OPERATION AND MAINTENANCE MANUAL

DUAL-PHASE EXTRACTION TREATMENT SYSTEM
LAUREL STATION CLEANUP ACTION
BELLINGHAM, WASHINGTON

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February 5, 2016

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ABBREVIATIONS AND ACRONYMS

BTEX	benzene, toluene, ethylbenzene, and xylenes
CAP	cleanup action plan
CMP	Compliance Monitoring Plan
COC	chemical of concern
CUL	cleanup level
DPE	dual-phase extraction
Ecology	Washington State Department of Ecology
EDR	Engineering Design Report
FID	flame ionization detector
FS	feasibility study
HMI	human machine interface
LGAC	liquid-phase granulated activated carbon
NWCAA	Northwest Clean Air Agency
OWS	oil water separator
O&M	operation and maintenance
PAH	polycyclic aromatic hydrocarbon
PID	photoionization detector
PMS	piping manifold shelter
PSB	pump station building
psi	pounds per square inch
PV	passive vent
PVC	polyvinyl chloride
RI	remedial investigation
Seneca	Seneca Companies (Des Moines, Iowa)
SVE	soil vapor extraction
TPH	total petroleum hydrocarbons
Trans Mountain	Trans Mountain Pipeline (Puget Sound) LLC
URS	URS Corporation (A subsidiary of AECOM)
VGAC	vapor-phase granulated activated carbon
VOC	volatile organic carbons
WAC	Washington Administrative Code

1.0 INTRODUCTION

This manual presents information and procedures necessary for the operation and maintenance (O&M) of the Dual-Phase Extraction (DPE) remediation treatment system installed at Trans Mountain Pipeline (Puget Sound) LLC's Laurel Station facility located at 1009 East Smith Road in Bellingham, Washington (Figure 1). The site is owned by Trans Mountain Pipeline (Puget Sound) LLC, hereafter referred to as Trans Mountain. It is currently operated by Kinder Morgan Canada.

The DPE system is one part of a cleanup action in progress at the facility to address petroleum-contaminated soil and perched groundwater. The cleanup action is being conducted under Consent Decree No. 14-2-01294-9 between Washington State Department of Ecology (Ecology) and Trans Mountain and is overseen by Ecology. The Site is listed in Ecology's Integrated Site Information System under the following:

- Facility Site Name: Laurel Station (Alternate Names: Laurel Pump Station and Trans Mountain Oil Pipe Line)
- Facility Address: 1009 East Smith Road, Bellingham, Washington 98226-9765, Whatcom County
- Facility Site Identification Number (FSID): 2893
- Cleanup Site Identification Number (CSID): 102

The chemicals of concern (COCs) in the treatment area are total petroleum hydrocarbons (TPH, gasoline-, diesel-, and oil-range) in soil and TPH and polycyclic aromatic hydrocarbons (PAHs) in perched groundwater. Cleanup levels (CULs) were established for these constituents in the Consent Decree. CULs were also established for benzene, toluene, ethylbenzene, and xylenes (BTEX) as these are commonly found with petroleum-based contamination. The DPE system was installed following removal of petroleum-contaminated soil in the area adjacent to the Piping Manifold Shelter (PMS) and Pump Station Building (PSB) (Figure 2). The DPE system is designed to treat contaminated soil and perched groundwater that was not removed during excavation in these two areas.

Ten DPE wells, one passive vent (PV) well and two monitoring wells were installed as part of or to support monitoring of the system (Figure 2). In addition, surface capping in the localized area was installed to minimize surface water runoff to the subsurface that feeds the perched groundwater. The DPE system components and controls necessary to network the wells and operate the system were installed in July 2015 by Seneca Companies (Seneca) from Des Moines, Iowa under contract to Kinder Morgan Canada with oversight from URS Corporation (URS, subsidiary of AECOM). The final installation inspections and checks were completed in August 2015. The DPE system is expected to operate three to five years until groundwater monitoring data indicates the concentrations of COCs are below CULs or vapor mass removal rates indicate decreasing trends.

This manual includes O&M procedures for the DPE system and summarizes the procedures that are discussed in the vendor supplied operation manual provided on disk in Appendix A. This manual does not replace the vendor-supplied manual. It is intended to supplement the manual and plans provided by Seneca by consolidating and clarifying essential system O&M information and by providing updated equipment information and operating procedures. All personnel are required to read and understand the contents of this O&M manual prior to performing O&M tasks.

Health and safety requirements are not addressed in this document. Health and safety is addressed in contractor/site-specific health and safety plans required to be reviewed and acknowledged by all personnel working with the DPE system or associated monitoring activities. Personnel that enter the facility must comply with Kinder Morgan Canada and facility-specific safety requirements.

2.0 DUAL-PHASE EXTRACTION SYSTEM COMPONENTS

The Laurel Station DPE system as constructed and installed in July 2015 consists of the following main components:

- Extraction wells (DPE-1 through DPE-10)
- Passive vent well (PV-1)
- Header pipe and well stub outs
- Containerized DPE system
  - Knockout tank and transfer pump
  - Inline vapor-phase particulate filters (3)
  - SVE blower
  - Liquid ring pump
  - Heat exchanger
  - Oil Water Separator (OWS) and transfer pump
  - Product effluent tank (to contain free-product from OWS)
  - Liquid-phase particulate bag filters (2)
- Liquid-phase granulated activated carbon filters (LGAC) (2)
- Vapor-phase granulated activated carbon filters (VGAC) (2)

The system was designed based on the Engineering Design Report (URS 2014). The DPE and monitoring well installation was revised (locations, depths, screened interval) based on site conditions encountered during soil removal. The site layout is shown on Figure 2, a process flow diagram is shown on Figure 3, and a Process and Instrumentation Diagram is provided on Figures 4A through 4D (markups of the design drawings). Well construction details for DPE and monitoring wells are provided in Table 1 and well logs are provided in Appendix B. As-built construction drawings are provided in Appendix C. Note these drawings are the design drawings with markups indicating additionally placed gauges and sampling ports installed after startup. These markups will serve as the as-built drawings until further notice.

DPE system equipment details and an equipment and supply list are provided in Tables 2 and 3, respectively. Photos showing DPE system equipment currently in place are provided in Appendix D. A detailed description of the above equipment is described in the following sections. The DPE system can be operated in DPE mode or Soil Vapor Extraction (SVE) mode depending on groundwater levels in the treatment area.

2.1 DPE, PV WELLS AND PIPING

The locations of the DPE and PV wells, subsurface and above-ground piping, header pipes, and input to the DPE treatment system are shown on Figure 2. Details of the piping are shown on the as-built drawings in Appendix C.

2.1.1 DPE Well Construction

Figure 5 shows a typical DPE well setup. Adjustable flex hose connected to PVC stinger pipe used for extracting water is placed in each DPE well. The stinger pipe can be adjusted by raising or lowering the flex hose (1-1/4-inch) to the desired depth which is determined by the thickness of the water column in each DPE well. Additional tubing (1/2-inch) inside each DPE well is connected to the well cap and goes to the bottom of the well. This tubing is used to guide a water level indicator into the DPE well to measure groundwater levels.

2.1.2 Pump Station Building

Wells DPE-1 through DPE-4 and passive vent well PV-1 are screened beneath and adjacent to the PSB. PV-1 is intended to enhance air flow through the treatment zone. Extracted vapor and groundwater from DPE-1 through DPE-4 is transferred to a main header pipe for the PSB area via transfer piping. From the header pipe, the extracted vapor and groundwater is transferred to the DPE containerized treatment system.

2.1.3 Piping Manifold Shelter

Wells DPE- 5 through DPE-8 are screened beneath or adjacent to the PMS to treat soil and groundwater in this area. Wells DPE-9 and DPE-10 are closer to the hill slope adjacent to the PMS and screened to treat isolated contaminated soil that could not be physically removed. Extracted vapor and groundwater is transferred to a main header pipe from all of these wells via transfer piping. From the PMS header pipe the extracted vapor and groundwater is transferred to the DPE containerized treatment system.

2.2 SVE MODE

The DPE system can be operated in SVE mode using a regenerative blower for low vacuum vapor-only extraction. The system is expected to operate in SVE most of the year as water levels in the DPE wells are expected to be very low or dry. Using a low vacuum (< 4-inches Hg) blower to operate the system during the dry periods is more energy efficient to remove vapors than using a liquid ring pump. Extracted vapor collected by the system is treated through granular activated carbon before release to the atmosphere.

2.3 DPE MODE

The DPE system is operated in DPE mode using a liquid ring pump for high vacuum (> 20-inches Hg) removal of water and vapor, water transfer pumps for groundwater extraction, and a knockout tank. Extracted vapor and groundwater are treated through granular activated carbon before release to the atmosphere (vapor) or discharge to the facility stormwater system (groundwater). Operation in the DPE mode using the high vacuum liquid ring pump is anticipated only when perched groundwater is present in adequate volume to maintain DPE operation. Operation of the DPE system will be recommended when greater than 2 feet of groundwater is present in at least 3 of the 10 DPE wells. Wells without groundwater present will be closed and the remaining wells will be operated in DPE mode.

2.4 VAPOR TREATMENT

When the system is operating, vapor is extracted from the well-field using either a SVE blower or a liquid ring pump into a knockout tank. The knockout tank is used to separate the groundwater from the vapors. The extracted vapor passes through three filters, a heat exchanger and a two stage VGAC treatment system prior to release to the atmosphere through a 10-foot stack. The VGAC vessels and stack are located outside of and on the south end of the containerized DPE system.

2.5 LIQUID TREATMENT

In high vacuum (DPE mode) operation, groundwater flows to a knockout tank. The extracted groundwater is pumped through an OWS, two bag filters and a two stage LGAC treatment system prior to discharge into the facility stormwater system. If free product is present in the groundwater, the oil water separator will separate the free product from the groundwater using baffles and an oil skimmer which will decant the free product into a product effluent tank for disposal. The groundwater discharge point to the stormwater system (EP1) and LGAC vessels are located outside on the north end of the containerized DPE system.

2.6 SYSTEM CONTROLS

The system controls are located in the control panel on the north end exterior of the containerized DPE system. They consist of a Human Machine Interface (HMI) and control switches.

2.6.1 Human Machine Interface (HMI)

The HMI is located inside the control panel. The HMI logs information on how long the system operates in DPE or SVE mode, system history, date and time of system shutdowns and alarm notifications. Alarm notifications are described in Table 4 and Appendix A (Section 8 Controls).

2.6.2 Control Switches

Five control switches (Hand-Off-Auto) are located inside the control panel. Each control switch on the control panel serves a specific function.

- Knockout Pump (Hand-Off-Auto) – Provides selection of manual override (Hand), shutting down operation (Off), or automatic operation (Auto) of the knockout tank pump.
- Discharge Pump (Hand-Off-Auto) – Provides selection of manual override (Hand), shutting down operation (Off), or automatic operation (Auto) of the discharge pump.
- Heat Exchanger (Hand-Off-Auto) – Provides selection of manual override (Hand), shutting down operation (Off), or automatic operation (Auto) of the heat exchanger.
- SVE Blower (Hand-Off-Auto) – Provides selection of manual override (Hand), shutting down operation (Off), or automatic operation (Auto) of the SVE blower.
- Liquid Ring Pump (Hand-Off-Auto) – Provides selection of manual override (Hand), shutting down operation (Off), or automatic operation (Auto) of the liquid ring pump.

2.6.3 Treatment System Valves

Treatment system valves are located inside the DPE containerized system as well as outside on the LGAC and VGAC treatment trains. The valves associated with the containerized system and liquid and vapor treatment systems are described in this section.

- Containerized DPE System
    - 1/4-inch and 3/8-inch ball valves used as sampling ports to collect vapor or groundwater samples from the treatment train.
    - Various ball valves along the treatment train used to isolate (open or close) the flow of vapors or groundwater along portions of the sampling train.

- 4-inch butterfly valve on the header pipes used to shut down flow to the entire treatment system.

- 2-inch globe valve used as a dilution valve. Opened only during SVE mode and used to increase air flow into the system if only a limited number of DPE wells are operating. Can also be used to dilute COCs extracted from the DPE wells before flow enters the treatment trains.

- 1-inch and 1-1/4-inch ball valves used as drains to remove stagnant or excess liquids during maintenance.

- LGAC

  - 1/4-inch ball valve used as an access port for sampling groundwater collected inside or discharged from the LGAC vessels.

  - Various ball valves along the liquid treatment train used to shut down the flow through the LGAC system to prevent discharge from the system.

- VGAC

  - 1/4-inch ball valves used as an access port for sampling vapors entering or leaving the VGAC vessels.

  - 1/2-inch ball valves used to drain the VGAC vessels during maintenance.

2.6.4 DPE Well Valves

DPE well valves are located inside the well vaults, at the well stub outs and on the header pipes. Valve locations can be found on drawings provided in Appendix C.

- Well Vault

  - 1/2-inch ball valve used as an access port for measuring groundwater levels as well as groundwater sampling.

  - 1-1/2-inch ball valve used to open or close the flow for vapor and groundwater coming from the DPE well.

- Well Stub Outs

  - 3/8-inch ball valve used as a sampling port to collect vapor samples from individual wells and to take flow measurement readings.

  - 2-inch ball valve used to isolate (open or close) the flow for vapor and groundwater coming from the DPE well.

  - 2-inch threaded globe valve used to regulate the flow of vapors and groundwater extracted from the DPE wells.

- Piping Manifold

  - 3/8-inch ball valve used as a sampling port to collect vapor samples from the well field and to measure flow.

  - 4-inch butterfly valve used to isolate (open or close) the flow of vapors or groundwater from all DPE wells treating the PSB or PMS.

2.7 INSTRUMENTATION

The following are the instruments used along the DPE treatment system.

- Sight flow window – This device is located at all DPE well stubs and visually indicates if vapor or groundwater is being extracted from each individual DPE well.

- Vacuum gauges – Located in well vaults, well stub outs, piping manifold and inside containerized DPE system. Used to monitor the vacuum levels at the wells or at individual locations along the treatment train.

- Pressure gauges – Located inside containerized DPE system, VGAC vessels and LGAC vessels. Used to monitor the pressure levels along the treatment train.

- Temperature gauges – Located inside containerized DPE system. Used to monitor the temperature of the liquid ring pump and heat exchanger inlet and outlet temperatures

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- Pitot tube (flow sensor) – Located inside containerized DPE system. This is a differential pressure gauge used to sense the flow of the exhaust stack and the dilution valve. This pressure reading can be converted to determine the flow rate exiting the stack and the flow rate entering the system through the dilution valve.

- Flow meter (rotameter) – Located inside the containerized DPE system prior to the OWS. This flow meter indicates the flow rate of extracted groundwater entering the OWS.

- Totalizer – Located on the northeast corner outside of the containerized DPE system, post LGAC treatment. This meter measures the total amount of water treated through the DPE system prior to discharge to the facility stormwater system.

- Emergency Stop (push button) – Two locations are available. One is located inside the containerized DPE system next to the door and one is outside the container door. When activated, a signal is sent to the HMI which will immediately shutdown the DPE system.

- Green Beacon Light – Located on the roof of the containerized DPE system. This light will go off when an alarm situation has been detected to notify on-site personnel to check on the DPE system.

- Supply Fan – This device is used to purge hot air from the interior of the containerized DPE system.

- Heater – This device is used to elevate the interior temperature of the containerized DPE system under extreme low temperature conditions.

3.0 SYSTEM OPERATION

The DPE system is intended to operate continuously for 2 to 3 years, with the exception of periodic maintenance or system failure. If it is determined that the system needs to operate beyond the designed 3 years then it can continue operating without any modifications because the equipment is designed for 5 years minimum. The following section provides a summary of the operating permits, startup procedures, operation of the DPE system and shutdown procedures.

3.1 SUBSTANTIVE REQUIREMENTS

An air permit was not required by the Northwest Clean Air Agency (NWCAA) since the DPE system is part of a cleanup action required by Ecology. However, the substantive requirements of NWCAA Sections, 300, 320 and 321 must be met. All vapor and groundwater removal by the system will be treated through vapor or liquid-phase granulated activated carbon treatment systems as described previously. Vapor sampling before and after the VGAC system will be monitored by field photo-ionization detector (PID) and/or flame-ionization detector (FID). Measurements indicating 50 parts per million (ppm) or greater volatile organic compounds will trigger carbon change-outs.

Treated groundwater will be sampled after the LGAC and before discharge to the facility stormwater system in compliance with Ecology's administrative order #11456 to the facility NPDES permit. All sampling activities including sampling methodology, analytical measurements and frequency are described in the Compliance Monitoring Plan (CMP) for the cleanup action (URS 2015) or updates to the CMP.

3.2 STARTUP PROCEDURES DPE MODE

Following are the general steps necessary to start operation of the DPE treatment system under DPE mode.

1. Record the date and time in the field log book.
2. Locate the system Control Panel. Switch the main power circuit breaker located in the control panel to the 'ON' position. The switch light should be illuminated.
3. Confirm each circuit breaker in the service panel is on.
4. Open well head vaults DPE-1 through DPE-10 and confirm the 1/2-inch ball valve sampling port on each well head is closed. Open the 1-1/2-inch ball valve on the underground lateral DPE pipes.
5. At DPE-1 through DPE-10 well stub outs, open the 2-inch true union ball valve for the wells planned to operate, slightly open the 2-inch flow control globe valve and make sure the 3/8-inch ball valve sampling ports are closed.
6. Close 3-inch ball valves associated with the SVE system and open the 3-inch ball valves associated with the DPE system.
7. Confirm all sampling port valves are closed inside the containerized DPE system.
8. Open all valves inside the containerized DPE system associated with groundwater flow through piping.

9. Close all sampling ports associated with the LGAC vessels and open all flow valves associated with groundwater flow through flex hose.

10. Verify that all secondary containment is sound.

11. In the Control Panel, turn the switch to the 'Auto' position for the Liquid Ring Pump, turn the knockout pump switch to the 'Auto' position, turn the Discharge Pump switch to the 'Auto' position and turn the heat exchanger switch to the 'Auto' position.

12. Make sure the SVE blower switch is in the 'Off' position.

The system should operate as long as no alarm conditions are present. See Table 4 for troubleshooting information should any alarms activate during startup. See Appendix D for photos showing location of valves and sampling ports.

3.3 STARTUP PROCEDURES SVE MODE

Following are the general steps necessary to start operation of the DPE treatment system under SVE mode.

1. Record the date and time in the field log book.

2. Locate the system Control Panel. Switch the main power circuit breaker located in the control panel to the 'ON' position. The switch light should be illuminated.

3. Confirm each circuit breaker in the service panel is on.

4. Open well head vaults DPE-1 through DPE-10 and close the 1/2-inch ball valve sampling port on the well head and open the 1-1/2-inch ball valve.

5. At DPE-1 through DPE-10 well stub outs, open the 2-inch true union ball valve for the wells to operate, open the 2-inch flow control globe valve and make sure the 3/8-inch ball valve sampling ports are closed.

6. Close 3-inch ball valves associated with the DPE system and open the 3-inch ball valves associated with the SVE system.

7. Confirm all sampling port valves are closed inside the containerized DPE system.

8. Open all valves inside the containerized DPE system associated with vapor flow through piping.

9. Close all sampling ports associated with the VGAC vessels and open all flow valves associated with vapor flow through flex hose.

10. In the Control Panel, turn the switch to the 'Auto' position for the SVE blower, turn the knockout pump switch to the 'Auto' position, turn the Discharge Pump switch to the 'Auto' position and turn the heat exchanger switch to the 'Auto' position.

11. Make sure the liquid ring pump switch is in the 'Off' position.

The system should operate as long as no alarm conditions are present. See Table 4 for troubleshooting information should any alarms activate during startup. See Appendix D for photos showing location of valves and sampling ports.

3.4 NORMAL OPERATION

The DPE system is designed to operate continuously in either DPE or SVE mode. During normal operation, the system can be adjusted to treat the entire well field or just certain areas of the PSB or PMS by adjusting associated valves. A process flow diagram of the system operating in DPE and SVE mode is shown in Figure 3.

3.4.1 Valve Positions

For DPE and SVE mode, all valves must be in the positions mentioned above in startup procedures during normal operations. Following initiation of the DPE system, the system operation can be adjusted so that select areas in the treatment zones are treated while others are not to maximize the effectiveness of the DPE cleanup in the treatment area.

1. To treat only the PSB area, locate the 4-inch butterfly valve on the PMS header pipe and turn to the closed position.

2. To only treat the PMS area, locate the 4-inch butterfly valve on the PSB header pipe and turn to the closed position.

3. To isolate and operate the DPE system only for certain wells, locate the 2-inch isolation ball valves located at the well stub outs of the DPE wells not intended for treatment and turn them to the closed position. Leave the 2-inch ball valves to the open position for the DPE wells intended for treatment.

4. To control the flow of DPE wells, locate the flow control Globe valves located at the well stub outs and rotate the Globe valve to the desired flow rate. A fully opened Globe valve indicates maximum flow. The flow can be verified by using an air anemometer and then slowly rotate open the Globe valve until the desired air flow is achieved.

3.4.2 Stinger Position

During normal operations, the stinger pipe is placed 1 to 2 feet above the bottom of the well. If water is present in the well, the stinger pipe can be adjusted to a desired depth in the water table to extract groundwater. This is done by loosening the well seal and pulling up or lowering the 1-1/4-inch flex hose to the desired depth. If the stinger pipe needs to be raised more than the flex hose allows then a section of the stinger pipe can be removed. Stinger pipe in each DPE well typically consist of 3 sections with lengths of 3.1, 5.1 and 10 feet.

3.5 SHUTDOWN PROCEDURES

Locate the system control panel. Turn all switches in the control panel to the ‘OFF’ position for normal shutdown, or if it is an emergency, push the ‘Emergency Stop’ button inside the trailer by the side door. The system will shut down and lock out the controls until the switch is reset. The ‘Emergency Stop’ button outside the trailer can be pushed as well, in case of an emergency.

4.0 ROUTINE OPERATION AND MAINTENANCE

Routine operation, periodic maintenance activities and as needed tasks such as carbon changeout, filter changeout, cold weather operation and repairs are described in the following sections. Table 3 provides suggested vendors when equipment needs repair or replacement. See Appendix D for photos showing locations of equipment, oil level locations and where to grease equipment.

4.1 WEEKLY TASKS

The following tasks should be performed weekly:

- DPE Treatment System
  - Record all temperature gauge readings T1 through T3.
  - Record all vacuum gauge readings V1 through V6.
  - Record all pressure gauge readings P1 through P14.
  - Record all flow readings F1 through F4.
  - Document any alarms that were triggered during the week.
  - Record total operational hours of SVE blower, liquid ring pump and heat exchanger.
  - Check oil levels.
  - Check fluid levels in OWS product effluent tank (reference Table 5 for conversion from fluid thickness to volume).
  - Check PID and FID readings at VGAC vessels at pre-, mid and post-treatment sampling locations.
  - Check for leaks in the system piping and hoses.
  - Replace damaged components as necessary.
- DPE wells and piping
  - Record all vacuum gauge readings at well stub outs for wells DPE-1 through DPE-10.
  - Indicate flow indicator position at well stub outs for wells DPE-1 through DPE-10.
  - Record all vacuum readings for header pipe for the PSB and PMS.
  - Indicate valve open position at well PV-1.
  - Check for leaks in the piping.
  - Replace damaged components as necessary.

All weekly task readings and observations will be recorded on field forms provided in Appendix E.

4.2 MONTHLY TASKS

The following tasks should be performed monthly:

- Check groundwater levels in wells DPE-1 through DPE-10.
- Check flow using an air anemometer at well stub outs for wells DPE-1 through DPE-10.
- Collect vapor samples in Tedlar bags at well stub outs of wells DPE-1 through DPE-10 and record PID and FID readings.
- Record all vacuum gauge readings inside well vaults for wells DPE-1 through DPE-10.
- Replace damaged components as necessary.
- Check LGAC secondary containment and remove leaves or debris buildup and dispose accordingly.
- Remove liquid or debris from particulate filters.
- Check and add seal oil to liquid ring pump assembly as needed.

Information for DPE well construction is included on laminated sheets in each well vault. A copy of this sheet for each well is provided in Appendix F.

4.3 QUARTERLY TASKS

The following tasks should be performed quarterly:

- Supply Fan
  - Check fan propeller on Fans 1 and 2 for any wear or corrosion.
  - Check all set screws and bolts for tightness.
  - Clean any debris that may be accumulated in the fan.
  - Remove and check fan filter screen. Replace the screen if necessary.
- Knockout Tank
  - Clean water level sight tubes and check the o-ring seal condition. Once sight tubes are clean, re-assemble and make sure the o-ring is re-installed properly.
  - Disassemble and clean knockout tank flow gauge, reassemble when complete.
- Heat Exchanger
  - Inspect entire heat exchanger and motor/fan assembly for loosened bolts, loose connections, broken components, rust, corrosion, fin/coil clogs and leakage. Make immediate repairs to all affected areas prior to restarting the system.
  - Inspect motors for lubrication. If needed, immediately grease components.

- Liquid Ring Pump Assembly

  - Inspect liquid ring pump for loosened bolts, loose connections, broken components, rust, corrosion and leakage. Make immediate repairs to all affected areas prior to restarting.

  - Check oil levels and color. If oil levels are running low, add oil to the appropriate level. Change the oil if the oil is dirty.

  - Inspect fluid strainer if debris is present remove the debris.

  - Check air filters. Change if necessary.

- Oil Water Separator (OWS)

  - Check to determine if excessive solids or debris have accumulated. If excessive solids have built up, the inlet should be cleaned as follows.

    1. Stop the flow of influent to the separator.
    2. Lift up separator cover.
    3. Dispose of separated oil compliant with disposal regulations.
    4. Remove waste from the separator.
    5. Clean and dispose of the solids compliant with disposal regulations.
    6. Clean and inspect float switches.
    7. Examine OWS for damage and repair any damage to internal coating.
    8. Clean water level sight tubes and check for wear and tear of the o-ring. Once sight tubes are clean, re-assemble and make sure the o-ring seal is re-installed properly.

- General DPE System

  - Open all in-line particulate filters associated with the vapor treatment train (Filters 1 through 3) and verify that they are free of debris and check gasket and o-ring for wear and tear. Replace filters, gasket and o-ring if needed. When re-assembling filter system make sure gasket and o-ring are properly installed.

  - Open all bag filters associated with the groundwater treatment train and verify that they are not clogged or torn. Replace filters if needed.

  - Exercise all valves along the DPE system and return to original position. Valves should never be left to the extreme open or closed position. Always back off slightly to prevent the valve from sticking in a completely open or closed position.

  - Check clean air intake and remove any obstructions or debris.

  - Check louvers inside and outside the DPE containerized system and remove any obstructions or debris.

  - Check Fernco couplers and saddle couplers along the system and tighten if necessary.

  - Check for damaged gauges and replace if necessary.

  - Check for corrosion.

- Check hose and tubing conditions for tears and repair or replace as necessary.
- Based on field data, adjust DPE system to maximize performance, such as increasing extraction flow in certain DPE wells or close off other DPE wells.
- Tighten hose clamps along treatment trains.

4.4 YEARLY TASKS

The following tasks should be performed yearly:

- Liquid Ring Pump Assembly
  - While the pump does not require greasing, the motor should be greased annually with high temperature lithium based grease of #2 consistency. The motor should be greased stationary with the motor warm.
  - Change seal fluid annually. Use DEKKER Vmaxol seal fluid. To change the fluid make sure the power is off. Drain fluid reservoir, vacuum pump and oil cooler using drain valves. When changing the system with new fluid make sure the pump is filled with oil to the shaft centerline. Do not fill past shaft centerline. Fill seal fluid reservoir to the fill line on the sight gauge. Temporarily open the air bleed valve on the top left corner of the oil cooler to remove all air from the system. Operate the pump for a few minutes, stop and check fluid level again.
  - Inspect separator filter element located in the separator reservoir. If back-pressure is higher than 4 psig this would indicate dirt build up and the separator element should be replaced.
- Check and tighten, if necessary, all electrical contacts for power and controls. Shut down and lockout/tagout power to the system before check.

4.5 AS-NEEDED TASKS

4.5.1 VGAC Changeout

During weekly site visits, the VGAC vessels are monitored using a PID meter as mentioned in Section 4.1. When PID readings exceed 50 ppm on the midpoint sampling port, the carbon from the lead vessel shall be replaced with virgin or regenerated carbon. The lag vessel will then be moved into the position of the lead vessel and the vessel that had the carbon replaced will become the new lag vessel. During carbon changeout, inspect the inside of the vessels to verify that no damage to the vessel has occurred. Once the carbon has been replaced, the DPE system can be restarted.

4.5.2 LGAC Changeout

Treated water that has gone through the LGAC vessels will be sampled according to the CMP and the Administrative Order #11456 prior to discharge into the facility stormwater system. If treated water analytical results are above the limits specified in the administrative order the system will be shut down and Ecology will be notified immediately. The treatment will be evaluated to assess if carbon replacement or treatment system redesign is necessary. If carbon changeout is required, the LGAC vessels will be drained and the carbon will be replaced with virgin or regenerated carbon. During carbon changeout, inspect the inside of the vessels to verify that no damage to the vessel has occurred. Once the carbon has been replaced, the DPE system can be restarted.

4.5.3 Filter Changeouts

The DPE system has been installed with two different types of particulate filters. The three Solberg filters are installed along the vapor treatment train and the two micron bag filters are installed along the groundwater treatment train.

- Solberg Filters should be inspected for debris accumulation weekly and if debris buildup is affecting performance or if a pressure drop of 10-inches water from the original reading is noticed, then the filters should be replaced immediately.

- Micron bag filters should be inspected weekly if the system is operating in DPE mode. If pressure increases exceed 10 psi from original readings then the filter bag should be replaced immediately. Actual pressure differential, pressure drops and frequency of filter bag changes can vary.

4.5.4 Liquid Ring Pump Seal Oil Change

As described in Section 4.1, seal oil levels should be inspected weekly. If seal oil levels are running low, immediately replace oil to the proper levels marked on the liquid ring pump equipment.

4.5.5 Cold Weather and Rainy Condition Operations

During sustained cold weather periods (ambient air temperatures below 35 degrees Fahrenheit for 3 or more consecutive days), the system should be switched from DPE mode to SVE mode or freeze protection added to the liquid-phase pipe and hose located outside the container. If utilized, make sure automatic electric heat cable is turned on and touching the pipes and hoses susceptible to freezing. Prior to switching to SVE mode, turn off all valves associated with the liquid treatment train drain and blow out all water lines as well as the LGAC vessels. Disconnect flex hose associated with the LGAC vessels and drain them out as well. Once all lines are free of water switch the system to SVE mode.

During rainy conditions, inspect the secondary containment and make sure that there is no oil sheen present on the standing water. If there is no sheen present, the secondary containment can be drained into the facility stormwater system. If there is sheen present, the sheen must be skimmed off and passed through the oil water separator.

4.5.6 Repairs

Repairs or replacement of equipment shall be done according to manufacturer's warranties and recommendations. Detailed steps in maintenance tasks, parts for equipment and repairs for each piece of equipment can be found in Appendix A. If a spill occurs, the DPE system will be immediately shutdown and the spill will be contained and cleaned up. If a faulty part is responsible for causing the spill, the part will be repaired or replaced. A spill kit will be available on-site at all times.

5.0 SAMPLING REQUIREMENTS

Groundwater sampling will be conducted quarterly until 2 years following shutdown of the DPE system. Treated groundwater discharge sampling will be conducted weekly when water is discharged during DPE system operations. For sampling procedures and analysis requirements refer to the CMP (URS 2015) and updates.

6.0 SYSTEM TROUBLESHOOTING

The troubleshooting guide shown in (Table 6) summarizes potential solutions to problems encountered during the first year of system operation. If problems occur that are not discussed in the troubleshooting guide or if the solutions provided do not remedy the problem, please consult the vendor operation manual provided in Appendix A or call the vendor. Additional system information such as pump curves and carbon vessel information is found in Appendix G.

Another useful tool when troubleshooting alarm conditions related to the DPE system is the Ladder Logic option located on the bottom of the HMI screen. Ladder Logic tracks various switches that may have tripped in the system and helps to isolate the problem. Associated symbols and labeling of equipment are presented in Appendix H. If problems persist, contact vendor for troubleshooting guidance.

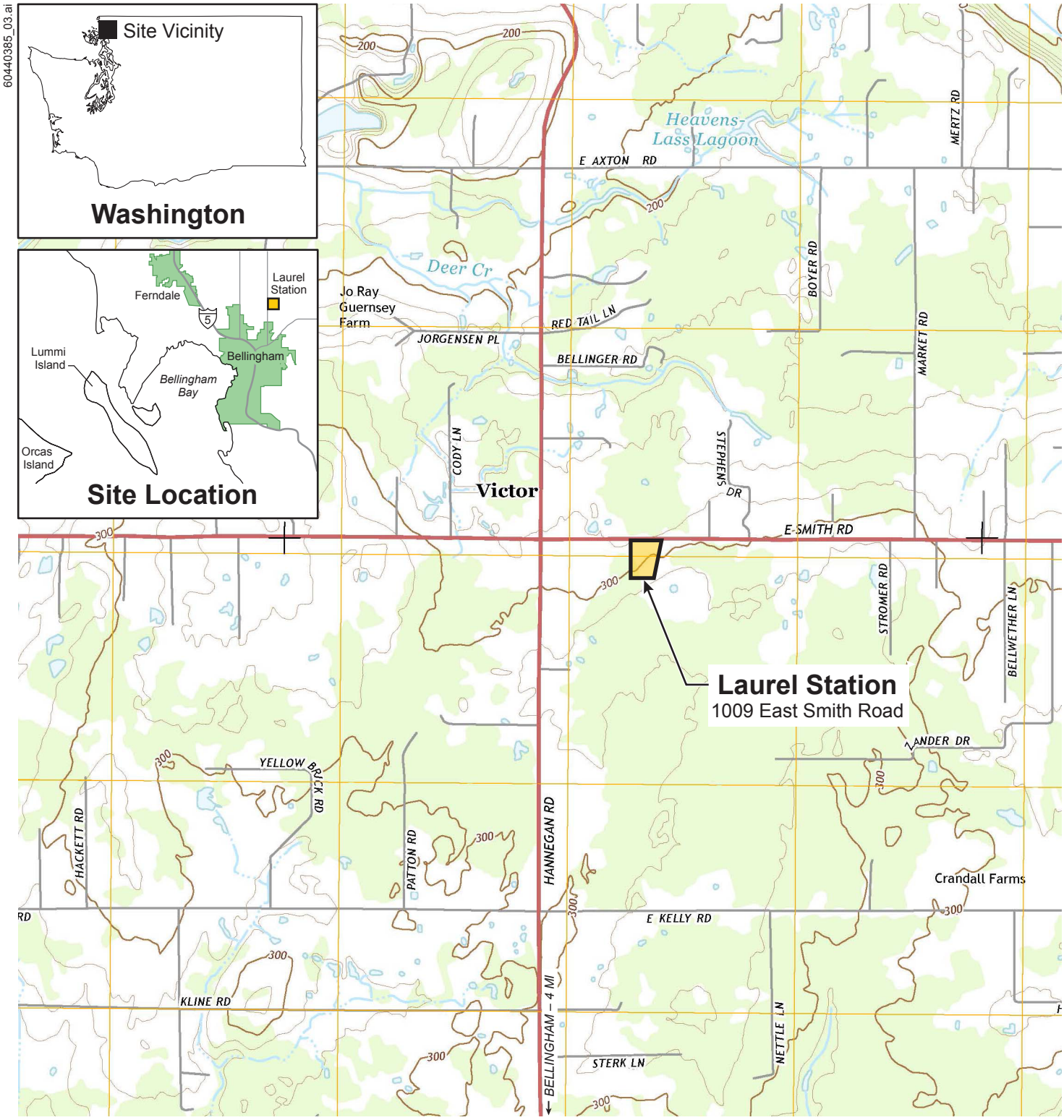
7.0 REFERENCES

URS Corporation (URS). 2014. Final Engineering Design Report, Laurel Station, 1009 East Smith Road, Bellingham, Washington. September 2014.

———. 2015. Final Compliance Monitoring Plan, Laurel Station, 1009 East Smith Road, Bellingham, Washington. January 2015.

Washington State Department of Ecology, 2014. Consent Decree 14-2-01294-9, Exhibit A Cleanup Action Plan, effective June 5, 2014.

FIGURES



Source: USGS 7.5-minute topographic quadrangle, Bellingham North, Washington, 2014

N

0 0.5 1.0

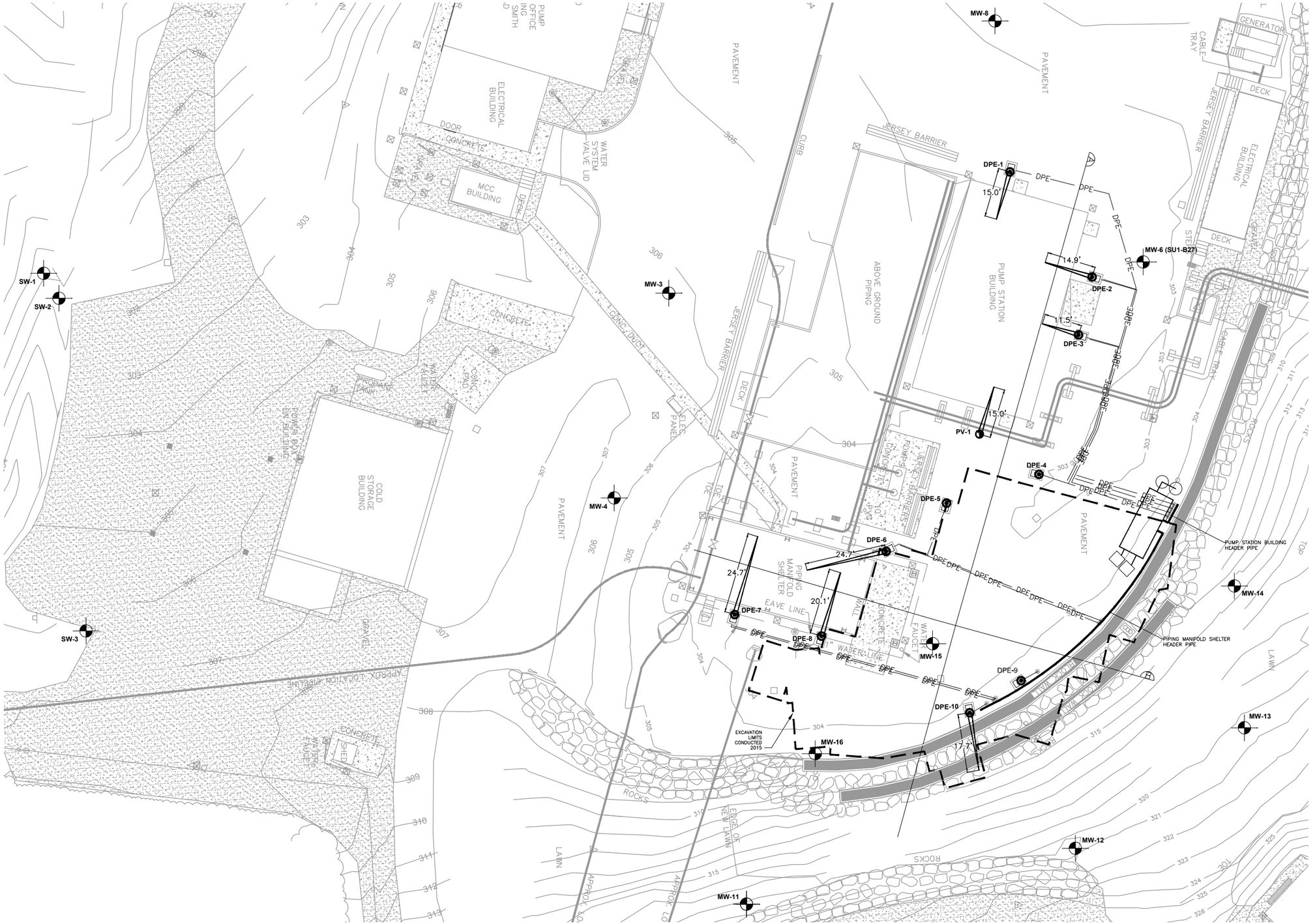
Scale in Miles

Figure 1

Site Location Map

URS

Laurel Station
Bellingham, Washington



Legend

- Cross Section Location
- DPE Container
- Liquid-Phase Carbon Vessels
- Vapor-Phase Carbon Vessels
- Dual Phase Extraction Well Vault
- Excavation Limits (2014-2015)
- Installed at Angle Shown With Horizontal Extent
- Dual-Phase Extraction (DPE) Well
- Monitoring Well
- Passive Vent Well
- Segmented Concrete Block (Retaining Wall)
- DPE — Underground DPE Lateral Pipe

NT

0 15 30

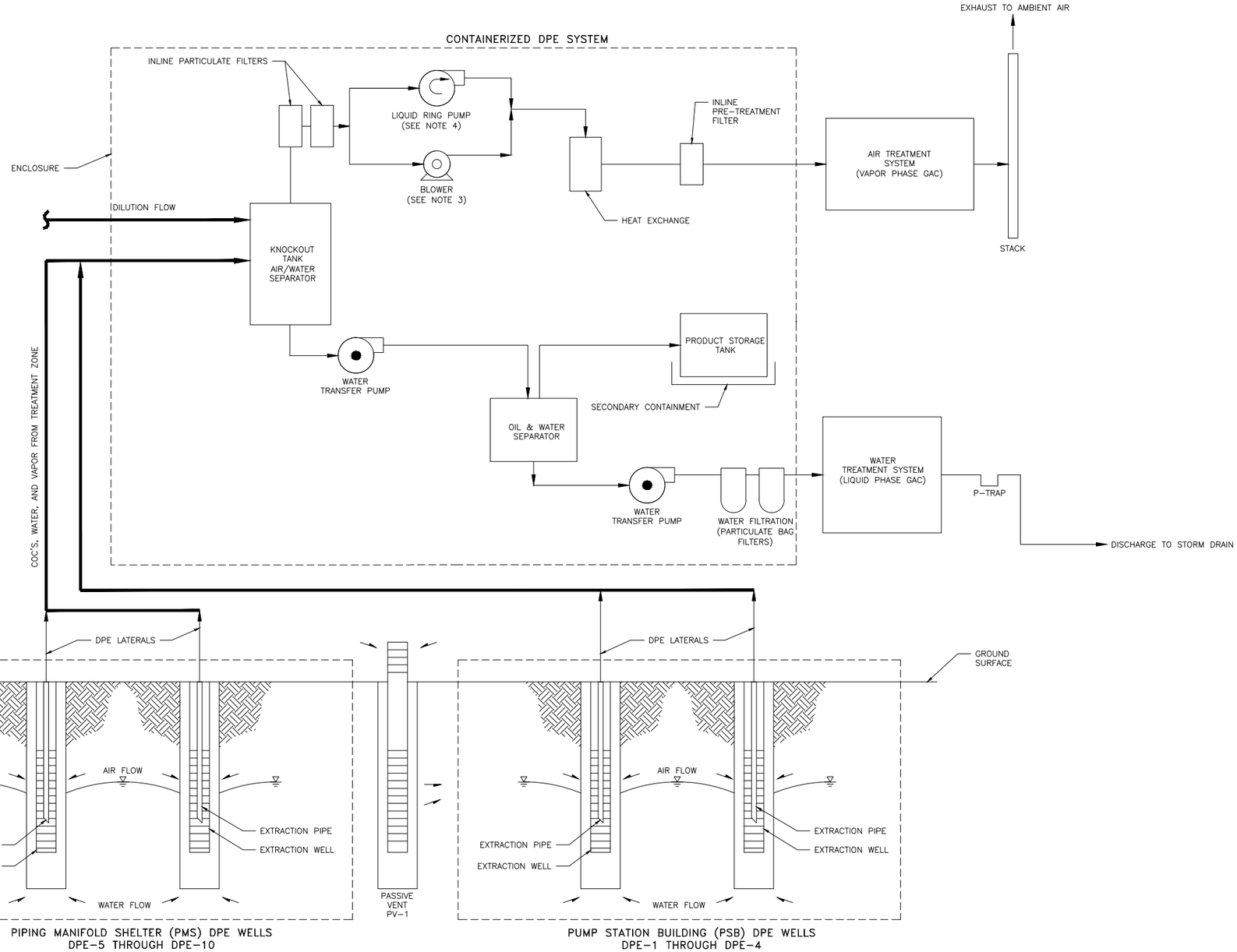
SCALE IN FEET

Figure 2

Site Plan and DPE Well Locations

Laurel Station
Bellingham, Washington

URS



NOTES:

1. SEE PIPING & INSTRUMENTATION DIAGRAM FOR EQUIPMENT DETAILS.
2. THE TWO VACUUM PUMPS (LIQUID RING AND REGENERATIVE BLOWER) CAN NOT RUN SIMULTANEOUSLY.
3. THE REGENERATIVE BLOWER CAN BE USED WHEN GROUNDWATER IS NOT PRESENT.
4. THE LIQUID RING PUMP CAN BE USED WHEN GROUNDWATER IS PRESENT.

LEGEND

- GROUNDWATER ELEVATION
- WATER TRANSFER PUMP
- LIQUID RING PUMP
- BLOWER
- DPE HEADER PIPE
- DPE LATERAL PIPING

Figure 3
Process Flow Diagram

URS

Laurel Station
Bellingham, Washington

Mod: 12/02/2015, 13:27 | Plotted: 12/03/2015, 11:03 | marshallm1 J:\GIS\Projects\Kinder Morgan\Laurel Pump Station\SubTasks\Remediation\Removal Excavation & DPE System\R05 (Asbuilt)\Working\Figure 3 (DPE Process Flow Diagram)_v2.dwg

MPE SYSTEM

ASBUILT

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

SUPPLY FAN
NYB #SN-122-M
0.25 HP, 240 V, 1900 CFM

SUPPLY FAN
NYB #SN-122-M
0.25 HP, 240 V, 1900 CFM

EMERGENCY STOP SWITCH (X2)

HEATER
CHROMALOX #CVEP-C-36-41-00-00
3.6 KW, 480V, 1 PHASE
XP

OUTSIDE ENCLOSURE
RED BEACON LIGHT
GREEN BEACON LIGHT
115V, 1 PHASE

FPI
STAINLESS STEEL

DILUTION AIR INTAKE
FILTER/SILENCER
SOLBERG #FS-30P-200

TO HIGH LEVEL ALARM LIGHT ON CONTROL PANEL LSHH

DISCHARGE PUMP ON LSH

DISCHARGE PUMP OFF LSL

WALL

2" SCH80PVC

DPI DWYER 2002

FI DWYER DS-300-2"

3" FLANGED OUTLET

12" FURNCO WITH STEEL PLATE

12"x5" THICK 304LSS MIST ELIMINATOR

4" SCH80PVC

4" FLANGE

4" PLAIN INLET

4" JOMAR BUTTERFLY VALVE

12"x24" STD BLACK PIPE

2.0" FEMALE THREADS

SITE TUBE

120 GALLON KO TANK
92-24-120-200

(0-30" HG) VI

SP 3/8"

8" CLEAN OUT FURNCO WITH STEEL PLATE

1.25" DRAIN

(0-30"HG) VI

2" FLANGED GLOBE VALVE

3" SCH80PVC

INLINE FILTER
SOLBERG #ST-235P-300C
3" INLET / OUTLET

INLINE FILTER
SOLBERG #CT-235P-300C
3" INLET / OUTLET

(0-30"HG) VI

SPILL CONTAINMENT

DWYER #1950P-15-2F
(3-15 PSID) SET @ 13" HG

LSH HM TSH MS LSL I HOA M SOL VSL

LIQUID RING PUMP
DEKKER #VMX0303KA1-01
20 HP, 230/460V. 3 PHASE
2.5" INLET / 3" OUTLET
300 ACFM @ 26" HG

3" GAL

(50-300°F) TI

PI (0-60"WCP) 3/8" SP

3" GAL

HM I MS HOA M

(0-100"WCV) VI

3" SCH80PVC

SVE BLOWER
AMETEK #EN808BA72MXL
7.5 HP, 230/460V. 3 PHASE
2.5" INLET / OUTLET
220 ACFM @ 4" HG

DWYER
TTE-104-W-LCD
SET @ 120°F

TS

DWYER
1950P-8-2F
SET @ 5 PSI

PSH

FILTER/SEPARATOR
SOLBERG #ST-235P-300C
3" INLET / OUTLET

0-30 PSI
(0-60"WCP)

PI

WALL

3" GAL

60"WCP
(0-30 PSI)

PI

TI (50-300°F)

3/8" SP

CONTINUED TO VAPOR PHASE CARBON ON SHEET 05

I MS HOA M

1" DRAIN

HEAT EXCHANGER
AMERICAN INDUSTRIAL #ACA-3301-3E
0.5 HP, 230/460V. 3 PHASE

BRASS

1" POLY FLEX RECURCULATION LINE

BRASS

PSB Header Pipe

Continued See Markups on sheet 6

WALL

1" DRAIN

PMS Header pipe

Continued See Markups on sheet 4D

2" SIGHT GLASS SG

2" SIGHT GLASS SG

1/4" VI

SP 3/8"

4" JOMAR BUTTERFLY VALVE

1/4" VI

SP 3/8"

SENECA INSTALL ON-SITE

I MS HOA M

(0-60PSI) PI

SP 1/4"

1.5" SCH80PVC

1.25" SCH80PVC

PROGRESSIVE CAVITY TRANSFER PUMP
CONTINENTAL #CP56C-CSQM
1.0 HP, 230/460V, 3 PHASE
15 GPM @ 25 PSI
1.5" INLET / 1.25" OUTLET

PSH

MERCOID
SA1111E-S5-K2
SET @ 25 PSI

DWYER
ROTOMETER
#VFC-143-EC

FI

CONTINUED TO OIL/WATER SEPARATOR ON SHEET 04

Seneca Companies
The Complete Solution

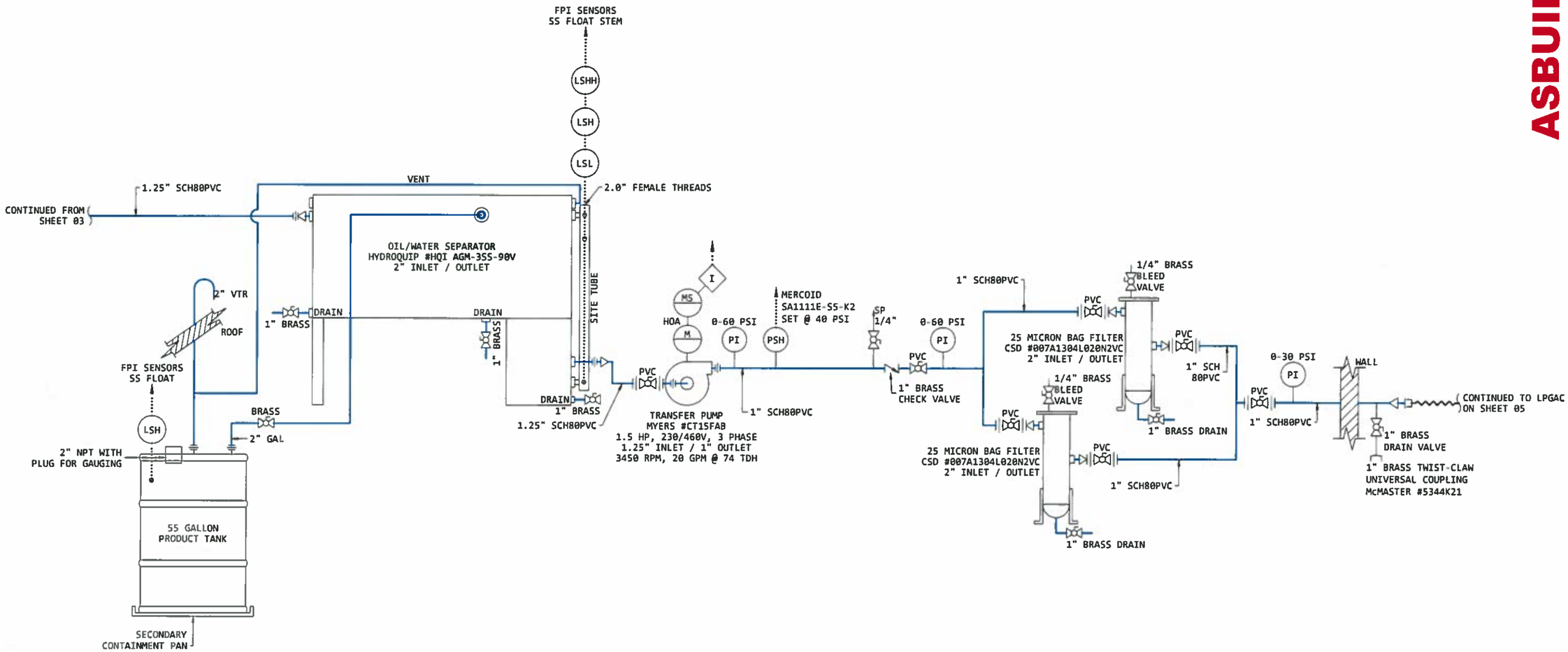
JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
PROCESS AND INSTRUMENTATION DIAGRAM

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: DAN NOLAN
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO: ~~03~~ 4A

FILE LOCATION: I:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005S01-06

WATER TREATMENT SYSTEM



No
Changes
needed

ASBUILT

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

Seneca Companies
The Complete Solution

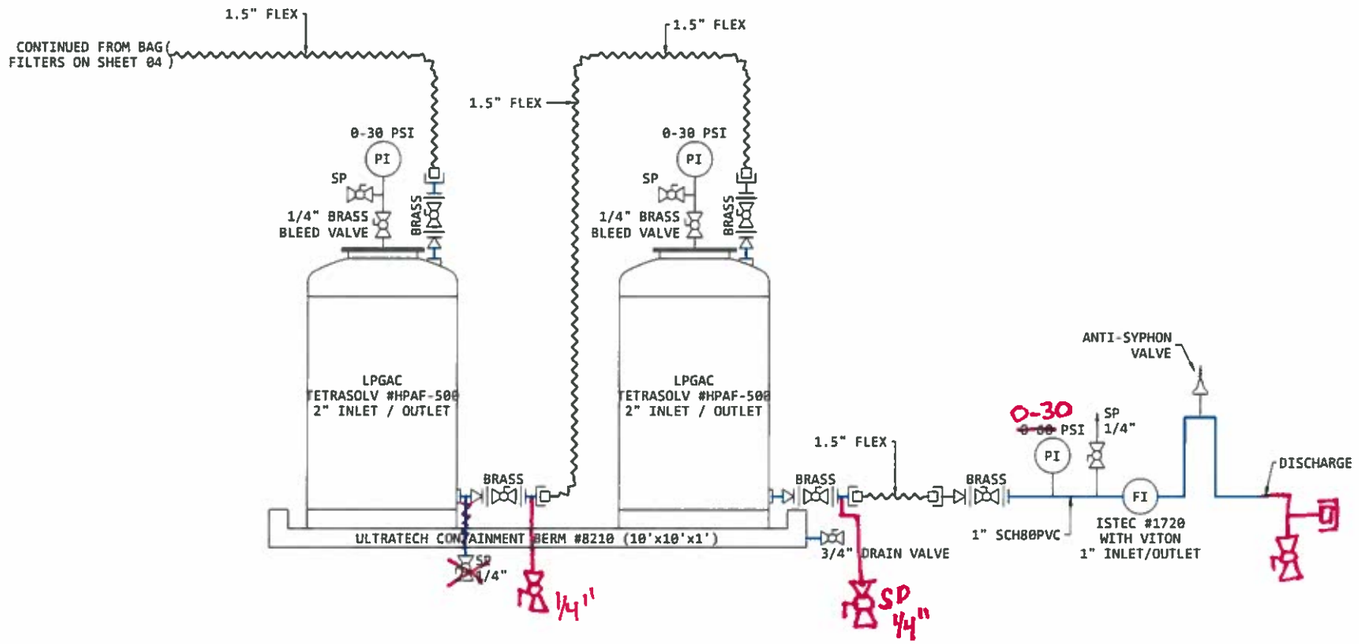
JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

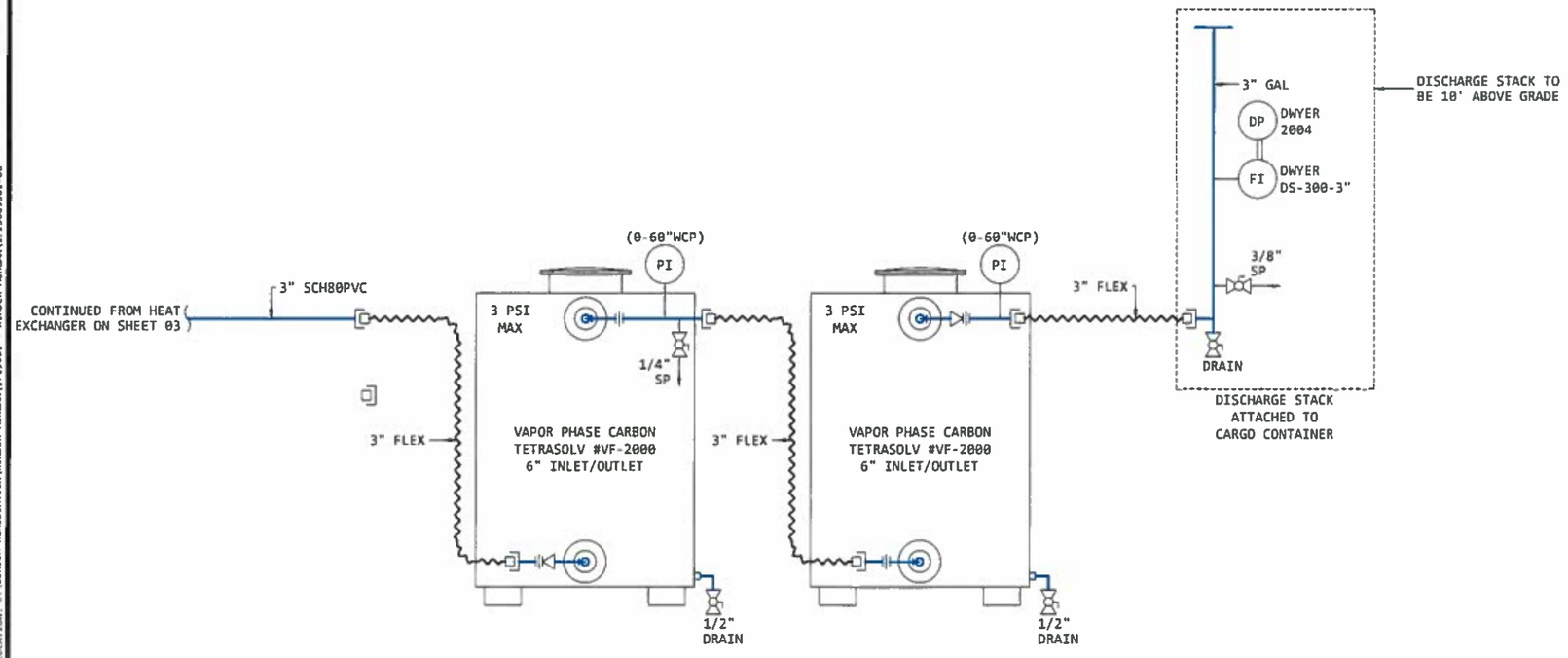
SHEET TITLE:
PROCESS AND INSTRUMENTATION DIAGRAM

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: DAN NOLAN
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO: 04 B

FILE LOCATION: I:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005S01-06

CARBON VESSELS





ASBUILT

REV NO	DATE
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02	06/11/2015
03	07/07/2015

Seneca Companies
The Complete Solution

JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
PROCESS AND INSTRUMENTATION DIAGRAM

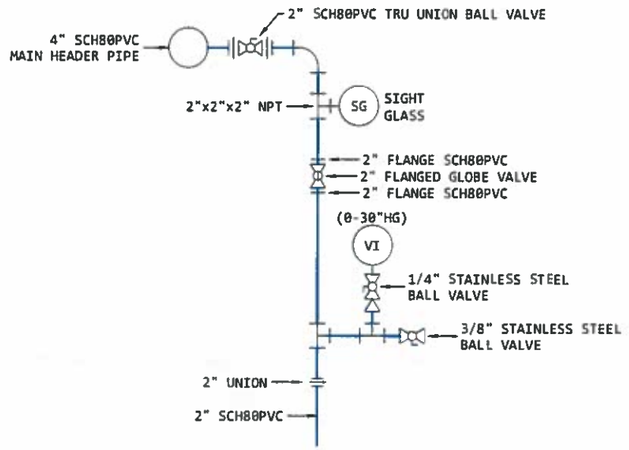
DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: DAN NOLAN
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO. ~~05~~ 4C

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005501.06

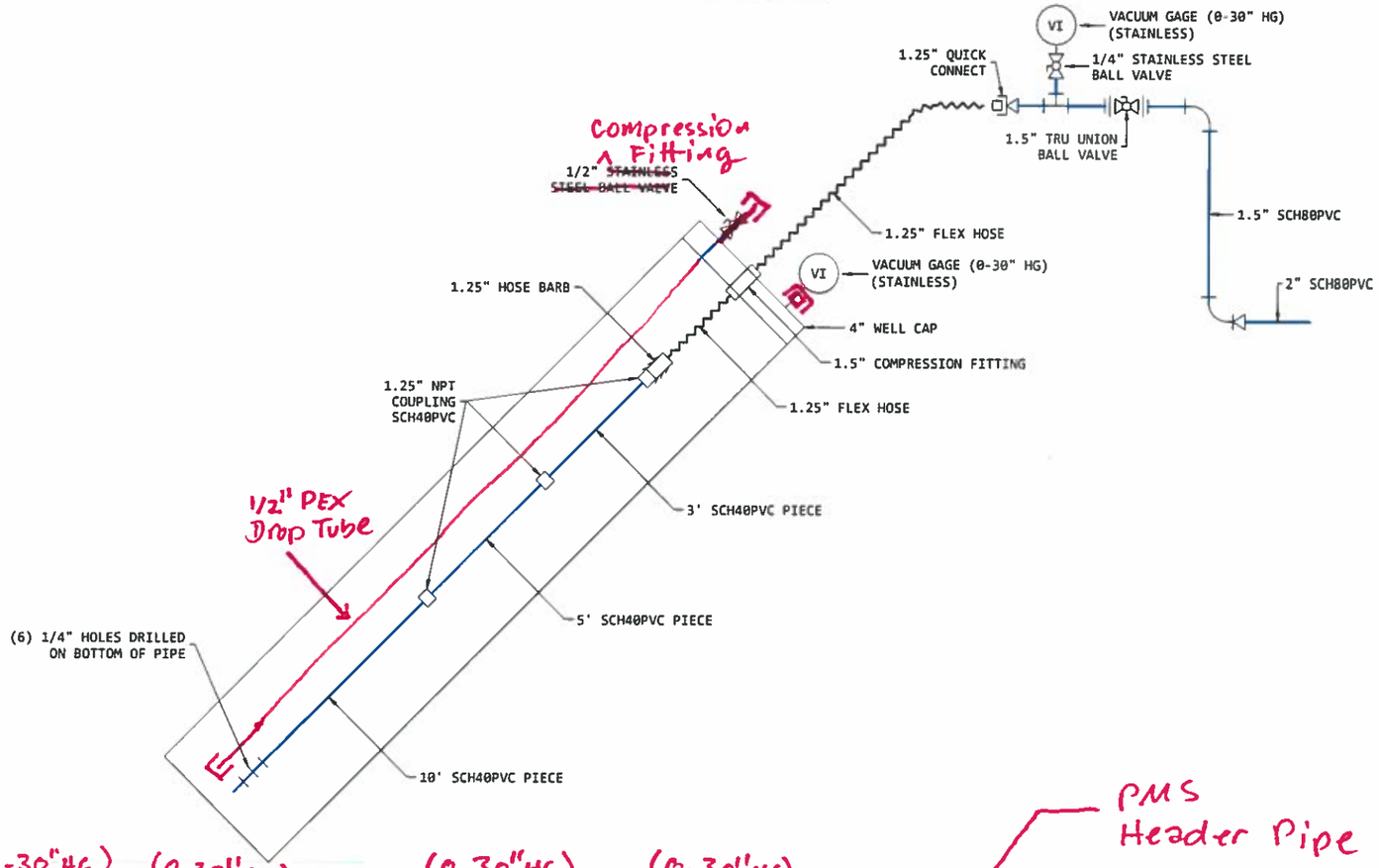
WELL STUB/WELL VAULT DETAILS

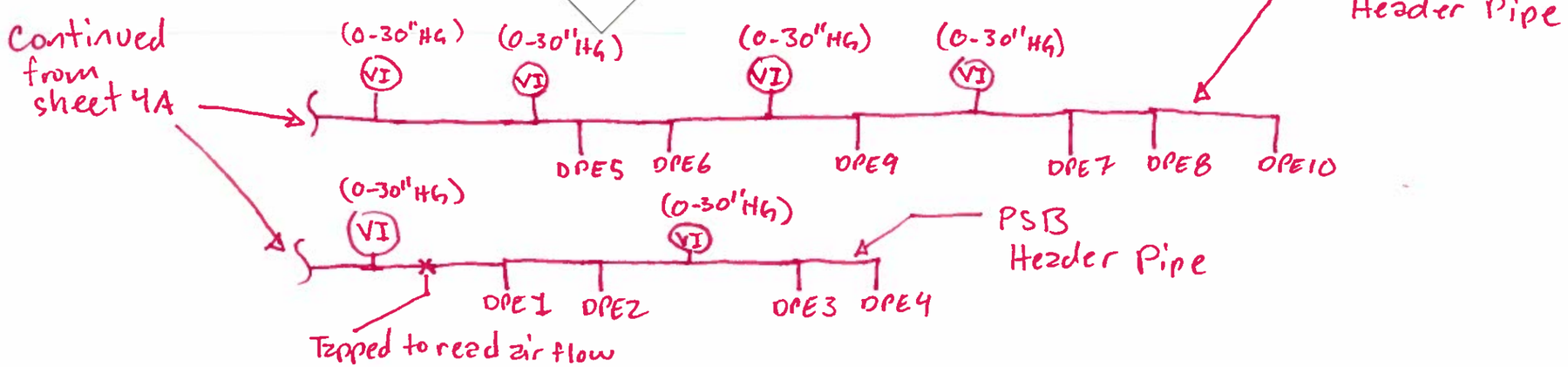
ASBUILT

WELL STUB



WELL VAULT





REV NO	DATE
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02	06/11/2015
03	07/07/2015

Seneca Companies
The Complete Solution

JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
PROCESS AND INSTRUMENTATION DIAGRAM

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: DAN NOLAN
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO: 06 4D

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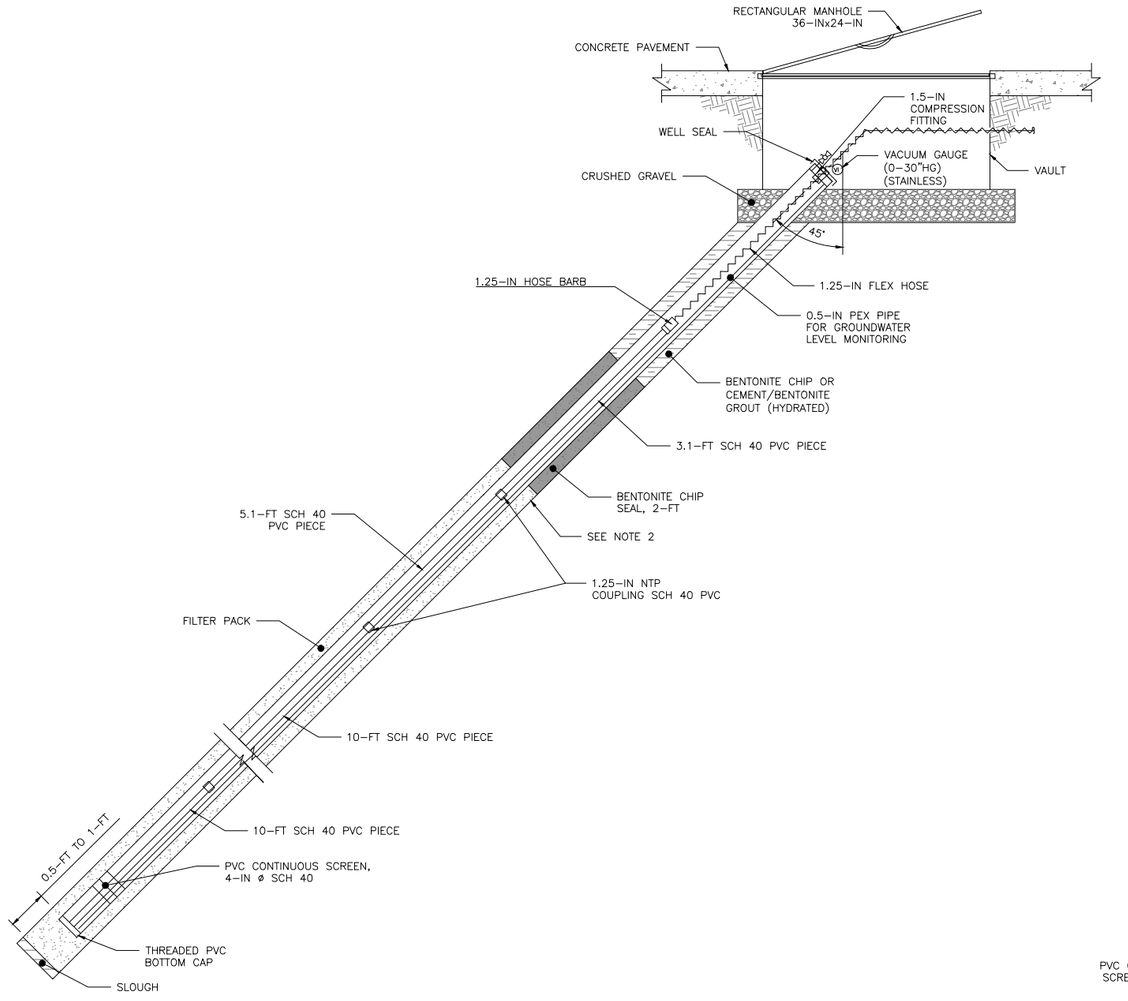
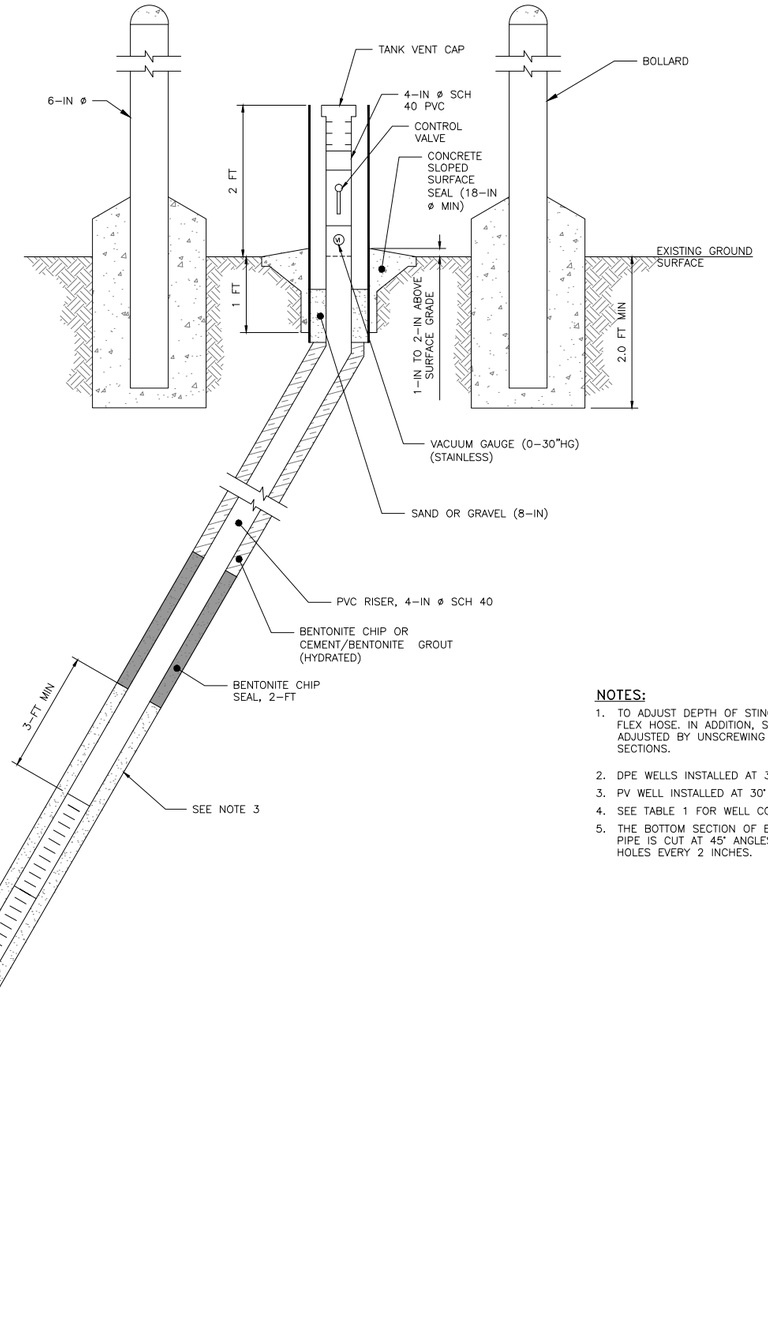


45°ANGLED DPE WELLS



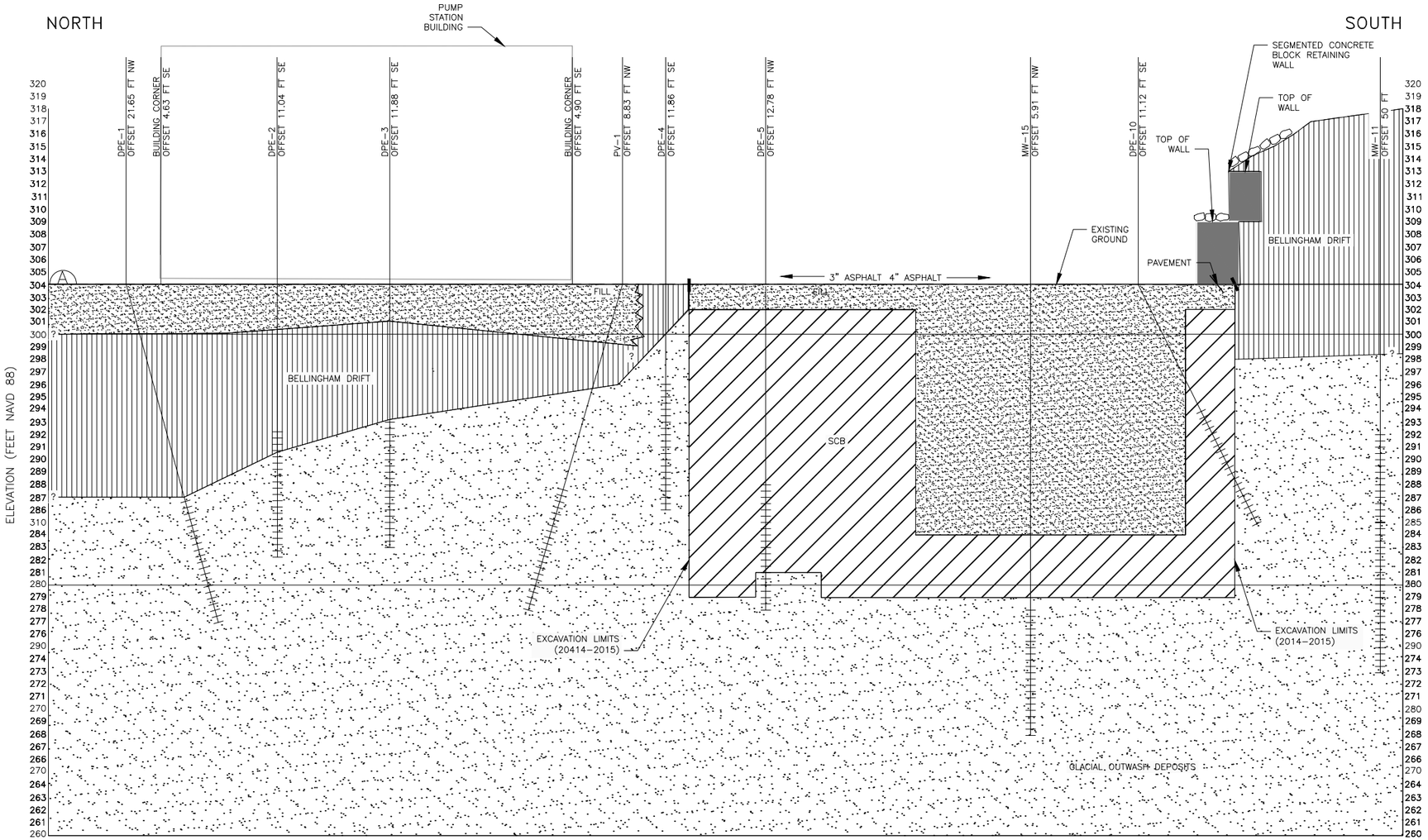
ANGLED PASSIVE VENT WELL

NOTES:

1. TO ADJUST DEPTH OF STINGER PIPE, LOWER OR RAISE FLEX HOSE. IN ADDITION, STINGER PIPE CAN BE ADJUSTED BY UNSCREWING UNIONS AND REMOVING SECTIONS.
2. DPE WELLS INSTALLED AT 30°, 35°, & 45°.
3. PV WELL INSTALLED AT 30°
4. SEE TABLE 1 FOR WELL CONSTRUCTION DETAILS.
5. THE BOTTOM SECTION OF EACH DPE WELL STINGER PIPE IS CUT AT 45° ANGLES AND HAS 0.25 INCH HOLES EVERY 2 INCHES.

