	Sue Byers	Change name from Procedure to Standard; revision to section 5.2 & App A to clarify client must be notified when required by the HASP
24 March 2015	05	Pat Vollertsen/Tony Tremblay/Julie Santaniello	Executive Summary added; removed LPS terminology and updated with current BBS language; updated Section 4 and 5; updated Exhibits A, B and C
6 August 2015	06	Tony Tremblay	Section 5.2 note added to detail that California OSHA Districts are requiring that employers report any serious injury or fatality that occurs at the workplace regardless of whether it is work-related or not

Implementation Date 22 October 2007	Arcadis HS Standard Name Incident Reporting and Investigation	ARCADIS Design & Consultancy for natural and built assets
Revision Date 26 April 2016	Arcadis HS Standard No. ARC HSMS010	Revision Number 07

Revision Date	Revision Number	Standard Developed/Reviewed By or Revised By	Reason for change
26 April 2016	07	Denis Balcer/Tony Tremblay/Pat Vollertsen/Julie Santaniello	Expanded reporting required for incidents incurred by in Section 2.2; added Temp Agency Worker information to Section 4.1 and Exhibit C; defined Incident Levels in Section 5.2; added OSHA reporting Section 5.2.1; updated Exhibits A-1, A-2, B-1 and B-2 and clarified text; WorkCare Incident Intervention flowchart moved to Exhibit D; rebranded standard.

Exhibit A-1 – Near Miss Reporting Process

(Hyperlink to standalone document)

ARCADIS Design & Consultancy for natural and built assets

Near Miss Reporting Process

Near Miss: Potential for and incident that **could have** resulted in illness, injury or damage to assets, but did not.

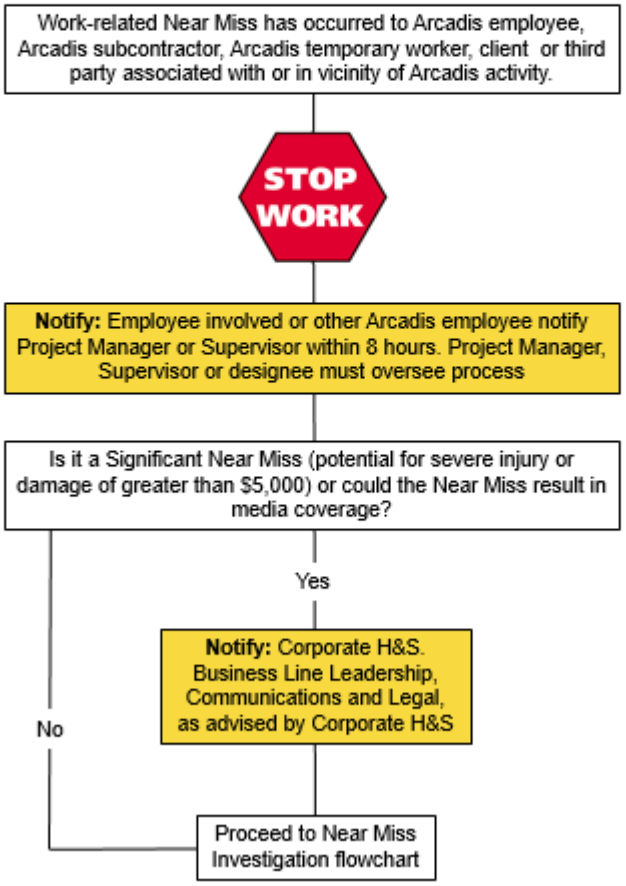


Exhibit A-2 – Near Miss Investigation Process

(Hyperlink to standalone document)

ARCADIS Design & Consultancy for natural and built assets

Near Miss Investigation Process

Near Miss: Potential for and incident that **could have** resulted in illness, injury or damage to assets, but did not.

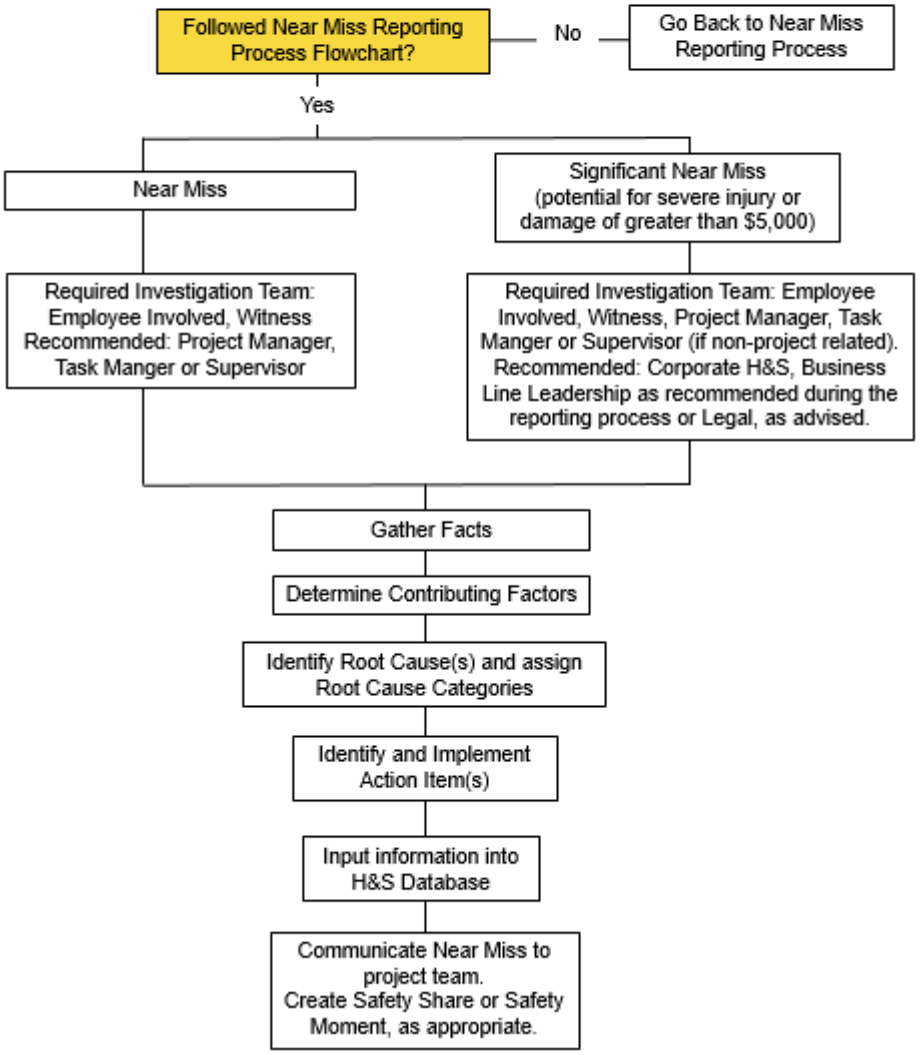


Exhibit B-1 – Incident Reporting Process

(Hyperlink to standalone document)

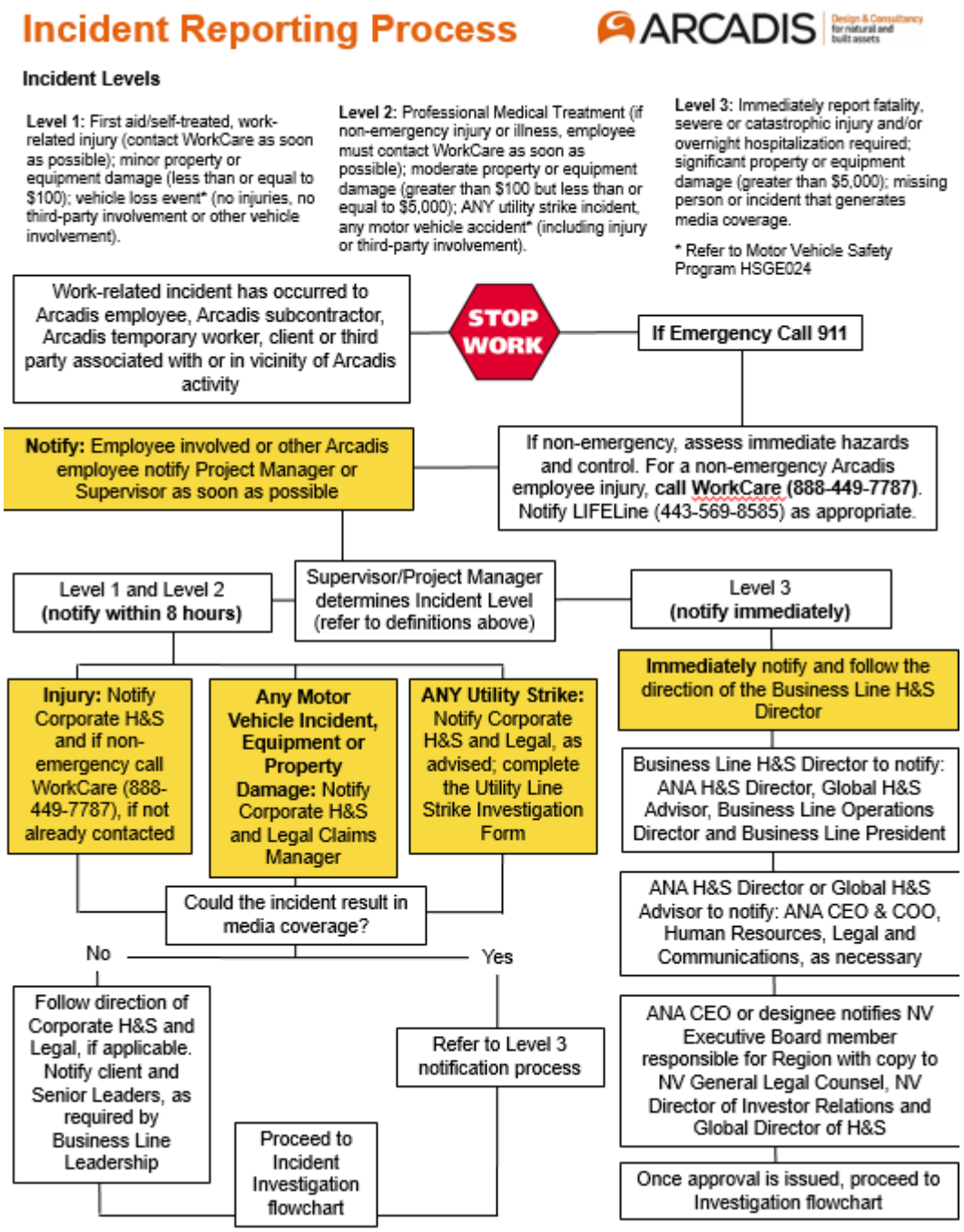


Exhibit B-2 – Incident Investigation Process

(Hyperlink to standalone document)

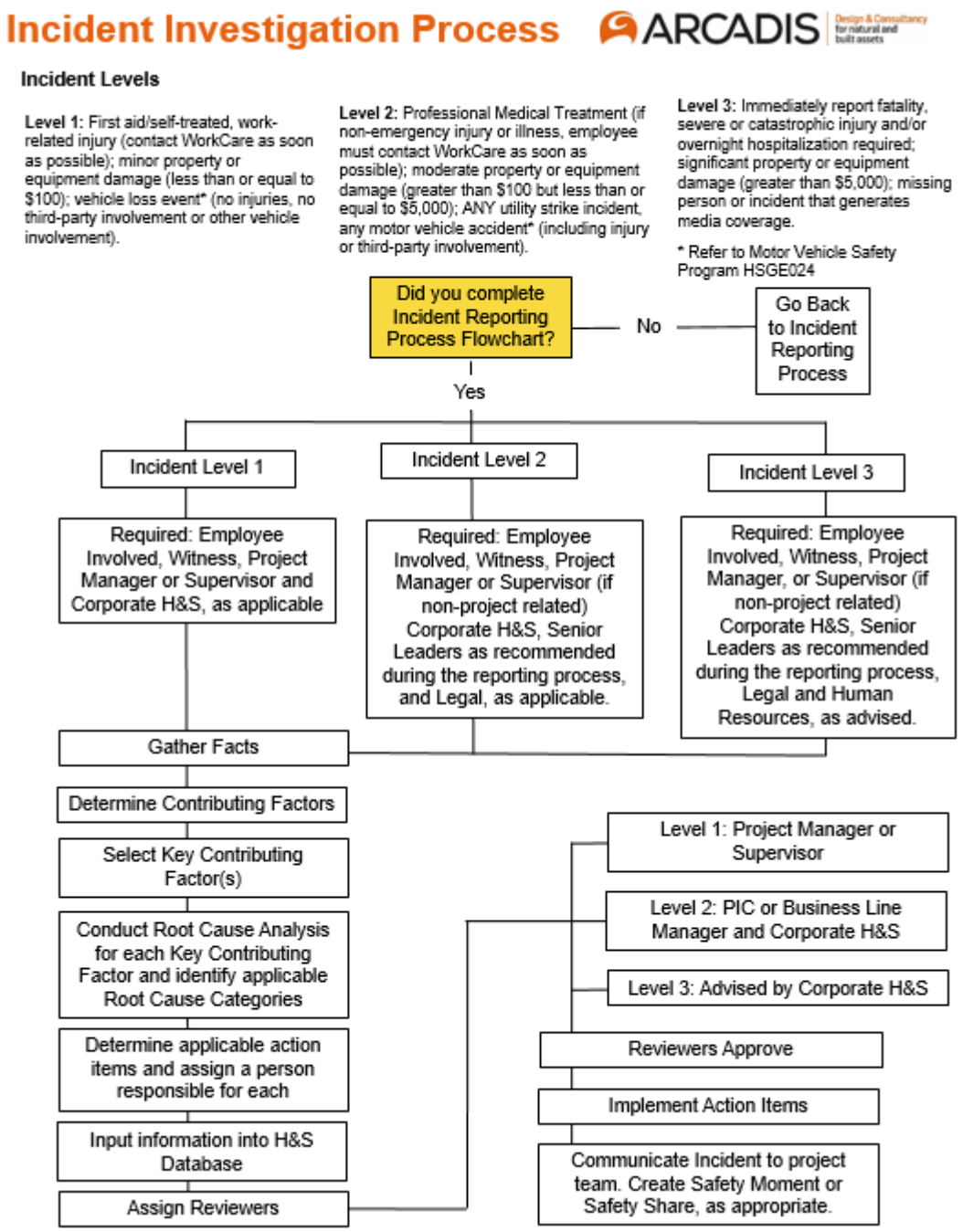


Exhibit C – Arcadis Temporary Workers

National Labor Relations Board (NLRB) Expansion of Joint Employer Doctrine and Potential OSHA Liability

Background

A recent NLRB decision expanded the definition of "joint employer." Arcadis project teams should be aware that this ruling potentially could expand liability under OSHA. Though OSHA's definition of "employer" still differs from the NLRB definition, the ruling is likely to influence OSHA's approach to inspections and citations involving temporary employees (and contractors).

Under the NLRB's new test, two or more otherwise-unrelated employers may be found to be a joint employer of the same employees if they "share or co-determine those matters governing the essential terms and conditions of employment." The focus, however, is not merely on the authority you may actually exert, but rather how much power you potentially have.

Temporary Labor Staffing Agencies

For some time, OSHA's published position has been that temporary staffing agencies and host employers share control over the employee, and are therefore jointly responsible for temp employees' safety and health; and that it is essential that both employers comply with all relevant OSHA requirements. With the new rule, it is likely that both the staffing agencies and the host employer will be more broadly exposed to the risk of OSHA citations.

Arcadis project teams have a responsibility to maintain safe working conditions onsite including temporary staffing agency employees. While the staffing agency and host company can be, and in many circumstances are, both cited by OSHA for violations potentially impacting the safety of temp agency workers, because the host company controls the workplace and generally supervises the work, the host company is primarily responsible for complying with applicable regulations, maintaining the safety and health of the workers, and accurate recordkeeping.

As such, as the "host employer" of temporary staffing workers, Arcadis would be responsible for recording the injuries and illnesses of temporary workers when day-to-day supervision occurs, and reporting these injuries to clients. "Day-to-day supervision" is when "…in addition to specifying the output, product or result to be accomplished by the person's work, the employer supervises the details, the means, methods and processes by which the work is to be accomplished." Thus, when providing day-to-day supervision of temporary staffing agency employees, Arcadis should record the workplace injuries or illnesses for those staff on the Arcadis OSHA logs.

Contractors

Similar to temporary agency employees, contractors may face increased exposure to OSHA citations. OSHA's multi-employer worksite citation policy allows OSHA to cite an employer for hazards that other employers' employees were exposed to when OSHA finds that the employer either 1) controlled the hazard, 2) created the hazard or 3) was responsible for correcting the hazard. As a result, the NLRB's expanded definition of "joint employer" could also expand the number of employers cited within this context, treating multiple contractors as controlling employers regardless of whether they had any real control over the hazards at the worksite.

Conclusion

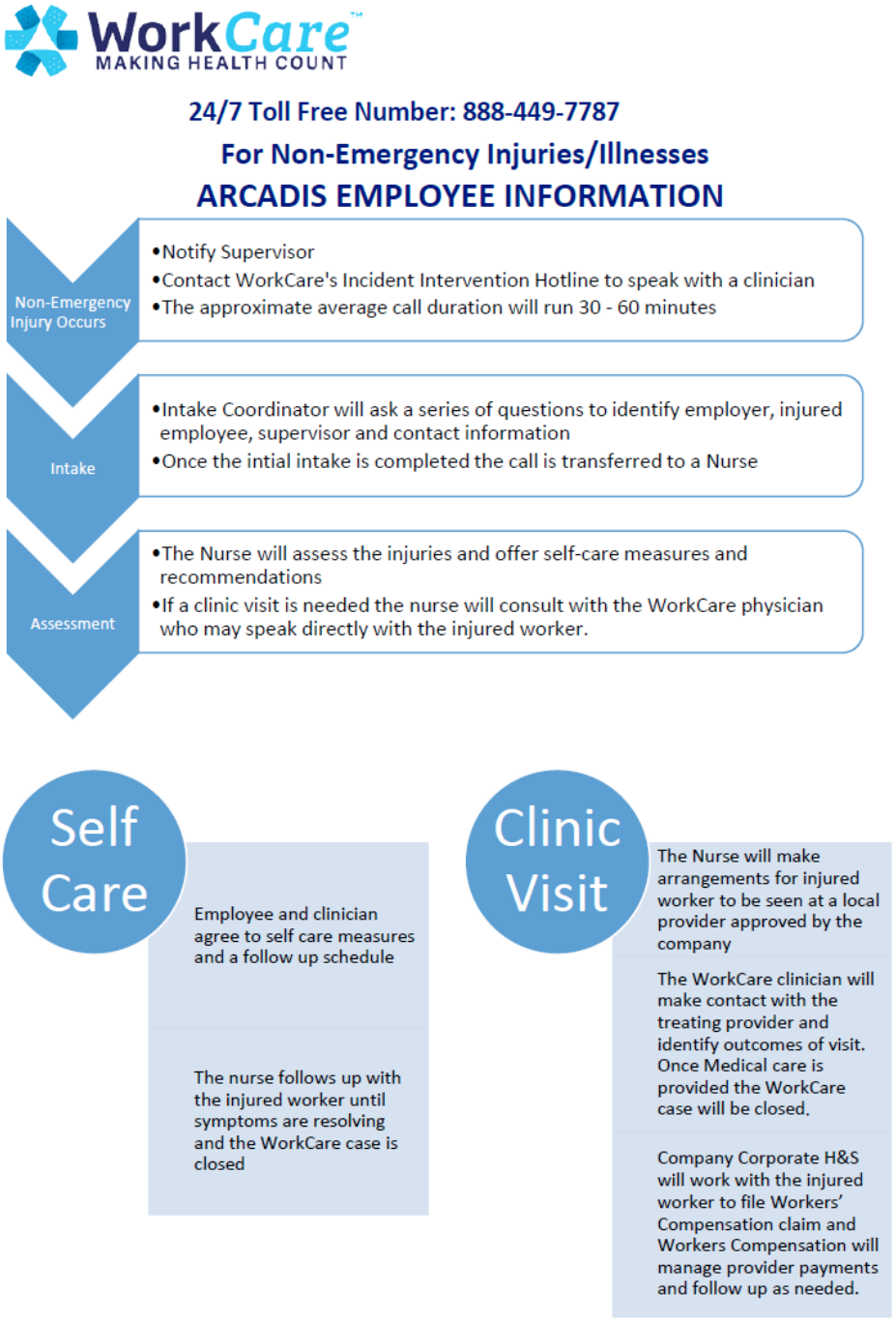
When acting as the “host employer”, Arcadis should ensure that temporary staffing agency workers receive appropriate training prior to work. For instance, if Arcadis regular employees go through training programs before being allowed to perform a certain job position or job function, then a temporary worker must undergo the same regulatory agency required training, either through the temporary agency or Arcadis, before the worker can begin performing the job (e.g., OSHA Hazard Communication, HAZWOPER, MSHA, Confined Space, etc.).

Moreover, when selecting personal protective equipment (PPE), as the host employer, Arcadis likely is primarily responsible for selecting, providing and ensuring the adequate use of PPE by temporary agency workers.

In the event of a work related injury or illness to an Arcadis temporary agency worker, Arcadis will be promptly notified and the appropriate reporting procedures followed as detailed in the Arcadis Incident Reporting and Investigation Standard (ARC HSMS010). A 4-Sight entry must be completed by the Project Manager/Department Manager in order to document the injury or illness of a temporary agency worker when Arcadis is providing day-to-day supervision.

When Arcadis is providing day-to-day supervision of temporary agency workers, the total hours worked by the temporary agency works must be recorded and reported by Arcadis annually, therefore, we are currently working with Accounting to best determine how to capture these hours worked.

Exhibit D – WorkCare Incident Intervention



EXECUTIVE SUMMARY

This Injury and Illness Prevention Program (IIPP) has been developed as part of the overall ARCADIS Health and Safety Program in an effort to provide our employees with a safe and healthful working environment. This program is a supplement to the ARCADIS Health and Safety program with the specific intent of meeting the requirements of the State of California Code of Regulations, Title 8, Section 3203.

This standard serves as the ARCADIS written program for compliance with the requirements of an IIPP as contained in Title 8 of the California Code of Regulations, Section 3203 (8 CCR 3203). While it is required to be maintained by ARCADIS offices and project sites within the State of California, it is recommended that it be maintained in other ARCADIS US offices and project sites as a Best Management Practice (BMP).

The Director of Health and Safety has the authority and responsibility for the overall development and implementation of the ARCADIS IIPP.

The H&S Coordinator is responsible for implementing the IIPP at his/her office and notifying workers of updates or changes in the IIPP.

The Site Health and Safety Officer (SHSO) is responsible for implementing the IIPP at the project site and notifying site employees and subcontractors of updates or changes in the IIPP.

The ARCADIS office Location Leader, manager, and supervisor will be responsible for periodically reviewing the health and safety needs of employees under their direction, and will serve as the initial contact for their employees' health and safety-related questions.

Employees are responsible for immediately reporting unsafe conditions in the workplace to their supervisors so that potentially hazardous situations can be addressed and in a timely fashion.

No specific training is required on this Health & Safety Standard (HSS); however, Section 5.8 defines training and competency requirements for other parts of the ARCADIS H&S program.

Documentation and records required by the IIPP standard will be maintained for a minimum of 1 year in the following locations:

- The written IIPP HSS will be maintained on The Source, which is accessible by all employees of the company.
- H&S Training will be documented in the ARCADIS training system.
- The Source, H&S team sites, and 4-Sight will be used to maintain records of inspections, incident investigations, Task Improvement Process (TIPs), Job Safety Analyses (JSAs), and other documentation.
- Site Health and Safety Plans (HASPs) and tailgate safety meeting documentation will be kept on site and in the project file at the office where the project is managed.

1. POLICY

It is ARCADIS US policy that, prior to the conduct of any task or work-related activity, hazards will be recognized and identified, analyzed, and assessed for the level of risk associated with those hazards, and that appropriate controls are implemented to assist in the prevention of injuries and illnesses to ARCADIS staff.

2. PURPOSE AND SCOPE

2.1 Purpose

This Injury and Illness Prevention Program (IIPP) has been developed as part of the overall ARCADIS Health and Safety Program in an effort to provide our employees with a safe and healthful working environment. This program is a supplement to ARCADIS' program for the purposes of meeting the requirements of State of California Code of Regulations, Title 8, Section 3203. It references other standards and documents within the ARCADIS program to help ensure that we identify, evaluate, and correct occupational hazards or unsafe acts in the workplace that may lead to employee illness or injury.

2.2 Scope

This standard serves as ARCADIS' written program for compliance with the requirements of an IIPP as contained in Title 8 of the California Code of Regulations, Section 3203 (8 CCR 3203). While it is required to be maintained by ARCADIS offices and project sites within the State of California, it is recommended that it be maintained in other ARCADIS US offices as well. All ARCADIS employees working in the State of California are required to be informed of their responsibility under Labor Code 6407.1, which requires them to comply with occupational safety and health standards applicable to their own actions and conduct.

For ARCADIS project sites in California, the project Health and Safety Plan (HASP) – ARC HSFS010 must include the IIPP HASP Supplement. This IIPP supplement shall be prepared to provide staff working at the site or field office with specific details on injury and illness prevention. The IIPP supplement within the HASP meets the requirements of the California CCR regulation (See Exhibit 1).

Preparation of the IIPP supplement shall be a best management practice (BMP; not a requirement) in those states where preparation of a specific IIPP is not required.

3. DEFINITIONS

Definitions of terms used with the ARCADIS H&S program are presented in ARC HSMS000 – ARCADIS H&S Management System.

4. RESPONSIBILITIES

4.1 Director of Health and Safety

The Director of Health and Safety has the authority and responsibility for the overall development and implementation of the ARCADIS IIPP. The Director of Health and

Safety and corporate H&S staff will also assist in resolving health and safety-related issues and questions as they arise.

4.2 Location Leaders, Managers, and Supervisors

In each ARCADIS California office, each Location Leader, manager, and/or supervisor will be responsible for periodically reviewing the health and safety needs of employees under their direction, and will serve as contacts for their employees' health and safety-related questions. If an issue arises that cannot be adequately addressed by the supervisor, he or she will contact the Director of Health and Safety or designate as soon as practical to resolve the issue. The supervisor is also responsible for notifying Corporate H&S within the timeframe designated by the Incident Reporting and Investigation standard (ARC HSMS010) following their being notified by an employee of a work-related injury or illness.

4.3 Office H&S Coordinators

An H&S Coordinator is designated in each office. In ARCADIS California offices, this employee is responsible for implementing the IIPP at his/her office and notifying workers of updates or changes in the IIPP. H&S Coordinators will forward employee suggestions, concerns, complaints, and other contacts regarding Health and Safety to the Corporate Health and Safety group as issues arise.

4.4 Project-Specific Site Health and Safety Officers

Similar to the Office H&S Coordinator role for ARCADIS offices, ARCADIS project sites will have a designated Site Health and Safety Officer (SHSO). The SHSO will be identified by name in the HASP and is responsible for implementing the site-specific HASP and components of this IIPP, as applicable. The SHSO will notify site workers of changes to the HASP, IIPP, and any other site-specific health and safety documents. The SHSO will forward employee, suggestions, concerns, complaints, and site-specific observations regarding site health and safety to the project H&S manager (if applicable) or to the Corporate Health and Safety group.