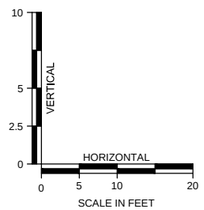
Figure 5
Typical DPE Well Set Up

NORTH



LEGEND

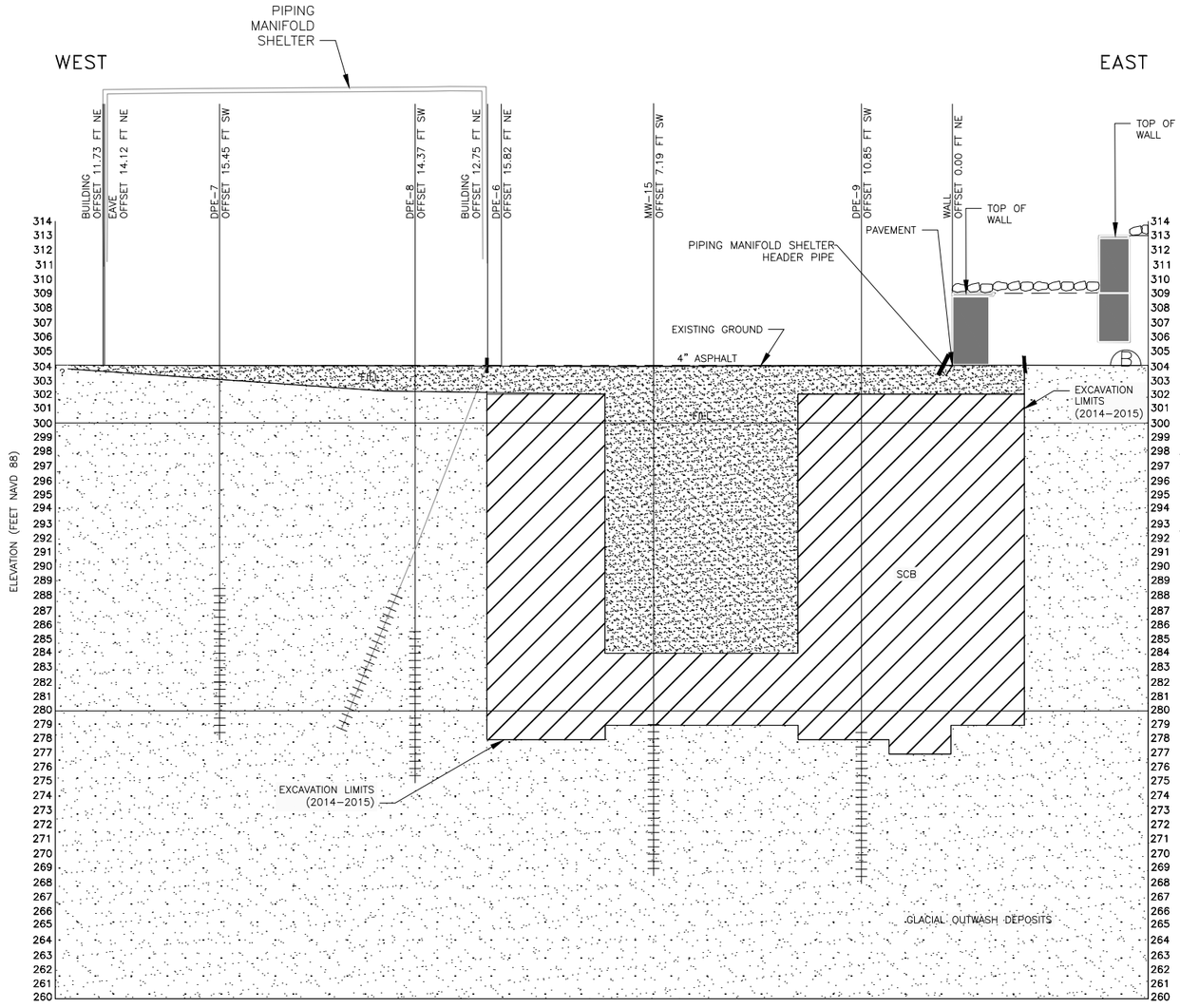
- BELLINGHAM DRIFT
- ? ESTIMATED DEPTH BASED ON AVAILABLE DATA
- EXCAVATION LIMITS (2014-2015)
- EXISTING GROUND
- FILL
- GLACIAL OUTWASH DEPOSITS
- RIP-RAP
- SCREENED INTERVAL OF WELL
- SEGMENTED CONCRETE BLOCK (RETAINING WALL)
- SOIL CEMENT BENTONITE (SCB)



A-A

Figure 6
NORTH TO SOUTH CROSS SECTION (A)
Laurel Station
Bellingham, Washington

URS



B-B

NORTH

LEGEND

- BELLINGHAM DRIFT
- ? ESTIMATED DEPTH BASED ON AVAILABLE DATA
- EXCAVATION LIMITS (2014-2015)
- EXISTING GROUND
- FILL
- GLACIAL OUTWASH DEPOSITS
- RIP-RAP
- SCREENED INTERVAL OF WELL
- SEGMENTED CONCRETE BLOCK (RETAINING WALL)
- SOIL CEMENT BENTONITE (SCB)

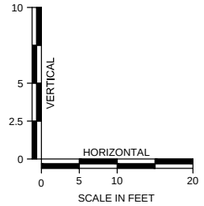


Figure 7
WEST TO EAST CROSS SECTION (B)
Laurel Station
Bellingham, Washington

URS

TABLES

Table 1
Well Construction Details

Well ID	Well Type	Angle Of Installed Well	Screened Interval (feet below TOC)	Diameter (Inches)	Well Casing Material	Screen Material	Screen Slot Size (Inches)	Sand Type
DPE-1	DPE	30°	16.9 to 25.5	4	Schedule 40 PVC	Schedule 40 PVC	0.030	#2/12
DPE-2	DPE	35°	12.7 to 20.9	4	Schedule 40 PVC	Schedule 40 PVC	0.030	#2/12
DPE-3	DPE	30°	10.8 to 19.5	4	Schedule 40 PVC	Schedule 40 PVC	0.030	#2/12
DPE-4	DPE	NA	6.5 to 16.5	4	Schedule 40 PVC	Schedule 40 PVC	0.030	#2/12
DPE-5	DPE	NA	14.5 to 24.5	4	Schedule 40 PVC	Schedule 40 PVC	0.030	#2/12
DPE-6	DPE	45°	10.3 to 24.4	4	Schedule 40 PVC	Schedule 40 PVC	0.030	#2/12
DPE-7	DPE	45°	10.3 to 24.4	4	Schedule 40 PVC	Schedule 40 PVC	0.030	#2/12
DPE-8	DPE	35°	11.9 to 28.3	4	Schedule 40 PVC	Schedule 40 PVC	0.030	#2/12
DPE-9	DPE	NA	24.5 to 34.5	4	Schedule 40 PVC	Schedule 40 PVC	0.030	#2/12
DPE-10	DPE	45°	3.9 to 18	4	Schedule 40 PVC	Schedule 40 PVC	0.030	#2/12
PV-1	Passive Vent	30°	17.3 to 26	4	Schedule 40 PVC	Schedule 40 PVC	0.030	#2/12
MW-3	MW	NA	24 to 34	2	Schedule 40 PVC	Schedule 40 PVC	0.010	#2/12
MW-4	MW	NA	20 to 30	2	Schedule 40 PVC	Schedule 40 PVC	0.010	#2/12
MW-6	MW	NA	11 to 26	2	Schedule 40 PVC	Schedule 40 PVC	0.010	#2/12
MW-8	MW	NA	23 to 38	2	Schedule 40 PVC	Schedule 40 PVC	0.010	#2/12
MW-11	MW	NA	25 to 45	4	SS	SS 304	NA	#2/12
MW-12	MW	NA	29 to 49	4	SS	SS 304	NA	#2/12
MW-13	MW	NA	39 to 59	4	SS	SS 304	NA	#2/12
MW-14	MW	NA	30 to 50	4	SS	SS 304	NA	#2/12
MW-15	MW	NA	25 to 35	4	Schedule 40 PVC	Schedule 40 PVC	0.030	#2/12
MW-16	MW	NA	25 to 35	4	Schedule 40 PVC	Schedule 40 PVC	0.030	#2/12
SW-1	MW	NA	5 to 20	2	Schedule 40 PVC	Schedule 40 PVC	0.020	#10/20
SW-2	MW	NA	40 to 50	2	Schedule 40 PVC	Schedule 40 PVC	0.020	#10/20
SW-3	MW	NA	20 to 30	2	Schedule 40 PVC	Schedule 40 PVC	0.020	#10/20

Table 1 (continued)
Well Construction Details

Notes:
DPE - dual-phase extraction
MW - monitoring well
NA - not applicable; these wells are vertical
PVC - polyvinyl chloride
SS - stainless steel
TOC - top of casing

Table 2
DPE System Equipment Details

System Item	Details
Knockout Tank	120 gallon air/water separator tank; rated for 650 ACFM
Liquid Ring Pump	20 HP, 230/460V 3-phase oil-sealed vacuum pump system; Operates up to 300 ACFM at 26-inches of Hg.
Heat Exchanger	0.5 HP, 230/460V 3-phase air-cooled heat exchanger; Operating pressure 150 psi. Operating temperature 400 F°.
Oil Water Separator (OWS)	OWS volume of 279 gallons, effluent tank volume 90 gallons, sludge volume 6 gallons, optimal product tank volume 60 gallons and 6 cubic feet of coalescing area
SVE Blower	7.5 HP, 230/460V 3-phase regenerative blower; Operates up to 220 ACFM at 4-inches of Hg.
Transfer Pump-1	1 HP 230/460V 3-phase progressive cavity transfer pump; Operates up to 15 gpm at 25 psi. Associated with Knockout Tank.
Transfer Pump-2	1.5 HP 230/460V 3-phase progressive transfer pump; Operates up to 20 gpm at 74 feet TDH. Associated with OWS.
Product Effluent Tank	55 gallon tank
Inline Vapor-Phase Particulate Filters	3 - Solberg inline particulate filters
Liquid-Phase Particulate Bag Filters	2 - 25 micron particulate bag filters
LGAC Vessel	500 pound carbon vessel (215 gallons)
VGAC Vessel	2,000 pound carbon vessel (800 gallons)

Notes:
ACFM - actual cubic feet per minute
DPE - dual-phase extraction
F° - fahrenheit
gpm - gallon per minute
Hg - mercury
HP - horse power
LGAC - liquid-phase granulated activated carbon
OWS - oil water separator
psi - pound per square inch
SVE - soil vapor extraction
TDH - total dynamic head
V - volt
VGAC - vapor-phase granulated activated carbon

Table 3
Equipment and Supply List with Suggested Vendors

Item Number	Item Name	Description and/or Purpose	Part Number	Suggested Vendor	Phone	Website
1	Liquid Ring Pump	20 HP Vmax oil-sealed vacuum pump	VMX0303KA1-01	Dekker, IN	(219) 861-0661	http://www.dekkervacuum.com/
2	Vacuum relief valve filter element	Replacement element for filter element	2924-0100-001	Dekker, IN	(219) 861-0661	http://www.dekkervacuum.com/
3	Separator Element	Replacement element for separator element	6300-1615-002	Dekker, IN	(219) 861-0661	http://www.dekkervacuum.com/
4	Seal fluid oil	Replacement for seal fluid	5220-0050-000	Dekker, IN	(219) 861-0661	http://www.dekkervacuum.com/
5	Oil Water Separator	Oil Water Separator	HQI AGM-3SS-90V	Hydroquip Inc, MA	(508) 399-5771	http://www.hydroquipinc.com/
6	Product Storage Drum	55 gallon drum	4115T18	McMaster Carr	(562) 692-5911	http://www.mcmaster.com/
7	SVE Blower	7.5 HP 3-phase 460 volt	EN808BA72MXL	Ametek Rotron, CA	(760) 487-5266	http://www.rotron.com/
8	EXP Supply Fan	New York Blower 1/4 HP	SN-122-M	Baxter Air Engineering, Woodinville, WA	(425) 486-6666	http://www.baxair.com/
9	Heat Exchanger	Vapor gas temperature control	ACA-3301-3E	American Industrial, VA	(434) 757-1800	http://www.aihti.com/
10	Transfer Pump	Meyers Class 1 Div 2 pump. 230/460V 3-phase, 1.5 HP	CT15FAB	Triangle Pumps, Ridgefield, WA	(360) 887-9530	http://www.trianglepump.com/
11	Pump Seal Kit	Meyers Pump Seal Kit	14525A000K	Triangle Pumps, Ridgefield, WA	(360) 887-9530	http://www.trianglepump.com/
12	Pump Gasket	Myers Pump Gasket	05059A446	Triangle Pumps, Ridgefield, WA	(360) 887-9530	http://www.trianglepump.com/
13	Progressive Cavity Pump	Continental Class 1 Div 2 pump, 1 HP	1HP	Seattle Pump and Equipment, Seattle, WA	(206) 283-5252	http://www.seattlepump.com/
14	Intake Filter/Silencer 2-inch	Replacement filter/silencer	FS-30P-200	Solberg, IL	(630) 616-4400	http://www.solbergmfg.com/
15	Inline Filter See Through Bucket	3-inch Replacement see through bucket for filter	STS-235P-300C	Solberg, IL	(630) 616-4400	http://www.solbergmfg.com/
16	Inline Filter Polyester Element	3-inch Replacement polyester element for filter	CT-235P-300C	Solberg, IL	(630) 616-4400	http://www.solbergmfg.com/
17	Intake Filter Silencer Element	Replacement filter silencer element	30P	Solberg, IL	(630) 616-4400	http://www.solbergmfg.com/
18	Inline Filter Element	Replacement filter element	235P	Solberg, IL	(630) 616-4400	http://www.solbergmfg.com/
19	Filter Housing	Replacement bag filter housing	007A1304L020N2VC	CSD, MI	(248) 340-9005	NA
20	Filter Bags	25 micron replacement bags	25 micron	CSD, MI	(248) 340-9005	NA
21	Filter Bags	50 micron replacement bags	50 micron	CSD, MI	(248) 340-9005	NA
22	EXP Convection Heater	Chromalox Replacement Convection Heater	CVEP-3.6 kw 460v 1P	Valin Corp, Renton, WA	(425) 282-6030	http://www.valin.com/
23	Secondary Containment	Ultratech secondary containment	UT-8210	Grainger	1-800-472-4643	http://www.grainger.com/
24	Vacuum Gauge	Stainless Steel Center Back 0 to 30-inches Hg	3859K2	McMaster Carr	(562) 692-5911	http://www.mcmaster.com/
25	Temperature Gauge	Ashcroft 50/300 Fahrenheit	30EI60R040	Paramount Supply, Bellingham, WA	(360) 647-8328	http://www.paramountsupply.com/
26	Pressure Gauge #15	Replacement Ashcroft #15 Pressure Gauge	63-1008A-02B-XSF7F-15#	Paramount Supply, Bellingham, WA	(360) 647-8328	http://www.paramountsupply.com/
27	Pressure Gauge #30	Replacement Ashcroft #30 Pressure Gauge	63-1008A-02B-XSF7F-30#	Paramount Supply, Bellingham, WA	(360) 647-8328	http://www.paramountsupply.com/
28	Pressure Gauge #60	Replacement Ashcroft #60 Pressure Gauge	63-1008A-02B-XSF7F-60#	Paramount Supply, Bellingham, WA	(360) 647-8328	http://www.paramountsupply.com/
29	Level Switches	Replacement Level Switches for tanks	NA	FPI Sensors, MI	1-800-852-9984	http://fpisensors.com/
30	Pressure Switch	Mercoid EXP Pressure Switch	SA1111E-S5-K2	Dwyer, IN	1 800-872-9141	http://www.dwyer-inst.com/
31	Pressure Switch	Dwyer EXP Pressure Switch	1950P-8-2F	Dwyer, IN	1 800-872-9141	http://www.dwyer-inst.com/
32	Temperature Transmitter	4-inch Temperature transmitter stem w/LCD	TTE-104-W-LCD	Dwyer, IN	1 800-872-9141	http://www.dwyer-inst.com/
33	Vacuum Switch	Dwyer EXP Vacuum Switch	1950P-15-2F	Dwyer, IN	1 800-872-9141	http://www.dwyer-inst.com/
34	Pitot Tube	Replacement 3-inch Pitot Tube	DS-300-3"	Dwyer, IN	1 800-872-9141	http://www.dwyer-inst.com/
35	Pitot Tube	Replacement 2-inch Pitot Tube	DS-300-2"	Dwyer, IN	1 800-872-9141	http://www.dwyer-inst.com/
36	Magnehelic Gauge	Replacement Magnehelic Gauge 0" to 2" w.c.	2002	Dwyer, IN	1 800-872-9141	http://www.dwyer-inst.com/
37	Magnehelic Gauge	Replacement Magnehelic Gauge 0" to 4" w.c.	2004	Dwyer, IN	1 800-872-9141	http://www.dwyer-inst.com/
38	Rotometer	Replacement 0-20 gpm rotometer	VFC-143-EC	Dwyer, IN	1 800-872-9141	http://www.dwyer-inst.com/
39	Flow Meter (Totalizer)	ISTEC 0 to 50 Max GPM	1720 Viton	ISTEC Corp, NJ	(973) 383-9888	http://www.istec-corp.com/
40	Sample Port Ball Valve	Jomar 3/8-inch Ball valve	100-702	Norpac Inc, Kent, WA	(253) 850-8800	http://www.norpacinc.com/
41	Viton Brass Drain Ball Valve	Jomar 1-inch Ball Valve	100-705	Norpac Inc, Kent, WA	(253) 850-8800	http://www.norpacinc.com/
42	1-inch Check Valve	Replacement brass 1-inch check valve	8517T25	McMaster Carr	(562) 692-5911	http://www.mcmaster.com/
43	1.25-inch Check Valve	Replacement brass 1.25-inch check valve	8517T26	McMaster Carr	(562) 692-5911	http://www.mcmaster.com/
44	Jomar 2-inch Drain Valve	Replacement brass 2-inch drain valve	100-708	Norpac Inc, Kent, WA	(253) 850-8800	http://www.norpacinc.com/
45	Jomar 2.5-inch Viton ball valve	Replacement brass 2.5-inch ball valve	100-709	Norpac Inc, Kent, WA	(253) 850-8800	http://www.norpacinc.com/
46	Jomar 4-inch Butterfly Valve	Replacement 4-inch butterfly valve	900-04-DSEL	Norpac Inc, Kent, WA	(253) 850-8800	http://www.norpacinc.com/
47	Jomar 1-inch PVC Ball Valve	Replacement 1-inch PVC ball valve	210-545	Norpac Inc, Kent, WA	(253) 850-8800	http://www.norpacinc.com/
48	Jomar 1.25-inch PVC Ball Valve	Replacement 1.25-inch PVC ball valve	210-546	Norpac Inc, Kent, WA	(253) 850-8800	http://www.norpacinc.com/
49	Jomar 1.5-inch PVC Ball Valve	Replacement 1.5-inch PVC ball valve	210-547	Norpac Inc, Kent, WA	(253) 850-8800	http://www.norpacinc.com/

Table 3
Equipment and Supply List with Suggested Vendors

Item Number	Item Name	Description and/or Purpose	Part Number	Suggested Vendor	Phone	Website
50	Jomar 2-inch PVC Ball Valve	Replacement 2-inch PVC ball valve	210-548	Norpac Inc, Kent, WA	(253) 850-8800	http://www.norpacinc.com/
51	Jomar 1-inch Anti-Siphon Valve	Replacement 1-inch Anti-Siphon Valve	4817K16	McMaster Carr	(562) 692-5911	http://www.mcmaster.com/
52	Jomar 1/4-inch Stainless Steel Ball Valve	Replacement 1/4-inch SS ball valve	100-961	Norpac Inc, Kent, WA	(253) 850-8800	http://www.norpacinc.com/
53	Sight Flow Window	WE Anderson Sight Flow Window	SFI-500B-2	Dwyer, IN	1 800-872-9141	http://www.dwyer-inst.com/
54	Sight Glass Window	2-inch Sight Glass With Window	4213K167	McMaster Carr	(562) 692-5911	http://www.mcmaster.com/
55	Threaded Globe Valve	2-inch Flanged Globe Valve	4737K58	McMaster Carr	(562) 692-5911	http://www.mcmaster.com/
56	Jomar 3/8-inch Stainless Steel Ball Valve	Replacement 3/8-inch SS ball valve	100-962	Norpac Inc, Kent, WA	(253) 850-8800	http://www.norpacinc.com/
57	Stinger Pipe	1-1/4-inch ID Sch 40 PCV pipe	NA	Local Hardware Store	NA	NA
58	Stinger Hose	1-1/4-inch ID clear flex hose	NA	McMaster Carr/Local Hardware Store	(562) 692-5911	http://www.mcmaster.com/
59	Pex Tubing	1/2-inch Pex tubing	NA	Local Hardware Store	NA	NA
60	Standard-Wall PVC Pipe Fitting	Assembly part for well seal	4880K851	McMaster Carr/Local Hardware Store	(562) 692-5911	http://www.mcmaster.com/
61	Flexible Reducing Coupling for Pipe 1.5-inch x 1.25-inch	Assembly part for well seal	4511K72	McMaster Carr/Local Hardware Store	(562) 692-5911	http://www.mcmaster.com/
62	Flexible Straight Fitting for Pipe 4-inch	Assembly part for well seal	4511K82	McMaster Carr/Local Hardware Store	(562) 692-5911	http://www.mcmaster.com/
63	Well Seal	4-inch well seal with 3 ports used for hose, gauge and water level port	WS4225 10P	Merrill MFG, IA	1 800-831-6962	http://merrillmfg.com

Notes: All Schedule 80 and 40 PVC pipe and fittings can be purchased at local stores such as Home Depot and Lowes. They can also be purchased on-line at Grainger.com
Equipment purchased should be model shown in table or equivalent. Obtain owners permission prior to purchase.

EXP - explosion proof
Hg - mercury
HP - horse power
ID - internal diameter
LCD - liquid crystal display
NA - not applicable
PVC - polyvinyl chloride
SVE - soil vapor extraction
W.C. - water column

Table 4
Alarm Summary

Alarm and Notification	Description/Solution
Emergency Stop Switch	When the Emergency Stop switch is activated, it will shutdown the Knockout Pump, Oil/Water Separator Transfer Pump, Heat Exchanger, SVE Blower and Liquid Ring Pump. The Emergency Stop PLC control circuit will unlatch. No motors or pumps will operate in the Auto or Manual Mode. Fix by resetting the system.
Emergency Stop Reset - HMI	This reset will reset the PLC Emergency Stop Control Circuit if all of the E-Stop Switches are reset. Relay "R1" is the E-Stop Relay. It must be energized for any motors to operate.
Power Monitor Alarm	The Power Monitor will monitor the incoming service power (Over and Under Voltage, Phase Loss and Phase Reversal). When active, it will shut off all 3-phase motors. When power is restored, the Power Monitor will reset and turn on Relay "R2".
Knockout (KO) Tank High Limit Alarm	When activated, it will shut down the SVE Blower and the Liquid Ring Pump (LRP). There is a 20 minute delay before the alarm is Latched. If the KO Tank Transfer Pump pumps down the liquid level to clear the Low Level Float within the 20 minutes, the system will restart. If not, the KO Tank High Limit Alarm is Latched. To reset the alarm, the tank must be pumped down to clear the Low Level Switch.
Oil Water Separator High Limit Alarm	When activated, it will shut down the KO Tank Transfer Pump, SVE Blower and the Liquid Ring Pump (LRP). There is a 20 minute delay before the alarm is Latched. If the Oil Water Separator Transfer Pump pumps down the liquid level to clear the Low Level Float within the 20 minutes, the system will restart. If not, the Oil Water Separator High Limit Alarm is Latched. To reset the alarm, the tank must be pumped down to clear the Low Level Switch.
Product Tank High Limit Alarm	When the Level Switch is activated, it will shutdown the KO Tank Transfer Pump, SVE Blower and the Liquid Ring Pump (LRP). The tank must be pumped down to reset the alarm.
Liquid Ring Pump (LRP) Low Oil Level Alarm	When activated, it will shutdown the LRP. Adjust the oil level to reset the alarm.
Liquid Ring Pump (LRP) High Oil Level Alarm	When activated, it will shutdown the LRP. Adjust the oil level to reset the alarm.
Liquid Ring Pump (LRP) High Temperature Alarm	When activated, it will shutdown the LRP. Discharge of the LRP is too hot. Temperature Snap Switch is set to 225 degrees F. (+ or - 5 degrees).
Liquid Ring Pump (LRP) Low Vacuum Alarm	When activated, it will shutdown the LRP. The Low Vacuum Switch is set to approximately 13-inches Hg.
Knockout (KO) Pump High Pressure Alarm	When activated, it will shutdown the KO Pump, SVE Blower and the LRP. The KO Pump Discharge Pressure Switch is set to approximately 25 psi.
Discharge Pump High Pressure Alarm	When activated, it will shutdown the KO Pump, Oil Water Separator Pump, SVE Blower and the LRP. The Oil/Water Separator Pump Discharge Pressure Switch is set to approximately 40 psi.
Heat Exchanger Discharge High Pressure Alarm	When activated, it will shutdown the SVE Blower and the LRP. The Heat Exchanger Discharge Pressure Switch is set to approximately 5 psi.
Heat Exchanger Discharge High Temperature Alarm	When activated, it will shutdown the Heat Exchanger, SVE Blower and the LRP. The Heat Exchanger Discharge Temperature Switch is set to approximately 120 degrees F.
Knockout (KO) Pump Motor Overload Alarm	When activated, it will shutdown the KO Pump, SVE Blower and the LRP. The "KO Pump Motor Starter" has "Tripped Out" due to a high overload condition.
Discharge Pump Motor Overload Alarm	When activated, it will shutdown the KO Pump, Oil/Water Separator Pump, SVE Blower and the LRP. The "Oil/Water Separator Pump Motor Starter" has "Tripped Out" due to a high overload condition.
SVE Blower Motor Overload Alarm	When activated, it will shutdown the SVE Blower. The "SVE Blower Motor Starter" has "Tripped Out" due to a high overload condition.
Liquid Ring Pump (LRP) Motor Overload Alarm	When activated, it will shutdown the LRP. The "LRP Motor Starter" has "Tripped Out" due to a high overload condition.
Heat Exchanger Motor Overload Alarm	When activated, it will shutdown the Heat Exchanger, SVE Blower and the LRP. The "Heat Exchanger Motor Starter" has "Tripped Out" due to a high overload condition.

Notes:
F - fahrenheit
HMI - human machine interface
Hg - mercury
KO - knockout
LRP - liquid ring pump
O - oil water separator
PLC - programmable logic controller
psi - pound per square inch
SVE - soil vapor extraction

Table 5
Fluid Thickness Chart
55 Gallon Product Effluent Tank

Thickness of Fluid in Drum (feet)	Calculated Fluid Volume (gallons)	Thickness of Fluid in Drum (feet)	Calculated Fluid Volume (gallons)	Thickness of Fluid in Drum (feet)	Calculated Fluid Volume (gallons)	Thickness of Fluid in Drum (feet)	Calculated Fluid Volume (gallons)	Thickness of Fluid in Drum (feet)	Calculated Fluid Volume (gallons)
0.00	**0.0**	0.55	**11.1**	1.11	**22.3**	1.67	**33.6**	2.23	**44.8**
0.01	**0.2**	0.56	**11.3**	1.12	**22.5**	1.68	**33.8**	2.24	**45.0**
0.02	**0.4**	0.57	**11.5**	1.13	**22.7**	1.69	**34.0**	2.25	**45.2**
0.03	**0.6**	0.58	**11.7**	1.14	**22.9**	1.70	**34.2**	2.26	**45.4**
0.04	**0.8**	0.59	**11.9**	1.15	**23.1**	1.71	**34.4**	2.27	**45.6**
0.05	**1.0**	0.60	**12.1**	1.16	**23.3**	1.72	**34.6**	2.28	**45.8**
0.06	**1.2**	0.61	**12.3**	1.17	**23.5**	1.73	**34.8**	2.29	**46.0**
0.07	**1.4**	0.62	**12.5**	1.18	**23.7**	1.74	**35.0**	2.30	**46.2**
0.08	**1.6**	0.63	**12.7**	1.19	**23.9**	1.75	**35.2**	2.31	**46.5**
0.09	**1.8**	0.64	**12.9**	1.20	**24.1**	1.76	**35.4**	2.32	**46.7**
0.10	**2.0**	0.65	**13.1**	1.21	**24.3**	1.77	**35.6**	2.33	**46.9**
0.11	**2.2**	0.66	**13.3**	1.22	**24.5**	1.78	**35.8**	2.34	**47.1**
0.12	**2.4**	0.67	**13.5**	1.23	**24.7**	1.79	**36.0**	2.35	**47.3**
0.13	**2.6**	0.68	**13.7**	1.24	**24.9**	1.80	**36.2**	2.36	**47.5**
0.14	**2.8**	0.69	**13.9**	1.25	**25.1**	1.81	**36.4**	2.37	**47.7**
0.15	**3.0**	0.70	**14.1**	1.26	**25.3**	1.82	**36.6**	2.38	**47.9**
0.16	**3.2**	0.71	**14.3**	1.27	**25.5**	1.83	**36.8**	2.39	**48.1**
0.17	**3.4**	0.72	**14.5**	1.28	**25.7**	1.84	**37.0**	2.40	**48.3**
0.18	**3.6**	0.73	**14.7**	1.29	**25.9**	1.85	**37.2**	2.41	**48.5**
0.19	**3.8**	0.74	**14.9**	1.30	**26.1**	1.86	**37.4**	2.42	**48.7**
0.20	**4.0**	0.75	**15.1**	1.31	**26.3**	1.87	**37.6**	2.43	**48.9**
0.21	**4.2**	0.76	**15.3**	1.32	**26.5**	1.88	**37.8**	2.44	**49.1**
0.22	**4.4**	0.77	**15.5**	1.33	**26.7**	1.89	**38.0**	2.45	**49.3**
0.23	**4.6**	0.78	**15.7**	1.34	**26.9**	1.90	**38.2**	2.46	**49.5**
0.24	**4.8**	0.79	**15.9**	1.35	**27.1**	1.91	**38.4**	2.47	**49.7**
0.25	**5.0**	0.80	**16.1**	1.36	**27.3**	1.92	**38.6**	2.48	**49.9**
0.26	**5.2**	0.81	**16.3**	1.37	**27.5**	1.93	**38.8**	2.49	**50.1**
0.27	**5.4**	0.82	**16.5**	1.38	**27.7**	1.94	**39.0**	2.50	**50.3**
0.28	**5.6**	0.83	**16.7**	1.39	**28.0**	1.95	**39.2**	2.51	**50.5**
0.29	**5.8**	0.84	**16.9**	1.40	**28.2**	1.96	**39.4**	2.52	**50.7**
0.30	**6.0**	0.85	**17.1**	1.41	**28.4**	1.97	**39.6**	2.53	**50.9**
0.31	**6.2**	0.86	**17.3**	1.42	**28.6**	1.98	**39.8**	2.54	**51.1**
0.32	**6.4**	0.87	**17.5**	1.43	**28.8**	1.99	**40.0**	2.55	**51.3**
0.33	**6.6**	0.88	**17.7**	1.44	**29.0**	2.00	**40.2**	2.56	**51.5**
0.34	**6.8**	0.89	**17.9**	1.45	**29.2**	2.01	**40.4**	2.57	**51.7**
0.35	**7.0**	0.90	**18.1**	1.46	**29.4**	2.02	**40.6**	2.58	**51.9**
0.36	**7.2**	0.91	**18.3**	1.47	**29.6**	2.03	**40.8**	2.59	**52.1**
0.37	**7.4**	0.92	**18.5**	1.48	**29.8**	2.04	**41.0**	2.60	**52.3**
0.38	**7.6**	0.93	**18.7**	1.49	**30.0**	2.05	**41.2**	2.61	**52.5**
0.39	**7.8**	0.94	**18.9**	1.50	**30.2**	2.06	**41.4**	2.62	**52.7**
0.40	**8.0**	0.95	**19.1**	1.51	**30.4**	2.07	**41.6**	2.63	**52.9**
0.41	**8.2**	0.96	**19.3**	1.52	**30.6**	2.08	**41.8**	2.64	**53.1**
0.42	**8.4**	0.97	**19.5**	1.53	**30.8**	2.09	**42.0**	2.65	**53.3**
0.43	**8.6**	0.98	**19.7**	1.54	**31.0**	2.10	**42.2**	2.66	**53.5**
0.44	**8.8**	0.99	**19.9**	1.55	**31.2**	2.11	**42.4**	2.67	**53.7**
0.45	**9.0**	1.00	**20.1**	1.56	**31.4**	2.12	**42.6**	2.68	**53.9**
0.46	**9.2**	1.01	**20.3**	1.57	**31.6**	2.13	**42.8**	2.69	**54.1**
0.47	**9.5**	1.02	**20.5**	1.58	**31.8**	2.14	**43.0**	2.70	**54.3**
0.48	**9.7**	1.03	**20.7**	1.59	**32.0**	2.15	**43.2**	2.71	**54.5**
0.49	**9.9**	1.04	**20.9**	1.60	**32.2**	2.16	**43.4**	2.72	**54.7**
0.50	**10.1**	1.05	**21.1**	1.61	**32.4**	2.17	**43.6**	2.73	**54.9**
0.51	**10.3**	1.06	**21.3**	1.62	**32.6**	2.18	**43.8**	2.74	**55.1**
0.52	**10.5**	1.07	**21.5**	1.63	**32.8**	2.19	**44.0**	2.75	**55.3**
0.53	**10.7**	1.08	**21.7**	1.64	**33.0**	2.20	**44.2**	2.76	**55.5**
0.54	**10.9**	1.09	**21.9**	1.65	**33.2**	2.21	**44.4**	2.77	**55.7**
0.55	**11.1**	1.10	**22.1**	1.66	**33.4**	2.22	**44.6**	2.78	**55.9**

Calculations assume the following:
Drum is in vertical position
Drum Inside Diameter is 1.85 feet
Drum is assumed to have a height less than 2.80 feet

Table 6
Troubleshooting Guide

System Component	Problem	Possible Cause	Solution
Supply Fan	Excessive Vibration	Loose bolts, excessive wearing of bearings, wear and erosion of propeller	Tighten loosened bolts and replace worn-out parts.
Heat Exchanger	Excessive Vibration	Loose bolts, excessive wearing of bearings, wear and erosion of propeller	Tighten loosened bolts and replace worn-out parts.
Liquid Ring Pump	System will not start with 'Hand' or 'Auto' switch	Circuit switch is off	Turn circuit switch to 'on' position and start the system.
		Alarm is on	Reset alarm and re-start the system.
		Low oil level	Check oil level and add oil if necessary.
		Oil separator element failure	Replace oil separator element and re-start the system.
	System shuts down while running	Loose electrical connections	Check for loose electrical connections and fix the connections.
		Low oil level	Check oil level and add oil if necessary.
		Buildup in oil strainer	Check oil strainer for buildup and clean or replace if necessary.
		Low vacuum	See below
		Oil separator element failure	Replace oil separator element and re-start the system.
	Does not achieve desired vacuum levels (Low Vacuum)	Lines open to atmosphere or dilution valve open	Check to see if lines are open to atmosphere and close the lines to limit loss of vacuum. Close dilution valve.
		Leaks in piping system	Check for leaks in piping system and repair.
		Not enough water in wells	Check water levels in DPE wells and if not enough water, switch the system to SVE mode.
		Inlet filter is clogged and damaged	Check for buildup in inlet filter and clean or replace if necessary.
	System overheats	Oil cooler is blocked	Check oil cooler for blockage and clean oil cooler externally with compressed air.
		Low oil level	Check oil level and add oil if necessary.
		Buildup in oil strainer	Check oil strainer for buildup and clean or replace if necessary.
	Excessive Vibration	Ungreased bearings	Grease bearings and rotate coupling by hand. If a rubbing noise or binding is observed, contact authorized dealer.
		Low oil level	Check oil level and add oil if necessary.
		Inlet filter is clogged and damaged	Check for buildup in inlet filter and clean or replace if necessary.
		Loose bolts and excessive wearing of bearings	Tighten loosened bolts and replace worn-out parts.
SVE Blower	Impeller does not turn	Impeller imbalance	Check impellers for foreign material, remove and clean if necessary.
		Circuit switch is off	Turn circuit switch to 'on' position and start the system.
	Motor overheats and trips	Defective bearings	Check and replace bearings if necessary.
		Impeller rubbing against housing	Adjust impeller so it is not rubbing against the housing.
		Impeller or air passage clogged by foreign material	Check filters and clean and replace if necessary.
		Unit operating beyond performance range	Reduce system pressure or vacuum.
		High vacuum	Check valves and adjust the valves until the vacuum decreases.
	Abnormal Sounds	Impeller rubbing against housing	Adjust impeller so its not rubbing against the housing.
		Impeller or air passage clogged by foreign material	Check filters and clean and replace if necessary.
		Defective bearings	Check and replace bearings if necessary.
	Below Standard Performance	Leaks in piping system	Check for leaks in piping system and repair.
		Piping and air passages clogged	Check filters and air passages, clean and replace if necessary.
		Low voltage	Check input voltage.
	Excessive Vibration	Loose bolts, excessive wearing of bearings	Tighten loosened bolts and replace worn-out parts.
Oil Water Separator (OWS)	Below Standard Performance	Exceeding OWS rated flow	Return flow rate to the designed flow rate.
		Accumulation of sludge	Check for sludge buildup. If necessary, clean and remove any sludge accumulation in OWS.
		Deep layer of product	Free product should be removed and the OWS put back in service once product is removed.
Liquid Carbon Filter Vessel	High pressure drop and inadequate flow	Clogged influent and effluent lines	Check influent and effluent lines for clogging and clean if necessary.
		Sediments and solids clogging surface of the media	Remove manway cover and inspect surface of media. If clogging is present backwash the media to clean.
		Air is trapped in the top of the filter system	Release air using vent valves.
	Leaks in system	Manway not sealed properly	Check for debris in manway. Clean if necessary and reseal.
		Damaged gasket	Replace damaged gasket.
		Loose bolts	Tighten loosened bolts and replace worn-out parts.

APPENDIX A

Seneca O&M Manual (On CD only)

Seneca Companies
The Complete Solution

HEADQUARTERS
Des Moines, Iowa

P.O. Box 3360
Des Moines, IA
50316

4140 E. 14th Street
Des Moines, IA 50313
Phone: 515-262-5000
Toll Free: 800-369-5500
Fax: 515-262-4951

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SECTION 1 ..... **O&M INSTRUCTIONS**

SECTION 2 ..... **ASBUILT DRAWINGS**

SECTION 3 ..... **BILL OF MATERIAL**

SECTION 4 ..... **TEMPERATURE CONTROL**
HEATERS-FANS-LIGHTS
HEAT EXCHANGER

SECTION 5 ..... **INSTRUMENTATION**
GAGES-SWITCHES
FLOWMETERS

SECTION 6 ..... **MAJOR EQUIPMENT**
PUMPS-BLOWERS
AIR STRIPPER

SECTION 7 ..... **FILTERS AND SEPARATORS**

SECTION 8 ..... **CONTROLS**
PROGRAM
PLC SOFTWARE

REMEDIATION SYSTEM OPERATIONS AND MAINTENANCE MANUAL

SECTION I:
Off-loading the system

SECTION II:
Inspection

SECTION III:
Safety Procedures

SECTION IV:
Installation of the System

SECTION V:
Start Up of the System

SECTION VI:
Description of System Operations

SECTION I: UNLOADING THE SYSTEM

WARNING!
ENSURE THAT THE FOUNDATION FOR THE TRAILER IS FLAT AND LEVEL PRIOR TO START-UP.
Upon placement of the trailer, inspect the structure to ensure that it sets level and shimmed as necessary. A level and stable trailer is essential for proper and efficient system operation.

SECTION II: INSPECTION

WARNING!
WHEN YOUR SYSTEM ARRIVES, INSPECT IMMEDIATELY FOR DAMAGE.
All components are carefully inspected and prepared for shipment at the factory. However, damage may occur during transport due to improper handling or exposure to the elements. Prior to off-loading, please ensure that all fasteners on pumps, tanks, motors, and other equipment are secured and tight.
If damage to the structure or equipment is found during the inspection process, contact Seneca Environmental Services' Remediation Department at (800)-369-3500.
During normal shipment of the system straps on the Oil/Water separator need to be snug, over tightening will cause damage to the separator. Remove any outside silencers, yard lights and filters to prevent damage during shipment. Confirm no loose equipment is in trailer that can shift and cause damage to system during transit. Completely drain and dry out system between operation and prevent freezing during winter months if not in use.

SECTION III: SAFETY PROCEDURES

The pre-packaged remediation system is fully automated. The equipment room handles the treatment of potentially hazardous materials. Therefore, vapors may be present in the room upon entry. Common safety practices should be implemented prior to entering the system for maintenance or repair. The system is not a confined space by definition, as the system does not have limited or constricted means for entry or exit. It is recommended that service personnel develop an entry program to be followed at all times. A recommended approach is to implement an "Entry Permit Program".

WARNING!
ALL ELECTRICAL WORK MUST BE COMPLETED BY A QUALIFIED LICENSED ELECTRICIAN.

TAKE MEASURES TO PROPERLY TAG AND LOCKOUT ELECTRICAL CIRCUITS PRIOR TO WORKING ON THE SYSTEM.

UNEXPECTED SYSTEM START-UP CAN CAUSE SERIOUS INJURY.

SECTION IV: INSTALLATION OF THE SYSTEM

The pre-packaged remediation system is just one component of your remediation design. The other components are the recovery well(s), underground piping and plumbing of influent lines. All these can affect the performance of the remediation system. Ensure that influent and effluent plumbing are properly sized to maintain the optimum air flow (CFM) rate that the system requires. This can be accomplished by using standard engineering practices, and calculations for friction loss due to pipe type, pipe size, number or 90 degree elbows, number of 45 degree elbows, and the number of valves by capability. *(If necessary, contact Seneca Environmental Services for useful Engineering Data for friction loss information.)

SECTION V : SYSTEM START-UP PREPARATION

Prior to beginning start-up procedures, inspect to make sure that the discharge lines are properly sized to handle the system throughout.

WARNING!
ALL ELECTRICAL AND PLUMBING HOOK-UPS MUST BE MADE BY QUALIFIED AND LICENSED ELECTRICIANS AND PLUMBERS. FAILURE TO DO SO MAY SEVERELY DAMAGE YOUR SYSTEM AND VOID ALL WARRANTIES!

ALWAYS ENSURE THAT THE MAIN POWER LEGS ARE PROPERLY IDENTIFIED AND ARE CONNECTED TO THE PROPER LUGS AT THE SERVICE PANEL!

DO NOT RUN FREE PHASE PRODUCT THROUGH ANY OF THE SVE COMPONENTS, SERIOUS INJURY AND OR DAMAGE TO EQUIPMENT COULD OCCUR!

CUSTOMER IS RESPONSIBLE TO SUPPLY ALL ENTRY SIGNS AS REQUIRED BY LOCAL AUTHORITY!

1. **Confirm main power legs are marked by a licensed electrician.**
   Improper electrical hook-up by anyone other than a licensed electrician may severely damage the system and void all warranties. Confirm HIGH LEG connection on all 230/120VAC systems prior to power being applied to and single phase load.

2. **Confirm system is properly grounded!!!!!!!!!!!!**

3. **Check motor rotations**
   Check for proper rotation on all motors before starting the system

Open Line Valves

4. Open all line valves. Valve handle will be in line with the pipe run when the valves are in the open position.

Close all sampling ports

5. Inspect all sampling ports contained in the system to make sure that they are in the closed position.

Check connections

6. Check the system influent and effluent connections making sure they are properly secure, and in the closed position.

Turn "ON" the main breaker

7. Switch the main power circuit breaker, located in the control panel, to the "ON" position.

Turn "ON" all breakers

8. Turn on each circuit breaker in the service panel.

Set system control switches to "AUTO" position

9. Set system control switch to the "AUTO" position.

Energize External Recovery System

10. As the system begins to run, monitor the system for 30 to 60 minutes. If a problem is identified, and a Seneca Representative is not present on-site for start up procedures, use EMERGENCY SHUT DOWN procedures to stop system operation and contact Seneca Remediation Services for help at (800)-369-3500.

Set system control switches to "OFF" position.

11. Set system control switches to "OFF" position for normal shutdown, or if emergency push "EMERGENCY STOP" inside the trailer by the side door. System will shutdown and lock out until switch is reset.

QUESTIONS?

Should you have any questions regarding this information, please do not hesitate to contact SENECA REMEDIATION SERVICES (**800)-369-3500.**

Technician's Notes:

Technician's Notes:

Technician's Notes:

KINDER MORGAN

1009 EAST SMITH ROAD
BELLINGHAM, WA 98226
PROJECT #1715005

DESCRIPTION	SHEET NUMBER
TITLE DIAGRAM	01
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PROCESS AND INSTRUMENTATION DIAGRAM - MPE SYSTEM	03
PROCESS AND INSTRUMENTATION DIAGRAM - WATER TREATMENT SYSTEM	04
PROCESS AND INSTRUMENTATION DIAGRAM - CARBON VESSELS	05
PROCESS AND INSTRUMENTATION DIAGRAM - WELL STUB/WELL VAULT DETAILS	06
EQUIPMENT LAYOUT	07
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ASBUILT

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01	06/05/2015
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KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
TITLE DIAGRAM

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: DAN NOLAN
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO. 01

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005501-06

SYMBOL SPECIFICATION

INSTRUMENT TYPE:

PS	PRESSURE SWITCH	SL	STATUS LAMP
PI	PRESSURE INDICATOR	PC	PRESSURE CONTROL
PT	PRESSURE TRANSDUCER	VI	VACUUM INDICATOR
FE	FLOW ELEMENT	TSH	TEMPERATURE SWITCH HIGH
FI	FLOW INDICATOR	DP	DIFFERENTIAL PRESSURE
FQI	FLOW METER (TOTALIZING)	PSL	PRESSURE SWITCH LOW
FT	FLOW TRANSMITTER	PSH	PRESSURE SWITCH HIGH
CI	CAPACITIVE SENSOR	LSHH	LEVEL SWITCH HIGH HIGH
TI	TEMPERATURE INDICATOR	LSH	LEVEL SWITCH HIGH
TT	TEMPERATURE TRANSDUCER	LSL	LEVEL SWITCH LOW
TS	TEMPERATURE SENSOR	HVS	HIGH VACUUM SWITCH
TSH	TEMPERATURE SWITCH	VSL	LOW VACUUM SWITCH
MJ	MECHANICAL JOINT	SOL	SOLENOID
LEL	EXPLOSIVITY METER		

LINE DESIGNATION:

2 - XXX - YY - Z

2 = SIZE IN INCHES

XXX: PROCESS LINE ABBREVIATION

AIR	AIR, ATMOSPHERIC PRESSURE
ASP	AIR SPARGE
BW	BACKWASH
CA	COMPRESSED AIR
CGW	CONTAMINATED GROUNDWATER
D	DRAIN
EFF	EFFLUENT
EXH	EXHAUST
GW	GROUNDWATER
NPW	NON-POTABLE WATER
P	PRODUCT
PW	POTABLE WATER
S	SANITARY
SL	SLUDGE
SP	SAMPLE PORT
SS	STORM SEWER
TF	TOTAL FLUIDS
V	VENT
VAP	VAPOR

YY: PIPING DESIGN TABLE ABBREVIATION

CPVC	CHLORINATED POLYVINYL CHLORIDE
CSP	CARBON STEEL PIPE
COP	COPPER PIPE
CMP	CORRUGATED METAL PIPE
CIP	CAST IRON PIPE
DIP	DUCTILE IRON PIPE
GAL	GALVANIZED STEEL PIPE
PE	POLYETHYLENE PIPE
PP	POLYPROPYLENE PIPE
PVC	POLYVINYL CHLORIDE PIPE
RCP	REINFORCED CONCRETE PIPE
RUB	RUBBER HOSE
SSP	STAINLESS STEEL PIPE
VCP	VITRIFIED CLAY PIPE
SG	SIGHT GLASS

VALVES, FITTINGS & PIPING

- HAND CONTROL
- BLOWDOWN
- GATE VALVE
- CLOSED VALVE
- GLOBE VALVE
- CHECK VALVE
- TRU UNION BALL/CHECK VALVE
- PLUG
- BALL VALVE
- TRU UNION BALL VALVE
- BUTTERFLY OR DAMPER
- NEEDLE VALVE
- DIAPHRAGM VALVE
- THREE WAY VALVE
- ELECTRIC CONTROL GATE
- ELECTRIC BUTTERFLY OR DAMPER
- BLEED OR PURGE CONNECTION
- AIR RELEASE VALVE
- SOLENOID VALVE
- VACUUM RELIEF VALVE
- PRESSURE RELIEF VALVE
- ANTI-SIPHON VALVE
- FOOT VALVE
- FLEXIBLE PIPE
- FLEXIBLE PIPE
- CROSSOVER
- FLANGED CONNECTION
- SCREWED CONNECTION
- UNION
- COUPLING

- EXPANSION JOINT/SLEEVE
- HOSE CONNECTION
- STRAINER
- PLUG
- PIPE CAP
- SLIP UPDRAFT VENT CAP
- ELBOW - TURNED UP
- ELBOW - TURNED DOWN
- ELBOW - 90°
- ELBOW - 45°
- ELBOW - LONG RADIUS
- REDUCING ELBOW
- QUICK CONNECT COUPLING
- BUSHING
- REDUCER (CONCENTRIC)
- TEE - REDUCING
- TEE - OUTLET UP
- TEE - OUTLET DOWN
- TEE
- SAMPLE PORT
- REGULATOR
- FLOW CONTROL VALVE (NONADJUSTABLE)
- FLOW CONTROL VALVE (ADJUSTABLE)
- SPECTACLE FLANGE

ARCHITECTURAL SYMBOL DESIGNATIONS

- 1 — KEY NOTE IDENTIFICATION
- A — SPECIAL CONSTRUCTION NOTES
- 3 — PLAN NOTE IDENTIFICATION
- 2 — VERTICAL GRID REFERENCE LINE
- A — HORIZONTAL GRID REFERENCE LINE
- 1/02 — INDICATES SECTION/DETAIL NUMBER; INDICATES DRAWING SHEET ON WHICH SECTION/DETAIL IS SHOWN
- [1/02] — INDICATES SECTION/DETAIL NUMBER; INDICATES DRAWING SHEET ON WHICH SECTION/DETAIL IS SHOWN
- 1/02 — INDICATES AREA SHOWN IN REFERENCED DETAIL
- 1/01 — ELEVATION REFERENCE DRAWING NUMBER
- B/01 — INDICATES SECTION / DETAIL NUMBER; SECTION CUT; INDICATES DRAWING SHEET ON WHICH SECTION IS SHOWN
- 1/02 — TITLE/TYPE OF DRAWING; SCALE OF DRAWING

INSTRUMENTATION CONTROLS & EQUIPMENT

- PUMP
- BLOWDOWN
- M — MOTOR
- MS — MOTOR STARTER
- I — INTERLOCK
- HOA — HAND, OFF, AUTO
- DISCONNECT SWITCH, UNFUSED
- DISCONNECT SWITCH, FUSED

- NORMALLY OPEN FLOAT SWITCH
- NORMALLY CLOSED FLOAT SWITCH
- NORMALLY OPEN CONTACT
- NORMALLY CLOSED CONTACT
- OPEN / CLOSED — TWO POSITION SWITCH
- MS — MOTOR STARTER / COIL
- OL — OVERLOAD RELAY/NORMALLY CLOSED
- MOTOR STARTER W/THERMAL OVERLOAD

ELECTRICAL SYMBOLS

- T_1 T_2 T_3 — THREE PHASE MOTOR
- T_1 T_2 — SINGLE PHASE MOTOR
- H_2 H_1 / X_2 X_1 — CONTROL TRANSFORMER
- CIRCUIT BREAKER
- INLINE FUSE
- FUSE (BOX)
- ISCM — INTRINSICALLY SAFE CONTROL MODULE
- SO — SEAL-OFF
- GROUND
- C — INDICATING LAMP (C = COLOR OF LENS)
- HM — HOUR METER
- ENCLOSURE
- NOT CONNECTED
- CONNECTED
- DEVICE TERMINAL
- CONTROL TERMINAL
- EXTERNAL TERMINAL
- HAZARDOUS AREA/CLASS 1

ASBUILT

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

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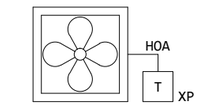
JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

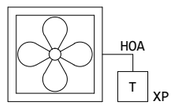
SHEET TITLE:
SYMBOL AND LEGEND DIAGRAM

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: DAN NOLAN
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO. 02

MPE SYSTEM

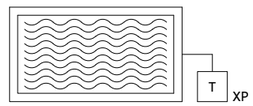


SUPPLY FAN
NYB #SN-122-M
0.25 HP, 240 V, 1900 CFM



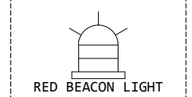
SUPPLY FAN
NYB #SN-122-M
0.25 HP, 240 V, 1900 CFM

EMERGENCY
STOP SWITCH
(X2)

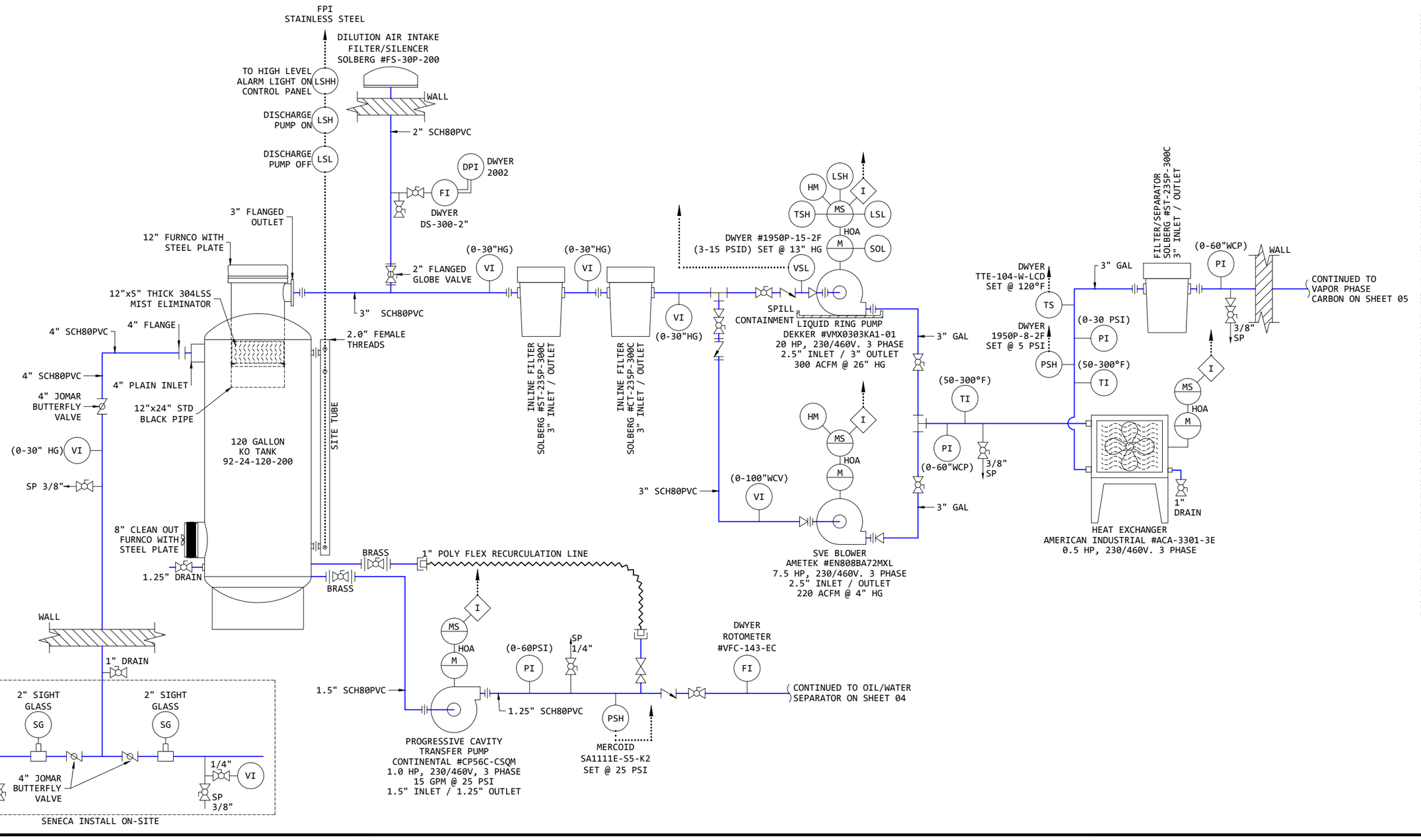


HEATER
CHROMALOX #CVEP-C-36-41-00-00
3.6 KW, 480V, 1 PHASE
XP

OUTSIDE ENCLOSURE



RED BEACON LIGHT
GREEN BEACON LIGHT
115V, 1 PHASE



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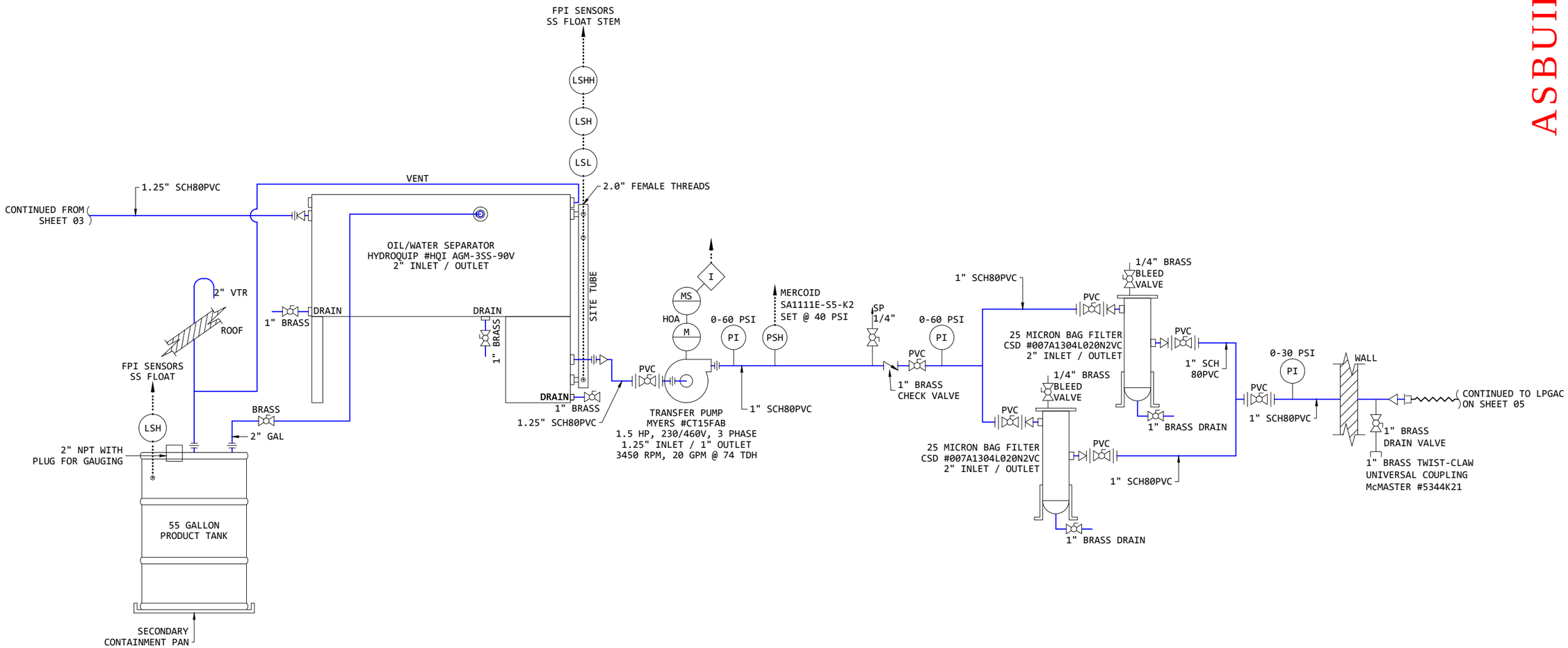
BELLINGHAM, WA 98226

SHEET TITLE:
PROCESS AND INSTRUMENTATION DIAGRAM

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: DAN NOLAN
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO. 03

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005S01-06

WATER TREATMENT SYSTEM



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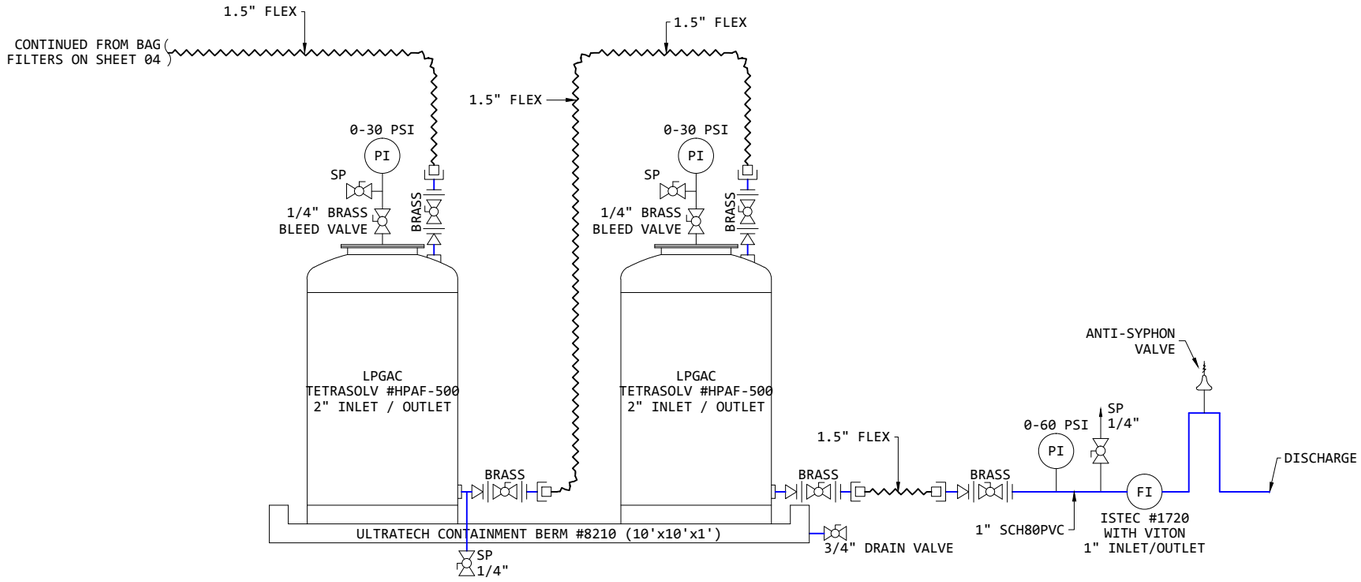
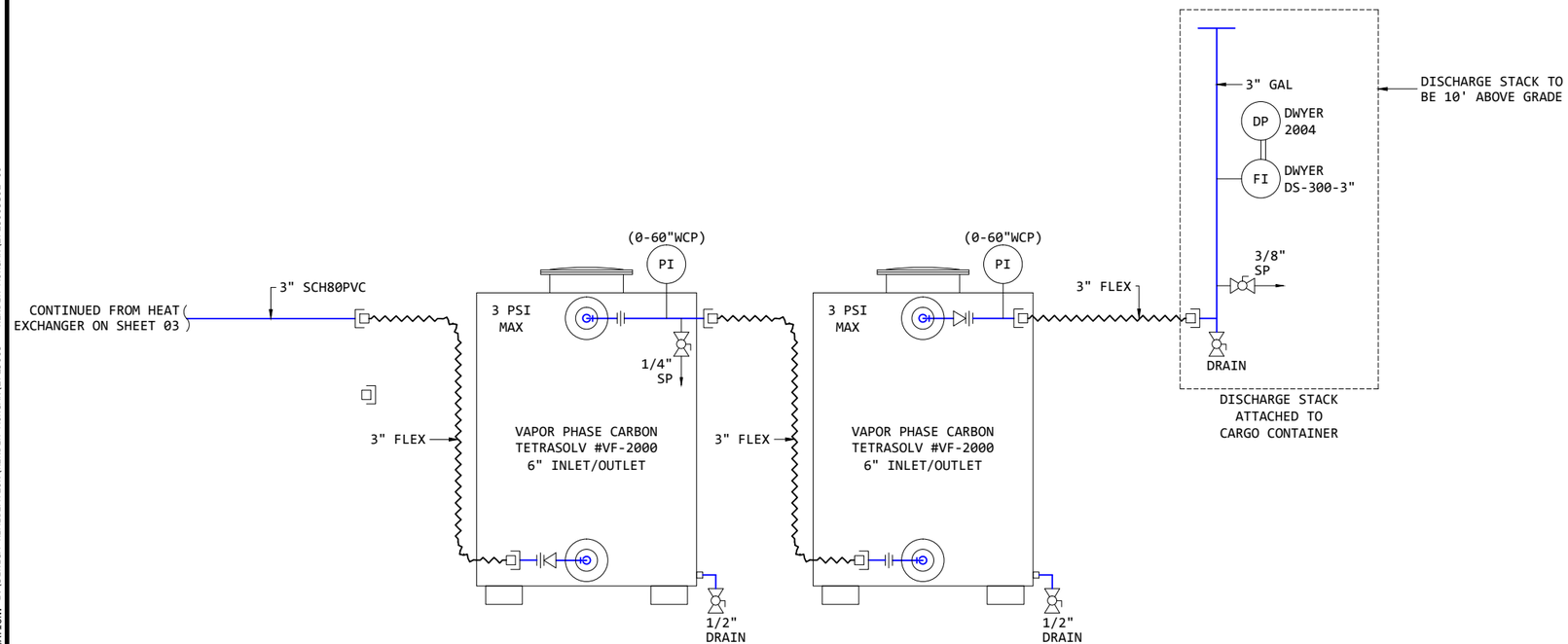
DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: DAN NOLAN
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO. 04

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005S01-06

CARBON VESSELS





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DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
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SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO. 05

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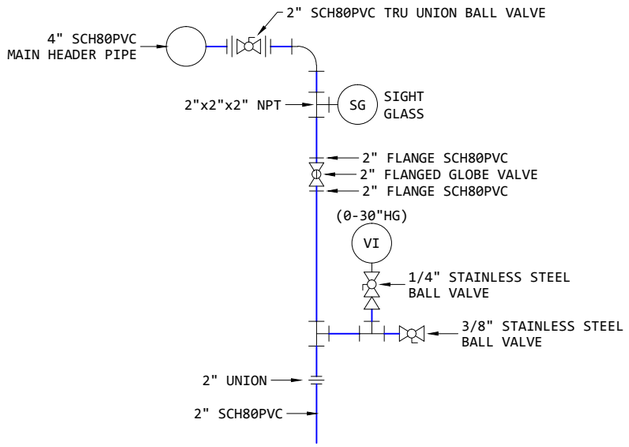
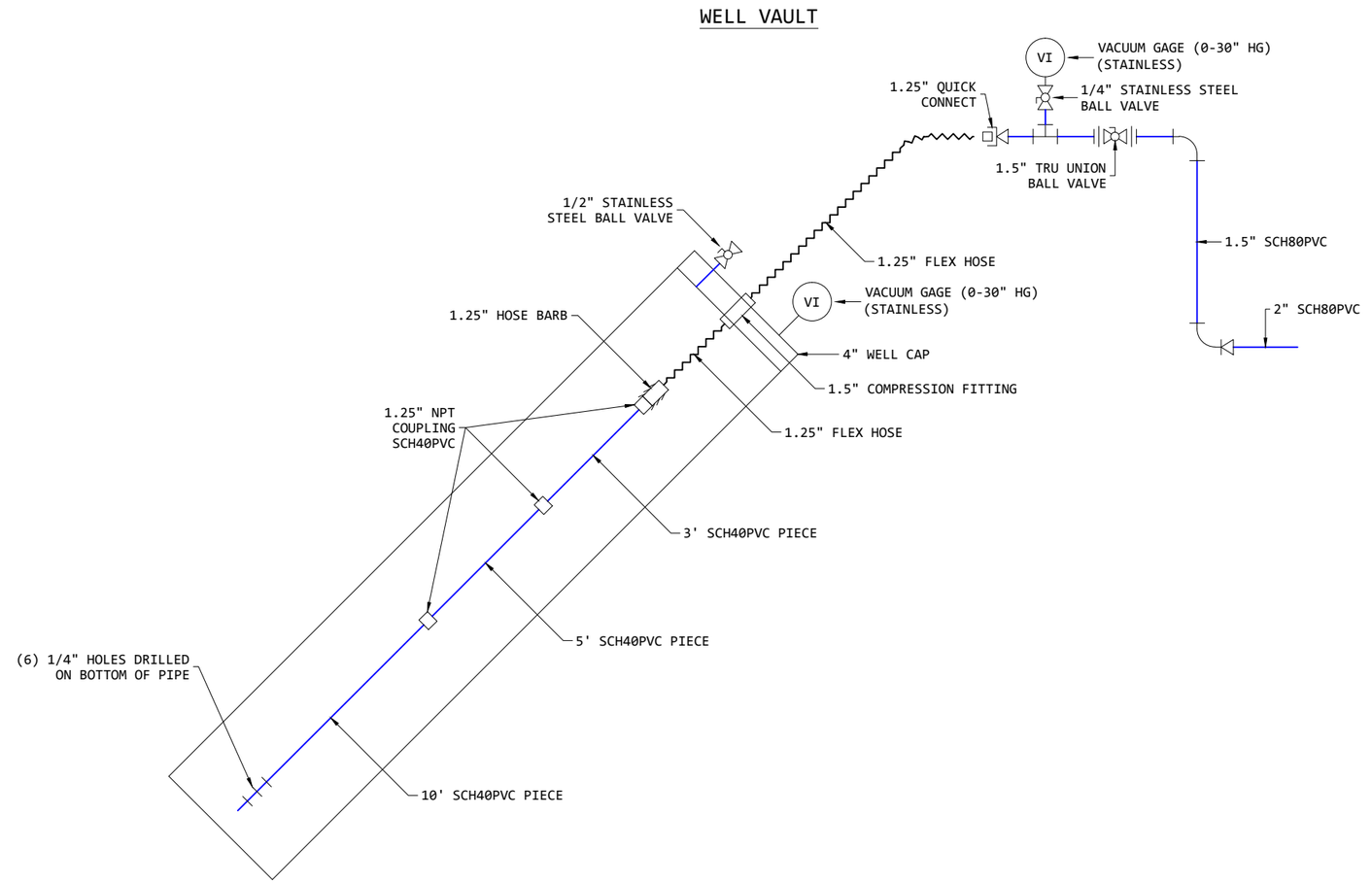
WELL STUB/WELL VAULT DETAILS

WELL STUB



WELL VAULT



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01	06/05/2015
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BELLINGHAM, WA 98226

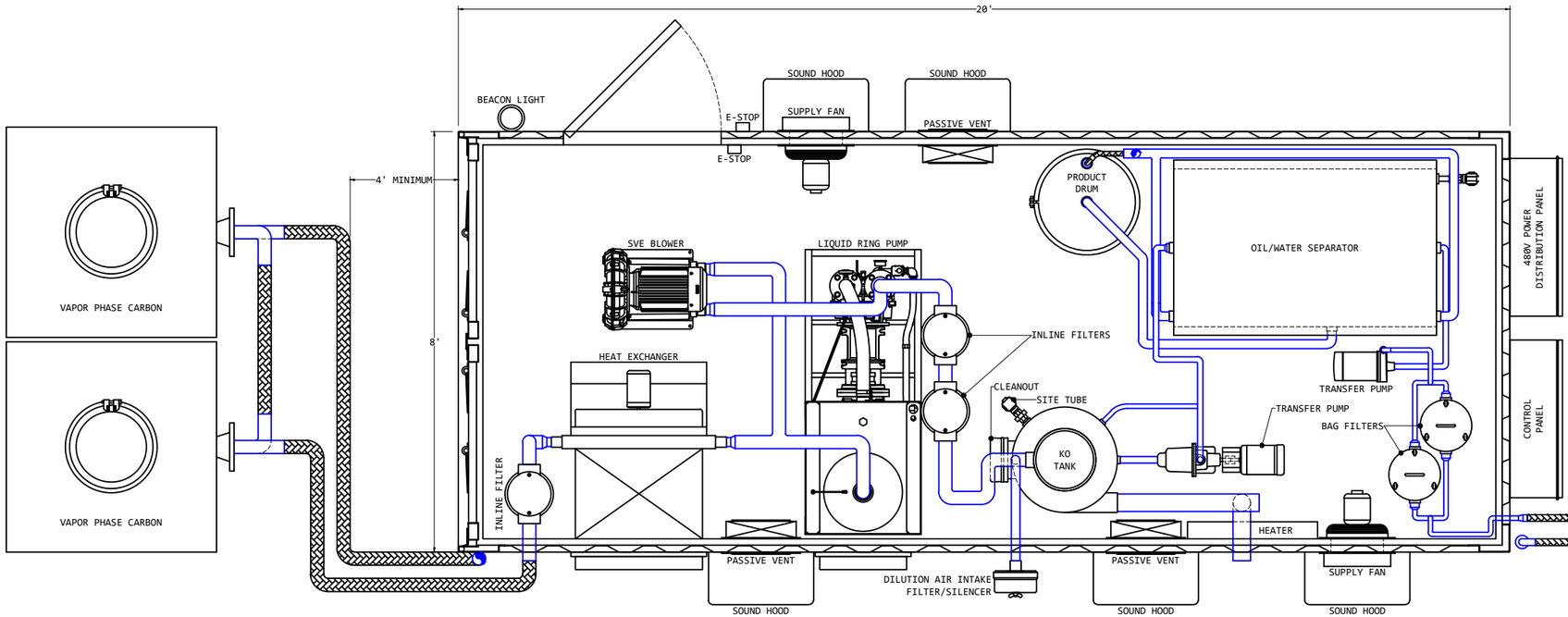
SHEET TITLE:
PROCESS AND INSTRUMENTATION DIAGRAM

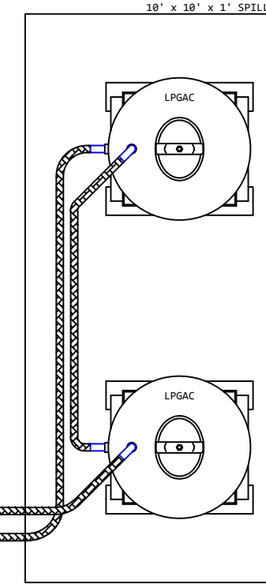
DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: DAN NOLAN
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO. 06

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005S01-06

EQUIPMENT LAYOUT

ASBUILT





NOTES:

1. PIPE SUPPORTS TO BE INSTALLED AS REQUIRED.
2. REFER TO PROCESS AND INSTRUMENTATION DIAGRAM FOR PIPING DETAIL (VALVES, SAMPLE PORTS, ETC.) AND SEQUENCE OF OPERATION.

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

Seneca Companies
The Complete Solution

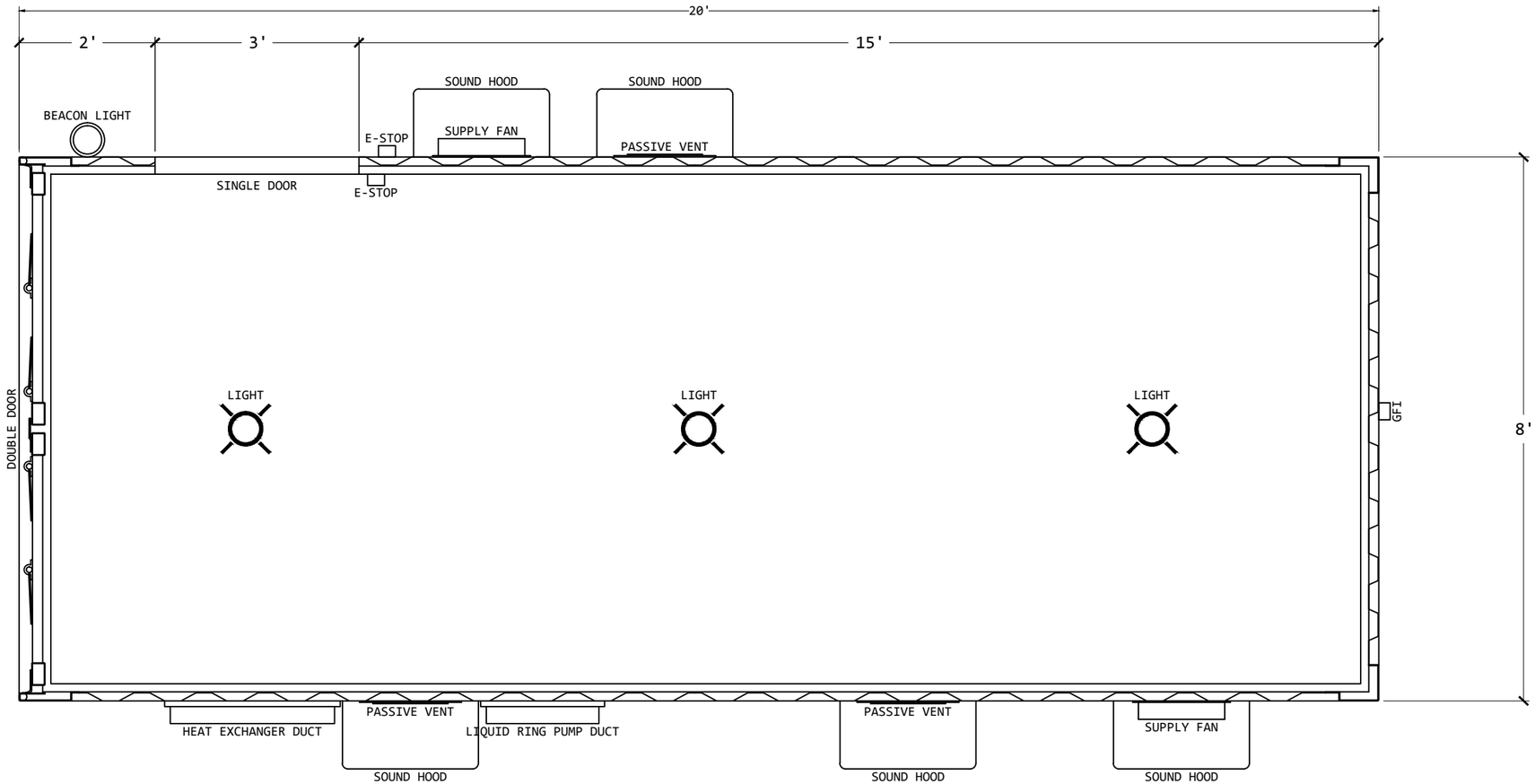
JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
EQUIPMENT LAYOUT

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: DAN NOLAN
SCALE: 3/8"=1'
PROJECT NO: 1715005
SHEET NO. 07

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005S07-09

MAIN FLOOR PLAN



ASBUILT

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

Seneca Companies
The Complete Solution

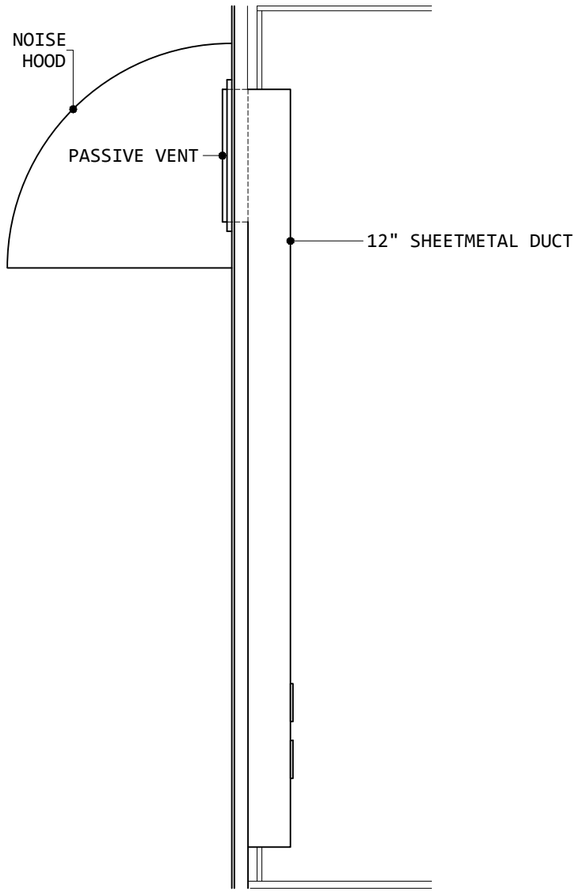
JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
MAIN FLOOR PLAN

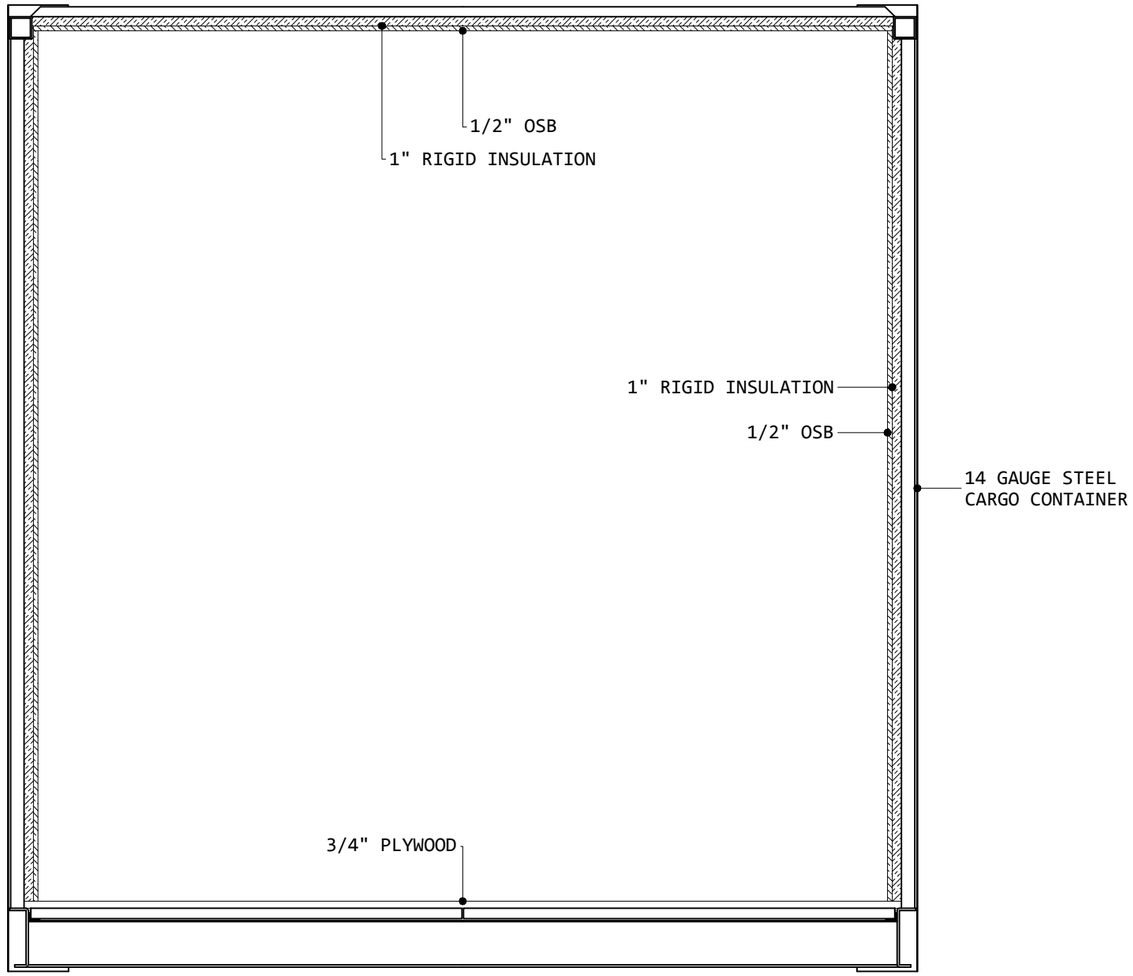
DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: DAN NOLAN
SCALE: 1/2"=1'
PROJECT NO: 1715005
SHEET NO. 08

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005S07-09

VENT DETAIL



WALL SECTION



GENERAL NOTES:

1. PIPE SUPPORTS TO BE INSTALLED AS REQUIRED.
2. REFER TO PROCESS AND INSTRUMENTATION DIAGRAM
3. FOR PIPING DETAIL (VALVES, SAMPLE PORTS, ETC.) AND SEQUENCE OF OPERATION.
4. SITE POWER - 480V, 3 PHASE, 3 WIRE.
5. SITE UTILITY CONNECTION BY OTHERS.

ASBUILT

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

Seneca Companies
The Complete Solution

JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
WALL SECTION

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: DAN NOLAN
SCALE: 3/4"=1'
PROJECT NO: 1715005
SHEET NO. 09

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005S07-09

ASBUILT

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

POWER SUPPLY
480 VAC, 3 PHASE, 3 WIRE, W/GRD, 100A
SUPPLIED BY OTHERS

L1 L2 L3
METER SOCKET
BY OTHERS
MAIN DISCONNECT
RATED: 480VAC, 3 PHASE
3 WIRE, 100 AMP
FUSED @ 100A
6GA
GRD
3GA 3GA 3GA
MAIN CONTROL PANEL
POWER DISTRIBUTION
MD1

NOTES:
1. CABLE SIZED PER LOCAL CODE AND UTILITY REQUIREMENTS.
2. SIZES SHOWN ARE MINIMUM REQUIRED RATINGS.
3. BOND NEUTRAL AND GROUNDS PER NEC CODE FOR UTILITY POWER DISTRIBUTION.
4. PHASE "B" (L2), MUST BE HIGH LEG ON DELTA SYSTEM. (MARKED WITH ORANGE TAPE)
5. ALL MAINTENANCE SHALL BE PERFORMED WITH DEVICES DISCONNECTED FROM THE POWER SUPPLY.
6. ALL SPLICES SHALL BE MECHANICALLY SECURE AND PROVIDE A GOOD ELECTRICAL CONTACT.
7. MINIMUM SUPPLY CONDUCTOR AMPACITY - 100 AMPS
   MAXIMUM SUPPLY OVER CURRENT PROTECTIVE DEVICE - 100 AMPS
   TYPE OF OVER CURRENT PROTECTIVE DEVICE - "R" CLASS FUSES
8. FLEX CONDUIT SHALL BE SECURED AT A MINIMUM EVERY 4 FEET.

CONTROL PANEL
480 VAC, 3 PHASE
480VAC
CP-2

CB18
100A
BRN 3GA
ORG 3GA
YEL 3GA

L1
L2
L3
480
L1
L2
240/120
N

BRN 12GA
YEL 12GA
F1
600VAC
20A
H1 H2 H3 H4 H5 H6 H7 H8
CONTROL TRANSFORMER
5.0 KVA
480-120/240V
X1 X2 X3 X4
F2
20A
WHT 12ga
WHT 12GA
RED 12GA
BLK 12GA
CB1
10A
BLK 14GA
WHT
L G N
L G N
1
2
BLK 14GA
WHT
CONTINUED ON TOP LEFT
OF SHEET E02

BLK
RED
WHT
CB2
20A
BLK 12GA
WHT
GFI
RECEPTACLE
120 VAC, 20 AMP

CB3
15A
BLK 12GA
INTERIOR
EX-ROOM
LIGHT SWITCH
150W
150W
150W
120 VAC, 2.5 AMPS
1 PHASE

WHT 12GA
F3
15A
BRN 12GA
ORG 12GA
YEL 12GA
HC
L1 L2 L3
T1 T2 T3
ORG 12GA
BRN 12GA
YEL 12GA
THERMOSTAT
HEATER
3.6 KW, 480 VAC
3 PHASE, 4.9 FLA

CB5
6-10A
MC-1
ORG
BRN
YEL 14GA
1 2 3
SYMCOM
POWER MONITOR
POWER MONITOR
460 VAC, 3 PHASE
6.0 WATTS

CB6
15A
RED 12GA
BLK
MOTOR M1
SUPPLY FAN #1
0.25 HP, 230 VAC, 1 PHASE
2.6 FLA

CB7
15A
RED 12GA
BLK
MOTOR M2
SUPPLY FAN #2
0.25 HP, 230 VAC, 1 PHASE
2.6 FLA

CB8
12A
LUCC05FU
CONTROL UNIT
ORG
BRN
YEL 12GA
MOTOR M3
KO PUMP
1.5 HP, 460 VAC, 3 PHASE
2.3 FLA

CB9
12A
LUB32
LUCC05FU
CONTROL UNIT
ORG
BRN
YEL 12GA
MOTOR M4
DISCHARGE PUMP
1.5 HP, 460 VAC, 3 PHASE
2.3 FLA

CB10
12A
LUB32
LUCC05FU
CONTROL UNIT
ORG
BRN
YEL 12GA
MOTOR M5
HEAT EXCHANGER
0.75 HP, 460 VAC, 3 PHASE
1.4 FLA

CB11
1.0A
LUB12
LUCA18FU
CONTROL UNIT
ORG
BRN
YEL 12GA
MOTOR M6
SVE BLOWER
7.5 HP, 460 VAC, 3 PHASE
9.3 FLA

CB12
60A
LUB32
MC7
L1 L2 L3
T1 T2 T3
OL7
L1 L2 L3
T1 T2 T3
ORG
BRN
YEL 10GA
MOTOR M7
LIQUID RING PUMP
20 HP, 480 VAC, 3 PHASE
24.0 FLA

HAZARDOUS AREA CLASS 1, DIV. 2, GROUP D
NON-HAZARDOUS AREA

Seneca Companies
The Complete Solution

JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
THREE LINE AC WIRING DIAGRAM
POWER DISTRIBUTION SYSTEM

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: RICH RICHARDS
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO. E01

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005E01-10

NOTES:
1. FOR CONNECTING TO ONLY RESISTIVE NON-ENERGY STORING DEVICES.
2. INSTALL IN ACCORDANCE WITH ART. 504 OF THE NATIONAL ELECTRIC CODE.
3. MAXIMUM CABLE LENGTH IS 900 FEET.
4. WARNING - SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY.
5. PROVIDES INTRINSICALLY SAFE CIRCUIT EXTENSIONS FOR USE IN CLASS 1, DIV. 2, GROUPS C & D, HAZARDOUS LOCATIONS WHEN CONNECTED PER INSTALLATION.
6. SMALLEST WIRE SIZE FOR BRANCH CIRCUITS IS 14 AWG.
7. MOTOR OVERLOAD RELAY MUST BE MANUALLY RESET.
8. LOCATED IN 480VAC PANEL (CP-2).

LEGEND:

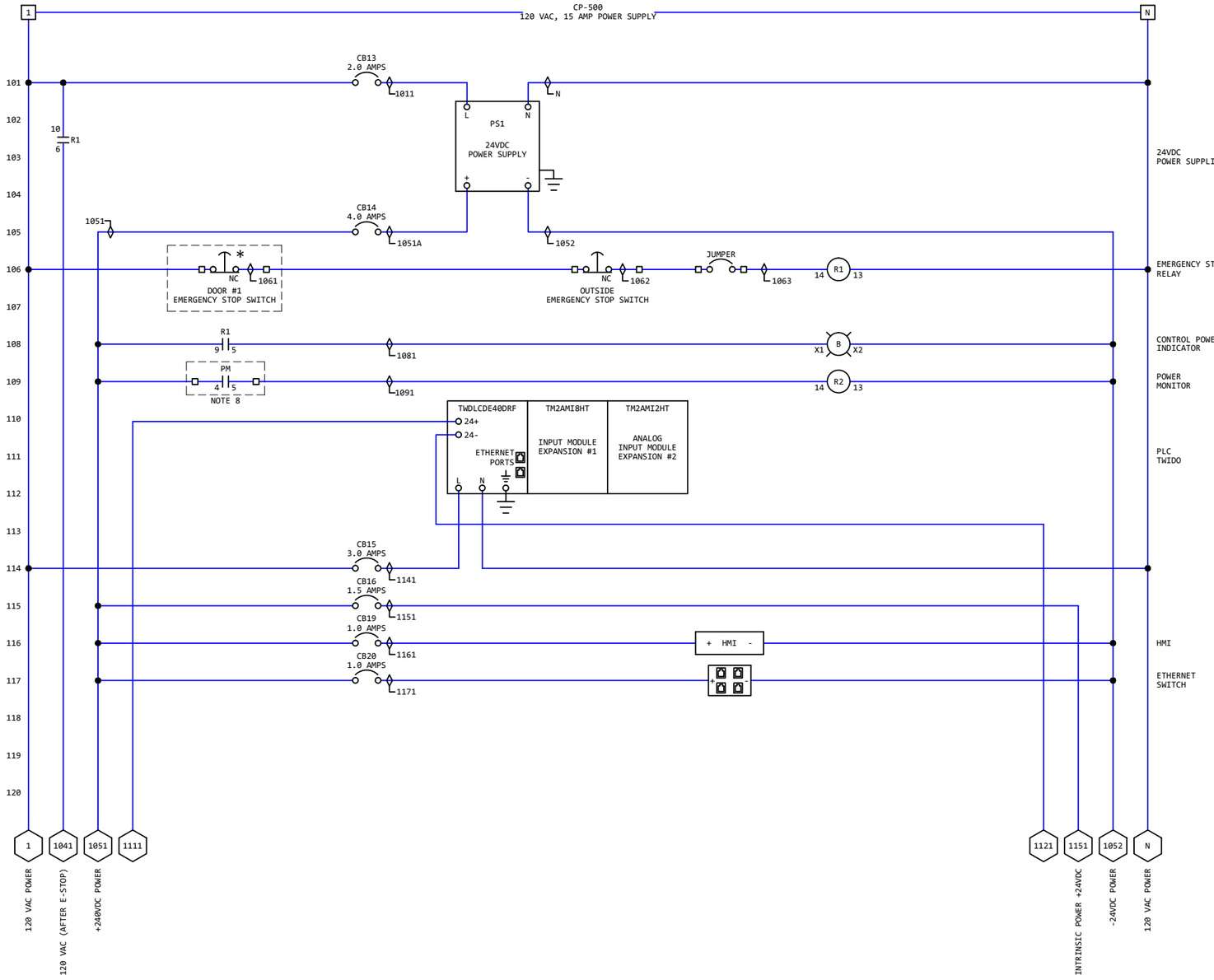
- – – – – DASHED LINES DENOTE WIRING TO FIELD DEVICES
- —E— DENOTES ETHERNET CABLE
- * DENOTES HAZARDOUS LOCATION
- ● DENOTES EQUIPMENT LOCATED IN FIELD LOCATION

LINE NUMBER DESCRIPTION

WIRING DIAGRAM SHEET NUMBER (1 OR 2 DIGITS) — LINE NUMBER (ALWAYS 2 DIGITS)

WIRE NUMBER DESCRIPTION

WIRING DIAGRAM SHEET NUMBER (1 OR 2 DIGITS) — WIRE NUMBER (1 OR 2 DIGITS) — LINE NUMBER (ALWAYS 2 DIGITS)



REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

ASBUILT

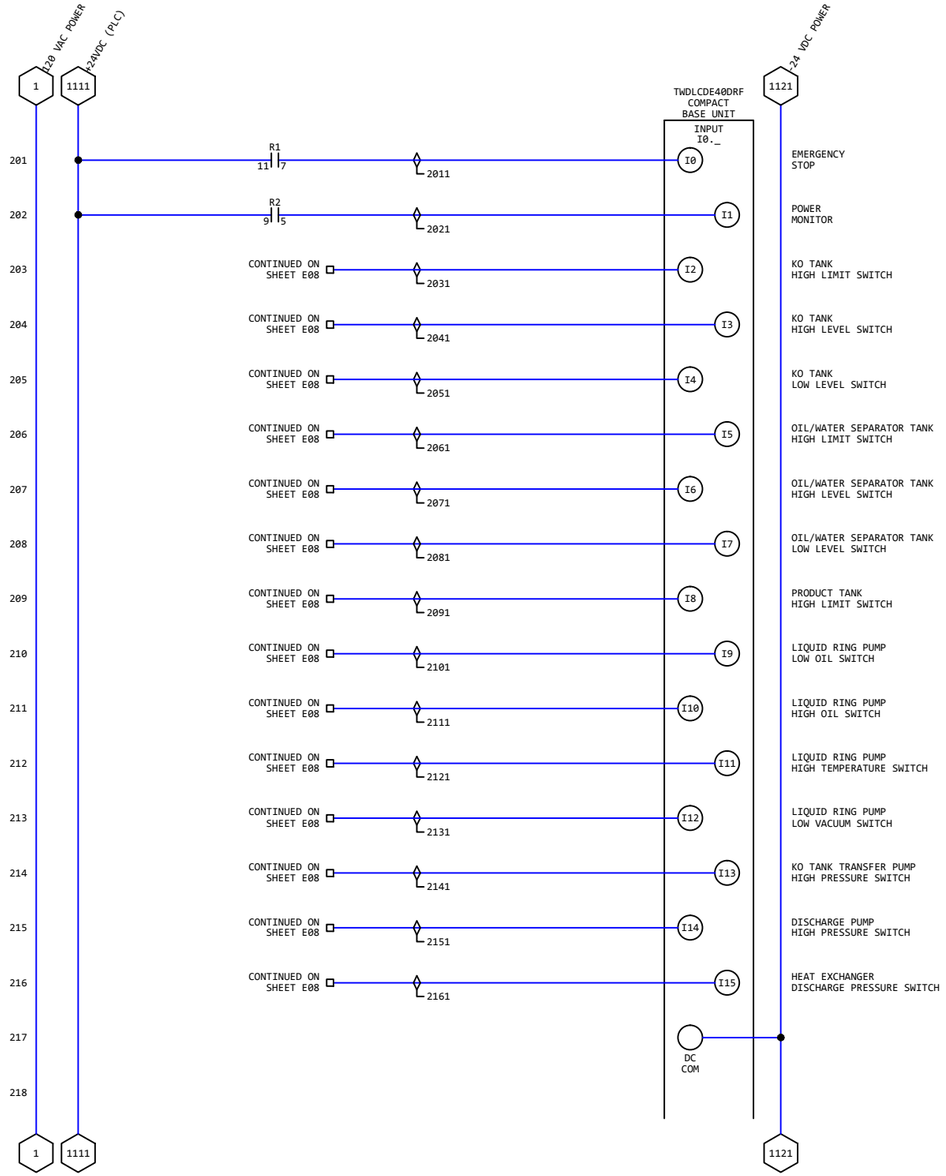
Seneca Companies
The Complete Solution

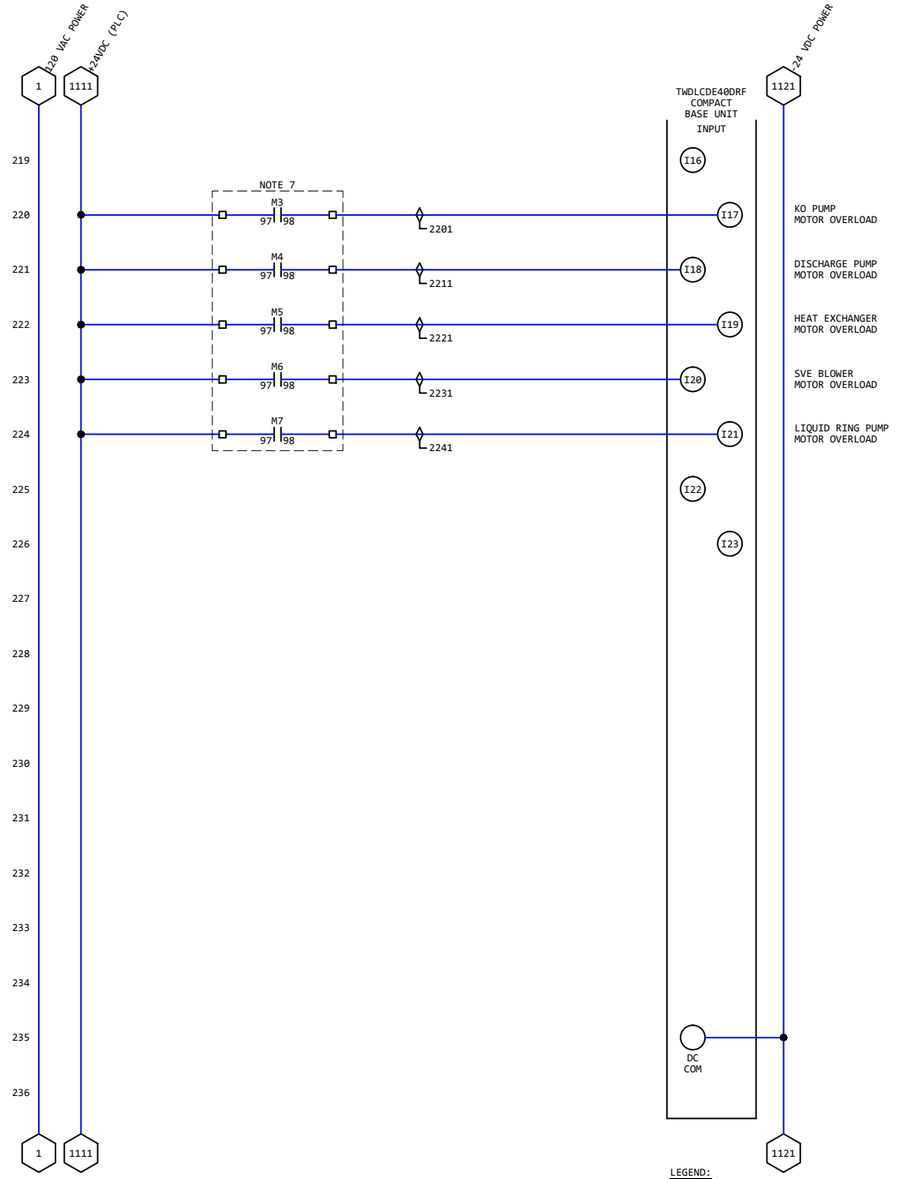
JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
MAIN CONTROL PANEL - POWER WIRING

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: RICH RICHARDS
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO. E02

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005E01-10





NOTES:
1. CABLE SIZED PER LOCAL CODE AND UTILITY REQUIREMENTS.
2. SIZES SHOWN ARE MINIMUM REQUIRED RATINGS.
3. ALL MAINTENANCE SHALL BE PERFORMED WITH DEVICES DISCONNECTED FROM THE POWER SUPPLY.
4. ALL SPLICES SHALL BE MECHANICALLY SECURE AND PROVIDE A GOOD ELECTRICAL CONTACT.
5. MINIMUM SUPPLY CONDUCTOR AMPACITY - 100 AMPS
   MAXIMUM SUPPLY OVER CURRENT PROTECTIVE DEVICE - 100 AMPS
6. FLEX CONDUIT SHALL BE SECURED AT A MINIMUM EVERY 4 FEET.
7. LOCATED IN 480V PANEL - CP-2.
8. LOCATED IN CONTROL PANEL - CP-1.
9. FOR CONNECTING TO ONLY RESISTIVE NON-ENERGY STORING DEVICES.
10. INSTALL IN ACCORDANCE WITH ART. 504 OF THE NATIONAL ELECTRIC CODE.
11. MAXIMUM CABLE LENGTH IS 900 FEET.
12. WARNING - SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY.
13. PROVIDES INTRINSICALLY SAFE CIRCUIT EXTENSIONS FOR USE IN CLASS 1, DIV. 2, GROUPS C & D, HAZARDOUS LOCATIONS WHEN CONNECTED PER INSTALLATION.
14. SMALLEST WIRE SIZE FOR BRANCH CIRCUITS IS 14 AWG.
15. MOTOR OVERLOAD RELAY MUST BE MANUALLY RESET.

LEGEND:
- – – – DASHED LINES DENOTE WIRING TO FIELD DEVICES
- —E— DENOTES ETHERNET CABLE
- —F/O— DENOTES FIBER OPTIC CABLE
- * DENOTES HAZARDOUS LOCATION (AREA 2)
- ● DENOTES EQUIPMENT LOCATED IN FIELD LOCATION

LINE NUMBER DESCRIPTION

WIRING DIAGRAM SHEET NUMBER (1 OR 2 DIGITS) — LINE NUMBER (ALWAYS 2 DIGITS)

WIRE NUMBER DESCRIPTION

WIRING DIAGRAM SHEET NUMBER (1 OR 2 DIGITS) — WIRE NUMBER (1 OR 2 DIGITS); LINE NUMBER (ALWAYS 2 DIGITS)

ASBUILT

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

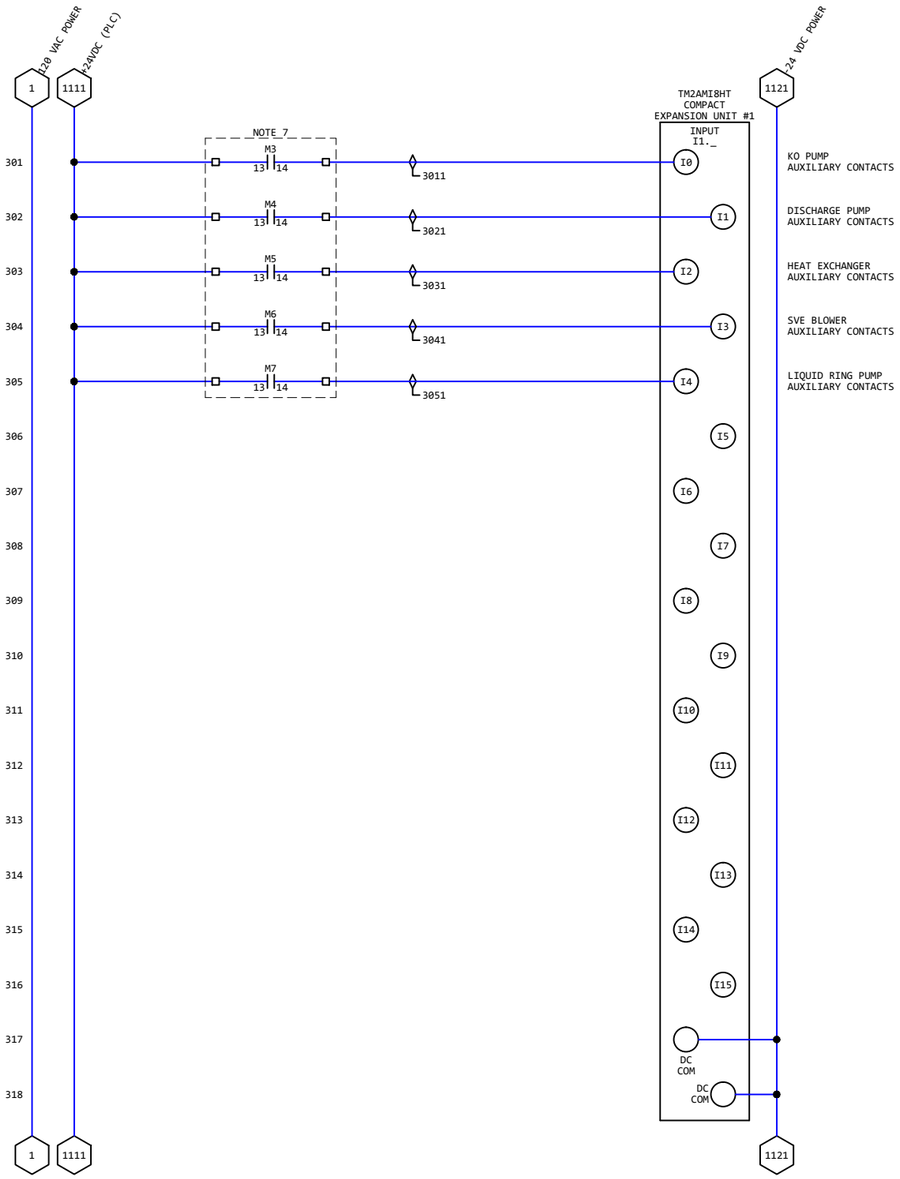
Seneca Companies
The Complete Solution

JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
MAIN CONTROL PANEL - PLC DISCRETE INPUTS - BASE UNIT

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: RICH RICHARDS
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO. E03

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005E01-10



NOTES:
1. CABLE SIZED PER LOCAL CODE AND UTILITY REQUIREMENTS.
2. SIZES SHOWN ARE MINIMUM REQUIRED RATINGS.
3. ALL MAINTENANCE SHALL BE PERFORMED WITH DEVICES DISCONNECTED FROM THE POWER SUPPLY.
4. ALL SPLICES SHALL BE MECHANICALLY SECURE AND PROVIDE A GOOD ELECTRICAL CONTACT.
5. MINIMUM SUPPLY CONDUCTOR AMPACITY - 100 AMPS
   MAXIMUM SUPPLY OVER CURRENT PROTECTIVE DEVICE - 100 AMPS
6. FLEX CONDUIT SHALL BE SECURED AT A MINIMUM EVERY 4 FEET.
7. LOCATED IN 480V PANEL - CP-2.
8. LOCATED IN CONTROL PANEL - CP-1.
9. FOR CONNECTING TO ONLY RESISTIVE NON-ENERGY STORING DEVICES.
10. INSTALL IN ACCORDANCE WITH ART. 504 OF THE NATIONAL ELECTRIC CODE.
11. MAXIMUM CABLE LENGTH IS 900 FEET.
12. WARNING - SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY.
13. PROVIDES INTRINSICALLY SAFE CIRCUIT EXTENSIONS FOR USE IN CLASS 1, DIV. 2, GROUPS C & D, HAZARDOUS LOCATIONS WHEN CONNECTED PER INSTALLATION.
14. SMALLEST WIRE SIZE FOR BRANCH CIRCUITS IS 14 AWG.
15. MOTOR OVERLOAD RELAY MUST BE MANUALLY RESET.

LEGEND:
- DASHED LINES DENOTE WIRING TO FIELD DEVICES
- E — DENOTES ETHERNET CABLE
- F/O — DENOTES FIBER OPTIC CABLE
- * DENOTES HAZARDOUS LOCATION (AREA 2)
- ● DENOTES EQUIPMENT LOCATED IN FIELD LOCATION

LINE NUMBER DESCRIPTION
WIRING DIAGRAM SHEET NUMBER (1 OR 2 DIGITS) — LINE NUMBER (ALWAYS 2 DIGITS)

WIRE NUMBER DESCRIPTION
WIRING DIAGRAM SHEET NUMBER (1 OR 2 DIGITS) — WIRE NUMBER (1 OR 2 DIGITS) — LINE NUMBER (ALWAYS 2 DIGITS)

ASBUILT

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

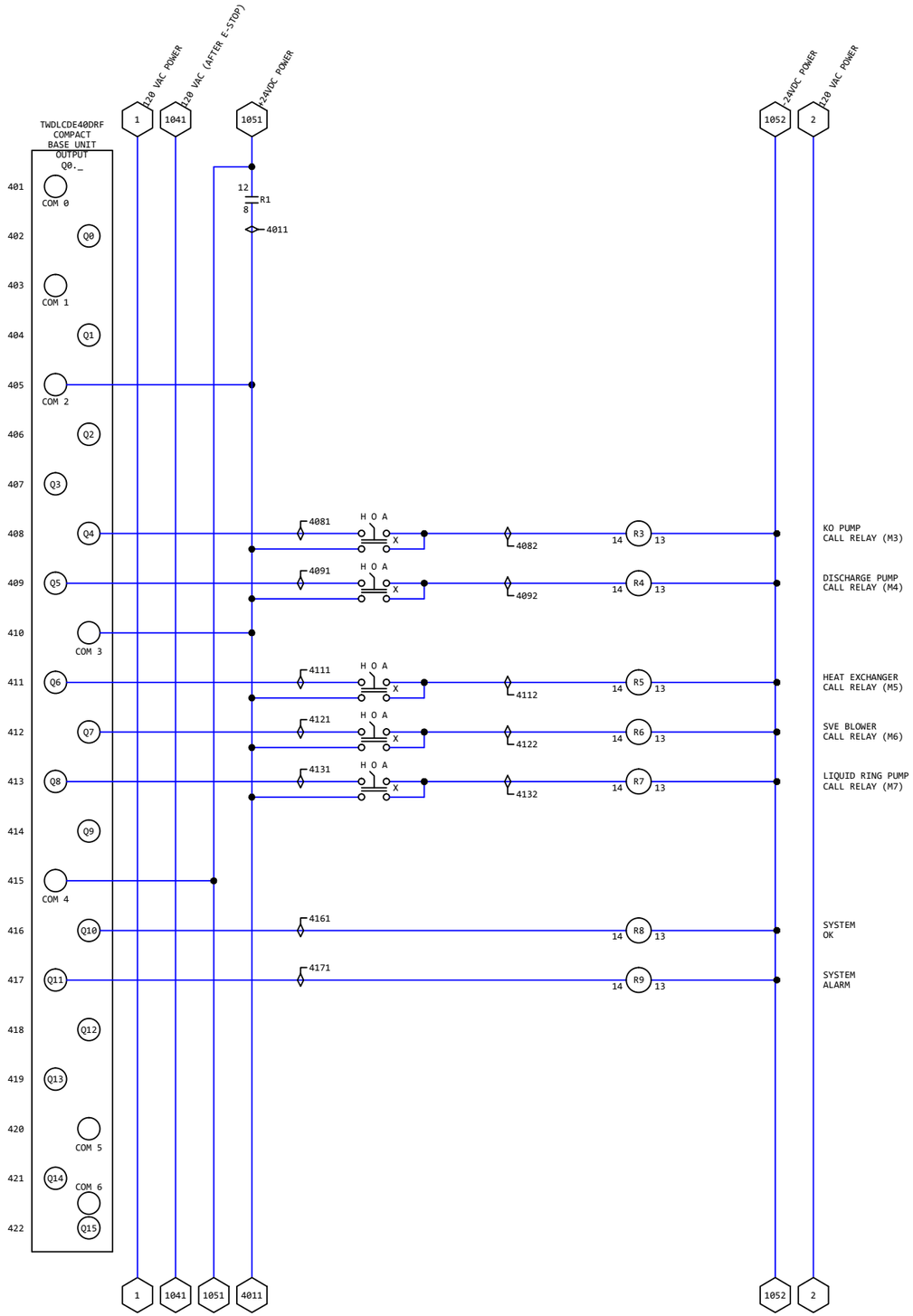
Seneca Companies
The Complete Solution

JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
MAIN CONTROL PANEL - PLC I/O LOGIC - EXPANSION UNIT #1

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: RICH RICHARDS
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO. E04

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005E01-10



NOTES:
1. CABLE SIZED PER LOCAL CODE AND UTILITY REQUIREMENTS.
2. SIZES SHOWN ARE MINIMUM REQUIRED RATINGS.
3. ALL MAINTENANCE SHALL BE PERFORMED WITH DEVICES DISCONNECTED FROM THE POWER SUPPLY.
4. ALL SPLICES SHALL BE MECHANICALLY SECURE AND PROVIDE A GOOD ELECTRICAL CONTACT.
5. MINIMUM SUPPLY CONDUCTOR AMPACITY - 100 AMPS
   MAXIMUM SUPPLY OVER CURRENT PROTECTIVE DEVICE - 100 AMPS
6. FLEX CONDUIT SHALL BE SECURED AT A MINIMUM EVERY 4 FEET.
7. LOCATED IN 480V PANEL - MC-1.
8. LOCATED IN CONTROL PANEL - CP-1.
9. FOR CONNECTING TO ONLY RESISTIVE NON-ENERGY STORING DEVICES.
10. INSTALL IN ACCORDANCE WITH ART. 504 OF THE NATIONAL ELECTRIC CODE.
11. MAXIMUM CABLE LENGTH IS 900 FEET.
12. WARNING - SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY.
13. PROVIDES INTRINSICALLY SAFE CIRCUIT EXTENSIONS FOR USE IN CLASS 1, DIV. 2, GROUPS C & D, HAZARDOUS LOCATIONS WHEN CONNECTED PER INSTALLATION.
14. SMALLEST WIRE SIZE FOR BRANCH CIRCUITS IS 14 AWG.
15. MOTOR OVERLOAD RELAY MUST BE MANUALLY RESET.

LEGEND:
- – – – DASHED LINES DENOTE WIRING TO FIELD DEVICES
- —E— DENOTES ETHERNET CABLE
- —F/O— DENOTES FIBER OPTIC CABLE
- * DENOTES HAZARDOUS LOCATION (AREA 2)
- ● DENOTES EQUIPMENT LOCATED IN FIELD LOCATION

LINE NUMBER DESCRIPTION

WIRING DIAGRAM SHEET NUMBER (1 OR 2 DIGITS) — LINE NUMBER (ALWAYS 2 DIGITS)

WIRE NUMBER DESCRIPTION

WIRING DIAGRAM SHEET NUMBER (1 OR 2 DIGITS) — WIRE NUMBER (1 OR 2 DIGITS); LINE NUMBER (ALWAYS 2 DIGITS)

ASBUILT

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

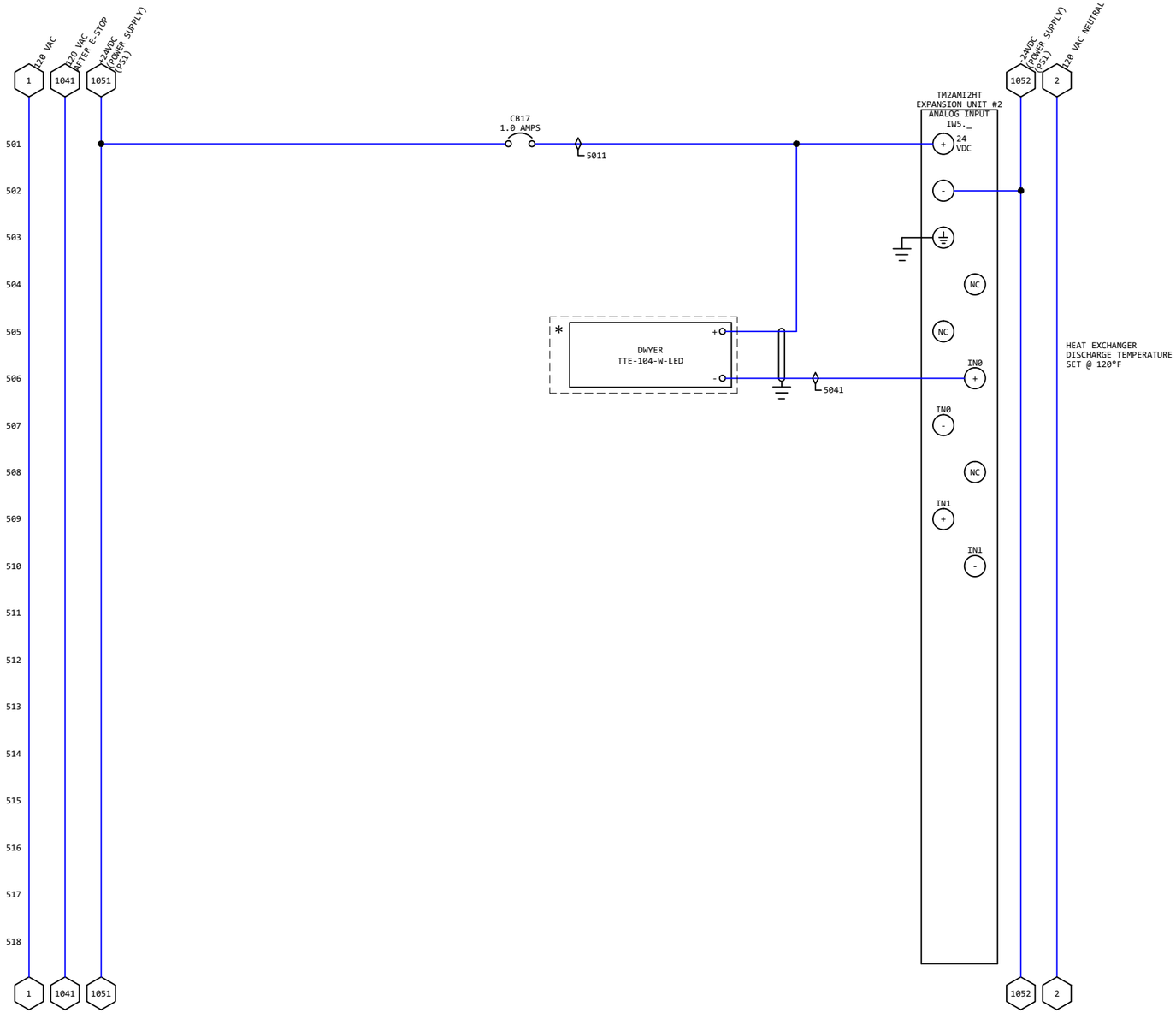
Seneca Companies
The Complete Solution

JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
MAIN CONTROL PANEL - PLC DISCRETE OUTPUTS - BASE UNIT

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: RICH RICHARDS
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO. E05

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005E01-10



NOTES:
1. CABLE SIZED PER LOCAL CODE AND UTILITY REQUIREMENTS.
2. SIZES SHOWN ARE MINIMUM REQUIRED RATINGS.
3. ALL MAINTENANCE SHALL BE PERFORMED WITH DEVICES DISCONNECTED FROM THE POWER SUPPLY.
4. ALL SPLICES SHALL BE MECHANICALLY SECURE AND PROVIDE A GOOD ELECTRICAL CONTACT.
5. MINIMUM SUPPLY CONDUCTOR AMPACITY - 100 AMPS
   MAXIMUM SUPPLY OVER CURRENT PROTECTIVE DEVICE - 100 AMPS
6. FLEX CONDUIT SHALL BE SECURED AT A MINIMUM EVERY 4 FEET.
7. LOCATED IN 480V PANEL - MC-1.
8. LOCATED IN CONTROL PANEL - CP-1.
9. FOR CONNECTING TO ONLY RESISTIVE NON-ENERGY STORING DEVICES.
10. INSTALL IN ACCORDANCE WITH ART. 504 OF THE NATIONAL ELECTRIC CODE.
11. MAXIMUM CABLE LENGTH IS 900 FEET.
12. WARNING - SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY.
13. PROVIDES INTRINSICALLY SAFE CIRCUIT EXTENSIONS FOR USE IN CLASS 1, DIV. 2, GROUPS C & D, HAZARDOUS LOCATIONS WHEN CONNECTED PER INSTALLATION.
14. SMALLEST WIRE SIZE FOR BRANCH CIRCUITS IS 14 AWG.
15. MOTOR OVERLOAD RELAY MUST BE MANUALLY RESET.

LEGEND:
- – – – DASHED LINES DENOTE WIRING TO FIELD DEVICES
- —E— DENOTES ETHERNET CABLE
- —F/O— DENOTES FIBER OPTIC CABLE
- * DENOTES HAZARDOUS LOCATION (AREA 2)
- ● DENOTES EQUIPMENT LOCATED IN FIELD LOCATION

LINE NUMBER DESCRIPTION
- WIRING DIAGRAM SHEET NUMBER (1 OR 2 DIGITS)
- LINE NUMBER (ALWAYS 2 DIGITS)

WIRE NUMBER DESCRIPTION
- WIRING DIAGRAM SHEET NUMBER (1 OR 2 DIGITS)
- WIRE NUMBER (1 OR 2 DIGITS)
- LINE NUMBER (ALWAYS 2 DIGITS)

ASBUILT

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

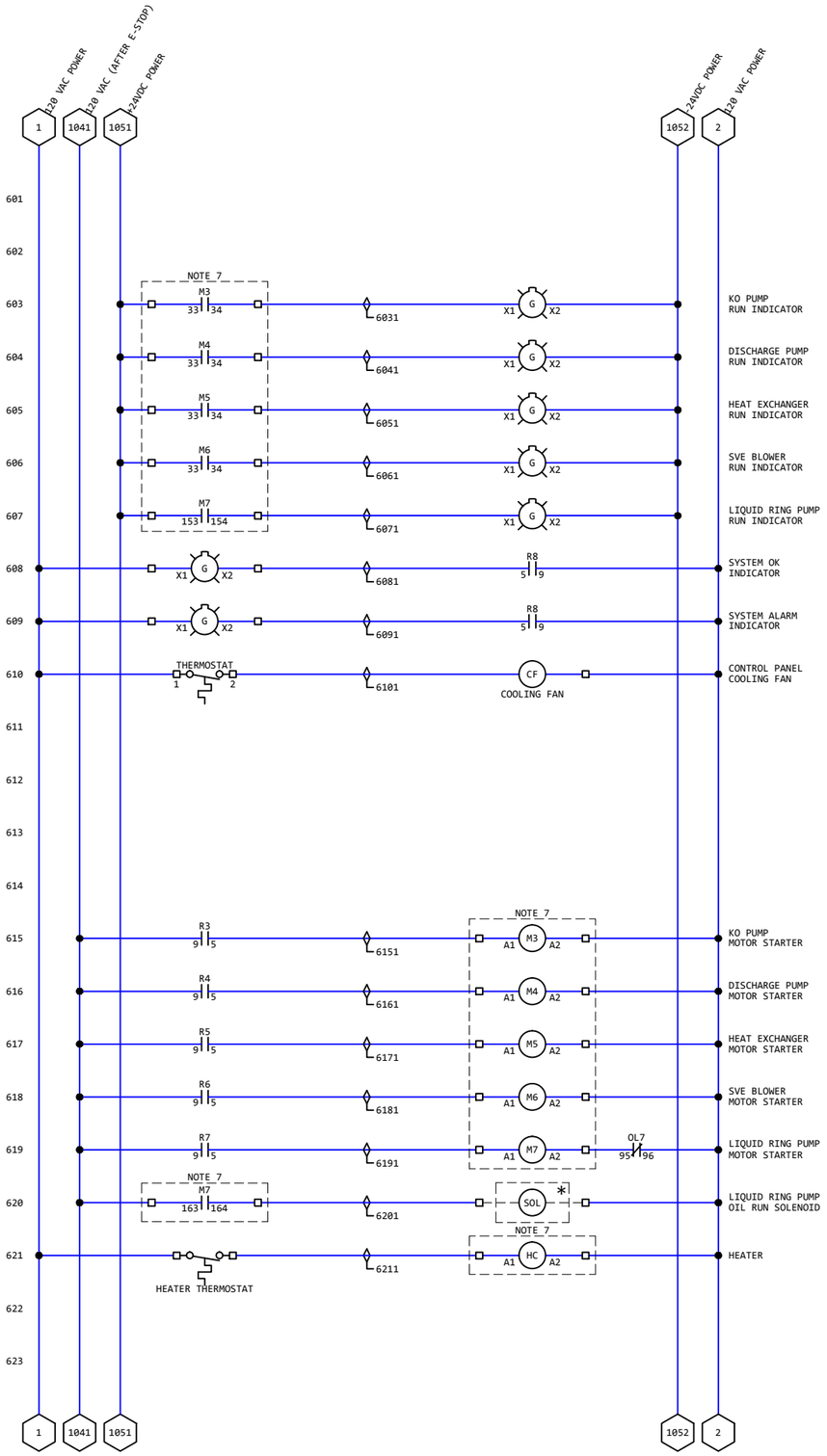
Seneca Companies
The Complete Solution

JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
MAIN CONTROL PANEL
PLC I/O LOGIC OUTPUTS - EXPANSION UNIT #2

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: RICH RICHARDS
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO. E06

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005E01-10



NOTES:
1. CABLE SIZED PER LOCAL CODE AND UTILITY REQUIREMENTS.
2. SIZES SHOWN ARE MINIMUM REQUIRED RATINGS.
3. ALL MAINTENANCE SHALL BE PERFORMED WITH DEVICES DISCONNECTED FROM THE POWER SUPPLY.
4. ALL SPLICES SHALL BE MECHANICALLY SECURE AND PROVIDE A GOOD ELECTRICAL CONTACT.
5. MINIMUM SUPPLY CONDUCTOR AMPACITY - 100 AMPS
   MAXIMUM SUPPLY OVER CURRENT PROTECTIVE DEVICE - 100 AMPS
6. FLEX CONDUIT SHALL BE SECURED AT A MINIMUM EVERY 4 FEET.
7. LOCATED IN 480V PANEL - CP-2.
8. LOCATED IN CONTROL PANEL - CP-1.
9. FOR CONNECTING TO ONLY RESISTIVE NON-ENERGY STORING DEVICES.
10. INSTALL IN ACCORDANCE WITH ART. 504 OF THE NATIONAL ELECTRIC CODE.
11. MAXIMUM CABLE LENGTH IS 900 FEET.
12. WARNING - SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY.
13. PROVIDES INTRINSICALLY SAFE CIRCUIT EXTENSIONS FOR USE IN CLASS 1, DIV. 2, GROUPS C & D, HAZARDOUS LOCATIONS WHEN CONNECTED PER INSTALLATION.
14. SMALLEST WIRE SIZE FOR BRANCH CIRCUITS IS 14 AWG.
15. MOTOR OVERLOAD RELAY MUST BE MANUALLY RESET.