4.5 ARCADIS Employees

Employees are responsible for immediately reporting unsafe conditions in the workplace to their supervisors so that potentially hazardous situations can be addressed in a timely fashion. Employees must also report incidents per ARC HSMS010 to their supervisors so they can be investigated, root causes determined, and appropriate corrective and preventive actions implemented.

Employees are encouraged to communicate with their supervisors or with the Director of Health and Safety or designate whenever they have a health and safety question, concern, or suggestion.

5. PROCEDURE

5.1 General Requirements

All ARCADIS employees will conduct themselves in accordance with the ARCADIS H&S Vision and Policy as described in ARC HSMS000 – ARCADIS H&S Management System. The ARCADIS Global H&S Vision Policy describes the commitment by

ARCADIS management to align health and safety with the company's core values of integrity, entrepreneurship, and agility. ARCADIS is committed to preventing injuries and illness for the benefit of all employees, clients, partners, and all other stakeholders.

Employees are frequently advised that they are expected to comply with the ARCADIS H&S program, including all rules, policies, and standards concerning health and safety in the workplace. Positive reinforcement and recognition of safety-conscious employees will be an integral part of the strategy to promote compliance. The company will periodically distribute discretionary awards to employees who display exemplary safety attitudes or contribute to ARCADIS' health and safety efforts. This recognition can come from a variety of sources including supervisors, managers, H&S staff, or others.

Health and safety performance will be reviewed as a part of each employee's performance evaluation. Failure to comply with ARCADIS' code of conduct may result in disciplinary action per the ARCADIS discipline program as administered in cooperation with the Human Resources Department.

A definition of health and safety violations includes, but is not limited to the following actions: an employee not following ARCADIS or client-specific verbal or written safety procedures, guidelines or rules, engaging in horseplay on the job, failure to wear required personal protective equipment (PPE) or abuse of selected PPE, or other such activity.

5.2 Communication

Employees will be informed regarding health and safety issues in the following ways:

- During initial orientation of new hires, employees will be informed of the procedures associated with this standard and ARCADIS' Hazard Communication Program (ARC HSGE007).
- New hires will be informed of the location of ARCADIS H&S standards and documents which are housed on The Source.
- H&S communications will be distributed during regular staff meetings at the project, group, or office level.
- H&S communications will be distributed via the conduct of H&S Moments at the beginning of meetings and conference calls.
- H&S communications will be distributed through regular communications via email, weekly announcements, The Source, and other vehicles.
- H&S communications will be distributed through the regular distribution of health and safety shares and lessons learned.
- H&S communications will be distributed through the ARCADIS Field Employee H&S Handbook.
- H&S communications will be distributed through periodic Health and Safety webinars or informational memoranda distributed by Corporate Health and Safety.
- Daily tailgate safety meetings will be conducted during field operations including review of the site HASP and or related Job Safety Analyses (JSAs).

- H&S communications will be distributed during various training courses provided for employees based on their job function.

Employees are encouraged to communicate directly with managers and supervisors in verbal or written form about hazardous health and safety conditions. Internal communication processes include mechanisms to ensure that employees have a way to communicate their H&S concerns, questions, suggestions, comments, or other issues. Once appropriate action is taken, the employee raising the issue is (at a minimum) provided a response within a practical timeframe.

Internal communication may be accomplished through a variety of vehicles, including but not limited to company newsletters, H&S moments, emails, Safety Shares, and Snap Communications. In addition, through the ARCADIS risk management tools, feedback is provided to discuss safe and questionable behaviors when appropriate.

Additionally, communications resulting from regulatory requirements are distributed to ensure employee access to the information.

It is the policy of ARCADIS that employees who report a hazardous situation or make a suggestion for improving health and safety conditions in the workplace will not be subject to any type of retaliation. In addition, anonymous reporting of concerns, complaints, or suggestions is also available through the ARCADIS Employee Assistance Program (EAP).

5.3 Hazard Recognition, Identification, Assessment, Communication, and Control

Hazard recognition, identification, assessment, communication, and control processes are defined by the following ARCADIS HSS:

ARC HSMS000 – ARCADIS H&S Management System

ARC HSMS002 – Hazard Assessment and Risk Control

ARC HSFS010 – Health and Safety Plans

ARC HSMS010 – Incident Reporting and Investigation

ARC HSGE007 – Hazard Communication

All project sites are required to have a HASP prepared in accordance with the above referenced HSS. The HASP will include a detailed hazard assessment identifying hazards and hazard controls for each planned task and scope of work specific to the project.

All employees are empowered, authorized, and expected to use their Stop Work Authority if they feel their health and safety is or is perceived to be compromised.

Unsafe or unhealthy conditions and work practices must be corrected expeditiously, with the most hazardous exposures given correction priority.

5.4 Incident Reporting and Investigation

Per ARC HSMS010, loss and near miss incidents will be reported and investigated. Through the use of the 4-Sight database, these investigations will determine the contributing factors and root causes of incidents, and the identification and implementation of corrective and preventive actions. Contributing factors, root causes, and corrective actions will be communicated to appropriate staff related to lessons learned developed from the incident investigation.

5.5 H&S Procedures

ARCADIS employees will follow the ARCADIS H&S standards and/or the ARCADIS Employee Field H&S handbook as published on the H&S section of The Source. These HSS form the basis for the code of conduct expected by ARCADIS staff including supervisors, managers, and leaders.

5.6 H&S Inspections

Periodic inspections of the workplace (office or project site) will be conducted by performing Task Improvement Process (TIP), evaluations, ARCADIS global/Third Party/Client-led assessments, and H&S site visits per the ARCADIS audit and assessment processes described in ARCADIS H&S Standard ARC HSMS009 – H&S Conformance Assessments. For the purposes of this HSS, the primary criteria for completing H&S inspections include inspections based on hours worked at the project site and/or the risk ranking of hazards present. The frequency of these inspections depends on the operations involved, the magnitude of the hazards, the proficiency of employees, changes in equipment or work processes, and the history of work-place injuries and illnesses. Inspections should be conducted by personnel who, through experience or training, are able to identify actual and potential hazards and understand safe work practices. The project site or office is expected to complete routine H&S inspections. An inspection must be completed when an injury or incident has occurred or where a hazard analysis has not been completed.

5.7 Corrective and Preventive Action

Root causes will be determined for deficiencies identified during inspections, issues identified during incident investigations, and questionable behaviours identified during TIPs. Based on these root causes, the appropriate solutions will be determined and implemented per ARC HSMS011.

5.8 Competency, Training, and Experience

ARCADIS US defines and documents the necessary competence levels that their employees require to work in conformance with the ARCADIS H&S Vision and Policy. A training matrix is provided to assist supervisors and managers in selecting training that employees need to maintain the defined competencies required for their job responsibilities. Competency is achieved through a variety of mechanisms including:

- Training
- Education
- Experience

In addition, ARCADIS defines and implements methods to evaluate the effectiveness of training provided to employees. These methods may include but are not limited to:

- Written or oral testing
- Auditing and review
- Hands-on demonstrations
- Behavioral observations and feedback

ARCADIS ensures that training is completed to meet company, legal, and client requirements within our areas of operation. In addition, ARCADIS US trains its employees and makes them aware of:

- The importance of conforming to the H&S Vision and Policy and any standards provided them to conduct their work in a healthy and safe way
- The H&S consequences of their work and the benefits of completing their work in a safe and healthful fashion
- The employees' roles and responsibilities within the HSMS
- The safe behaviors for completing job tasks and the at-risk or unsafe behaviors that could result in employee injury or illness

Documentation of health and safety training for each employee is maintained for at least 1 year.

5.9 Emergency Planning, Preparedness, and Response

Each location will develop and implement an emergency preparedness and response plan per ARC HSMS008.

6. TRAINING

No specific training is required on this HSS; however, Section 5.8 defines training and competency requirements for other parts of the ARCADIS H&S program.

7. REFERENCES

H&S Page on The Source

ARC HSFS010 – Health and Safety Plans

ARC HSGE007 – Hazard Communication

ARC HSMS000 – ARCADIS H&S Management System

ARC HSMS002 – Hazard Assessment and Risk Control

ARC HSMS008 – Emergency Preparedness and Response

ARC HSMS010 – Incident Reporting and Investigation

ARC HSMS009 – H&S Conformance Assessments

8. RECORDS

Consistent with the ARCADIS Human Resources Records Retention policy HR 2.12, documentation and records required by the IIPP standard will be maintained for a minimum of 1 year in the following locations:

- The written IIPP will be maintained by the Director of Health and Safety on The Source, which is accessible by all employees of the company.
- H&S Training will be documented in the ARCADIS training system.
- The Source, H&S team sites, and 4-Sight will be used to maintain records of inspections, incident investigations, TIPs, Job Safety Analyses (JSAs), and other documentation.
- Site HASPs and tailgate safety meeting documentation will be kept on site and in the project file at the office where the project is managed.

9. APPROVALS AND HISTORY OF CHANGE

Approved By: Tony Tremblay, CSP – Corporate H&S, Director of Technical Programs

History of Change

Revision Date	Revision Number	Standard Developed/Reviewed By or Revised By	Reason for change
11 January 2010	01	Mike Thomas	Original document
16 April 2012	02	Sue Byers	Executive Summary added; terminology changed from JLA to JSA, LPO to TIP
25 June 2014	03	Alec MacAdam/Tony Tremblay	Updated Header/Footer; updated online reference from APEX to The Source; updated for CalOSHA CCR Title 8 3203 compliance; section 5.6 clarifies “project site or office inspections will be conducted based on the operations involved, the magnitude of the hazards, the proficiency of employees, changes in equipment or work processes, and the history of work-place injuries and illnesses”, and inclusion of the IIPP HASP Supplement

EXHIBIT 1 – IIPP HASP Supplement Template

Link to IIPP HASP Supplement

IIPP HASP Supplement for Project Sites and Offices

The purpose of the ARCADIS Illness and Injury Prevention Program (IIPP) is to establish location specific written guidelines to ensure the safety of employees working at ARCADIS offices or project sites located in the state of California (best management practice for other locations). It is the intention of ARCADIS to provide a safe and healthy working environment for all of its employees.
All ARCADIS employees and subcontractors will be offered a copy and are required to implement and following the principles set forth in this IIPP.
The purpose of this HASP Supplement is to communicate the specific details of the IIPP associated with the specific California office or project site for which this supplement has been prepared.
A copy of the ARCADIS H&S Standard ARC HSGE008 (Injury and Illness Prevention Program) must be included as an attachment to all California project site HASPs or office Emergency Response Hazard Communication Plans to meet the requirements of CCR Title 8 3203.
The programmatic details of the ARCADIS H&S Standard ARC HSGE008 are incorporated by reference.

This IIPP HASP supplement has been prepared to be used as a location specific IIPP template to address the required components of the IIPP as mandated by CCR Title 8, Section 3203.

Scope and Application:
This document serves as the written Injury Illness Prevention Plan for ARCADIS activities for the following ARCADIS office and/or project site:

ARCADIS Office or Project Site: _____

This HASP supplement is supported by the following documents, which are presented as references supporting this supplement:

ARCADIS Office or Project Site Documents: _____
(e.g., HASP or Office Emergency Response & HazCom Plan, Field Sampling Plan, SOPs, etc.)

Responsibility §3203(a)(1):
Roles and responsibilities are detailed in the office/site HASP. See the "Emergency Information" and "Tasks, Roles & Training Sections".

ARCADIS California IIPP Program Administrator: _____
ARCADIS Office H&S Coordinator / Site Health and Safety Officer: _____

Compliance §3203(a)(2):
All employees are responsible for applying the ARCADIS TRACK process in evaluating hazards and assessing risk for all work tasks, using safe work practices, following all directives, policies and procedures, and for assisting in maintaining a safe work environment. See the ARCADIS H&S Standard ARC HSGE008 for the steps detailing compliance with the ARCADIS H&S program.

Communication §3203(a)(3):
ARCADIS recognizes the importance of two-way communication between management and staff to address health and safety issues with the objective of planning for and maintaining an injury-free, productive workplace. A description of the policy and procedures developed to facilitate a continuous flow of health and safety focused communications between management and staff is provided in the ARCADIS H&S Standard ARC HSGE008.

Office/site specific workplace hazard methods of communication include the following:

- ☐ Site Health & Safety Plan
- ☐ Tailgate Safety Meetings
- ☐ Job Safety Analysis (JSA)
- ☐ Safety Data Sheets (SDS)
- ☐ Other: _____
- ☐ Task Improvement Process (TIPs)
- ☐ Emergency Response & HazCom plan
- ☐ Safety Committee Meetings
- ☐ Safety bulletins/Client procedures

Workplace Hazard Assessment §3203(a)(4):
Initial workplace hazard analysis is completed during the preparation of the project site HASP or office HazCom plan. Periodic inspections will be performed to identify and evaluate workplace hazards in all areas of the office or project site. Inspections and the associated observations will be conducted in accordance with the ARCADIS H&S Standard ARC HSGE008.
Periodic inspections will consist of identification and evaluation of workplace hazards using the H&S management assessments, H&S compliance assessments, TIPs, site/office inspections or ARCADIS global/Third Party/Client-Led H&S assessments to identify and evaluate workplace hazards.

Note: The primary criteria for conducting inspections are the number of hours worked at the site or office and the risk ranking of the hazards present. See the project specific HASP "Signatures" tab or office Emergency Response and Hazard Communication plan for a detail of proposed TIPs, assessments and inspections.

Accident Investigations §3203(a)(5):
All near misses, calls to WorkCare, and injuries must be reported to ARCADIS Corporate H&S as soon as possible. Procedures for investigating workplace accidents, incidents and injuries are described in the ARCADIS H&S Standard ARC HSGE008 and documents referenced therein. For incidents involving third parties the ARCADIS Legal Counsel must be contacted. Approval from legal counsel is required before a 4-Sight incident investigation entry is prepared.

Hazard Correction and Communication §3203(a)(6):
Unsafe or unhealthy work conditions, practices or procedures shall be corrected in a timely manner based on the severity of the hazard(s). Hazards shall be corrected according to the procedures outlined in the ARCADIS H&S Standard ARC HSGE008.

Note: When an imminent hazard exists which cannot be immediately abated without endangering employee(s) and/or property, All ARCADIS employees and subcontractors will Stop Work and leave the area. Employees identified to correct the hazardous condition will do so only when provided with the necessary training and protection to address the hazard safely.

Training and Instruction §3203(a)(7):
All employees, including managers and supervisors, shall have training and instruction on general and job-specific health and safety practices. Project site specific training requirements are communicated in the site specific HASP under the "Tasks, Roles and Training" tab.
A detailed discussion of the competency, training requirements and training process for the IIPP are covered in the ARCADIS H&S Standard ARC HSGE008.

Record Keeping §3203(b)(1) & (2):
Records of workplace hazard assessments and inspections will be maintained in accordance with the ARCADIS Human Resources policy HR 2.12 for record retention.
Project teams or office staff who are responsible for recording of the assessment or inspection will include at a minimum; the person(s) conducting the inspection, any unsafe conditions and work practices that have been identified and the action taken to correct the identified unsafe conditions and work practices.
Also, Documentation of health and safety training for each employee including the employees name, training dates, training program, and training providers are recorded and maintained by the ARCADIS Training Center. All employees receiving training conducted via third party training vendors are required to send a certificate of completion or similar record to the Training Center.

Labor - Management Safety Committee §3203(a)(3):
Establishment of a "Labor - Management Safety Committee" is a recommendation of §3203(c) when working in facilities with unionized employees and as such is not required for an IIPP to be complete. If establishment of a Labor - Managment Safety Committee is not applicable the process and procedures to formalize, document and communicate the health and safety related reporting is described in this IIPP. The components of the ARCADIS H&S Communications program is provided in the ARCADIS H&S Standard ARC HSGE008.

Notes:

EXECUTIVE SUMMARY

Through the use of personal protective equipment (PPE), ARCADIS employees are protected from occupational hazards in the event that engineering and administrative controls are not sufficient or practical. PPE will be provided to ARCADIS full time and permanent part time employees who regularly conduct field work or visit project sites outside of office environments at no cost following training on the proper use and maintenance of PPE.

Project managers are responsible for assessing potential hazards on a worksite and determining the applicable PPE.

Project personnel are responsible for understanding and utilizing "Stop Work Authority" should a hazard present itself that was not previously identified or has been identified in concentrations that are higher than anticipated.

This minimum level of PPE (hard hat; safety glasses; class II high-visibility vest, shirt or coat; and protective footwear with safety toe cap) is expected to be worn on all project sites unless in a field trailer or vehicle, unless a specific exemption has been established within an approved HASP or modification to a task specific JSA or Permit to Work upon completion/review of the hazard analysis.

PPE selection will be based on an evaluation of the performance characteristics of the PPE relative to the following:

- The requirements and limitations of the tasks or work environment
- The task-specific conditions and duration of the work
- The hazards and potential hazards identified at the site

PPE may be categorized into levels A, B, C or D.

- Level A offers the highest skin and respiratory protection
- Level B offers a high degree of respiratory protection with lesser levels of skin protection
- Level C is used when the concentration and type of airborne substance is known, and the criteria for using an air purifying respirator are met
- Level D offers the least skin and respiratory protection

PPE training will include, at minimum:

- When and what PPE is necessary
- How to put on, adjust, wear and take off the PPE
- Limitations of the PPE
- Proper care, maintenance, useful life, and proper disposal of PPE

1. POLICY

It is the policy of ARCADIS to assess the workplace to identify and assess hazards in order to appropriately implement controls for those hazards. In addition, it is ARCADIS policy to supply personal protective equipment (PPE) for employees in a working environment where engineering and administrative controls are not feasible or effective in the control of hazards. ARCADIS will train and supply this PPE at no cost to the employee.

2. PURPOSE AND SCOPE

2.1 Purpose

The purpose of PPE is to shield or isolate individuals from the chemical, physical and biologic hazards that may be encountered in their work environment. A hazard analysis or assessment will be performed before a job task is begun to evaluate if PPE is necessary to protect an employee from identified hazards and determine the type of PPE required. This analysis will include the identification of hazards/suspected hazards and their routes of exposure.

Combinations of protection may be needed to provide the appropriate level of protection for any given work environment. The level of PPE may change during a job, so periodic task evaluation will be conducted to ensure that the most appropriate PPE is being used. Over-protection, as well as under-protection, can create additional hazards and should be avoided where possible.

Subcontractors and other non-ARCADIS employees must supply their own PPE. ARCADIS will not supply PPE to any non-ARCADIS employees unless specific arrangements and agreements are made with the other party.

This Health and Safety Standard (HSS) provides guidance on the proper selection, use, care and maintenance of PPE.

2.2 Scope

Whenever possible, engineering, substitution and administrative controls will be used to reduce or eliminate hazards. When such controls are not feasible, practical or adequate, PPE will be used to protect employees from exposure to hazards during ARCADIS-related work tasks.

3. DEFINITIONS

Definitions related to personal protective equipment can be found in Exhibit 1.

4. RESPONSIBILITIES

4.1 ARCADIS Management

ARCADIS Management is responsible for providing resources for the acquisition of PPE and for the conduct of hazard assessments.

4.2 Project Managers

Project Managers are responsible, as part of the project hazard assessment, for determining PPE necessary to complete the project. In addition, the Project Manager is responsible for determining client requirements with respect to PPE. Project Managers notify health and safety staff of biological, chemical and physical hazards present or potentially present on the site, as well as verifying that any specific state and/or local requirements for PPE have been identified. Project Managers are also responsible for ensuring that project staff has the appropriate and applicable training for PPE use prior to those staff beginning work.

4.3 Corporate Health and Safety

Corporate Health and Safety is responsible for keeping this standard up-to-date with current regulatory requirements and best practices and for assisting in determining the appropriate PPE for a particular task and work environment and for assisting in the identification of appropriate vendors of such PPE.

4.4 Health and Safety Staff

Project Health and Safety Staff including designated Writers and Reviewers of Project Health and Safety Plans (HASPs) are responsible for developing control processes and techniques on specific projects based on the physical, chemical and biological hazards expected to be encountered on project facilities.

It is the responsibility of the Site Safety Officer (SSO) to verify that any employee-owned PPE brought to the job site is adequate for the task, properly fitted to the employee, and has been properly maintained and is cleaned in accordance with this standard.

4.5 ARCADIS Staff

ARCADIS staff is responsible for completing PPE training as required by this policy and standard, and for following all hazard control processes designated by the Project Manager, Project Health and Safety Staff and the project HASP. Employees must choose appropriate, properly fitted PPE where required, and are responsible for inspecting their PPE for wear, damage and effectiveness. Employees that bring their own PPE to the job site must ensure that the equipment is adequate for the task (e.g., meets minimum ANSI requirements, AUS requirements and client requirements), and has been properly maintained in a sanitary and reliable condition in accordance with this standard.

If project personnel believe that a hazard is present that was not previously identified or is at levels that are higher than expected, they should stop work and notify project health and safety staff or the project manager immediately and not proceed until authorized.

Staff are expected to comply with minimum PPE requirements as established by ARCADIS policy and HASP requirements and/or task specific PPE requirements detailed in the task specific Job Safety Analysis (JSA) or Permit to Work.

5. PROCEDURE

5.1 Minimum PPE Requirements

All full time and permanent part time employees that regularly conduct field work or visit project sites outside of office environments will be issued a field bag that contains, at a minimum, the following PPE:

- An ARCADIS branded hardhat
- Two pair of safety glasses, one clear pair and one tinted pair, or one pair of prescription safety glasses with transitional lenses
- Hearing protection
- A minimum, Type 2 reflective vest in either orange, lime green or yellow

Office locations will stock extra bags with the equipment listed above for use by other staff that do not regularly go to field locations. Additional PPE and H&S equipment will be issued to staff based on the hazards they face on specific projects (i.e. respirators, goggles, chaps, etc.).

ARCADIS has established the following minimum PPE requirement for field activities that must be worn unless excepted by the HASP, JSA or Permit to Work:

- Type I Hardhat (Class G rating if there is potential danger of contact exposure to low voltage conductors)
- Safety Glasses (Z87.1)
- Class 2 reflective traffic vest, coat or shirt in either orange, lime green or yellow
- Protective Footwear, e.g. steel toe safety shoes (minimum I/50 Impact resistance for the toe area which is an impact resistance rating of at least 50-foot pounds; C/50 Compression resistance for the toe area which correlates to 1750 pounds of compression resistance).

This minimum level of PPE is expected to be worn on all project sites unless in a field trailer or vehicle, unless a specific exemption has been established within an approved HASP or modification to a task specific JSA or Permit to Work upon completion/review of the hazard analysis.

The goal in this section is to specify PPE for work that is not governed by a JSA or Permit to Work to avoid conflicts in PPE requirements. The PPE specified in a JSA/Permit to Work is automatically the PPE requirement for all work governed by the JSA/Permit to Work. As a result, it is critical to take the time during JSA/Permit development to consider and identify the proper PPE required for the activity. Please note that the template JSA

PPE information may not be the appropriate PPE for your project and should be adjusted accordingly.

Note: Project Teams must check and comply with state, local and/or client requirements for specific minimum PPE requirements and adjust the HASP, JSA or Permit to Work process accordingly.

Temporary full time/part time employees (temp staff) will be provided all of the above PPE; however, standard steel toed safety boots will only be provided to temp staff employees with the approval of the administrative supervisor and Project Manager. If the administrative supervisor or Project Manager elects to not provide protective footwear or other non-specialty required footwear to temp staff, the employee will be informed of the requirement to provide their own footwear meeting project health and safety requirements prior to hire.

No ARCADIS staff should arrive at a field or project site without this minimum PPE.

5.2 The PPE Program

The basic objectives of a PPE program are to protect the wearer from safety and health hazards; and to prevent injury to the wearer from incorrect use and/or malfunction of the PPE. This document serves as the overall ARCADIS PPE program and is used as guidance for the development of a project-specific PPE program which becomes part of a project-specific health and safety plan. A project-specific PPE program in combination with this HSS will address the following:

- PPE selection based upon site hazards (Hazard Identification/Assessment).
  - Identify the hazards/suspected hazards and their potential routes of exposure (e.g., skin, inhalation, ingestion or eye contact).
- The use and limitations of the equipment including limitations during temperature extremes and under certain medical conditions;
- The work mission duration;
- Maintenance, storage, decontamination and disposal of PPE;
- Training including proper fit and how to properly put on and take off PPE;
- PPE inspection procedures prior to, during, and after use; and
- Periodic evaluation of the effectiveness of the PPE program.

5.3 PPE Selection

The use of PPE can itself create significant worker hazards, such as heat stress, physical and psychological stress and impaired vision, mobility and communication. Over-protection, as well as under-protection and poor fit, can be hazardous and should be avoided where possible. Site or project-specific health and safety plans take into

consideration engineering, substitution, and administrative controls first as a means to eliminate/reduce the need for PPE. When it is not feasible or practical to eliminate the use of PPE, PPE must be properly fitted to each affected employee, and PPE selection will be based on an evaluation of the performance characteristics of the PPE relative to the following:

- The requirements and limitations of the tasks or work environment;
- The task-specific conditions and duration; and
- The hazards and potential hazards identified at the site.

The level of protection will be increased whenever it is shown that increased protection is necessary to reduce employee exposures to the hazards. It may be decreased when it is shown that this will not result in hazardous exposure to employees.

5.4 Levels of PPE Protection

For work on hazardous sites, a combination of PPE may be categorized into levels A, B, C, or D with level A offering the highest level of protection and D the lowest. Monitoring the effectiveness of PPE will be done throughout a project to ensure that the appropriate level of protection is being worn. These levels of protection are described below.

5.4.1 Level A Protection

Level A PPE offers the highest level of respiratory and skin protection and should be worn when:

- The hazardous substance has been identified and requires the highest level of protection of the skin, eyes, and respiratory system based on either:
  - The measured (or potential) high concentrations of atmospheric gases, vapors, or particulates; or
  - If site operations and work functions involve a high potential for splash, immersion, or exposure to unexpected vapors, gases, or particulates which are harmful to skin eyes, or the respiratory system.
- There is a known or suspected high degree of hazard to the skin and skin contact is possible.
- Conducting work in a confined, poorly ventilated area and the other criteria requiring Level A PPE have not been determined.

Level A equipment includes:

- NIOSH approved positive pressure, full-face piece self contained breathing apparatus (SCBA), or positive pressure supplied airline respirator with escape SCBA;
- Totally encapsulating chemical-protective suit (material based on the hazard);

- Chemical resistant outer **and** inner gloves (type and material based on the hazard);
- Chemical resistant boots with steel toe and shank;
- Disposable protective suit, gloves and boots (depending on suit construction, may be worn over the totally encapsulating suit);
- Coveralls (optional, as applicable);
- Long underwear (optional, as applicable); and
- Hard-hat - under suit (optional, as applicable).

5.4.2 Level B Protection

Level B PPE offers a high degree of respiratory protection with lesser levels of skin protection. Level B PPE should be worn when:

- The type and atmospheric concentration of substances have been identified and require a high level of respiratory protection but less skin protection;
- The atmosphere contains less than 19.5 percent oxygen; or
- The presence of incompletely identified vapors or gases is indicated by direct reading organic vapor detection instruments, but the vapors and gases are not suspected of containing high levels of chemical harmful to the skin or capable of being absorbed through the skin. Level B is the minimum level of protection that should be worn when there is insufficient information to determine the hazards or potential hazards of the substance.