LEGEND:
- DASHED LINES DENOTE WIRING TO FIELD DEVICES
- E — DENOTES ETHERNET CABLE
- F/O — DENOTES FIBER OPTIC CABLE
- * DENOTES HAZARDOUS LOCATION (AREA 2)
- ● DENOTES EQUIPMENT LOCATED IN FIELD LOCATION

LINE NUMBER DESCRIPTION
WIRING DIAGRAM SHEET NUMBER (1 OR 2 DIGITS) — LINE NUMBER (ALWAYS 2 DIGITS)

WIRE NUMBER DESCRIPTION
WIRING DIAGRAM SHEET NUMBER (1 OR 2 DIGITS) — WIRE NUMBER (1 OR 2 DIGITS) — LINE NUMBER (ALWAYS 2 DIGITS)

ASBUILT

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

Seneca Companies
The Complete Solution

JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
MAIN CONTROL PANEL - MOTOR CONTROLS

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: RICH RICHARDS
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO. E07

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005E01-10

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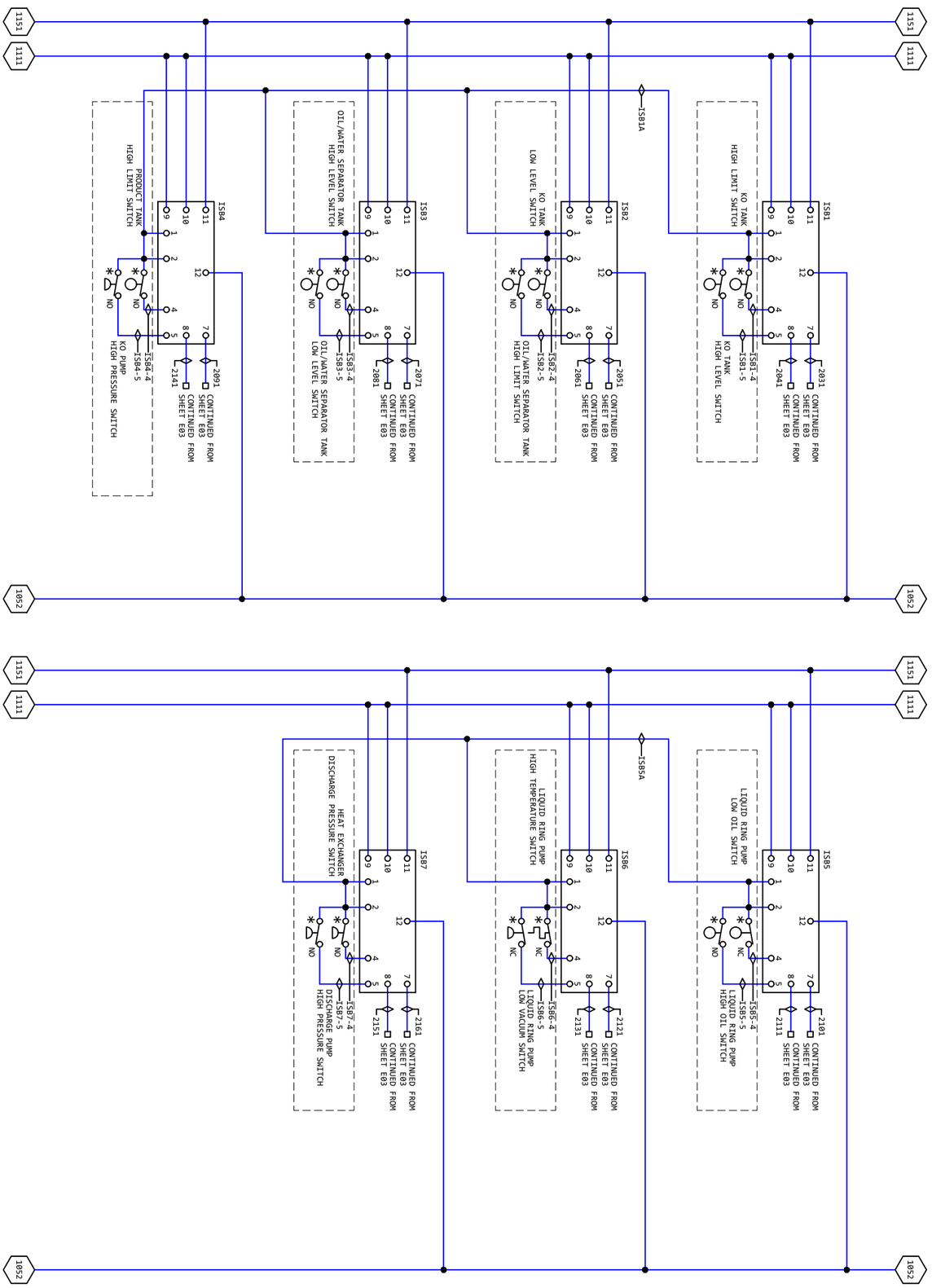

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DATE:	04/17/2015
DRAWN BY:	DARRICK MORRALL
CHECKED BY:	RICH RICHARDS
SCALE:	NO SCALE
PROJECT NO:	1715005
SHEET NO:	E08

JOB DESCRIPTION:

KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:

MAIN CONTROL PANEL - INTRISIC BARRIERS

Seneca Companies
The Complete Solution

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

SWING PANEL

BACK PANEL

ASBUILT

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

Seneca Companies
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JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
MAIN CONTROL PANEL - SWING/BACK PANEL LAYOUT

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: RICH RICHARDS
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO. E09

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005E01-10

QTY	DESCRIPTION	MANUFACTURER	PART NUMBER
	Panel Hardware		
1	Enclosure - PLC Panel	Hoffman	CSD363612
1	Sub Panel	Hoffman	CP3636
1	Swing Panel	Hoffman	A36P36
1	Hinge Kit	Hoffman	ANADFK
1	Drawing Pocket	Hoffman	ADP2
1	Door Handle	Hoffman	CWHK
1	Cooling Fan Thermostat	Hoffman	ATEMNO
1	Cooling Fan 4"	Hoffman	A4AXFN
1	Cooling Fan 4" Finger Guard	Hoffman	AGARD4
2	Fan Shrouds 4"	Hoffman	T4S3R
3	Vents 4"	Hoffman	AFLT44
1	Mini Circuit Breaker 1.0A 1P Exhaust Fan	Square-D	60101
	480 Volt Panel Hardware		
1	Enclosure 480V	Hoffman	CSD36288
1	Sub Panel	Hoffman	CP3624
1	Door Handle	Hoffman	CWHK
	480V Panel Disconnect		
1	Main Breaker 600V 100A	Square-D	HDL36100C
	Panel Switches		
5	Hand-Off-Auto Switch Maintain - Illuminated	Telemecanique	ZB4BK1333
5	Contact Block	Telemecanique	ZB4BZ103
	Panel Lights-Meters		
5	Pilot Light Assembly-Lens White 24vdc	Telemecanique	XB4BVB1
1	Pilot Light Assembly-Lens Blue 24vdc	Telemecanique	XB4BVB6
	Panel Labels		
5	Legend Plate Hand/Off/Auto	Telemecanique	ZBY2387
	Motor Starters-Overloads-Breakers		
	Liquid Ring Pump		
1	Contactor 20HP 480V 3Ph 27FLA	Square-D	LC1D40AG7
1	Overload Module 23-32A	Square-D	LRD332
1	Auxiliary Contacts	Square-D	LAD8N20
1	Surge Suppressor	Square-D	LAD4RC3U
1	Circuit Breaker 480V 3P 60A	Square-D	GV7RE80
	SVE Blower		
1	Contactor 7.5HP 480V 3Ph 11.0FLA	Square-D	LUB32
1	Overload Module 4.5-18A	Square-D	LUCA18FU
1	Auxiliary Contacts	Square-D	LUFN20
1	Auxillary Contacts - Overload	Telemecanique	LUA1C20
1	Incoming Line Barrier	Telemecanique	LU9SPO
	Heat Exchanger		
1	Contactor 0.5HP 480V 3Ph 1.1FLA	Square-D	LUB32
1	Overload Module 1.25-5A	Square-D	LUCA05FU
1	Auxiliary Contacts	Square-D	LUFN20
1	Auxillary Contacts - Overload	Telemecanique	LUA1C20
1	Incoming Line Barrier	Telemecanique	LU9SPO
	KO Tank Transfer Pump		
1	Contactor 1.0HP 480V 3Ph 2.1FLA	Square-D	LUB32
1	Overload Module 1.25-5A	Square-D	LUCA05FU
1	Auxiliary Contacts	Square-D	LUFN20
1	Auxillary Contacts - Overload	Telemecanique	LUA1C20
1	Incoming Line Barrier	Telemecanique	LU9SPO
	Discharge Pump		
1	Contactor 1.5HP 480V 3Ph 3.0FLA	Square-D	LUB32
1	Overload Module 1.25-5A	Square-D	LUCA05FU
1	Auxiliary Contacts	Square-D	LUFN20
1	Auxillary Contacts - Overload	Telemecanique	LUA1C20
1	Incoming Line Barrier	Telemecanique	LU9SPO
	Heater		
1	Contactor	Square-D	LC1D12G7
1	Fuses Holder, Heater 600V 2P 30A	Ferraz/Shawmut	US3J3I
2	Fuses, Heater 600V 15A	Ferraz/Shawmut	AJT15
	Exhaust Fan		
2	Mini Circuit Breaker Lights 240VAC 15A 2P	Square-D	60146
	PLC		
1	PLC - TWIDO 40 I/O 120-230VAC Pwr	Telemecanique	TWDLCAE40DRF
1	Digital Input Module 8Pt.	Telemecanique	TM2DDI8DT
0	Digital Output Module 8Pt.	Telemecanique	TM2DRA8RT
1	Analog Input Module 2Ch 4-20mA	Telemecanique	TM2AMI2HT
1	Battery	Telemecanique	TSXPLP01
1	Mini Circuit Breaker 1.5A 1P PLC	Square-D	60102

	HMI		
1	HMI 5.7" Color w/Ethernet, Compact Flash	Square-D	HMISTU855
1	Flash Drive 8GB	Kingston	DTMCK/8GB
1	Mini Circuit Breaker 1.0A 1P HMI	Square-D	60101
	Ethernet Switch		
1	Ethernet Switch 4 Port	N-Tron	104TX
1	Circuit Breaker 1P 1A Ethernet Switch	Square-D	60101
	Ethernet Cables		
1	1' Ethernet Cable	3E	QTN530100001
1	2' Ethernet Cable	3E	QTN530100002
1	6' Ethernet Cable	3E	QTN27250
1	Panel Mount Ethernet Port 22mm	WAG	51205068
	Intrinsic/Isolation Barriers		
7	Discrete Barriers	Turk	IM1-22EX-R/24VDC
	Panel Protection		
1	Surge Arrestor	Ferraz/Shawmut	ST1201PG
1	Circuit Breaker Phase Monitor 1P 4A	Square-D	MGN61326
1	Phase Monitor	SymCom	460
	Misc. Panel Items		
1	Power Supply 24VDC 4.2A	Puls	ML100100
1	Mini Circuit Breaker Primary 120vac 3A	Square-D	60104
1	Mini Circuit Breaker Secondary 4.0A 1P	Square-D	60105
1	Mini Circuit Breaker Analog Devices 24vdc 1A	Telemecanique	60101
1	Auxillary Relay 120vac	Telemecanique	RXM4AB2F7
7	Auxillary Relay 24vdc	Telemecanique	RXM4AB2BD
8	Relay Socket	Telemecanique	RXZE2S114M
1	120Vac Relay Varistor	Telemecanique	RXM021FP
7	24Vdc Relay Varistor	Telemecanique	RXM021BN
1	Flashing Beacon - Red	Federal Signal	SLM100R
1	Flashing Beacon - Green	Federal Signal	SLM100G
1	Wall Mount Base Dual	Federal Signal	SLMBT120-240/GY
2	Grounding Bus Bar	Square-D	PK15GTAL
6	Din Rail	IDEC	BNDN1000
36	Din Rail Retainers	IDEC	BNL5
1	Din Rail Retainers	Allen-Bradley	1492-EAJ35
4	Terminal Blocks 2 Conductor	Allen-Bradley	1492-JD3
1	End Barrier	Allen-Bradley	1492-EBJD3
67	Terminal Blocks	Square-D	9080GR6
31	Terminal Blocks	Square-D	9080GM6
7	End Barrier	Square-D	9080GM6B
2	Terminal Block Green	WAGO	2002-1307
2	End Barrier	WAGO	2002-1391
1	Terminal Block 3 Conductor	WAGO	2002-3218
1	End Barrier	WAGO	2002-3291
3	Power Distribution 480vac	Ferraz/Shawmut	FSPDB3A
3	Power Distribution 240/120vac	Ferraz/Shawmut	FSPDB2A
8	Distribution Block Pins	Ferraz/Shawmut	FSPIN1
1	Mini Circuit Breaker Control Pwr 120VAC 10A	Square-D	60110
1	Mini Circuit Breaker Lights 120VAC 15A	Square-D	60112
1	Mini Circuit Breaker GFI 120VAC 20A	Square-D	60113
2	Fuses Holder, Control Transformer 600V 2P 30A	Ferraz/Shawmut	US3J2I
4	Fuses, Control Transformer 600V 20A	Ferraz/Shawmut	AJT20
	Other Items		
3	Thermostat	Columbus Electric	EP-ETD-8D
1	Emergency Stop Switch - Exp	Appleton	EFKBUM1
1	Emergency Stop Switch Box - Exp	Appleton	EFDC175NLQ
3	Light	Appleton	VXHA1075G
1	Light Switch Box - Exp	Killark	SWB-2
1	Light Switch Cover - Exp	Killark	XNS-2C
1	Light Switch	P&S	PS20AC1-W
1	GFI Receptacle	P&S	2095-TRWRW
1	GFI Cover	Intermatic	CKMUV
1	WP Box 1G 3 Hole 1/2" Hubs	Raco	5385-0
1	Distribution Transformer 5.0KVA 480-120/240V 1Ph	Hammond	C1F005LES
1	Surge Arrestor 480/277V 3Ph 40kA Per Phase	Square-D	SDSA3650D

ASBUILT

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

Seneca Companies
The Complete Solution

JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
MAIN CONTROL PANEL - BILL OF MATERIAL

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: RICH RICHARDS
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO. E10

QTY	Description	Manufacturer	Part Number
	Equipment		
1	Liquid Ring Vacuum Pump	Dekker	VMX0303KA1-01
1	Motor	Dekker	20 Hp 230/460V 3Ph
1	Check Valve	Dekker	Included
1	Heat Exchanger	Dekker	Included
1	Oil Level Indicator	Dekker	Included
1	Solenoid Valve, NEMA 7	Dekker	Included
1	High Oil Level Switch, NEMA 7	Dekker	Included
1	Low Oil Level Switch, NEMA 7	Dekker	Included
1	High Temp Switch, NEMA 7	Dekker	Included
12	Vacuum Relef Valve Filter Element SPARE	Dekker	2924-0100-001
2	Separator Element (Annual) SPARE	Dekker	6300-1615-002
6	Seal Oil (5 Gallon Pail) SPARE	Dekker	5220-0050-000
1	Oil Water Separator w/Gasket Lid	Hydroquip	HQI AGM-3SS-90V
1	Hinged Lid with Prop	Hydroquip	Option Included
1	Product Storage Drum 55Gal	McMaster Carr	4115T18
1	Secondary Containment-Storage Drum	Seneca	Custom Pan
1	SVE Blower 7.5 Hp 230/460 V 3 Phase	Ametek Rotron	EN808BA72MXL
2	EXP Supply Fan	New York Blower	SN-122-M 1/4 Hp
1	Heat Exchanger	American Industrial	ACA-3301-3E
1	Transfer Pump Class 1, Div 2	Myers	CT15FAB 1.5 Hp 230/460 3 Phase
3	Myers Pump Seal Kit SPARE	Myers	14525A000K
3	Myers Pump Gasket SPARE	Myers	05059A446
1	Progressive Cavity Pump Class 1, Div 2	Continental	CP56C-CSQM 1Hp w-Stator Barrior
3	Continental Pump Rebuilt Kit SPARE	Continental	CTL Rebuild
1	Air/Water Separator	Seneca	120 Gallon
1	Intake Filter/Silencer 2"	Solberg	FS-30P-200
2	Inline Filter See Through Bucket 3"	Solberg	STS-235P-300C
1	Inline Filter Polyester Element 3"	Solberg	CT-235P-300C
16	Intake Filter/Silencer Element	Solberg	30P
16	Inline Filter Element	Solberg	235P
2	Filter Housings	CSD	007A1304L020N2VC
2	Spring Bag Hold Down	CSD	Option
100	Filter Bags SPARE	CSD	25 Micron
100	Filter Bags SPARE	CSD	50 Micron
2	Liquid Phase Carbon	TetraSolv	HPAF-500
1	Virgin Carbon Adder	TetraSolv	1000 lbs
2	Vapor Phase Carbon	TetraSolv	VF-2000
1	Virgin Carbon Adder	TetraSolv	4000 lbs
1	EXP Convection Heater	Chromalox	CVEP-3.6 kW 460V 1P
1	Secondary Containment	Ultratech	UT-8210 with Drain in Sidewall
	Enclosure		
1	Enclosure	Great Lakes	20'L X 8'W
1	Double Rear Doors	Great Lakes	Standard
1	36" Curb Side Door	Great Lakes	Option Included
1	Painted-Custom Paint Specs	Great Lakes	
	Instrumentation		
36	Vacuum Gage Back Mount	Ashcroft	63-1008A-02B-XSF7F-VAC 0-30" HG
2	Temperature Gage	Ashcroft	30EI60R040 50/300F
2	Pressure Gage	Ashcroft	63-1008A-02B-XSF7F-15#
7	Pressure Gage	Ashcroft	63-1008A-02B-XSF7F-30#
3	Pressure Gage	Ashcroft	63-1008A-02B-XSF7F-60#
3	Level Switches KO Tank	FPI	Stainless Steel
3	Level Switches Oil Water Separator	FPI	Stainless Steel
1	Level Switches Product Drum	FPI	Stainless Steel
2	EXP-Pressure Switch-Transfer Pumps	Mercoid	SA1111E-S5-K2
1	EXP-Pressure Switch-Heat Exchanger	Dwyer	1950P-8-2F
1	Temperature Transmitter 4" Stem w/LCD	Dwyer	TTE-104-W-LCD
1	EXP Vacuum Switch	Dwyer	1950P-15-2F
1	Pitot Tube	Dwyer	DS-300-3"
1	Magnehelic Gage	Dwyer	2004
1	Pitot Tube	Dwyer	DS-300-2"
1	Magnehelic Gage	Dwyer	2002
1	Rotometer 2-20 GPM	Dwyer	VFC-143-EC
1	Flow Meter Rate/Total	ISTEC	1720 with Viton 0-50 Max GPM
	Valves		
6	Sample Port-Ball Valve	Jomar	100-702 3/8"
11	Ball Valve-Viton Brass Drain	Jomar	100-705 1"
1	Check Valve-Brass	Midco	1"
1	Check Valve-Brass	Midco	1.25"

1	Product Drain Ball Valve-Brass	Jomar	100-708 2"
2	Ball Valve-Viton Brass	Jomar	100-709 2.5"
1	Butterfly Valve-EPDM	Jomar	900-04-DSEL 4"
9	Ball Valve-Viton True Union	Jomar	210-545 1" PVC
2	Ball Valve-Viton True Union	Jomar	210-546 1.25" PVC
1	Ball Valve-Viton True Union	Jomar	210-547 1.5" PVC
1	Ball Valve-Viton True Union	Jomar	210-548 2" PVC
1	Anti-Siphon Valve	Midco	1"
	ITEMS TO TAKE ON SITE		
	Manifold Outside of Enclosure		
2	Butterfly Valve-EPDM	Jomar	900-04-DSEL 4"
4	Flanges PVC		4" Flanges PVC
2	Bolt Kits		
2	Sample Port-Ball Valve	Jomar	100-702 3/8"
2	Ball Valve Stainless Steel 1/4"	Jomar	100-961
2	Sight Flow Window	WE Anderson	SFI-500B-2
2	Vacuum Gage	Ashcroft	
2	Sch 80 PVC T 4" x 4" x 2" 2" NPT		
	Well Stub Detail - On Site Valves and Fittings		
10	Ball Valve-Viton True Union	Jomar	210-548 2" PVC
10	2" Sight Glass with window	McMaster Carr	4213K167
11	2" Globe Valve-Flanged	New Way	GL1RA8
10	Ball Valve Stainless Steel 1/4"	Jomar	100-961
10	Ball Valve Stainless Steel 3/8"	Jomar	100-962
10	T 3/8 x 3/8 x 1/2"	Spears	T 3/8 x 3/8 x 1/2" Galvanized
10	Bushing 1/2" x 1/4"	Spears	Bushing 1/2" x 1/4" Galvanized
1	4" Sch 80 PVC T	Spears	4" Sch 80 PVC T
5	4" Sch 80 PVC Flange	Spears	4" Sch 80 PVC Flange
	Well Vault Detail - On Site Valves and Fittings		
12	Sch 80 PVC Reducer 2" x 1.5"	Spears	
80	Sch 80 PVC Pipe 1.5"	Spears	1.5"
24	Sch 80 PVC90 1.5"	Spears	1.5"
11	Ball Valve-Viton True Union	Jomar	210-547 1.5" PVC
12	Sch 80 PVC Reducer T 1.5" x 1/2" FPT	Spears	
12	Sch 80 PVC Hex Bushing 1/2" x 1/4"	Spears	
10	Ball Valve Stainless Steel 1/4"	Jomar	100-961
10	Pipe Nipple 1/4"		
10	Sch 80 Reducer 1.5" x 1.25"		
10	Sch 80 Male Adapter 1.25"		
11	Quick Connect Male x FNPT Poly	Sprayer Specialty	61223
11	Quick Connect Female x Barb Poly	Sprayer Specialty	61268
50	Hose Clamp 1.25"	Sprayer Specialty	UT-162
2	Hose 1.25" 100' Reels	Sprayer Specialty	K114
	Well Seal Detail		
10	Well Seal Needs to Fit Compression Fitting, Ball Valve and Vacuum Gage	Midco	
11	Compression Fitting to fit 1.25" Hose	Midco	
10	Ball Valve Stainless Steel 1/2"	Jomar	100-963
22	Pipe Nipple 1/2"	Midco	Galvanized
22	Pipe Nipple 1/4"	Midco	Galvanized
22	Coupling 1/4"	Midco	Galvanized
	In Well Detail		
10	Hose Barb 1.25" Poly	Sprayer Specialty	A114
24	Sch 40 PVC Female Adapter 1.25"	Spears	435-012
24	Sch 40 PVC Male Adapter 1.25"	Spears	436-012
220	Sch 40 PVC Pipe 1.25"	Spears	

HUBBELL KILLARK
P. O. Box 5325, St. Louis, MO 63115-0325 USA

INSTALLATION DATA SHEET

"V" SERIES INCANDESCENT FIXTURE FITTING FOR
CLASS I, DIV. 2 HAZARDOUS LOCATIONS. REFER TO
FIXTURE NAMEPLATE FOR CLASSIFIED LOCATION
INFORMATION.
ALSO, SUITABLE AS ENCLOSURE TYPE 3 & 4 WHEN USED
WITH CLEAR, HEAT-RESISTANT GLOBE, CAT. NO. VCGP-100; -200.

IMPORTANT - Verify that there is ground continuity in the electrical system. Refer to the fixture body for the specific supply temperature rating required.

WARNING - Turn OFF the supply circuit before installing fixture.

NOTE - All installations must comply with applicable local and/or National Electrical Code.

UL APPLICATION DATA

A COMPLETE FIXTURE CONSISTS OF AN INCANDESCENT FIXTURE BODY, A SPLICE BOX AND A GLOBE. MAY ALSO BE PROVIDED WITH AN OPTIONAL GLOBE GUARD AND/OR REFLECTOR.

FIXTURE BODY	SPLICE BOX	GLOBE	GUARD	REFLECTOR
VXFC-100-N34	VB-1; VB-2 VBC-1; VBC-2 VD-4 VGA-1; VGA-2 VGC-1; VGC-2 VGH-1; VGH-2 VGX-1; VGX-2 VXA-1; VXA-2	VCG-100 VCGP-100 VAMG-100 VGG-100 VBG-100 VRG-100 VRSG-100	VAG-100	VPRSD-100
VXFC-200-N34		VCG-200 VCGP-200 VAMG-200 VGG-200 VBG-200 VRG-200	VAG-200	VPRSD-200

MAY ALSO BE PROVIDED WITH CAT. NO. VBA, VFPS ADAPTER MOUNTING PLATES OR VFL BRACKET MOUNT ADAPTER.
REFLECTORS ARE NOT FOR USE WITH VD-4 SPLICE BOX.
SUITABLE FOR ENCLOSURE TYPE 3 & 4 WHEN USED WITH VCGP-100 OR VCGP-200 HEAT-RESISTANT GLOBE.

REMEMBER TO SAVE ONE OF THESE SHEETS FOR MAINTENANCE PERSONNEL

THE NEW YORK BLOWER COMPANY
7660 Quincy Street
Willowbrook, IL 60527-5530
Visit us on the Web: http://www.nyb.com
Phone: (800) 208-7918 Email: nyb@nyb.com

INSTALLATION MAINTENANCE, OPERATING INSTRUCTIONS

IM-200

BELT AND DIRECT DRIVE PROPELLER FANS

A WORD ABOUT SAFETY

Air moving equipment involves electrical wiring, moving parts, sound, and air velocity or pressure which can create safety hazards if the equipment is not properly installed, operated and maintained. To minimize this danger, follow these instructions as well as the additional instructions and warnings on the equipment itself.

All installers, operators and maintenance personnel should study AMCA Publication 410, "Recommended Safety Practices for Air Moving Devices", which is included as part of every shipment. Additional copies can be obtained by writing to New York Blower Company, 7660 Quincy St., Willowbrook, IL 60527.

ELECTRICAL DISCONNECTS

Every motor driven fan should have an independent disconnect switch to isolate the unit from the electrical supply. It should be near the fan and must be capable of being locked by maintenance personnel while servicing the unit, in accordance with OSHA procedures.

MOVING PARTS

All moving parts must have guards to protect personnel. Safety requirements vary, so the number and type of guards needed to meet company, local and OSHA standards must be determined and specified by the user. Never start a fan without having all safety guards installed. Check regularly for damaged or missing guards and do not operate any fan with guards removed. Fans can also become dangerous because of potential “windmilling”, even though all electrical power is disconnected. Always block the rotating assembly before working on any moving parts.

SOUND

Some fans can generate sound that could be hazardous to exposed personnel. It is the responsibility of the system designer and user to determine sound levels of the system, the degree of personnel exposure, and to comply with applicable safety requirements to protect personnel from excessive noise. Consult **nyb** for fan sound power level ratings.

AIR PRESSURE AND SUCTION

In addition to the normal dangers of rotating machinery, fans present another hazard from the suction created at the fan inlet. This suction can draw materials into the fan where they become high velocity projectiles at the outlet. It can also be extremely dangerous to persons in close proximity to the inlet, as the forces involved can overcome the strength of most individuals. Inlets and outlets that are not ducted should be screened to pre-vent entry and discharge of solid objects.

RECEIVING AND INSPECTION

The fan and accessories should be inspected on receipt for any shipping damage. Turn the propeller by hand to see that it rotates freely and does not bind. If shutters are provided, check these accessories for free operation of all moving parts.

F.O.B. factory shipping terms require that the receiver be responsible for inspecting the equipment upon arrival. Note damage or shortages on the Bill of Lading and file any claims for damage or loss in transit. **nyb** will assist the customer as much as possible; however, claims must be originated at the point of delivery.

HANDLING AND STORAGE

Fans should be lifted by the panel mounting flanges only. Never lift a fan by the propeller, shaft, motor, motor bracket, panel inlet or any fan part not designed for lifting. A spreader should be used to avoid damage.

Whenever possible, fans and accessories should be stored in a clean, dry location to prevent rust and corrosion of steel components. If outdoor storage is necessary, protection should be provided. The fan should be covered to prevent the accumulation of dirt and moisture. Cover motors with waterproof material. Refer to the bearing section for further storage instructions.

Check shutters for free operation and lubricate moving parts prior to storage. Inspect the stored unit periodically. **Rotate the propeller by hand every two weeks to redistribute grease on internal bearing parts.**

FAN INSTALLATION

nyb propellers are dynamically balanced when fabricated. Complete fans are test run at operating speeds to check the entire assembly for conformance to **nyb** vibration limits. Nevertheless, all units must be adequately supported for smooth operation.

Rough-in wall opening of sufficient size so that, when framed in, the finished opening will accept the fan. It is preferable to frame in the opening with 2 x 6 material, or other similar suitable material or metal channels adequate to support the fan as shown in Figure 1. Slide the fan into the framed opening in the wall. Securely fasten with bolts or screws around the fan panel. A distance of at least one and one-half times the diameter of the fan should be allowed between the fan inlet or discharge opening and any adjacent wall or large obstruction. Additional framing may be necessary for optional shutters.

If shutters are used, they should be mounted in such a way that the blades are in a horizontal position and overlap like shingles on the side exposed to the weather. The motor on motorized shutters and the tie rods on automatic shutters should face the inside. To install, butt the shutter flange up to the wooden frame on the outside of the wall and secure it with lag screws. Do not bend or twist the shutter frame when tightening the screws. Once the shutter is installed, be certain that the blades open and close freely.

If the shutter is motorized, wire the motor. **When supply type fans are used with motorized shutters, it is necessary that a time delay switch be used between the power source and the fan motor to provide time for the shutter to open fully before the fan is activated.**

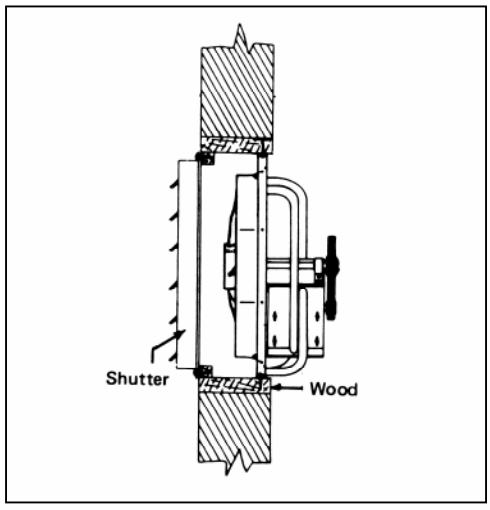


Figure 1

V-BELT DRIVE Installation (Bare Fans/Replacement)

1. Remove all foreign material from the fan and motor shafts. Coat shafts with machine oil for easier mounting.

2. Mount sheaves on shafts after checking sheave bores and bushings for nicks or burrs. Avoid using force. If resistance is encountered, lightly polish the shaft with emery cloth until the sheave slides on freely.

3. Adjust the motor on its base to a position closest to the fan shaft. Install belts by working each one over the sheave grooves until all are in position. Never pry the belts into place. Sufficient motor adjustment is provided for easy installation of the proper size belts.

4. Adjust sheaves and the motor shaft angle so that the sheave faces are in the same plane. Check this by placing a straightedge across the faces of the sheaves. Any gap between the edge and sheave faces indicates misalignment. Important: This method is only valid when the width of the surface between the belt edge and the sheave face is the same for both sheaves. When they are not equal, or when using adjustable-pitch sheaves, adjust so that all belts have approximately equal tension. Both shafts should be at right angles to the center belt.

Belt Tensioning

1. Check belt tension with a tensioning gage and adjust using the motor slide base. Insufficient tension shortens belt life, can reduce fan performance and may cause vibration. Excess tension shortens bearing life. The lowest allowable tension is that which prevents slippage under full load. Belts may slip during start-up, but slipping should stop as soon as the fan reaches full speed. For more precise tensioning methods, consult the drive manufacturer's literature.

2. Recheck setscrews, rotate the drive by hand and check for rubbing, then complete the installation of optional guards.

3. Belts tend to strecth somewhat after installation. Recheck tension after several days of operation. Check sheave alignment, as well as setscrew and/or bushing bolt tightness.

START-UP

Safe operation and maintenance includes the selection and use of appropriate safety accessories for the specific installation. This is the responsibility of the system designer and requires consideration of equipment location and accessibility as well as adjacent components. All safety accessories must be installed properly prior to start-up.

Safe operating speed is a function of system temperature and propeller design. Do not under any circumstances exceed the maximum safe fan speed published in the **nyb** bulletin, which is available from your **nyb** field sales representative.

Procedure

1. If the drive components are not supplied by **nyb,** verify with the manufacturer that the starting torque is adequate for the speed and inertia of the fan.

2. Inspect the installation prior to starting the fan. Check for any loose items or debris that could be drawn into the fan or dislodged by the fan discharge. Turn the propeller by hand to check for binding.

3. Check drive installation and belt tension.

4. Check the tightness of all setscrews, nuts and bolts. When furnished, tighten hub setscrews with the propeller oriented such that the setscrew is positioned underneath the shaft.

5. Install all remaining safety devices and guards. Verify that the supply voltage is correct and wire the motor. “Bump” the starter to check for proper propeller rotation.

6. Setscrews should be rechecked after a few minutes, eight hours and two weeks of operation (see Table 1 for correct tightening torques).

NOTE: Shut the fan down immediately if there is any sudden increase in fan vibration.

WHEEL SETSCREW TORQUES

Setscrew Diameter (in.)	Carbon Steel Setscrew Torque	
	lb. - in.	lb. - ft.
1/4	75	6.2
5/16	144	12
3/8	252	21
7/16	393	33
1/2	600	50

FAN MAINTENANCE

nyb fans are manufactured to high standards with quality materials and components. Proper maintenance will ensure a long and trouble-free service life.

Do not attempt any maintenance on a fan unless the electrical supply has been completely disconnected and locked. In many cases, a fan can windmill despite removal of all electrical power. The rotating assembly should be blocked securely before attempting maintenance of any kind.

The key to good fan maintenance is regular and systematic inspection of all fan parts. Inspection frequency is determined by the severity of the application and local conditions. Strict adherence to an inspection schedule is essential.

Regular fan maintenance should include the following:

1. Check the fan propeller for any wear or corrosion, as either can cause catastrophic failures. Check also for the build-up of material which can cause imbalance resulting in vibration, bearing wear and serious safety hazards. Clean or replace the propeller as required.

2. Check the V-belt drive for proper alignment and tension (see section on V-belt drives). If belts are worn, replace them as a set, matched to within manufacturer’s tolerances.

3. Fans with standard captured bearings in formed housing require no service.

4. During any routine maintenance, all setscrews and bolts should be checked for tightness. See the table for correct torques.

5. When installing a new propeller, the propeller should be positioned in the housing with even spacing between the edge of the orifice and the propeller.

PROPELLER BALANCE

Airstreams containing particulate or chemicals can cause abrasion or corrosion of fan parts. This wear is often uneven and can lead to significant propeller imbalance over time. When such wear is discovered, a decision must be made to rebalance or replace the propeller.

The soundness of all parts should be determined if the original thickness of components is reduced. Be sure there is no hidden structural damage. The airstream components should also be cleaned to remove any build-up of foreign material. Specialized equipment can be used to rebalance a cleaned propeller that is considered structurally sound.

Balance weights should be rigidly attached at a point that will not interfere with other fan components nor disrupt airflow. Remember that centrifugal forces can be extremely high at the outer radius of a fan propeller.

BEARINGS

Storage

Any stored bearing can be damaged by condensation caused by temperature variations. Therefore, **nyb** fan bearings are filled with grease at the factory to exclude air and moisture. Such protection is adequate for shipment and subsequent immediate installation.

For long term or outdoor storage, mounted bearings should be regreased and wrapped with plastic for protection. **Rotate the fan propeller by hand at least every two weeks to redistribute grease on internal bearing parts.**

Operation

Check the setscrew torque before start-up (see table for correct values). Since bearings are completely filled with grease at the factory, they may run at an elevated temperature during initial operation. Surface temperatures may reach 180°F. This is normal. Bearing surface temperatures will decrease when the internal grease quantity reaches a normal operating level.

Replacement

If captured bearings need replacement, install new bearings into neoprene rings, check correct position of propeller with orifice, position bearings in die-formed recess and tighten setscrews. Replace die-formed bearing cap and tighten four bolts.

COMMON FAN PROBLEMS

Excessive Vibration

A common complaint regarding industrial fans is “excessive vibration”. **nyb** is careful to ensure that each unit is precisely balanced prior to shipment; however, there are many other causes of vibration including:

1. Loose mounting bolts, setscrews, or bearings.
2. Misalignment or excessive wear of bearings.
3. Misaligned or unbalanced motor.
4. Bent shaft due to mishandling or material impact.
5. Accumulation of foreign material on the propeller.
6. Excessive wear or erosion of the propeller.
7. Excessive system pressure or restriction of airflow due to closed shutters.
8. Inadequate structural support, mounting procedures or materials.
9. Externally transmitted vibration.

Inadequate Performance

1. Incorrect testing procedures or calculations.
2. Fan running too slowly.
3. Propeller rotating in wrong direction.
4. Propeller not properly centered relative orifice.
5. Poor system design or closed shutters.
6. Obstruction near inlet or outlet.
7. Sharp deflection of airstream at fan inlet or outlet.

Excessive Noise

1. Fan operating near “stall” due to incorrect system design or installation.
2. Vibration originating elsewhere in the system.
3. System resonance or pulsation.
4. Improper location or orientation of fan intake and discharge.
5. Inadequate or faulty design of supporting structures.
6. Nearby sound reflecting surfaces.
7. Loose accessories or components.
8. Loose drive belts.
9. Worn bearings.

Premature Component Failure

1. Prolonged or major vibration.
2. Inadequate or improper maintenance.
3. Abrasive or corrosive elements in the airstream or surrounding environment.
4. Misalignment or physical damage to rotating components or bearings.
5. Bearing failure from incorrect or contaminated lubricant.
6. Excessive fan speed.
7. Extreme ambient or airstream temperatures.
8. Improper belt tension.
9. Improper tightening of propeller setscrews.

REPLACEMENT PARTS

It is recommended that only factory-supplied replacement parts be used. **nyb** fan parts are built to be fully compatible with the original fan, using specific alloys and tolerances. These parts carry a standard **nyb** warranty.

When ordering replacement parts, specify the part name, **nyb** shop and control number, fan size, type, arrangement, and bore. Most of this information is on the nameplate attached to the fan.

For assistance in selecting replacement parts, contact your local **nyb** representative or visit: http://www.nyb.com.

Example: Part required: Propeller
Shop/control number: B-10106-100
Fan description: ED30

Suggested replacement parts include:

Propeller	Component parts: Shutter
Shaft	Motor
Bearing Assembly	V-Belts

LIMITED PRODUCT WARRANTY

All products are warranted by **nyb** to be free from defects in materials and workmanship for a period of one (1) year after shipment from its plant, provided buyer demonstrates to satisfaction of **nyb** that the product was properly installed and maintained in accordance with **nyb**'s instructions and recommendations and that it was used under normal operating conditions.

This warranty is limited to the replacing and/or repairing by **nyb** of any part or parts which have been returned to **nyb** with **nyb**'s written authorization and which in **nyb**'s opinion are defective. Parts not manufactured by **nyb** but installed by **nyb** in equipment sold to the buyer shall carry the original manufacturer’s warranty only. All transportation charges and any and all sales and use taxes, duties, imports or excises for such part or parts shall be paid for by the buyer. **nyb** shall have the sole right to determine whether defective parts shall be repaired or replaced.

This warranty does not cover any customer labor charges for replacement of parts, adjustments or repairs, or any other work unless such charges shall be assumed or authorized in advance, in writing, by **nyb.**

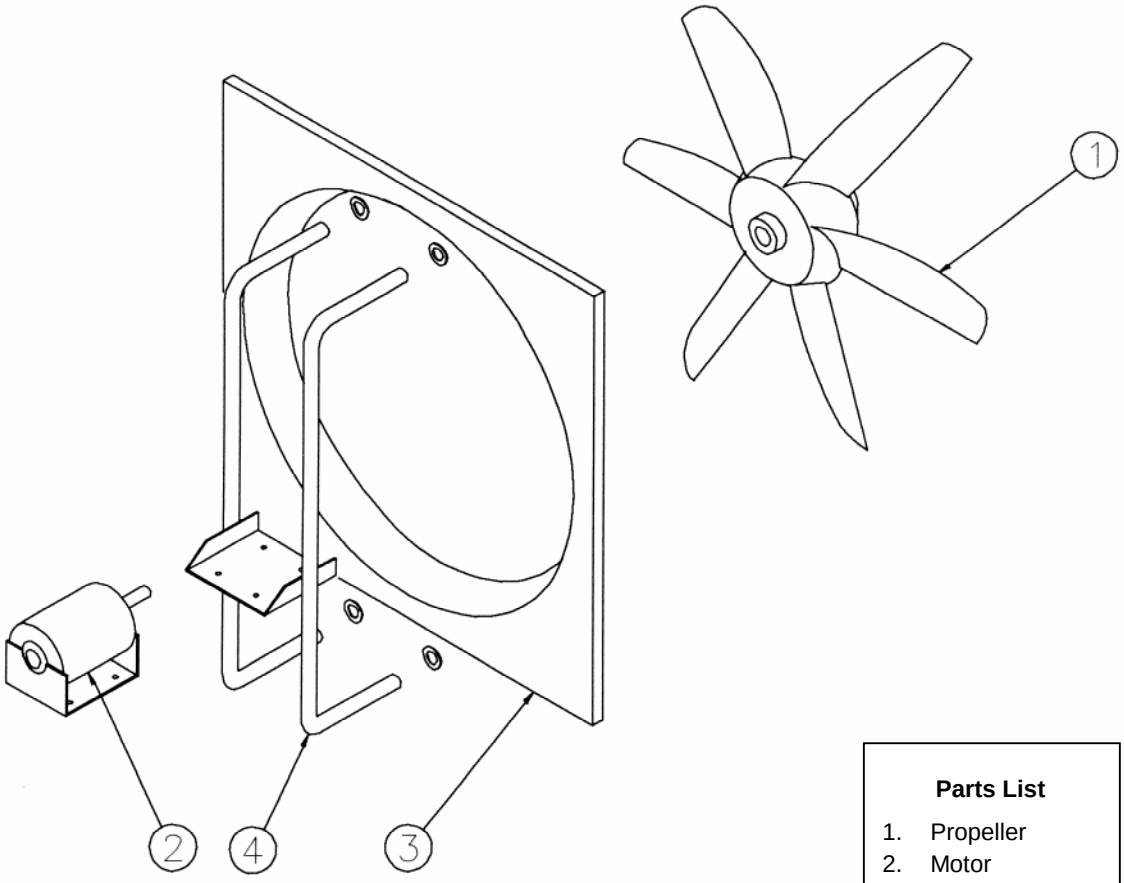
This warranty does not cover any product which, in the judgement of **nyb,** has been subject to misuse or neglect, or which has been repaired or altered outside **nyb**'s plant in any way which may have impaired its safety, operation or efficiency, or any product which has been subject to accident.

This warranty shall be null and void if any part not manufactured or supplied by **nyb** for use in any of its products shall have been substituted and used in place of a part manufactured or supplied by **nyb** for such use.

There are no warranties, other than those appearing on the acknowledgement form **INCLUDING NO WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE,** given in connection with the sale of the goods sold hereunder. The buyer agrees that his sole and exclusive remedy, and the limit of **nyb**'s liability for loss from any cause whatsoever, shall be the purchase price of the goods sold hereunder for which a claim is made.

The New York Blower Company 7660 Quincy Street Willowbrook, Illinois 60527-5530

DIRECT DRIVE
MODEL F
PROPELLER FAN

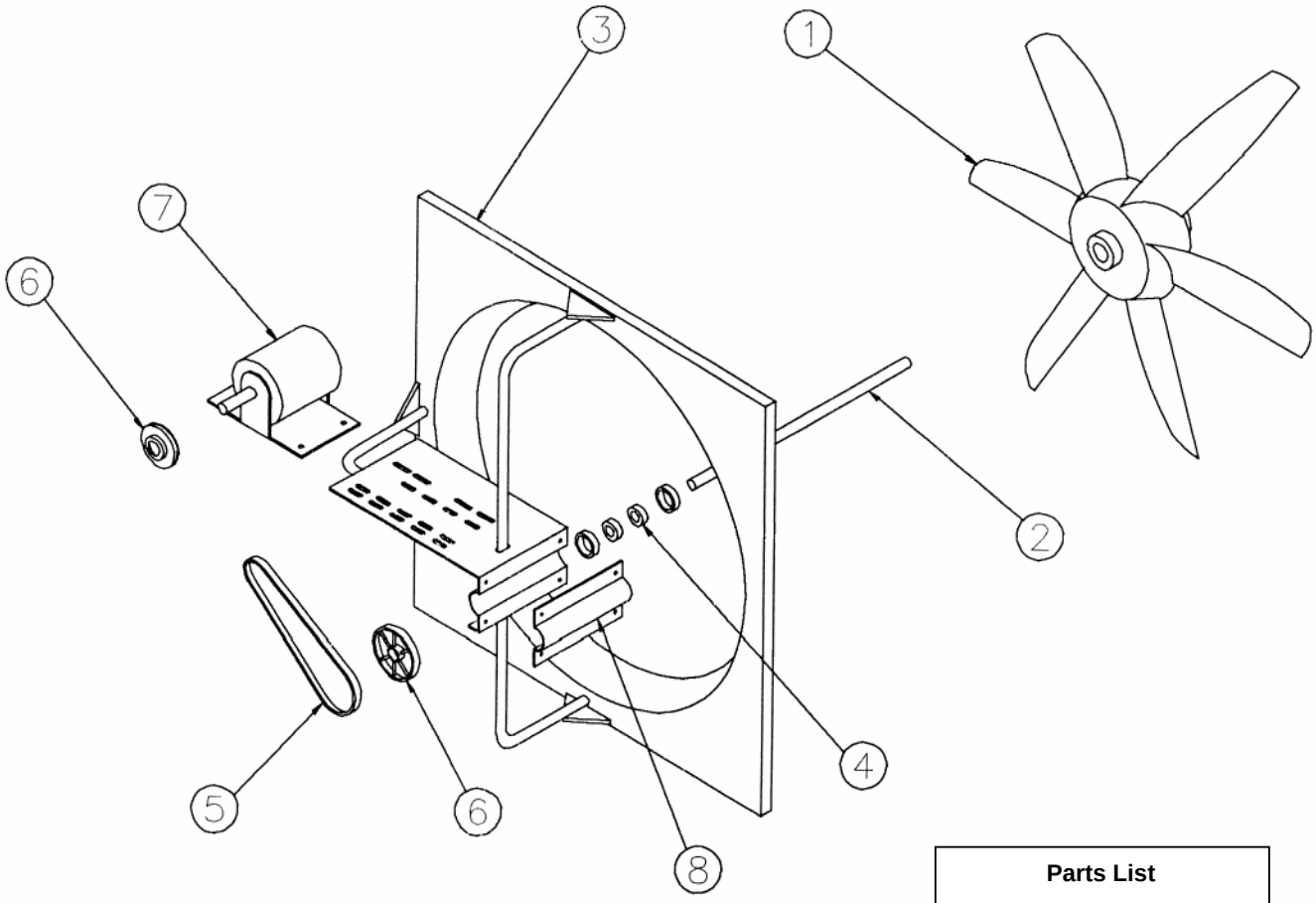


Parts List

1. Propeller
2. Motor
3. Fan Panel
4. Fan Frame

For assistance in selecting replacement parts, contact your local **nyb** representative or visit: http://www.nyb.com.

BELT DRIVE
MODEL D
PROPELLER FAN



Parts List

1. Propeller
2. Shaft
3. Fan Frame
4. Bearings
5. Belt
6. Sheaves
7. Motor
8. Bearing Cap

For assistance in selecting replacement parts, contact your local **nyb** representative or visit: http://www.nyb.com.

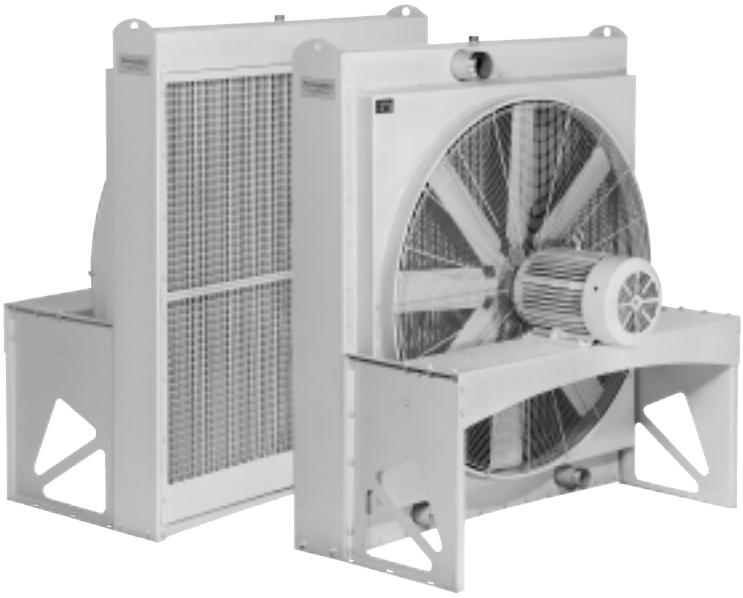
American Industrial Heat Transfer Inc.®

Manufacturers of Quality Heat Exchangers

Visit our web site at
www.aihti.com

INSTALLATION & MAINTENANCE MANUAL
2001

Shell & Tube Heat Exchangers



Air Cooled Heat Exchangers

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SHELL & TUBE HEAT EXCHANGERS STANDARD FEATURES

1- MOUNTING BRACKET
Heavy gauge steel mounting brackets are adjustable in orientations to 360 degrees.

2- BONNET
Provides fluid into tubes with minimum restriction. One, two, or four pass interchangeability.

3- FLOW CAVITY
Generously sized to allow for minimum pressure drop and more uniform flow.

4- TUBES JOINT
Roller expanded tube joint to integral forged hub.

5- TUBES SHEET
Precision-machined tube-sheet provides for long lasting high strenght service.

6- THREAD
CNC precision threading to provide accurate leakproof connections.

7- BAFFLES
CNC manufactured baffles to provide maximum turbulence and heat transfer with a minimum fluid pressure drop.

8- FINISH
Gray semigloss enamel suitable for outdoor service. Can be used as a base for additional coats.

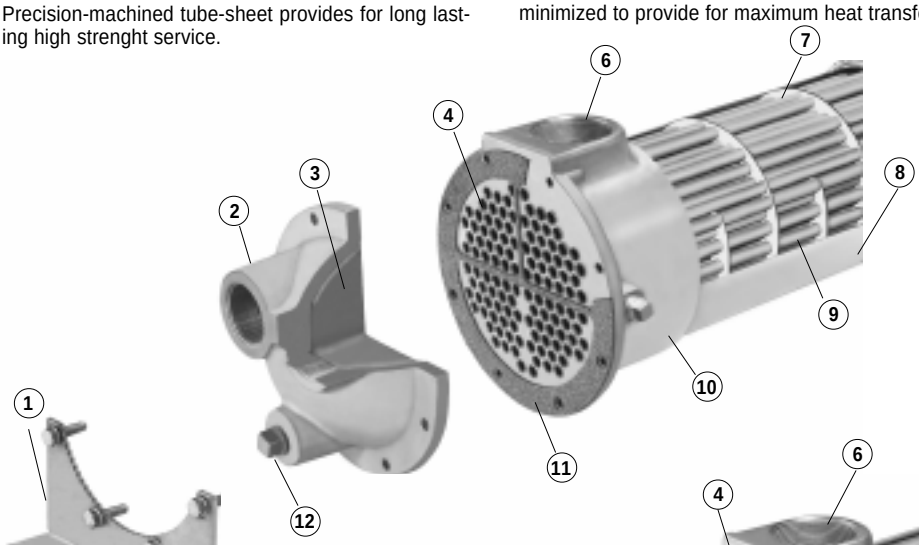
9- SHELL & TUBE BUNDLE ASSEMBLY
CNC precision manufactured parts to guarantee a close fit between the baffles, tubes, and shell. Clearances are minimized to provide for maximum heat transfer.

10- HUB
Premium quality forging with full opening designed for minimum pressure drop.

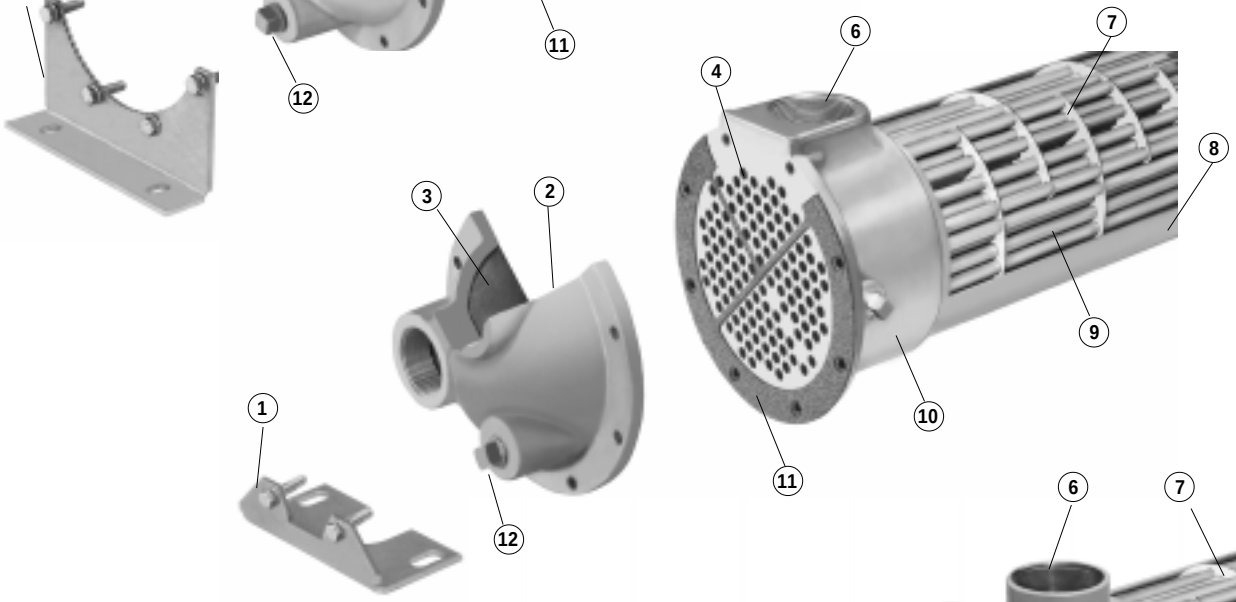
11- FULL FACE GASKET
Full-face composite gasket for maximum pressure and temperature.

12- DRAIN PORT
Drain ports allow for easy draining of tube side. Optional zinc anode can be inserted in place of plug.

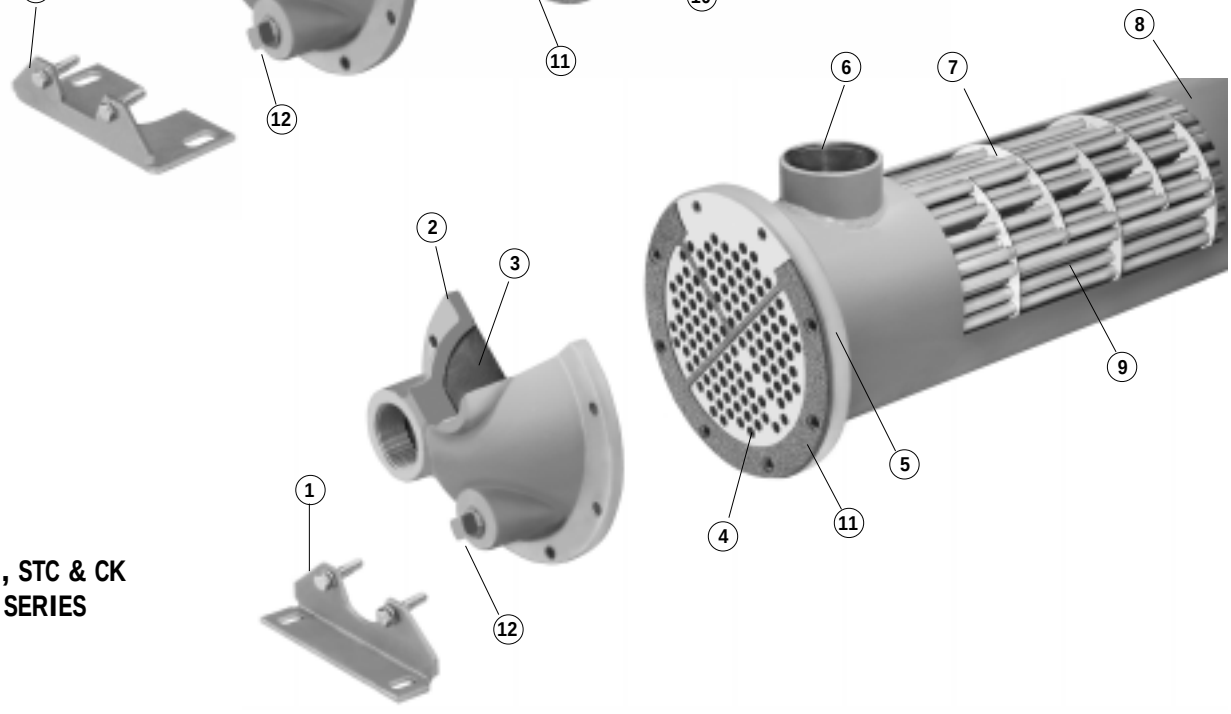
Note: Standard Feature descriptions are qualified by and subject to product specifications which are available from American Industrial upon request.



AB , AB-2000, SAE, STS & EAB SERIES



AA , STA & FBF SERIES



CS , STC & CK SERIES

Receiving

a) Inspect unit for any shipping damage before uncrating. Indicate all damages to the trucking firms' delivery person, and mark it on the receiving bill before accepting the freight. Make sure that there is no visible damage to the outside surface of the heat exchanger. *Since the warranty is based upon the unit date code located on the model identification tag, removal or manipulation of the identification tag will void the manufacturers warranty.*

b) When handling the shell & tube heat exchanger, special care should be taken to avoid dropping the unit since mishandling could cause the heat exchanger to crack and leak externally. Mishandling of the unit is not covered under the manufacturers warranty. All units are shipped with partial wood/corrugated cardboard containers for safe handling.

c) Standard Enamel Coating: American Industrial provides its standard products with a normal base coat of oil base air cure enamel paint. The enamel paint is applied as a temporary protective and esthetic coating prior to shipment. While the standard enamel coating is durable, American Industrial does not warranty it as a long-term finish coating. It is strongly suggested that a more durable final coating be applied after installation or prior to long-term storage in a corrosive environment to cover any accidental scratches, enhance esthetics, and further prevent corrosion. It is the responsibility of the customer to provide regular maintenance against chips, scratches, etc... and regular touch up maintenance must be provided for long-term benefits and corrosion prevention.

d) Special Coatings: American Industrial offers as customer options, Air-Dry Epoxy, and Heresite (Air-Dry Phenolic) coatings at additional cost. American Industrial offers special coatings upon request, however American Industrial does not warrantee coatings to be a permanent solution for any equipment against corrosion. It is the responsibility of the customer to provide regular maintenance against chips, scratches, etc... and regular touch up maintenance must be provided for long-term benefits and corrosion prevention.

Installation

a) American Industrial recommends that the equipment supplied should be installed by qualified personnel who have solid understanding of system design, pressure and temperature ratings, and piping assembly. Verify the service conditions of the system prior to applying any shell & tube heat exchanger. If the system pressure or temperature does not fall within the parameters on model rating tag located on the heat exchanger, contact our factory prior to installation or operation.

b) Plan the installation to meet the requirements indicated on the piping installation diagram as illustrated (page 4). It is recommended to put the hot fluid to be cooled through the shell side and the cold fluid through the tube side. The indicated port assembly sequence in the diagram maximizes the performance, and minimizes the possibility of thermal shock. In instances where the fluids are required to be reversed, *hot fluid in the tubes and cold fluid in the shell* the heat exchanger will work with reduced performance.

c) When installing a series EAB heat exchanger (expansion below), it is recommended to use a shoulder bolt to allow the heat exchanger to move freely while expanding and contracting due to high differential temperatures.

d) It is recommended to use flexible hose wherever possible to reduce vibration and allow slight movement. However, hoses are not required. Hydraulic carrying lines should be sized to handle the appropriate flow and to meet system pressure drop requirements based upon the systems parameters, and not based upon the units supply and return connection size. We recommend that a low cracking pressure direct acting relief valve be installed at the heat exchanger inlet to protect it from pressure spikes by bypassing oil in the event the system experiences a high flow surge. If preventative filtration is used it should be located ahead of the cooler on both shell and tube side to catch any scale or sludge for the system before it enters the cooler. Failure to install filters ahead of the heat exchanger could lead to possible heat exchanger failure due to high pressure if the system filters plug.

e) Standard shell & tube coolers are built with a rolled tube-sheet construction. However, the differential operating temperature between the entering shell side fluid and the entering tube side fluid should not exceed 150°F. If this condition exists, a severe thermal shock could occur leading to product failure and mixing of the fluids. For applications with a differential temperatures of 150°F or more, we recommend using a series with a floating tube-sheet, u-tube, or expansion joint to reduce the potential for the effects of thermal shock.

g) Water requirements vary from location to location. If the source of cooling water is from other than a municipal water supply, it is recommended that a water strainer be installed ahead of the heat exchanger to prevent dirt and debris from entering and clogging the flow passages. If a water modulating valve is used it is recommended to be installed at the inlet to the cooler to regulate the water flow.

h) For steam service, or other related applications, please consult our engineering department for additional information.

Maintenance

a) Inspect the heat exchanger for loosened bolts, connections, rust spots, corrosion, and for internal or external fluid leakage. Any corroded surfaces should be cleaned and recoated with paint.

b) *Shell side:* In many cases with clean hydraulic system oils it will not be necessary to flush the interior of the shell side of the cooler. In circumstances where the quality of hydraulic fluid is in question, the shell side should be disconnected and flushed on a yearly basis with a clean flushing oil/solvent to remove any sludge that has been deposited. For severe cases where the unit is plugged and cannot be flushed clean with solvent, the heat exchanger should be replaced to maintain the proper cooling performance.

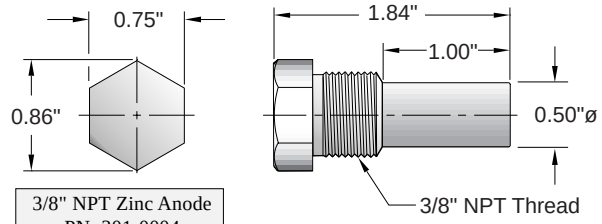
c) *Tube side:* In many cases it will be necessary to clean the tube side of the heat exchanger due to poor fluid quality, debris, calcium deposits, corrosion, mud, sludge, seaweed, etc.... To clean

the tube side, flush with clean water or any good quality commercial cleaner that does not attack the particular material of construction. With straight tube heat exchangers you can use a rod to carefully push any debris out of the tubes.

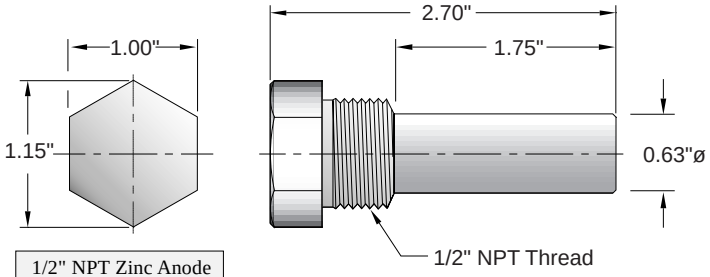
d) Zinc anodes are normally used to reduce the risk of failure due to electrolysis. Zinc anodes are a sacrificial component designed to wear and dissolve through normal use. Normally, zinc anodes are applied to the water supply side of the heat exchanger. Depending upon the amount of corrosive action, one, two, three, or more anodes can be applied to help further reduce the risk of failure. American Industrial Heat Transfer, Inc. offers zinc anodes as an option, to be specified and installed at the request our customers. It is the responsibility of the customer to periodically check and verify the condition of the zinc anode and replace it as needed.

Applications vary due to water chemical makeup and quality, material differences, temperature, flow rate, piping arrangements, and machine grounding. For those reasons, zinc anodes do not follow any scheduled factory predetermined maintenance plan moreover they must be checked routinely by the customer, and a maintenance plan developed based upon the actual wear rate.

If substantial wear occurs or zinc dissolves without replacement, premature failure or permanent damage may occur to the heat exchanger. American Industrial does not warranty customer applications. It is the responsibility of the customer to verify and apply the proper system materials of construction and overall system requirements. Failures resulting from properly applied or misapplied use of zinc anode(s) into non-specified or specified applications will be the sole responsibility of the customer.



3/8" NPT Zinc Anode PN: 301-0004
AB-400 thru AB-1000 AA-400 thru AA-1000 CS-600 thru CS-1000



1/2" NPT Zinc Anode PN: 301-0003
AB-1200 thru AB-2000 AA-1200 thru AA-1600 CS-1200 thru CS-1700

e) A routine maintenance schedule should be developed and adjusted to meet your systems requirements based upon water quality, etc….Failure to regularly maintain and clean your heat exchanger can result in a reduction in operational performance and life expectancy.

TUBE SIDE PASSES

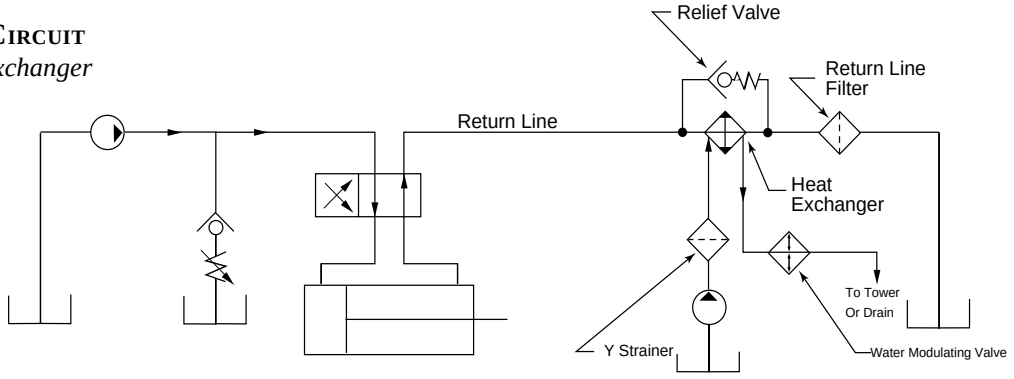
The number of passes (SP,TP &FP) refers to the number of runs back and forth of the cooling fluid on the tube side of the heat exchanger. Tube passes are normally determined by the rate (gpm) of water available to be used for cooling purposes *(see table E)*. The purpose of multi-passes are to increase turbulence by increasing the velocity. ***Normally tube side passes will not affect pricing.***

TABLE E- *Flow Rate for Tube Side*

Shell dia . Code	Liquid Flow - Tube Side					
	SP		TP		FP	
	Min.	Max.	Min.	Max.	Min.	Max.
400	3.5	21	—	—	—	—
600	7.5	48	3.5	24	2	12
700	9	61	4.5	30	2.2	15
800	10	50	4.5	38	3	21
1000	20	120	10	70	5.0	37
1200	30	250	15	112	7.5	56
1600	57	460	29	180	14	90
1700	57	300	29	180	14	90
2000	90	650	45	320	25	160

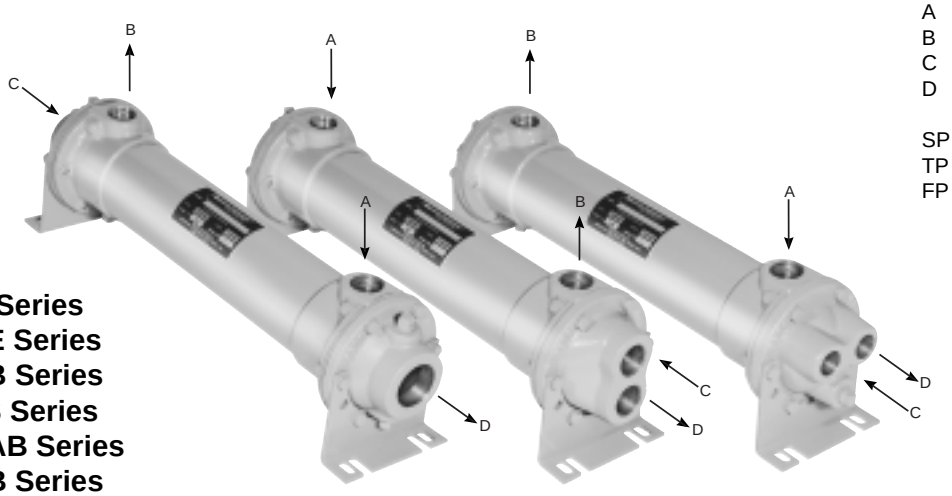
TYPICAL HYDRAULIC CIRCUIT

with water cooled heat exchanger



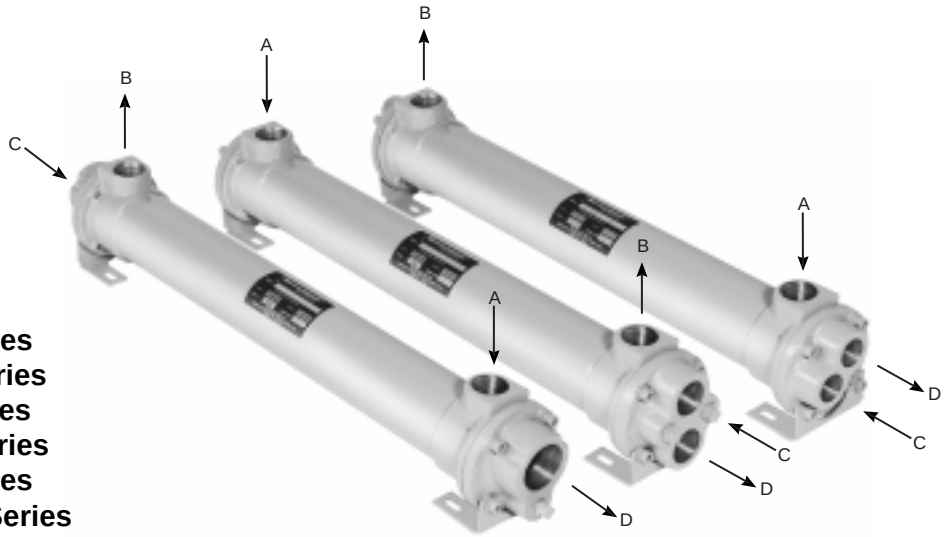
A ..... Hot fluid to be cooled
B ..... Cooled fluid
C ..... Cooling water in
D ..... Cooling water out

SP ..... Single Pass
TP ..... Two Pass
FP ..... Four Pass



AB Series
SAE Series
EAB Series
STS Series
SRAB Series
UAB Series
URAB Series

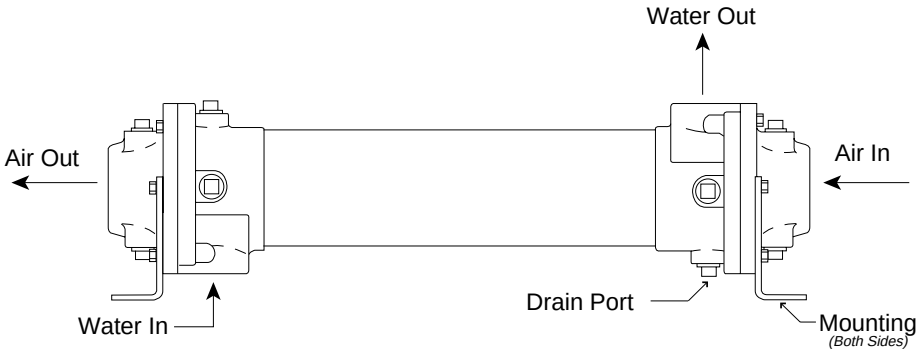
ONE PASS **TWO PASS** **FOUR PASS**



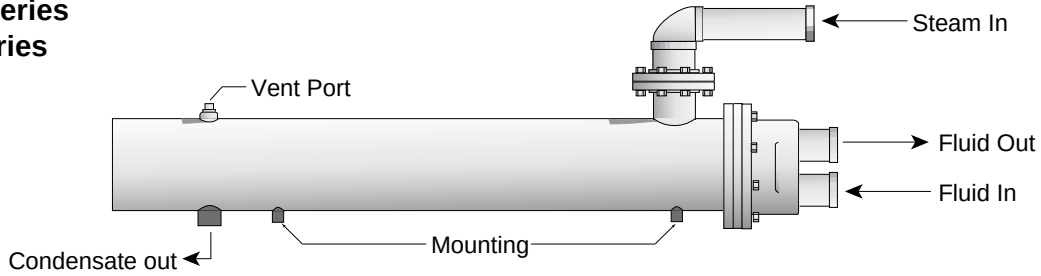
AA Series
STA Series
CS Series
STC Series
CK Series
SRCS Series
URCS Series

ONE PASS **TWO PASS** **FOUR PASS**

ABR Series



URCSR Series
UCSR Series

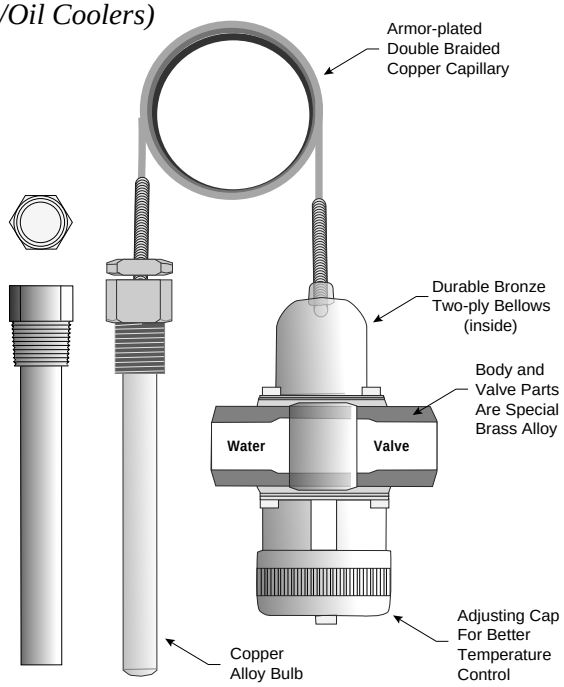


THERMOSTATIC MODULATING WATER VALVE WITH BULB WELL ASSEMBLY

(for Shell & Tube Heat Exchangers And Air/Oil Coolers)

SPECIFICATIONS

Sizes	0.375", 0.50", 0.75", 1.00", 1.25" FPT
Fluid Pressure	125psi (max.)
Standard Temperature	40° - 100° F., 60° - 140° F., 100° - 175° F., 125° - 200° F., 140° - 240° F., 200° - 275°F.
Body	Brass alloy casting
Valve Parts	Brass alloy
Standard Capillary Length	6' & 20' foot
Standard Bulbs	For 3/8" & 1/2" valve sizes: 5/8" x 6 with 3/4" union connections. For 3/4" & 1" valve sizes: 5/8" x 8-1/4" with 3/4" union connections. Stainless steel construction available.
Standard Bulb Mounting	3/4" NPT
Seat Disk	Buna-N-replaceable
Seat Bead	Stainless Steel - replaceable



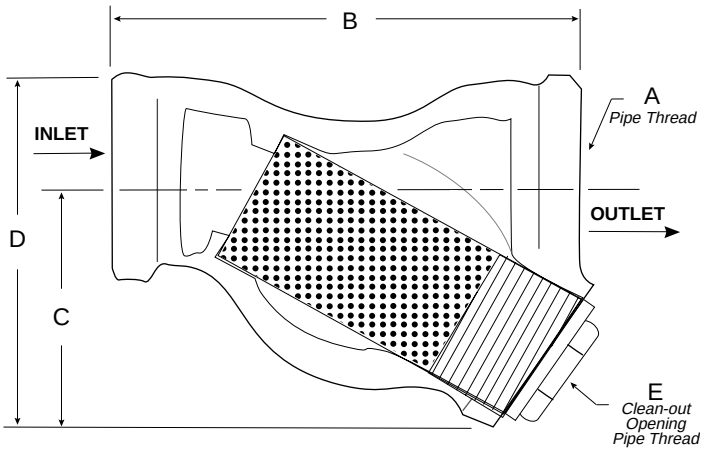
APPLICATION INFORMATION

- Built for machine tool and hydraulic applications.
- Adjustable temperature range.
- Response to temperature changes.
- Direct acting bellows for longer service.