Level B PPE equipment includes:

- NIOSH approved positive pressure, full face piece self contained breathing apparatus 1(SCBA), or positive pressure supplied air respirator with escape SCBA;
- Hooded chemical resistant clothing (overalls and long sleeve jacket; coveralls; one or two piece chemical splash suit; disposable chemical resistant overalls) (materials based on the hazards);
- Chemical resistant outer **and** inner gloves (material based on the hazards);
- Chemical resistant boots with steel toe and shank;
- Coveralls (optional, as applicable);
- Outer chemical resistant boot covers (optional, as applicable);
- Hard hat (optional, as applicable); and

- Face shield (optional as applicable).

5.4.3 Level C Protection

Level C PPE is used when the concentration and type of airborne substance is known, and the criteria for using an air purifying respirator are met. It should be worn when:

- Atmospheric contaminants, liquid splashes, or other direct contact will not adversely affect or be absorbed through any exposed skin;
- The types of air contaminants have been identified, concentrations measured, and an air purifying respirator is available that can remove the contaminants; and
- All criteria for the use of an air purifying respirator are met.

Level C PPE equipment includes:

- NIOSH approved full face or half mask air purifying respirator (with appropriate cartridges based on the hazards);
- Hooded chemical resistant clothing (overalls and long sleeve jacket; coveralls; one or two piece chemical splash suit; disposable chemical resistant overalls) (materials based on the hazards);
- Chemical resistant outer **and** inner gloves (select appropriate materials based on the hazards);
- Chemical resistant boots with steel toe and shank;
- Coveralls (optional, as applicable);
- Outer chemical resistant boot covers (optional, as applicable);
- Hard hat (optional, as applicable);
- Escape mask (optional, as applicable); and
- Face shield (optional, as applicable).

5.4.4 Level D Protection

Level D PPE offers the least skin and respiratory protection and should be worn when the atmosphere contains no known hazards, and work functions preclude splashes, immersions or the potential for unexpected inhalation of or contact with hazardous levels of any chemicals.

Level D PPE equipment may include any or all of the following depending on the hazards of the site:

- Chemical resistant boots with steel toe and shank (optional, as applicable);
- Coveralls (optional, as applicable);
- Gloves (optional, as applicable);
- Outer chemical resistant boots (disposable) (optional, as applicable);
- Safety glasses or chemical splash goggles (optional, as applicable);
- Hard hat (optional, as applicable);
- Escape mask (optional as applicable); and
- Face shield (optional as applicable).

5.5 Combinations of Protection

Combinations of protection are acceptable if the task hazard analysis and the site conditions warrant modification of PPE levels.

5.6 Equipment List

5.6.1 Eye/Face Protection

All employees engaged in or working in or adjacent to areas with eye-hazardous activities or operations, such as but not limited to flying objects and hazardous chemicals shall wear appropriate eye protection.

It is strongly encouraged that eye protection be worn when present on any project site, including construction sites

- Safety glasses with side shields are required for impact protection and shall meet ANSI Standard Z87.1 requirements.
- Chemical goggles (for protection against chemical splash).
- Face shields (for face protection from chemical splash and are not a substitute for primary eye protection).
- Full-face respirators can provide eye and face protection in lieu of safety glasses, goggles or face shields.
- Shaded eye protection meeting the minimum shade requirements established in 29 CFR 1910.133 (for employees exposed to sources of injurious light radiation [e.g., welding, cutting, lasers]).
- For prescription eye protection contact your supervisor to fill out an AOSafety order form available on the ARCADIS Health and Safety website (The Source). For temporary staff, standard prescription safety glasses will be provided with the

approval of the administrative supervisor and Project Manager. If the administrative supervisor or Project Manager elects to not provide standard prescription safety glasses to temp staff, the employee will be informed of the requirement to provide their own prescription safety meeting project health and safety requirements prior to hire.

5.6.2 Respiratory Protection

Respirators will be provided and used in accordance with the ARCADIS Respiratory Protection Policy/Standard ARC HSGE017 and 29 CFR 1910.134.

5.6.3 Hearing Protection

Hearing protection will be provided and used in accordance with the ARCADIS Hearing Conservation Policy/Standard ARC HSIH008 and 29CFR 1910.95.

5.6.4 Foot Protection

Basic foot protection is required for all ARCADIS job sites and industrial locations. Specialized footwear will be provided as required by the nature of the work. Special foot protection may include, but is not limited to, chemically resistant, thermally shielded, metatarsal guards, etc.

One pair of leather safety boots will be provided as necessary by ARCADIS. The employee purchasing the footwear is required to ensure that it meets any of the consensus standards as specified by OSHA 29 CFR 1910.136 which include:

- ASTM F2413-11 Standard Specification for Performance Requirements for Protective (Safety) Toe Cap Footwear

  Note: ASTM F2413-11 Standard Specification for Performance Requirements for Protective (Safety) Toe Cap Footwear contains performance requirements for footwear to protect workers' feet from the following hazards by providing:

  1. Impact resistance (I) for the toe area of footwear (75 foot-pounds);
  2. Compression resistance (C) for the toe area of the footwear (75/ 2,500 pounds);
  3. Metatarsal impact protection (Mt) that reduces the chance of injury to the metatarsal bones at the top of the foot (75 foot-pounds);
  4. Conductive properties (Cd) which reduce hazards that may result from static electricity buildup; and reduce the possibility of ignition of explosives and volatile chemicals (electrical resistance zero â€“ 500,000 ohms);
  5. Electric hazard protection (EH) to protect the wearer when accidental contact is made by stepping on live electrical wire (capable of withstanding the application of 18,000 volts at 60 hertz for one minute

with no current flow or leakage current in excess of one milliampere, under dry conditions);

6. Static dissipative properties (SD) to reduce hazards due to excessively low footwear electrical resistance that may exist where SD footwear is required (must have a lower limit of electrical resistance of 106 ohms and an upper limit of 108 ohms when tested at 50-volts); and
7. Puncture resistance (PR) (when viewed at a 90° angle, the test pin tip must not visually penetrate beyond the face of the material nearest the foot after an applied force of 270 pounds, no signs of de-lamination or cracking after 1.5 million flexes and no sign of corrosion, de-lamination or deterioration after being exposed to a five percent salt solution for 24-hours.)

- ASTM F-2412-2005, "Standard Test Methods for Foot Protection," and ASTM F-2413-2005, "Standard Specification for Performance Requirements for Protective Footwear"

- ANSI Z41-1999, "American National Standard for Personal Protection -- Protective Footwear"

Safety shoes worn by ARCADIS staff during field work must be equipped with protective (safety) toe cap that has a minimum I/50 Impact resistance rating for the toe area which is an impact resistance rating of at least 50-foot pounds and a C/50 Compression resistance rating for the toe area which correlates to 1750 pounds of compression resistance.

Puncture resistant soles or in-soles equipped in the safety boots are project driven based on the Hazard Assessment. Some clients may require puncture resistant soles or in-soles.

The maximum expenditure or reimbursement for approved safety shoe purchases will be $150. Reimbursement requests must be approved by the employee's supervisor.

It should be noted that some clients may prohibit the use of athletic-style safety shoes ("safety sneakers") due to the difficulties created by these styles in supervising proper use of protective footwear.

5.6.5 Head Protection

Hard hats meeting ANSI Z89.1 will be provided to protect employees from impact, penetration, falling objects and/or limited electrical shock and burn, as appropriate for work site hazards. A hard hat must be replaced when it becomes damaged, contaminated (and contamination cannot be removed) or it has been struck by an object of sufficient size to potentially compromise its integrity.

Hardhats must resist penetration by objects, be water resistant and slow burning, and have a chin strap if it is worn while working at elevation. It must be worn square on the head and not be pushed back, to the side or forward.

Baseball-style caps will interfere with the ability of a suspension to work properly during an impact; they should not be worn under protective headgear.

There are two types and three classes of head protection described in ANSI standard.

Other hazard situations to consider are:

- In areas of heavy vegetation or in any area where hunters may be present, it is recommended that some type of brightly colored head protection be worn. For example, a bright orange or yellow baseball cap or stocking cap.
- If cold exposure is an issue, hardhat liners are available (made specifically for the particular hardhat) or if a hardhat is not required, some type of insulated head protection such as a stocking cap should be worn.
- Because it can degrade headwear material and reduce the level of protection, insect repellent should not be applied to or inserted into headwear. The headwear manufacturer should be consulted for instructions on the use of insect repellents and other chemicals on its' products.

5.6.6 Hand Protection

Appropriate hand protection will be provided if employee's hands are exposed to hazards while on the job.

Such as:

- pinch points
- sharp/pointed tools or objects
- incorrect or inadequate tool use
- improper use
- rotating/energized/automated parts
- abrasive materials
- inadequate job planning
- lack of/inadequate protection
- changing weather conditions and extreme temperatures
- hazardous material
- Jewelry and loose clothing.

Once these hazards are identified, the appropriate glove or hand protection must be selected. When choosing gloves, keep in mind:

- Hazardous Chemicals/Substances to be Contacted
- Nature of Contact (total immersion, splash, etc.)
- Duration of Contact
- Area of Protection (hand only, forearm, arm)
- Equipment (rotating, sharp edges, etc.)
- Grip (dry, wet, oily)
- Thermal Protection
- Abrasion/Cut/Puncture Resistance
- Tear/Tensile Strength
- Ergonomics (size, heat stress, dexterity)
- Decontamination/Disposal

In selecting chemically protective gloves, the toxic properties of the chemical(s) will be determined. Information provided on the manufacturer's label or by chemical compatibility charts regarding breakthrough time, permeation rate and degradation should be considered during selection.

5.6.7 Body Protection

Protective clothing, gloves, boots, and other protective equipment will be provided as appropriate for the hazards associated with the tasks being performed.

Long pants are required for all field work unless approval is granted by corporate H&S. Additional protection such as cooling vests may be required. In environments with potential biological hazards such as ticks, plants or snakes, gloves and long sleeves should be worn along with head protection of some kind to protect the scalp. In areas of roadway work or other vehicle traffic high visibility Class II safety vests will be worn.

Chemically Protective Clothing (CPC) will be selected by evaluating the performance characteristics of the CPC against the requirements and limitations of the site and task-specific conditions. This selection should be performed by an employee with training and experience taking into consideration:

- Permeation, degradation, penetration of the CPC by the chemical and;
- Durability, flexibility, fit, temperature effects, ease of decontamination, compatibility with other necessary equipment (e.g., hardhats, SCBA, etc.); and duration of use that could affect the employees ability perform the task.

Where required, appropriate Fire Resistant (FR) protective clothing must be used where there is a potential for electrical arc flash hazards (refer to the ARCADIS Electrical Safety

Standard HSFS006 for additional information). Jobs that expose workers to fire dangers require the use of FR protective clothing.

5.6.8 Specialized Equipment

All other specialized safety equipment required for an assignment (e.g., work gloves, specialized protective clothing, hip boots, field rain gear, personal floatation devices) will be provided by ARCADIS as specified in the HASP.

5.6.9 Extreme Cold Environments

Supervisors are responsible for ensuring that staff is properly equipped to protect themselves while working in extreme cold environments. The following is suggested as appropriate PPE for cold conditions:

- Hats/hat liners and gloves
- Thermal clothing
- Hi-Visibility clothing
- Winter footwear

Use of specialized equipment will be charged to projects in accordance with established policy and rental rates.

5.7 Maintenance/Storage/Disposal

5.7.1 PPE Maintenance and Disposal

PPE must be inspected by the user before and after each use for defects, rips, tears and/or damaged parts. Damaged or compromised PPE will not be used and must be repaired before re-use or disposed. PPE must be disposed of according to the HASP and other project plans for the site. If non-disposable, PPE must be decontaminated and sanitized before being reused according to the HASP. Contaminated PPE which cannot be properly decontaminated by normal procedures must be disposed of accordingly.

Employees are responsible for using and maintaining PPE in a sanitary and reliable condition.

5.7.2 PPE Storage

All PPE must be stored to protect against dust, sunlight, extreme heat and cold, excessive moisture and damaging chemicals. Storage must be in accordance with the manufacturer's specifications and OSHA requirements.

5.7.3 Contaminated Boots

Single-use boots or boot covers which become contaminated on the job will be waste profiled, as necessary, and properly disposed. Work boots will be properly decontaminated upon exiting contaminated work zones (exclusion zones). Work boots that are damaged on the job must be replaced.

6. TRAINING

Training in the proper use of PPE will generally be provided in conjunction with HAZWOPER training or via coursework selected and approved by Corporate H&S. Training will be completed prior to the employee's use of PPE, when changes in the work place alter the use or type of PPE, and when inadequacies in the employee's knowledge or use of PPE are noted.

The training will include at a minimum:

- When and what PPE is necessary;
- How to put on, adjust, wear and take off the PPE;
- Limitations of the PPE; and
- Proper care, maintenance, useful life, and proper disposal of PPE.

Retraining will be conducted when the workplace changes making the earlier training obsolete, the type of PPE changes or when the employee demonstrates lack of use, improper use, or insufficient skill or understanding.

7. REFERENCES (regulation citation, technical links, publications, etc.)

29 CFR 1910.120 "Hazardous Waste Operations and Emergency Response"

29 CFR 1910 Subpart I "Personal Protective Equipment"

29 CFR 1910.136 Foot Protection

29 CFR 1910.6 Incorporation by reference

8. RECORDS - DATA RECORDING AND MANAGEMENT

Records of the PPE training are retained by the employee and in the ARCADIS training database. Medical clearance for respirator use is maintained by the employee and ARCADIS' medical vendor.

9. APPROVALS AND HISTORY OF CHANGE

Approved by: Tony Tremblay, CSP – Corporate H&S, Director of Technical Programs

History of Change

Revision Date	Revision Number	Standard Developed/Reviewed By or Revised By	Reason for change
20 February 2009	01	Miriam Koesterich/Mike Thomas	Original document
19 August 2011	02	Sue Byers/Mija Coppola	Updated footwear protection consensus standards, clarified contaminated work boot section and updated document format
2 February 2012	03	Tony Tremblay	Clarified temp staff PPE issues in sections 5.1 and 5.6.1
16 January 2013	04	Pat Vollertsen/Tony Tremblay	Added hand protection to section 5.1, added to employee responsibility in section 4.5, and added information on when eye protection should be worn in section 5.6
12 February 2013	05	Amanda Tine/Tony Tremblay	Added that PPE must be properly fitted. Added requirements for employees that bring their own PPE; Added Retraining information into Section 6
23 June 2014	06	Tony Tremblay	Identified minimum PPE requirements for ARCADIS field work in section 5.1 of HSS; Updated footwear protection consensus standard information in Section 5.6.4; and updated foot protection definition

Exhibit 1 – Definitions

Eye/Face Protection - Equipment designed to provide eye or face protection when exposed to hazards from flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors, or potentially injurious light radiation.

Foot Protection - Footwear designed to provide foot and toe protection when working in areas where there is a danger of foot injuries due to falling or rolling objects, or objects piercing the sole, and/or where an employee's feet are exposed to electrical hazards. These include such measures as safety toe cap and puncture resistant soles.

Hand and Body Protection - Equipment designed to provide protection to the hands and body during exposures to potential hazards such as potential for skin absorption of harmful substances, sharp objects, abrasive surfaces, punctures, temperature extremes and chemical contact.

Hazard Assessment - The process utilized to identify hazards in the workplace and to select the appropriate PPE to guard people against potential hazards.

Head Protection - Equipment designed to provide protection to the head during exposure to potential hazards such as falling objects, striking against objects or electrical hazards.

Hearing Protection - Equipment designed to provide protection to an individual's hearing during exposure to excessive noise levels and any 8hr work day with noise levels consistently 85dB or above.

Personal Protective Equipment (PPE) - Equipment designed to provide protection to the wearer from potential hazards to the eyes, face, hands, head, feet, ears, extremities and respiratory system.

Respiratory Protection - Equipment designed to provide protection to the wearer from potential inhalation hazards such as vapors, mists, particulates and gases.

EXECUTIVE SUMMARY

The hazards related to benzene exposure are well-defined. It is the policy of ARCADIS to prevent and minimize occupational exposure to benzene through the use of engineering and administrative controls and personal protective equipment (PPE).

Benzene is frequently encountered on ARCADIS projects as a contaminant in soils, ground and surface water, sediments and other environmental media. Benzene is primarily an inhalation hazard.

Principals in Charge (PIC), Project Managers (PM) and Task Managers (TM) are responsible for determining if benzene is or is potentially present on a project site in addition to determining client requirements with respect to the control of benzene hazards.

All project personnel must have completed Emergency Response & Hazard Communication training which covers emergency response procedures, fire prevention, fire extinguisher use, and hazard communication, and will be made aware of their office specific Emergency Response and Fire Protection Plan as required by the ARCADIS Emergency Response and Fire Safety standard ARC HSMS08.

Project Personnel are also responsible for completing benzene training as required and for following all hazard control processes.

Prolonged or repeated exposure to concentrations above the permissible occupational exposure limits may lead to blood disorders, including anemia, leucopenia (low white blood cell counts) and leukemia (cancer of the blood system).

Periodic Monitoring - shall be conducted at least annually until at least two consecutive exposure determinations (no less than 7 days apart) indicate the exposure is below the OSHA Action Level (0.5 ppm).

Initial benzene training is required for all employees assigned to a work area suspected or known to contain benzene. Annual benzene training is required for all employees actually or potentially exposed to benzene levels greater than the OSHA Action Level.

Initial medical surveillance is required if the following occurs:

- If employee personal exposures are reasonably expected to exceed the Benzene Action Level (0.5 ppm) on at least 30 calendar days per year.
- If employee personal exposures are reasonably expected to exceed the OSHA PEL (1 ppm is the 8-hour Time Weighted Average) on a least 10 calendar days per year.

All exposure, medical and training records shall be kept for 30 years.

1. POLICY

ARCADIS understands the hazards of personal exposure to benzene. Based on this understanding, ARCADIS will implement the appropriate controls to minimize or eliminate the hazards of benzene. These controls will focus first on engineering controls to mitigate benzene hazards where appropriate and practical. Administrative controls may also be implemented as appropriate and practical. Where it is not appropriate or practical to implement engineering and administrative controls, personal protective equipment (PPE) will be implemented to control benzene hazards below known occupational exposure limits.

2. PURPOSE AND SCOPE

2.1 Purpose

2.1.1 Benzene Exposure Protection – This Health and Safety Standard (HSS) provides information to protect ARCADIS employees, subcontractors and other affected personnel from exposures to benzene while conducting work on ARCADIS projects.

2.1.2 OSHA Requirements – This policy meets the requirements of the U.S. Occupational Safety and Health Administration (OSHA) regulations including Title 29 Code of Federal Regulations (CFR) Part 1910.1028 and 29 CFR 1926.1128.

2.2 Scope

This HSS applies to projects where benzene is known or thought to be present, and where ARCADIS employees, subcontractors and other affected personnel are or could be exposed to benzene above the Action Level**. This HSS does not apply to the following exemptions:**

- The storage, transportation, distribution, dispensing, sale or use of gasoline, motor fuels or other fuels containing benzene subsequent to its final discharge from bulk wholesale storage facilities.
- Loading and unloading operations at bulk wholesale storage facilities which use vapor control systems for all loading and unloading operations.
- The storage, transportation, distribution or sale of benzene or liquid mixtures containing more than 0.1 percent benzene in intact containers or in transportation pipelines while sealed in such a manner as to contain benzene vapors or liquid.
- Containers and pipelines carrying mixtures with less than 0.1 percent benzene and natural gas processing plants processing gas with less than 0.1 percent benzene.
- Work operations where the only exposure to benzene is from liquid mixtures containing 0.1 percent or less of benzene by volume or the vapors released from such liquids.
- Oil and gas drilling, production and servicing operations.
- Coke oven batteries.

3. DEFINITIONS

Definitions related to Benzene can be found in Exhibit 1.

4. RESPONSIBILITIES

4.1 Principal-In-Charge (PIC), Project Managers (PM) and Task Managers (TM)

PICs, PMs and TMs are responsible, as part of the project hazard assessment, for determining if benzene is or is potentially present on a project site. In addition, the project or task manager is responsible for determining client requirements with respect to the control of benzene hazards. Project and Task Managers should consult with corporate health and safety staff or other internal safety/industrial hygiene staff when working on sites containing benzene in which staff may be exposed above the Action Level. Project and Task Managers are also responsible for ensuring that project staff has the appropriate and applicable training for benzene prior to those staff beginning work.

4.2 Corporate Health and Safety

Corporate Health and Safety is responsible for keeping this HSS up-to-date with current regulatory requirements and best practices. In addition, Corporate Health and Safety oversees the Emergency Response and Hazard Communication training, medical surveillance program for benzene, as applicable and provides access to online training or a benzene training package for presentation to appropriate staff.

4.3 Project Health and Safety Staff

Project Health and Safety Staff, including designated Writers and Reviewers of Project Health and Safety Plans (HASPs), are responsible for developing control processes and techniques on specific projects to minimize employee exposure to benzene based on the levels of benzene expected to be encountered on project facilities.

4.4 Employees

Employees are responsible for reading the site-specific Emergency Response and Fire Prevention Plan, being familiar with emergency procedures. completing benzene training as required by this policy and standard, and for following all hazard control processes and airborne monitoring designated by the Project Manager, Project Health and Safety Staff and the project HASP. If project personnel believe that benzene is present that was not previously identified or is at levels that are higher than expected, they should stop work and notify project health and safety staff or the project manager immediately and not proceed until authorized.

5. PROCEDURE

5.1 Benzene Hazards

- Benzene is primarily an inhalation hazard. Benzene vapor does not present an appreciable skin hazard, however, benzene liquid is absorbed through the skin.

- The acute (short term) effects of inhalation exposure are similar to most other hydrocarbons (narcosis, dizziness, weakness, headache, nausea).

- Prolonged or repeated exposure to concentrations above the permissible exposure limits may lead to blood disorders, including anemia, leucopenia (low white blood cell counts) and leukemia (cancer of the blood system).

- As with most hydrocarbons, repeated/prolonged skin exposure to liquid may lead to the aforementioned disease(s) of the blood.

- Benzene liquid is also highly flammable. It should be stored in tightly closed containers in a cool, well-ventilated area.

- Benzene vapor may form explosive mixtures in air. All sources of ignition must be controlled. Use non-sparking tools when opening or closing benzene containers.

- Fire extinguishers must be readily available where benzene is used or stored. Employees will be trained to know where they are located and how to operate them.

- Smoking is prohibited in areas where benzene is used or stored.

- All project personnel must have completed Emergency Response & Hazard Communication training which covers emergency response procedures, fire prevention, fire extinguisher use, and hazard communication, and will be made aware of their office specific Emergency Response and Fire Protection Plan as required by the ARCADIS Emergency Response and Fire Safety standard ARC HSMS08.

5.2 Exposure Limits and Regulated Areas

The following personal exposure limits are established for benzene by inhalation:

- OSHA ACTION LEVEL – 0.5 parts per million (ppm) benzene in air 8-hour TWA.

- OSHA PELs
  - TWA = 1.0 ppm benzene in air averaged over an 8 hour period.
  - STEL = 5.0 ppm benzene in air averaged over any 15 minute period.

- OSHA occupational exposure limits that apply to operations exempt from the benzene standard (29 CFR 1910.1028 or 29 CFR 1926.1128)
  - TWA – 10 ppm over 8 hours
  - Acceptable Ceiling Concentration – 25 ppm
  - Acceptable maximum peak above the acceptable ceiling concentration for an 8-hour shift – 50 ppm for maximum duration of 10 minutes

- 2014 ACGIH TLVs
  - TWA – 0.5 ppm benzene in air averaged over an 8 hour period
  - STEL – 2.5 ppm benzene in air averaged over an 8 hour period

  - ACGIH designates benzene with a skin notation – meaning that there is a significant contribution to overall exposure by the cutaneous route including mucous membranes and the eyes, and by contact with vapors, liquids and solids containing benzene.

- Personal exposure is the concentration of benzene to which a person would be exposed if that person were not wearing respiratory protection. Personal exposures shall be measured over the exposure period in the breathing zone of the employee. Personal exposures should not be determined by area sampling.

- REGULATED AREA

  - An area where the benzene exposure does or can be expected to exceed the PELs or TLVs. Since it may be difficult to determine the exposure time for employees working in areas with concentrations that exceed PEL or TLV values, the facility/location may wish to regulate any area that exceeds 0.5 ppm benzene or per the requirements of the client or of the project HASP.

  - The PEL for benzene is relatively low as compared to the PEL or TLV of other hydrocarbons such as gasoline (300 ppm); therefore, depending on exposure conditions, it may be possible to exceed the PEL or TLV for benzene even though other hydrocarbon levels are not considered very high. Refer to Exhibit 2 - PID Action Levels for Those Projects Where Gasoline is the Chemical of Concern (9March2012 Communication to Staff) for details with regards to benzene associated with gasoline exposure.

5.3 Actions for Employee Exposures Greater Than or Equal to the OSHA Action Level or ACGIH TLV – TWA, but Less than the OSHA PEL – TWA

- Training: Annual benzene training is required.

- Respiratory Protection: full-face air purifying respirators equipped with organic vapor cartridges will be used per the project HASP.

- Medical Surveillance: Initial and annual medical exams (see below) are required if employee personal exposures do or can be reasonably expected to exceed the Action Level on at least 30 calendar days during the coming year.

- Periodic Monitoring - shall be conducted at least annually until at least two consecutive exposure determinations (no less than 7 days apart) indicate the exposure is below the Action Level.

5.4 Actions for Employee Exposures Greater Than PELs

- Respiratory Protection: respirators shall be used in all regulated areas.

- Training: Annual benzene training is required.

- Medical Surveillance: Initial and annual medical exams (see below) are required if employee personal exposures do or can be reasonably expected to exceed the PEL on a least 10 calendar days during the coming year.

- Written Program: A written program to reduce personal exposure is required detailing the methods to be used to reduce exposures below the TLVs and the OSHA Action Level. These written programs will be in the form of the project HASP based on project-specific and client requirements. The HASP will indicate the schedule for the implementation of the any benzene-related hazard control processes or methods. The HASP is reviewed at least annually in accordance with the HASP HSS (ARC HSFS010 – Health and Safety Plans). All project personnel must have access to the project HASP at all times.

- Periodic Monitoring - at least every 6 months until at least two consecutive exposure determinations (no less than 7 days apart) indicate the exposure is below the PEL; then annually until at least two consecutive exposure determinations (no less than 7 days apart) indicate the exposure is below the PEL Action Level.

5.5 Exposure Monitoring

- Representative personal exposure monitoring is required for each type of operation involving the handling of or potential exposure to benzene.

- Personal exposure monitoring shall utilize standard industrial hygiene sampling techniques and recordkeeping.

  - Passive badges such as the 3M 3500 or charcoal tube sampling may be used for this sampling activity.

  - Detection tubes shall not be used for compliance personal exposure determination but may be used for work and confined space entry permitting and defining regulated areas.

  - Employees who have been monitored for benzene exposure shall be notified of the monitoring results within 15 working days of receipt of these results. If the PEL is exceeded, the notification must indicate the follow-up plans or corrective actions to be taken to reduce exposures to below the PEL.

- Personal STEL monitoring should be used to characterize exposures for specific tasks such as gauging, O&M of treatment equipment, hose connect and disconnect, maintenance tasks such as flange breaking, etc.

- Personal TWA monitoring can be used for extended tasks, such as well developing and sampling, loading, tasks inside vessel holds, tank cleaning, and maintenance tasks such as pump removal, etc.

- Area sampling can be used to determine regulated areas; the sampling media shall determine the duration of sampling:

  - Detection tubes (Kitagawa #118SB, or Draeger 0.5/c) can be used for real-time determination.

  - Charcoal tube samples must be taken for at least 15 minutes.

- Periodic Monitoring is required if exposures exceed the Action Level or PELs.

5.6 Requirements for Regulated Areas

- Posting: Regulated areas shall be indicated such as by barricades, barricade tape, painted demarcations, or other devices.

- A sign shall be posted at the access to the regulated area with the warning:

1. DANGER

2. BENZENE

3. CANCER HAZARD

4. FLAMMABLE - NO SMOKING

5. AUTHORIZED PERSONNEL ONLY

6. RESPIRATOR REQUIRED

[Minimum lettering height: DANGER BENZENE 4"; others 3"]

- Respiratory Protection: Respirators shall be worn by all personnel when in a regulated area, regardless of the time period or over-all personal exposure measurement.

- Labeling

  – In addition to appropriate Hazard Communication labeling, containers or equipment containing > 0.1% benzene must also be labeled as such:

DANGER
CONTAINS BENZENE
CANCER CAUSING AGENT

  – Pipelines do not need to be labeled.

5.7 Exposure Reduction

- Written Program

  – The Project Manager and the Project Health and Safety Staff will develop a written program for exposure reduction if there is a determination that employee exposures may exceed the PELs or TLVs.

  – The written program must list the corrective actions that will be taken to reduce employee exposure to at or below the PELs and TLVs:

  – identify regulated areas/tasks;

  – engineering controls;

  – revised work practices;

  – respiratory protection and protective clothing; and

- schedule of development and implementation.

- Spills and Emergencies
  - An emergency is any occurrence which may result in an unexpected significant release of benzene that may result in a significant inhalation or skin exposure. After an emergency, appropriate monitoring must be conducted to assure the ambient benzene levels are back to normal; and conduct appropriate medical surveillance for affected employee(s).

- Respiratory Protection and Personal Protective Equipment
  - Respirators shall be worn, maintained and managed in accordance with the OSHA Standard (29 CFR 1910.134) and ARCADIS Health and Safety Standard ARC HSGE017 – Respiratory Protection. In addition, any client requirements on project sites will be followed.
  - Per the project HASP, respiratory protection will be worn at all times when airborne concentrations of benzene exceed the OSHA Action Level or the ACGIH TLV-TWA. The respirator will be a full-face air purifying respirator equipped with organic vapor cartridges. Action limits for upgrading to a higher level of protection will be documented in the project HASP or per client requirements.
  - Appropriate eye protection will be worn as necessary. Protective clothing and gloves suitable for the particular product (such as for gasoline) will generally be suitable for protection against the benzene in that product. For most hydrocarbon products, nitrile gloves, provide adequate protection. Chemical resistant clothing may vary depending on the product and degree of exposure.
  - For occupational exposure to “pure” benzene the following materials are recommended:
    - Gloves: poly-vinyl alcohol (PVA)
    - Clothing: Saranex or Barricade (DuPont) or equivalent.

5.8 Medical Surveillance

- Initial medical surveillance is required:
  - If employee personal exposures are reasonably expected to exceed the OSHA Action Level on at least 30 calendar days per year; or
  - If employee personal exposures are reasonably expected to exceed the OSHA PEL on a least 10 calendar days per year.

- Periodic exams are required on an annual basis for employees who continue to meet the criteria listed above. Annual exams may be discontinued after the exam conducted the year after personal exposures fall below the limits stated above in this section.

- The specific medical exam requirements are explained in detail in ARCADIS Health and Safety Standard ARC HSGE010 - Medical Surveillance.

- The physician must be supplied a copy of the OSHA benzene regulation 29 CFR 1910.1028 and a description of the employee's benzene exposure.

- For employees exposed to benzene from an emergency, a urine sample must be taken at the end of the shift. A urinary phenol test must be performed on the sample within 72 hours.

- OSHA regulations for benzene have specific medical removal provisions for medical examinations results falling outside of certain criteria. The facility/location should contact the Corporate Health and Safety Manager if the examining physician indicates that an employee may fall into these criteria.

6. TRAINING

Initial benzene training is required for all employees assigned to a work area suspected or known to contain benzene.

Annual benzene training is required for all employees actually or potentially exposed to greater than the Action Level (TWA > 0.5 ppm).

Initial and annual training shall consist of:

- The operations that involve benzene exposure.
- The methods/observations that can be used to detect the presence or release of benzene.
- The physical and health hazards of benzene.
- Methods used to protect against the hazards of benzene.
- The proper use of personal protective equipment in emergency situations.
- The meaning of a regulated area and how such are demarcated.
- A review of the applicable standard and where copies can be found.
- An explanation of the medical surveillance program.

7. REFERENCES

OSHA 29 CFR 1910.1028 Benzene

OSHA 29 CFR 1926.1128 Benzene - The requirements applicable to construction work under this section are identical to those set forth at 1910.1028

ACGIH TLVs and BEIs – Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices

ARCADIS Medical Surveillance HSP – ARC HSGE006

ARCADIS Emergency Response and Fire Safety HSP – ARC HSMS008

OSHA Toxic and Hazardous Substances Table Z-2

8. RECORDS

- All exposure, medical and training records shall be kept for 30 years.
- All exposure and medical records shall be made available to appropriate regulatory agencies upon written request.
- Employees who have been monitored for benzene exposure shall be notified of the monitoring results within 15 working days of receipt of these results; a written request is not required.

9. APPROVALS AND HISTORY OF CHANGE

Approved By: Tony Tremblay, CSP – Corporate H&S, Director of Technical Programs

History of Change

Revision Date	Revision Number	Developed by/revised by or reviewed by	Reason for change
26 March 2007	01	Pat Vollertsen/Mike Thomas	Original document
7 June 2007	02	Pat Vollertsen/Mike Thomas	Change to new template
6 September 2007	03	Pat Vollertsen/Mike Thomas	Changing over to new template format
22 February 2008	04	Mija Coppola	Template change
24 August 2011	05	Tony Tremblay	Exemptions and corresponding exposure limits added; Executive Summary Added; Format Updated
13 April 2012	06	Tony Tremblay	Approver changed to Tony Tremblay
11 February 2013	07	Amanda Tine/Tony Tremblay	Added that all employees are made aware of site-specific emergency plans as part of training; Added precautions for fire related hazards in section 5.1
13 June 2014	08	Tony Tremblay	Standard Reviewed; Section 4 Updated; Section 5.2 has reference to Exhibit 2 added; Added reference to 29 CFR 1926.1128 in Section 7 and added hyperlinks to OSHA Standards; Updated History of Change table format and header/footer format; Exhibit 2 - PID Action Levels for Those Projects Where Gasoline is the Chemical of Concern (9March2012 Communication to Staff) added to the benzene standard for staff reference

EXHIBIT 1 - DEFINITIONS

Benzene—is a colorless liquid with a sweet odor. It evaporates into the air very quickly and dissolves slightly in water. It is highly flammable and is formed from both natural processes and human activities. Some industries use benzene to make other chemicals which are used to make plastics, resins, and nylon and synthetic fibers. Benzene is also used to make some types of rubbers, lubricants, dyes, detergents, drugs, and pesticides. Benzene is also a natural part of crude oil, gasoline and cigarette smoke.

Benzene is encountered on ARCADIS projects, frequently, as a contaminant in soils, ground and surface water, sediments, and other environmental media. Personnel may also encounter benzene in other forms at certain client facilities at which ARCADIS works. It can be encountered at petroleum-related facilities, chemical production facilities and other types of industrial sites.

Action Level—the airborne concentration established by OSHA that triggers certain regulatory requirements.

HSS—Health and Safety Standard

Permissible Exposure Limit (PEL)—an average airborne concentration regulatory limit established by OSHA above which requires control to protect people from adverse health effects.

Short Term Exposure Limit (STEL)—a PEL or TLV established as a limit of exposure measured over a designated period of time less than 8 hours.

Threshold Limit Value (TLV)—a recommended average airborne concentration limit established by ACGIH. The TLVs are reviewed and updated as appropriate annually.

Time Weighted Average (TWA)—a measurement of airborne exposure to a chemical compound measured and averaged over a designated period of time for comparison to an STEL or an 8-hour PEL or TLV.

EXHIBIT 2 - PID Action Levels for Those Projects Where Gasoline is the Chemical of Concern (9March2012 Communication to Staff)

This message was sent to: Oil/Gas Client Sector PICs, Market Sector Managers, Market Sector Leaders, TKI Support Staff and HASP Reviewers

ARCADIS
Infrastructure · Water · Environment · Buildings

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A message from Corporate Health & Safety

PID Action Levels for Those Projects Where Gasoline is the Chemical of Concern

Questions regarding exposure monitoring for those sites with gasoline as the chemical of concern have arisen:

1. Are the action levels set to require benzene specific monitoring once a PID value of 0.5 ppm was measured over-restrictive and reasonable?
2. Is the current ACGIH TLV for gasoline (300 ppm) sufficient to maintain employee exposure to benzene below the current ACGIH TLV-PEL (0.5 ppm)?

A group including Tony Tremblay, Kurt Merkle, Mike Thomas and Sam Moyers initiated discussions, research and data analysis to review benzene exposures on gasoline contaminated sites and what reasonable exposure monitoring and action levels should be.

We attempted to contact the ACGIH for a response to the gasoline TLV question back in December of 2011 and have yet to receive a response. We did find that there was some research studies from the 1990's that summarized that the 300 ppm TLV for gasoline is not adequate to maintain benzene concentration below the current TLV of 0.5 ppm (assuming gasoline contains anywhere between 1-3% benzene).

We asked staff/project teams for air sampling data specific to benzene and decided to move forward by having the BP Foxglove project teams collect both real-time and lab analysis data to assist in evaluating this issue. With the help of Jim Bedessem and David Blane, air sampling data at an ARCADIS project was collected.

Current Occupational Exposure Limit Information:

Substance	ACGIH TLV		OSHA PEL	
	TWA (ppm)	STEL (ppm)	TWA (ppm)	STEL (ppm)
Benzene	0.5	2.5	1	5
Gasoline	300	500	N/A	N/A

Some background information with regards to benzene concentration in gasoline.

We found and reviewed an article that appeared in the October 1991 Applied Occupational and Environmental Hygiene (AOEH) journal titled "Compliance with the OSHA Benzene Permissible Exposure Limit (PEL) at the Gasoline Vapor PEL" that discusses compliance with the 300 ppm total gasoline vapor level and compliance with the OSHA PEL for benzene (1 ppm at the time of the article and currently still 1 ppm). The mean benzene concentration in gasoline ranged from 1.35 – 1.72 % by volume in 1990. Variation in the benzene content of gasoline vapor is dependent primarily on two factors: 1) the liquid benzene content of liquid gasoline; and 2) the seasonal (winter to summer) hydrocarbon blends of gasoline.

The most recent EPA Mobile Source Air Toxics (MSAT2) final rule (72 FR 8428, February 26, 2007) Pre-Compliance report indicated that refineries in the US reported benzene in gasoline averaged 0.99% by volume in 2010. In the coming years, this will be reduced to 0.62% benzene on average. Therefore, much of the data in the AOEH journal was gathered at a time when benzene levels in gasoline were 3X greater than present day levels. For our analysis, we assumed that gasoline at our project sites contains approximately 1% benzene.

Breathing zone air samples were collected by the AOEH articles authors. The air monitoring results from the 1991 study indicated: Benzene vapor concentrations associated with a 300-ppm gasoline vapor level were 1.3 and 2.7 ppm for winter and summer, respectively. Gasoline vapor concentrations of 235 ppm in winter and 109 ppm in summer represented upper limit concentrations at which benzene concentrations did not exceed the OSHA PEL of 1 ppm. Based on the results, the article concluded that maintaining a total gasoline level below 109 ppm as an 8-hour TWA would result in an employee benzene exposure below 1 ppm over an 8-hour TWA. The article also references another study that suggests a total gasoline vapor concentration of 300 ppm results in an average benzene concentration of 1.8 ppm with gasoline that has 1% benzene by volume.

With this information we conservatively established a real-time PID monitoring level that can keep our employee exposure to benzene well below the ACGIH TLV-TWA and STEL.

Since we are using the more stringent ACGIH TLV-TWA of 0.5 ppm for benzene, we would need to target a gasoline level of **less than 54.5 ppm** to maintain employee exposure to benzene below the TLV-TWA of 0.5 ppm.

BP Portfolio Air Sampling Summary (Feb 2012)

During excavation of gasoline contaminated soil, ARCADIS conducted various air monitoring (both

real-time and passive diffusion badge samples for lab analysis) to assess TVOC, gasoline and benzene levels in order to assess the relative value of direct-read benzene monitoring and to document the TVOC levels vs. the measured benzene levels.

With regards to the lab analysis data from the diffusion badge samples, lab analysis documented employee exposure to gasoline ranged from <1.6 ppm to 4.4 ppm gasoline (well below the ACGIH TLV-TWA of 300 ppm) and employee exposure to benzene ranged from <0.04 to 0.06 ppm benzene (well below the ACGIH TLV-TWA of 0.5 ppm).

Spot measurements using a PID instrument equipped with a 10.6 eV lamp (CF = 1) ranged from 0 to 151 ppm TVOC.

Based on the review of the research articles from the 1990's and our own air sampling data, implementing the current requirement for benzene-specific monitoring once a PID value of 0.5 ppm is measured is not necessary, nor is it practical.

Real-Time Monitoring Action level for sites where gasoline is the Chemical of Concern (Initial monitoring for each task/impact with COC and then every 15 minutes)

Based on our gasoline/benzene exposure air monitoring results and review of the AOEH article, we calculate that a 0-30 ppm range as measured with a PID (equipped with 10.6 eV lamp; CF = 1) will maintain employee exposure to benzene below the current ACGIH TLV-TWA of 0.5 ppm. These Action Levels will now be used across the company for those sites that are dealing with gasoline as the chemical of concern:

> **0 to less than or equal to 30 ppm** (as measured by PID equipped with 10.6 eV lamp; CF = 1): Level D PPE; use engineering/administrative controls to minimize exposure to gasoline/TVOC
>
> **>30 to less than or equal to 300 ppm** (as measured by PID equipped with 10.6 eV lamp; CF = 1): Upgrade to Level C PPE (full-face air purifying respirator equipped with VOC cartridges);re-evaluate engineering/administrative controls in use and determine if additional engineering/administrative controls are necessary; continue to use engineering/administrative controls to keep exposure levels as low as possible
> (Once PID reading exceeds 30 ppm, begin continuous monitoring/data-logging using PID)
>
> **>300 ppm** (as measured by PID equipped with 10.6 eV lamp; CF = 1): Stop Work Level; Contact SSO

Although we are eliminating the requirement for benzene-specific monitoring with regards to our gasoline COC sites, we still want to have various project teams collect both TWA and STEL samples for both gasoline / benzene along with minute by minute PID real-time air monitoring results to further validate our action levels during different seasons.

Further discussions with our XOM, Chevron and BP portfolio project teams will be initiated by Rebecca Lindeman regarding the need for collecting this air sampling data and submitting the results to Mike Thomas, Kurt Merkle and Tony Tremblay for review/filing.

Short-Form HASP Revision

Revision 10 of the AUS Standard HASP Template will have the action level set to 30 ppm for gasoline. A notation will also appear indicating benzene specific monitoring will not be required if using the Action Levels as outlined above. Existing HASPs must be revised.

Approval for Implementation of these Action Levels

A technical review of the Action Levels selected was conducted by Michael Ramer, CIH (Principal Scientist, Environment Division) and these Action Levels have been approved for implementation by Mija Coppola – AUS Corporate Director of H&S.

If there are any questions with regards to why the PID monitoring Action Levels have been adjusted, please feel free to contact Tony Tremblay, Kurt Merkle, Mike Thomas or Sam Moyers.

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EXECUTIVE SUMMARY

Projects conducted in cold environments may be necessary in various ARCADIS business operations. It is the policy of ARCADIS to protect employees from environmental stressors related to cold and/or wet conditions through the use of engineering and administrative controls as well as personal protective equipment (PPE). This Health & Safety Standard (HSS) provides direction on the prevention and treatment of cold-related illnesses and injuries.

The most common cold related illnesses and injuries include:

- Cold Burn
- Frostnip
- Frostbite
- Hypothermia
- Trench Foot
- Chilblains

Personnel will be responsible for understanding the signs and symptoms involved in cold stress in both themselves and other personnel on the project site.

Environmental risk factors for cold stress include:

- Low temperatures
- High velocity air movement
- Dampness
- Cold water
- Some pressurized tanks/cylinders can become extremely cold when the contents are released quickly

For those ARCADIS staff working in cold and/or wet conditions, there are a number of preventative and protective measures that staff can implement to minimize potential for cold related illness/injuries including:

- Monitor your physical condition and that of your coworkers;
- Paying special attention to hands, feet, head, neck and face when choosing appropriate PPE to protect against the hazards of the cold:
    - Wear several layers of loose clothing for insulation (tight clothing reduces blood circulation to the extremities)l
    - Boots should be insulated.and in some cases, waterproof
    - Wear a hat to reduce the loss of body heat from your head.
    - Be aware that some clothing may restrict movement resulting in a hazardous situation;
- Acclimation to working in cold environments by implementing a physical fitness training regimen prior to starting work;
- Ensuring proper hydration to maintain electrolytes and body temperature;
- Depending on situation/location, consider including chemical hot packs in your first aid kit;
- Where possible, select the warmest part of the day to perform work outside; and
- Taking rest breaks in warm, dry shelters.

1. POLICY

It is ARCADIS policy that employees who are required to work in cold environments be protected from related hazards. Cold-related illness and injury may be prevented through the use of engineering, administrative controls and/or personal protective equipment (PPE).

2. PURPOSE AND SCOPE

2.1 Purpose

The purpose of this HSS is to provide direction on the prevention and treatment of cold-related illnesses and injuries.

2.2 Scope

This standard applies to ARCADIS employees and subcontractors who work on projects and operations where cold stress may be encountered.

3. DEFINITIONS

Definitions relating to Cold Stress can be found in Exhibit 1.

4. RESPONSIBILITIES

4.1 Project Managers and Task Managers

Project Managers (PMs) and Task Managers (TM) are responsible for ensuring that cold stress is considered and addressed in project hazard/risk assessments and project planning.

4.2 Employees

ARCADIS employees are responsible for understanding the signs and symptoms that can lead to cold stress and adhere to the prescribed control and mitigation processes and methods. They will report to the PM or TM any signs and symptoms of cold stress exhibited by themselves or by other personnel on the project site. ARCADIS employees are responsible for reviewing and understanding this Cold Stress HSS.

4.3 Corporate Health and Safety

Corporate H&S staff are responsible for keeping this HSS up-to-date with safe work practices and working with the Training Team to develop Cold Stress training content and/or assessing third-party training content.

5. PROCEDURE

5.1 Major Risk Factors for Cold-Related Illnesses and Injuries

5.1.1 Personal Risk Factors

- Wearing inadequate, inappropriate (i.e. cotton) or wet clothing increases the effects of cold on the body.
- Lack of hydration to replace metabolized electrolytes.
- Inadequate acclimatization to cold weather related stresses.

- Consumption of certain drugs or medications such as alcohol, nicotine, caffeine and medication which inhibits the body's response to the cold or impairs judgment.
- Existing illness such as; common virus, diabetes, heart, vascular and thyroid problems - may make a person more susceptible to hazards of the cold.
- Becoming exhausted or immobilized, especially due to injury or entrapment may speed up the adverse effects of cold weather.

5.1.2 Environmental Risk Factors

- Performing work in environmental conditions such as; low temperatures, high velocity air movement, dampness and potential for cold water emersion.
- Wind chill is a critical factor when evaluating work conditions.
- Continuous contact with a cold and/or highly thermo-conductive surface such as; stone, ice, concrete or metal.
- Working in facilities where refrigerated processes are in operation or where no mechanized heat is provided.

5.2 Assessing the Work Environment

Each ARCADIS employee needs to evaluate the work environment to identify and assess potential cold-stress risk factors and appropriate controls (e.g., apply TRACK skills).For example, each employee will need to:

- Understand the weather condition(s) that may exist throughout the work day (air temperature, humidity, water temperature, and wind speed for example);
- Determine how much physical activity is anticipated;
- Determine length of the work shift/potential exposure time to evaluate planned work/rest schedule;
- Evaluate the type of clothing/PPE being worn; and
- Consider personal medical conditions that may be aggravated by working in the cold.

Based on this assessment, ARCADIS employees will need to consider the risk and implement appropriate controls before proceeding with work.

5.3 Preventative Measures and Controls

5.3.1 Safe Work Practices

- Ensure that personnel remain hydrated. Dehydration may increase the susceptibility of cold injury due to a change in blood flow to the extremities.
- Educate personnel on the symptoms of cold-related stresses - heavy shivering, uncomfortable coldness, severe fatigue, drowsiness or euphoria.

- Acclimatization - allowing for a period of adjustment to the cold before beginning a full work schedule. This process may be accelerated and enhanced by implementing a physical fitness training program prior to start of work.

- Whenever possible, select the warmest hours of the day to do work outside.

- Reduce periods of inactivity in cold conditions, and take frequent short breaks in warm, dry shelters.

- Depending on situation/location, consider including chemical hot packs in your first aid kit.

5.3.2 Protective Clothing Guidance

Protective clothing is generally needed for work at or below 39°F (4°C), but keep in mind that warmer temperatures coupled with wind and rain can lead to cold stress, so 39°F is a guideline temperature. Clothing should be selected to suit the temperature, weather conditions (e.g., wind speed, rain), the level and duration of activity, and job design. These factors are important to consider so that employees can regulate the amount of heat and perspiration generated while working. If the work pace is too fast or if the type and amount of clothing are not properly selected, excessive sweating may occur. The clothing next to body will become wet and the insulation value of the clothing will decrease dramatically. This increases the risk for cold injuries, therefore, consider the following guidance:

- Clothing should be worn in multiple layers which provide better protection than a single thick garment. The air between layers of clothing provides better insulation than the clothing itself. Having several layers also gives employees the option to open or remove a layer before you get too warm and start sweating or to add a layer when you take a break. It also allows you to accommodate changing temperatures and weather conditions. Successive outer layers should be larger than the inner layer, otherwise the outermost layer will compress the inner layers and will decrease the insulation properties of the clothing.

- The inner layer should provide insulation and be able to "wick" moisture away from the skin to help keep it dry. Base layers should be made of hydrophobic synthetic weave to enhance moisture transportation away from the skin. (e.g. polypropolene or wool). Thermal underwear made from polyesters or polypropylene is suitable for this purpose.

  - Cotton clothing should be avoided as a base layer touching the skin due to its hydrophilic moisture retention properties. However, for those employees using Arc-Rated (AR) or Flame Resistant (FR) clothing, please keep in mind that only natural fiber undergarments are recommnended.

- Additional layers of clothing should provide adequate insulation for the weather conditions under which the work is being done. These additional layers should also be easy to open or remove before an employee gets too warm to prevent excessive sweating during strenuous activity. Employees should consider a middle layer of hydrophobic synthetic fabric to transfer moisture and retain insulation in a damp environment.

- For work in wet conditions, the outer layer of clothing should be waterproof. Consider an outer layer provided with a waterproof breathable membrane to break the wind (e.g. Gore-Tex® or other proprietary fabric). The outer layer should have the means for closing off and opening the waist, neck and wrists to help control how much heat is retained or given off. Some jackets have netted pockets and vents around the trunk and under the arm pits (with zippers or Velcro fasteners) for added ventilation possibilities

- Clothing should be kept clean since dirt fills air cells in fibers of clothing and destroys its insulating ability.

- Consider keeping a change of clothing available in case work clothing becomes damp or wet.

- Pay special attention to protecting feet, hands, head, neck and face:

  - Excessive heat loss can occur through the head. When appropriate, additional insulation when wearing a hard hat, may include an insulated hard hat liner, skull cap, scarf and/or ear warmers.
  - In extreme temperatures, hands should be covered at all times to reduce potential for cold-burns as well as frostbite. Ill-fitting gloves can impair circulation and increase susceptibility to frostbite/frostnip. Be aware of tight fitting gloves and consider mittens for the added benefit that portable hotpockets can be carried inside mittens. For work below 1.4°F (-17°C), mittens should be used. Cotton is not recommended. It tends to get damp or wet quickly, and loses its insulating properties. Wool and synthetic fibers, on the other hand, do retain heat when wet.
  - Consider using felt-lined, rubber bottomed, leather-topped boots with removable felt insoles for heavy work in cold weather conditions since leather is porous, allowing the boots to "breathe" and let perspiration evaporate. Footwear should be insulated to protect against cold and dampness. A dual layer sock system consisting of a thin liner sock inside an insulating outter sock is highly recommended. Whatever sock is chosen should not cause the insulated boot to fit too snugly. Overly snug footwear allows for body heat loss due to conductive heat transfer. If work involves standing in water or slush, then waterproof boots should be worn. While these waterprooof boots protect the feet from getting wet from cold water in the work environment, they also prevent the perspiration to escape. The insulating materials and socks may become wet more quickly than when wearing leather boots and increase the risk for frostbite.
  - Avoid steel shank and/or steel toe boots where an appropriate composite material substitute (e.g. carbon-fiber, ceramic and/or Kevlar toe/insert) is available.
  - Protective eyewear should be treated with anti-fog spry prior to wearing in cold conditions.

5.3.3 Engineering Controls

Some engineering controls to consider implementing:

- Use of an on-site source of heat, for example, air jets, radiant heaters or contact warm plates.

- Shield work areas from drafty or windy conditions.
- Provide a heated shelter (e.g. vehicle, building, tent) for employees who experience prolonged exposure to equivalent wind-chill temperatures of 30°F /-1°C or less.
- When taking breaks in the shelter ensure that snow and ice are removed from clothing prior to entry to minimize water generation.
- Use thermal insulating material on equipment handles when temperatures drop below 30°F / -1°C.

5.4 Types of Cold Stress - Signs and Symptoms

5.4.1 Frostnip/Frostbite

Skin exposed to temperatures a little below the freezing mark can take hours to freeze, but very cold skin can freeze in minutes or seconds. Air temperature, wind speed, and moisture all affect how cold the skin becomes. A strong wind can lower skin temperature considerably by dispersing the thin protective layer of warm air that surrounds our bodies. Wet clothing readily draws heat away from the skin because water is a potent conductor of heat. The evaporation of moisture on the skin also produces cooling. For these reasons, wet skin or clothing on a windy day can lead to frostbite even if the air temperature is above the freezing mark. The extent of permanent injury, however, is determined not by how cold the skin and the underlying tissues become but by how long they remain frozen.

Frostbite is an injury to the body that is caused by freezing. Frostbite causes a loss of feeling and color in the affected areas. It most often affects the nose, ears, cheeks, chin, fingers, or toes. Frostbite can permanently damage body tissues, and severe cases can lead to amputation. In extremely cold temperatures, the risk of frostbite is increased in workers with reduced blood circulation and among workers who are not dressed properly.