Note: Please consult factory if a non-cataloged temperature is required.

The type 56-T valve gives smooth regulation of water and other fluids. It's designed for rugged application. For example: hydraulic power packaging equipment, hydraulic presses, plastic molding equipment, and anywhere reliability in temperature control is demanded.
The type 56-T valve is a better designed product that won't leak or chatter. For dependability, every valve is factory tested three times in different temperature baths. They are direct acting with sturdy walls, and the inner spring is zinc coated. The seat beads are stainless steel to resist the erosive effects of *wire drawing* and provide durability for your needs. Additional features include mounting in any position, Buna-N seat disc, and manual flushing.

"Y" STRAINER *(for Shell & Tube Heat Exchangers And Air/Oil Coolers)*



MODEL	SIZE A (NPT)	DIMENSIONS (Inches) B	C	D	E (NPT)	WT. (lbs.)
18 - Y	0.38"	2.50"	2.63"	2.00"	0.25"	0.75
	0.50"	2.50"	2.63"	2.00"	0.25"	0.75
	0.75"	3.50"	3.75"	2.75"	0.50"	1.75
	1.00"	3.50"	3.75"	2.75"	0.50"	1.75
20 - Y	0.50"	4.00"	3.25"	2.50"	0.38"	1.75
	0.75"	4.00"	3.25"	2.50"	0.38"	1.75
	1.00"	4.75"	4.38"	3.38"	0.75"	4.00
	1.25"	6.00"	5.13"	3.88"	0.75"	4.75
	1.50"	6.00"	5.13"	3.88"	0.75"	4.75
	2.00"	8.13"	6.38"	4.63"	0.75"	13.00
PRESSURE RATINGS, ALL MODELS: 125lbs. per Sq.In.						

APPLICATIONS & SPECS. ("Y" Strainers)

These strainers are engineered for water or steam, and are adaptable for many other uses. Cleaning is accomplished by simply removing a pipe plug without disconnecting any piping. Or, if it is desirable to clean without interrupting service, a blow-off valve can be connected to the clean-out opening. ***Note:*** Pumps, control valves, traps, or other equipment controlling the flow of liquids or gases require proper protection with strainers for trouble free operation.

18 - Y BRASS STRAINERS

The 18 - Y strainer body is a red brass casting. Standard units have 50 mesh brass wire screens. Brazing connections are available on special order instead of pipe threads.

20 - Y STRAINERS

The 20 - Y strainer has a heavy cast iron body with machined pipe thread inlet and outlet (National Pipe Thread N.P.T.). It contains a strainer screen of 0.02" thick brass with 100, 1/16" perforations per inch.

Receiving:
a) Inspect unit for any shipping damage before uncrating. Indicate all damages to the trucking firms' delivery person and mark it on the receiving bill before accepting the freight. Make sure that the core and fan are not damaged. Rotate the fan blade to make sure that it moves freely. *Since the warranty is based upon the unit date code located on the model identification tag, removal or manipulation of the identification tag will void the manufacturers warranty.*

b) When handling the heat exchanger, special care should be taken to avoid damage to the core and fan. All units are shipped with wood skids for easy forklift handling

c) Standard Enamel Coating: American Industrial provides its standard products with a normal base coat of oil base air cure enamel paint. The enamel paint is applied as a temporary protective and esthetic coating prior to shipment. While the standard enamel coating is durable, American Industrial does not warranty it as a long-term finish coating. It is strongly suggested that a more durable final coating be applied after installation or prior to long-term storage in a corrosive environment to cover any accidental scratches, enhance esthetics, and further prevent corrosion. It is the responsibility of the customer to provide regular maintenance against chips, scratches, etc... and regular touch up maintenance must be provided for long-term benefits and corrosion prevention.

d) Special Coatings: American Industrial offers as customer options, Air-Dry Epoxy, and Heresite (Air-Dry Phenolic) coatings at additional cost. American Industrial offers special coatings upon request, however American Industrial does not warranty coatings to be a permanent solution for any equipment against corrosion. It is the responsibility of the customer to provide regular maintenance against chips, scratches, etc... and regular touch up maintenance must be provided for long-term benefits and corrosion prevention.

Installation:
a) American Industrial recommends that the equipment supplied should be installed by qualified personnel who have solid understanding of system design, pressure and temperature ratings, and piping assembly. Verify the service conditions of the system prior to applying any air cooled heat exchanger series cooler. If the system pressure or temperature does not fall within the parameters on model rating tag located on the heat exchanger, contact our factory prior to installation or operation.

b) In order for the heat exchanger to properly function, installation should be made with minimum airflow obstruction distance of not less than twenty (20) inches on both fan intake and exiting side of the heat exchanger.

c) Process piping should beinstalled as indicated on the model diagram, with the process flow entering into the INLET port and exiting out the OUTLET port (see illustrations pages 9-10). Flexible hose or non rigid plumbing can be used to reduce the risk of failure due to thermal expansion of the core or hydraulic vibration. We suggest that preventative filtration should be located ahead of the cooler to catch any scale or sludge for the system before it enters the cooler.

For hydraulic oil coolers is it suggested that a three-way thermal bypass valve or a direct acting low-pressure (30psi or 60psi) relief valve be installed at the inlet to the cooler to protect it in cold weather environments.

d) Flow line sizes should be sized to handle the appropriate flow to meet the system pressure drop requirements. If the nozzle size of the heat exchanger is smaller than the process line size an increased pressure differential at the heat exchanger may occur.

e) A brazed construction coil does not allow internal tube access. A serviceable core® will allow full accessibility to the internal tubes for cleaning and maintenance.

g) Electric motors should be connected only to supply source of the same characteristics as indicated on the electric motor information plate. Prior to starting, verify that the motor and fan spin freely without obstruction. Check carefully that the fan turns in the correct rotation direction (normally counter clockwise) from the motor side (fan direction arrow). Failure to operate the fan in the proper direction could reduce performance or cause serious damage to the heat exchanger or other components. Fan blades should be rechecked for tightness after the first 100 hours of operation.

h) It is important to apply the catalog recommended flow rate for the hydraulic motor that corresponds with the specific model being used. A case drain is required for hydraulic motor installation. Failure to connect case drain can result in motor failure. The proper flow rate and direction to the hydraulic motor are critical to ensure fan direction and RPM. Exceeding the recommended RPM could result in fan failure and cause severe damage to the heat exchanger. See fan rotation (pages 9-10)

Maintenance
Regular maintenance intervals based upon the surrounding and operational conditions should be maintained to verify equipment performance and to prevent premature component failure. Since some of the components such as, motors, fans, load adapters, etc... are not manufactured by American Industrial, maintenance requirements provided by the manufacture must be followed.

a) Inspect the entire heat exchanger and motor/fan assembly for loosened bolts, loose connections, broken components, rust spots, corrosion, fin/coil clogging, or external leakage. Make immediate repairs to all affected areas prior to restarting and operating the heat exchanger or its components.

b) Heat exchangers operating in oily or dusty environments will often need to have the coil cooling fins cleaned. Oily or clogged fins should be cleaned by carefully brushing the fins and tubes with water or a non-aggressive degreasing agent mixture *(Note: Cleaning agents that are not compatible with copper, brass, aluminum, steel or stainless steel should not be used).* A compressed air or a water stream can be used to dislodge dirt and clean the coil further. Any external dirt or oil on the electric motor and fan assembly should be removed. *Caution: Be sure to disconnect the electric motor from its power source prior to doing any maintenance.*

c) In most cases it is not necessary to internally flush the coil. In circumstances where the coil has become plugged or has a substantial buildup of material, flushing the coil with water or a solvent may be done. Flushing solvents should be non-aggressive suit-

able for the materials of construction. Serviceable Core® models can be disassembled and inspected or cleaned if required.

d) Most low horsepower electric motors do not require any additional lubrication. However, larger motors must be lubricated with good quality grease as specified by the manufacture at least once every 6-9 months or as directed by the manufacture. T.E.F.C. air ventilation slots should be inspected and cleaned regularly to prevent clogging and starving the motor of cooling air. To maintain the electric motor properly see the manufactures requirements and specifications.

e) Fan blades should be cleaned and inspected for tightness during the regular maintenance schedule when handling a fan blade care must be given to avoid bending or striking any of the blades. Fan blades are factory balanced and will not operate properly if damaged or unbalanced. Damaged fan blades can cause excessive vibration and severe damage to the heat exchanger or drive motor. Replace any damaged fan with an American industrial suggested replacement.

f) Air cooled exchanger cabinets are constructed using 7ga. through 18ga. steel that may be bent back into position if damaged. Parts that are not repairable can be purchased through American Industrial.

g) Coil fins that become flattened can be combed back into position. This process may require removal of the coil from the cabinet.

Brazed Core Maintenance

It is not advisable to attempt repairs to brazed joints of a brazed construction coil unless it will be done by an expert in silver solder brazing. Brazed coils are heated uniformly during the original manufacturing process to prevent weak zones from occurring. Uncontrolled reheating of the coil may result in weakening of the tube joints surrounding the repair area. In many instances brazed units that are repaired will not hold up as well to the rigors of the system as will a new coil. American Industrial will not warranty or be responsible for any repairs done by unauthorized sources. Manipulation in any way other than normal application will void the manufactures warranty.

Serviceable Core® Maintenance

Units containing a Serviceable Core® have bolted manifold covers that can be removed for cleaning or repair purposes. Most AOCH or AOCS cores manufactured after January 1, 1998 are Serviceable Cores®.

Servicing Sequence

American Industrial has gone to great lengths to provide components that are repairable. If the heat exchanger core requires internal cleaning or attention the following steps will explain what must be done to access the internal tubes. Be sure to order gasket kits or repair parts prior to removal and disassembly to minimize down time.

a) To clean the internal tubes first remove all connection plumbing from the unit.

b) Be sure the unit is drained of all water etc...

c) Place the heat exchanger in an area that it can be accessed from all sides. Remove the core from the cabinet if required (AOCH, AOCS).

d) Mark the cover ① and tube-sheet ③ for both covers so that they can be replaced into the same position when finished. Remove the manifold cover bolts ② and hardware and place them into a secure place.

e) The manifold covers are tightly compressed and may need some prying to separate them from the gasket ≈ , physically remove the cover assemblies ① from both sides.

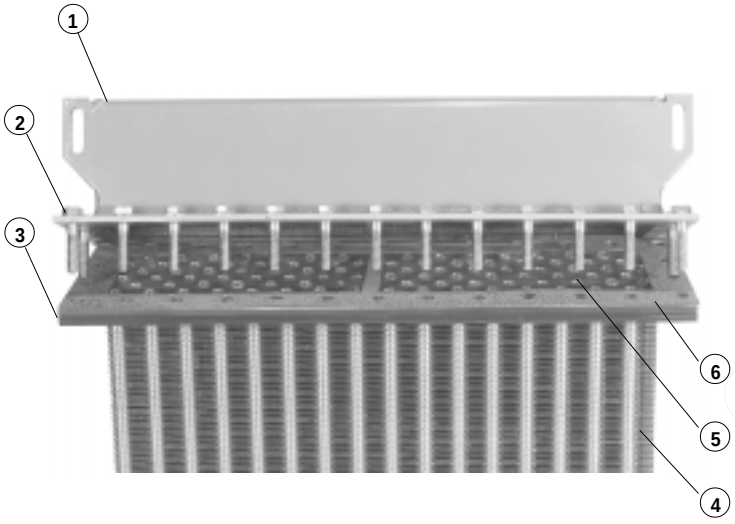
f) The tubes √ and turbulators ⑤ are now accessible for cleaning. Note: turbulators are installed on AOCH & AOCS cores only. If you need to remove the turbulator that runs through the tubing, it will be necessary to first squeeze the flattened end of the protruding turbulator ⑤, so that on end will fit through the tube. From the opposite end pull the turbulator ⑤ out. You may need to use pliers to grip and pull the turbulators ⑤ out, especially if there is debris lodged inside. As the turbulators ⑤ come out, most of the dirt will too, so be prepared. *It is suggested that gloves be worn when handling the turbulators ⑤ as they may be sharp.*

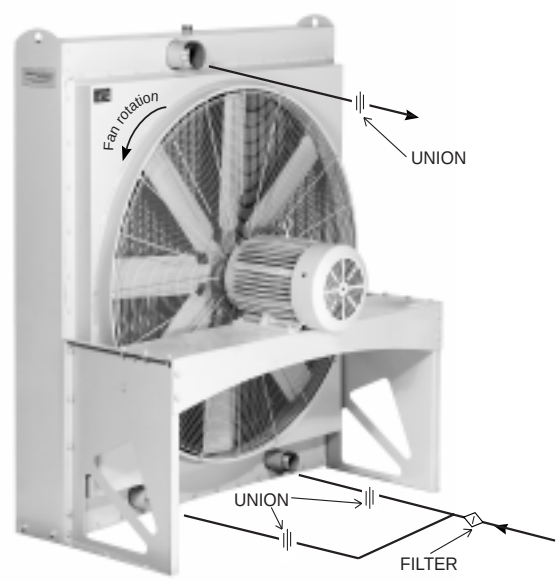
We suggest a mild water-soluble degreaser be used with a brush. Tubing I.D. is .325 a plastic bristle brush on a rod will work best for cleaning the tubes √ . Steel brushes should be avoided since the steel is harder than the copper tubing and may heavily score the tubes √ if used.

g) If there are any leaking tubes √ you may plug them by carefully forcing a soft metal plug into the hole and tapping it tight. You may in some cases weld the leaking tube shut however, care should be taken since excessive heat may cause surrounding tube joints to loosen and leak.

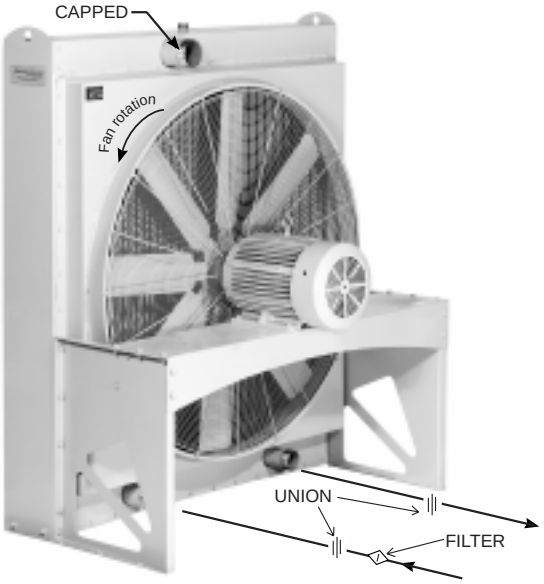
h) When finished cleaning or repairing, be sure to replace ALL of the turbulators ⑤ back into any open tubes √ . When the turbulators ⑤ protrude from the opposite end flatten them again so they are tight and cannot be removed.

i) When finished reattach the manifold covers ① in the same position they were removed, using new gaskets ≈ , bolts ②, and hardware. We suggest using a torque wrench to final tighten the bolts ②. *For 5/16" bolts 22-23 ft-lbs, for 3/8" bolts to 38-42 ft-lbs.* Since bolts and hardware can physically fatigue during application we suggest new bolt kits be used when reassembling.



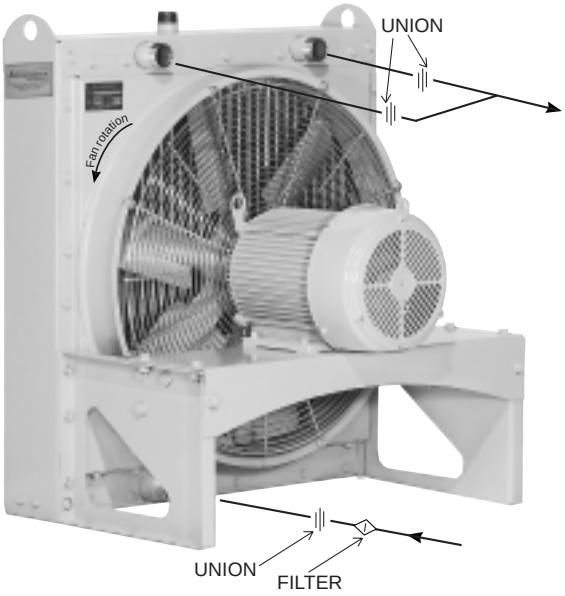


ONE PASS



TWO PASS

AOCS - 1005 through AOCS - 3015



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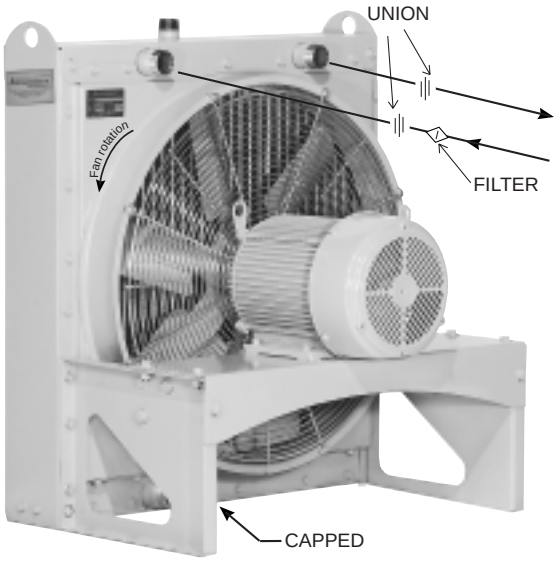
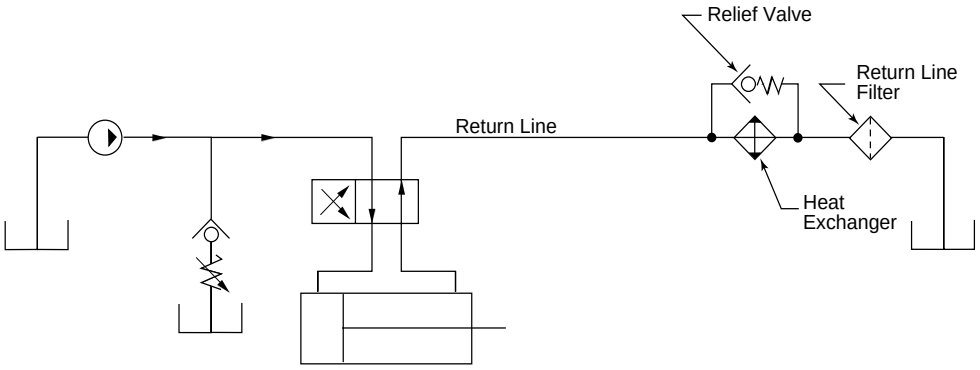


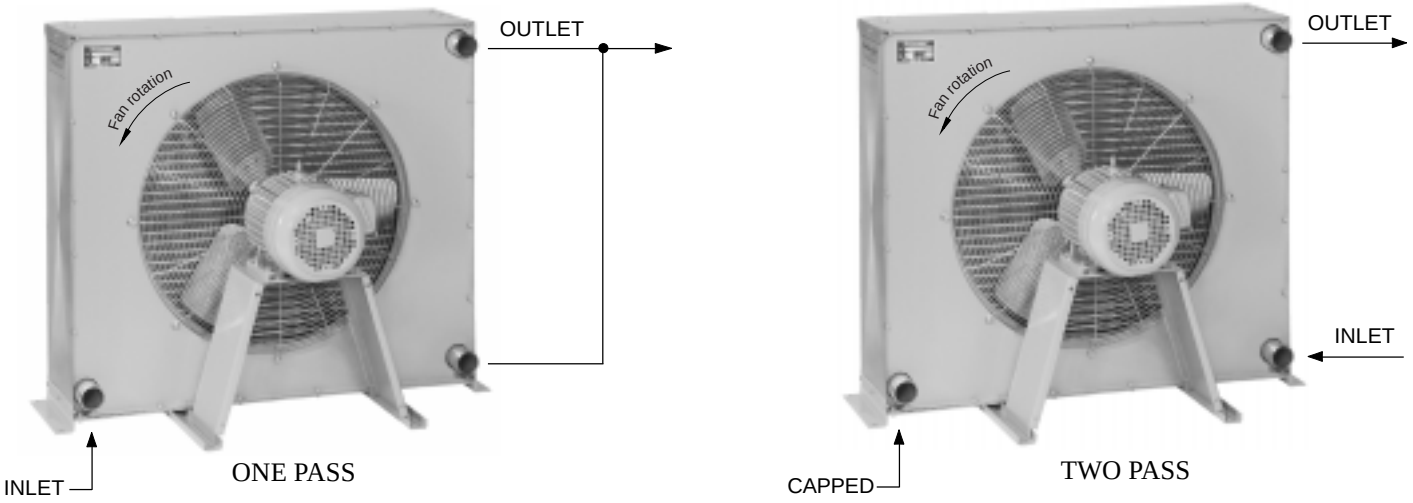
TWO PASS

AOCS - 201 through AOCS - 603

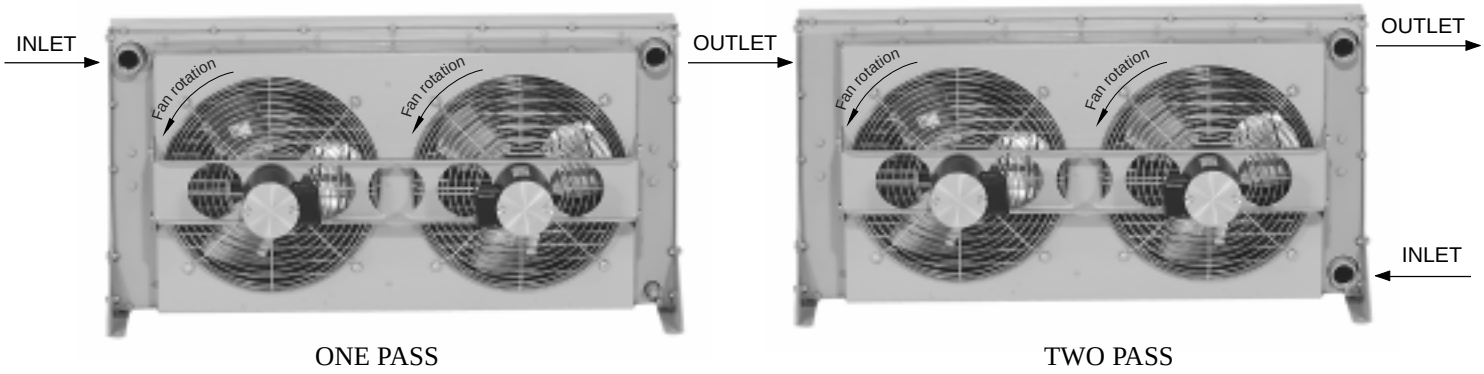


TYPICAL HYDRAULIC CIRCUIT

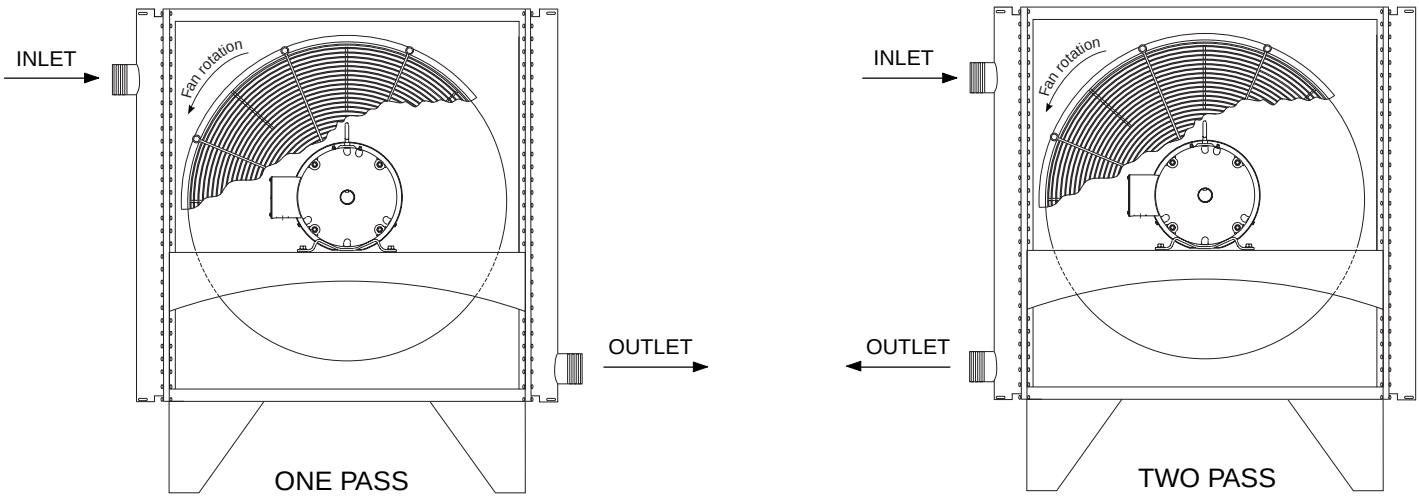
with air cooled heat exchanger



AC, ACF & AOCH Series

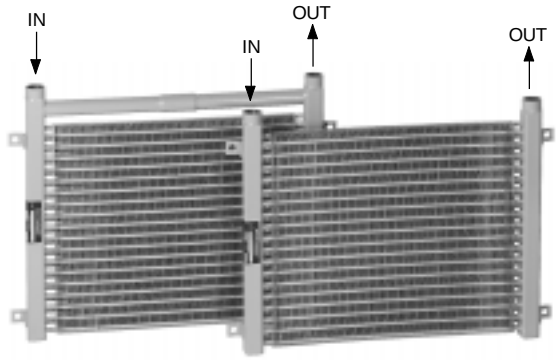


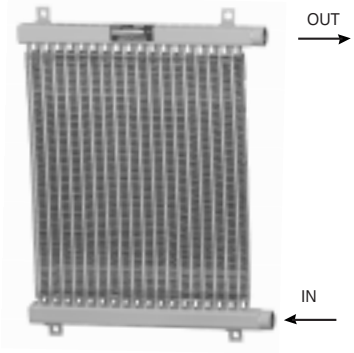
EOC Series



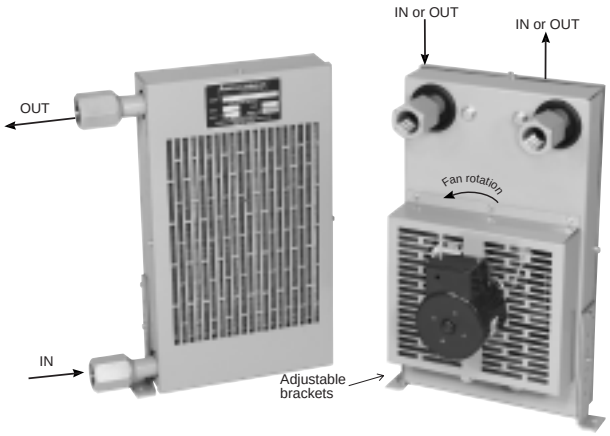
ACA Series

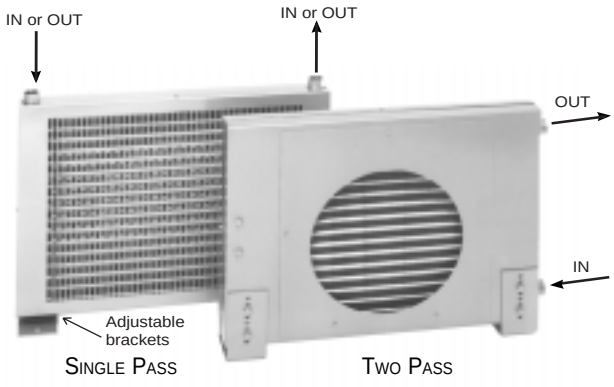
AOM & AOMR Series



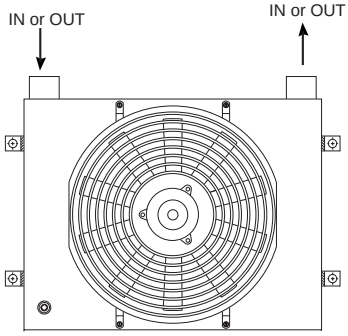


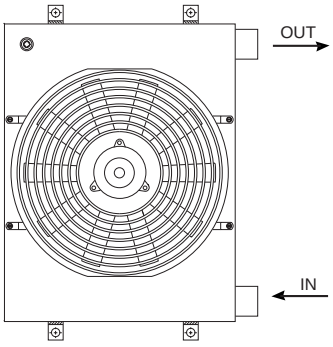
BM Series

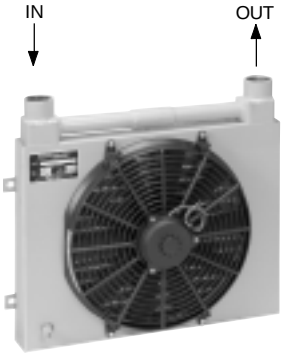




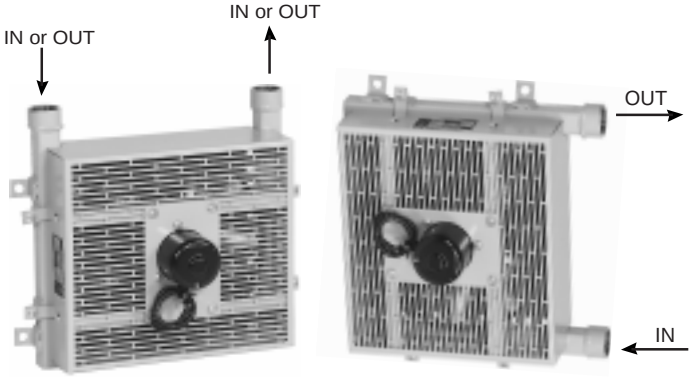
LP Series







AOMF



ELECTRICAL TEMPERATURE CONTROLLER WITH BULB WELL ASSEMBLY (for Air/Oil Coolers)

SPECIFICATIONS:
A) Material: Copper

B) Power Limits:

1)For three phase motor operation, use only with a magnetic starter, 125 VA max. (VA =volts x amps)
2)For pilot duty, 125 VA max.
3)For direct connection to motor:

120v AC/8.0 amps max	230v AC/5.1 amps max
277v AC/4.2 amps max	460v AC/2.0 amps max

4)Temperature operating range: 55°F to 175°F.

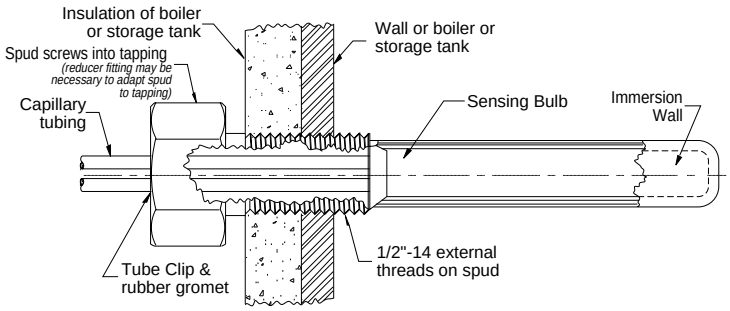
APPLICATIONS (Temperature Controller)

The TC511 temperature controllers are designed to control the temperature of air or liquids in ducts, pipes, tanks, and boilers. Typical uses include control of dampers and valves in heating, cooling, or heating-cooling systems. The TC511 has 1 spdt switch. It makes or breaks a circuit on a change in temperature at the sensing bulb. Fast response models with adjustable differential are available for duct installation. They respond approximately 4 times faster than standard models.

INSTALLATION

When installing this product:

1. Read instructions carefully. Failure to follow the instructions could damage the product or cause a hazardous condition.
2. Check the ratings given in the instructions and on the product to make sure the product is suitable for your application.
3. Installer must be a trained, experienced service technician.
4. After installation is complete, check out product operation as provided in the instructions.



LOCATION AND MOUNTING.

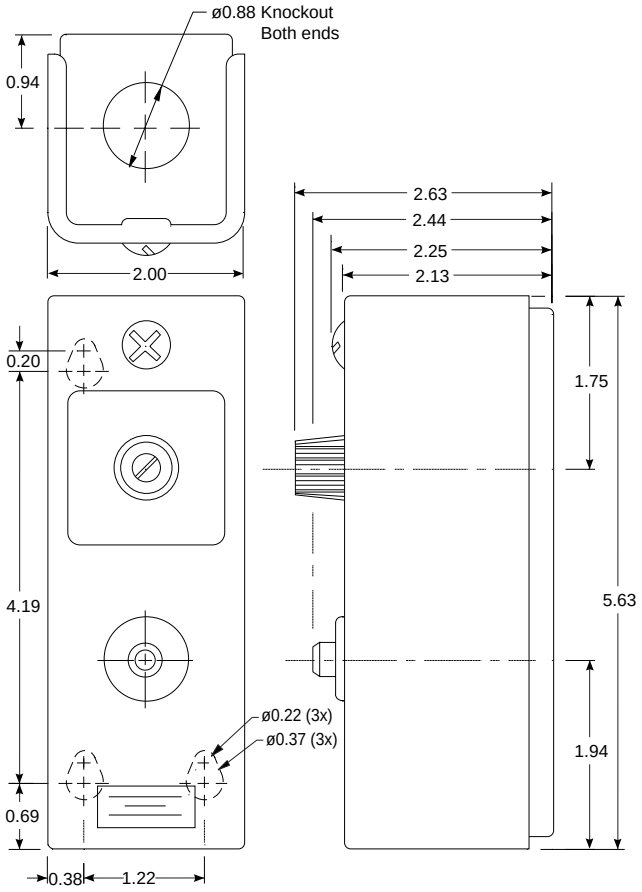
The controller may be installed in any convenient position. Mount it with 3 screws through the slotted holes in the back of the case. Be sure to consider the length of the capillary before mounting the controller.

Install the sensing element where it is exposed to the average temperature of the controlled medium. The sensing bulb may be directly immersed or mounted in a well. Fast response models must use the capillary holder furnished with the device. The remote sensing bulb of standard models should be held in place with a capillary holder, immersion well, or compression fitting. Sharp bends or kinks in the capillary tubing affect the efficiency of the controller and must be avoided. Excess capillary should be carefully coiled and left directly beneath the controller.

NOTE: When pressure fittings are used in areas of vibration (such as pipe lines) the bulb must be adequately supported.

OPERATION

As the temperature of the controlled medium falls below the set point less differential, the TC511 switch makes terminal R to B and energizes a normally close solenoid valve to provide heat. In cooling applications, the TC511 makes terminal R to W as the temperature rises above the set point, energizing cooling equipment.

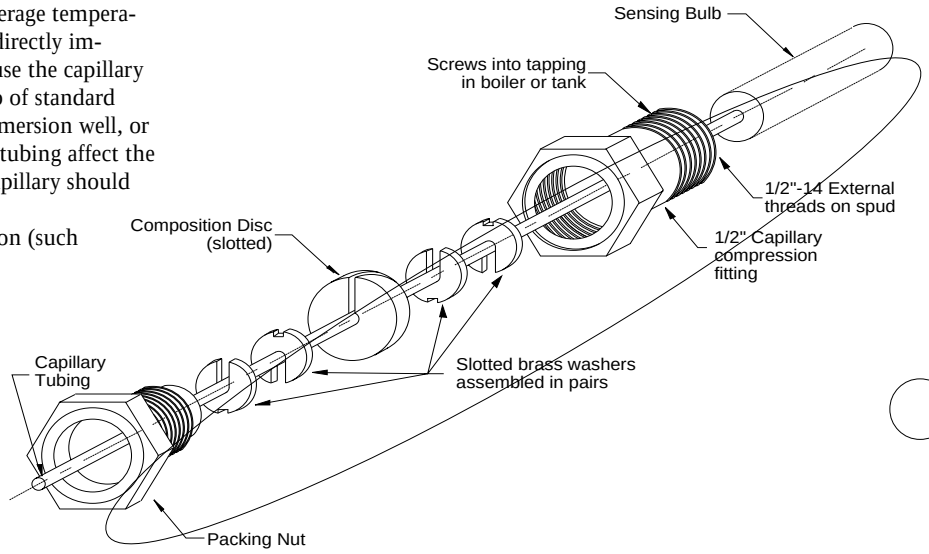


ELECTRICAL RATINGS:

TC511 models with adjustable differential:

TC511 models with fixed differential -125 VA at 120/208/240/277 Vac.

MAXIMUM BULB PRESSURE: 50 psi (344.7 kPa) for direct immersions.



STANDARD TERMS AND CONDITIONS OF SALE

April 1, 2000 Supersedes all prior "Standard Terms And Conditions Of Sale"

All sales by American Industrial Heat Transfer Inc. ("Seller") to the party to whom a Seller's Acknowledgment is addressed ("Purchaser") are subject to the following terms and conditions in addition to the terms and conditions contained in any acknowledgement or sales order confirming your order ("Seller's Acknowledgement"). Where terms of any such Seller's Acknowledgement conflict with the following terms and conditions, the terms and conditions of Seller's Acknowledgement shall control. These Terms and Conditions shall apply to all transactions between Seller and Purchaser unless superseded by new Terms and Conditions delivered by Seller or by the express terms and conditions contained in Seller's Acknowledgment.

Acceptance. All purchase orders are accepted by Seller at its General Offices in Zion, Illinois. Seller's acceptance of any purchase order it receives is expressly limited to the exact terms contained here and in this Seller's Acknowledgment. Additional or different terms contained in Purchaser's offer or any attempt by Purchaser to vary any of the terms here and in Seller's Acknowledgment shall be rejected but such proposal shall not operate as a rejection of Purchaser's offer unless such variances are in the terms of the description, quantity, price or delivery schedule of the goods or services to be provided hereunder, in which case such additional or different terms shall be deemed material and such offer shall be deemed accepted without said additional or different terms or attempted variations. Acceptance by Seller of any purchase order containing terms additional to or different from the terms contained in this Seller's Acknowledgment or containing modifications of the terms contained here and in Seller's Acknowledgment shall not be deemed as assent to those additional, different or modified terms. Purchaser's receipt of Seller's Acknowledgment without prompt written objection thereto, or Purchaser's acceptance of all or any part of the goods or services ordered from Seller, shall constitute assent by Purchaser to the terms contained here and in Seller's Acknowledgment. If this Seller's Acknowledgment shall be deemed an offer by Seller to sell goods or services to Purchaser, such offer is expressly limited to the exact terms contained herein. The dispatch of a purchase order by Purchaser shall then constitute Purchaser's acceptance of these Standard Terms and Conditions of Sale and Seller's Acknowledgment. If this Seller's Acknowledgment is deemed an offer as aforesaid, any proposal by Purchaser for additional or different terms or any attempt by Purchaser to vary any of the terms of this Seller's Acknowledgment in Purchaser's purchase order is hereby objected to and rejected; provided, however, that any such proposal by Purchaser shall not operate as a rejection of Seller's offer unless it contains variances in the terms of the description, quantity, price or delivery of the goods or services to be provided hereunder, in which case any such proposal shall be deemed material, and this Seller's Acknowledgment shall be deemed accepted without said additional or different terms or attempted variations.

Payment Terms. The full amount billed or contracted for is due and payable thirty (30) days from delivery of the goods or performance of services. A finance charge computed at the periodic rate of one and one-half percent (1.5%) per month (which is an annual rate of eighteen percent (18%)) on the unpaid balance will be made on accounts not paid when due, and Purchaser agrees to pay such charges and pay attorneys' fees if action is brought to collect from Purchaser. Unless otherwise specified, 100% of the price quoted for any tooling is to be paid with the placement of the order to Seller. Samples submitted shall be deemed approved and accepted if written notice of rejection is not received within thirty (30) days after date of submittal. Purchaser agrees that Seller shall have a possessory lien on all tools and other property of Purchaser which is in Seller's possession for the total amount owing by Purchaser to Seller for all tooling and other work and for all parts, materials and services of all kinds supplied or rendered by Seller to Purchaser, which lien shall be enforceable in the manner provided in the Uniform Commercial Code.

Taxes. Any tax which the Seller may be required to pay or collect through assessment or otherwise, under any existing or future law upon or with respect to the sale, purchase, delivery, transportation, storage, processing, use or consumption of any goods or services described herein, including, without limitation, taxes upon or measured by receipt from sales or services (but excluding taxes based upon the income of Seller), shall be for the account of Purchaser and be added to the price of such goods or services. Purchaser shall promptly pay the amount thereof to Seller upon demand but may in lieu of such payment, furnish to Seller evidence of the issuance of tax exemption certificates acceptable to the appropriate taxing authorities.

Prices. Except as otherwise provided, all price quotations are valid for thirty (30) days. Prices are based on costs prevailing on the date of quotation and, therefore, are subject to change at any time to reflect increased costs. Prices are quoted on samples, blueprints, or drawings on hand, and any modification thereof subjects this quotation to adjustment. Quotations are is based on the continuous production of the quantity specified, smaller runs subject to increase in price. If higher quantity level is desired by Purchaser, Seller will render a quotation based upon the revised requirements set forth by Purchaser.

Credit. All orders are subject to the approval of Seller's Credit Department, and Seller may at any time refuse to make shipment or delivery if Purchaser fails to fulfill the terms and conditions of payment or fails to provide security satisfactory to Seller's Credit Department. Seller reserves right to refuse or cancel credit and require full payment prior to shipment. If in Seller's opinion the financial condition of Purchaser at any time does not justify continuation of production or shipment on the terms of payment specified, Seller may require full or partial payment in advance or such further assurance as Seller shall require to justify such continued production or shipment.

Default in Payment and Bankruptcy of Purchaser. If Purchaser fails to make payments on any agreement between Purchaser and Seller in accordance with Seller's terms, Seller, in addition to any other remedies available to it, may, at its option, (a) defer further shipments until such payments are made and satisfactory credit arrangements are reestablished, (b) cancel the unshipped balance of any order or (c) take any other action available under applicable law. In the event of any proceedings, voluntary or involuntary, in bankruptcy or insolvency by or against Purchaser, the inability of Purchaser to pay its debts as they become due, or in the event of the appointment, with or without Purchaser's consent, of an assignee for the benefit of creditors or of a receiver, then Seller shall be entitled, in its sole discretion, to cancel the unshipped balance of any order without any liability.

Transportation Charges. All prices, quotations, shipments and deliveries by Seller are F.O.B. Seller's plant and risk of loss passes to Purchaser once goods are tendered for such delivery. All transportation and other charges including handling fees are for the account of Purchaser, including any increase or decrease in such charges prior to shipment.

Method of Shipment. Method and route of shipment is at Seller's discretion, unless Purchaser supplies explicit instructions, which are subsequently accepted by Seller in writing. Seller does not assume responsibility for any damage directly or indirectly resulting from delays in delivery. When parts are broken or damaged in transit from Seller to Purchaser, it is considered the responsibility of Purchaser to file a claim with the carrier for said breakage or damage. If the method of shipment specified by Purchaser is deemed by Seller to be unavailable or otherwise unsatisfactory, Seller reserves right to use an alternate method or route or both whether or not at a higher cost to Purchaser. Seller shall promptly notify Purchaser of any such change. The risk of loss or damage to the goods shipped shall pass to the Purchaser when the goods are delivered to the carrier for shipment and Purchaser shall be responsible for insuring such goods thereafter.

Producing or Shipping Point. Seller reserves right to produce and ship all or any part of the goods specified in any order from any of its plants or facilities.

Force Majeure. Seller shall not be liable for any delay in the performance of orders, or in the delivery or shipment of goods, or for any damages suffered by Purchaser as a result of such delay when such delay is occasioned by causes beyond Seller's control. Such causes shall include but are not limited to an act of God or the public enemy, fire, explosion, flood, unusually severe weather, drought, war, riots, sabotage, vandalism, accident, embargo, government priority, government action or failure of the government to act when action is required, requisition or allocation or other action of any governmental authority, interruption of or delay in transportation, inadequacy or shortage or failure of supply of materials or equipment, breakdowns, non-scheduled shutdowns for repairs, plant accidents, labor shortage, strikes, labor trouble, or by compliance with any order or request of the United States Government or any officer, department, agency, instrumentality or committee thereof. It is understood and agreed that economic conditions affecting the ability or desirability of the performance of this agreement by either party shall not be deemed to constitute "force majeure" circumstances as contemplated by this paragraph. The Seller shall have the right to cancel the entire agreement with Purchaser or any part thereof in the event of the happening of any such cause beyond the Seller's control without any resulting liability.

Good Delivery. Shipments made by Seller within a reasonable time after the specified date of delivery shall constitute a good delivery. No right of cancellation shall accrue to Purchaser based on such a delivery.

Permissible Variations. Goods shipped by Seller shall be within the limits and sizes published by Seller, subject, however, to Seller's right to ship overages or underages in accordance with Seller's standard practices and goods shipped by Seller will be subject to standard variations provided such variations are non-functional or are not material in nature.

LIMITED WARRANTY. SELLER MAKES NO WARRANTIES EXPRESSED OR

IMPLIED, INCLUDING BUT NOT BY WAY OF LIMITATION, ANY IMPLIED WARRANTY OF MERCHANTABILITY AND ANY IMPLIED WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE, ON ANY ORDER EXCEPT THAT SELLER WARRANTS TITLE TO ALL GOODS FURNISHED BY SELLER AND EXCEPT THAT SELLER WARRANTS FOR A PERIOD OF ONE YEAR FROM THE DATE MARK LOCATED ON THE SELLER'S IDENTIFICATION TAG THAT ALL GOODS DESCRIBED ON SELLER'S ACKNOWLEDGMENT OF PURCHASER'S PURCHASE ORDER WILL BE MANUFACTURED IN ACCORDANCE WITH THE SPECIFICATIONS, IF ANY, SET FORTH IN SAID PURCHASE ORDER AND EXPRESSLY ACCEPTED IN SELLER'S ACKNOWLEDGMENT SUBJECT TO SELLER'S STANDARD MANUFACTURING VARIATIONS AND PRACTICES. IN THE CASE OF COMPONENTS OR ACCESSORIES FURNISHED BY SUPPLIERS TO SELLER, PURCHASER'S WARRANTY FROM SELLER SHALL BE LIMITED TO THE WARRANTY OF THE COMPONENT OR ACCESSORY SUPPLIER. THE FOREGOING WARRANTIES ARE THE SOLE AND EXCLUSIVE WARRANTIES APPLICABLE TO THE GOODS DELIVERED, AND ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION ANY WARRANTY OF MERCHANTABILITY, ARE HEREBY EXPRESSLY DISCLAIMED AND NEGATED. WITHOUT LIMITING THE GENERALITY OF THE FOREGOING, PURCHASER ACKNOWLEDGES THAT SELLER'S PRODUCTS ARE NOT PACKAGED OR PROTECTED FOR LONG PERIODS OF STORAGE AND THUS MAY CORRODE OR RUST OVER TIME.

Damaged Goods. If any goods should arrive at Purchaser's destination in a damaged condition or should a shortage occur, Purchaser shall immediately report the damage or shortage to the delivering carrier and to Seller. Any loss or shortage occasioned by damage or otherwise occurring in transit will be for account of Purchaser. Allegedly defective goods or parts are to be returned by Purchaser to a destination specified by Seller, freight charges prepaid by Purchaser. All repairs and replacements are subject to verification and inspection by Seller. Seller shall not be responsible for costs of de-installation and re-installation of goods or parts returned.

Claims. Claims respecting the condition of goods, compliance with specifications or any other matter affecting goods shipped to Purchaser must be made promptly and, unless otherwise agreed to in writing by Seller, in no event later than twenty-one (21) days after receipt of the goods by Purchaser. Purchaser shall set aside, protect and hold such goods without further processing until Seller has an opportunity to inspect and advise of the disposition, if any, to be made of such goods. In no event shall any goods be returned, reworked or scrapped by Purchaser without the express written authorization of Seller. If field service is rendered by the Seller at Purchaser's request and the alleged defect is found not to be with the Seller's product, component or accessory, the Purchaser shall pay for the time and expenses of the field representative. Bills for service, labor or other expenses that have been incurred by the Purchaser, their customer or agent, without approval or authorization by the Seller, will not be accepted. Changes or repairs attempted or made in the field without Seller's written authorization automatically void all warranties.

LIMITATION OF PURCHASER'S REMEDIES. PURCHASER'S REMEDIES WITH RESPECT TO ANY CLAIM ARISING OUT OF ANY ORDER, ANY GOODS DELIVERED PURSUANT TO ANY ORDER AND EXPRESSLY ACCEPTED IN SELLER'S ACKNOWLEDGMENT, OR SELLER'S PERFORMANCE IN CONNECTION WITH ANY ORDER, INCLUDING, WITHOUT LIMITATION, ANY CLAIM ARISING OUT OF ANY RECALL, DEFECT OR ALLEGED DEFECT IN ANY GOODS OR SERVICES FURNISHED BY SELLER, SHALL BE LIMITED EXCLUSIVELY TO THE RIGHT OF REPAIR OR REPLACEMENT OF SUCH GOODS OR SERVICES, AT SELLER'S OPTION. WITHOUT IN ANY WAY LIMITING THE GENERALITY OF THE FOREGOING, IN NO EVENT SHALL SELLER BE LIABLE FOR ANY CONSEQUENTIAL OR INCIDENTAL DAMAGES, INCLUDING, WITHOUT LIMITATION, ANY LOSS OF ANTICIPATED PROFITS INCURRED BY PURCHASER WITH RESPECT TO ANY GOODS OR SERVICES FURNISHED BY SELLER, OR ANY DAMAGES ARISING FROM INJURIES TO PERSONS AS A RESULT OF PURCHASER'S OR A THIRD PARTY'S NEGLIGENCE. SELLER'S WARRANTY DOES NOT COVER FAILURES RESULTING FROM THE IMPROPER INSTALLATION, MOUNTING DESIGN OR APPLICATION OR FROM CORROSION. THE PROVISIONS OF THIS PARAGRAPH ARE A MATERIAL TERM OF THIS TRANSACTION.

Warranty Procedures. If Purchaser experiences a problem with Sellers goods and believes that it is covered by Seller's warranty, or Purchaser has equipment that needs to be repaired or replaced, contact Seller through Purchaser's local distributor. The basic information that Purchaser will need to begin the process is the complete nameplate data. Products will not be accepted for return unless an RGA (Return Goods Authorization) number has been assigned by Seller and the product for return or repair is shipped prepaid. Products returned for warranty evaluation must be complete (without missing components), and unaltered (not disassembled, manipulated cleaned or the like). The product(s) must have the original model tag fully intact. Products returned for warranty consideration are subject to a $100 minimum fee plus any additional handling charges in the event that the reason for the return is not covered by Seller's warranty. Additional handling fees are to cover the cost of failure analysis, testing and the like. All handling charges will be waived for products that are subject to a valid warranty claim. Products to be returned for warranty are to be shipped prepaid via Seller assigned carrier.

Returns and Returns Procedures. In order to return a product for credit, test, or repair, Purchaser must follow the procedures outlined in this paragraph and, in the case of repairs, the immediately following paragraph. Failure to follow return procedures could result in lost items, delays, additional service charges, warranty denial or refusal of shipment. All items being returned to Seller must be accompanied with an RGA (Return Goods Authorization) number for identification purposes. Products returned without a clearly marked RGA number will not be processed. RGA numbers can be obtained only through Seller. Products being returned for restock and credit must be complete (without missing components), unused, and within one year of original factory purchase. The products must have the original model tag fully intact. Returned products must be free of dents, customer applied paint, rust, or any permanent alterations of any type. Products shipped for restock are to be shipped prepaid. Heat exchangers being returned for credit are subject to a 30% restocking charge. Other items such as, without limitation, valves and temperature controls are subject to a 15%-50% restocking charge to be determined by the products' usage or salability. Restocking charges are applied to cover the cost or the retest and refitting equipment to new condition. Seller will issue credit only after a thorough inspection has been performed. NO DEBITS WILL BE HONORED UNTIL AFTER RETURN INSPECTION APPROVAL.

Repairs. Products being returned for repair, refit, test or similar matters must be drained completely prior to shipment. Purchaser must clearly label the product with information to identify the Purchaser and Seller's RGA number. Purchaser should also include a note with instructions for service, failure, nature of problem and the fluids that are used inside of the product. A base handling charge of $100 will be applied for each product regardless of condition that it is in when returned for evaluation. Products being returned for evaluation must be shipped prepaid. Quotations for repair, test, cleaning, and similar matters will be issued shortly after return to Seller. All products returned shall be considered abandoned by Purchaser and may be scrapped if the Purchaser or shipper renders no disposition instructions after 45 days from notification by written quotation. Seller does not warranty any repaired products under any circumstances. Products repaired and the repairs are the sole responsibility of the owner of the products. Products sent to Seller for evaluation will be returned, upon request and at the owner's expense.

Quality Assurance. Seller shall have no obligation to ensure that any goods or services purchased from Seller meet any special quality assurance specifications and/or other requirements unless such specifications and/or other requirements are set forth in Purchaser's purchase order or separately provided in writing to Seller and, in either case, expressly accepted in this Seller's Acknowledgment and Purchaser represents that goods which it purchases from Seller will not be applied by Purchaser or resold by Purchaser for application to, any critical end use, including, without limitation, use in connection with or in any way related to the construction or operation of a nuclear facility unless the appropriate specification and/or other requirement for such end use is set forth in Purchaser's purchase order and is expressly accepted in a separate writing by Seller. In the event that any such goods or any services supplied by Seller in connection therewith are applied to a critical end use without the appropriate specification and/or other requirement therefor having been set forth in Purchaser's purchase order and expressly accepted in a separate writing by Seller, Purchaser shall indemnify and hold Seller harmless against any and all damages or claims for damages made by any person for any injury, fatal or nonfatal, to any person or for any damage to the property of any person incident to or arising out of such application, including, without limitation, any loss resulting from radioactive, toxic, explosive, or other hazardous properties of source material, special nuclear material, or by-product material as such terms are defined in the Atomic Energy Act of 1954 or any law amendatory thereof or regulations adopted pursuant thereto. The Seller reserves the right to improve its products through changes in design or material, as it may deem desirable without being obligated to incorporate such changes in products of prior manufacture.

Cancellation. Purchaser Orders cannot be cancelled without cause by Purchaser without the express written consent of the Seller. Should Purchaser attempt to cancel an order without cause, Purchaser shall reimburse Seller against all loss occasioned by such cancellation, including loss of anticipatory profits and liability for commitments made by Seller relating to the Purchase Order and shall purchase any existing inventory and work in process which Seller has in its possession to fulfill Seller's existing orders for Purchaser at the time of cancellation. As used herein, "cause" shall mean a material breach of Seller's duties and obligations hereunder and the failure to cure such breach after Purchaser notifies Seller of such breach and affords Seller a reasonable time to cure same.

Confidentiality and Publicity. Purchaser shall consider all information furnished by Seller to be confidential and shall not disclose any such information to any person, firm or corporation, other than Purchaser's or Seller's employees, subcontractors or government inspectors, unless authorized to do so by Seller in writing. Purchaser shall not disclose in any manner to third parties, including, without limitation to, advertising, or publishing concerns, Seller's identity or the identity of any subsidiaries or affiliates of Seller. Unless otherwise agreed to in writing, no commercial, financial or technical information disclosed in any manner or at any time by Purchaser to Seller shall be deemed secret or confidential and Purchaser shall have no rights against Seller with respect thereto except such rights as may exist under patent laws.

Tooling. If and to the extent any Purchase Order relates to the purchase of tools, jigs, die fixtures, equipment, drawings and specifications (collectively, "tooling") or specifically requires tooling for completion by Seller, then Seller shall at all times be and remain the owner of such tooling and shall bear the risk of loss and be responsible for insuring same. If any Purchase Order requires the development of such tooling, then the price quoted by Seller is based on a minimum production of a specified quantity of parts from such tooling and, in the event Purchaser does not ultimately purchase such quantity of parts, an equitable adjustment in the purchase price for products shall be made to reflect such lower quantity and Seller's unamortized cost of the tooling so produced. Seller's price quotation is based upon estimated usage of tooling but no representations or warranties are made by Seller that the tooling so built will ultimately be capable of producing product in accordance with such anticipated usage. Purchaser agrees to pay for changes in tooling made necessary by changes in specifications accepted by Seller, such changes to be made at Purchaser's risk. Parts produced from Purchaser's supplied tooling cannot be guarantied by Seller. Purchaser provided tooling is not insured and Seller shall not be responsible or liable for any loss or damage thereto or for any materials or equipment owned or furnished by Purchaser. Purchaser shall be solely responsible for insuring such tooling and Purchaser waives any claim or right of subrogation it may have against Seller arising out of Seller's failure to insure such tooling. Seller reserves the right to charge Purchaser the reasonable costs and expenses of refurbishing any tooling if so required by Seller to fulfill any Purchase Order. When for a period of one (1) year no orders are received for parts to be produced from tooling, Seller may notify Purchaser in writing at Purchaser's last known address in Seller's files that tooling is no longer proprietary to Purchaser and, with respect to Purchaser supplied tooling, such tooling shall become Seller's property or, at Seller's option, Seller man return such tooling to Purchaser at Purchaser's expense.

Prototypes. If this Purchase Order relates to the production of a prototype by Seller for or on behalf of Purchaser, (a) such prototypes will be manufactured in accordance with Purchaser's specifications including material selection and (b) actual product produced by Seller may vary from such prototype in a non-material and non-functional manner. Seller's sole liability in the event it is unsuccessful in producing a prototype in accordance with Purchaser's specifications shall be limited to the purchase price paid by Purchaser with respect thereto. Purchaser shall be responsible for the cost of all tooling necessary for the development of the prototype as provided in the paragraph Captioned "Tooling" above.

Technical Assistance and Advice. Seller's warranty shall not be enlarged and no obligation or liability shall arise out of Seller's rendering of technical assistance, technical advice facilities, service or recommendations made by Seller in connection with Purchaser's purchases of the goods hereunder. Said technical services, advice, assistance or recommendations made by Seller or any representative of Seller concerning any use or application of any goods furnished hereunder is believed to be reliable, but SELLER MAKES NO WARRANTY, EXPRESS OR IMPLIED, AND THE SAME ARE HEREBY EXPRESSLY DISCLAIMED as to the same and the results to be obtained. Purchaser assumes all responsibility for loss or damage resulting from the use of any such goods.

Indemnification. Purchaser agrees to indemnify, save harmless and defend Seller from and against any and all liability for loss, damage or injury to person or property in any manner arising out of or incident to the performance of any Seller's Acknowledgment or other sale by Seller or its servants, employees, agents or representatives. Without limiting the generality of the foregoing, Purchaser will indemnify and hold harmless Seller, its officers, employees, agents, successors, assigns, customers and users of its products from and against any and all losses, expenses, claims, suits and liabilities (including incidental and consequential damages and court costs and attorneys fees) arising as a result of any claim that the manufacture, use, sale or resale of goods delivered by Seller in accordance with Purchaser's specifications or designs infringes on any patent, utility model, industry design, copyright or other intellectual property rights in any country. Without limiting the generality of the paragraph captioned "LIMITATION OF PURCHASER'S REMEDIES" above, in the case of any claim of infringement or the sale of products is enjoined, Seller shall have no obligation to procure for Purchaser the right to continue using such products or to replace same with equivalent non-infringing products or to modify the products so they become non-infringing.

Setoffs. Purchaser shall make no deduction or setoff for any claim arising out of or from any transaction with Seller nor shall Purchaser take any discount, credit or allowance without Seller's written consent.

Assignment. Purchaser shall not assign any order or any interest therein without the written consent of Seller. Any such actual or attempted assignment without Seller's prior written consent shall entitle Seller to cancel such order upon written notice to Purchaser.

Termination. Seller may terminate any order or any part thereof for any reason at Seller's convenience upon written notice to Purchaser. Upon such termination, Purchaser agrees to waive all claims for damages including, without limitation, any loss of anticipated profits, and to accept as its sole remedy for termination the reasonable additional costs of obtaining substitute goods of the same quantity and quality, provided that in no event shall such costs exceed the price of the order or part thereof so terminated as stated on Seller's Acknowledgment. Any claim for adjustment not asserted within sixty (60) days from the date of such termination shall be deemed to have been waived by Purchaser.

Allocation of Risk. Purchaser acknowledges that these Standard Terms and Conditions of Sale and Seller's Acknowledgment allocates risks with respect to goods and/or services sold to Purchaser and this risk allocation is reflected in the prices to be paid by Purchaser for said goods and/or services purchased hereunder. Purchaser warrants that it has read this provision, understands it and is bound by its terms.

Packaging. Seller will use all reasonable means to comply with any packaging, loading or bracing requirements specified in any order. Seller will charge for compliance with Purchaser's special requirements in accordance with Seller's price list for extras in effect at time of shipment. If no packaging, loading or bracing requirements are specified by Purchaser, Seller shall comply with the minimum requirements customarily applied by Seller to the method of transportation used for such goods.

Entire Agreement. These Standard Terms and Conditions of Sale and Seller's Acknowledgment and any other documents referred to on the face thereof constitute the entire agreement between Seller and Purchaser.

Modification. No addition or modification of the terms and conditions of these Standard Terms and Conditions of Sale and Seller's Acknowledgment shall be binding on Seller unless specifically agreed to by Seller in writing.

Waiver. Seller's failure to insist on performance of any of these Standard Terms and Conditions of Sale and Seller's Acknowledgment or to exercise any right or privilege or Seller's waiver of any breach hereunder shall not thereafter waive any other terms, conditions, or privileges, whether of the same or similar type.

Governing Law. Seller and Purchaser's agreement shall be governed by and interpreted in accordance with the laws of the State of Illinois of the United States of America. Manufacture, shipment and delivery are subject to any prohibition, restriction, priority, allocation, regulation or condition imposed by or on behalf of the United States of America or any other governmental body with appropriate jurisdiction which may prevent or interfere with fulfillment of any order.

Re-orders. Re-orders, if accepted by Seller, are considered as placed under the same terms and conditions as Purchaser's previous order, when such orders are not placed pursuant to a formal written proposal and acceptance.

Disclosure. Seller shall have the right to disclosure of the identity of Purchaser and the nature of the work Seller is performing on Purchaser's behalf to Seller's customers and prospective customers and in any promotional materials provided such disclosure does not contain any confidential and proprietary information concerning Purchaser.

DISPUTES. SELLER AND PURCHASER AGREE TO SUBMIT ANY DISPUTES REGARDING ANY ORDER, ANY GOODS DELIVERED PURSUANT TO ANY ORDER AND EXPRESSLY ACCEPTED IN SELLER'S ACKNOWLEDGMENT, OR SELLER'S PERFORMANCE IN CONNECTION WITH ANY ORDER, INCLUDING WITHOUT LIMITATION SELLER'S LIMITED WARRANTY OBLIGATION, TO MEDIATION BY AN INDEPENDENT MEDIATOR TO BE MUTUALLY AGREED UPON BY SELLER AND PURCHASER. THE COST OF SUCH MEDIATION SHALL BE BORNE EQUALLY BY SELLER AND PURCHASER. IN THE EVENT SUCH MEDIATION DOES NOT RESOLVE THEIR DISPUTE, SELLER AND PURCHASER AGREE TO SUBMIT SUCH DISPUTE TO AN INDEPENDENT ARBITRATOR, TO BE MUTUALLY AGREED UPON BY SELLER AND PURCHASER OR, OTHERWISE, CHOSEN BY THE MEDIATOR. SELLER AND PURCHASER AGREE THAT ALL MEDIATION AND ARBITRATION SHALL BE CONDUCTED IN ZION, ILLINOIS. THE NON-PREVAILING PARTY AT THE ARBITRATION SHALL PAY THE PREVAILING PARTY'S ATTORNEYS' FEES AND COSTS INCURRED IN PARTICIPATING IN THE ARBITRATION.

ACA Series

• Heavy-duty Serviceable Core® air cooled air after-coolers for compressor sizes up to 500 HP.

AOCH Series *with screen & Serviceable Core®*

• Industrial high capacity air/oil heat exchanger available in 8 standard sizes with electric or hydraulic drive.

URCS Series

• U-tube heat exchangers for steam services with removable tubes bundle in copper, 316L SS, or 90/10 Cu Ni.

EOC Series *with electric motor & filter as an option.*

• Versatile industrial/mobile grade heat exchanger available with optional filter, AC, DC, and hydraulic drives.

AC,ACHM & ACF Series

• Industrial air/oil heat exchanger available in 8 standard sizes with electric or hydraulic drive.

CS Series

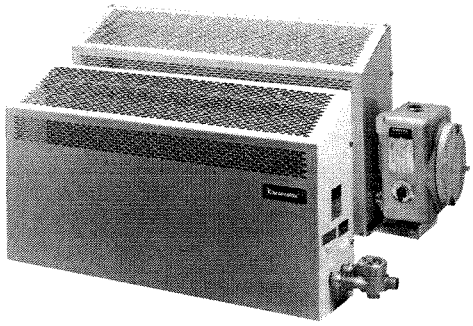
• Heat exchangers in copper, 316L SS, or 90/10 Cu Ni.

Chromalox®

Installation, Operation
and
RENEWAL PARTS IDENTIFICATION

SERVICE REFERENCE	
DIVISION 4	SECTION CVEP
SALES REFERENCE (Supersedes PF457-6)	PF457-7
	161-302639-001
DATE MARCH, 2004	

Type CVEP-C
Convection Air Heater for Hazardous Locations



NOTICE: Carefully remove heater from carton and check for shipping damage. Any damage claims should be entered immediately with the carrier.

GENERAL

Type CVEP Convection Heaters are designed for use in Class I, Div I hazardous environments. Units without control options are suitable for areas classified as Groups B, C & D. Units with built-in controls can be supplied for groups C and D or B, C and D. Refer to classification stamped on heater nameplate.

⚠WARNING

FIRE/EXPLOSION HAZARD. To prevent ignition of hazardous atmospheres, this heater should not be installed in areas where vapors or gases having an ignition temperature less than 280°C (536°F)(T2A) at 1.8kW, 3.6kW, 4.5kW, 7.6kW, 9.0kW or 180°C (356°F)(T3A) at 1.6kW, 3.2kW, 4.0kW are present.
These heaters must not be operated in ambient temperatures exceeding 40°C (104°F).

1. Connect air heaters to the same line voltage as on heater nameplate.
2. Heaters can be mounted individually end to end.
3. Heaters can be mounted directly on any type of surface masonry, concrete, block, plastered walls, metal framework, etc.-using appropriate hardware.
4. All controls such as thermostat and contactor, when required must have the same explosion-proof rating as heater.
5. Do not install one unit above the other.
6. Units are mounted a minimum of 8" above the floor.
7. Heaters are mounted on wall in a horizontal position with terminal end at right. **Never** recess heater into wall.
8. **NOTE:** Article 500 of the National Electric Code (NEC) outlines requirements for installation of electrical equipment in hazardous (Classified) locations.
9. All unit electrical installation fittings, conduit, wiring and seals must meet NEC and local codes for hazardous locations. External line fusing or circuit breaker protection is required.
10. Failure to understand and follow these installation instructions and the "WARNING" notes contained therein may result in severe personal injury, death or substantial property damage.

⚠WARNING

ELECTRIC SHOCK HAZARD. Any installation involving electric heaters must be performed by a qualified person and must be effectively grounded in accordance with the National Electrical Code to eliminate shock hazard.

INSTALLATION

⚠WARNING

ELECTRIC SHOCK HAZARD. Disconnect all power before installing or servicing heater. Failure to do so could result in personal injury or property damage. Heater must be installed by a qualified person in accordance with the National Electrical Code, NFPA 70.

1. Remove front panel by removing screws.
2. Locate desired heater position on wall.
3. Locate mounting holes for rear panel. Rear panel must be a minimum of 8" from the floor.
4. Refer to Figure 1A, 1B or 1C for mounting hole layout for each cabinet size.
5. Drill a pilot hole in wall mounting surface at each mounting hole location. Use a convenient small size drill.
6. Drill the mounting holes in accordance with size in Table 1. Insert anchors where applicable.
7. Fasten rear panel to wall with screws noted in Table 1.
8. Replace front panel and screws.

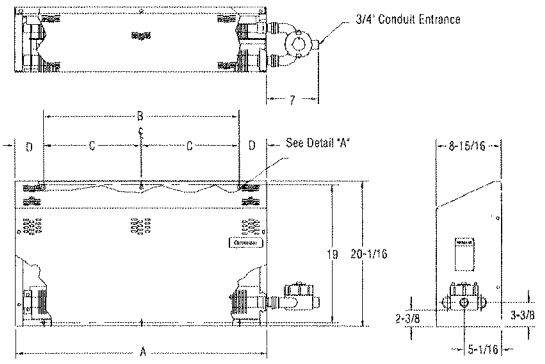
⚠WARNING

FIRE HAZARD. Never operate heater with front panel off. Adequate air flow across heating elements requires the front panel to be in place. The heating elements could overheat causing equipment damage or personal injury.