Three nearly simultaneous physiological processes underlie frostbite injury: tissue freezing, tissue hypoxia, and the release of inflammatory mediators.

Symptoms of Frostbite:

- Reduced blood flow to hands and feet (fingers or toes can freeze)
- Sharp pain progressing to numbness with red skin at first, then turning cold and white
- Tingling or stinging
- Aching
- Bluish or pail, waxy skin
- Skin becomes hard and numb. Blisters may form following thawing.
- Usually affects the fingers, hands, toes, feet, ears and nose first.

Frostbite is classified by degree of injury (first, second, third, or fourth), or simply divided into two types, superficial (corresponding to first- or second-degree injury) and deep (corresponding to third- or fourth-degree injury). Most frostbite injuries affect the feet or

hands. The remaining 10% of cases typically involve other exposed body parts (e.g. nose, ears, cheeks, etc.). Once frostbite sets in, the affected part begins to feel cold and, usually, numb; this is followed by a feeling of clumsiness. The skin turns white or yellowish. Many patients experience severe pain in the affected part during rewarming treatment and an intense throbbing pain that arises two or three days later and can last days or weeks. As the skin begins to thaw during treatment, edema (excess tissue fluid) often accumulates, causing swelling. In second- and higher-degree frostbite, blisters appear. Third-degree cases produce deep, bloodfilled blisters and, during the second week, a hard black eschar (scab). Fourth-degree frostbite penetrates below the skin to the muscles, tendons, nerves, and bones.

Like frostbite, frostnip is associated with ice crystal formation in the tissues, but no tissue destruction occurs and the crystals dissolve as soon as the skin is warmed. Frostnip affects areas such as the earlobes, cheeks, nose, fingers, and toes. The skin turns pale and one experiences numbness or tingling in the affected part until warming begins.

5.4.2 Hypothermia

When exposed to cold temperatures, your body begins to lose heat faster than it can be produced. Prolonged exposure to cold will eventually use up your body's stored energy. The result is hypothermia, or abnormally low body temperature. A body temperature that is too low affects the brain, making the victim unable to think clearly or move well. This makes hypothermia particularly dangerous because a person may not know it is happening and will not be able to do anything about it.

Symptoms of hypothermia:

- Body temperature drops below 95°F / 35°C
- Fatigue or drowsiness
- Uncontrolled shivering
- Cool, bluish skin
- Slurred speech
- Clumsy movements
- Irritable, irrational or confused behavior

5.4.3 Cold Water Immersion

Cold water immersion creates a specific condition known as immersion hypothermia. It develops much more quickly than standard hypothermia because water conducts heat away from the body 25 times faster than air. Typically people in temperate climates don’t consider themselves at risk from hypothermia in the water, but hypothermia can occur in any water temperature below 70°F. Survival times can be lengthened by wearing proper clothing (wool and synthetics and not cotton), using a personal flotation device (PFD, life vest, immersion suit, dry suit), and having a means of both signaling rescuers (strobe lights, personal locator beacon, whistles, flares, waterproof radio) and having a means of being retrieved from the water.

5.4.4 Trench Foot

Trench foot, also known as immersion foot, is an injury of the feet resulting from prolonged exposure to wet and cold conditions. Trench foot can occur at temperatures as high as 60°F if the feet are constantly wet. Injury occurs because wet feet lose heat 25-times faster than dry feet. Therefore, to prevent heat loss, the body constricts blood vessels to shut down circulation in the feet. Skin tissue begins to die because of lack of oxygen and nutrients and due to the buildup of toxic products.

Symptoms of trench foot include:

- Reddening of the skin
- Numbness
- Leg cramps
- Swelling
- Tingling pain
- Blisters or ulcers
- Bleeding under the skin
- Gangrene (the foot may turn dark purple, blue, or gray)

5.4.5 Chilblains

Chilblains are caused by the repeated exposure of skin to temperatures just above freezing to as high as 60°F. The cold exposure causes damage to the capillary beds (groups of small blood vessels) in the skin. This damage is permanent and the redness and itching will return with additional exposure. The redness and itching typically occurs on cheeks, ears, fingers, and toes.

Symptoms of chilblains include:

- Redness
- Itching
- Possible blistering
- Inflammation
- Possible ulceration in severe cases

5.5 First Aid and Emergency Procedures

Contact Emergency Medical Services and WorkCare to discuss first aid/emergency procedures.

5.5.1 Frostnip/Frostbite

- Emergency medical help should always be summoned whenever frostbite is suspected.
- Move the person to a warm dry area. Do not leave the person alone.
- Remove any wet or tight clothing that may cut off blood flow to the affected area.
- Do not rub the affected area. Rubbing causes damage to the skin and tissue.
- It should be noted that experts advise rewarming in the field only when emergency help will take more than two hours to arrive and refreezing can be prevented.
- First line of rewarming should include bundling the affected area in warm dry clothing and blankets to utilize body heat to treat the affected area.
- Should the affected area not respond to body heat only, gently place the affected area into a luke warm water bath and slowly and gratually increase temperature, but do not exceed 105°F. Monitor the water temperature to slowly warm the tissue. Do not pour warm water directly on the affected area because it will warm the tissue too fast causing tissue damage. Warming takes about 25-40 minutes.
- After the affected area has been warmed, it may become puffy and blister. The affected area may have a burning feeling or numbness. When normal feeling, movement, and skin color have returned, the affected area should be dried and wrapped to keep it warm.
- Discuss with WorkCare whether blisters should be debrided (cleaned by removing foreign material) or simply covered with aloe vera.
- Discuss with WorkCare whether the patient should be given ibuprofen to combat inflammation.
- The key to prehospital treatment is to avoid partial thawing and refreezing, which releases more inflammatory mediators and makes the injury substantially worse. If there is a chance the affected area may get cold again, do not warm the skin. If the skin is warmed and then becomes cold again, it will cause severe tissue damage.
- Seek medical attention as soon as possible.

5.5.2 Hypothermia

- Call for emergency help.
- Move the person to a warm, dry area. Do not leave the person alone.
- Remove any wet clothing and replace with warm, dry clothing or wrap the person in blankets.
- Have the person drink warm, sweet drinks (sugar water or sports-type drinks) if they are alert. Avoid drinks with caffeine (coffee, tea, or hot chocolate) or alcohol. Handle hypothermia victims gently and do not give anything by mouth if they are unconscious.

- Have the person move their arms and legs to create muscle heat. If they are unable to do this, place warm bottles or hot packs in the arm pits, groin, neck and head areas. Do not rub the person's body or place them in warm water bath, as this may stop their heart.

5.5.3 Trench Foot

Workers suffering from trench foot should:

- Remove shoes/boots and wet socks.
- Dry their feet.
- Avoid walking on feet, as this may cause tissue damage.

5.5.4 Chilblains

Workers suffering from chilblains should:

- Avoid scratching.
- Slowly warm the skin.
- Use corticosteroid creams to relieve itching and swelling.
- Keep blisters and ulcers clean and covered.

6. TRAINING

Unless working in the Arctic, there is no specific training requirement for ARCADIS staff, however, each ARCADIS employee is responsible for reviewing and understanding this Cold Stress HSS. Reasonable effort should be made by ARCADIS staff working in cold working environments, and those who supervise them, to be able to recognize and know what steps to take to prevent cold-stress.

Working in the Arctic involves project-specific requirements and specialized training, including but not limited to Working on the North Slope (Alaska) and Learn to Return – Survival Training (Canada and Alaska) or similar. ARCADIS staff must also comply with client-specific requirements when it comes to selecting survival school training.

7. REFERENCES (regulation citation, technical links, publications, etc.)

- Fact Sheet No. OSHA 98-55 ProtectingWorkersinColdEnvironments.pdf
- OSHA – The Cold Stress Equation 1998 OSHA Coldcard.html
- NIOSH – Hazards and Exposures www.cdc.gov/niosh/topics/coldstress
- OSHA – Cold Stress Guide, Workplace Safety & Health Topics – Cold Stress
- Canadian Centre for Occupational Health and Safety Cold Environments - Working in the Cold
- OSHA – Tips to Protect Workers in Cold Environments

8. RECORDS - DATA RECORDING AND MANAGEMENT

This HSS will be reviewed on a routine basis and revised as appropriate. When revised, the revision date/number will be documented under “History of Change” and the prior plan archived per company policy.

9. APPROVALS AND HISTORY OF CHANGE

Approved By: Tony Tremblay, CSP – Corporate H&S, Director of Technical Programs

History of Change

Revision Date	Revision Number	Standard Developed/Reviewed By or Revised By	Reason for change
31 May 2013	01	Keith Antell/Tony Tremblay	Original document
3 February 2015	02	Tony Tremblay	Section 7 links updated

EXHIBIT 1 – DEFINITIONS

Cold Burn – instant superficial freezing of tissue when touching a very cold object, tool or specific types of liquids or gases.

Cold Stress – Injuries or health effects that come from working under cold conditions. Four factors contribute to cold stress: cold air temperature, high velocity air movement, dampness of the air and contact with cold water or surfaces.

Cold Water, as defined by the US Coast Guard, means water where the monthly mean low water temperature is normally 59 degrees F (15 degrees C) or less.

Fingertip Fissures – Deep, intractable and very painful fissuring that may occur on the fingertips when exposed to prolonged or repeated cold conditions.

Frostbite – Exposed skin is susceptible to frostbite when the air temperature is below 0°F or when there are high winds combined with cold temperatures. Symptoms may include loss of sensation, cold, pale and waxy skin. Frostbite can lead to tissue damage, scarring and possible amputation.

Frost Nip – the freezing of the skin and superficial tissue. The skin turns white after exposure to cold wind. It is similar to frostbite by less severe.

Hydrophilic Material – Materials that exhibit a strong affinity for water, e.g. cotton.

Hydrophobic material – Materials that exhibit a lack of affinity for water. Typically a polyester fabric (polypropolyene, polar fleece or a number of other proprietary names) that does not absorb water/perspiration. Additionally, body heat will cause a capillary effect moving moisture away from the skin to the out surface of the fabric. This capillary action will keep the wearer warmer over a longer period than a hydrophilic fabric.

Hypothermia – the chilling of the body's core temperature below 95°F (35°C). Hypothermia usually happens at very cold temperatures, but can also occur in cooler temperatures, for example, if an individual is submersed in water or becomes chilled from rain. Symptoms may include: shivering (uncontrolled), slurred speech, memory loss, erratic behavior, clumsy movements and bluish/purple colored skin.

Trench Foot – caused by continuous exposure to the cold without freezing, combined with constant dampness or immersion in water. Water temperatures do not have to be below freezing. Symptoms of trench foot include a tingling and/or itching sensation, pain, swelling, cold and blotchy skin, numbness and a prickly or heavy feeling in the foot.

Wind Chill Temperature - is how cold people and animals feel when outside. Windchill is based on the rate of heat loss from exposed skin caused by wind and cold. As the wind increases, it draws heat from the body, driving down skin temperature and eventually the internal body temperature. Therefore, the wind makes it feel much colder. If the temperature is 0 degrees Fahrenheit and the wind is blowing at 15 mph, the wind chill is -19 degrees Fahrenheit. At this wind chill temperature, exposed skin can freeze in 30 minutes.

EXHIBIT 2 – OSHA COLD STRESS EQUATION

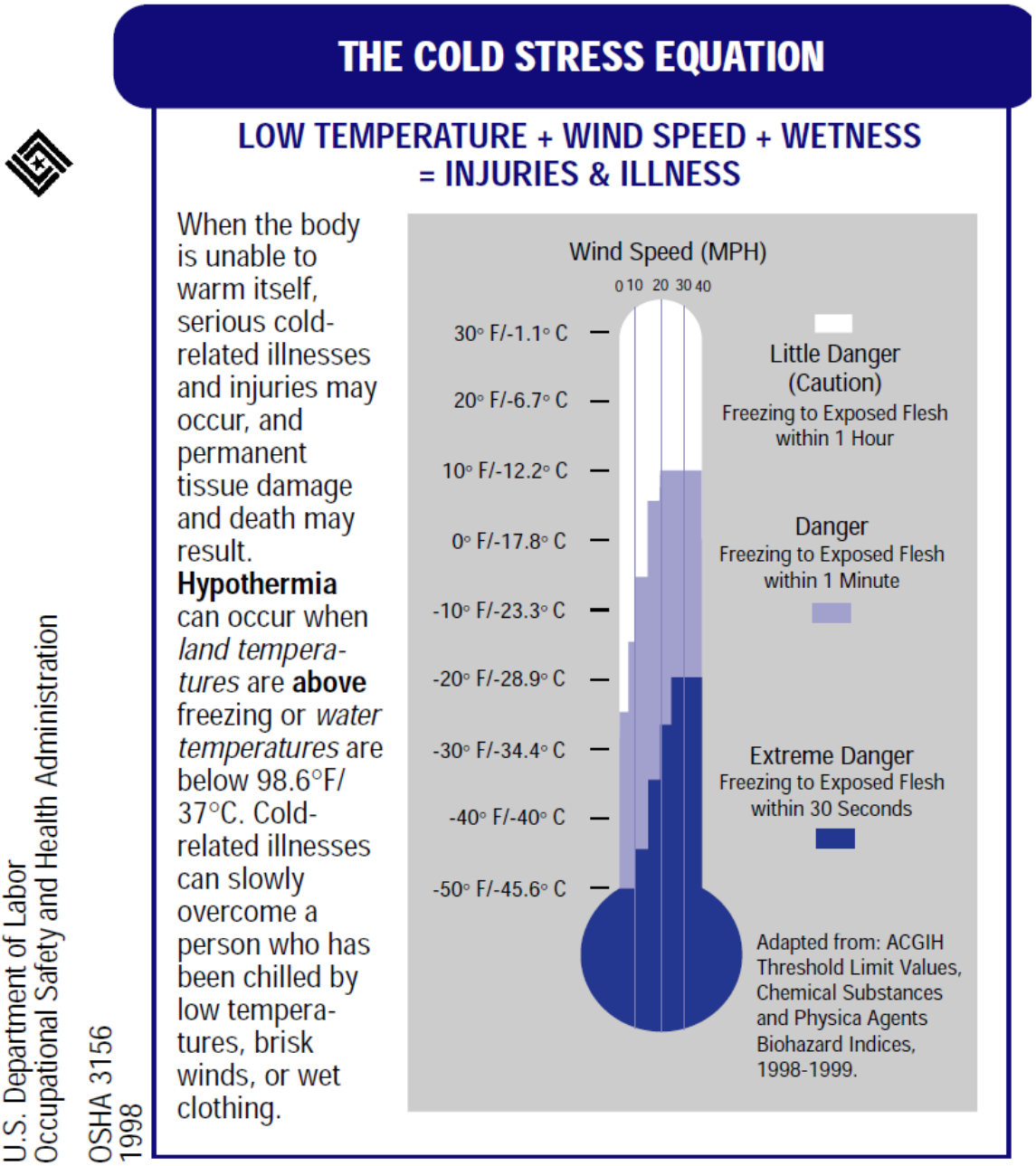

EXHIBIT 3 – NATIONAL WEATHER SERVICE Windchill Chart

NWS Windchill Chart

Wind (mph) \ Temperature (°F)	Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5		36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10		34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15		32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20		30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25		29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30		28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35		28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40		27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45		26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50		26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55		25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60		25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times — 30 minutes — 10 minutes — 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

EXHIBIT 4 – SASKATCHEWAN DEPARTMENT OF LABOR
Work/Warm-up Schedule for a 4-Hour Shift (Guidance Information)

Work Warm-up Schedule for Outdoor Activities

This information applies to moderate to heavy physical work activity in any four-hour period. At the end of the four-hour period an extended break in a warm location is expected. Warm-up breaks are assumed to provide 10 minutes in a warm environment. These guidelines apply to workers wearing dry clothing.

Sunny sky Air temperature		No noticeable wind		Wind 8 km/h (5 mph)		Wind 16 km/h (10 mph)		Wind 24 km/h (15 mph)		Wind 32 km/h (20 mph)	
°C below zero *	°F below zero *	Max. work period	Number of breaks**	Max. work period	Number of breaks**	Max. work period	Number of breaks**	Max. work period	Number of breaks**	Max. work period	Number of breaks**
26 to 28	15 to 19	120 minutes	1	120 minutes	1	75 minutes	2	55 minutes	3	40 minutes	4
29 to 31	20 to 24	120 minutes	1	75 minutes	2	55 minutes	3	40 minutes	4	30 minutes	5
32 to 34	25 to 29	75 minutes	2	55 minutes	3	40 minutes	4	30 minutes	5	Non-emergency work should stop	
35 to 37	30 to 34	55 minutes	3	40 minutes	4	30 minutes	5	Non-emergency work should stop			
38 to 39	35 to 39	40 minutes	4	30 minutes	5	Non-emergency work should stop					
40 to 42	40 to 44	30 minutes	5	Non-emergency work should stop							
43 and below _	45 and below	Non-emergency work should stop									

* All temperatures are approximate
** Number of breaks: This includes a normal break after 2 hours and the number of additional warm-up breaks needed.

Apply the schedule one step lower for work with limited physical activity. For example, at -35°C (-30°F) with no noticeable wind, a worker with a job requiring little physical movement should have a maximum work period of 40 minutes with four breaks in a four-hour period.

If reliable weather reports are not available, use the following as a guide to estimate wind velocity:

- An 8 km/h (5 mph) wind will move a light flag
- A 16 km/h (10 mph) wind will fully extend the flag
- A 24 km/h (15 mph) wind will raise a newspaper sheet
- A 32 km/h (20 mph) wind will produce blowing and drifting snow

Environment Canada may report a wind chill index. If wind speeds are higher than those identified in the chart, a wind chill index of -51°C should be used to determine the point at which all non-emergency work should stop.

Implementation Date	ARCADIS HS Standard Name	ARCADIS Design & Consultancy for natural and built assets
28 October 2009	Emergency Action and Fire Safety	
Revision Date	ARCADIS HS Standard No.	Revision Number
27 September 2019	ARC HSMS008	04

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QUICK SHEET

Applicability

The Emergency Action and Fire Safety Health & Safety Standard (HSS) applies to all Arcadis offices with ten or more employees. Office Health & Safety Coordinators will ensure that an appropriate Emergency Action Plan ("EAP"), which incorporates a Fire Safety Plan, specific to the office location, is in place and reviewed annually. Plans for project sites will be completed as part of the Health & Safety Plan (HASP) as outlined in HASP HSS (ARC HSFS010). Remote workers are exempt from this HSS. However, employees should follow a similar planning process to prepare for emergencies in the home.

Need to Know

The primary purpose of the EAP is to inform employees on what to do in the event of an emergency, including how and where to evacuate. Arcadis offices may utilize an EAP provided by their property owner or Management Company but must verify that the EAP meets all requirements as outlined in this Health and Safety Standard (HSS) and, if it does not, amend the EAP so that requirements are met.

Training

New hires, regardless of job function or hours worked per week, will be trained on their office location's EAP. All employees will review their office EAP annually and participate in provided training when responsibilities or designated actions under the EAP or the EAP changes.

Equipment

Although employees are not required to use fire extinguishers, those employees who may be more likely to use fire extinguishers as part of their work including employees working on project sites where it is required, employees assigned to company vehicles that have fire extinguishers as part of their equipment, and any others as applicable, are required to undergo training annually.

Permits or Forms Required

The EAP template will be used to create an office-specific plan. Each EAP will include the following, at a minimum:

- Emergency evacuation procedures and evacuation route assignments;
- Employee notification procedures during an emergency;
- Preferred means of reporting fires and other emergencies;
- Actions to be taken in an emergency;
- Rescue and medical duties for those employees who are to perform them; and
- Emergency Response Warden and Buddy names and responsibilities.

The primary purpose of the Fire Safety Plan is to minimize the possibility of fires in the workplace. The plan should include the following:

- A list of fire hazards in the workplace;
- Housekeeping procedures that will be followed;
- Explanation of alarm system in place at the office along with any fire suppression and/or smoke alarm systems;
- Names or titles of personnel or vendors who are responsible for maintenance of equipment and systems installed to prevent or control fires; and
- Presence or absence of fire extinguishers.

Office Health & Safety Coordinators ensure that an appropriate EAP, which incorporates a Fire Safety Plan, specific to the office location, is in place and reviewed annually where an office has ten or more people.

1. POLICY

It is the policy of Arcadis to inform employees of evacuation, emergency response and fire safety procedures by means of a location-specific Emergency Action Plan ("EAP").

2. PURPOSE AND SCOPE

2.1 Purpose

This Health & Safety Standard (HSS) provides guidelines so that Arcadis office locations can implement an appropriate EAP, specific to the office location. The EAP includes response to emergency situations that can be reasonably expected, including fire, and notification and evacuation procedures, process by which employees will be accounted for, and where employees may go to for additional information or questions.

2.2 Scope

An EAP is required of all Arcadis office locations with ten (10) or more employees. Arcadis offices may utilize an EAP provided by their property owner or Management Company but must verify that the Plan meets all requirements as outlined in this Health & Safety Standard (HSS) and, if it does not, amend the EAP so that requirements are met.

Offices with less than 10 employees are not required to have a written plan and may communicate this information verbally unless otherwise required by a local or state regulatory authority.

3. DEFINITIONS

The definitions associated with this HSS are presented in Exhibit 1 of this document. A list of acronyms and abbreviations used in this HSS is provided in Exhibit 2.

4. RESPONSIBILITIES

4.1 Corporate Health & Safety

Corporate Health & Safety will:

- Review this HSS and make updates as necessary.
- Communicate the program to appropriate staff.
- Provide technical assistance as necessary.

4.2 Office H&S Coordinators

Office Health & Safety Coordinators or their designee will:

- Prepare the EAP and make it available to all employees, when a written EAP is required.

- Review the EAP at least annually, revise as necessary and communicate changes to the office.
- Complete or delegate completion of monthly fire extinguisher, housekeeping, and, where applicable, first aid kit and AED inspections (refer to the First Aid/CPR/AED HSS [ARC HSGE004]).
- Make the EAP available to new hires.
- Assist in coordinating annual Fire Warden training.
- Annually, at a minimum, remind staff to review the EAP and familiarize themselves with the details of the EAP.

4.3 Location Leaders

Location Leaders will:

- Support the Office H&S Coordinator by making sure resources are available to implement the EAP, such as identification of Fire Wardens and Buddies, or assist with monthly office inspections;
- In the event of an emergency, to work with other local resources (will vary by office), which may include, but not be limited to: Property Management, Office H&S Coordinator, local law enforcement, and/or facilities staff to understand the local situation, receive guidance from emergency response personnel in the area and communicate to staff, and to guide actions as appropriate; and
- Establish a process to account for all workers assigned to the office, including Remote Workers.

4.4 Supervisors and Group Leaders

Supervisors and Group Leaders confirm that the new hires for which they are responsible are aware of their office location's EAP, or if a written EAP is not required, that the EAP is described to them, and that the new hire completes the required training and quiz, which is assigned to all employees upon hire.

Supervisors and Group Leaders shall assign annual fire extinguisher training to those staff required to use a fire extinguisher (client or project related requirement) and for those employees who are assigned company vehicles that have a fire extinguisher as part of the vehicle equipment.

4.5 Fire Wardens ("Wardens")

Fire Wardens will be aware of all persons within their assigned area, including those who may require assistance in an emergency, whether temporary or permanent in nature.

Wardens will:

- Assist and direct employees and guests in an evacuation and other emergency response actions.
- Notify the Primary Warden or Office H&S Coordinator of the need to assign an Emergency Response Buddies.
- Notify the Primary Warden or Office H&S Coordinator of any concern regarding the Plan or any issue seen during an evacuation (real or drill).

In offices where multiple Wardens are assigned, one Warden will be designated "Primary Warden" and will be responsible for coordinating duties of the Wardens. The Office H&S Coordinator may serve as the Primary Warden.

4.6 Emergency Response Buddy ("Buddy")

Buddies are responsible for helping employees or visitors who need assistance in an evacuation or other emergency situation; assistance may be temporary or permanent in nature. In an evacuation, the buddy will do one of the following:

- If the employee needing assistance is able to safely navigate to the exit and assigned meeting location, the Buddy will escort him/her to the designated meeting location.
- If the employee needing assistance is not able to safely navigate to the exit and/or assigned meeting location, one Buddy will escort the employee to a designated area such as an enclosed **stairwell** and wait until Emergency Personnel arrive to assist. The Buddy will notify Emergency Personnel or a Warden of their location in the building.

4.7 Administrative Assistant (at Arcadis locations that have an administrative assistant)

Administrative Assistants are responsible for understanding the EAP for their location and, as applicable, their role in an emergency. Their role may include but is not limited to:

- Calling 911 or other authority.
- Initiating the EAP and providing instructions for staff such as building evacuation, location of the emergency (e.g., fire, gas odor), weather warning, etc., if safe to do so.
- If applicable, directing Emergency Personnel to the location of the employee, client, or visitor who has been injured.
    - If a location has given the Administrative Assistant responsibilities in an emergency, their role will be outlined as suggested in EAP template (Exhibit 3).

4.8 Arcadis Employees

All Arcadis employees will:

- Take part in Emergency Response and Hazard Communication training upon hire, which will cover emergency response procedures, fire prevention, fire extinguisher use, and hazard communication.

- Be knowledgeable of the EAP for their office location, including safe exits and location of their designated meeting area.
- Review and comply with the office EAP or project site unless otherwise directed by Emergency Personnel, Warden, Primary Warden or Office H&S Coordinator.

5. PROCEDURE

5.1 Emergency Action Plan

The primary purpose of the EAP is to inform employees on what to do in the event of an emergency, including how and where to evacuate. Arcadis offices may use an EAP provided by their property owner or Management Company but must verify that the EAP meets all requirements as outlined in this standard and, if it does not, amend the EAP so that requirements are met. If no EAP is available from the property owner/management company, an EAP will be developed. Exhibit 3 shows a portion of the template plan that may be used and links to the full template. Offices with less than 10 employees are not required to have a written plan and may communicate this information verbally unless otherwise required by a local or state regulatory authority.

Evacuation and meeting location maps should be posted in locations regularly used by employees, will include exit and alarm locations and may include designated meeting locations, location of other emergency equipment (e.g. fire extinguishers) and Warden names/areas of responsibility.

Where applicable, a sufficient number of persons will be designated and trained as Fire Wardens, and a Primary Warden named. The Occupational Safety Health Administration (OSHA) recommends one Warden for every 20 employees. Refer to Section 5.1.1 for additional information on assigning Wardens.

The Emergency Action Plan will include the following:

- Emergency evacuation procedures and evacuation route assignments:
    - Copy of the evacuation map.
    - Location of emergency equipment including but not limited to fire pull boxes, fire extinguishers, etc.
    - Refuge or safe areas will be designated, both inside and outside the building, and
    - Outside meeting locations and procedures to account for all employees will be designated.
- Employee notification procedures during an emergency.
- Preferred means of reporting fires and other emergencies.
    - Emergency phone numbers should be posted in conspicuous locations when telephones serve as a means of reporting emergencies.

- Actions to be taken in an emergency.
    - All location specific Plans will include actions to take in the event of:
        - Fire emergencies
        - Solicitors
        - Threats and violence
        - Bomb threat
        - Utility issues, such as gas, potable water and electrical issues
        - Suspicious mail
        - Acts of terrorism
    - In addition, location specific Plans will include actions to take in emergencies specific to their geographical area, such as:
        - Tornados
        - Earthquakes
        - Hurricanes
        - Flooding
        - Blizzards, ice storms
- Rescue and medical duties for those employees designated as first responders (details in Section 5.3).
- Warden and Buddy names and responsibilities.

Where applicable, the EAP will also include the procedures for employees who remain behind to operate critical equipment. (This is generally not applicable to Arcadis offices. Critical equipment is equipment that would endanger lives or aggravate the emergency situation if it ceased to function.)

The plan will be reviewed annually and updated, if required, by the Office H&S Coordinator or their designee. The Office H&S Coordinator remind office staff annually to review the EAP. When changes are made to the EAP, the change will be communicated to all members of the office.

5.1.1 Wardens for Activity Based Workstation Office Settings

In an Activity Based Workstation (ABW) office setting, where Wardens are difficult to assign due to no or very limited assigned seating, it is every employee's responsibility working in an ABW "shared workspace" to act as a Warden to ensure their own safety and the safety of their colleagues and office visitors. It is each employee's responsibility to review the office EAP and know the safe egress routes and designated meeting areas, thus ensuring a safe evacuation for

all personnel. If specific employees are assigned seats based on their role, are capable of, and have agreed to act as a Warden, then specifically identify these employees in the Emergency Plan Chain of Command and Contact Information table.

5.2 Fire Safety

The primary purpose of the Fire Safety Plan is to minimize the possibility of fires in the workplace.

In the event of a fire, employees are required to immediately follow the evacuation process set forth in the office EAP. Fire extinguishers located at Arcadis office locations are not intended for employee use. While no Arcadis employee is required to use a fire extinguisher, all employees are advised in the Emergency Response and Hazard Communication training as to the general principles of fire extinguisher use and the hazards involved in incipient stage firefighting. Employees should never attempt to use an extinguisher if there is any question that their personal safety could be compromised.

The plan should include the following:

- A list of fire hazards in the workplace. For each of these fire hazards, the plan should include:
    - Proper handling and storage procedures,
    - Potential ignition sources,
    - Control procedures,
    - Type of equipment that can control a fire involving the source, and
    - Names or titles of personnel responsible for the control of fire hazards.
- Housekeeping procedures will be followed to eliminate or reduce the accumulation of combustible materials in the workplace. Monthly housekeeping inspections, done to help eliminate fire hazards and keep pathways clear, should be documented. Exhibit 4 is a sample inspection form that can be used for this purpose.
- Explanation of alarm system in place at the office along with any fire suppression and/or smoke alarm systems.
    - Alarm systems should provide warning for necessary emergency action and should be capable of being distinguished above ambient noise and light levels.
    - Alarm systems generally include an audible smoke and/or fire alarm and visual alarm (e.g., strobe lights), but alarm systems may vary depending on state and local fire codes and building age.
    - For most offices, these systems are installed and maintained by the building property managers.

- Names or titles of personnel or vendors who are responsible for maintenance of equipment and systems installed to prevent or control fires.
- Presence or absence of fire extinguishers.
    - Although Arcadis employees are not designated to use fire extinguishers at office locations, if they are provided in the Arcadis suite, monthly visual inspections are recommended unless done by building management. Names of those responsible for the inspection should be noted in the EAP.
    - Documentation of the inspection is maintained for each extinguisher and can be recorded on the extinguisher tag or on an inspection form such as the one found in Exhibit 4 and should include the inspection date, who did the inspection, and any corrective action taken.

If building management owns and maintains the fire extinguishers verify fire extinguisher annual maintenance/service, and periodic testing, and note these completion dates on the inspection documentation form/tag. If Arcadis owns and maintains fire extinguishers, the employee designated to inspect the fire extinguishers will notify the Office H&S Coordinator and Location Lead when a vendor needs to be contacted to perform the annual certifications. The coordination and cost of these inspections will be the office responsibility.

5.3 First Aid/CPR

First Aid/Emergency Response personnel will be designated if medical/emergency facilities are not located in near proximity. Refer to the First Aid/CPR/AED HSS (ARC HSGE004) for additional information on emergency responder requirements and training.

6. TRAINING

6.1 New Hires

New hires, regardless of job function or hours worked per week, will be trained on their office location's EAP. Training will include the following:

- Location of the written EAP (if location is required to have a written plan);
- Employee responsibilities under the EAP;
- Evacuation procedures and meeting location;
- Emergency procedures; and
- Identification and responsibilities of persons tasked with implementation of the EAP.

Employees identified as Fire Wardens and other whose work may deem it necessary will undergo fire extinguishers training annually.

6.2 All Employees

Annually, review the office EAP when requested by the Office H&S Coordinator.

In addition, training will be provided whenever an employee's responsibilities or designated actions under the EAP or the EAP changes. Although employees are not required to use fire extinguishers, those employees who may be more likely to use fire extinguishers as part of their work including employees working on project sites where it is required, employees assigned to company vehicles that have fire extinguishers as part of their equipment, and any others as applicable, are required to undergo training annually.

6.3 Wardens

Employees who have been identified as Fire Wardens shall be trained on their responsibilities as follows:

- Upon assignment
- Annually, and
- Whenever their responsibilities or designated actions under the Plan or the Plan changes.

Exhibit 5 provides a sample agenda for this training.

7. REFERENCES

OSHA Regulations (Standards – 29 CFR) Part 1910 Subpart E "Means of Egress"

OSHA Regulations (Standards – 29 CFR) Part 1910 Subpart L "Fire Protection"

Office locations must verify the EAP also meets any requirements set forth by an applicable state OSHA or local fire code.

Arcadis First Aid/CPR/AED Health & Safety Standard (ARC HSGE004)

8. RECORDS

8.1 Fire Extinguisher Inspections

Fire extinguisher inspection documentation should be maintained until the annual maintenance check is completed. All records will be kept locally by the Office H&S Coordinator.

8.2 Housekeeping Checks

A record of the housekeeping checks shall be maintained and kept by the Office H&S Coordinator.

8.3 Emergency Action and Fire Safety Plan

The EAP will be reviewed at least annually and revised as appropriate. The revision date and number will be documented under "History of Change" Section and the prior plan archived per Arcadis policy.

9. APPROVALS AND HISTORY OF CHANGE

Julie Santaniello, CSP – Corporate H&S Manager of Technical Programs

History of Change

Revision Date	Revision Number	Standard Developed/Reviewed By or Revised By	Reason for change
28 Oct 2009	01		Original document
15 Feb 2013	02	Amanda Tine/Tony Tremblay	Arcadis logo updated; Executive Summary added; Definitions moved into Exhibit 1; Exhibit references were hyperlinked; Near Proximity definition in section 5.3 was corrected with current OSHA Interpretive Guidance; Added information regarding specific employee training on use of fire extinguishers; Added Supervisor responsibility for assigning fire extinguisher training; Added Exhibit 6

Implementation Date 28 October 2009	ARCADIS HS Standard Name Emergency Action and Fire Safety	ARCADIS Design & Consultancy for natural and built assets
Revision Date 27 September 2019	ARCADIS HS Standard No. ARC HSMS008	Revision Number 04

Revision Date	Revision Number	Standard Developed/Reviewed By or Revised By	Reason for change
3 August 2018	03	Julie Santaniello	Template update; revised language from “Emergency Response” to “Emergency Action” to be consistent with OSHA; changed Emergency Response Warden role to Fire Warden; Section 5.1 updated to reflect the EAP template additions; added Section 5.1.1 containing information about Fire Wardens in ABW offices; Section 5.3 revised to refer to First Aid/CPR/AED HSS (ARC HSGE004); updated reviewer from Tony Tremblay to Julie Santaniello; Exhibits renumbered correctly.
27 September 2019	04	Julie Santaniello	Template update; Exhibit numbering update; Emergency Action Plan template updates to Section 7 Fire Safety and Section 16 Coping with Threats and Violence.

EXHIBIT 1 - DEFINITIONS

Emergency Personnel – Ambulance, Fire Department, Police or other authority responding to an emergency.

Emergency Response "Buddy" – Employees who volunteer to aid personnel needing temporary or permanent assistance during an evacuation or other emergency situation.

Fire Warden ("Warden") – Employees who volunteer and are trained to assist in an evacuation and other emergency response actions, and who can be contacted by any employee who needs more information about the Plan or their responsibilities under the plan.

Exit – Either the portion of an exit route that is generally separated from other areas to provide a protected way of travel to the exit discharge (e.g., a fire resistance-rated enclosed stairway that leads from one floor to another or to the outside), or the door or other means by which a room or building may be vacated in an emergency.

Lead Warden – One who oversees and assists the Fire Wardens and Buddies in the event of an emergency.

Meeting Area – That designated area where staff gathers following an evacuation alarm or announcement. May be a location inside or outside a building.

EXHIBIT 2 - ACRONYMS AND ABBREVIATIONS

ABW	Activity Based Working
AED	Automated External Defibrillator
ANA	Arcadis North America
Arcadis	Arcadis U.S. Inc.
BBP	Bloodborne Pathogens
CPR	Cardiopulmonary Resuscitation
EAP	Emergency Action Plan
EMS	Emergency Medical Services
H&S	Health and Safety
HSS	Health and Safety Standard
OSHA	Occupational Safety and Health Administration

EXHIBIT 3 – EMERGENCY ACTION PLAN TEMPLATE

(Link to the Emergency Action Plan Template)

ARCADIS Design & Consultancy for natural and built assets

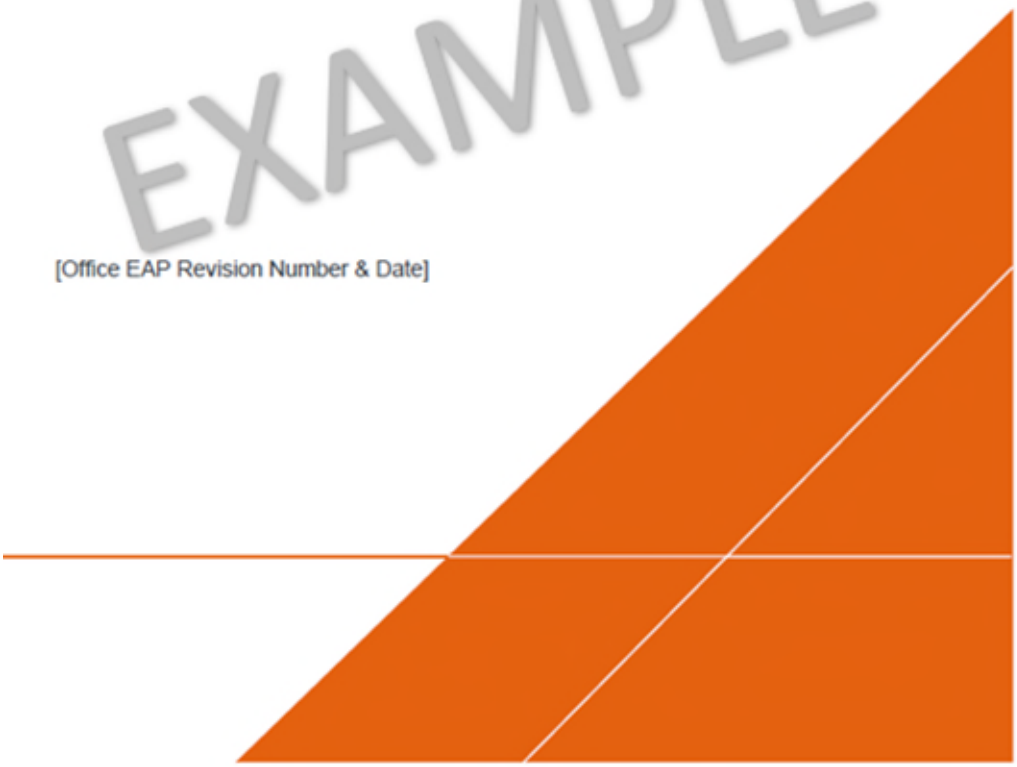
EMERGENCY ACTION PLAN

[Office Name]

[Office Address

EXAMPLE

[Office EAP Revision Number & Date]



Emergency Action Plan [INSERT OFFICE]

EMERGENCY ACTION PLAN

[INSERT OFFICE NAME]

[INSERT BUILDING MANAGEMENT CO- NAME]

Prepared by:

[AUTHORS]

Revision Number and Date:

[OFFICE REVISION # AND [illegible]

*The following general information has been developed to assist you with the safe and efficient handling of an emergency. **Please read it carefully**. This information is in no way all-inclusive, and may be expanded, altered, or revised periodically.*

Emergency Action and Fire Safety H&S Standard_Rev 4_27 September 2019

EXAMPLE

Emergency Action Plan [INSERT OFFICE]

CONTENTS

1 Emergency Contact Information and Phone Numbers 1
2 Emergency Preparedness 2
3 Office Closure Procedure 3
4 Roles & Responsibilities 3
Office Location Leader 3
Office H&S Coordinator 4
5 Overview of Life Safety Systems 4
6 Elevator Emergency 4
7 Fire Safety 5
Cautionary Steps for Preventing Fires 5
Housekeeping 6
Fire Evacuation Proced[illegible]es 6
In[illegible]duals Ne[illegible] Assista[illegible]ce 8
8 Accide[illegible] Illnes[illegible] – Em[illegible]gency M[illegible]dical Support 8
9 Tornado[illegible] high win[illegible] procedures 9
10 Flooding, [illegible]ricanes, and tsunamis 10
Flood and Tsunami Safety Guidance 11
Flooding Safety Guidance: 11
Once the Flood Begins 12
After the Water Recedes 12
11 Unforeseen Inclement Weather 13
12 Earthquake 13
Procedures to Follow After an Earthquake 14
13 Gas Leak – Noxious Odors 15
14 Utility Service Interruption 15
Potable Water Supply Interruption 15
Fire Suppression System Interruption 15
Electrical Service Interruption 15
15 Solicitors 15

EXAMPLE

Emergency Action Plan [INSERT OFFICE]

16 Coping with Threats and Violence 16
General Guidance for Various Threatening Situations 18
Office Lockdown 18
Office Shelter-In-Place 19
Additional Resources 20
17 Bomb Threat 20
Telephone Threats 20
Written Threats 21
Searching Procedures 21
18 Suspicious Mail 21
19 Acts of Terrorism 22
Federal Bureau of Investigation 22
Centers for Disease Control and Prevention 22
20 History of Change 22

EXAMPLE

APPENDICES

Appendix A Evacuation Routes and Designated Meeting Area
Appendix B Emergency Notification Plan Chain of Command and "Call Tree"
Appendix C Employee Headcount Sheet
Appendix D Critical Communications Information Checklist
Appendix E Bloodborne Pathogens Exposure Control Plan Template
Appendix F United States Department of Homeland Security Active Shooter Pamphlet
Appendix G Bomb Threat Questionnaire

1 EMERGENCY CONTACT INFORMATION AND PHONE NUMBERS

Local Emergency Contacts	Phone Numbers
Office Address <INSERT>	<INSERT>
Fire Rescue – Emergency	911
Fire Rescue - Non-emergency <INSERT>	<INSERT>
County Sheriff Department – Emergency	911
County Sheriff Department - Non-emergency	<INSERT>
<INSERT ADDITIONAL AS NEEDED>	<INSERT>
<INSERT ADDITIONAL AS NEEDED>	<INSERT>
<INSERT ADDITIONAL AS NEEDED>	<INSERT>

What if I need to call 911 using Skype for Voice?

Only use Skype if a landline or cell phone is not available. A Skype for Business phone number can only be associated to one physical location and cannot be updated dynamically. Your accounts number is associated with your assigned office location. This is the Emergency Location for your account and the address that will be sent to the Emergency Services operator if you call 911 using Skype for Voice. If you happen to be working from a different location other than your assigned office, it is recommended that you use a different device to contact Emergency Services (911), if available. If no other device is available, be certain to ensure that the Emergency Services Operator knows your current address for accurate dispatch response.

EXAMPLE

Nearest Hospital [NAME & ADDRESS]	Phone Numbers
General Information Number	<INSERT>
Emergency Services-24-hour Number	<INSERT>
TDD Calls (Hearing Impaired)	<INSERT>

Other Contacts	Phone Numbers
Public Service Company (gas leaks)	<INSERT>
Elevator Emergency	<INSERT>
National Weather Service	<INSERT>
State Poison Control Center	<INSERT>

Other Contacts	Phone Numbers
County Public Health Department	<INSERT>
Metropolitan Water District (water leaks)	<INSERT>
<UTILITY COMPANY> (electrical)	<INSERT>
<UTILITY COMPANY> (gas)	<INSERT>

[INSERT COMPANY NAME] Building Management Emergency Numbers	PHONE NUMBERS
Senior Real Estate Manager (As applicable)	<INSERT>
Real Estate Manager (As applicable)	<INSERT>
Building Engineer/Facility Manager (As applicable)	<INSERT>
24 Hour Emergency Line (As applicable)	<INSERT>

Notification Chain of Command	Phone Numbers
Office Location Leader – Primary Contact <INSERT NAME>	<INSERT>
Office Location Leader –Delegate/Secondary Contact <INSERT NAME>	<INSERT>
Remote Worker's Point of Contact (If other than Location leader) <INSERT NAME>	<INSERT>
Office Emergency Response Coordinator(s) <If Other than the Location Leader or H&S Coordinator> <INSERT NAME>	<INSERT>
H&S Coordinator – Primary Contact <INSERT NAME>	<INSERT>
H&S Coordinator – Delegate – Secondary Contact <INSERT NAME>	<INSERT>
Property Management/Building Owner/Facility Manager – Primary Contact <INSERT NAME>	<INSERT>
Property Management/Building Owner/Facility Manager – Delegate/Secondary Contact (As applicable) <INSERT NAME>	<INSERT>

EXAMPLE

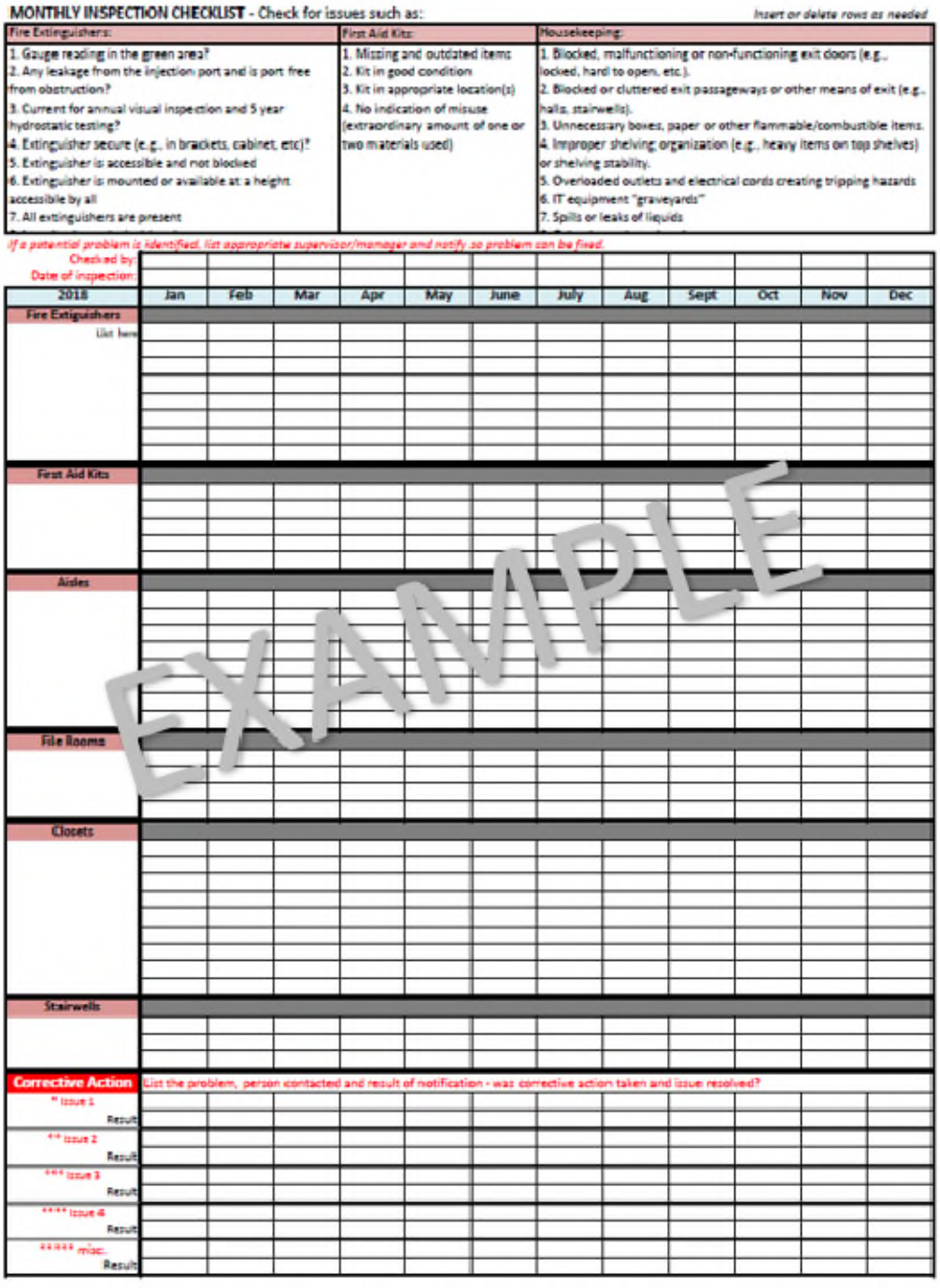
2 EMERGENCY PREPARDENESS

This Emergency Action Plan (EAP) has been prepared to provide an outline of responsibilities and associated actions to take in event of an evacuation and/or an emergency. Many common, but not all potential, emergency situations are covered in this Plan.

As part of the Arcadis emergency preparedness program, all employees will participate in life safety evacuation drills conducted by or in coordination with Office Location Leaders, Building Management, and the Local Fire Department. All Arcadis employees will be trained and be familiar with the office evacuation

EXHIBIT 4 – HOUSEKEEPING AND FIRE EXTINGUISHER CHECKLIST

(Link to Housekeeping and Fire Extinguisher Checklist)



MONTHLY INSPECTION CHECKLIST - Check for issues such as:

Insert or delete rows as needed

Fire Extinguishers:	First Aid Kits:	Housekeeping:
1. Gauge reading in the green area? 2. Any leakage from the injection port and is port free from obstruction? 3. Current for annual visual inspection and 5 year hydrostatic testing? 4. Extinguisher secure (e.g., in brackets, cabinet, etc)? 5. Extinguisher is accessible and not blocked 6. Extinguisher is mounted or available at a height accessible by all 7. All extinguishers are present	1. Missing and outdated items 2. Kit in good condition 3. Kit in appropriate location(s) 4. No indication of misuse (extraordinary amount of one or two materials used)	1. Blocked, malfunctioning or non-functioning exit doors (e.g., locked, hard to open, etc.). 2. Blocked or cluttered exit passageways or other means of exit (e.g., halls, stairwells). 3. Unnecessary boxes, paper or other flammable/combustible items. 4. Improper shelving organization (e.g., heavy items on top shelves) or shelving stability. 5. Overloaded outlets and electrical cords creating tripping hazards 6. IT equipment "graveyards" 7. Spills or leaks of liquids

If a potential problem is identified, list appropriate supervisor/manager and notify so problem can be fixed.

Checked by:

Date of inspection:

2018	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Fire Extiguishers												
(list here)												
First Aid Kits												
Aisles												
File Rooms												
Closets												
Stairwells												
Corrective Action	List the problem, person contacted and result of notification - was corrective action taken and issue resolved?											
* Issue 1 Result												
** Issue 2 Result												
*** Issue 3 Result												
**** Issue 4 Result												
***** misc. Result												

EXAMPLE

EXHIBIT 5 – FIRE WARDEN ANNUAL TRAINING SAMPLE AGENDA

1. Overview of importance of emergency preparedness
2. Emergency notification procedures and chain of command
3. Fire Warden responsibilities
4. Review life safety systems – building fire alarm, fire pull boxes, sprinklers, fire extinguishers, emergency lighting, etc.
5. Fire evacuation procedures
    a. Map of building
    b. Review all routes out of the building
    c. Individuals needing assistance
    d. Meeting area(s)
6. Accident/Illness
    a. Reporting medical emergencies, including contacting 911
7. Severe weather/natural disaster actions
8. Gas leak/noxious odor action procedures
9. Utility service interruption
10. Intruders and solicitors reporting
11. Coping with threats and violence
12. Bomb threat procedures
13. Suspicious mail identification and procedures
14. Acts of terrorism reporting

Attachment E
BNSF Specific Safety
Documents

Contractor Safety Orientation

provided by

Contractor Safety Action Plan Sections

1. BNSF Safety Vision
2. Overview
3. General Information
4. Contractor Credential Requirements
5. Job Safety Briefings
6. Regulatory Training Programs
7. Federal Railroad Administration (FRA) Roadway Worker Requirements
8. Compliance Affirmation

Please note: Only sections 3 & 8 require input.

Appendix

A. Personal Protective Equipment (PPE)
B. Vehicle Operations
C. Fire Safety
D. Incident & Injury Form

BNSF 24-hour Emergency
1-800-832-5452

1. BNSF Safety Vision

The BNSF Safety Vision establishes our fundamental values, a unity of purpose and projects a clear image of the future that has the best interests of all its people at heart.

	"We believe every accident or injury is preventable. Our vision is that BNSF Railway will operate free of accidents and injuries."
Culture	A culture that makes safety its highest priority and provides continuous self-examination as to the effectiveness of our safety process and performance.
Work Environment	A work environment, including the resources and tools, that is safe and accident-free where all known hazards will be eliminated or safe-guarded.
Work Practices and Training	Work practices and training for all workers that makes safety essential to the tasks we perform.
An Empowered Work Force	An empowered work force in which all take responsibility for personal safety, the safety of fellow workers and the communities we serve.

2. Overview

The purpose of a Safety Action Plan (SAP) is to have a structured approach for maintaining safe work activities. Well-developed plans and proper training helps workers understand their roles and responsibilities, which results in fewer and less severe injuries and less equipment damage. General Contractors may submit a SAP including subcontractors or require each subcontractor to submit their own SAP.

REQUIREMENT

The Safety Action Plan must be available as follows:

1. One copy per company uploaded to Contractor Orientation at www.bnsfcontractor.com
2. Site-specific versions provided to the BNSF Project Manager or Employee in Charge (EIC)
3. Site-specific versions maintained with each work group on BNSF property

3. General Information

Company Name:
Arcadis US, Inc. Highlands R
Contractor who is the main point of contact on BNSF property:
Sam Moyers | Director of Transportation Sa | 18656212117 | sam.moyers@arcadis.com
BNSF employee who is contractor's main point of contact:
CHARLES.THOMAS@BNSF
Work Site Location:
Addressed in Site Specific S
Type of Work to be Performed:
Addressed in Site Specific S
Contract Type:

- (●) Primary/General Contractor
- ( ) Subcontractor

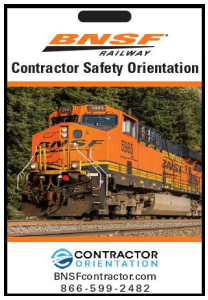
Will your subcontractor(s) complete their own Safety Action Plan or are you covering them on your SAP?
Not Covered
List any subcontractors you will have working on behalf of your company on BNSF property:
Subcontractor 1: *(Required)*
Addressed in Site Specific S | Addressed in Site Specific S |
Subcontractor 2:
Subcontractor 3:
Subcontractor 4:
Subcontractor 5:
Addtional Subcontractors:
List any specific training or qualifications
your employees will have based on the work they will perform.
Addressed in Site Specific SAP or HASP
Other:
If contractors are utilized, their names and contact information will be in the Site-Specific SAP or HASP.