INSTALLATION

CVEP MODELS WITHOUT CONTROLS — GROUPS B, C AND D

Figure 1A

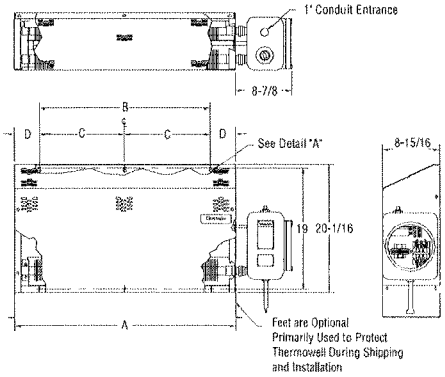


Dimensions (In.)

kW	A	B	C	D
1.6 1.8 3.6	34	20	10	7
3.2 7.6	58	32	16	13
4.0 4.5 9.0	70	48	24	11

CVEP MODELS WITH BUILT-IN CONTROLS — GROUPS B, C AND D

Figure 1B

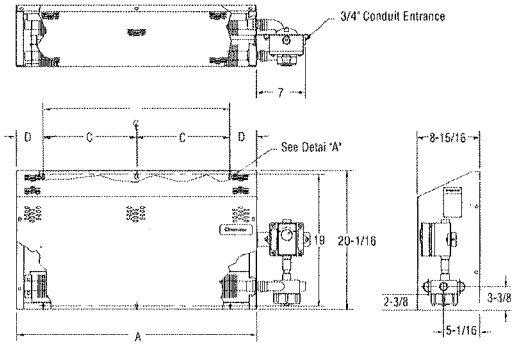


Dimensions (In.)

kW	A	B	C	D
1.6 1.8 3.6	34	20	10	7
3.2 7.6	58	32	16	13
4.0 4.5 9.0	70	48	24	11

CVEP MODELS WITH THERMOSTAT ONLY — GROUPS C AND D

Figure 1C

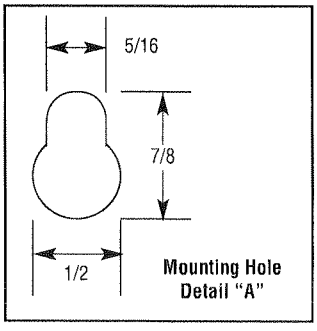


Dimensions (In.)

kW	A	B	C	D
1.6 1.8 3.6	34	20	10	7
3.2 7.6	58	32	16	13
4.0 4.5 9.0	70	48	24	11

Table 1 — Suggested Heater Mounting Screws — Types and Sizes

Type of Mounting Surface	** Accessory Hardware	Screw Type	Drill Size and Type	Screw Size to Fit Mtg Hole Size
Concrete Block Masonry	Ackerman	Rd. Hd. Mach. Steel	1/2" Masonry	† 1/4" x 20 x.....lg
	Lead Anchor	Rd. Hd. Mach Steel or Pan Hd. Metal (Self Tapping)	5/16" Masonry	† # 1/4" x .....lg
Wood Studs	— —	Wood or Metal (Self Tapping)	— —	† # 1/4" x .....lg
Plaster wall Hollow or Similar Type	— —	Toggle Bolt	#7 Twist	† # 1/4" x .....lg
* Metal Beam, Channel, etc.	Nuts Washers	Rd. Hd. Mach. Steel	#7 Twist	† 1/4" x 20 x.....lg



*If clearance permits use washer, lockwasher and nut; otherwise drill and tap to these lengths add thickness of beam, washers, nut, etc.
**If mounting structure permits. Except plastered hollow walls explosive type anchors can be used. Suggested size noted in Table and/or sketches be used to determine size of anchors.
†Select overall length of screw to provide a minimum penetration of 1 inch into base wall material.

WIRING

⚠WARNING

ELECTRIC SHOCK HAZARD. Any installation involving electric heaters must be performed by a qualified person and must be effectively grounded in accordance with the National Electrical Code to eliminate shock hazard.

1. All wiring should be done in accordance with local codes and the National Electrical Code by a qualified person as defined in the NEC.
   CAUTION: ***Use copper conductors only.***
2. Rough-in-line-wiring to unit in manner approved for hazardous locations. (See warning below.)
3. Wire per diagrams 1 through 6 based on the rating and control options listed in table 2. Refer to table 3 for amperage specifications.
4. Remove cover of conduit box for connections. Use either opening and plug the other with the plug provided.
5. In single phase units the heaters must be wired in parallel, combining L1 to L1, L2 to L2 and for 3 phase unit, L3 to L3.
6. Re-assemble cover with a minimum of 7 turns.

⚠WARNING

FIRE/EXPLOSION HAZARD.(Group B atmospheres) To prevent ignition of Group B atmospheres, conduit runs must not exceed 3/4" in size and all conduit runs 1/2" size and larger must have a sealing fitting connected within 2", 6" or 18" of the terminal enclosure depending on the exact model. For correct placement, refer to data located on the enclosure label.

Single Phase — No Controls, 120-277V & Heater Amps < 22A

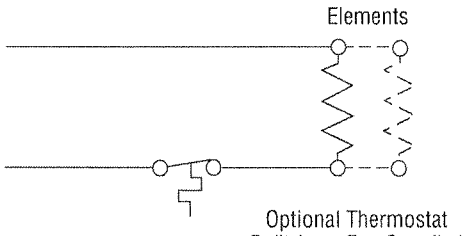


Diagram 1

Single Phase — No Controls, Volts > 277V & 120–277V When Heater Amps > 22A

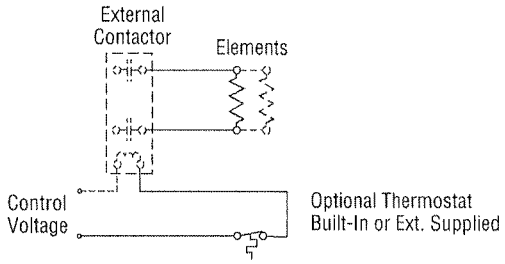


Diagram 2

Three Phase – No Controls

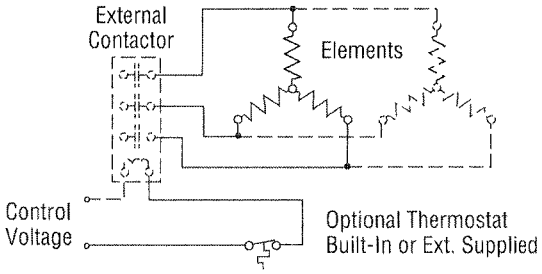


Diagram 3

Single or Three Phase With Controls — Contactor & Transformer

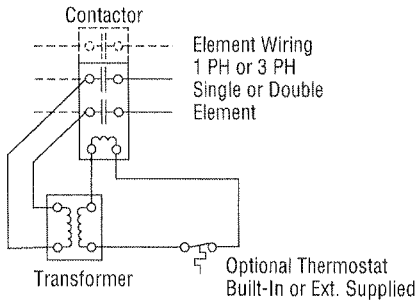


Diagram 4

Single or Three Phase With Controls — Contactor & Line Voltage Control

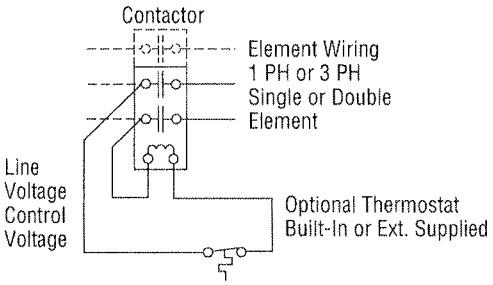


Diagram 5

Single or Three Phase With Controls — Contactor & External Supplied Control Voltage

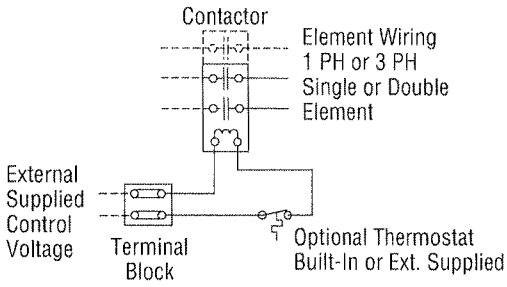


Diagram 6

OPERATION

⚠CAUTION

The system designer is responsible for the safety of this equipment and should install adequate back-up controls and safety devices with their electric heating equipment. Where the consequences of failure could result in personal injury or property damage, back-up controls are essential.

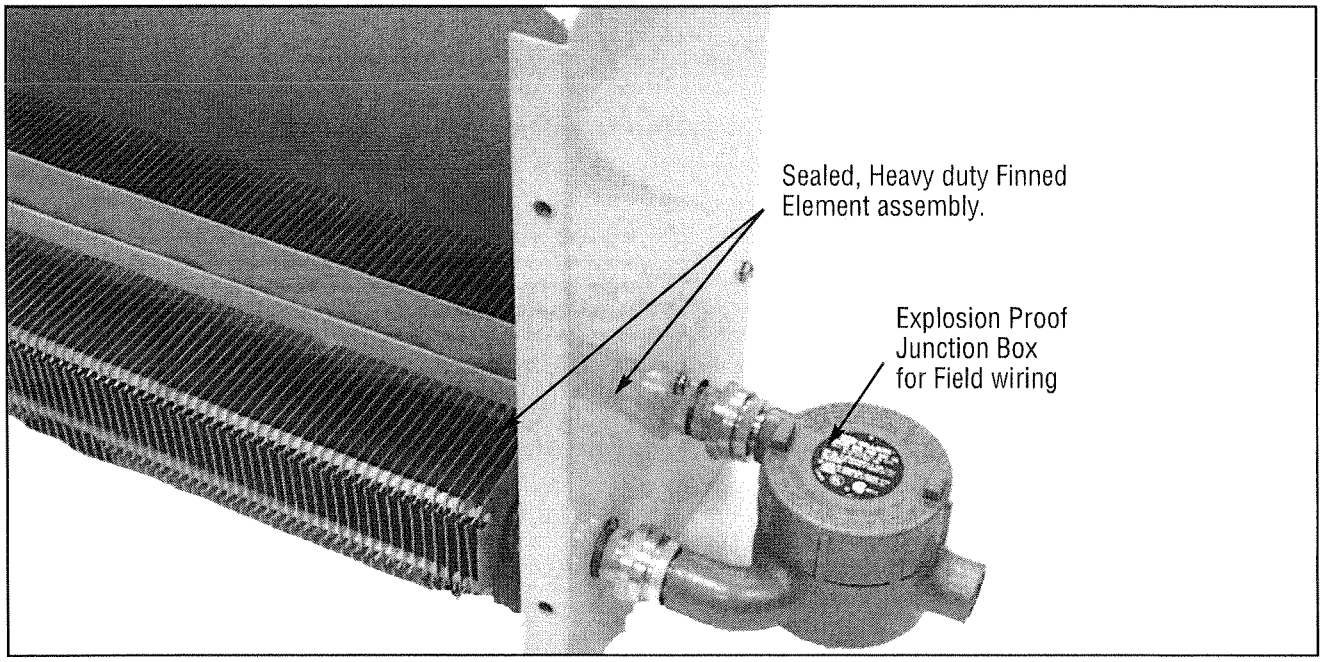
1. Do not operate heater at voltages in excess of that stamped on the heater since excess voltage will shorten heater life and cause high element temperatures which may exceed allowable temperatures of operation in a hazardous atmosphere.

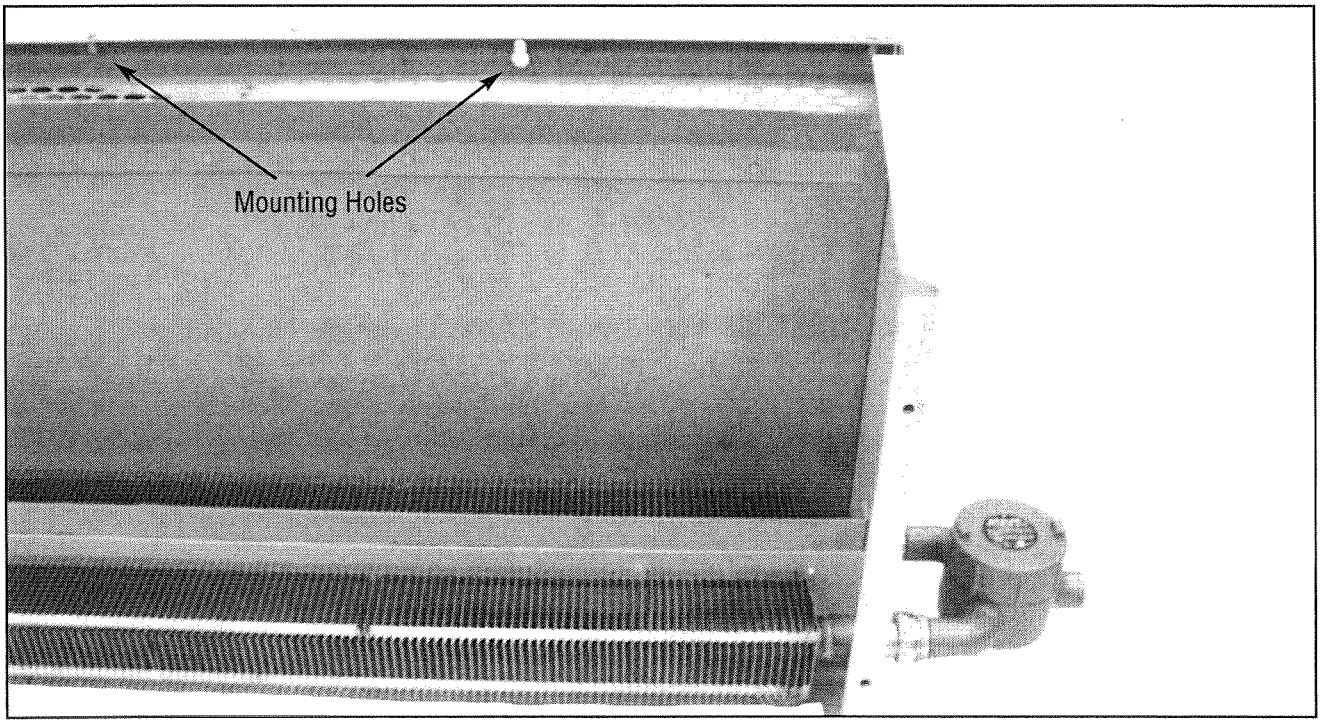
MAINTENANCE

⚠WARNING

ELECTRIC SHOCK HAZARD. Disconnect all power before installing or servicing heater. Failure to do so could result in personal injury or property damage. Heater must be installed by a qualified person in accordance with the National Electrical Code, NFPA 70.

1. Before activating for next heating season, vacuum or use compressed air to remove accumulated dust or lint, which otherwise may restrict proper air flow.
2. Periodically check all electrical connections and retighten to avoid electrical wiring difficulties.
3. Check to ensure terminal cover is tightly closed, before energizing.





RENEWAL PARTS IDENTIFICATION

MANUFACTURER MODEL NUMBER BREAKDOWN (located on unit nameplate)

Model

CVEP — **Explosion Proof Convection Heater**

CVEP-C	Code	kW	Temperature Rating ID Number	°F	°C	(BTU)
	16	1.6	T3A	356	180	5,500
	18	1.8	T2A	536	280	6,150
	32	3.2	T3A	356	180	11,000
	36	3.6	T2A	536	280	12,300
	40	4.0	T3A	356	180	13,600
	45	4.5	T2A	536	280	15,350
	76	7.6	T2A	536	280	25,930
	90	9.0	T2A	536	280	30,700

Code	Voltage	Maximum kW Allowable
1	120	1.8
2	240	9.0
3	380	9.0
4	480	9.0
5	415	9.0
6	575	9.0
7	277	9.0
8	208	9.0
9	600	9.0

Code	Phase
1	1Ø
3	3Ø (Not available in 120, 277V)

Code	Control Combination Contactor Coil	Transformer Secondary
00	None	None
30	24 Volt	24 Volt
31	24 Volt	None
32	120 Volt	120 Volt
33	120 Volt	None
34	208/240 Volt	None
35	277 Volt	None

Code	Temperature Control
00	None
40	Thermostat 40 - 90°F Group B, C & D
42	Thermostat Group C & D 50 - 90°F

CVEP-C	36	2	1	30	42	

TABLE 2 — TEMPERATURE SPECIFICATIONS
DIMENSIONS REPLACEMENTS ELEMENTS REQUIREMENTS

Temperature Rating T3A 356˚F (180˚C) — Common To Units W & W/O Suffix B

kW	BTU	Volts	Phase	Amps	Model	Width A	Height B	Depth C	Wt. (Lbs.)	Element P/N	Qty.
1.6	5,500	208	1	7.7	CVEP-C-16-81	34"	20-1/16"	8-15/16"	58	003-304650-002	2
1.6	5,500	208	3	4.4	CVEP-C-16-83	34"	20-1/16"	8-15/16"	58	003-304650-005	2
1.6	5,500	240	1	6.7	CVEP-C-16-21	34"	20-1/16"	8-15/16"	58	003-304650-096	2
1.6	5,500	240	3	3.8	CVEP-C-16-23	34"	20-1/16"	8-15/16"	58	003-304650-006	2
1.6	5,500	277	1	5.8	CVEP-C-16-71	34"	20-1/16"	8-15/16"	58	003-304650-004	2
1.6	5,500	480	1	3.3	CVEP-C-16-41	34"	20-1/16"	8-15/16"	58	003-304650-091	2
1.6	5,500	480	3	1.9	CVEP-C-16-43	34"	20-1/16"	8-15/16"	58	003-304650-009	2
1.6	5,500	575	3	1.6	CVEP-C-16-63	34"	20-1/16"	8-15/16"	58	003-304650-010	2
3.2	11,000	208	1	15.4	CVEP-C-32-81	58"	20-1/16"	8-15/16"	94	003-304650-023	2
3.2	11,000	208	3	8.9	CVEP-C-32-83	58"	20-1/16"	8-15/16"	94	003-304650-026	2
3.2	11,000	240	1	13.3	CVEP-C-32-21	58"	20-1/16"	8-15/16"	94	003-304650-097	2
3.2	11,000	240	3	7.7	CVEP-C-32-23	58"	20-1/16"	8-15/16"	94	003-304650-027	2
3.2	11,000	277	1	11.6	CVEP-C-32-71	58"	20-1/16"	8-15/16"	94	003-304650-025	2
3.2	11,000	480	1	6.7	CVEP-C-32-41	58"	20-1/16"	8-15/16"	94	003-304650-093	2
3.2	11,000	480	3	3.8	CVEP-C-32-43	58"	20-1/16"	8-15/16"	94	003-304650-030	2
3.2	11,000	575	3	3.2	CVEP-C-32-63	58"	20-1/16"	8-15/16"	94	003-304650-031	2
4.0	13,600	208	1	19.2	CVEP-C-40-81	70"	20-1/16"	8-15/16"	112	003-304650-045	2
4.0	13,600	208	3	11.1	CVEP-C-40-83	70"	20-1/16"	8-15/16"	112	003-304650-048	2
4.0	13,600	240	1	16.7	CVEP-C-40-21	70"	20-1/16"	8-15/16"	112	003-304650-046	2
4.0	13,600	240	3	9.6	CVEP-C-40-23	70"	20-1/16"	8-15/16"	112	003-304650-049	2
4.0	13,600	277	1	14.4	CVEP-C-40-71	70"	20-1/16"	8-15/16"	112	003-304650-047	2
4.0	13,600	480	1	8.3	CVEP-C-40-41	70"	20-1/16"	8-15/16"	112	003-304650-094	2
4.0	13,600	480	3	4.8	CVEP-C-40-43	70"	20-1/16"	8-15/16"	112	003-304650-052	2
4.0	13,600	575	3	7.0	CVEP-C-40-63	70"	20-1/16"	8-15/16"	112	003-304650-053	2

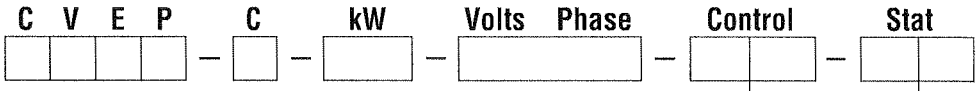
Temperature Rating T2A 536˚F (280˚C)

kW	BTU	Volts	Phase	Amps	Model	Width A	Height B	Depth C	Wt. (Lbs.)	Element P/N	Qty.
1.8/3.6	6,150/12,300	208	1	8.7/17.3	CVEP-C-18/36-81	34"	20-1/16"	8-15/16"	46/58	003-304650-034	1 or 2
1.8/3.6	6,150/12,300	208	3	5.0/10.0	CVEP-C-18/36-83	34"	20-1/16"	8-15/16"	46/58	003-304650-038	1 or 2
1.8/3.6	6,150/12,300	240	1	7.5/15.0	CVEP-C-18/36-21	34"	20-1/16"	8-15/16"	46/58	003-304650-098	1 or 2
1.8/3.6	6,150/12,300	240	3	4.3/8.7	CVEP-C-18/36-23	34"	20-1/16"	8-15/16"	46/58	003-304650-039	1 or 2
1.8/3.6	6,150/12,300	277	1	6.5/13.0	CVEP-C-18/36-71	34"	20-1/16"	8-15/16"	46/58	003-304650-036	1 or 2
1.8/3.6	6,150/12,300	480	1	3.8/7.5	CVEP-C-18/36-41	34"	20-1/16"	8-15/16"	46/58	003-304650-037	1 or 2
1.8/3.6	6,150/12,300	480	3	2.2/4.3	CVEP-C-18/36-43	34"	20-1/16"	8-15/16"	46/58	003-304650-042	1 or 2
1.8/3.6	6,150/12,300	575	3	1.8/3.6	CVEP-C-18/36-63	34"	20-1/16"	8-15/16	46/58	003-304650-043	1 or 2
7.6	25,930	208	1	36.5	CVEP-C-76-81	58"	20-1/16"	8-15/16"	94	003-304650-055	2
7.6	25,930	208	3	21.1	CVEP-C-76-83	58"	20-1/16"	8-15/16"	94	003-304650-058	2
7.6	25,930	240	1	31.7	CVEP-C-76-21	58"	20-1/16"	8-15/16"	94	003-304650-099	2
7.6	25,930	240	3	18.3	CVEP-C-76-23	58"	20-1/16"	8-15/16"	94	003-304650-059	2
7.6	25,930	277	1	27.4	CVEP-C-76-71	58"	20-1/16"	8-15/16"	94	003-304650-057	2
7.6	25,930	480	1	15.8	CVEP-C-76-41	58"	20-1/16"	8-15/16"	94	003-304650-095	2
7.6	25,930	480	3	9.1	CVEP-C-76-43	58"	20-1/16"	8-15/16"	94	003-304650-062	2
7.6	25,930	575	3	7.6	CVEP-C-76-63	58"	20-1/16"	8-15/16"	94	003-304650-063	2
4.5/9.0	15,350/30,700	208	1	21.6/43.3	CVEP-C-45/90-81	70"	20-1/16"	8-15/16"	87/112	003-304650-065	1 or 2
4.5/9.0	15,350/30,700	208	3	12.5/25.0	CVEP-C-45/90-83	70"	20-1/16"	8-15/16"	87/112	003-304650-069	1 or 2
4.5/9.0	15,350/30,700	240	1	18.8/37.5	CVEP-C-45/90-21	70"	20-1/16"	8-15/16"	87/112	003-304650-100	1 or 2
4.5/9.0	15,350/30,700	240	3	10.8/21.7	CVEP-C-45/90-23	70"	20-1/16"	8-15/16"	87/112	003-304650-070	1 or 2
4.5/9.0	15,350/30,700	277	1	16.2/32.5	CVEP-C-45/90-71	70"	20-1/16"	8-15/16"	87/112	003-304650-067	1 or 2
4.5/9.0	15,350/30,700	480	1	9.4/18.8	CVEP-C-45/90-41	70"	20-1/16"	8-15/16"	87/112	003-304650-068	1 or 2
4.5/9.0	15,350/30,700	480	3	5.4/10.8	CVEP-C-45/90-43	70"	20-1/16"	8-15/16"	87/112	003-304650-073	1 or 2
4.5/9.0	15,350/30,700	575	3	4.5/9.0	CVEP-C-45/90-63	70"	20-1/16"	8-15/16"	87/112	003-304650-074	1 or 2

REPLACEMENT PARTS

Model Any Voltage	Front Cover Assembly	Rear Cover Assembly	Right Side Panel	Left Side Panel	Element Support Bracket
CVEP-C-16/18/36	207-304644-101	207-304644-001	207-304644-201	304-304644-301	027-304646-001
CVEP-C-32/76	207-304644-102	207-304644-002	207-304644-201	304-304644-301	027-304646-001
CVEP-C-40/45/90	207-304644-103	207-304644-003	207-304644-201	304-304644-301	027-304646-001

*** Included when unit is equipped with control(s).**



Code	Control Combination	
	Contactor Coil	Transformer Secondary
00	None	None
30	24 Volt	24 Volt
31	24 Volt	None
32	120 Volt	120 Volt
33	120 Volt	None
34	208/240 Volt	None
35	277 Volt	None

Code	Thermostat
00	None
40	300-049197-003
42	300-113075-003

Contactor		
Coil Voltage	30 Amp	50 Amp
24V	072-304551-001	072-304551-002
120V	072-304551-007	072-304551-008
208/240V	072-304551-013	072-304551-014
277V	072-304551-019	072-304551-020

Primary Voltage	Secondary Voltage	Transformer
208/240/480	24	315-304252-002
208/240/480	120	315-304252-001
277	24	315-304252-004
575	24	315-304252-005
277/575	120	315-304252-003

WARRANTY AND LIMITATION OF REMEDY AND LIABILITY

Chromalox warrants only that the Products and parts manufactured by Chromalox, when shipped, and the work performed by Chromalox when performed, will meet all applicable specification and other specific product and work requirements (including those of performance), if any, and will be free from defects in material and workmanship under normal conditions of use. All claims for defective or nonconforming (both hereinafter called defective) Products, parts or work under this warranty must be made in writing immediately upon discovery, and in any event, within one (1) year from delivery, provided, however all claims for defective Products and parts must be made in writing no later than eighteen (18) months after shipment by Chromalox. Defective and nonconforming items must be held for Chromalox's inspections and returned to the original f.o.b. point upon request. THE FOREGOING IS EXPRESSLY IN LIEU OF ALL OTHER WARRANTIES WHATSOEVER, EXPRESS, IMPLIED AND STATUTORY, INCLUDING, WITHOUT LIMITATION, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

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W2008M

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PRECISION HEAT AND CONTROL
2150 N. RULON WHITE BLVD., OGDEN, UT 84404
Phone: 1-800-368-2493 www.chromalox.com

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ASHCROFT®

PRESSURE GAUGE INSTALLATION, OPERATION AND MAINTENANCE

I&M008-10098-5/02 (250-1353-K) Rev. 01/12

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1.0 SELECTION & APPLICATION

Users should become familiar with ASME B40.100 (Gauges – Pressure Indicating Dial Type – Elastic Element) before specifying pressure measuring gauges. That document – containing valuable information regarding gauge construction, accuracy, safety, selection and testing – may be ordered from:

ASME International
Three Park Avenue
New York, N.Y. 10016-5990
800-843-2763 (US/Canada)
001-800-843-2763 (Mexico)
973-882-1170 outside North America
email: infocentral@asme.org
www.asme.org

WARNING: To prevent misapplication, pressure gauges should be selected considering media and ambient operating conditions. Improper application can be detrimental to the gauge, causing failure and possible personal injury, property damage or death. The information contained in this manual is offered as a guide in making the proper selection of a pressure gauge. Additional information is available from Ashcroft Inc.

The following is a highlight of some of the more important considerations:

1.1 Range – The range of the instrument should be approximately twice the maximum operating pressure. Too low a range may result in (a) low fatigue life of the elastic element due to high operating stress and (b) susceptibility to overpressure set due to pressure transients that exceed the normal operating pressure. Too high a range may yield insufficient resolution for the application.

1.2 Temperature – Refer to Section 2 of this manual for important information concerning temperature related limitations of pressure gauges, both dry and liquid filled.

1.3 Media – The material of the process sensing element must be compatible with the process media. Use of a diaphragm seal with the gauge is recommended for process media that (a) is corrosive to the process sensing element; (b) contain heavy particulates (slurries) or (c) are very viscous including those that harden at room temperature.

1.4 Oxidizing media – Gauges for direct use on oxidizing media should be specially cleaned. Gauges for oxygen service should be ordered to variation X6B and will carry the ASME required dial marking "USE NO OIL" in red letters. Gauges for direct use on other oxidizing media may be ordered to variation X6W. They will be cleaned but carry no dial marking. *PLUS!*™ Performance gauges or Halocarbon filled gauge or diaphragm fill is required for use with oxidizing media; order variation XCF.

1.5 Pulsation/Vibration – Pressure pulsation can be dampened by several mechanisms; the patented *PLUS! Performance* gauge will handle the vast majority of applications. One exception to this is high frequency pulsation which is difficult to detect. The only indication may be an upscale zero shift due to movement wear. These applications should be addressed with a liquid filled gauge, or in extreme cases, a remotely mounted liquid filled gauge connected with a length of capillary line. The small diameter of the capillary provides excellent dampening, but can be plugged. The Ashcroft 1106 pulsation dampener and 1112 snubber are auxiliary devices which dampen pulsation with less tendency to plug.

1.6 Gauge fills. – Once it has been determined that a liquid filled gauge is in order, the next step is selecting the type of fill. **Glycerin** satisfies most applications. While being the least expensive fill, its usable temperature range is 20/180°F. **Silicone** filled gauges have a broader service range: –40/250°F. Oxidizing media require the use of **Halocarbon,** with a service range of –40/250°F. Pointer motion will be slowed at the low end of the low end of these temperature ranges.

1.7 Mounting – Users should predetermine how the gauge will be mounted in service: stem (pipe), wall (surface) or panel (flush). Ashcroft wall or panel mounting kits should be ordered with the gauge. See Section 3.

2.0 TEMPERATURE

2.1 Ambient Temperature – To ensure long life and accuracy, pressure gauges should preferably be used at an ambient temperature between –20 and +150°F (–30 to +65°C). At very low temperatures, standard gauges may exhibit slow pointer response. Above 150°F, the accuracy will be affected by approximately 1.5% per 100°F. Other than discoloration of the dial and hardening of the gasketing and degradation of accuracy, non-liquid filled Type 1279 (phenolic case) and 1379 (aluminum case) Duragauge® gauge, with standard glass windows, can withstand continuous operating temperatures up to 250°F. Unigauge models 2½″ and 3½″ 1009 and 1008S liquid filled gauges can withstand 200°F but glycerin fill and the acrylic window of Duragauge® gauges will tend to yellow. Silicone fill will have much less tendency to yellow. Low pressure, liquid filled Types 1008 and 1009 gauges may have some downscale errors caused by liquid fill expansion. This can be alleviated by venting the gauge at the top plug (pullout the blue plug insert). To do this the gauge must be installed in the vertical position.

Although the gauge may be destroyed and calibration lost, gauges can withstand short times at the following temperatures: gauges with all welded pressure boundary joints, 750°F (400°C); gauges with silver brazed joints, 450°F (232°C) and gauges with soft soldered joints, 250°F (121°C). For expected long term service below –20°F (–30°C) Duragauge® and 4½″ 1009 gauges should be hermetically sealed and specially lubricated; add "H" to the product code for hermetic sealing. Add variation XVY for special lubricant. Standard Duralife® gauges may be used to –50°F (–45°C) without modification.

2.2 Accuracy – Heat and cold affect accuracy of indication. A general rule of thumb for **dry gauges** is 0.5% of full scale change for every 40°F change from 75°F. Double that allowance for gauges with hermetically sealed or liquid filled cases, except for Duragauge® gauges where no extra allowance is required due to the elastomeric, compensating back. Above 250°F there may exist very significant errors in indication.

2.3 Steam service – In order to prevent live steam from entering the Bourdon tube, a siphon filled with water should be installed between the gauge and the process line. Siphons can be supplied with ratings up to 4,000 psi. If freezing of the condensate in the loop of the siphon is a possibility, a diaphragm seal should be used to isolate the gauge from the process steam. Siphons should also be used whenever condensing, hot vapors (not just steam) are present. Super heated steam should have enough piping or capillary line ahead of the siphon to maintain liquid water in the siphon loop.

2.4 Hot or very cold media – A five foot capillary line assembly will bring most hot or cold process media within the recommended gauge ambient temperature range. For media above

750°F (400°C) the customers should use their own small diameter piping to avoid possible corrosion of the stainless steel. The five foot capillary will protect the gauges used on the common cryogenic (less than –300°F (200°C) gases, liquid argon, nitrogen, and oxygen.) The capillary and gauge must be cleaned for oxygen service. The media must not be corrosive to stainless steel, and must not plug the small bore of the capillary.

2.5 Diaphragm seals – A diaphragm seal should be used to protect gauges from corrosive media, or media that will plug the instrument. Diaphragm seals are offered in a wide variety of designs and corrosion resistant materials to accommodate almost any application and most connections. Visit www.ashcroft.com for details.

2.6 Autoclaving – Sanitary gauges with clamp type connections are frequently steam sterilized in an autoclave. Gauges equipped with polysulfone windows will withstand more autoclave cycles than those equipped with polycarbonate windows. Gauges equipped with plain glass or laminated safety glass **should not be autoclaved.** Gauge cases should be vented to atmosphere (removing the rubber fill/safety plug if necessary) **before** autoclaving to prevent the plastic window from cracking or excessively distorting. If the gauge is liquid filled, the fill should be drained from the case and the front ring loosened before autoclaving.

3.0 INSTALLATION

3.1 Location – Whenever possible, gauges should be located to minimize the effects of vibration, extreme ambient temperatures and moisture. Dry locations away from very high thermal sources (ovens, boilers etc.) are preferred. If the mechanical vibration level is extreme, the gauge should be remotely located (usually on a wall) and connected to the pressure source via flexible tubing.

3.2 Gauge reuse – ASME B40.100 recommends that gauges not be moved indiscriminately from one application to another. The cumulative number of pressure cycles on an in-service or previously used gauge is generally unknown, so it is generally safer to install a new gauge whenever and wherever possible. This will also minimize the possibility of a reaction with previous media.

3.3 Tightening of gauge – Torque should never be applied to the gauge case. Instead, an open end or adjustable wrench should always be used on the wrench flats of the gauge socket to tighten the gauge into the fitting or pipe. NPT threads require the use of a suitable thread sealant, such as pipe dope or teflon tape, and must be tightened very securely to ensure a leak tight seal.

CAUTION: Torque applied to a diaphragm seal or its attached gauge, that tends to loosen one relative to the other, can cause loss of fill and subsequent inaccurate readings. Always apply torque **only** to the wrench flats on the lower seal housing when installing filled, diaphragm seal assemblies or removing same from process lines.

3.4 Process isolation – A shut-off valve should be installed between the gauge and the process in order to be able to isolate the gauge for inspection or replacement without shutting down the process.

3.5 Surface mounting – Also known as wall mounting. Gauges should be kept free of piping strains. The gauge case mounting feet, if applicable, will ensure clearance between the pressure relieving back and the mounting surface.

3.6 Flush mounting – Also known as panel mounting. The applicable panel mounting cutout dimensions can be found at www.ashcroft.com

4.0 OPERATION

4.1 Frequency of inspection – This is quite subjective and depends upon the severity of the service and how critical the accuracy of the indicated pressure is. For example, a monthly inspection frequency may be in order for critical, severe service applications. Annual inspections, or even less frequent schedules, are often employed in non-critical applications.

4.2 In-service inspection – If the accuracy of the gauge cannot be checked in place, the user can at least look for (a) erratic or random pointer motion; (b) readings that are suspect – especially indications of pressure when the user believes the true pressure is 0 psig. Any gauge which is obviously not working or indicating erroneously, should be immediately valved-off or removed from service to avoid a possible pressure boundary failure.

4.3 When to check accuracy – Any suspicious behavior of the gauge pointer warrants that a full accuracy check be performed. Even if the gauge is not showing any symptoms of abnormal performance, the user may want to establish a frequency of bench type inspection.

4.4 When to recalibrate – This depends on the criticality of the application. If the accuracy of a 3-2-3% commercial type gauge is only 0.5% beyond specification, the user must decide whether it's worth the time and expense to bring the gauge back into specification. Conversely if the accuracy of a 0.25% test gauge is found to be 0.1% out of specification then the gauge should be recalibrated.

4.5 Other considerations – These include (a) bent or unattached pointers due to extreme pressure pulsation; (b) broken windows which should be replaced to keep dirt out of the internals; (c) leakage of gauge fill; (d) case damage – dents and/or cracks; (e) any signs of service media leakage through the gauge including its connection; (f) discoloration of gauge fill that impedes readability.

4.6 Spare parts – As a general rule it is recommended that the user maintain in inventory one complete Ashcroft® instrument for every ten (or fraction thereof) of that instrument type in service.

5.0 GAUGE REPLACEMENT

It is recommended that the user stock one complete Ashcroft® instrument for every ten (or fraction thereof) of that instrument type in service. With regard to gauges having a service history, consideration should be given to discarding rather than repairing them. Gauges in this category include the following:

a. Gauges that exhibit a span shift greater than 10%. It is possible the Bourdon tube has suffered thinning of its walls by corrosion.

b. Gauges that exhibit a zero shift greater than 25%. It is likely the Bourdon tube has seen significant overpressure leaving residual stresses that may be detrimental to the application.

c. Gauges which have accumulated over 1,000,000 pressure cycles with significant pointer excursion.

d. Gauges showing any signs of corrosion and/or leakage of the pressure system.

e. Gauges which have been exposed to high temperature or exhibit signs of having been exposed to high temperature – specifically 250°F or greater for soft soldered systems; 450°F or greater for brazed systems; and 750°F or greater for welded systems.

f. Gauges showing significant friction error and/or wear of the movement and linkage.

g. Gauges having damaged sockets, especially damaged threads.

h. Liquid filled gauges showing loss of case fill.

NOTE: ASME B40.100 does not recommend moving gauges from one application to another. This policy is prudent in that it encourages the user to procure a new gauge, properly tailored by specification, to each application that arises.

6.0 ACCURACY: PROCEDURES/DEFINITIONS

Accuracy inspection – Readings at approximately five points equally spaced over the dial should be taken, both upscale and downscale, before and after lightly rapping the gauge to remove friction. **A pressure standard with accuracy at least four times greater than the accuracy of the gauge being tested is recommended.**

Equipment – A finely regulated pressure supply will be required. It is critical that the piping system associated with the test setup be leaktight. The gauge under test should be positioned as it will be in service to eliminate positional errors due to gravity.

Method – ASME B40.100 recommends that **known** pressure (based on the reading from the pressure standard used) be applied to the gauge under test. Readings including any error from the nominal input pressure, are then taken from the gauge under test. The practice of aligning the pointer of the gauge under test with a dial graduation and then reading the error from the master gauge ("reverse reading") can result in inconsistent and misleading data and should NOT be used.

Calibration chart – After recording all of the readings it is necessary to calculate the errors associated with each test point using the following formula: ERROR in percent = 100 times (TRUE VALUE minus READING) ÷ RANGE. Plotting the individual errors (Figure 1) makes it possible to visualize the total gauge characteristic. The plot should contain all four curves: upscale – before rap; upscale – after rap; downscale – before rap; downscale – after rap. "*Rap*" means lightly tapping the gauge **before** reading to remove friction as described in ASME B40.100.

Referring to Figure 1, several classes of error may be seen:

Zero – An error which is approximately equal over the entire scale. This error can be manifested when either the gauge is

FIG. 1

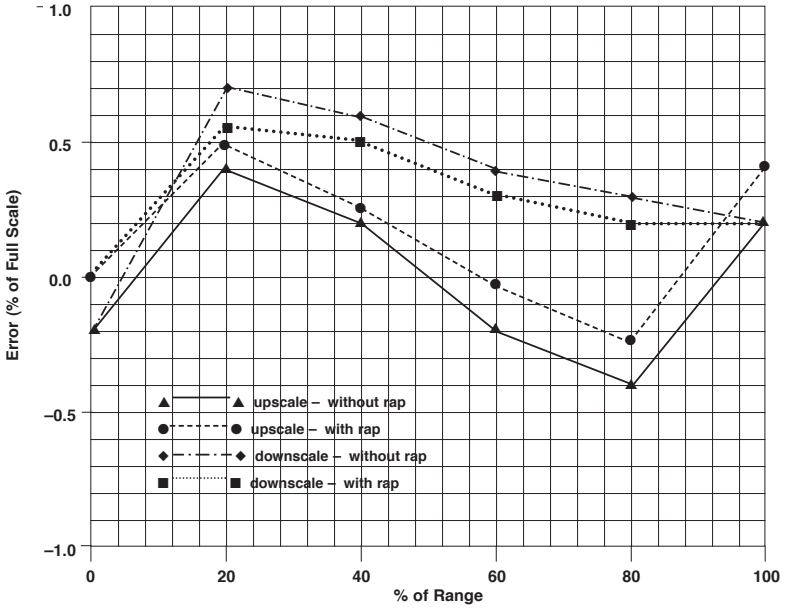
TYPICAL CALIBRATION CHART

INDICATED VALUE (PSI)

True Value – PSI	Increasing – Without RAP	Increasing – With RAP	Decreasing – Without RAP	Decreasing – With RAP
0	–.4	0	–.4	0
40	+.8	+1.0	+1.4	+1.1
80	+.4	+.5	+1.2	+1.0
120	–.4	–1.0	+.8	+.6
160	–.8	–.5	+.6	+.4
200	+.4	+.8	+.4	+.4

ERROR (% OF FULL SCALE)

True Value – % of Range	Increasing – Without RAP	Increasing – With RAP	Decreasing – Without RAP	Decreasing – With RAP
0	–.20	0	–.20	0
20	+.40	+.50	+.70	+.55
40	+.20	+.25	+.60	+.50
60	–.20	–.05	+.40	+.30
80	–.40	–.25	+.30	+.20
100	+.20	+.40	+.20	+.20



dropped or overpressured and the Bourdon tube takes a permanent set. This error may often be corrected by simply repositioning the pointer. Except for test gauges, it is recommended that the pointer be set at midscale pressure to "split" the errors.

Span – A span error exists when the error at full scale pressure is different from the error at zero pressure. This error is often proportional to the applied pressure. Most Ashcroft gauges are equipped with an internal, adjusting mechanism with which the user can correct any span errors which have developed in service.

Linearity – A gauge that has been properly spanned can still be out of specification at intermediate points if the response of the gauge as seen in Figure 1 (Typical Calibration Chart) is not linear. The Ashcroft Duragauge® pressure gauge is equipped with a rotary movement feature which permits the user to minimize this class of error. Other Ashcroft gauge designs (e.g., 1009 Duralife®) require that the dial be moved left or right prior to tightening the dial screws.

Hysteresis – Some Bourdon tubes have a material property known as hysteresis. This material characteristic results in differences between the upscale and downscale curves. This class of error can **not** be eliminated by adjusting the gauge movement or dial position.

Friction – This error is defined as the difference in readings before and after lightly tapping the gauge case at a check point. Possible causes of friction are burrs or foreign material in the movement gearing, "bound" linkages between the movement and the bourdon tube, or an improperly tensioned hairspring. If correcting these potential causes of friction does not eliminate excessive friction error, the movement should be replaced.

6.1 Calibration – Rotary Movement Gauges and Type 1259 Gauges – Inspect gauge for accuracy. Many times gauges are simply "off zero" and a simple pointer adjustment using the micrometer pointer is adequate. If inspection shows the gauge warrants recalibration to correct span and/or linearity errors, proceed as follows:

a. Remove ring, window and, if solid front case, the rear closure assembly.

b. Pressurize the gauge **once** to full scale and back to zero.

c. Refer to Figure 2 (Ashcroft System Assembly w/Rotary Gear Movement) for a view of a typical Ashcroft rotary system assembly with component parts identified. Refer to Figure 2A for link configuration of Type 1259 gauge.

FIG. 2 ASHCROFT SYSTEM ASSEMBLY W/ROTARY GEAR MOVEMENT

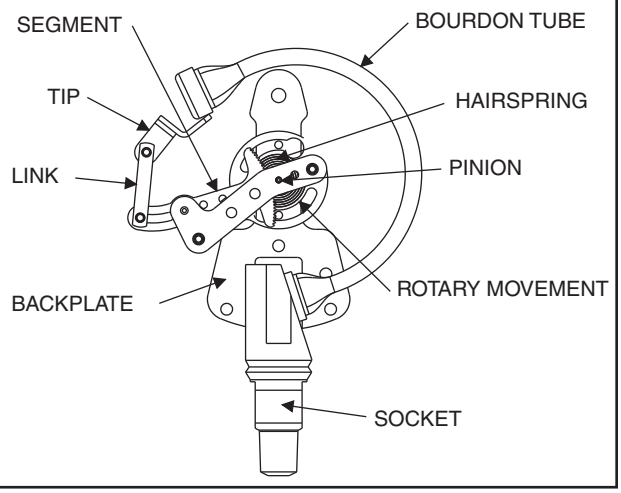
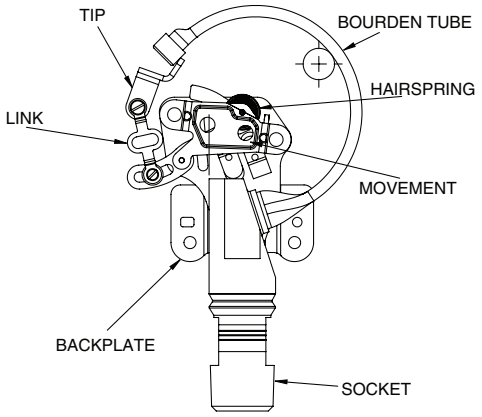


FIG. 2A ASHCROFT TYPE 1259 SYSTEM ASSEMBLY



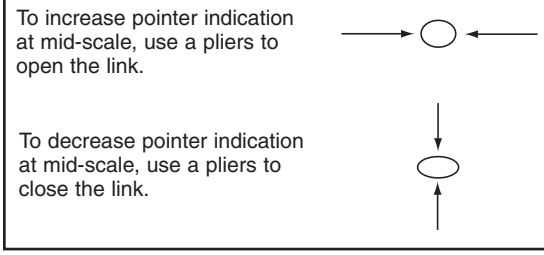
d. Adjust the micrometer pointer so that it rests at the true zero position. For open front gauges the pointer and dial must also be disassembled and the pointer should then be lightly pressed onto the pinion at the 9:00 o'clock position.

e. Apply full scale pressure and note the magnitude of the span error. With open front gauges, ideal span (270 degrees) will exist when at full scale pressure the pointer rests exactly at the 6:00 o'clock position.

f. If the span has shifted significantly (span error greater than 10%), the gauge should be replaced because there may be some partial corrosion inside the Bourdon tube which could lead to ultimate failure. If the span error exceeds 0.25%, loosen the lower link screw and move the lower end of the link toward the movement to increase span or away to decrease span. An adjustment of 0.004 inch will change the span by approximately 1%. This is a repetitive procedure which often requires more than one adjustment of the link position and the subsequent rechecking of the errors at zero and full scale pressure.

g. Apply midscale pressure and note error in reading. Even though the gauge is accurate at zero and full scale, it may be inaccurate at the midpoint. This is called linearity error. For corrections to linearity with the Type 1259 gauges refer to Figure 2B. For rotary movement gauges,

FIG. 2B LINEARITY ADJUSTMENT & LINK CONFIGURATION FOR ASHCROFT TYPE 1259



note the following: if the error is positive, the movement should be rotated counter clockwise. Rotating the movement one degree will change this error by approximately 0.25%. Rotating the movement often affects span and it should be subsequently rechecked and readjusted if necessary according to step 6.1e and 6.1f.

h. While recalibrating the gauge, the friction error – difference in readings taken with and without rap – should be noted. This error should not exceed the basic accuracy

of the gauge. If the friction error is excessive, the movement should be replaced. One possible cause of excessive friction is improper adjustment of the hairspring. The hairspring torque,or tension, must be adequate without being excessive. The hairspring should also be level, unwind evenly (no turns rubbing) and it should never tangle.

NOTES:

1 For operation of test gauge external zero reset, refer to page 17.

2 For test gauge calibration procedure, refer to Figure 2 on page 18.

7.0 DIAPHRAGM SEALS

7.1 General – A diaphragm seal (isolator) is a device which is attached to the inlet connection of a pressure instrument to isolate its measuring element from the process media. The space between the diaphragm and the instrument's pressure sensing element is solidly filled with a suitable liquid. Displacement of the liquid fill in the pressure element, through movement of the diaphragm, transmits process pressure changes directly to a gauge, switch or any other pressure instrument. When diaphragm seals are used with pressure gauges, an additional 0.5% tolerance must be added to the gauge accuracy because of the diaphragm spring rate.

Used in a variety of process applications where corrosives, slurries or viscous fluids may be encountered, the diaphragm seal affords protection to the instrument where:

- The process fluid being measured would normally clog the pressure element.
- Pressure element materials capable of withstanding corrosive effects of certain fluids are not available.
- The process fluid might freeze due to changes in ambient temperature and damage the element.

7.2 Installation – Refer to bulletin OH-1 for information regarding (a) seal configurations; (b) filling fluids; (c) temperature range of filling fluids; (d) diaphragm material pressure and temperature limits; (e) bottom housing material pressure and temperature limits; (f) pressure rating of seal assembly; (g) accuracy/temperature errors of seal assembly; (h) diaphragm seal displacement. The volumetric displacement of the diaphragm must at least equal the volumetric displacement of the measuring element in the pressure instrument to which the seal is to be attached.

It is imperative that the pressure instrument/diaphragm seal assembly be **properly** filled prior to being placed in service. Ashcroft diaphragm seal assemblies should only be filled by a seal assembler certified by Ashcroft Inc. Refer to section 3.3 for a cautionary note about not applying torque on either the instrument or seal relative to the other.

7.3 Operation – All Ashcroft® diaphragm seals, with the exception of Type 310 mini-seals, are continuous duty. Should the pressure instrument fail, or be removed accidentally or deliberately, the diaphragm will seat against a matching surface preventing damage to the diaphragm or leakage of the process fluid.

7.4 Maintenance – Clamp type diaphragm seals – Types 100, 200 and 300 – allow for replacement of the diaphragm or diaphragm capsule, if that ever becomes necessary. The Type 200 top housing must also be replaced with the diaphragm. With all three types the clamping arrangement allows field disassembly to permit cleaning of the seal interior.

7.5 Failures – Diaphragm failures are generally caused by either corrosion, high temperatures or fill leakage. Process media build-up on the process side of the diaphragm can also require seal cleaning or replacement. Consult Customer Service, Stratford CT for advice on seal failures and/or replacement.

WARNING: All seal components should be selected considering process and ambient operating conditions to prevent misapplication. Improper application could result in failure, possible personal injury, property damage or death.

8.0 DAMPENING DEVICES

8.1 General – Some type of dampening device should be used whenever the pressure gauge may be exposed to repetitive pressure fluctuations that are fairly rapid, high in magnitude and especially when transitory pressure spikes exceeding the gauge range are present (as with starting and stopping action of valves and pumps). A restricted orifice of some kind is employed through which pressure fluctuations must pass before they reach the Bourdon tube. The dampener reduces the magnitude of the pressure pulse thus extending the life of the Bourdon tube and movement. This reduction of the pressure pulsation as "seen" by the pressure gauge is generally evidenced by a reduction in the pointer travel. If the orifice is very small the pointer may indicate the average service pressure, with little or no indication of the time varying component of the process pressure.

Commonly encountered media (e.g. – water and hydraulic oil) often carry impurities which can plug the orifice over time thus rendering the gauge inoperative until the dampener is cleaned or replaced.

Highly viscous media and media that tend to periodically harden (e.g., asphalt) require a diaphragm seal be fitted to the gauge. The seal contains an internal orifice which dampens the pressure fluctuation within the fill fluid.

8.2 Throttle Screws & Plugs – These accessories provide dampening for the least cost. They have the advantage of fitting completely within the gauge socket and come in three types: (a) a screwed-in type which permits easy removal for cleaning or replacement; (b) a pressed in, non-threaded design and (c) a pressed in, threaded design which provides a highly restrictive, helical flow path. Not all styles are available on all gauge types.

8.3 Ashcroft Pulsation Dampener – Type 1106 Ashcroft pulsation dampener is a moving pin type in which the restricted orifice is the clearance between the pin and any one of five preselected hole diameters. Unlike a simple throttle screw/plug, this device has a self-cleaning action in that the pin moves up and down under the influence of pressure fluctuations.

8.4 Ashcroft Pressure Snubber – The heart of the Type 1112 pressure snubber is a thick porous metal filter disc. The disc is available in four standard porosity grades.

8.5 Ashcroft Needle Valves – Type 7001 thru 7004 steel needle valves provide varying degrees of dampening. These devices, in the event of plugging, can easily be opened to allow the pressure fluid to clear away the obstruction.

8.6 Chemiquip® Pressure Limiting Valves – Model PLV-255, PLV-2550, PLV-5460, PLV-5500 and PLV-6430, available with and without built-in snubbers, automatically "shut off" at adjustable preset values of pressure to protect the gauge from damage to overpressure. They are especially useful on hydraulic systems wherein hydraulic transients (spikes) are common.

9.0 TEST EQUIPMENT & TOOL KITS

See our website www.ashcroft.com for more details

9.1 Pressure Instrument Testing Equipment

Type 1305D Deadweight Tester

Type 1327D Pressure Gauge Comparator

Type 1327CM “Precision” Gauge Comparator

9.2 Tools & Tool Kits For Recalibration of 4½˝ and Larger Gauges

Type 2505 universal carrying case for 1082 test gauge

Type 266A132-01 span wrench for 1082 test gauge

Type 1281 socket O-Ring kit for 1279/1379 lower connect

Type 1285 4½˝ ring wrench for 1279/1379 lower & back connect

Type 1286 6˝ ring wrench for 1379 lower & back connect

Type 3220 pointer puller (all gauges except 1009 Duralife®)

Type 3530 pinion back-up tool for 1009 Duralife®

Type 3220 Handjack set

Type 1105 Tool Kit

9.3 Kits to Convert a Dry Gauge to a Liquid Filled or Weather Proof Case Gauge

Type 1280 conversion kit for 4½˝ lower connect 1279/1379

Type 1283 conversion kit for 4½˝ back connect 1279/1379

Type 1284 conversion kit for 6˝ lower & back connect

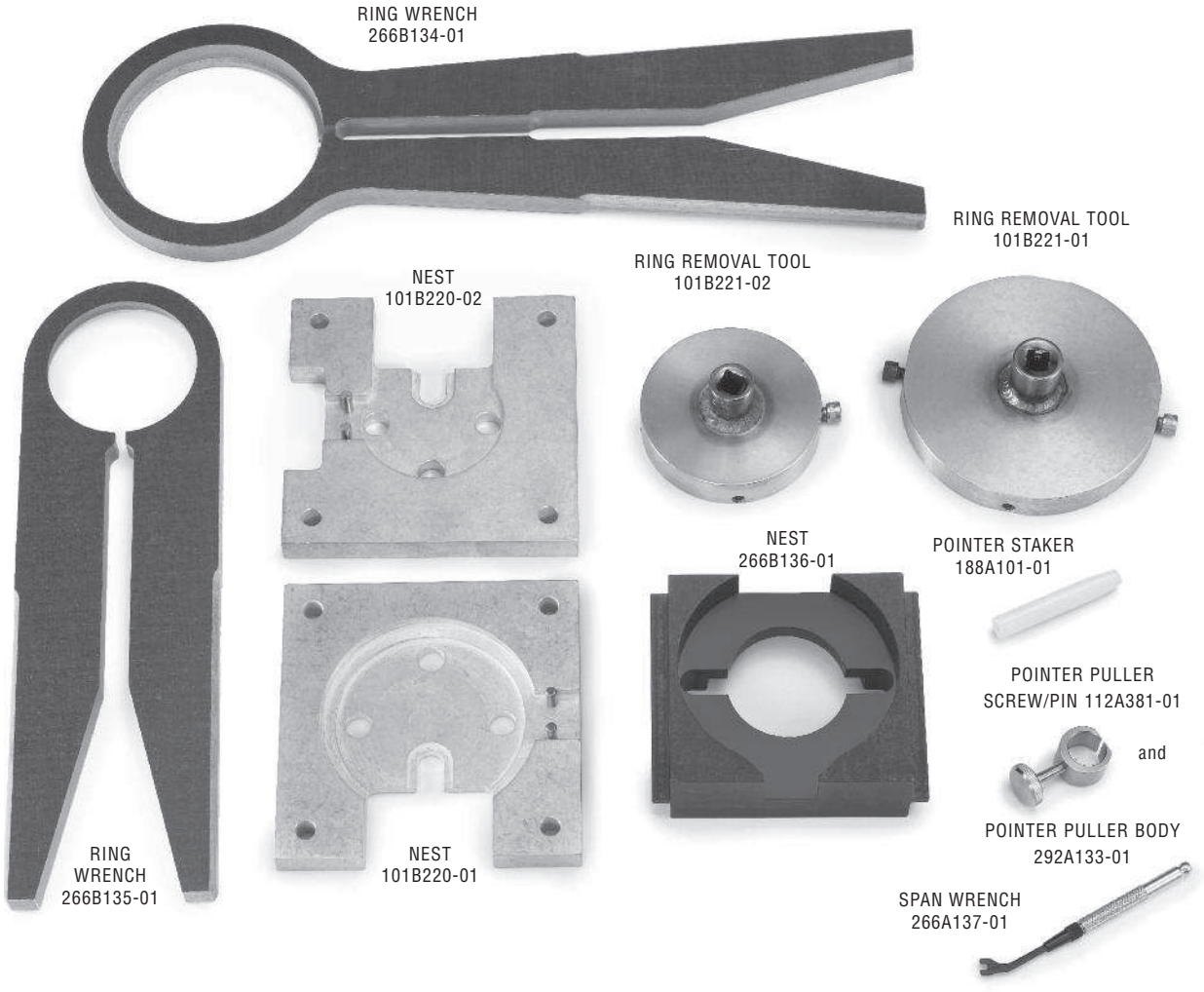
TYPE 1105
TOOL KIT

TYPE 3220
HAND JACK SET

9.4 2½ & 3½ 1009 Duralife® Gauge Tools

Description	Part No.
Pointer Puller Screw/Pin[2][3][4]	112A381-01
Pointer Puller Body[2][3][4]	292A133-01
Pointer Staker[2][4]	188A101-01
Span Wrench[2][5] (to adjust span)	266A137-01
Ring Wrench 3½″[1][5] (for ring removal) (35 1009)	266B134-01
Ring Wrench 2½″[1][5] (for ring removal) (25 1009)	266B135-01
Nest 2½″ & 3½″[1][5] (to hold gauge for ring removal) (25/35 1009)	266B136-01
Ring Removal Tool[6] (25 1009)	101B221-02
Ring Removal Tool[6] (35 1009)	101B221-01
Nest 2½″[6] (to hold gauge for ring removal) (25 1009)	101B220-02
Nest 3½″[6] (to hold gauge for ring removal) (35 1009)	101B220-01
Type 1230 throttle plug insertion (¼ NPT) for 1009 Duralife®)	1230
Type 1231 throttle plug insertion (½ NPT) for 1009 Duralife® (body only)	1231
Tool to open orifice on push-in throttle plug	101A206-01

(1) Formerly 1206T Tool Kit.
(2) Formerly some parts in 1205T Tool Kit.
(3) Both parts must be purchased together.
(4) Previous and current design.
(5) Previous design only.
(6) Current design only.



ASHCROFT® Type 1188 Bellows Gauge Calibration Procedure

CALIBRATION & TROUBLE CORRECTION DIAGRAM

RANGE SPAN ADJUSTMENT

- **RANGE TOO SHORT** — Adjust slide "S" inward
- **RANGE TOO LONG** — Adjust slide "S" outward

POINTER JUMPING

- **STICKY PARTS** — Clean all bearings and gear teeth
- **LOOSE HAIRSPRING** — Remove backlash by disengaging pinion & rotate to tighten
- **COUNTER BALANCE RUBBING** — Bend if necessary to clear socket in travel

NOTE: After adjusting range span, set both movement stops. Set the underload stop so that the pointer will stop at zero. Set the overload stop so that the pointer will pass the maximum range approximately 5˝.

After adjusting span re-zero pointer by removing from pinion and re-assembling at the proper dial mark.

SLUGGISH MOVEMENT

TIGHT HAIRSPRING — Loosen by disengaging pinion & rotate

NON LINEAR

- **NON LINEAR FIRST 3RD.** → **ADJ. ANGLE OF PULL BY INCREASING ANGLE "A"**
- **NON LINEAR LAST 3RD.** → **ADJ. ANGLE OF PULL BY DECREASING ANGLE "A"**

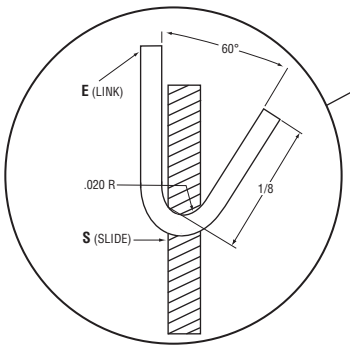
NOTE: To increase or decrease angle "A," bend tip inward or outward as required. Doing this may run the movement segment off the pinion. This can be corrected by cutting off one end off the link "E" decreasing its length, or makin a new length from .032 dia. phos. bronze wire.

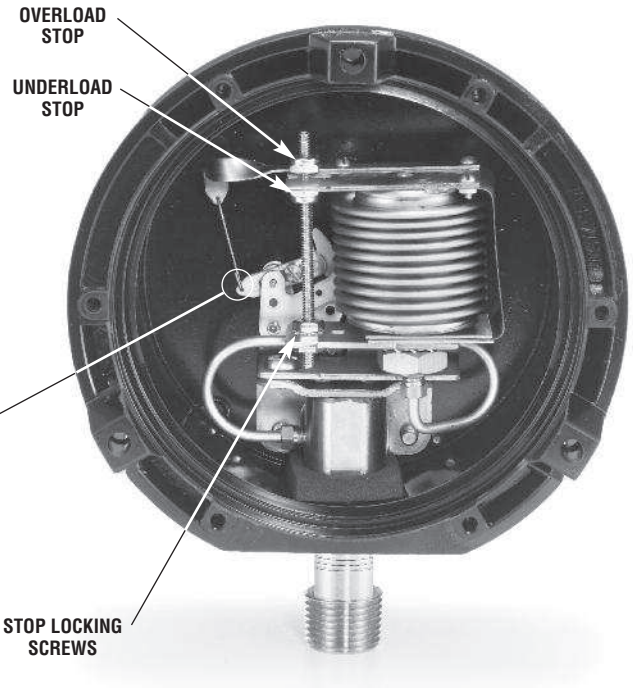
Caution: When reproducing link end, follow figure 44 very closely. this will prevent too much play, or, binding in operation.

REF: Replacing System Bellows

After assembling bellows to the gauge socket securely, subject system to 30 psi for five minutes, allowing bellows to travel approximately 1/8˝ against the overload stop. After this, heat treat system for 15 hours at 250°F, this procedure is necssary to prevent gauge drift.

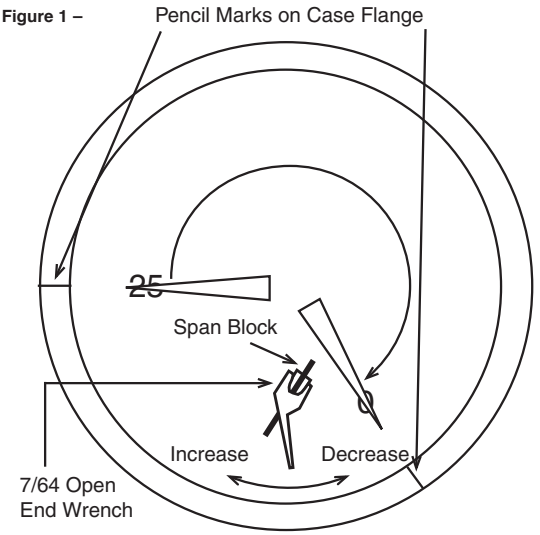
SLIDE AND LINK (angle "A")
Enlarged view of slide and link





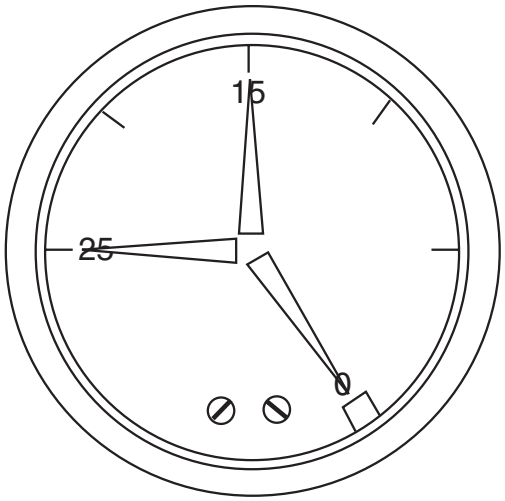
1. Remove ring, window and gasket pointer.
2. Using a pencil, refer to dial and mark the 0 and 25˝ Hg positions on the case flange.
3. Remove dial.
4. Apply 25˝ Hg vac.
5. Lightly press pointer onto pinion carefully aligning it with the 25˝ Hg vac. mark on the flange.
6. Release vacuum fully.
7. Note agreement of pointer to zero mark on flange.
8. If span is high or low, turn span block as shown in Figure 1.

Figure 1 –



9. Repeat steps 4 through 8 until span is correct.
10. Remove pointer.
11. With 25˝ Hg vac applied, reassemble dial, dial screws (finger tight) and point.
12. Apply 15˝ Hg vac. and note accuracy of indication. If required, slide dial left or right to reduce error to 1% maximum.
13. Firmly tighten dial screws.
14. Firmly tap pointer onto pinion.
15. recheck accuracy at 15 and 25˝ Hg vac. (Figure 2).
16. Reassemble window, gasket and ring.

Figure 2 –

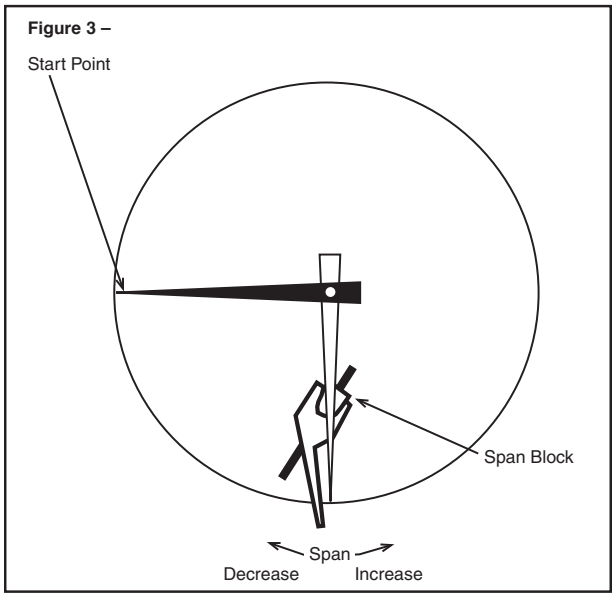


Notes: See page 10 for any tools required to calibrate.

For models produced prior to September 2008 for 2½˝ version and December 2008 for 3½˝ version.
Back of gauge will have a date code sticker.

Step 1. With the dial off, install pointer at 9 o'clock "lightly," Figure 3.

Figure 3 –

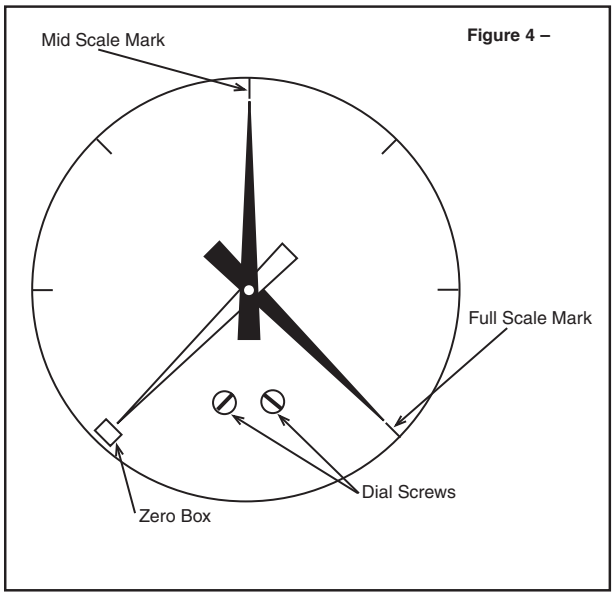


Step 2. Go to full scale pressure…rotate span block with tool until pointer rests at 6 o'clock.

Step 3. Go to zero pressure (9 o'clock)…if pointer has not moved away from start point, go to Step 4. If pointer has moved, repeat Step 1 until span is correct.

Step 4. Install dial with screws snug.

Figure 4 –



Step 5. Install pointer centered in zero box, Figure 4.

Step 6. Go to full scale pressure…check that pointer is within 1% of full scale mark. If not, remove pointer and dial and return to step 1, Figure 4.

Step 7. Go to mid-scale pressure…rotate dial until mid-scale mark is aligned with pointer, Figure 4.

Step 8. Tighten dials screws and stake on pointer.

Step 9. Check zero and full scale. Reassemble window, gasket and ring.

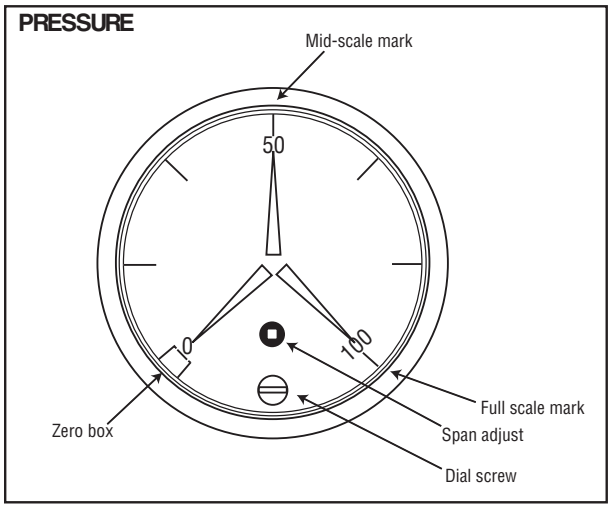
Notes: See page 10 for any tools required to calibrate.

For models produced prior to September 2008 for 2½˝ version and December 2008 for 3½˝ version.
Back of gauge will have a date code sticker.

ASHCROFT® Current Type 1009 Duralife® Calibration Procedure – Pressure and Vacuum Range

Calibration – 1009 Duralife® Gauge –
Inspect gauge for accuracy. At times gauges are simply "off zero" and opening the ventable plug at the top of the gauge will relieve internal gauge pressure and correct the offset. If this is not adequate and inspection shows that the gauge warrants recalibration to correct zero, span and/or linearity errors, proceed as follows:

Remove ring, window, and gasket using Ashcroft Ring Removal Tools P/N 101B220-02 and 101B221-02 for 2½" gauges and 101B220-01 and 101B221-01 for 3½" gauges.



Positive Pressure Ranges –

1. Adjust pointer with a slotted screwdriver until it is in the center of the zero box. This is often all that is required it correct calibration issues.

2. Apply full scale pressure. If error exceeds 1% rotate the black span adjustment device with a #0 square drive bit. Clockwise increases span, counterclockwise decrease span.

3. Fully exhaust pressure and check that pointer still is still in the zero box. If not, repeat step 1 and 2

4. Once 0 and full scale are within tolerance, pressurize gauge to mid-scale.

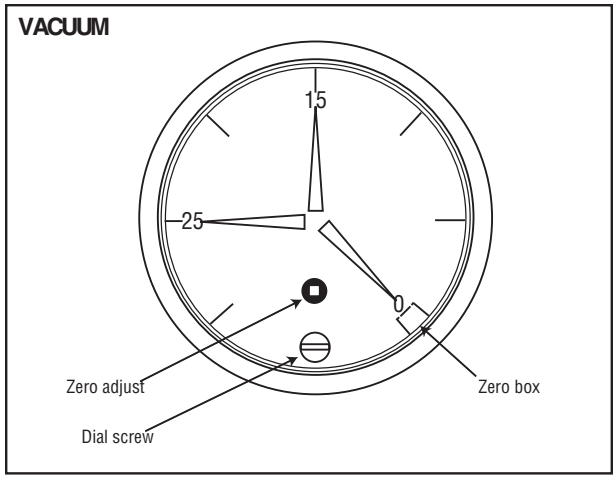
5. If gauge is within 1%, calibration is complete. If not loosen the dial screw and rotate dial left or right to adjust midpoint. Retighten dial screw.

6. If an adjustment was made in step 5, recheck the gauge at zero and full scale, adjust accordingly until zero, mid and full scale points are in tolerance.

Vacuum Range –

1. Adjust pointer with a slotted screwdriver until it is in the center of the zero box. This is often all that is required it correct calibration issues.

2. Apply 25 inches Hg vacuum. If the error exceeds 1% adjust pointer with a slotted screwdriver until gauge is within tolerance.



3. Vent to 0 pressure and check pointer position in the zero box. If error exceeds 1% rotate the black span adjustment device with a #0 square drive bit. Clockwise rotation moves pointer clockwise, counterclockwise rotation moves the pointer counterclockwise.

4. Repeat step 1 and 2 until 0 and 25 inches of Hg are within gauge tolerance.

5. Apply 15 inches Hg vacuum. If gauge is within 1%, calibration is complete. If not loosen the dial screw and rotate dial left or right to adjust midpoint. Retighten dial screw.

6. If an adjustment was made in step 4, recheck the gauge at zero and 25 inches of Hg vacuum, adjust accordingly until zero, 15 and 25 inches Hg are in tolerance.

7. Continue below.

Re-assemble window and ring to gauge:

a. If plastic window is used, push window back into front of gauge, ensure the o-ring does not roll out of window groove (lubricate if necessary). Align the tabs of the window with the tabs of the case front. Once window is in place, install ring and tighten with tools referenced above and shown on page 10.

b If safety glass is used, reinstall window, gasket, and ring. Ensure that the gasket is seated properly under all four tabs of the ring and does not wrinkle when ring is tightened.

Note: Tighten ring: Apply 120-200inlb of torque. Rotate ring clockwise to tighten. Warning: over tightening of safety glass may induce cracking.

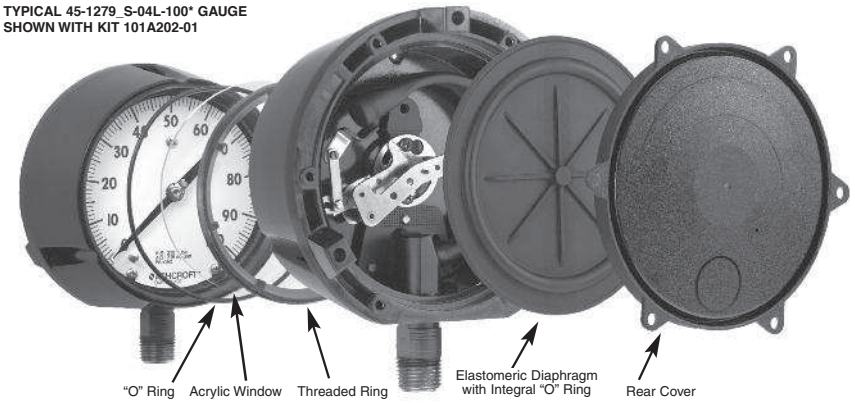
Notes: See page 10 for any tools required to calibrate.

For models produced after September 2008 for 2½" version and December 2008 for 3½" version.
Back of gauge will have a date code sticker.

Type 1279 & 1379 Solid Front Duragauge® Pressure Gauge Liquid Fill Conversion Instructions

ASHCROFT®

TYPICAL 45-1279_S-04L-100* GAUGE
SHOWN WITH KIT 101A202-01



	1279		1379		
	4½˝ LOWER	4½˝ BACK	4½˝ LOWER	4½˝ BACK	6˝ LOWER & BACK
KIT PART NO.	101A202-01	101A203-01	1280	1283	1284
	QUANTITY INCLUDED				
ACRYLIC WINDOW	1	1	1	1	1
FRONT O-RING	1	1	1	1	1
DIAPHRAGM(1)	1	1	1	1	2(1-LC:1-BC)
REAR COVER	1	1	1	1	2(1-LC:1-BC)
COVER SCREWS	4	4	-	-	-
THROTTLE SCREWS	2	2	2	2	2
GARTER SPRING	–	1	1	1	1
FILL IDENTIFICATION	1	1	1	1	1
THREADED RING	–	–	1	1	1

1. When Halocarbon fill is a requirement, rear case diaphragm bladder material is Viton instead of the standard Buna diaphragm bladder. Consult factory for part number.

	Ambient Temp. Limits		60 psi and Under Down Scale Zero Shift Required
	°F	°C	
Weatherproof	–50/150	–45/65	N/A
Hermetically Sealed	–10/125	–25/50	N/A
Glycerin Filled	0/150	30/65	.15 psi
Silicone Filled	–50/150	–45/65	.12 psi

1. Unscrew front threaded ring (turn CCW). Remove and discard glass window. For range spans 60 psi and under, shift pointer down scale by the amount shown in the table. With either the glass or plastic window, replace the O-ring with one furnished in the kit.
2. Remove protective paper from acrylic plastic window taking care not to scratch window. Assemble window in gauge.
3. Moisten face of threaded ring with silicone oil or silicone grease where ring bears up against window. Replace front threaded ring and tighten firmly hand tight. See instructions on reverse side for applying proper torque to ring to establish desired squeeze on O-ring seal. **(Fig. 4).**
   It is important to hold gauge **rigidly,** otherwise ring lugs may be damaged during removal or assembly process.
4. From rear of gauge, remove and discard these parts: rear cover and cover gaskets from case.
   Note: Disregard Step Nos. 5a and 5b if converting to hermetically sealed version. When converting a 45-1379 with the top fill hole configuration, p/n 256A176-01 fill plug is required and must be ordered separately.
5. **Filling Procedures:**
   a. **Manual Filling Procedure:** Place gauge face down on bench and **tip gauge** by blocking up front with a ⅜ inch block at the 12 o'clock dial position. Tipping of the gauge is necessary so fluid will flow into front cavity of the case. Pour in fill liquid to within about 1⁄16 inch of rear seal lip. When bubbles stop rising, front cavity is filled. Remove ⅜ inch block and pour in liquid until level is about 1⁄16 inch below rear sealing lip.
   Note: An alternative method of filling is to fill the front dial cavity, adding the front window, etc., as in Step No. 3. Then fill the rear of the gauge. This method eliminates the need to tip the gauge.
   b. **Vacuum Pump Fill Procedure:** (This procedure is recommended when filling a large number of gauges.) Place gauge face down and insert a ⅛ inch diameter tube, connected to a vacuum pump, through the 12 o'clock position hole in the rear, solid front portion of the case **(see Fig. 5).** Evacuate the air from the front dial cavity while pouring in the fill fluid through the case back. The vacuum will displace the air with fluid. When the dial cavity is solidly filled, remove the tubing and continue to pour the fill fluid to within 1⁄16 inch BELOW the O-ring channel lip. Pre-measuring fill amount is not necessary with above methods. For reference, amount of fill is approximately 400 ml. or 14 fluid oz. (4½˝ GA.) and 455 ml. or 16 fluid oz. (6˝ GA.).
   c. **Note:** The liquid fill level should be ⅜˝ (±⅛) as measured from the inside of the ring at the 12:00 o'clock position.
6. On lower connection gauges, assemble rear seal diaphragm to case.
   For back connection gauges see instructions on reverse side. **(Fig. 2/4).**
7. **For 1279:**
   Assemble rear cover and six self tapping screws in a criss-cross pattern and torque to 12 in lbs. (±2 in lbs.)
   For 1379:
   - Thread rear ring and torque to 200 in lbs
   - Install stainless steel back cover using two screws. Torque screws to 14 in lbs. (±2 in lbs.)
8. Assemble throttle screw to threaded hole in socket.
   Note: If system is monel (socket wrench flat stamped "PHS" or "PH") use monel throttle screw.
9. Check appropriate box on fill identification label, and peel off label back, and attach fill label to gauge case.
10. If gauge is to be repackaged:
    a. Include enclosed instruction sheet inside carton.
    b. Change type number on carton label to:
       (1) Hermetically Sealed – 1279(*)SH.
       (2) Liquid Filled – 1279(*)SL.
       *Bourdon Tube System Code

Glycerin or silicone should not be used in applications involving Oxygen, Chlorine, Nitric Acid, Hydrogen Peroxide or other strong oxidizing agents, because of danger of spontaneous chemical reaction, ignition or explosion. Halocarbon should be specified. Products with this fill can be ordered from factory.
The use of fluids other than those listed in the table above (for example, Hydrocarbon-based oils) may result in leakage caused by a reaction between the fluid and the elastomeric seals. Consult the factory before filling with any other fluid.

Type 1279 & 1379 Solid Front Duragauge® Pressure Gauge Liquid Fill Conversion Instructions

ASHCROFT®

INSTRUCTIONS FOR USING CONE TOOL AND RING WRENCH

Garter Spring & Diaphragm Assembly (Back Connection Gauge Only)

A. Place cone tool over socket shank as shown.

B. Moisten lip of socket and outer O-ring surface with silicone oil or grease.

C. Place diaphragm with rib side facing upward over cone into case grove.
Diaphragm O-ring must be completely in socket-shank grove.

D. Place garter spring over cone as shown and slide onto diaphragm in socket grove

E. Assemble rear cover with screws per step 7.

Front Ring Assembly (All Gauges)

A. Assemble ring to case by hand to start.

B. Place ring on wrench as shown

C. Use ½˝ drive extension and torque ring to 200 in. lb

Alternate Method

A. Tighten ring snugly by hand

B. Mark case and ring.

C. Turn ring another 100 to 120 degrees (slightly less than ½ turn) using the ring wrench and ½˝ drive socket wrench or place the blunt end of a wooden or plastic dowel against a ring lug and tap with a hammer.

INSTRUCTIONS FOR LIQUID FILLING ASHCROFT® TYPE 1279 AND 1379 SOLID FRONT DURAGAUGE® PRESSURE GAUGES USING A VACUUM PUMP

A. Insert a length of ⅛ ˝ diameter tubing through the 12 o'clock position hole in the rear, solid front portion of the case, as shown.

B. Evacuate the air from the front dial cavity while pouring in the fill fluid through the case back. The vacuum will displace the air with fluid.*

C. When the dial cavity is solidly filled, remove the tubing and continue to pour the fill fluid to within 1/16 ˝ below the o-ring channel lip, as shown.

D. When converting a 45-1379 with the top fill hole configuration, p/n 256A176-01 fill plug is required and must be ordered separately.

*To prevent breakage, reduce vacuum to 15 in. Hg for plain glass and safety glass.

BACK CONNECTION ASSEMBLED GAUGE

Fig. 2

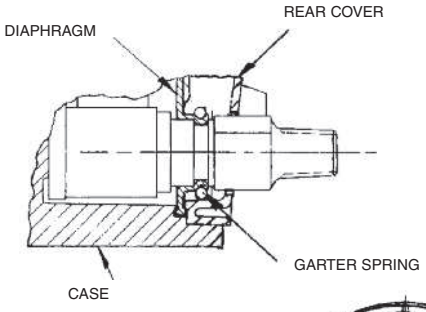


Fig. 3

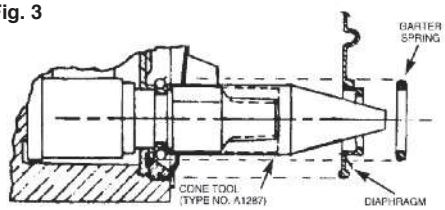


Fig. 4

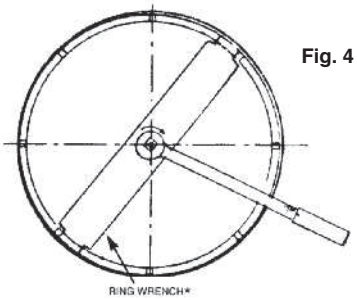
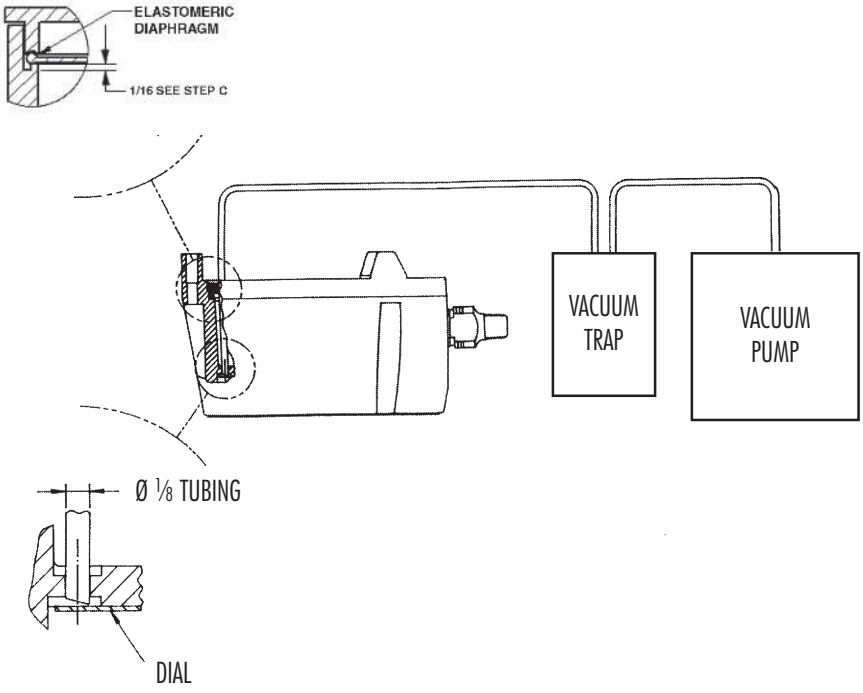
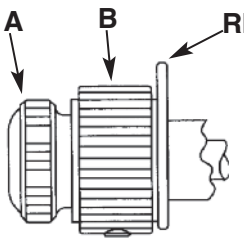


Fig. 5



INSTRUCTIONS FOR USE OF EXTERNAL EASY ZERO™ ADJUST FEATURE*

Fig. 1



1. LOOSEN RING-LOCKING SCREW **A**.
2. OBTAIN REQUIRED ADJUSTMENT BY ROTATING KNOB **B** CLOCKWISE OR COUNTER-CLOCKWISE.
3. TIGHTEN SCREW **A** DOWN ON KNOB **B**.

*Applicable only for test gauge with hinged ring design.

ADDITIONAL CALIBRATION INSTRUCTIONS

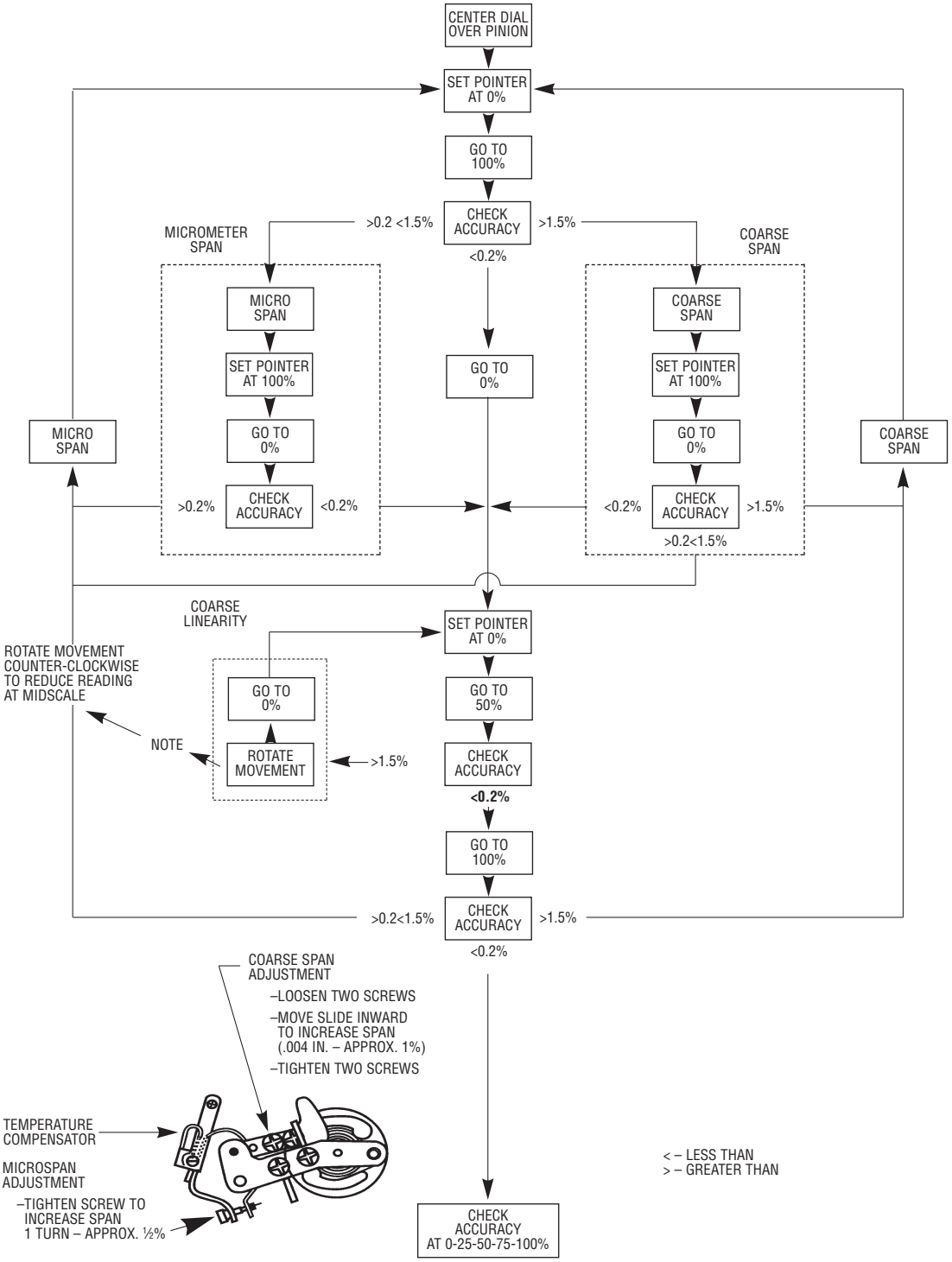
1) "Standards shall have nominal errors no greater than ¼ of these permitted for the gauge being tested." *(Ref: ASME B40=100-1998)*
2) The instrument used as the calibration standard should have a maximum range no greater than 2x that of the gauge being tested. (i.e. Do not use a 400psi standard to test a 15psi gauge.)
3) "Known pressure shall be applied at each test point on increasing pressure (or vacuum) from one end to the other end of the scale. At each test point the gauge shall be . . .
lightly tapped, and then read . . ."
(*Ref: ASME B40.1 ¶ 6.2.4.1*)
4) To read gauge indication, move eye over red pointer tip at OD of printed dial until red reflection in mirror band is no longer visible, and then read the pointer position in reference to the dial.

Installation and Maintenance Instructions for ASHCROFT® Type 1082 Test Gauge Calibration Procedure – Pressure Range

ASHCROFT®

Fig. 2

THIS TEST GAUGE IS PROVIDED WITH A MICROSPAN™ ADJUSTMENT TO SIMPLIFY CALIBRATION. THE FLOW CHART BELOW OUTLINES THE RECOMMENDED CALIBRATION PROCEDURE



 I&M008-10082 11/01 RevB (250-2917-4) AMR 10/07

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Visit our web site www.ashcroft.com

Mercoid®

Series EDA Electronic Pressure Controller

Specifications - Installation and Operating Instructions

DWYER INSTRUMENTS, INC.
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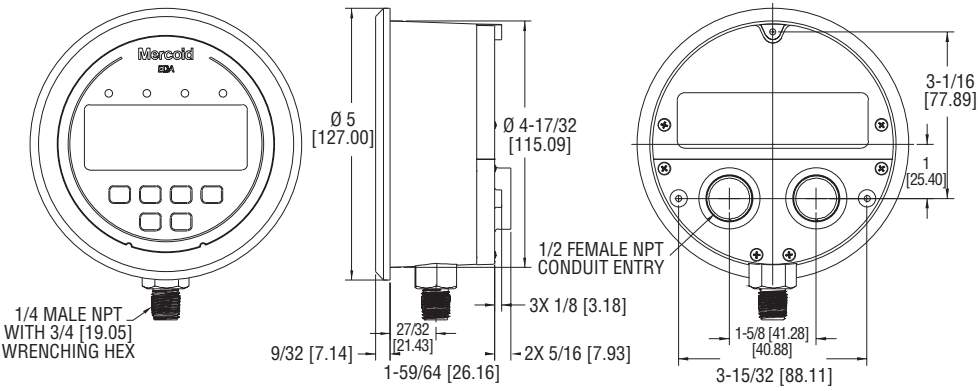
Dimensions


Mercoid
DA
1/4 MALE NPT
WITH 3/4 [19.05]
WRENCHING HEX
Ø 5
[127.00]
Ø 4-17/32
[115.09]
1/2 FEMALE NPT
CONDUIT ENTRY
3X 1/8 [3.18]
9/32 [7.14]
27/32
[21.43]
2X 5/16 [7.93]
1-59/64 [26.16]
3-1/16
[77.89]
1
[25.40]
1-5/8 [41.28]
[40.88]
3-15/32 [88.11]

SPECIFICATIONS
Service: Compatible liquids and gases.
Wetted Materials: 316L SS.
Housing: Glass filled plastic.
Accuracy: ±1% of F.S. including linearity, hysteresis, and repeatability (indicator and transmitter).
Stability: < ± 2% of F.S. per year.
Pressure Limits: Ranges up to 6,000 psi: 1.5 x range; 8,000 psi range: 10,000 psi.
Temperature Limits: Ambient: 20 to 140°F (-6.6 to 60°C); Process: 0 to 176°F (-18 to 80°C).
Compensated Temperature Limits: 32 to 122°F (0 to 50°C).
Thermal Effect: ±0.05% of F.S./°F.
Process Connection: 1/4″ NPT male, 1/4″ BSPT male, or 7/16" SAE.
Display: 4-digit backlit LCD (Digits: 0.60″H x 0.33" W).
Display Update: 600 ms (dampening set to 1).
Power Requirements: 12 to 28 VDC (⎓) / AC (~) 50/60 Hz. (Can work at 8 VDC (⎓) for 45 seconds). For T5 option: 14 to 30 VDC (⎓) / AC (~) 50/60 Hz.
Power Consumption: 2.5 watts.
Electrical Connections: Removable terminal blocks with two 1/2″ female NPS conduit connections.
Enclosure Rating: Weatherproof type 4X IP65 (IP65 not evaluated by UL). Unit is rated weatherproof but if unit is panel mounted, panel will not maintain 4X rating.
Warm Up Time: <10 seconds.
Mounting Orientation: Any position.
Weight: 1.18 lbs (535 g).
Installation Category: II (transient over-voltage).
Pollution Degree: 2.
Altitude Limit: 6560 ft (2000 m) max.
Environment: Intended for indoor and outdoor use.
Humidity: 0 to 95% RH up to 104°F (40°C) non-condensing, 10 to 50% at 140°F (60°C) non-condensing.

SWITCH SPECIFICATIONS
Switch Type: 2 SPDT relays.
Electrical Rating: 5A @ 120/240 VAC (~) 50/60 Hz, 1A @ 28 VDC (⎓).
Repeatability: ±1% of FS (switching only).
Set Points: Adjustable 0-100% of FS.
Switch Indication: External LED for each relay on the front panel.
Switch Reset: Manual or automatic.

TRANSMITTER SPECIFICATIONS
Output Signal: 4 – 20 mA, 1 - 6 VDC (⎓), 1 - 5 VDC (⎓), 0 - 5 VDC (⎓), or 0 - 10 VDC (⎓)(direct or reverse output selection).
Minimum Excitation: 14 VDC (⎓).
Zero and Span Adjustments: Menu scalable within the range.

Model Number Chart

Example	EDA							EDAW-N1E1-01T0-SST
Series	EDA							Electronic Pressure Controller
Housing		W						Weatherproof
Process Connection			N1 B1 A1					1/4″ NPT male bottom 1/4″ BSPT male bottom 7/16″ SAE male bottom
Electrical Connection				E1				Two 1/2″ female NPT conduit connections
Range					01 02 03 04 05 06 07 08 09 10 11* 12*			0 – 30” Hg vacuum 0 – 20 psi 0 – 60 psi 0 – 100 psi 0 – 150 psi 0 – 300 psi 0 – 600 psi 0 – 1000 psi 0 – 1500 psi 0 – 3000 psi 0 – 6000 psi 0 – 8000 psi
Transmitter Output						T0 T1 T2 T3 T4 T5		None 4 to 20 mA 1 to 5 VDC 0 to 5 VDC 1 to 6 VDC 0 to 10 VDC
Options							STW NIST 23444	Stainless Steel Tag NIST Certificate Special Cleaning

*Not UL listed.

Display

The EDA has two displays: a lower larger display and a smaller upper display. The Home Display is the normal display while the control is in operation if there are no errors or functions active. The Home display will indicate the process variable at the current condition with the lower display and the selected pressure units for the process variable with the upper display. When programming the unit both displays are also used. The Programming Chart in this instruction manual indicates what both displays show while programming the unit. For programming descriptions in this instruction manual the format used is “**lower display – upper display**”. For example **Ctrl – 1SP** shows that **Ctrl** would be in the lower display and **1SP** would be in the upper display.

When the user presses the **E** key to edit an item’s value the upper display will flash “**EDIT**” and the lower display will blink. When the user presses the **E** key to then save the edit to the value the upper display will flash “**SAVE**” and the lower display will stop blinking.

1.0 INSTALLATION

1.1 UNPACKING

Remove the EDA from the shipping carton and inspect for damage. If damage is found, notify the carrier immediately.

1.2 MOUNTING

The EDA can be pipe, panel, or surface mounted. For pipe mounting thread the unit into a mating female fitting on the pipe. Use a wrench on the 3/4″ hex at the base of the housing to tighten the unit to the mating fitting. Do not thread the unit in by force on the housing. For panel mounting the unit fits into a 4-13/16" (122.24 mm) panel cut out. Insert the unit into the panel opening and secure in place with the machine screws and adaptors provided with the unit as shown in Figure 1 below. Maximum panel thickness is 1/8" (3.5 mm) with supplied screws. For surface mounting, panel mount the unit into the A-370 mounting bracket (See the Dwyer catalog or website for ordering details) also shown in Figure 1. The unit can also be directly surface mounted, as shown in Figure 2, with the proper panel cutout for the conduit entrances. Support the pressure connection hex with a wrench if attaching a fitting to the unit in the case of panel or flush mounting so that the pressure connection does not twist. Use a small amount of plumber's tape or other suitable sealants to prevent leaks around fitting.

Figure 1: Panel Mounting and Mounting in A-370 Bracket

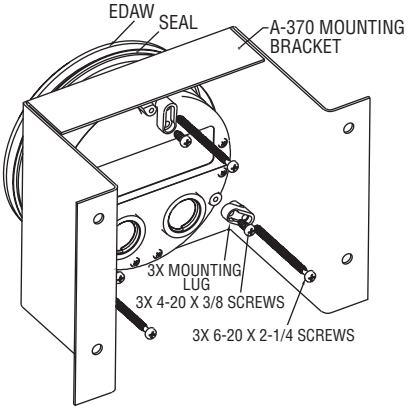
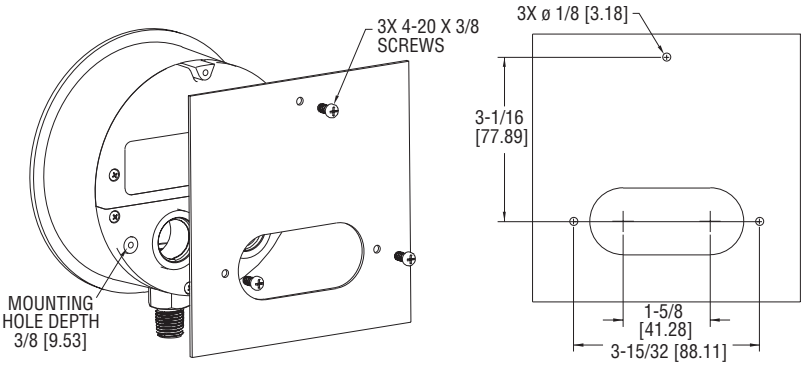


Figure 2: Surface Mounting



1.3 ELECTRICAL CONNECTIONS

CAUTION: POWER MUST BE OFF WHILE WIRING CONNECTIONS ARE BEING MADE.
CAUTION: Do not exceed the specified supply voltage rating. Permanent damage not covered by the warranty may result.
CAUTION: To maintain type 4X rating of the enclosure, 1/2 NPT conduit fittings must have a UL type 4X outdoor rating.

Note: Installation must be made in accordance with local codes and regulations. When fishing wire through the conduit connection do not allow the wire to touch or press on components on the boards. Damage to the circuitry may result.

Electrical connections are made to the removable terminal blocks inside the enclosure. Remove the top back cover, do not remove bottom cover. Feed stripped and tinned leads through the conduit opening and connect them as shown in Figure 3. The EDA provides two 1/2″ NPT female ports for conduit connection. The conduit connections must be made such that condensation is not allowed to enter the sensor housing. If necessary install a conduit breather drain in a separate conduit body to prevent buildup of moisture. It is recommended that shielded twisted pair wire be used for the transmitter output option if the potential exists for interference from external noise sources. When replacing top back cover tighten screws to 2 ±.25 in. lbs.

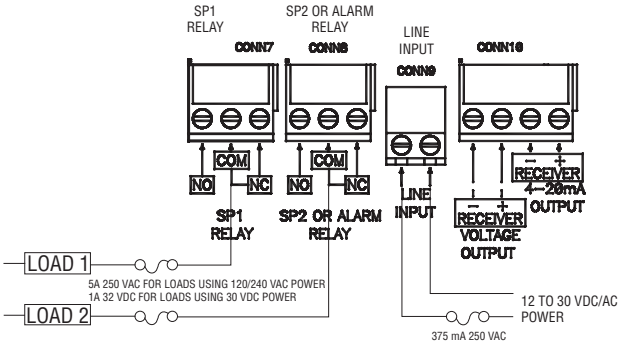


Figure 3: Wiring

An external power supply of 12-28 VDC/AC with minimum current capability of 200 mA must be used to power the unit. The power supply connection is not polarity sensitive so the positive and negative connections may be made to either terminal of CONN9 terminal block.

For voltage output option, connect the voltage receiver (-) to terminal 1 and voltage receiver (+) to terminal 2 of the CONN10 terminal block. For current output option, connect the current receiver (-) to terminal 3 and current receiver (+) to terminal 4 of CONN10 terminal block. DO NOT APPLY EXTERNAL POWER TO CONN10 TERMINALS - PERMANENT DAMAGE NOT COVERED BY WARRANTY WILL RESULT.

Loads can be connected to connectors CONN7 and CONN8 terminal blocks based on the Control settings:

- For single set point mode (**CtrL-1SP**), connect the Load to **SP1** relay (CONN7).
- For two set points mode (**CtrL-2SP**), connect the Load1 to **SP1** relay (CONN7) and Load2 to **SP2** relay (CONN8).
- For single set point and alarm mode (**CtrL-SPAL**), connect the Load1 to **SP1** relay (CONN7) and Load2 to **ALARM** relay (CONN8).

Wiring

An external switch or circuit breaker should be added to during the installation as a disconnecting device. The switch or circuit breaker must meet the requirements of IEC 60947-1 and IEC 60947-3, shall disconnect all current carrying conductors, and shall not interrupt the protective earth ground. The disconnecting switch or circuit breaker must be marked or labeled with the symbols “I” for on and “O” for off, per IEC 60417-5007 & IEC 60417-5008 and shall be marked as “Disconnecting Device”. Do not position the PLS in a space where it is difficult to operate the disconnecting device that provides power. 300V @ 90°C 18 AWG/0.75 mm² wiring with PVC or equivalent insulation with 94-V0 or FV-0 flammability rating is recommended for the switch outputs and power. Terminal blocks rated for 16-22 solid or stranded copper conductor. 6 lb in is suggested tightening torque.

⚠ WARNING As a permanently installed piece of equipment, a power disconnect switch, circuit breaker, or other approved disconnect device must be installed in close proximity to the installed board and within easy reach of the operator. This disconnect device must include a label indicating its function as a mains disconnect. A circuit breaker or fuse device is recommended (see Figure 3).

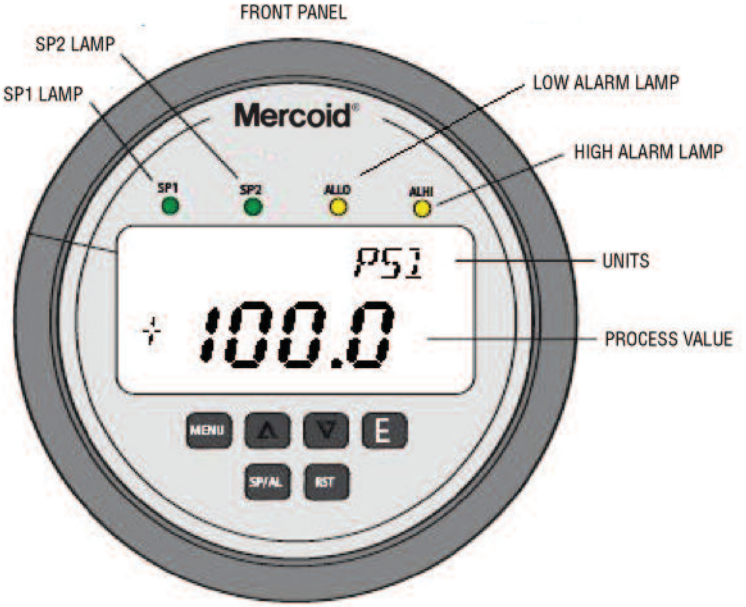
Explanation of Symbols:

Symbol	Publication	Description
⎓	IEC 50417 - 5031	Direct current
~	IEC 50417 - 5032	Alternating current
⏚	IEC 50417 - 5019	Protective conductor terminal
|	IEC 50417 - 5007	On (supply)
◯	IEC 50417 - 5008	Off (supply)

2. OPERATING INSTRUCTIONS

2.1 FRONT PANEL & KEY FUNCTIONS

Figure 4: Front Panel Functions



Key Functions

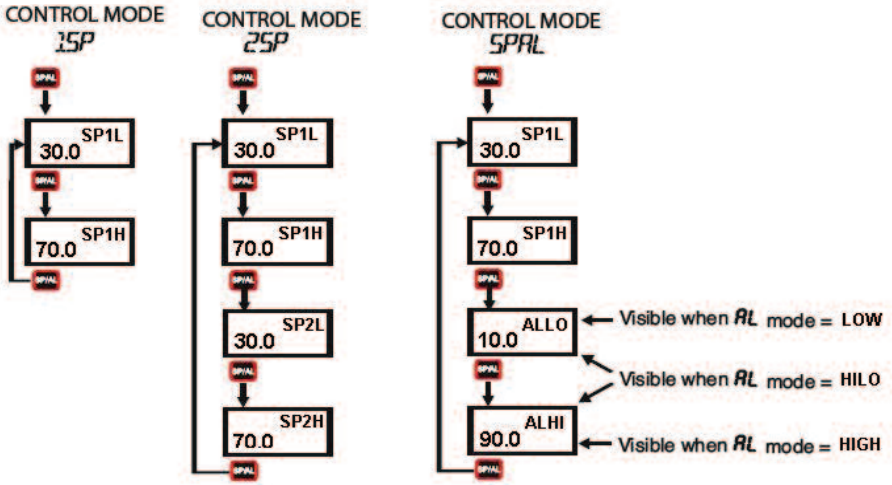
	HOME POSITION FUNCTION	MAIN MENU FUNCTION	ITEM FUNCTION
SP/AL SP/AL	Sequences the display through SET POINT and ALARM settings	Return to home position	Return to home position
MENU MENU	Allows access to the menus	Return to home position	Return to previous menu
▲ UP ARROW		Sequences through menus	Increments a value
▼ DOWN ARROW		Sequences through menus	Decrements a value
E ENTER	Displays full scale range of unit	Enter into items	Changes a value or setting. Press ENTER and display will blink. Adjust with UP or DOWN arrows. Press ENTER to store. Display will stop blinking.
RST RESET	Clears or resets an Alarm (alarm set for manual reset)		Peak/Valley resets display to present value.

2.2 SET POINTS & ALARMS

Setting Set Points and Alarms

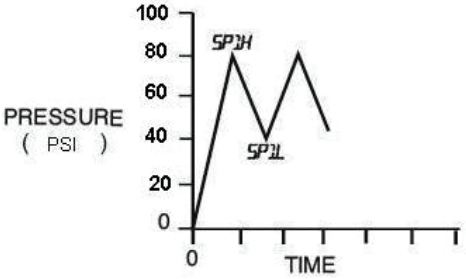
The SP/AL hot key provides direct access to the Set Point and Alarm settings.

The Set Point and Alarm settings that are displayed are based upon the Control (CtrL) menu item.



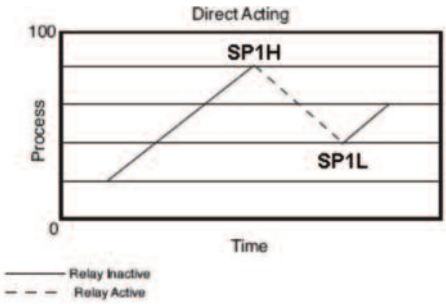
Set Point Adjustment

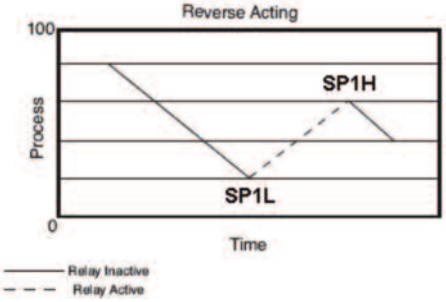
Adjusting the set points is quick and simple. Instead of setting a set point and dead band, simply adjust **SP1H**, Set Point 1 High, and **SP2H**, Set Point 2 High, for the desired relay turn on point, and then adjust **SP1L**, Set Point 1 Low, and **SP2L**, Set Point 2 Low, for the desired relay turn off point.



In the above graph, an instrument with a 100 psi range would have the **SP1** relay turn ON at 80 psi and OFF at 40 psi. **SP1H** sets the relay turn ON point, and **SP1L** sets the relay turn OFF point.

Relay Action





The relays outputs normally function in the direct acting mode, which means the relays turn ON with an increase in pressure. **SP1** and **SP2** may be configured to act as reverse acting relays (refer to the **CtrL** menu item). When set for reverse acting, **SP1H** and **SP2H** set the relay turn OFF point, and **SP1L** and **SP2L** set the relay turn ON point. The above graph demonstrates direct and reverse action on process (pressure) change.

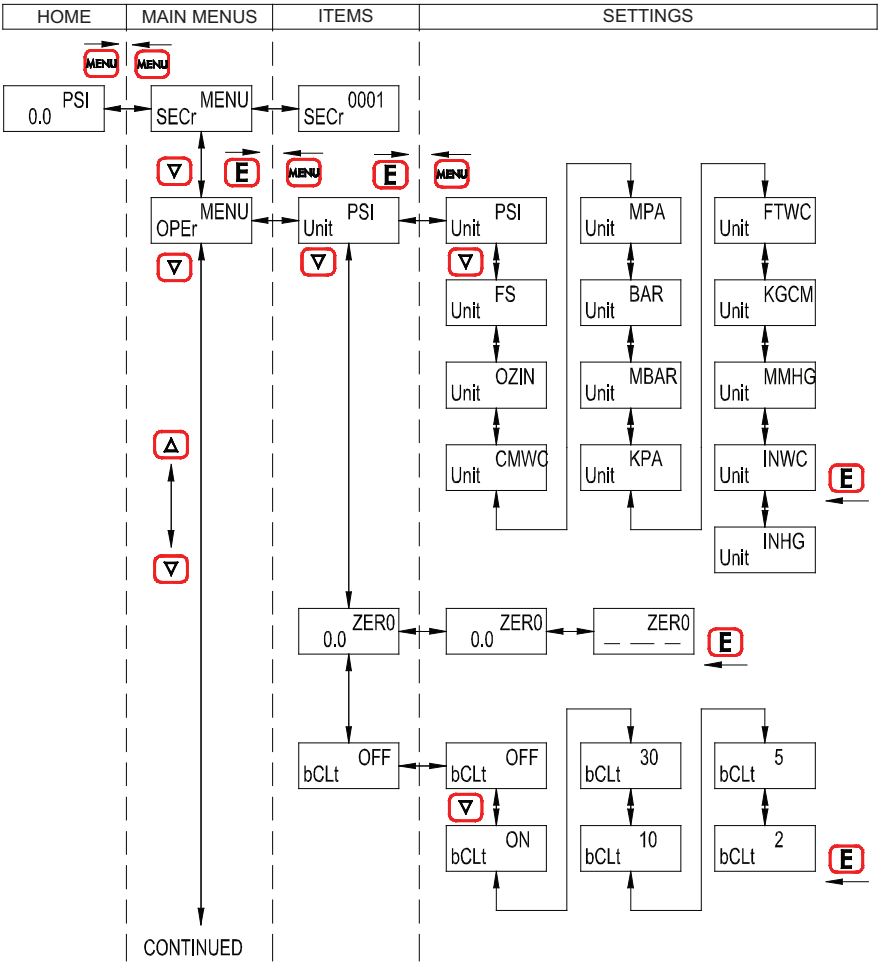
Alternating (Lead/Lag) Operation

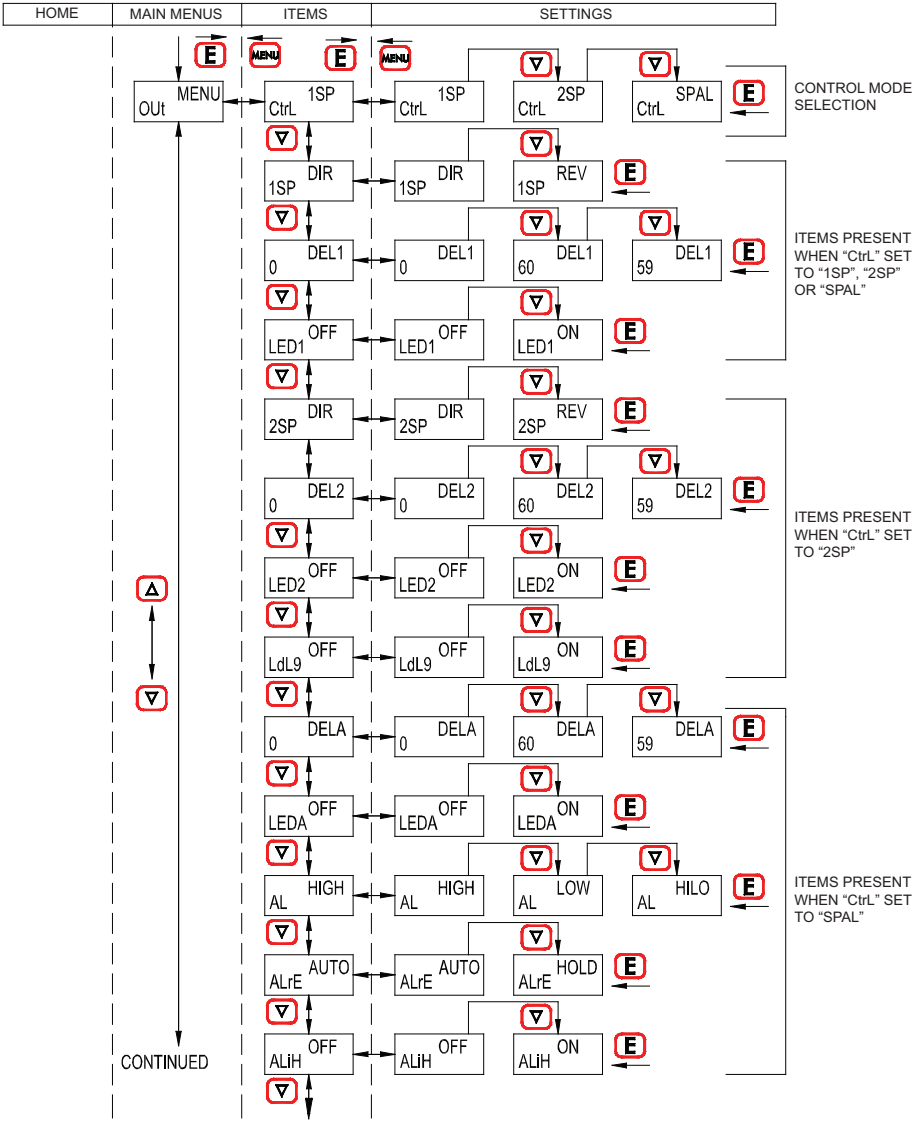
The EDA is designed to easily operate a pair of pumps in an alternating operation to minimize pump wear. The unit has programmable on and off set points for pump one and two. If the lead/lag feature is turned off then the relays remain attached to their corresponding set points, **SP1H** and **SP1L** control relay 1 (pump 1) and **SP2H** and **SP2L** control relay 2 (pump 2). There is no alternating function.

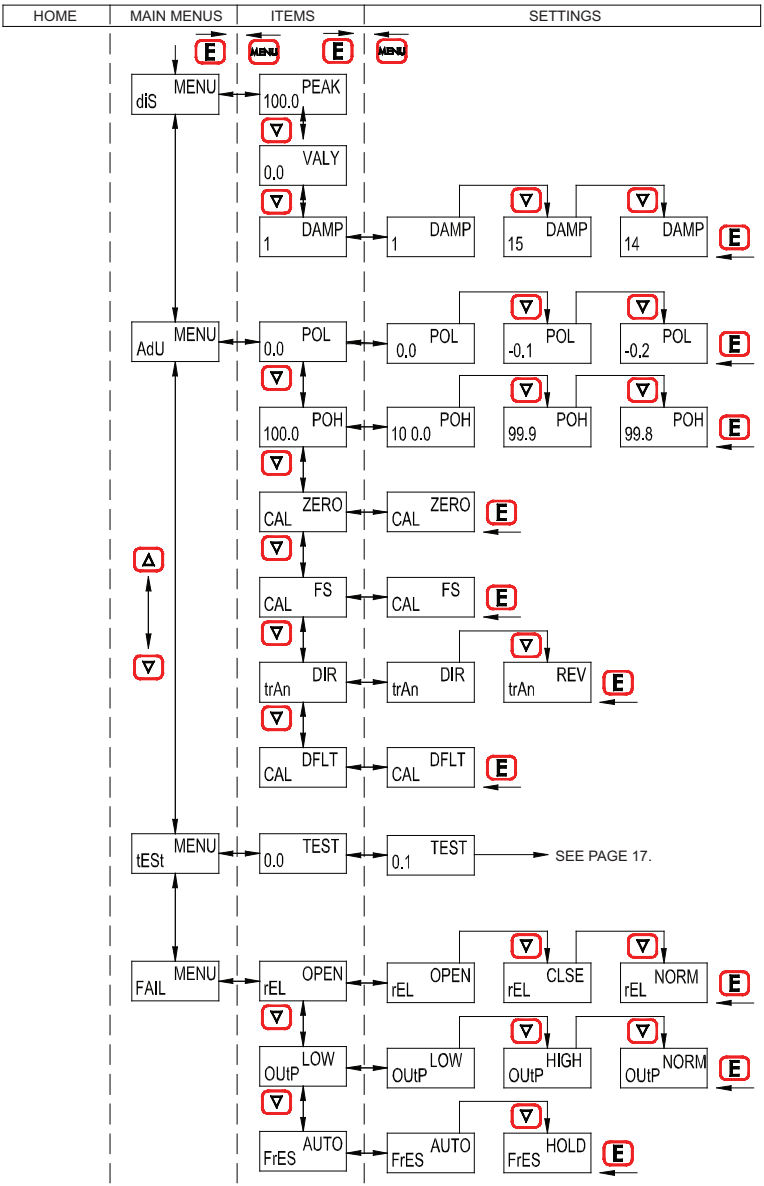
If lead/lag feature is turned on then the relays will alternate with set points **SP1H** and **SP1L** to **SP2H** and **SP2L** with every cycle of set points. The Last relay turned off will be last relay turned on with the next cycle. On the first cycle on increase of pressure, assuming direct acting, the **SP1** relay (pump 1) will come on and then on further increase of pressure the **SP2** relay (pump 2) will come on. On the subsequent decrease of pressure the **SP2** relay (pump 2) will come off and then the **SP1** relay (pump 1) will come off. When pressure increases on the next cycle the relay used on the last cycle for **SP2** will now be used for **SP1**, so that **SP1** now controls pump 2 and **SP2** now controls pump 1. Even if **SP2** is not used on the pressure cycle the relays still alternate on next cycle.

2.3 PROGRAMMING CHART

MENU MAP




HOME
MAIN MENUS
ITEMS
SETTINGS
MENU
OUt
CONTINUED
1SP
CtrL
DIR
1SP
DEL1
0
OFF
LED1
2SP
DIR
DEL2
0
OFF
LED2
OFF
LdL9
DELA
0
OFF
LEDA
HIGH
AL
AUTO
ALrE
OFF
ALiH
1SP
2SP
SPAL
REV
60
59
ON
LOW
HILO
HOLD
CONTROL MODE SELECTION
ITEMS PRESENT WHEN “CtrL” SET TO “1SP”, “2SP” OR “SPAL”
ITEMS PRESENT WHEN “CtrL” SET TO “2SP”
ITEMS PRESENT WHEN “CtrL” SET TO “SPAL”


HOME
MAIN MENUS
ITEMS
SETTINGS
MENU
diS
PEAK
100.0
VALY
0.0
DAMP
1
15
14
AdU
POL
0.0
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-0.2
POH
100.0
10 0.0
99.9
99.8
ZERO
CAL
FS
DIR
trAn
REV
DFLT
tESt
TEST
0.1
SEE PAGE 17.
FAIL
OPEN
rEL
CLSE
NORM
LOW
OUtP
HIGH
AUTO
FrES
HOLD

2.4 MAIN MENU SELECTIONS

Menu Selections
Press the **MENU** button to start the menu so that the upper right displays reads **MENU**. Press the ▼ key to advance to the next menu item. You can press the ▲ key to go back to the previous menu. Press the **E** key to enter a menu.

SECr Security Menu
Lock out access to set point and alarm settings, or lock out access to all settings.

OPEr Operation Menu
Select pressure units, zero the display, and turn the backlight on or off.

Out Output Menu
Select relay mode of operation, alternating function, time delay, and lamp indication.

diS Display Menu
Monitor and adjust display related settings: Peak, Valley and Dampening.

AdU Advanced Functions Menu
Modify advanced function parameters: transmitter output scaling, direct or reverse output setting, calibration, or restoring factory default calibration.

tESt Test Menu
Simulate input over the range without pressure to test switch and transmitter output function.

FAIL Failsafe Menu
Set the relay and transmitter outputs to certain preset values when failsafe conditions occur. Error codes will show on the display indicating the problem. User chooses if relay is de-energized, energized, or no action taken. With transmitter option, user chooses an output of 3.6 mA, 22 mA, or no action taken.

Menus and Values

SECr Security Menu

SECr When the security item is selected, the present security level is displayed in the upper right hand display. To change the security level, adjust the number displayed to the password value in the Password Table, shown below, by pressing the ▲ or ▼ key and then pressing the **E** key at the desired security level.

Security Level Displayed	**Access**	**Password Value to Enter**
1	All menus access	10
2	Menu Access SP/AL Locked	70
3	SP/AL Access Menus Locked	90
4	All settings locked	111

The password values shown in the table cannot be altered, so retain a copy of these pages for future reference.

OPEr Operation Menu

Unit Pressure Units

With the display reading **Unit - PSI**, press the **E** key. The upper display will blink. Press the ▼ key to change unit then press **E** key to save the new unit.

PSI	Pounds per square inch
FS	% of full scale
OZIN	Ounces per square inch
CMWC	Centimeters of water column
MPA	Megapascals
BAR	Bar
MBAR	Millibar
KPA	Kilopascals
FTWC	Feet of water column
KGCM	Kilograms per square centimeter
MMHG	Millimeters of mercury
INWC	Inches of water column
INHG	Inches of mercury

Pressure Range vs. Available Units

PSI	KG/CM2	BAR	INHg	FTWC	KPA	MPA	INWC	MBAR	CMWC	MMHg	OZ/IN2	% FS
-14.70	-1.033	-1.013	-29.93	-33.94	-101.4	-0.101	-407.3	-1013	-1034	-761	-235.2	100
20.00	1.406	1.379	40.7	46.1	137.9	0.1379	554	1379	1406	1035	320.0	100
60.0	4.22	4.14	122.2	138.4	414	0.414	1663			3105	960	100
100.0	7.03	6.89	203.6	230.7	689	0.689	2771				1600	100
150.0	10.55	10.34	305.4	346.0	1034	1.034					2400	100
300.0	21.09	20.68	611	692	2068	2.068						100
600	42.2	41.4	1222	1384		4.14						100
1000	70.3	68.9	2036	2307		6.89						100
1500	105.5	103.4	3054	3460		10.34						100
3000	210.9	206.8				20.68						100
6000	422	414				41.4						100
8000	562	551				55.1						100

ZERO Auto Zero

Note: DO NOT apply any pressure when performing this function. With the display reading **xx - ZERO**, press the **E** key. The upper display will blink. Press **E** again to zero the display. The display will read 0.0 if the zero offset is less than ±5% of full scale.

bCLt Backlight

ON	Backlight always on.
OFF	Backlight always off.
30	Backlight stays on for 30 minutes.
10	Backlight stays on for 10 minutes.
5	Backlight stays on for 5 minutes.
2	Backlight stays on for 2 minutes.

OUt Output Menu

CtrL Control Mode
- **1SP** Single set point.
- **2SP** Two fully independent set points.
- **SPAL** Single set point and alarm.

1SP **SP1**, Set Point 1, Reverse or Direct Acting
- **DIR** Direct. Relay turns on with increasing pressure.
- **REV** Reverse. Relay turns on with decreasing pressure.

DEL1 **SP1**, Set Point 1, Time Delay
Sets the amount of time a set point condition must be continuously met before the set point condition is recognized. The **DEL1** delay is adjustable from 0-60 seconds.

LEd1 **SP1**, Set Point 1, Lamp
- **OFF** The **SP1** LED on the front panel turns OFF when the **SP1** relay turns OFF. The **SP1** LED on the front panel turns ON when the **SP1** relay turns ON.
- **ON** The **SP1** LED on the front panel turns ON when the **SP1** relay turns OFF. The **SP1** LED on the front panel turns OFF when the **SP1** relay turns ON.

The following **SP2** function values are only activated when **CtrL** is set to **2SP**:

2SP **SP2**, Set Point 2, Reverse or Direct Acting
- **DIR** Direct. Relay turns on with increasing pressure.
- **REV** Reverse. Relay turns on with decreasing pressure.

DEL2 **SP2**, Set Point 2, time delay
Sets the amount of time a set point condition must be continuously met before the set point condition is recognized. The **DEL2** delay is adjustable from 0-60 seconds.

LEd2 **SP2**, Set Point 2, Lamp
- **OFF** The **SP2** LED on the front panel turns OFF when the **SP2** relay turns OFF. The **SP2** LED on the front panel turns ON when the **SP2** relay turns ON.
- **ON** The **SP2** LED on the front panel turns ON when the **SP2** relay turns OFF. The **SP2** LED on the front panel turns OFF when the **SP2** relay turns ON.

LdL9 Relay Alternation (See page 8)
- **OFF** There is no alternating function.
- **ON** Relays will alternate with set points **SP1H/L** and **SP2H/L** with every cycle of set points. **2SP** control mode only.

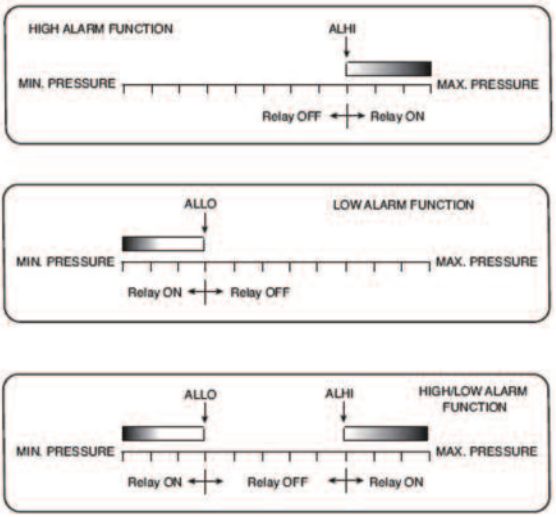
The following alarm function menu items are activated when **CtrL** is set to **SPAL**:

DELA Alarm Delay
Sets the amount of time an alarm condition must be continuously met before the alarm condition is recognized. The alarm delay is adjustable from 0 - 60 seconds.

LEdA Alarm Lamps
OFF The **ALLO** LED or **ALHI** LED on the front panel turns OFF when the alarm relay turns OFF. The **ALLO** LED or **ALHI** LED on the front panel turns ON when the alarm relay turns ON.
ON The **ALLO** LED or **ALHI** LED on the front panel turns ON when the alarm relay turns OFF. The **ALLO** LED or **ALHI** LED on the front panel turns OFF when the alarm relay turns ON.

AL Alarm Type (see Alarm Adjustment below)
HIGH High alarm only.
LOW Low alarm only.
HILO For a high and low guard band type alarm. Share the same relay output.

Alarm Adjustment
Alarm settings are dependent upon the selected alarm type. The EDA pressure controller alarm may be configured as a High Alarm, Low Alarm, or High/Low Alarm. Alarm settings may be set to anywhere within the range of the instrument. The dead bands of the alarms are fixed at 1% of full scale.



ALrE Alarm Reset
AUTO Automatic reset.
HOLD Manual reset. An alarm is reset by pressing the **RST** key on the front panel.

ALiH Low Alarm Inhibit
OFF Alarm inhibit is off.
ON Alarm inhibit is on.
Note: If **ALiH** is selected ON, a low alarm condition is suspended upon power up until the process value passes through the alarm set point once.

diS Display Menu

PEAK Peak
The Peak feature stores the highest pressure reading the instrument has measured since the last reset or power up. At power up **PEAK** is reset to the present pressure reading. To manually reset the **PEAK** value, press the **RST** (RESET) key while in **PEAK**.

VALY Valley
The Valley feature stores the lowest pressure reading the instrument has measured since the last reset or power up. At power up **VALY** is reset to the present pressure reading. To manually reset the **VALY** value, press the **RST** (RESET) key while in **VALY**.

DAMP Dampening
Adjust from 1-15. Dampening stabilizes the display from instabilities due to things such as vibration and excessive pressure fluctuations. The dampening setting adjusts the amount of readings that are averaged for each display update. Adjust the dampening value until the display reads a stable value for the application.

AdU Advanced Menu

POL, Process Output Low, and **POH**, Process Output High are used to scale the transmitter output for a unit with the output option of 4 to 20 mA, 0-5 VDC, 0-10 VDC, 1-5 VDC, or 1-6 VDC. Below shows with 4 to 20 mA output option.

POL Process Output Low
Set to the desired display reading for the 4 mA output. May be set from 2% below minimum scale up to **POH**.

POH Process Output High
Set to the desired display reading for the 20 mA output. May be set from **POL** to 2% above maximum scale.

CAL – ZERO Zero Calibration
DO NOT apply any pressure when performing this function. With the display reading **CAL - ZERO**, press the **E** key. The upper display will blink. Press the **E** key again to complete the zeroing of the instrument or press the **MENU** key to cancel.

CAL – FS Full-scale Calibration
With the display reading **CAL - FS**, apply full-scale pressure to the unit, press the **E** key. The upper display will blink. Press the **E** key again to complete the calibration or press the **MENU** key to cancel.

trAn sets the transmitter output option function for a unit with the output option of 4 to 20 mA, 0-5 VDC, 0-10 VDC, 1-5 VDC, or 1-6 VDC. Below shows with 4 to 20 mA output option.

trAn

DIR Direct Output. 4 mA output at zero, 20 mA output at full scale pressure.
REV Reverse Output. 20 mA output at zero, 4 mA output at full scale pressure.

CAL - DFLT Factory Default Calibration
With the display reading **CAL - DFLT**, press the **E** key. The upper display will blink. Press **E** again to restore the original factory calibration values or press the **MENU** key to cancel.

tESt Test Menu

tESt When selected the unit simulates a pressure input over the range to test the programming and output function. To start an automatic simulated cycling through the pressure range press the **E** key. This test will run continually until the **E** key is pressed again. To manually adjust the simulated pressure press the ▲ or ▼ key to adjust the pressure value. To exit **tESt** press the **MENU** key.

FAIL Failsafe Menu

The Failsafe menu is used to set the relay and transmitter outputs to certain preset values when failsafe conditions occur. Error codes will show on the display indicating the problem. See Diagnostic Error Messages on the next page.

rEL Relay Output Failsafe Condition

- **OPEN** The relay is de-energized upon failsafe condition. The NO contacts will be opened, and the NC contacts will be closed.
- **CLSE** The relay is energized upon failsafe condition. The NO contacts will be closed, and the NC contacts will be opened.
- **NORM** No change applied to the relay upon failsafe condition.

OUtP sets the transmitter output option failsafe condition for a unit with the output option of 4 to 20 mA, 0-5 VDC, 0-10 VDC, 1-5 VDC, or 1-6 VDC. See below chart of transmitter output action according to output signal type.

OUtP Transmitter Output Failsafe Condition

- **LOW** Transmitter output goes to low failsafe condition.
- **HIGH** Transmitter output goes to high failsafe condition.
- **NORM** No change applied to transmitter output upon failsafe condition.

Output signal	4-20 mA	0-5 VDC	0-10 VDC	1–6 VDC	1-5 VDC
LOW	3.6 mA	-0.125 VDC	-0.250 VDC	0.875 VDC	0.9 VDC
HIGH	22 mA	5.625 VDC	11.250 VDC	6.625 VDC	5.5 VDC

FrEs Failsafe reset

- **AUTO** Automatic reset - Failsafe is reset automatically when the failsafe error condition is removed.
- **HOLD** Manual reset - Failsafe is reset when the **MENU** key is pressed.

4. DIAGNOSTIC ERROR MESSAGES

Display	Meaning
Err1	Low temperature limit
	A temperature below 0°F has been applied to the sensor
Err2	High temperature limit
	A temperature above 180°F has been applied to the sensor
Err3	Sensor failure
	The micro-controller is receiving invalid signal from the sensor
Err4	Over pressure limit
	Proof pressure have been exceeded
Err5	Keypad short

5. MAINTENANCE/REPAIR

Upon final installation of the Series EDA, inspect and clean with water or damp cloth at regular intervals. The Series EDA is not field serviceable and should be returned if repair is needed (field repair should not be attempted and may void warranty.

6. WARRANTY/RETURN

Refer to “Terms and Conditions of Sales” in our catalog and on our website. Contact customer service to receive a Return Goods Authorization number before shipping the product back for repair. Be sure to include a brief description of the problem plus any additional application notes.

Printed in U.S.A. 6/13 FR# 76-443725-00 Rev.4

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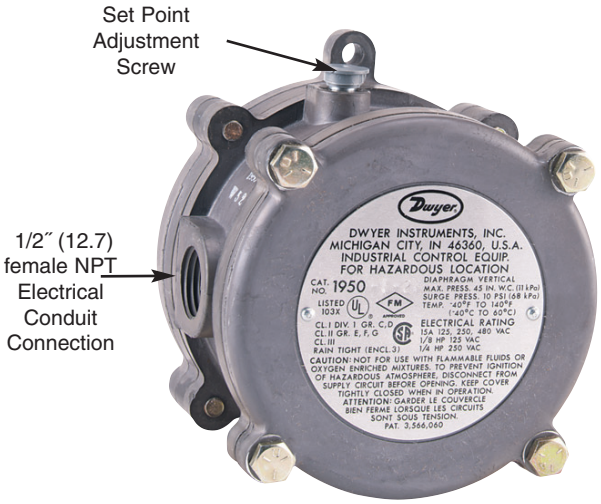
Fax: 219/872-9057 **e-mail: info@dwyer-inst.com**

Series 1950 Explosion-Proof Differential Pressure Switches

Specifications - Installation and Operating Instructions



Series 1950 Explosion-Proof Differential Pressure Switches combine the best features of the Dwyer Series 1900 Pressure Switch with an integral explosion-proof and weather-proof housing. Each unit is UL & CSA listed; FM approved for use in Class I, Groups C & D; Class II, Groups E, F, & G; and Class III atmospheres (NEMA 7 & 9). They are totally rain-tight for outdoor installations. Twelve models allow set-points from .03 to 20 inches w.c. and from .5 to 50 psi (3.4 to 345 kPa).

Easy access to the SPDT switch for electrical hook-up is provided by removing the top plate of the three-part aluminum housing. Adjustment to the set point of the switch can be made without disassembling the housing. The unit is very compact, about half the weight and bulk of equivalent conventional explosion-proof switches.

CAUTION

For use only with air or compatible gases. Use of the Model 1950 switch with explosive media connected to the Low pressure port (including differential pressure applications in such media) is not recommended. Switch contact arcing can cause an explosion inside the switch housing which, while contained, may render the switch inoperative. If switch is being used to sense a single positive pressure relative to atmosphere, run a line from the low pressure port to a non-hazardous area free of combustible gases. This may increase response time on -0 and -00 models.

NOTE: The last number-letter combination in the model number identifies the switch's electrical rating (number) and diaphragm material (letter). The 2F combination is standard as described in the physical data above. In case of special models, a number 1 rating is the same as 2; a number 3 or 4 rating is 10A 125, 250, 480 VAC; 1/8 H.P. 125 VAC; 1/4 H.P. 250 VAC; a number 5 or 6 rating is 1A 125 VAC. Letter B indicates a Buna-N diaphragm; N = Neoprene; S = Silicone; and V = Viton®.

UL and CSA Listed, FM Approved For
CL. I GR. C, D - CL. II GR. E, F, G - CL. III

Series 1950 Switches
Operating ranges and deadbands

To order specify Model Number	Operating Range: Inches, W.C.	Approximate Dead Band	
		At Min. Set Point	At Max. Set Point
1950-02-2S	0.03 to 0.10	0.025	0.05
1950-00-2F	0.07 to 0.15	0.04	0.05
1950-0-2F	0.15 to 0.5	0.10	0.15
1950-1-2F	0.4 to 1.6	0.15	0.20
1950-5-2F	1.4 to 5.5	0.3	0.4
1950-10-2F	3.0 to 11.0	0.4	0.5
1950-20-2F	4.0 to 20.0	0.4	0.6
Model Number	**Operating Range: PSI**	**Approximate Dead Band**	
		Min. Set Point	Max. Set Point
1950P-2-2F	0.5 to 2.0	0.3 psi	0.3 psi
1950P-8-2F	1.5 to 8.0	1.0 psi	1.0 psi
1950P-15-2F	3.0 to 15.0	0.9 psi	0.9 psi
1950P-25-2F	4.0 to 25.0	0.7 psi	0.7 psi
1950P-50-2F	15.0 to 50	1.0 psi	1.5 psi

SPECIFICATIONS

Service: Air and non-combustible, compatible gases.
Wetted Materials: Consult factory.
Temperature Limits: -40 to 140°F (-40 to 60°C); 0 to 140°F (-17.8 to 60°C) for 1950P-8, 15, 25, and 50. -30 to 130°F (-34.4 to 54.4°C) for 1950-02.
Pressure Limits:
Continuous: 1950's - 45″ w.c. (0.11 bar);
1950P's - 35 psi (2.41 bar); 1950P-50 only - 70 psi (4.83 bar).
Surge: 1950's - 10 psi (0.69 bar), 1950P's - 50 psi (3.45 bar), 1950P-50 only - 90 psi (6.21 bar).
Enclosure Rating: IP64, NEMA 3, 7 and 9.
Switch Type: Single-pole double-throw (SPDT).
Electrical Rating: 15 A @, 125, 250, 480 VAC, 60 Hz. Resistive 1/8 HP @ 125 VAC, 1/4 HP @ 250 VAC, 60 Hz.
Electrical Connections: 3 screw type, common, normally open and normally closed.
Process Connections: 1/8″ female NPT.
Mounting Orientation: Diaphragm in vertical position. Consult factory for other position orientations.
Set Point Adjustment: Screw type on top of housing.
Weight: 3.25 lb (1.5 kg); 1950-02 model, 4.4 lb (2 kg).
Agency Approvals: CE, UL, CSA, FM.