Requirement

Current copies of Safety Data Sheets (SDSs) for hazardous materials **must** be provided to the BNSF Project Manager or EIC **and** be maintained on-site.

4. Contractor Credential Requirements

BNSF Contractor Orientation



Contractors and subcontractors must complete Contractor Orientation at www.bnsfcontractor.com to gain an understanding of the information needed to work safely on BNSF property. After completion of the orientation modules, contractors will receive a BNSF Contractor badge. This badge displays the modules completed, expiration date, and must be made available upon request.

eRailSafe Background Verification

Contractors and subcontractors must complete the eRailSafe background verification before entering BNSF property or having access to BNSF information systems. Each approved eRailSafe applicant will receive a photo ID badge, which must be worn visibly on their person. www.erailsafe.com

5. Job Safety Briefings

The Contract employer **must** ensure their workers receive Job Safety Briefings at the start of each work shift **and** as needed during the course of the day; e.g. personnel changes, weather changes, and/or changes in assignments.

- Job Safety Briefings will include Emergency Preparedness Information and summarize the findings of Risk Assessment activities.
- In addition to critical safety and response preparation, Job Safety Briefings provide information on potential exposures in the work environment, discussion about the best ways to minimize risk to exposure, and potential cues to pause the work.

Begin each shift with a

JOB SAFETY BRIEFING

1. LIFE-SAVING PROCESSES & EMERGENCY PREPAREDNESS	BNSF 24-hour Emergency 1-800-832-5452
Who is CPR qualified? Who is First Aid qualified?	Where is the defibrillator? Where is the First Aid Kit?
Is there cell, radio and/or land line contact? If not, who will establish it?	Who will create written directions to job site to use in case of emergency (latitude/longitude recommended)?
What are the emergency numbers? • Medical • Fire • Police	Who will make the emergency call? Who will meet emergency personnel?
2. DISCUSS THE TASK AT HAND	How will weather conditions, crew experience levels, equipment and processes affect the task to be performed?
3. IDENTIFY THE EXPOSURES	What are the exposures present for the task to be performed?
4. DISCUSS WAYS TO MINIMIZE RISK	How do we control risk for each exposure?
5. IDENTIFY CUES TO PAUSE THE WORK	What are the cues for pausing the work to rebrief?
Weather, location, schedules and equipment can change in a moment's notice—changing the level of risk. One briefing at the beginning of the shift is often not enough to ensure everyone is aware of changes throughout the day. When you notice that things have changed, pause and choose safety.	 Pause the work Assess conditions Understand the risk Strategize a safer plan Execute the plan

Consider the exposures below and how you might protect yourself and your workers.

LIFE-SAVING PROCESSES	
	Life-Saving Processes are proactive processes we consistently perform that may help protect us from the most critical risks.
EXPOSURES	
	Line of Fire/Release of Energy is an exposure that exists when a person or an object may be unexpectedly struck between two objects coming together. To mitigate risk to this exposure, avoid placing your body in a position to be hit, cut, struck or sprayed if something shifts, moves, releases or travels unexpectedly.
	Pinch Point is an exposure that exists when a person places his/her fingers or toes between objects that could crush them if the object came together unexpectedly.
	Ascending/Descending is an exposure that exists in environments where moving from one level to another may be necessary. Mitigate risk to this exposure by using three-point contact, avoiding jumping from one level to another, using hand rails on stairs and looking before stepping when climbing and going from one place to another.
	Walking/Path of Travel exposure is an exposure along a path of travel that could cause a slip, trip or fall. Look in your path of travel before moving, scan the path, use designated pathways when walking and take the safest route available to mitigate this exposure.

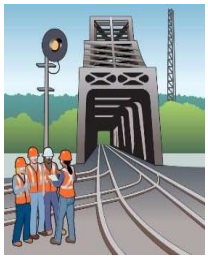
6. Regulatory Training Programs

Contract companies are responsible to ensure their workers and subcontractors are properly trained to meet all regulatory requirements prior to beginning work for BNSF. Examples include:

- Arc Flash/Electrical Worker
- Fall Protection
- Lead Safety

- Asbestos
- Confined Space
- DOT Training
- Environmental/Hazardous Waste
- Excavatoin (Trenching/Shoring)
- FRA Bridge Worker Safety
- FRA Roadway Worker
- Hazard Communications
- Hearing Conservation
- Lockout/Tagout
- Personal Protective Equipment
- Respiratory Protection
- Other Safety Training Programs

7. Federal Railroad Administration (FRA) Roadway Worker Requirements



Per the FRA, Roadway Worker duties include inspection, construction, maintenance or repair of track, bridges, roadway, signal and communication systems, electric traction systems, roadway facilities or roadway maintenance machinery on or near track or with the potential of fouling a track, and other personnel directly involved with their protection.

For contractors or subcontractors performing Roadway Worker duties as defined above,

1. Contractor and subcontractor companies must provide these workers annual FRA Roadway Worker Protection (RWP) training, **and** these contract workers must be able to provide current RWP training documentation. *RWP concepts should be reinforced in Job Safety Briefings.*
2. Contractor and subcontractor companies must ensure they are in compliance with the FRA Part 219 Drug & Alcohol Testing requirements and the FRA Part 243 Training, Qualification, and Oversight requirements. Contact the FRA at rrswebinquiries@dot.gov with any questions.

8. Compliance Affirmation

The following section serves as your company's Compliance Affirmation to this document:

Name: Sam Moyers

Title: Director of Transportation Sa

Date: 2023-01-11

Thank you for completing your Safety Action Plan!

Appendix

A. Personal Protective Equipment (PPE)

PPE compliance is strictly enforced as per Section 21 of BNSF Safety Rules. Your contract may require a variety of work and tasks in different environments, and all workers must have the proper PPE while on BNSF property.

All individuals must have the appropriate PPE when on BNSF property, including:

- Eyewear & Face Protection
- Steel-toed boots/anti-slip footwear
- Hard Hat
- Hearing Protection
- Gloves/Hand Protection
- High-Visibility, ANSI Class II or III vest (based on type of work performed)

Other specialty PPE as identified/required by BNSF Safety Rules for task at hand.

B. Vehicle Operations

Vehicle Operation Guidelines

Every day, there is a wide variety of vehicles operating safely and without incident. However, we must remember that we work in an unforgiving environment.

Identify Exposures and Discuss the Best Ways to Minimize Risk

Line of Fire/Release of Energy

- Obey all traffic control signs and be aware of current surroundings at all times to avoid being in the line of fire from other vehicle traffic
- When at non-public crossings, stop before crossing the track(s), unless the vehicle is foul of a previously crossed track. Yield to trains, engines, rail cars, and on-track equipment before proceeding across the track(s).
- Identify and comply with proper clearance requirements prior to operating vehicles between tracks.

Ascending Descending

- Use caution when boarding or disembarking vehicles. Verify stable footing before getting in or out of the vehicle.
- Do not place your feet where your eyes have not been.

Pinch Point

- Keep fingers away from door hinges, and feet/toes away from door edges to prevent them from being crushed if door shuts/slams unexpectedly.
- Use the door handles or latches when opening and closing doors.

Life-Saving Processes

- Know and obey local, state and federal laws and vehicle operation regulations, both on and off company property
- Wear seat belts while operating or riding in equipment or vehicles that are equipped with them, as required.
- While driving, do not use cellular phones or similar handheld devices for voice communications in other than hands-free mode. Do not read or manually enter text messages.
- Use headlights any time the vehicle is moving.

What should be done before operating any vehicle and why?

- A thorough pre-use inspection of the vehicle should be performed with proper documentation and correction of any defects found to ensure that vehicles are in optimally safe condition.
- Operators must be trained and authorized for the vehicle that they will be using, where required. Every driver must carry a valid driver's license.
- When driving a car or truck, workers are expected to comply with posted speed limits and operate the vehicle in a safe and careful manner.
- Studies show that seat belts save lives. Workers must wear seat belts while operating or riding in vehicles on BNSF property.

What is the safest way to back up a vehicle?

It's best to position the vehicle to avoid backing up, if possible. If backing up is necessary, inspect the areas to the rear before beginning the movement to ensure that no people or obstructions are in the path.

- Position someone near the back of the vehicle to guide the movement, when possible.
- Sound the horn (three short blasts) in vehicles not equipped with back-up alarms.
- Stop if the person guiding the movement disappears from view.

What are the proper procedures for parking safely?

- Avoid parking on an incline, if possible. If parking on an incline is unavoidable, the driver should set the emergency brake and take other precautions to prevent the vehicle from rolling unexpectedly.
- Do not park so that vehicle is fouling a track or roadway. If fouling is necessary to perform duties, do so only if proper protection has been established.

C. Fire Safety

Before performing hot work tasks in right-of-way areas, work groups must perform a **thorough Fire Safety Risk Assessment,** ensure the **proper precautions** are in place, confirm that **specific fire-fighting tools are available** and establish **an emergency plan** to help prevent fires from being started by hot work activity.

What hazards may be present when performing hot work tasks in right-of-way areas?

Hand welding, cutting and grinding operations result in sparks or slag that can readily ignite a fire. In addition, serious injury can occur should clothing ignite.

What precautions can be taken when performing these operations to help prevent fires?

- Use protective screens or blankets to contain errant sparks or slag.
- Wet down the immediate work area and surrounding area before work begins.
- Make saw and torch cuts to the centers of track and direct small-scale grinding sparks to ballast to better contain sparks and slag.

What steps must be taken before work begins in right-of-way areas?

Before performing hot work activities, work groups must conduct a **Fire Safety Risk Assessment** to:

- Determine current fire conditions, including whether local work restrictions are in effect and/or whether special permits are required.
- Establish the response capabilities of the local fire agency.

What factors should be considered when doing a Fire Safety Risk Assessment?

A thorough fire safety risk assessment must take into consideration factors such as:

- Vegetation Type
- Temperature
- Time of day of work activities
- Rainfall
- Wind speed/direction
- Type and extent of work actvities
- Relative humidity

How does weather factor into fire safety during hot work tasks?

- Each work group must complete a **fire risk assessment** before work begins. This assessment should include considerations such as weather conditions and the use of a wind meter to determine wind speed. Hot work operations **should not** be conducted when wind speeds exceed 30 mph.

What elements must an Emergency Preparedness Plan include?

- Verify that Emergency Preparedness plans contain contacts and response times for responding fire agencies, as well as directions to the work site.
- Identify and communicate escape routes.
- Mechanically clear and/or apply herbicides along right-of-way areas to inhibit the growth of vegetation that provides fuel for fires.
- Comply with local fire agency requirements. Be sure to clear low spots, areas around culverts, etc. of vegetation that could provide fuel for fires.

D. Incident & Injury Form

NON-EMPLOYEE PERSONAL INJURY DATA COLLECTION

Please complete this form and provide to the BNSF supervisor, who will input this information into the EHS Star system. For questions call (817) 352-1267 or Safety.IncidentReporting@BNSF.com

Accident City/State: _____ **Date:** _____ **Time:** _____

Line Segment/Mile Post: _____ **County:** _____

Temperature: _____ **Weather:** _____

Name (Last/First/MI): _____

Job Title: _____ **Age:** _____ **Gender:** _____

Company: _____

eRailSafe Badge Number: _____ **Expiration Date:** _____

BNSF Contractor Badge Number: _____ **Expiration Date:** _____

Injury: _____ **Body Part:** _____
(e.g., laceration) (e.g., hand)

Description of accident (include how accident occurred, potential cause, etc.):

_____

_____

_____

Work activity in progress at time of accident: _____

Tools, machinery, or hazardous materials involved in accident: _____

_____

Treatment Received (include medications):

_____

_____

_____

Dr. Name: _____ **Date:** _____

Dr. Street Address: _____ **City:** _____ **State:** _____ **Zip:** _____

Treatment Facility Name: _____

Treatment Facility Street Address: _____ **City:** _____ **State:** _____ Zip: _____

Diagnosis: _____

THIS REPORT IS PART OF BNSF'S ACCIDENT REPORT PURSUANT TO THE ACCIDENT REPORTS STATUTE AND, AS SUCH SHALL NOT "BE ADMITTED AS EVIDENCE OR USED FOR ANY PURPOSE IN ANY SUIT OR ACTION FOR DAMAGES GROWING OUT OF ANY MATTER MENTIONED IN SAID REPORT…" 49 U.S.C. § 20903. See 49 C.F.R. § 225.7(b).

UPDATED: August 17, 2022
Subject to change at any time

COVID-19 Response and Control Protocol

This protocol is grounded in guidance from the Centers for Disease Control and Prevention (CDC). It should be adjusted based on circumstances, public health department guidance, applicable laws and company policy. Ensure you use the most up to date version of this protocol found on the Employee Portal.

Mask Use

Face mask use is recommended but not required when indoors on BNSF property or in public settings when community transmission is at a High level. Local COVID-19 Community Levels are regularly updated by the CDC. Employees must also adhere to any additional locally applicable COVID-19 prevention measures and face mask requirements.

Symptom Monitoring

Employees are required to self-screen for COVID-19 symptoms prior to entering the worksite and be alert for symptoms throughout the day. If COVID-19 symptoms are experienced, isolate from others and stay home following your department's standard time off process for illness (see "What should I do if I have COVID-19 symptoms?" section). It is recommended to seek care and testing. If the employee tests positive for COVID-19, follow instructions below.

Diagnosis or Positive COVID-19 Test

An employee diagnosed with or testing positive for COVID-19 must isolate from others, report using the COVID-19 Reporting Tool on the BNSF Employee Portal and stay home for at least five days from symptom onset (or test date if asymptomatic). Follow the department's standard time off process for illness.* The employee may return to work when the COVID-19 return criteria are met (see "Returning to Work" section).

** Employees are required to submit a copy of their positive COVID-19 test via email to covidtest@bnsf.com [include your name and employee ID (ex. B123456)] within three days of the initial report. For scheduled employees, you will lay off sick until your positive COVID-19 test is verified, at which point the time off will be converted to a medical leave of absence backdated to the case start date. The test result must include the employee's name and the date the test was administered if available. Home tests will qualify as proof for the first COVID-19 medical leave of absence after August 17, 2022; subsequent COVID-19 medical leaves of absence will require the employee to submit a lab administered test with the employee's name and date.*

The employee's supervisor is to isolate the employee's work environment and equipment as soon as possible and initiate enhanced cleaning as needed based on movement patterns and time from exposure.

The BNSF Medical Team will monitor the situation closely and may take additional actions, including case investigation and contact tracing, if a situation warrants.

Onsite Contractors

Contractors with COVID-19 will immediately remove themselves from BNSF property, notify their employer and BNSF point of contact, and follow their employer's guidance. The contractor should not return to BNSF premises until their employer's protocols and/or CDC criteria are met.

BNSF Sourcing team will send an email notification to specific designated individuals on the BNSF Medical team (Mike.Ray@bnsf.com & Candy.Raglin@bnsf.com) with the contractors work location and other relevant details.

Close Contacts
If you are in close contact to a person with COVID-19, the CDC recommends you should 1) monitor for symptoms, 2) wear a well-fitting mask for ten days while around others or at work, and 3) test five days after your last exposure. If at any time you test positive for COVID-19, follow protocols for positive employees.

What should I do if I have COVID-19 symptoms?

If you are experiencing symptoms of COVID-19, follow these five steps:

1. **Recognize the symptoms:** People with one or more of these symptoms may have COVID-19: Fever or chills, cough, shortness of breath or difficulty breathing, fatigue, muscle or body aches, headache, new loss of taste or smell, sore throat, congestion or runny nose, nausea or vomiting, or diarrhea.

2. **Seek medical care and testing as needed:**

   - If you are experiencing a medical emergency, call 911 and get medical attention immediately.
   - Follow your doctor's recommendations and review the CDC guidance for Steps When Sick.
   - Take care of yourself and family. BNSF offers access to EAP licensed mental health professionals at 800-383-2327 to help you navigate these uncertain times.

3. **Notify your supervisor and use Self-Reporting Tool:**

   - Do not come to work or immediately remove yourself from the work environment if you have symptoms or test positive for COVID-19.
   - Notify your supervisor and use the COVID-19 Reporting Tool (including those working from home) if you test positive for COVID-19. A copy of your positive COVID-19 test must also be submitted via email to covidtest@bnsf.com [include your name and employee ID (ex. B123456)] within three days of submitting the initial report.
   - Cooperate with local Human Resources and Medical representatives who will coordinate appropriate workplace response and notifications.

4. **Follow leave processes:**

   - **Salaried/Exempt employees:** Normal sick leave rules apply, and sick days are paid at 100% of regular salary. See Sick Leave Corporate Rule for more details. If you need to use Short-Term disability benefit, let your supervisor know and HR will assist you.

     Union Represented/Scheduled employees: Scheduled employees should follow your department's standard time off process for illness, utilizing unused vacation, personal leave

days, sick or other paid time off granted in their collective bargaining agreement. In addition to applicable leave benefits, scheduled employees may be granted an unpaid medical leave of absence upon submission of a qualifying positive test result. Lay off sick until your positive COVID-19 test is verified, at which point the time off will be converted to a medical leave of absence backdated to the case start date. The test result must include your name and the date the test was administered if available. Home tests will qualify as proof for the first COVID-19 medical leave of absence after August 17, 2022; subsequent COVID-19 medical leaves of absence will require the employee to submit a lab administered test with the employee's name and date. After a seven-day waiting period, sickness benefits may also be available through the RRB. See RRB.gov for more details.

Returning to Work Following COVID-19-Related Leave

If you are getting ready to return to work following a leave of absence related to COVID-19, follow the instructions below and contact your supervisor as soon as possible before your anticipated return date to review a transition plan.

Determining your return to work date

If you were in home isolation because you contracted COVID-19, you can return to work after these three things have happened:

- At least 5 full days* have passed since your symptoms first appeared (or since the date of your first positive diagnostic test if asymptomatic). Day 0 is your first day of symptoms or a positive viral test. Day 1 is the first full day after your symptoms developed or your test specimen was collected.
- You are fever-free for 24 hours (without the use of fever-reducing medication)
- Your symptoms have improved

You will be automatically returned to work following 5 full days from symptom onset (or test date if asymptomatic). If you are experiencing fever or your symptoms have not improved and need to continue your leave past day 5, call the BNSF Medical team by 5:00pm CT on day 5 from symptom onset at 877-878-3095 Option 2.

**NOTE: If you had moderate illness (if you experienced shortness of breath or had difficulty breathing), or severe illness (you were hospitalized) due to COVID-19, or you have a weakened immune system, you need to isolate through day 10. If you had severe illness or have a weakened immune system, consult your doctor before ending isolation. Scheduled employees should follow existing protocols as outlined in your return-to-work paperwork if you have been hospitalized or not worked 30 days or more.*

Precautions to take after ending isolation

After you have ended isolation, wear your mask through day 10. Alternatively, if you have access to antigen tests, you should consider using them to determine how long to continue mask use. A mask should be worn until two sequential negative tests are confirmed 48 hours apart.

Attachment F
Railroad Worker Protection

DOT Facts-201a

What is Roadway Worker Protection (RWP) Training?

Railroad safety is governed by the US Department of Transportation, Federal Railroad Administration (FRA) under 49 CFR Part 214. This regulation requires railroads to ensure "roadway workers" are trained under the railroad's program for on-track safety when performing work within 4 ft of the field side of the near running rail of a railroad track. This training must meet content expectations of the FRA. It should be noted that all Class I railroads apply 49 CFR Part 214 roadway worker training requirements to any work being performed within 25 ft of the field side of the near running rail and others, like Canadian National (CN), may require this training anywhere on their property without regard to proximity to the rail.

"Roadway worker" is defined as any employee of a railroad, or of a contractor to a railroad, whose duties include inspection, construction, maintenance or repair of railroad track, bridges, roadway, signal and communication systems, electric traction systems, roadway facilities or roadway maintenance machinery on or near track or with the potential of fouling a track, and flagmen and watchmen/lookouts.

Your railroad client may require you to be Roadway Worker Protection (RWP) trained and also trained under the railroad's general safety program for contractors. Commonly referred to as "on-track safety training", "FRA Training", or "safety orientation," you will likely receive a basic version of RWP under these orientation programs. Contact your project manager or supervisor for the railroad project of interest to ensure all training requirements are met. Training is required annually.

Training Requirements for Work in Vicinity of Railroad Tracks which is not performed under Contract to a Railroad

The project team must contact the railroad owning the track to confirm any specific training requirements when not under contract to the railroad. If not under contract to a railroad and the host railroad does not require specific training for work performed in the regulatory foul zone (within 4 ft of the field side of the near running rail) when performing the work, then ARCADIS requires, at a minimum, completion of basic Roadway Worker Protection training meeting 49 CFR Part 214 requirements provided by www.railroadeducation.com. Alternatively, ARCADIS will accept CSX, NS, and CN classroom training on RWP to meet the 49 CFR Part 214 requirements.

This minimum training requirement also applies to work performed at railroad crossings while in the public right-of-way.

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Revision 6, 11/20/2014

General Training Requirements by Railroad:

Railroads requiring classroom based training meeting both railroad safety orientation and RWP training requirements include:

- CSX Transportation (CSX)
- CN

You will be issued a card from these railroads indicating you have had the required training and must have this card on your person when performing work any time you are on railroad property.

Norfolk Southern (NS) Railroad does not require any additional training beyond FRA requirements for roadway workers. NS does not offer classroom training designed to meet FRA requirements for liability reasons, but Roadway Worker Training (RWT) does offer a NS specific classroom RWP training. However, NS generally accepts RWP training from any recognized source that meets the minimum RWP requirements under 49 CFR Part 214. Employees working on and about NS track should be familiar with NS Contractor Safety Guidelines to address general site health and safety requirements.

Other class I railroads including Union Pacific Railroad (UPRR) and Kansas City Southern (KCS) require online training having two separate components: 1) focusing on railroad specific health and safety policies and procedures and 2) to address RWP training requirements. For these railroads, the training is conducted through www.contractororientation.com and www.railroadeducation.com. You will be issued 2 badges (one for each training) which you are required to have on your person any time you are on the railroad property.

Canadian Pacific (CP) requires two components be completed prior to entering CP property: 1) e-RAILSAFE (both U.S.-specific and Canada-specific versions exist), and 2) you must read the Minimum Safety Requirement for Contractors Entering Railway Property (again, both U.S.-specific and Canada-specific versions exist). Both documents can be found on the internal ARCADIS CP Team Site.

BNSF Railway requires online training through BNSF Contractor Safety Orientation (http://bnsfcontractor.com/), which is coordinated through the ARCADIS Training Center, and also requires completion of RWP training through www.railroadeducation.com unless otherwise instructed by an authorized BNSF representative.

Amtrak requires online training through www.AmtrakContractor.com .

For commuter railroads and short line railroads, contact the railroad for specific training requirements.

Railroad Security Training and Background Checks:

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Your railroad client may require you to be a participant in e-RAILSAFE as part of security requirements under Federal Railroad Administration and Department of Homeland Security recommendations. This on-line program will collect information from you, including your picture and social security number, for the purpose of performing background checks for the railroad. You will be issued an e-RAILSAFE badge which the railroad will require you to have on your person when working on railroad property. A security training module will also be part of the e-RAILSAFE security program. The security screening program is required to be renewed every 2 years. The process for issuing an eRAILSAFE badge can require up to three weeks.

Railroads currently participating in e-RAILSAFE security screening include, but not limited to:

- CSX Transportation
- BNSF Railway
- CN
- UPRR
- NS
- Conrail
- Canadian Pacific

Since eRAILSAFE deals with background checks, this activity is coordinated and arranged through corporate Human Resources. Contact Paula Harrison in the Toledo office (alternate: Anne Bergen-Taylor in Highlands Ranch office) to enroll in eRAILSAFE.

<u>Additional requirements for Union Pacific and CSX Railroads:</u>

UPRR has a video required to be viewed annually providing an overview of health and safety issues related to UPRR work. This video is available for viewing on the ARCADIS Training Center team site.

CSX may require an additional video or presentation to be viewed relating to contractor safety on CSX property. If this video is required, you will either view it during your classroom session or be instructed during the classroom session on how to access and view the video or presentation.

Any railroad issuing a training revision mid-year for any reason will require all employees trained under that railroad's RWP program to be trained in the new requirements within timeframes specified by the railroad.

How to enroll in RWP/On Track Safety courses:

These training offerings can be assigned to the employee needing the training by their supervisor through the ARCADIS Training Center.

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Frequently Asked Questions:

Q1: If I get trained by one railroad, it that training valid for other railroads?

A1: For the railroad specific health and safety policies and procedures portion of the training, it is unlikely to transfer. So, for employees requiring on-line training, employees will have to complete all courses taken through www.contractororientation.com . Employees completing RWP training through www.railroadeducation.com will only need to complete that course once for all railroads requiring training from that vendor. CN and CSX training meeting RWP requirements are generally not transferrable to other railroads and vice versa.

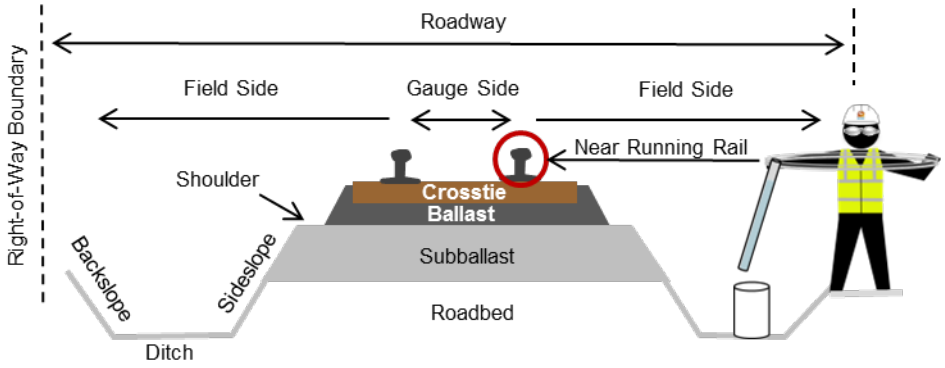
The e-RAILSAFE security screening is good for multiple railroads provided an additional fee is paid to e-RAILSAFE for each railroad requested.

Q2: The training seems duplicative and not relevant to our work activities. Are you sure we are supposed to have all of this training?

A2: The railroad specifies required training and the vendor(s) to be used. ARCADIS has no control over the training content.

Q3: Define "field side of the near running rail"

A3: The graphic below illustrates this concept.



Tangent (Straight) Track

Q4: What training is required for plant, tourist, scenic, or excursion tracks?

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A4: Refer to DOT Facts-201b for information on these types of tracks.

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DOT Facts-201b
Safety Best Practices on Plant, Tourist, Scenic and Excursion Tracks

This fact sheet provides best practice guidance when working on or near plant, tourist, scenic and excursion railroad tracks not subject to Federal Railroad Administration (FRA) Regulations.

Tracks not Governed by the FRA

Railroad tracks not governed by the FRA are tracks which are not part of the "general railroad system of transportation" which means the network of standard gage track over which goods may be transported throughout the nation and passengers may travel between cities and within metropolitan and suburban areas. Tracks which are used exclusively to move or handle rail cars inside a facility are not covered by FRA regulations covering health and safety but are instead governed by the Occupational Health and Safety Administration (OSHA). These types of tracks are commonly referred to as "plant tracks". They remain outside of the general railroad system of transportation even when they connected to that system by means of a switch. However, if a railroad operating in the general railroad system of transportation is delivering or picking up rail cars, that portion of the "plant tracks" is governed by FRA during those operations.

For tourist, scenic, and excursion tracks, similar rules apply if the tracks are off the general railroad system of transportation and are insular. The term "insular" only applies to tourist operations over tracks outside of the general system used exclusively for such operations. FRA considers a tourist railroad to be insular if its operations are limited to a separate enclave in such a way that there is no reasonable expectation that the safety of any member of the public "except a business guest, a licensee of the tourist operation or an affiliated entity, or a trespasser" would be affected by the operation.

Additionally, the FRA does not regulate railroad tracks less than 24 gage.

Safety Best Practices on Non-FRA Regulated Tracks

ARCADIS policy is to utilize general railroad health and safety rules on all railroad tracks without regard to applicability to FRA regulations. To achieve the highest level of health and safety, especially on plant tracks, ARCADIS recommends the following requirements be integrated into project specific health and safety plans and/or Job Safety Analyses (JSAs).

- Do not foul any track unless client provided track protection is in place. Fouling means within 4 ft of the field side of the near running rail. Coordinate with designated client

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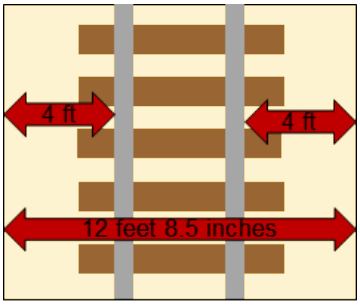
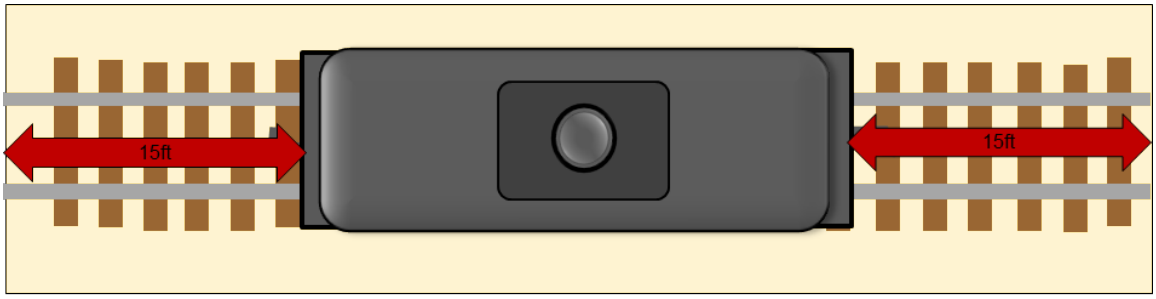
representatives and/or utilize client specific procedures to render the track inaccessible to rail traffic, if fouling of the track is required. When working within the foul zone, the track must be made inaccessible by means of a derail, switch, or other device that will prevent entry of a train or on track equipment traffic into the work area.



Foul Zone

- Do not foul a track with equipment unless the track is made inaccessible to train traffic as described above. "Equipment" means any object that an individual cannot pick up and carry in a timely manner and may include hoses or piping that might cross the track.
- Wear a high visibility traffic vest (Class II minimum) when working within 25 ft of the tracks.
- When walking across tracks, always stop and look both directions prior to crossing.
- Never step on rails because they may be slick and create a slip or fall hazard.
- Do not cross over, through or between rail cars or on track equipment.
- Never carry objects that obstruct your view of the track and keep hands out of pockets when crossing tracks.
- Except when on a plant roadway, never cross within 15 ft of stationary rail cars or other on track equipment.



Do Not Cross Within 15 ft of a Standing Railcar

- Do not use cell phones or radios within 25 ft of the track unless they are used for emergency situations or to communicate with the client on rail traffic issues within the facility.
- Stop work, increase distance from track (preferably 25 ft from the nearest rail) and face oncoming rail traffic during passing rail traffic in your work area.
- Use caution when walking in areas where ballast is present as the ballast may shift or roll creating a slip and fall hazard.
- Do not undermine the integrity of tracks by digging out ballast or soil to run hoses or piping under the track unless approved by the client and a competent person.
- If adjacent tracks are within 25 ft of the active work area when fouling a track, recommendations specified in this fact sheet also apply to those tracks.

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Frequently Asked Questions

Q1) We are planning to do work within 25 ft of a rail spur that is on client property. Once a week, CSX delivers and picks up cars at the facility using this spur. We plan on scheduling our work so we will not be near the rail spur on the day CSX delivers. Do we have to have "FRA Training"?

A1) Yes, ARCADIS policy is to ensure all field staff on the project that may be working near the referenced spur be trained in On-Track Safety Rules required by 49 CFR Part 214 (commonly referred to a "FRA Training") even when working on days where CSX delivery is not anticipated. Only work in the portion of the track accessed by CSX would require "FRA Training". Contact the host railroad (CSX in this case) for training guidance or refer to DOT Facts-201a for more information.

Q2) Our client does not have any safety requirements for working on or around their plant tracks. What should we do in this situation?

A2) Follow guidance specified in this fact sheet. If active rail activities are or have a reasonable potential to occur while ARCADIS work is being performed in proximity to the track or tracks, utilize a dedicated watchman lookout trained under 49 CFR Part 214 requirements. CSX, NS, CN and www.railroadeducation.com training provide content meeting this ARCADIS requirement.

Q3) What if my work activity is inside a building that is within 25 ft of the rail with active rail traffic. Do I have to pay attention to the rail operations being performed or have special training?

A3) the 25 ft of the field side of the near running rail is the goal for open area work. If the work activity is separated by a permanent wall, fence or similar barricade at a closer distance to the rail, the distance subject to DOT Fact Sheet 201b will be determined as the distance between the barricade and the field side of the near running rail.

Q4) What about tracks at amusement parks and zoos, including tracks for "kiddie train rides" that my run through these properties?

A4) The requirements of this fact sheet apply to amusement park/zoo trains during park operating hours or times when they are in operation (safety checks prior to park opening, etc.). Work with the client or property owner/representative concerning appropriate times to access areas that might affect these operations.

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Q5) The client stated the section of track where we will be working is no longer used. Do the requirements of this fact sheet apply?

A5) The project team can rely on client information concerning track use and frequency. However, if the track is connected to a section of plant track that is used, confirm the section of the track in the work area is inaccessible by observing for presence of derails, switch positions or other device/condition creating inaccessibility. If track inaccessibility cannot be confirmed through field observation, requirements of this fact sheet will apply. See also Q2 above.

Q6) Where can I get training meeting the FRA training requirements?

A6) See DOT Facts-201a for training information.

Q7) There is a lot of information in this fact sheet. Can I just print it off and attach it to my HASP instead of copying the information in the HASP or JSA?

A7) This fact sheet should be reviewed and applicable recommendations transcribed into a specific project JSA or within the project specific HASP. Integration of applicable client requirements should also be considered. This will allow the project team to carefully consider all requirements and plan properly for work in vicinity of railroad tracks.

Q8) Does work in vicinity of rapid transit trains in cities require FRA Training or can we just follow requirements in this fact sheet?

A8) If the rapid transit system is on exclusive use tracks, follow this fact sheet, paying particular attention to Q2 above, if the client or operating rapid transit entity does not provide specific guidance or safety requirements to be followed. Otherwise follow the operating rapid transit system entities safety requirements. If the system is operated on tracks that are defined as general railroad system of transportation tracks, then "FRA Training" is required when work is performed in proximity to the tracks.

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DOT Facts-201e
Short-Term Track Fouling

Vehicle Track Fouling:

Except when vehicles are crossing at a railroad grade crossing, ARCADIS has a zero foul policy concerning vehicle operation within 7 ft of the field side of the near running rail unless the work area is controlled by working limits in accordance with the operating railroad's Roadway Worker Protection (RWP) rules.

At roadway grade crossings, vehicles should be operated in such a manner that they can stop >7 ft (ARCADIS policy) from the field side of the near running rail if a train is approaching. In no case will an ARCADIS driver permit an ARCADIS vehicle to remain stationary within the foul zone of a track due to backed up traffic on a roadway or due to red lights.

On railroad property or a roadway grade crossings without automated signals warning of an approaching train, ARCADIS drivers will stop the vehicle >7 ft from the field side of the near running rail and look both directions for presence of oncoming trains or on track equipment prior to crossing the tracks. ARCADIS drivers operating commercial motor vehicles must follow applicable requirements of section 5.3 of ARC DOT-005 "*Driving Commercial Motor Vehicles*"

Employee Track Fouling:

Except when crossing tracks to get to the other side, ARCADIS requires all work activities within 4 ft of the field side of the near running rails (track fouling) to be conducted under RWP rules of the client or host railroad. For Class I railroads, ARCADIS expects any work performed within 25 ft of the field side of the near running rails to be conducted under RWP rules of the client or host railroad This includes watchman/lookout under rules for Train Approach Warning (TAW) or working under Working Limits. ARCADIS does not permit ARCADIS employees to operate under individual train detection unless the operating railroad issues a working radio and the employee has knowledge of its use and communication provided.

Track fouling within working limits requires an employee in charge (EIC) to be designated. Track fouling outside of working limits requires designation of a EIC for some railroads and a Designated Railroad Point of Contact (POC) for others. The project team must coordinate closely with the client or host railroad to determine accessibility to the EIC/POC, or if the EIC/POC is required be present on the project site. This coordinated determination shall be clearly communicated to all field staff during the job briefing which must include the invovlement of the EIC/POC. If the client or host railroad determines that the EIC/POC is not required to be on site for some or all of the project duration, the following applies:

- The provisions fact sheet DOT Facts-201d apply.

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- The required job briefing will be conducted by phone or radio if EIC/POC is not present on site.
- The employee will only foul the track for that period of time necessary to perform the task. Prior to entry into the foul zone the employee will stop, look in both directions for oncoming trains or on-track equipment, then proceed to the work location.
- The employee will position himself or herself during work in such a manner that he/she can watch for trains coming from either direction and maintain visual contact with the Watchman/Lookout. If work activity will require focused work, the employee must also be in verbal contact with a watchman/lookout.
- Except as described below, the employee will leave the foul zone promptly upon completion of work activity, egress to the field side of the track and stay clear of the the track until the next work location is accessed .
- Walking down the center of the track to access the next work location is prohibited if:
    - the watchman/lookout must change location during move to the next location, or
    - employee loses sight and/or communication with the watchman/lookout
- When utlizing watchman/lookout, employees shall stop work and clear the track if conditions are present where the rules for TAW can not be fully implemented.
- Employees shall stop work and seek clarifiaction if instructions issued from the client or host railroad are inconsistent with their training.

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DOT Facts-201g
General Requirements for Working in the Railroad Right-of-Way

The following are general procedures and requirements that apply to all railroad work under ARCADIS control *subject to Federal Railroad Administration (FRA) jurisdiction* (refer to DOT Facts-201b for general requirements when working on non-FRA jurisdiction tracks). Specifically, ARCADIS ensures that its employees and subcontractors:

- Warn co-workers or others of unsafe acts and/or hazards.
- Keep the work areas clean and orderly, and protected from controllable hazards.
- Use designated walkways.
- Have proper first aid supplies available on the job site so that prompt first aid services can be provided to any person that may be injured on the job site.
- Promptly notify the client railroad of any recordable injury (as defined by the U. S. Occupational Safety and Health Administration), or applicable client standard (accident/incident, Safety Rule Violation, etc) to an employee that occurs during the performance of work at the job site.
- Promptly notify the host railroad of any damage to railroad property.
- Does not use, work under the influence of, or have in their possession any alcoholic beverage or illegally obtained drug, narcotic, or other substance while on railroad property.
- Do not carry or have possession of firearms or other weapons while on railroad property.
- Properly dispose of all waste in accordance with applicable federal and state regulations.
- No open fires on railroad property.
- When driving in vehicles, stop at all railroad crossings to ascertain the way is clear.
- Notify the client railroad of any spill observed in their work area. Any spill from a locomotive or car is to be reported immediately.
- Participate in and comply with any job briefings conducted by the railroad representatives. During these briefings, ARCADIS and the railroad specify safe work procedures, the potential hazards of the job, and emergency response procedures. If any participant has any questions or concerns about the work, the employee must voice them during the job briefing. Additional job briefings will be conducted during the work as conditions, work procedures, or personnel change.

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- Take precautions to prevent injury to themselves, other employees, and the public.

- Perform all track work that meets the minimum safety requirements established by the FRA's Track Safety Standards Title 49 CFR Part 214. If ARCADIS will do work on the track, it will coordinate all activities with railroad representatives.

- Protect all excavations, holes and trenches to prevent injuries to other workers, railroad employees or the public.

- Call utility locators and use other means (including contacting railroad personnel) to avoid hitting buried utilities before digging.

- Comply with the following safety procedures when working around any railroad track:
  - Always be on the alert for moving equipment.
  - ARCADIS and subcontractor employees must always expect movement on any track, at any time, in either direction.
  - Do not step or walk on the top of the rail, frogs, switches, guardrails, or other track components.
  - Do not step between rails at switches.
  - In passing around the ends of standing cars, engines, roadway machines or work equipment, leave a minimum of 25 feet between yourself and the end of the equipment. Do not go between pieces of equipment if the opening is less than 50 feet as a minimum.
  - Avoid walking or standing on a track unless authorized by the railroad representative.
  - Before stepping over or crossing tracks, look in both directions first.
  - Do not sit on, lie under, or cross between cars except as required in the performance of your duties and only when equipment has been protected against movement and authorized by the railroad representative.
  - Do not leave tools or materials close to the track when trains are passing.
  - Do not lay equipment and tools across rails.

- Follow all HASP requirements.

- Wear a badge or readily shown identification showing employment with ARCADIS or its authorized subcontractor.

Unless otherwise instructed by the Project Manager, all client reporting specified in this section will be reported to the client by the Project Manager.

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DOT Facts-201h
Personal Protective Equipment for Railroad Work

ARCADIS expects its employees and its subcontractors to be suitably dressed to perform their duties safely and in a manner that will not interfere with their vision, hearing, or free use of their hands or feet. Specifically, proper personal protective equipment (PPE) should include:

- Waist length shirts with collars and at least ¼ length sleeves.
- Trousers that cover the entire leg. If flare-legged trousers are worn, the trouser bottoms are tied to prevent catching.
- Lace up safety-toed work boots that conform to the American National Standards Institute (ANSI) or American Society of Testing and Materials (ASTM) requirements. The boots have a defined heel and are at least 6 inches high to provide adequate ankle support. The soles must be oil proof and should be puncture proof.
- No loose or ragged clothing, neckties, finger rings, or other loose jewelry while in the field or per client railroad requirements.

In addition, PPE worn must meet requirements specified by OSHA and railroad rules and regulations. In particular, the PPE to be worn whenever outside of an office or vehicle:

- Hard hat with six-point suspension that meets the American National Standards Institute (ANSI) Z89.1 latest revision with the company logo on it. Note: The color of and allowable markings on the hard hat varies with client requirements. Check the client requirements for the appropriate color and markings before proceeding with any work.
- A reflective traffic vest that meets ANSI Class 2 or greater requirements. Check with client on any color, construction or special retroreflectivity requirements.
    - ARCADIS expects vest and retroreflectivity materials to be clean and free of fading or defect that might impair visibility, especially during night operations.
    - Traffic vests must be clasped at all times.
- Safety glasses with permanent side shields that meet the ANSI standard for occupational and educational eye and face protection, Z87.1 latest revision. Additional eye protection must be provided to meet specific job situations such as welding, grinding, burning, etc.
- Hearing protection that affords enough attenuation to give protection from noise levels that will be occurring on the job site. Hearing protection, in the form of plugs or muffs, are worn when employees are within:
    - 100 feet of locomotive/refrigeration car or roadway/work equipment.
    - 15 feet of power operated tools.

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- 150 feet of jet blowers or pile drivers.
- 150 feet of retarders in use (when within 10 feet, Contractor Employees must wear dual ear protection plugs and muffs).

Other types of PPE, such as respirators, fall protection equipment, and face shields, are worn as dictated by the working conditions or area in which the employees are working.

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DOT Facts-201j
Railroad Workplace H&S Standard Definitions
Text in red and all graphics draft for employee comment until 8/29/2014

The following definitions are used in the ARCADIS Railroad Workplace H&S Standard (ARC HSSP-002), in associated support documents or during a job safety briefing.

Adjacent Tracks – means two or more tracks with track centers spaced less than 25 feet apart.

Class I Railroads – As used in the standard means any work performed on property owned or operated by CSX, Norfolk Southern, Union Pacific, Burlington Northern Santa Fe, Kansas City Southern, Canadian National, and Canadian Pacific.

Competent Person – means one who is capable of identifying existing and predictable hazards in the workplace and who is authorized to take prompt corrective action to eliminate them.

Controlled Track - means track upon which the railroad's operating rules require that all movements of trains must be authorized by a train dispatcher or a control operator.

Designated Railroad Point of Contact (POC) – *ARCADIS Definition:* An employee of the client or host railroad designated by the host railroad to coordinate work activities with ARCADIS and ARCADIS subcontractors within or outside of working limits and has immediate access to a working radio. This individual includes, but is not limited to, an Employee in Charge, Flagman, Roadmaster, or Yardmaster if working outside of working limits and an EIC when working within working limits.

Employee – means an individual who is engaged or compensated by a railroad, or by a contractor to a railroad, to perform any of the duties defined in this policy.

Employee-in-Charge (EIC) (aka Roadway Worker-in-Charge or RWIC) – means a designated roadway worker who is responsible for all movements and on-track safety for a roadway work group within working limits. Each employee-in-charge must be qualified on operating and on-track worker rules and physical characteristics. Each employee-in-charge must maintain immediate access to a working radio when practicable. When not practicable, the employee-in-charge must be equipped with a radio capable of monitoring transmission from train movements in the vicinity.

Employer – means a railroad, or a contractor to a railroad, that directly engages or compensates individuals to perform any of the duties defined in this policy.

Field Side of the Near Running Rail – means upon approaching the track the rail closest upon approach and field side means the outside face of the rail (Figure 1).

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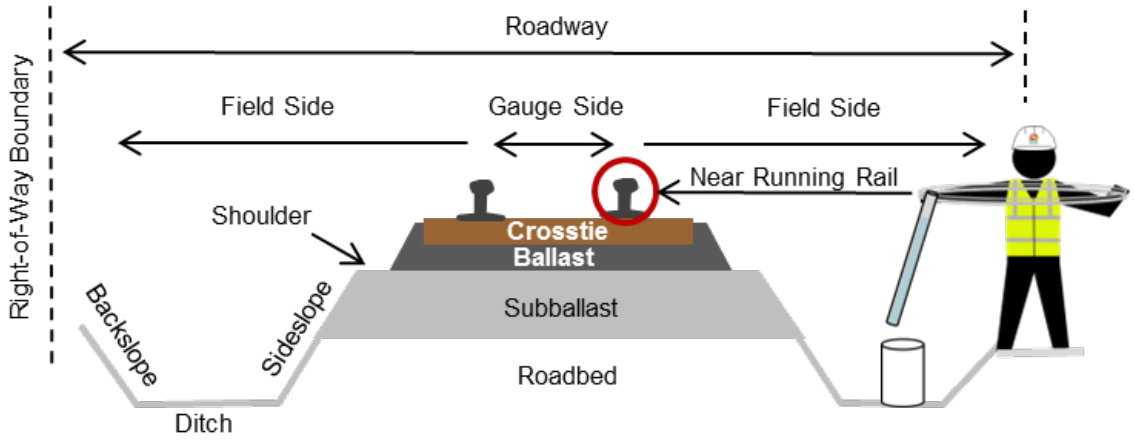
Figure 1: Track Terms



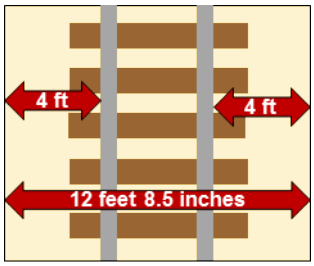
Tangent (Straight) Track

Flagman – when used in relation to roadway worker safety means an employee designated by the railroad to direct or restrict the movement of trains past a point on a track to provide on-track safety for roadway workers, while engaged solely in performing that function.

Foul Time – is a method of establishing working limits on controlled track in which a roadway worker is notified by the train dispatcher or control operator that no trains will operate within a specific segment of controlled track until the roadway worker reports clear of the track.

Fouling a Track – means the placement of an individual or an item of equipment in such proximity to a track that the individual or equipment could be struck by a moving train or on-track equipment, or in any case is within four feet of the field side of the near running rail (Figure 2, see also Figure 1). An individual client may have a greater distance defined as fouling a track. The project manager should clarify this with the client prior to beginning work.

Figure 2. Foul Zone by FRA Regulation



Foul Zone

Hi-Rail Vehicle – means a roadway maintenance machine that is manufactured to meet Federal Motor Vehicle Safety Standards and is equipped with retractable flanged wheels so that the vehicle may travel over the highway or on railroad tracks.

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Inaccessible Track – means a method of establishing working limits on non-controlled track by physically preventing entry and movement of trains and equipment.

Individual Train Detection – means a procedure by which a lone worker acquires on-track safety by seeing approaching trains and leaving the track before they arrive and which may be used only under strictly defined circumstances as permitted by the railroad client.

Lone Worker – means an individual roadway worker who is not being afforded on-track safety by another roadway worker, who is not a member of a roadway workgroup, and who is not engaged in a common task with another roadway worker. Each lone worker must maintain immediate access to a working radio when practicable. When not practicable, the lone worker must be equipped with a radio capable of monitoring transmission from train movements in the vicinity. Some railroads do not allow non-railroad employees to be lone workers. ARCADIS will not designate any employee or subcontractor employee as a lone worker unless there is written authorization from the client railroad to make this designation.

Non-Controlled Track – means a track upon which trains are permitted by railroad rule or special instruction to move without receiving authorization from a train dispatcher or control operator.

Non-FRA Regulated Tracks means tracks which are not part of the “general railroad system of transportation” which means the network of standard gage track over which goods may be transported throughout the Nation and passengers may travel between cities and within metropolitan and suburban areas. Tracks which are used exclusively to move or handle rail cars inside a facility are not covered by FRA regulations covering health and safety but are instead governed by the Occupational Health and Safety Administration (OSHA). These types of tracks are commonly referred to as “plant tracks”. They remain outside of the general railroad system of transportation even when they connected to that system by means of a switch. However, if a railroad operating in the general railroad system of transportation is delivering or picking up rail cars, that portion of the “plant tracks” is governed by FRA during those operations.

For tourist, scenic, and excursion tracks, similar rules apply if the tracks are off the general railroad system of transportation and are insular. The term “insular” only applies to tourist operations over tracks outside of the general system used exclusively for such operations. FRA considers a tourist railroad to be insular if its operations are limited to a separate enclave in such a way that there is no reasonable expectation that the safety of any member of the public "except a business guest, a licensee of the tourist operation or an affiliated entity, or a trespasser" would be affected by the operation.

Additionally, the term includes railroad tracks less than 24 gage.

On-Track Safety (OTS) – means a state of freedom from the danger of being struck by a moving railroad train or other railroad equipment, provided by operation and safety rules that govern track occupancy by personnel, trains, and on-track equipment.

Qualified – means a status attained by an employee who has successfully completed any required training for, has demonstrated proficiency in, and has been authorized by the employer to perform the duties of a particular position of function.

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Railroad - means all forms of non-highway ground transportation that run on rails or electro-magnetic guideways, including (1) commuter or other short-haul rail passenger service in a metropolitan or suburban area, and (2) high-speed ground transportation systems that connect metropolitan areas, without regard to whether they use new technologies not associated with traditional railroads. Such term does not include rapid transit operations within an urban area that are not connected to the general railroad system of transportation.

Railroad bridge - means a structure supporting one or more railroad tracks above land or water with a span length of 12 feet or more measured along the track centerline. This term applies to the entire structure between the faces of the back walls of abutments or equivalent components, regardless of the number of spans, and includes all such structures, whether of timber, stone, concrete, metal, or any combination thereof.

Railroad bridge worker or bridge worker - means any employee of, or employee of a contractor of, a railroad owning or responsible for the construction, inspection, testing, or maintenance of a bridge whose assigned duties, if performed on the bridge, include inspection, testing, maintenance, repair, construction, or reconstruction of the track, bridge structural members, operating mechanisms and water traffic control systems, or signal, communication, or train control systems integral to that bridge.

Red Zone – means the area surrounding the working equipment and employees which, if entered by an individual, creates the potential for injury as a result of being struck by equipment, tools, or material.

Roadway work group - means two or more roadway workers organized to work together on a common task.

Roadway worker – means, per FRA requirements, any employee or contractor of a railroad, whose duties include inspection, construction, maintenance or repair of railroad track, bridges, roadway, signal and communication systems, electric traction systems, roadway facilities or roadway maintenance machinery on or near track or with the potential of fouling a track, and flagmen and watchmen/lookouts. In addition, an ARCADIS employee or ARCADIS subcontractor who conducts construction, environmental, infrastructure, survey, or other work within 25 feet of an active rail line is considered by ARCADIS as a Roadway worker and must meet the requirements of Roadway workers in this policy.

Roadway Worker-in-Charge or RWIC - See Employee in Charge definition above

Train approach warning - means a method of establishing on-track safety by warning roadway workers of the approach of trains in ample time for them to move to or remain in a place of safety in accordance with the requirements of this part.

Train coordination - means a method of establishing working limits on track upon which a train holds exclusive authority to move whereby the crew of that train yields that authority to a roadway worker.

Train dispatcher - means the railroad employee assigned to control and issue orders governing the movement of trains on a specific segment of railroad track in accordance with the operating rules of the railroad that apply to that segment of track.

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Watchman/lookout - means an employee who has been annually trained and qualified to provide warning to roadway workers of approaching trains or on-track equipment. Watchmen/lookouts shall be properly equipped to provide visual and auditory warning such as whistle, air horn, white disk, red flag, lantern, or fusee. A watchman/lookout's sole duty is to look out for approaching trains/on-track equipment and provide at least fifteen seconds advanced warning to employees before arrival of trains/on-track equipment.

Work or Working – as used in the Railroad Workplace H&S Standard (ARC HSSP002) means any activity performed in the interest of ARCADIS performed in a railroad right-of-way or as described in DOT Facts-201b, “Safety Best Practices for Plant, Tourist, Scenic and Excursion Tracks”. The act of crossing a track either by walking or using a vehicle does not constitute work unless otherwise specified by the client or host railroad.

Working limits - means a segment of track with definite boundaries established in accordance with this part upon which trains and engines may move only as authorized by the roadway worker having control over that defined segment of track. Working limits may be established through “exclusive track occupancy'', “inaccessible track'', “foul time'' or “train coordination''.

Working Radio- means a radio capable of monitoring railroad communications and transmissions as required by 49 CFR Part 220.

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