RESPONSE TIME: Because of restrictive effect of flame arrestors, switch response time may be as much as 10-25 seconds where applied pressures are near set point.

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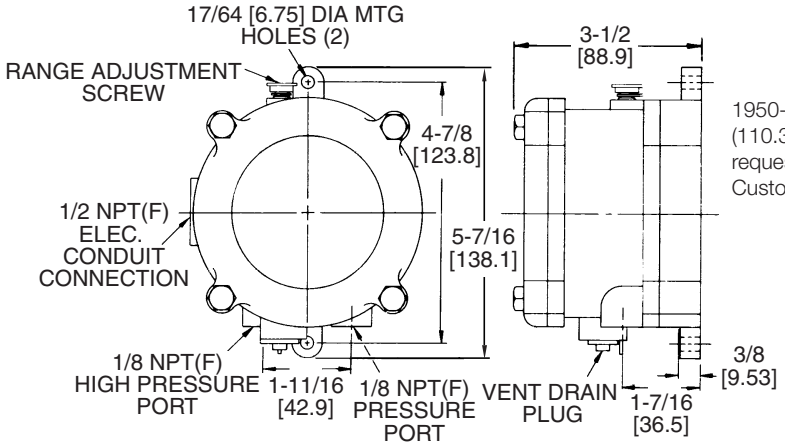

1950-02: 7-3/4″ (196.9) dia. x 4-11/32″ (110.3) depth. For complete dimensions request drawing 28-700175-00 from our Customer Service Department

1950 Switch Outline Dimensions

INSTALLATION

1. Select a location free from excess vibration and corrosive atmospheres where temperatures will be within the limits noted under Specifications on reverse. Switch may be installed outdoors or in areas where the hazard of explosion exists. See reverse for specific types of hazardous service.

2. Mount standard switches with the diaphragm in a vertical plane and with switch lettering and Dwyer nameplate in an upright position. Some switches are position sensitive and may not reset properly unless they are mounted with the diaphragm vertical.

3. Connect switch to source of pressure, vacuum or differential pressure. Metal tubing with 1/4″ O.D. is recommended, but any tubing which will not restrict the air flow can be used. Connect to the two 1/8″ female NPT pressure ports as noted below:

A. Differential pressures - connect pipes or tubes from source of greater pressure to high pressure port marked HIGH PRESS, and from source of lower pressure to low pressure port marked LOW PRESS.

B. Pressure only (above atmospheric pressure) - connect tube from source of pressure to high pressure port. The low pressure port is left open to atmosphere.

C. Vacuum only (below atmospheric pressure) - connect tube from source of vacuum to low pressure port. The high pressure port is left open to atmosphere.

4. To make electrical connections, remove the three hex head screws from the cover and after loosening the fourth captive screw, swing the cover aside. Electrical connections to the standard single pole, double throw snap switch are provided by means of terminals marked “COM” (common), “NO” (norm open), “NC” (norm closed). The normally open contacts close and the normally closed contacts open when pressure increases beyond the set point. Switch loads for standard models should not exceed the maximum specified current rating of 15 amps resistive. Switch capabilities decrease with an increase in ambient temperature, load inductance, or cycling rate. Whenever an application involves one or more of these factors, the user may find it desirable to limit the switched current to 10 amps or less in the interest of prolonging switch life.

ADJUSTMENT: To Change the Set point

1. Remove the plastic cap and turn the slotted Adjust-ment Screw at the top of the housing clockwise to raise the set point pressure and counter-clockwise to lower the set point. After calibration, replace the plastic cap and re-check the set point.

2. The recommended procedure for calibrating or checking calibration is to use a “T” assembly with three rubber tubing leads, all as short as possible and the entire assembly offering minimum flow restriction. Run one lead to the pressure switch, another to a manometer of known accuracy and appropriate range, and apply pressure through the third tube. Make final approach to the set point very slowly. Note that manometer and pressure switch will have different response times due to different internal volumes, lengths of tubing, fluid drainage, etc. Be certain the switch is checked in the position it will assume in use, i.e. with diaphragm in a vertical plane and switch lettering and Dwyer nameplate in an upright position.

3. For highly critical applications check the set point adjustment and if necessary, reset it as noted in step A.

MAINTENANCE

The moving parts of these switches need no maintenance or lubrication. The only adjustment is that of the set point. Care should be taken to keep the switch reasonably clean. Periodically the vent drain plug should be rotated, then returned to its original position. This will dislodge deposits which could accumulate in applications where there is excessive condensation within the switch. The Series 1950 Explosion-Proof Differential Pressure Switch is not field serviceable and should be returned if repair is needed (field repair should not be attempted and may void warranty). Be sure to include a brief description of the problem plus any relevant application notes. Contact customer service to receive a return goods authorization number before shipping.

Printed in U.S.A. 3/05 FR# 26-440332-00 Rev. 10

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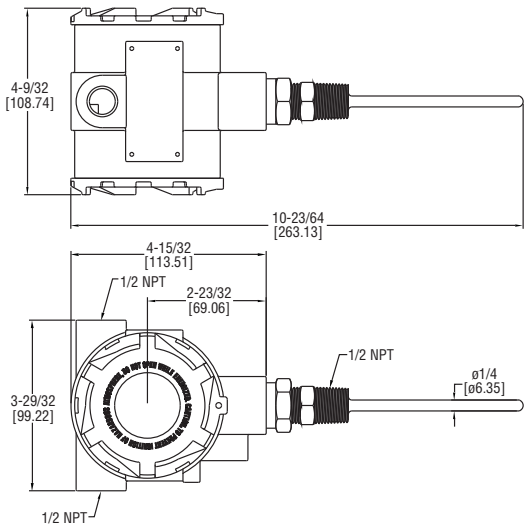
Series TTE Explosion-Proof RTD Temperature Transmitter

Installation and Operation Instructions



The Series TTE Explosion-Proof RTD Temperature Transmitter is the ideal product for hazardous temperature measurement applications. The TTE series has seven pre-programmed temperature ranges that are selectable via an internal dip switch. For those applications that need a custom range, the transmitter can be easily configured for any range between -30 to 250°F with a minimum span of 40°F. The span and zero can be quickly adjusted with a simple push button design. The compact housing allows for the transmitter to be mounted in virtually any application.

The Series TTE is ideally suited for refrigeration, building automation, commercial hot water heaters and boilers, and water chillers applications.

SPECIFICATIONS

Temperature Sensor: Pt1000, 0.00385 DIN.
Output Temperature Ranges: User selectable – any range between –30 to 250°F with a minimum span of 40°F.
Temperature Limits: Ambient: 0 – 158°F (-18 to 70°C). Process: -30 to 250°F (-34.4 to 121.1°C).
Accuracy: Transmitter +/0.1% F.S. Probe +/-0.3% F.S.
Thermal Drift Effects: +/-0.02%/°C max.
Response Time: 250 ms.
Wetted Materials: 316 stainless steel.
Process Connection: 1/2″ male NPT.
Conduit Connection: 1/2″ female NPT.
Probe Length: 2″ to 18″ (depending on model).
Pressure Limits: 2000 PSI.
Power Requirements: 10 to 35 VDC.
Output Signal: 4-20 mA (two wire loop powered).
Optional Display: 2 lines X 8 character LCD.
Enclosure Rating: NEMA 4X (IP66) and explosion-proof for Class I, Groups B, C, D; Class II, Groups E, F, G; Class III.
Weight: 2 lb 8 oz (1134 g).
Agency Approvals: FM, CE.

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INSTALLATION

1. **Location:** Select a location where the temperature of the transmitter will be between 0 and 158°F. Distance from the receiver is limited only by total loop resistance.
2. **Position:** The transmitter is not position sensitive. Units with the optional display should be mounted for ease of viewing the display.
3. **Electrical Connection:**
   Wire Length - The maximum length of wire connecting the 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 lower resistance to minimize the size and cost of connecting leads.

Current (4-20 mA) Output Operation

An external power supply is required. See Fig. A for diagram of the connection of the power supply, transmitter and receiver. The range of appropriate receiver load resistance (RL) for the DC power supply voltage available is expressed by the formula:

$$R_L = \frac{V_{ps} - 10}{20mADC}$$

Shielded cable is recommended for control loop wiring.

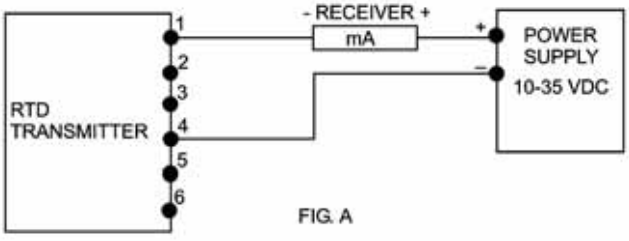

FIG. A

Explosion-Proof Installation Notes:

1. Install in accordance with any applicable national electric code.
2. Plug unused conduit openings. Plug must engage a minimum of 5 threads.
3. Use a conduit seal within 18 inches of conduit entry.
4. Disconnect power before servicing.

Electrical connections to the RTD Transmitter are made to the terminal block located inside the housing. Unscrew and remove the cover. Wire as shown in FIG. B.

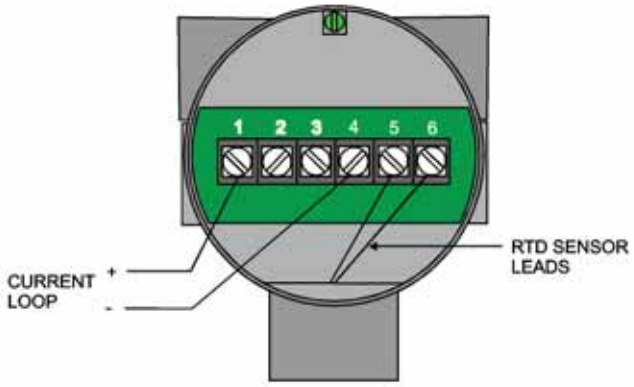

FIG. B

Temperature Range Selection

The RTD Transmitter has 7 built in temperature ranges and a user settable range that are selectable by setting the Dip Switch located inside the housing (Fig C). Switches 2, 3, and 4 are used to set the range. To set the desired range, unscrew and remove the cover and set the Dip Switch according to the following table:

	DIP SWITCH		
Selectable Ranges	**2**	**3**	**4**
40 to 90°F (4.4 to 32.2°C)	OFF	OFF	OFF
-20 to 140°F (-28.9 to 60°C)	ON	OFF	OFF
0 to 100°F (-17.8 to 37.8°C)	OFF	ON	OFF
30 to 240°F (-1.1 to 115.6°C)	ON	ON	OFF
32 to 212°F (0 to 100°C)	OFF	OFF	ON
32 to 122°F (0 to 50°C)	ON	OFF	ON
-30 to 65°C (-1.1 to 18.3°C)	OFF	ON	ON
User Settable	ON	ON	ON

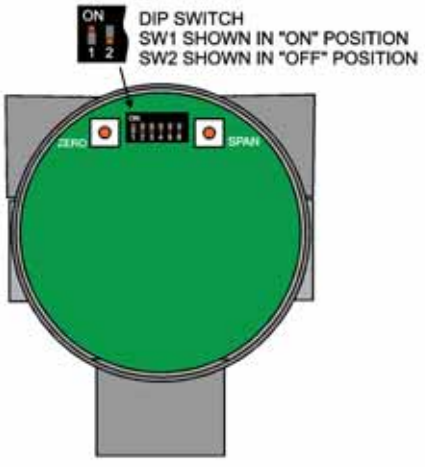

FIG. C

Setting and Calibrating the User Settable Range
By setting SWITCH 2, 3, and 4 on, the RTD Transmitter may be adjusted to a custom user specified range. The range may be any values between –30°F and +250°F (-34 to +121°C) with a MINIMUM SPAN of 40°F (22°C).

Equipment Required
In order to calibrate the unit for a custom range, a precision RTD simulator that can simulate a 1000 OHM DIN type RTD or precision decade box is required. The device must be capable of generating the correct RTD resistance to 0.1% or better.

Calibration Procedure
1. Set DIP SWITCHES 2, 3 and 4 ON.
2. Remove the RTD sensor leads from terminals 5 and 6 (Fig. B). Connect the precision RTD simulator or decade box to terminals 5 and 6.
3. Wire instrument as previously discussed. A current meter may be wired in series with the unit to verify the correct current output, but this is not necessary for calibration. Apply power to the unit.
4. If a precision RTD simulator is used, make sure it is set to simulate a 1000 OHM DIN 0.00385 RTD. Then set it to the desired minimum temperature. If a decade box is used refer to the table in Appendix A (°F) or Appendix B (°C) and set it to the resistance that represents the desired minimum temperature.
5. Press the ZERO button. If the unit has the optional LCD, the display will read ZERO OK momentarily. If a current meter is wired, it will read 4.00mA.
6. Repeat step 4 using the value for the maximum desired temperature.
7. Press the SPAN button. If the unit has the optional LCD, the display will read SPAN OK momentarily. If a current meter is wired, it will read 20.00mA.
8. Turn off power to the unit. Disconnect the RTD simulator or decade box and reconnect the RTD sensor to terminals 5 and 6. Calibration is complete.

Note: The calibration procedure does not effect the calibration of any of the built in ranges.

°F and °C Selection
If the unit has the optional LCD display, DIP SWITCH 1 sets the display to read in °F or °C. SWITCH 1 “OFF” = °F
SWITCH 1 “ON” = °C.

Output Current Display
If the unit has the optional LCD display, the lower display will show the output current if DIP SWITCH 5 is “ON”. Setting DIP SWITCH 5 “OFF” causes the lower display to be blank.

Open RTD Protection
Upon detecting an open RTD, the unit may be set to force the output to read 3.5mA or 21mA based upon the setting of DIP SWITCH 6.
SWITCH 6 “OFF”, output forced to 3.5mA
SWITCH 6 “ON”, output forced to 21mA

Calibration
The unit requires no calibration. An internal precision resistor continually self calibrates the unit. Calibration may be verified by removing the sensor leads and testing the unit against a precision RTD simulator or a precision decade box. If the unit is found to out of calibration it must be returned to the factory for service.

MAINTENANCE
Upon final installation of the Series TTE Explosion Proof RTD Temperature Transmitter, no routine maintenance is required. A periodic check of the system calibration is recommended. The Series TTE is not field serviceable and should be returned if repair is needed (field repair should not be attempted and may void warranty). Be sure to include a brief description of the problem plus any relevant application notes. Contact customer service to receive a return goods authorization number for shipping.

Appendix A - RTD Table, ˚F Plt 1000 DIN 0.00385

Values are in ohms

TEMP, °F	-0	-1	-2	-3	-4	-5	-6	-7	-8	-9
-30	864.7									
-20	886.6	884.4	882.2	880.0	877.8	875.6	873.5	871.3	869.1	866.9
-10	908.5	906.3	904.1	901.9	899.7	897.6	895.4	893.2	891.0	888.8
-0	930.3	928.2	926.0	923.8	921.6	919.4	917.2	915.0	912.9	910.7
TEMP, °F	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
0	930.3	932.5	934.7	936.9	939.1	941.2	943.4	945.6	947.8	950.0
10	952.1	954.3	956.5	958.7	960.9	963.0	965.2	967.4	969.6	971.7
20	973.9	976.1	978.3	980.4	982.6	984.8	987.0	989.1	991.3	993.5
30	995.7	997.8	1000.0	1002.2	1004.3	1006.5	1008.7	1010.9	1013.0	1015.2
40	1017.4	1019.5	1021.7	1023.9	1026.0	1028.2	1030.4	1032.5	1034.7	1036.9
50	1039.0	1041.2	1043.4	1045.5	1047.7	1049.9	1052.0	1054.2	1056.3	1058.5
60	1060.7	1062.8	1065.0	1067.1	1069.3	1071.5	1073.6	1075.8	1077.9	1080.1
70	1082.3	1984.4	1086.6	1088.7	1090.9	1093.0	1095.2	1097.4	1099.5	1101.6
80	1103.8	1106.0	1108.1	1110.3	1112.4	1114.6	1116.7	1118.9	1121.0	1123.2
90	1125.3	1127.5	1129.6	1131.8	1133.9	1136.1	1138.2	1040.4	1142.5	1144.7
TEMP, °F	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
100	1146.8	1149.0	1151.1	1153.3	1155.4	1157.6	1159.7	1161.8	1164.0	1166.1
110	1168.3	1170.4	1172.6	1174.7	1176.9	1179.0	1181.1	1183.3	1185.4	1187.6
120	1189.7	1191.8	1194.0	1196.1	1198.3	1200.4	1202.5	1204.7	1207.0	1208.9
130	1211.1	1213.2	1215.4	1217.5	1219.6	1221.8	1223.9	1226.0	1228.2	1230.3
140	1232.4	1234.6	1236.7	1238.8	1241.0	1243.1	1245.2	1247.3	1249.5	1251.6
150	1253.7	1255.9	1258.0	1260.1	1262.2	1264.4	1266.5	1268.6	1270.8	1272.9
160	1275.0	1277.1	1279.3	1281.4	1283.5	1285.6	1287.8	1289.9	1292.0	1294.1
170	1296.2	1298.4	1300.5	1302.6	1304.7	1306.9	1309.0	1311.1	1313.2	1315.3
180	1317.5	1319.6	1321.7	1323.8	1325.9	1328.0	1330.2	1332.3	1334.4	1336.5
190	1338.6	1340.7	1342.8	1345.0	1347.1	1349.2	1351.3	1353.4	1355.5	1357.6
TEMP, °F	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
200.0	1359.7	1361.9	1364.0	1366.1	1368.2	1370.3	1372.4	1374.5	1376.6	1378.7
210.0	1380.8	1383.0	1385.1	1387.2	1389.3	1391.4	1393.5	1395.6	1397.7	1399.8
220.0	1401.9	1404.0	1406.1	1408.2	1410.3	1412.4	1414.5	1416.6	1418.7	1420.8
230.0	1422.9	1425.0	1427.1	1429.2	1431.3	1433.4	1435.5	1437.6	1439.7	1441.8
240.0	1443.9	1446.0	1448.1	1450.2	1452.3	1454.4	1456.5	1458.6	1460.7	1462.8
250.0	1464.9									

Appendix B - RTD Table, ˚C Plt 1000 DIN 0.00385

Values are in ohms

TEMP, °C	-0	-1	-2	-3	-4	-5	-6	-7	-8	-9
-30	888.2	878.3	874.3	870.4	866.4					
-20	921.6	917.7	913.7	909.8	905.9	901.9	898.0	894.0	890.1	886.2
-10	960.9	956.9	953.0	949.1	945.2	941.2	937.3	933.4	929.5	925.5
-0	1000.0	996.1	992.2	988.3	984.4	980.4	976.5	972.6	968.7	964.8
TEMP, °C	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
0	1000.0	1003.9	1007.8	1011.7	1015.6	1019.5	1023.4	1027.3	1031.2	1035.1
10	1039.0	1042.9	1046.8	1050.7	1054.6	1058.5	1062.4	1066.3	1070.2	1074.1
20	1077.9	1081.8	1085.7	1089.6	1093.5	1097.4	1101.2	1105.1	1109.0	1112.9
30	1116.7	1120.6	1124.5	1128.3	1132.2	1136.1	1140.0	1143.8	1147.7	1151.5
40	1155.4	1159.3	1163.1	1167.0	1170.9	1174.7	1178.6	1182.4	1186.3	1190.1
50	1194.0	1197.8	1201.7	1205.5	1209.4	1213.2	1217.1	1220.9	1224.7	1228.6
60	1232.4	1236.3	1240.1	1243.9	1247.8	1251.6	1255.4	1259.3	1263.1	1266.9
70	1270.8	1274.6	1278.4	1282.2	1286.1	1289.9	1293.7	1297.5	1301.3	1305.2
80	1309.0	1312.8	1316.6	1320.4	1324.2	1328.0	1331.8	1335.7	1339.5	1343.3
90	1347.1	1350.9	1354.7	1358.5	1362.3	1366.1	1369.9	1373.7	1377.5	1381.3
TEMP, °C	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
100	1385.1	1388.9	1392.6	1396.4	1400.2	1404.0	1407.8	1411.6	1415.4	1419.1
110	1422.9	1426.7	1430.5	1434.3	1438.0	1441.8	1445.6	1449.4	1453.1	1456.9
120	1460.7	1464.5								

Printed in U.S.A. 12/08

FR# 02-443554-00 Rev.1

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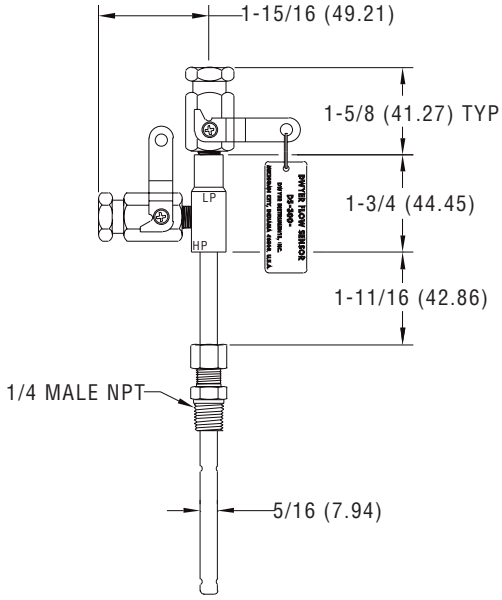
Series DS-300 Flow Sensors

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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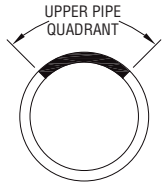
POSITION

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

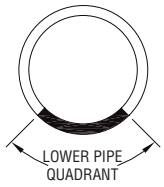
Install in upper quadrant of pipe



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

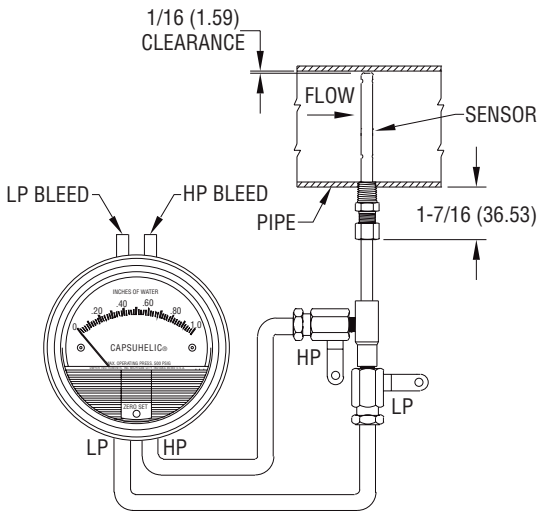
Connect the slide pressure tap to the high pressure port of the Magnehelic® (air only) or Capsuhelic® gage or transmitting instrument and the top connection to the low pressure port.

See the connection schematics below.

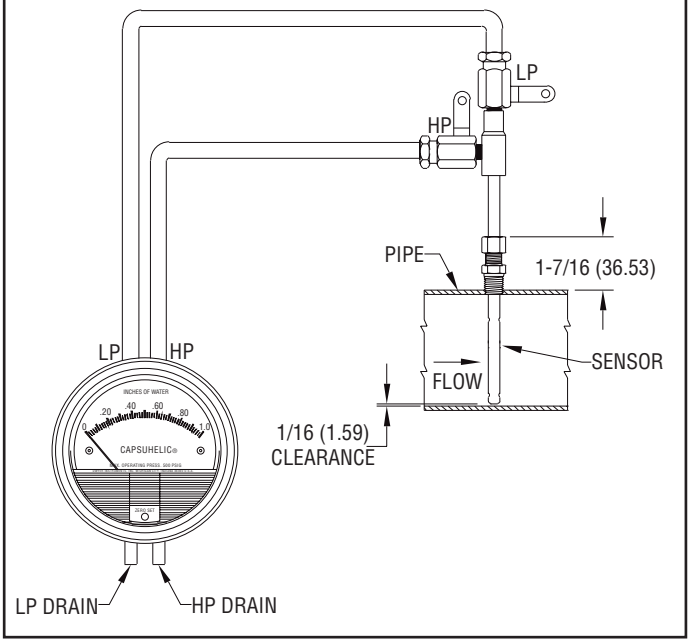
Bleed air from instrument piping on liquid flows. Drain any condensate from the instrument piping on air and gas flows.

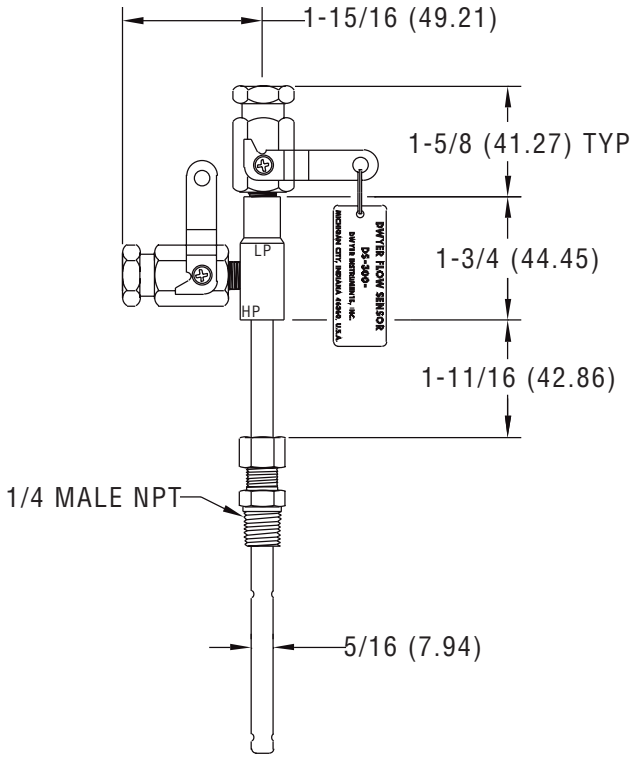
Open valves to instrument to place flow meter into service. For permanent installations, a 3-valve manifold is recommended to allow the gage to be zero checked without interrupting the flow. The Dwyer A-471 Portable Test Kit includes such a device.

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

Printed in U.S.A. 7/04 FR# 72-440451-01 Rev. 2

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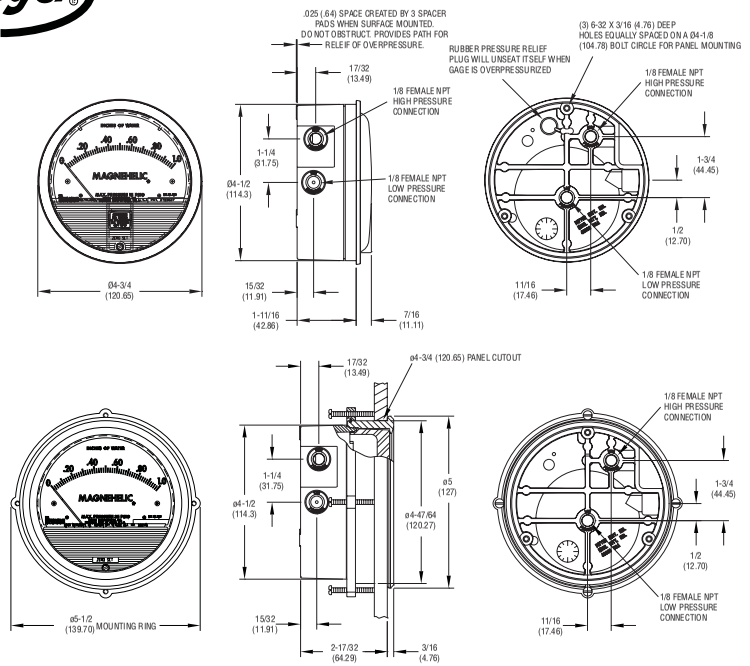
Magnehelic® Differential Pressure Gage



**The blowout plug is not used on models above 180 inches of water pressure, medium or high pressure models, or on gages which require an elastomer other than silicone for the diaphragm.*

STANDARD GAGE ACCESSORIES: Two 1/8″ NPT plugs for duplicate pressure taps, two 1/8″ pipe thread to rubber tubing adapters and three flush mounting adapters with screws.

MP AND HP GAGE ACCESSORIES: Mounting ring and snap ring retainer substituted for 3 adaptors, 1/4" compression fittings replace 1/8" pipe thread to rubber tubing adaptors.

OVERPRESSURE PROTECTION: Standard Magnehelic® Differential Pressure Gages are rated for a maximum pressure of 15 psig and should not be used where that limit could be exceeded. Models employ a rubber plug on the rear which functions as a relief valve by unseating and venting the gage interior when over pressure reaches approximately 25 psig (excludes MP and HP models). To provide a free path for pressure relief, there are four spacer pads which maintain .023″ clearance when gage is surface mounted. Do not obstruct the gap created by these pads.

SPECIFICATIONS

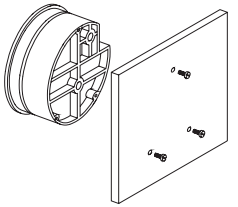
Service: Air and non-combustible, compatible gases. (Natural Gas option available.)
Wetted Materials: Consult factory.
Housing: Die cast aluminum case and bezel, with acrylic cover. (MP model has polycarbonate cover).
Accuracy: ±2% of full scale (±3% on - 0, -100 Pa, -125 Pa, 10MM and ±4% on -00, - 00N, -60 Pa, -6MM ranges), throughout range at 70°F (21.1°C).
Pressure Limits: -20″ Hg to 15 psig.† (-0.677 bar to 1.034 bar); MP option: 35 psig (2.41 bar), HP option: 80 psig (5.52 bar).
Overpressure: Relief plug opens at approximately 25 psig (1.72 bar), standard gages only. The blowout plug is not used on models above 180 inches of water pressure, medium or high pressure models, or on gages which require an elastomer other than silicone for the diaphragm.
Temperature Limits: 20 to 140°F (-6.67 to 60°C). *Low temperature models available as special option.
Size: 4″ (101.6 mm) diameter dial face.
Mounting Orientation: Diaphragm in vertical position. Consult factory for other position orientations.
Process Connections: 1/8″ female NPT duplicate high and low pressure taps - one pair side and one pair back.
Weight: 1 lb 2 oz (510 g), MP & HP 2 lb 2 oz (963 g).

†For applications with high cycle rate within gage total pressure rating, next higher rating is recommended. See Medium and High pressure options.
Note: May be used with hydrogen when ordering Buna-N diaphragm. Pressure must be less than 35 psi.

INSTALLATION

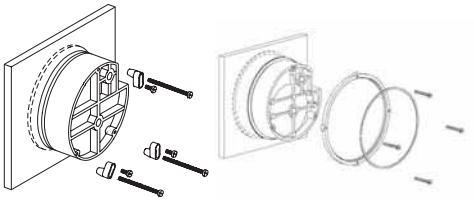
Select a location free from excessive vibration and where the ambient temperature will not exceed 140°F (60°C). Also, avoid direct sunlight which accelerates discoloration of the clear plastic cover. Sensing lines may be run any necessary distance. Long tubing lengths will not affect accuracy but will increase response time slightly. Do not restrict lines. If pulsating pressures or vibration cause excessive pointer oscillation, consult the factory for ways to provide additional damping.
All standard Magnehelic® Differential Pressure Gages are calibrated with the diaphragm vertical and should be used in that position for maximum accuracy. If gages are to be used in other than vertical position, this should be specified on the order. Many higher range gages will perform within tolerance in other positions with only rezeroing. Low range models of 0.5" w.c. plus 0.25" w.c. and metric equivalents must be used in the vertical position only.

SURFACE MOUNTING



Locate mounting holes, 120° apart on a 4-1/8" dia. circle. Use No. 6-32 machine screws of appropriate length.

FLUSH MOUNTING



Provide a 4-9/16" dia. (116 mm) opening in panel. Provide a 4-3/4" dia. (120 mm) opening for MP and HP models. Insert gage and secure in place with No. 6-32 machine screws of appropriate length, with adapters, firmly secured in place.

PIPE MOUNTING

To mount gage on 1-1/4" - 2" pipe, order optional A-610 pipe mounting kit.

TO ZERO GAGE AFTER INSTALLATION

Set the indicating pointer exactly on the zero mark, using the external zero adjust screw on the cover at the bottom. Note that the zero check or adjustment can only be made with the high and low pressure taps both open to atmosphere.

OPERATION

Positive Pressure: Connect tubing from source of pressure to either of the two high pressure ports. Plug the port not used. Vent one or both low pressure ports to atmosphere.
Negative Pressure: Connect tubing from source of vacuum or negative pressure to either of the two low pressure ports. Plug the port not used. Vent one or both high pressure ports to atmosphere.
Differential Pressure: Connect tubing from the greater of two pressure sources to either high pressure port and the lower to either low pressure port. Plug both unused ports.
When one side of the gage is vented in dirty, dusty atmosphere, we suggest an A-331 Filter Vent Plug be installed in the open port to keep inside of gage clean.

A. For portable use of temporary installation use 1/8" pipe thread to rubber tubing adapter and connect to source of pressure with flexible rubber or vinyl tubing.
B. For permanent installation, 1/4" O.D., or larger, copper or aluminum tubing is recommended.

MAINTENANCE

No lubrication or periodic servicing is required. Keep case exterior and cover clean. Occasionally disconnect pressure lines to vent both sides of gage to atmosphere and re-zero. Optional vent valves should be used in permanent installations. The Series 2000 is not field serviceable and should be returned if repair is needed (field repair should not be attempted and may void warranty). Be sure to include a brief description of the problem plus any relevant application notes. Contact customer service to receive a return goods authorization number before shipping.

WARNING

Attempted field repair may void your warranty. Recalibration or repair by the user is not recommended.

TROUBLE SHOOTING TIPS

Gage won't indicate or is sluggish.

1. Duplicate pressure port not plugged.
2. Diaphragm ruptured due to overpressure.
3. Fittings or sensing lines blocked, pinched, or leaking.
4. Cover loose or "O"ring damaged, missing.
5. Pressure sensor, (static tips, Pitot tube, etc.) improperly located.
6. Ambient temperature too low. For operation below 20°F (-7°C), order gage with low temperature, (LT) option.

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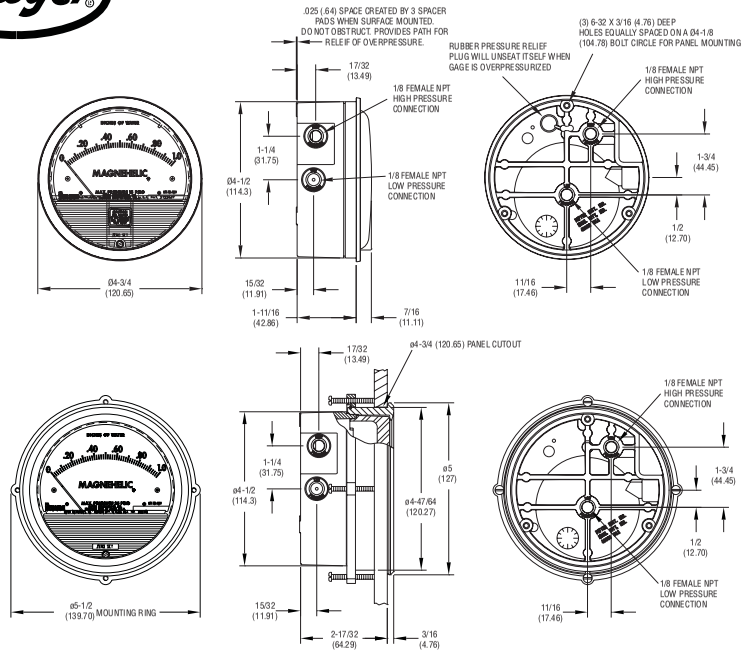
Bulletin A-27

Magnehelic® Differential Pressure Gage

INSTRUCCIONES Y LISTA DE PARTES



(El tapón de goma no es usado en los modelos sobre 180 pulgadas de presión de agua, modelos de presión media o alta, o en instrumentos que requieren un elastizado en cualquier otro material que no sea silicona para el diafragma.)

Accesorios: Tapones 1/8" NPT para las conexiones duplicadas, dos adaptadores de rosca 1/8" NPT a tubo de goma; y tres adaptadores para montaje al ras y tornillos.

Accesorios para Los Modelos MP y HP: El anillo de montaje y el retensor del anillo de presión son substituidos por 3 adaptadores, accesorios de compresión de 1/4" remplazan a los adaptadores de rosca 1/8" a tubo de goma.

Protección Para Sobrepresión: Los Manómetros Diferenciales Magnehelic Estándar están clasificados para una presión máxima de 15 psi y no se deberían de usar donde el límite puede excederse. Los modelos emplean un tapón de goma en el trasero que funciona como una válvula de alivio desmontándose y ventilando el interior del instrumento cuando la sobrepresión alcanza aproximadamente 25 psig. (Los modelos MP y HP son excluidos) Para proveer un camino libre para el alivio de presión, el instrumento viene con rodilleras que mantienen un espacio de .023" cuando el instrumento es montado en superficie. No bloque el espacio creado por estas rodilleras.

ESPECIFICACIONES

Servicio: aire y gases no combustibles, gases compatibles. (ópcion disponible para uso con gas natural).
Materiales Mojados: Consulte con la fábrica.
Carcasa: Caja y anillo de retención de aluminio fundido a presión con tapadera de acrílico. (El modelo MP tiene la tapadera de policarbonato.)
Exactitud: ±2% de fondo de escala a 21 °C
Mod. 2000-0 ±3%; Mod. 2000-00 ±4%
Límite de Presión: -20 Hg. a 15 psig. † (-0.677 bar a 1,034 bar); opción MP: 35 psig (2.41 bar), opción HP: 80 psig (5.52 bar).
Sobrepresión: El tapón de alivio se abre aproximadamente a los 25 psig, modelos estandard únicamente. El tapón de goma no es usado en los modelos sobre 180 pulgadas de presión de agua, modelos de presión media o alta, o en instrumentos que requieren un elastizado en cualquier otro material que no sea silicio para el diafragma.
Límite de Temperatura: -6.67 a 60ºC. * Modelos de baja temperatura disponibles como opción especial.
Dimensiones: diám. 120,65 mm x 55,6 prof.
Orientación de Montaje: El diafragma debe ser usado solo en posición vertical. Consulte con la fábrica para otras orientaciones de posición.
Conexiones: 1/8" NPT para alta y baja presión, duplicadas (atrás, a los lados).
Peso: 510 g, MP y HP 963 g.

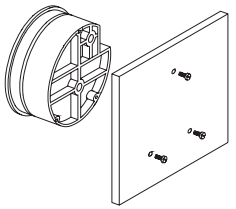
† Para aplicaciones con alto ciclo de velocidad dentro de la clasificación de presión total del instrumento, la próxima clasificación mas alta es recomendada. Vea las opciones de media y alta presión.

El instrumento puede ser usado con hidrogeno cuando se ordena con diafragma de Buna-N. La presion tiene que ser menos de 35 psi.

Instalacíon

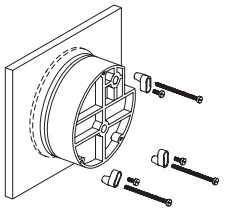
Seleccione un lugar libe de exceso de vibraciones, y donde la temperatura ambiente no supere los 60°C. Evite luz solar directa, para evitar decoloración de la cubierta plástica. Las conexiones de proceso pueden tener cualquier longitud sin afectar la exactitud, pero pueden extender el tiempo de respuesta del instrumento. Si hay pulsación de presión o vibración, consulte a fábrica sobre medios de amortiguación.
Los MAGNEHELIC han sido calibrados con el diafragma vertical, y deben ser usados en esas condiciones. Para otras posiciones, se debe especificar en la orden de provisión. Los de rango elevado pueden ser usados en diversas posiciones, pero se debe reajustar el cero. Los modelos de la serie 2000-00 y equivalentes métricos deben ser usados solo verticalmente.

Montaje en Superficie



Perfore tres orificios separados 120° sobre una circunferencia de 105 mm de diám. y sostenga el instrumento con tres tornillos 6-32 de long. apropiada.

Montaje alineado



Perfore un circulo de 115 mm de diám. en el panel, y sostenga el instrumento mediante los.

Montaje Sobre Pipa

Para montar el instrumento sobre pipas de 32 a 50 mm de diám., ordene el adaptador opcional A-610.

Puesta a Cero Después de Instalar

Deje las conexiones de presión abiertas a atmósfera y ajuste a cero desde tornillo del panel frontal.

Operacion

Presión Positiva: Conecte la tubería desde la fuente de presión a cualquiera de las dos conexiones de alta presión (HIGH), bloqueando la no usada; Las conexiones de baja (LOW) presión pueden dejarse uno o los dos abiertos a la atmósfera.
Presión Negativa: Repita el procedimiento anterior, conectado en este caso las conexiones de baja presión (LOW). Deje las otras conexiones abiertas.
Presión diferencial: Conecte el tubo correspondiente a la presión más positiva al cualquiera de los conectores de alta presión (HIGH) bloqueando el no usado, y la más baja presión o presión negativa (vacío) al conector de baja presión (LOW). Puede usarse cualquier conector de cada par, dejando siempre uno bloqueado. Si se deja una conexión abierta a la atmósfera, se recomienda el uso de un filtro tipo A-331 en el lugar correspondiente para mantener limpio el interior del instrumento. Para uso portable, o instalación temporaria, uso adapta dores para rosca de tubo de 1/89 a tubo flexible, y conecte a proceso mediante una tubería de goma, o equivalente. Para instalación permanente, se recomienda el uso de tubo de cobre o aluminio de por lo menos 1/4" de diám. exterior.

No se requiere mantenimiento específico alguno, ni lubricación. Periódicamente, desconecte el instrumento, ventee la presión acumulada, y reajuste el cero. Para instalaciones permanentes, se debe usar un juego de válvulas de montaje permanente para el venteo.
El instrumento de Serie 2000 no puede ser re parado en el campo y debería de ser regresado si reparos son necesarios (Reparos en el campo no deben de ser intentados y pueden cancelar la garantía.). Asegurarse de incluir una descripción breve del problema más cualquier notas pertinentes a la aplicación para devolución de productos antes de enviar el instrumento.

Cuidado! : La recalibración en campo puede invalidar la garantía. No se recomienda la recalibracion por parte del usuario. En caso necesario envie el instrumento con transporte pago a:

Localización De Fallas

• *El instrumento no indica, o es lento en reacción.*
1. Conexión duplicada abierta.
2. Diafragma roto por sobrepresión.
3. Tubería de conexión perforada, con pérdidas o pinchazos.
4. Anillo de retención flojo, u "O " ring dañado.
5. Conexión a proceso indebida o inadecuada.
6. Temperatura muy baja. Para este caso ordene tipos LT (baja temperatura).

Printed in U.S.A. 2/08 FR# 12-440212-10 Rev.1

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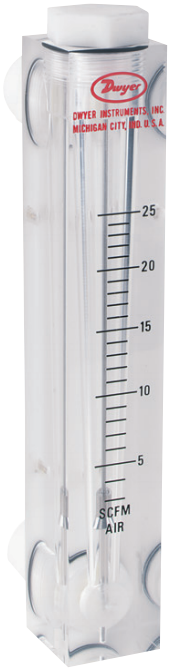
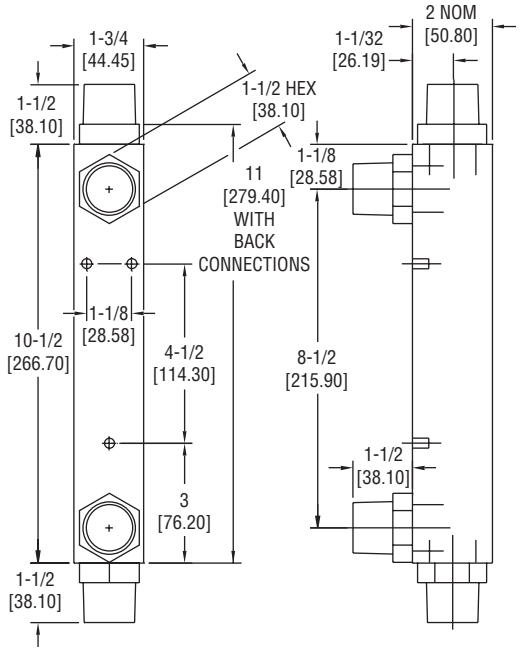
VFC Series Visi-Float® Flowmeter

Specifications - Installation and Operating Instructions



Back Connections



Dwyer Series VFC Visi-Float® flowmeters are available in two basic styles, either back or end connected with direct reading scales for air or water. Installation, operation, and maintenance are simple and require only a few common sense precautions to assure long, accurate, trouble-free service.

CALIBRATION

All Dwyer flowmeters are calibrated at the factory and normally will remain within their accuracy tolerance for the life of the device. If at any time you wish to re-check its calibration, do so only with instruments or equipment of certified accuracy. Do not attempt to check the Dwyer Visi-Float® flowmeter with a similar flowmeter as even minor variations in piping and back pressure can cause significant differences between the indicated and actual readings. If in doubt, your Dwyer flowmeter may be returned to the factory and checked for conformance at no charge.

LOCATION

Select a location where the flowmeter can be easily read and where the temperature will not exceed 120°F (49°C). The mounting surface and piping to the flowmeter should be free from vibration which could cause fatigue of fittings or mounting inserts. Piping must be carefully arranged and installed to avoid placing stress on fittings and/or flowmeter body. Avoid locations or applications with strong chlorine atmospheres or solvents such as benzene, acetone, carbon tetrachloride,etc. Damage due to contact with incompatible gases or liquids is not covered by warranty. Compatibility should be carefully determined before placing in service.

SPECIFICATIONS

Service: Compatible gases & liquids.

Wetted Materials:

Body: Acrylic plastic.

O-Ring: Buna-N (Viton® available).

Metal Parts: Stainless steel.

Float: Stainless steel.

Temperature & Pressure Limits: 100 psig (6.9 bar) @ 120°F (48°C).

Accuracy: 2% of full scale.

Process Connection: VFC: 1″ female NPT back connections. End connections optional. VFCII: 1″ male NPT back connections. End Connections optional.

Scale Length: 5″ typical length.

Mounting Orientation: Mount in vertical position.

Weight: 24-25 oz (.68-.71 kg).

PIPING

Inlet Piping:

It is good practice to approach the flowmeter inlet with as few elbows, restrictions and size changes as possible. Inlet piping should be as close to the flowmeter connection size as practical to avoid turbulence which can occur with drastic size changes. The length of inlet piping has little effect on normal pressure fed flowmeters.

For vacuum service, the inlet piping should be as short and open as possible to allow operation at or near atmospheric pressure and maintain the accuracy of the device. Note that for vacuum service, any flow control valve used must be installed on the discharge side of the flowmeter.

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Discharge Piping
Piping on the discharge side should be at least as large as the flowmeter connection. For pressure fed flowmeters on air or gas service, the piping should be as short and open as possible. This allows operation at or near atmospheric pressure and assures the accuracy of the device. This is less important on water or liquid flowmeters since the flowing medium is generally incompressible and back pressure will not affect the calibration of the instrument.

POSITION AND MOUNTING
All Visi-Float® flowmeters must be installed in a vertical position with the inlet connection at the bottom and outlet at the top.

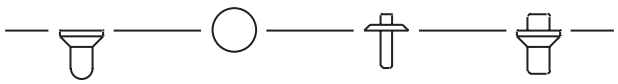
Surface Mounting
Drill three holes in panel using dimensions shown in drawing. Holes should be large enough to accommodate #10 - 32 machine screws. If back connected model, drill two additional holes for clearance of fittings. Install mounting screws of appropriate length from rear. Mounting screws must not be longer than the panel thickness plus $^3/_8$≤ (9.66 mm), or the screw will hit the plastic and may damage the meter. The screws will require additional force during the initial installation, since the insert boots are of a collapsed thread type and must be expanded into the plastic for the knurled surface to take hold. Insert boots will not have the proper 10-32 threads until the first screw has been inserted to expand the boot. Attach piping using RTV silicone sealant or Teflon® tape on threads to prevent leakage.

CAUTION: Do not overtighten fittings or piping into fittings. Maximum recommended torque is 10 ft. (lbs) (13.56 newton (meter)). Hand tighten only.

In Line Mounting
Both end connected and back connected models may be installed in-line supported only by the piping. Be sure that flowmeter is in a vertical position and that piping does not create excess stress or loading on the flowmeter fittings.

OPERATION
Once all connections are complete, introduce flow as slowly as possible to avoid possible damage. With liquids, make sure all air has been purged before taking readings. Once the float has stabilized, read flow rate by sighting across the largest diameter of the float to the scale graduations on the face of the device.

The standard technique for reading a Variable Area Flowmeter is to locate the highest point of greatest diameter on the float, and then align that with the theoretical center of the scale graduation. In the event that the float is not aligned with a grad, an extrapolation of the float location must be made by the operator as to its location between the two closest grads. The following are some sample floats shown with reference to the proper location to read the float.



Variable Area Flowmeters used for gases are typically labeled with the prefix “S” or “N”, which represents “Standard” for English units or “Normal” for metric units. Use of this prefix designates that the flowmeter is calibrated to operate at a specific set of conditions, and deviation from those standard conditions will require correction for the calibration to be valid. In practice, the reading taken from the flowmeter scale must be corrected back to standard conditions to be used with the scale units. The correct location to measure the actual pressure and temperature is at the exit of the flowmeter, except under vacuum applications where they should be measured at the flowmeter inlet. The equation to correct for nonstandard operating conditions is as follows:

$$Q_2 = Q_1 \times \sqrt{\frac{P_1 \times T_2}{P_2 \times T_1}}$$

Where: Q_1 = Actual or Observed Flowmeter Reading
Q_2 = Standard Flow Corrected for Pressure and Temperature
P_1 = Actual Pressure (14.7 psia + Gage Pressure)
P_2 = Standard Pressure (14.7 psia, which is 0 psig)
T_1 = Actual Temperature (460 R + Temp °F)
T_2 = Standard Temperature (530 R, which is 70°F)

Example: A flowmeter with a scale of 10-100 SCFH Air. The float is sitting at the 60 grad on the flowmeter scale. Actual Pressure is measured at the exit of the meter as 5 psig. Actual Temperature is measured at the exit of the meter as 85°F.

$$Q_2 = 60.0 \times \sqrt{\frac{(14.7 + 5) \times 530}{14.7 \times (460 + 85)}}$$

Q_2 = 68.5 SCFH Air

MAINTENANCE
The only maintenance normally required is occasional cleaning to assure proper operation and good float visibility.

Disassembly
The flowmeter can be completely disassembled by removing the connection fittings and top plug. When lifting out the float guide assembly, be careful not to lose the short pieces of plastic tubing on each end of the guide rod which serve as float stops.

Cleaning
The flowmeter body and all other parts can be cleaned by washing in a mild soap and water solution. A soft bristle bottle brush will simplify cleaning of the flow tube. Avoid benzene, acetone, carbon tetrachloride, gasoline, alkaline detergents, caustic soda, liquid soaps, (which may contain chlorinated solvents), etc., and avoid prolonged immersion.

Re-assembly
Install the lower fitting and then the float and float guide. Finally install the upper fitting and plug being certain that both ends of the float guide are properly engaged and the float is correctly oriented. A light coating of silicone stop cock grease or petroleum jelly on the “O” rings will help maintain a good seal as well as ease assembly.

ADDITIONAL INFORMATION
For additional flowmeter application information, conversion curves, correction factors and other data covering the entire line of Dwyer flowmeters, please request a dwyer full-line catalog.

Printed in U.S.A. 3/04 FR# 51-440448-00 Rev. 3

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ISTEC
Flow Measurement & Control

FLOWMETER

ENGINEERING MANUAL
1700 SERIES

FLOW MEASUREMENT & CONTROL SOLUTIONS

5 Park Lake Rd., Sparta, NJ 07871
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PRODUCT OVERVIEW

ISTEC's "Super-Jet'' 1700 Series Water Meters are the latest design in multi-wing flow meters. The result: high reliability with great accuracy at a low cost. The design of the ''Super-Jet'' flow chamber guides the water through the meter to minimize turbulence. For the 1" through 2" meters, no straight piping to the flow meter is necessary for accuracy that exceeds AWWA standards.

All ISTEC flow meters are designed with a trickle-flow indicator showing even the smallest water flow. The flow counter is non-resettable and available with contact pulsers for remote reading or computer interconnections.

For easy installation, all ISTEC flow meters up to 1½'' are available with union connections and the 2'' model is equipped with standard flanges. The smooth running, self-aligning turbine adds to the list of innovative features providing long life, accuracy and reliability.

COMPONENT DESCRIPTION

BODY

Pipe Size ½" (15mm) to 1½" (40mm)	Brass
Pipes Size 2" (50mm)	Cast Iron

CONNECTIONS

Pipe Size ½" (15mm) to 1" (25mm)	NPT or Sweat
Pipe Size 1¼" (32mm) to 1½" (40mm)	NPT
Pipes Size 2" (50mm)	ANSI 150# Flange

FLOW INSERT

Turbine	Polyamide Fiber Reinforced
Pivot	Stainless Steel
Bearing	Ceramic
Magnet	Cobalt/Samarium
Strainer	Polypropylene
O-Ring	Synthetic Rubber or Viton

COUNTER

Calibration	U.S. Gallons (Metric Available)
Housing	Plastic
Gears	Plastic

ENVIRONMENTAL

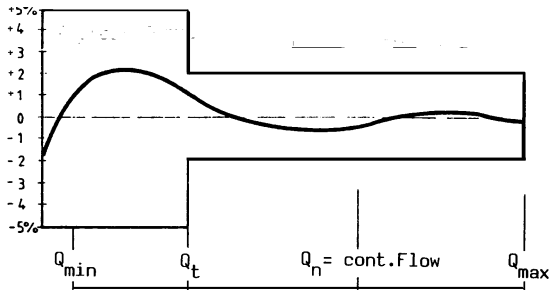
Maximum Temperature	200ºF (90ºC)
Maximum Pressure	150 PSI (10 BAR)

TECHNICAL SPECIFICATIONS

P/N			1700	1710	1720	1730	1740	1750
FLOW RANGE		MIN	0.13 gpm	0.22 gpm	0.5 gpm	0.5 gpm	0.8gpm	1.3 gpm
			30 lph	50 lph	120 lph	120 lph	200 lph	295 lph
		CONT	6.6 gpm	11 gpm	26.4gpm	26.4gpm	44.0 gpm	66.0 gpm
			1.5 m^3ph	2.5 m^3ph	6 m^3ph	6 m^3ph	10 m^3ph	15 m^3ph
		MAX	13.0 gpm	20 gpm	50.0 gpm	50.0 gpm	90.0 gpm	132.0 gpm
			3.0 m^3ph	5.0 m^3ph	12 m^3ph	12 m^3ph	20 m^3ph	30 m^3ph
PULSE		gal/pulse	N/A	N/A	N/A	N/A	N/A	N/A
		liters/pulse	N/A	N/A	N/A	N/A	N/A	N/A
WEIGHT		pounds	1.1	1.4	5.5	5.5	12.0	27.0
		kilograms	0.5	0.6	2.5	2.5	5.4	12.4

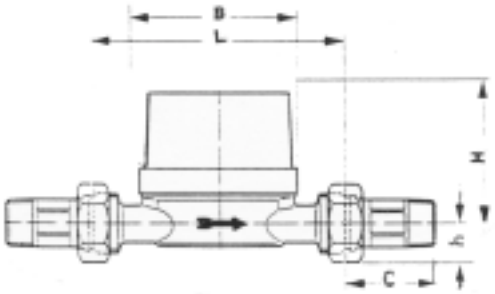
P/N			1702	1712				1752
FLOW RANGE		MIN	0.13 gpm	0.22 gpm				1.3 gpm
			30 lph	50 lph				295 lph
		CONT	6.6 gpm	11 gpm				66.0 gpm
			1.5 m^3ph	2.5 m^3ph				15 m^3ph
		MAX	13.0 gpm	20 gpm				132.0 gpm
			3.0 m^3ph	5.0 m^3ph				30 m^3ph
PULSE		gal/pulse	1	1				10
		liters/pulse	1	1				10
WEIGHT		pounds	1.1	1.4				27.0
		kilograms	0.5	0.6				12.4

TYPICAL FLOWMETER ACCURACY CHART

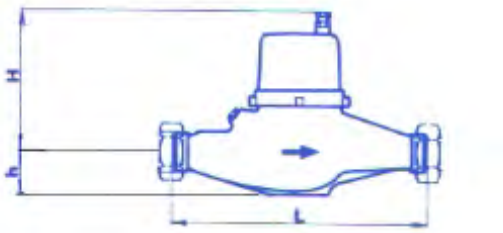


DIMENSIONS

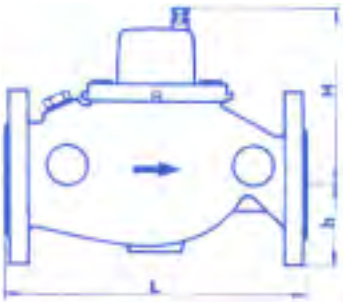
P/N	**1700 1702**	**1710 1712**	**1720**	**1730**	**1740**	**1750 1752**
Size	1/2" 15mm	3/4" 20mm	1" 25mm	1-1/4" 32mm	1-1/2" 40mm	2" 50mm
L (Body)	4-5/16" 110mm	5-1/8" 130mm	10-1/4" 260mm	10-1/4" 260mm	11-3/4" 300mm	10-1/2" 270mm
C (NPT)	2-3/8" 60mm	2-1/2" 63mm	2-5/8" 67mm	2-7/8" 73mm	2-7/8" 73mm	N/A
C (Sweat)	11/16" 17mm	7/8" 22mm	1-1/16" 27mm	N/A	N/A	N/A
B Width	2-3/4" 70mm	2-3/4" 70mm	3-5/8" 92mm	3-5/8" 92mm	4-3/4" 120mm	N/A
H Height	2" 50mm	2" 50mm	3-5/8" 92mm	3-5/8" 92mm	3-5/8" 92mm	5-3/8" 137mm
h Height	3/4" 20mm	7/8" 22mm	1-7/8" 48mm	1-7/8" 48mm	1-7/8" 48mm	3-1/2" 89mm



Flowmeter ½” & ¾”



Flowmeter 1” to 1-1/2”



Flowmeter 2”

FLOWMETER SPECIFICATION: 1700 SERIES

AS MANUFACTURED BY ISTEC CORPORATION
5 Park Lake Road, Sparta, NJ 07871

The contractor shall furnish and install as shown on the plans a multi-wing turbine type Flowmeter. The Flowmeter shall be factory assembled, calibrated and tested, incorporating the following features:

BODY

The Flowmeter shall have a line size of _____ inch(s)/_____mm(s). The body shall be constructed of brass (from ½" (15mm) to 1-1/2" (40mm) sizes) or cast iron (from 2" (50mm) to 12" (300mm)).

FLOW INSERT

The Flow Insert shall be the "single-jet" type on the ½" (15mm) and ¾" (20mm) sizes. It shall be the "multi-jet" style on the 1" (25mm) through 12" (300mm) sizes. The insert assembly shall be capable of being replaced without removing the meter body.

COUNTER

The unit shall have a hermetically sealed "dry-type" mechanical counter. The counter will read in U.S. gallons (cubic meters available) and shall be non-resettable.

ACCURACY

The Flowmeter shall have an accuracy of ± 1.5%.

FLOW RANGE

The Flowmeter shall have a minimum flow rating of _____ gpm (_____ lph/or m^3ph). It shall have a continuous flow rating of_____ gpm (_____ m^3ph). The peak flow, which the meter can not be subjected to for more than one hour per day, shall be_____ gpm (_____ m^3ph).

PULSER

The Flowmeter shall provide a "pulse" type output of 1 contact closure for every 1/10/100 gallon(s) of flow (metric counters provide 1 pulse for every 1/10/100 liters of flow).

DEKKER
VACUUM TECHNOLOGIES, INC.

Installation
Operation
and
Maintenance
Manual

Vmax

Vmax LT Vmax VFD

Oil-sealed
liquid ring vacuum pump systems

SERIAL NO.:_____

June, 2006/13

OIL-SEALED LIQUID RING VACUUM PUMP SYSTEMS
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INTRODUCTION

The ***Vmax*** oil-sealed liquid ring vacuum pump system have been designed to give you safe, reliable trouble-free service, provided some of the basic maintenance guidelines as set out in this manual are followed. Compared with other vacuum pump systems the ***Vmax*** oil-sealed liquid ring vacuum pump system offers the advantages of no metal-to-metal contact between the impeller and casing. Grease lubricated bearings are mounted external to the pumping chamber, isolated by mechanical shaft seals. This means that the pump requires no internal lubrication. However, a vacuum pump is a rotating piece of equipment and operators must exercise good judgment and follow proper safety procedures to avoid damage to the equipment or personal injury. Please review and follow all instructions in this manual before attempting to install, start or operate equipment.

Safety

All products offered by DEKKER have been designed and manufactured for safe operation. However, the responsibility for safe operation rests with those who use and maintain these products. Your safety department should establish a safety program based on OSHA, federal, state and local codes. It is important that due consideration be given to hazards which arise from the presence of electrical power, hot liquids, toxic gases and rotating equipment. Proper installation and care of protective devices is essential to safe system operation. These safety procedures are to be used in conjunction with the instructions contained in this manual.

STORAGE

Keep the system in a cool dry environment and close the seal fluid isolation valve. Plug all open ports to keep out dirt and foreign objects. Every 2 - 3 months rotate the impeller by rotating the shaft by hand.

INSTALLATION

The design of the piping system, foundation layout and plant location are the responsibility of the purchaser. Dekker Vacuum Technologies, Inc. and its representatives may offer advice but cannot assume responsibility for operation and installation design.

Please consult an authorized dealer or a specialist skilled in the design of plant layout, system piping design and foundation design. The installer should carefully read this manual before installing the equipment. DEKKER or your local dealer can provide start up assistance in most instances at reasonable cost.

Unpacking

Upon receipt of pump or system, immediately inspect for signs of damage. Carefully remove packing or crating from around pump or system. Be sure to keep equipment in upright position. DEKKER products ship F.O.B. factory, which means that any damage is the responsibility of the carrier and should be reported to them.

Lifting

Lift the equipment carefully and with weight evenly distributed. DEKKER is not responsible for equipment that has been damaged through mishandling or dropping.

Location

Install the unit in a well ventilated and dust free area. The pump or system should be a minimum distance of 3 feet from surrounding walls to allow for checking fluid level, temperatures, pressures and general servicing.

Mounting

The pump or system must be installed on a level surface in a horizontal position. The foundation must be designed to support the total unit weight, without any settlement or crushing, be rigid and substantial enough to absorb any equipment vibration, maintain true alignment with any drive mechanism, and must permanently support the system baseplate at all points. The vacuum system must be leveled and secured with foundation bolts. Foundation bolts must be of adequate size to withstand the mechanical stresses exerted on it.

Systems larger than 40 HP should also be grouted into position. The foundation should be constructed to allow for ¾ to 1-½ inch of grout. The baseplate is set on shims and the grout is poured between the foundation and the baseplate. To have the required body to support the baseplate, grout should be at least ¾ inch thick.

The number and location of shims will be determined by the design of the baseplate. Firm support should be provided at points where weight will be concentrated at the anchor bolt locations. Use enough, and large enough shims to provide rigid support. Baseplates are usually designed with openings to allow pouring grout. When the baseplate has been shimmed and leveled and the anchor bolts have been snugly tightened, a dam is constructed around the foundation to contain the grout. The dam level should be at least ½ inch above the top surface of the shims. Grout should be poured inside and around the outside of the baseplate and leveled. Allow the grout to dry for a minimum of 48 hours before tightening the anchor bolts.

Please note that the pump/motor coupling and V-belt units will need to be realigned prior to start-up, except with monoblock units.

Ventilation

Locate the vacuum system in an area with sufficient airflow and accessibility. To prevent excessive ambient temperature rise it is imperative to provide adequate ventilation. Cooling is an important aspect of reliable equipment operation and it is therefore important to install the unit in a reasonably cool area where the temperature does not exceed 110°F (43°C). For higher ambient temperatures contact the factory.

For water-cooled vacuum systems it is necessary to check cooling water supply. A proper, consistent water flow must be maintained for adequate cooling.

Electrical Preparation

All system wiring is performed at the factory if a control panel is supplied. Check area classification to ensure all electrical enclosures comply to code. Required customer wiring is minimal, but should be done by a qualified electrician in compliance with OSHA, National Electric Code and any other applicable local electrical code concerning switches, fused disconnects, etc. DEKKER includes a wiring diagram in the control panel for use by the installer. DEKKER recommends that a main disconnect switch be fitted between the vacuum system and the incoming power.

Wire Size Chart (AWG) by Vmax Horsepower
Recommended Wire Size and Disconnect Size for Vmax Systems

Vmax System Model No.	HP	Serv Fact	Full Load Amperage at 200V	230V	460V	Volt. Tol.	Copper AWG (kcmil) 200V	230V	460V	Recommended Conduit Size in Inches 200V	230V	460V	Recommended Disconnect (Amps) 200V	230V	460V	Recommended Class J Fuse 200V	230V	460V
VMX0023MA1	1.5	1.15		4.0	2.0	±13%	14			1/2"				15	15		9	5
VMX0023KA1	1.5	1.15		3.8	1.9	±10%												
VMX0036MA1	3	1		7.8	3.9	±13%								25	15		17.5	8
VMX0036KA1	3	1.15		7.2	3.6	±10%												
VMX0063MA1	5	1.15		14.4	7.2	±13%	10							40	20		25	15
VMX0063KA1	5	1.4	13.8	12.0	6.0	±10%												
VMX0083MA1	5	1.15		14.4	7.2	±13%												
VMX0083KA1	5	1.4	13.8	12.0	6.0	±10%							40	40	20	30	25	15
VMX0103MA1	7.5	1		18.8	9.4	±13%	8							60	35		40	20
VMX0103KA1	7.5	1.3	22.0	19.0	9.5	±10%	10						60	60	35	40	35	20
VMX0153MA1	10	1		24.8	12.4	±13%	8							60	35		45	25
VMX0153KA1	10	1.28	27.6	24.0	12.0	±10%	10						70	60	35	50	45	25
VMX0203KA1	15	1.3	45.0	39.0	19.5	±10%	6			3/4"			100	100	60	80	70	35
VMX0303KA1	20	1.25	58.4	50.8	25.4	±10%	4			1"			125	110	60	100	90	45
VMX0303KA1-20	20XP	1.15		50.8	25.4	±10%							150	150	70	125	110	60
VMX0453KA1	25	1.3	74.6	62.0	31.0	±10%	2			1-1/4"								
VMX0453KA1-20	25XP	1.15	83.0	72.2	36.1	±10%												
VMX0553KA1	40	1.3	114.0	99.0	49.5	±10%	00		4	1-1/4"		1"	200	200	100	200	175	90
VMX0553KA1-20	40XP	1.15	142.3	123.4	61.9	±10%	000	00	4	2"	1-1/4"	1"	250	225	150	250	200	100
VMX0753KA1	50	1.28	142.3	123.8	61.9	±10%												
VMX1003KA1	60	1.15	169.7	146.8	73.4	±10%			2			1-1/2"	300	250	150	300	250	125
VMX1103KA1	75	1.15	200.0	174.0	87.0	±10%	250	0000	2	2-1/2"			350	300	150	350	300	150
VMX1203KA1	100	1.15	266.8	232.0	116.0	±10%	400	350	0				450	400	200	450	400	200

NOTES: 1. Based on no more than three single insulated conductors rated 0-2000 volts.

2. Conduit sizes shown does include ground conductor if required (over 60 amperes).

3. Wire sizes are based on THHN 75 deg. C rated conductors.

4. Approved trade size conduit or metal tubing.

5. Motors with voltage tolerance of +/-13% have a voltage range of 200-260V, and 400-520V. Use the disconnect and fuse corresponding to the 230V or 460V range

6. Above information is general information. Please confirm actual motor full load amperage before proceeding.

After the electrical wiring connections are completed, check the incoming voltage to make sure that the incoming voltage is the same as the vacuum system voltage. Line voltage should be within the voltage tolerance as specified on the motor. Check the system for proper motor rotation. The direction of rotation is always clockwise when looking at the shaft of the pump and is marked by an arrow on the motor or pump housing. Jog the motor by pressing the START button, and then the STOP button. If the rotation is incorrect switch any two of the three main power leads on the contactor inside the control panel. Failure to do so could result in serious equipment damage.

WARNING: Install, ground, and maintain equipment in accordance with the National Electrical Code and all applicable federal, state and local codes.

WARNING: For NFPA 99 hospital and generator applications: please shut down the vacuum pumps prior to generator testing. The rapid stop and restart may cause damage to the pump and/or motor.

Vmax-VFD Operational Instructions

Some systems are equipped with a Variable Frequency Drive (VFD) with an Operator Interface Module (OIM) remote keypad.

Following are brief general instructions and charts. Please refer to Vmax-VFD system-specific operation instructions included with each Vmax-VFD system.

On systems with a VFD, remember to open the seal fluid valve located under the separator tank before startup. Upon power up of the system, the VFD will go thru an initial self-check, and the remote OIM will display the main menu.

There are two custom windows that will display on the OIM (Operator Interface Module) screen by pressing the ESC/PROG button on the keypad. The first screen shows three items, the first item is total run hours that the motor has run, second is Torr set point (vacuum level set point) and finally Torr feed back (vacuum level pump is at) (Torr (mmHg) = 760 – ("HgV x 25.4). When you press F3 again, the second screen shows HP (horse power), AMPS, and Hz (Hertz). Pressing F3 again will bring you back to the first display screen.

The High Temperature light will be on. You must push the Alarm Condition Reset button before you can place the system in the required mode of operation.

In Manual Mode, the system will run at a constant RPM. In Auto Mode, the system will monitor a set point that the operator sets. The vacuum set point for the system is achieved by using the Operator Interface Module (OIM) on the front door of the control panel (some models may have the OIM inside the front door of the panel). Using the up and down arrows on the keypad, a window will pop up displaying the (% OIM Ref). By pressing the up or down arrow key, the % value will increase or decrease to the required percentage of the transducer output signal (preset to 26.33% = 22" HgV).

The VFD chart on the next page gives you the % VFD value that is associated with the transducer voltage which then correlates to a vacuum level. The VFD will maintain the vacuum level at the set point by increasing or decreasing the RPM of the motor. To verify whether the VFD is in Auto or Manual mode, look in the upper right-hand corner of the screen. If it is in Manual mode it will display Man, and if it is in Auto mode it will display Auto. To change the desired mode, press the F1 button in the main menu screen.

All system wiring is performed at the factory. Check area classification to ensure all electrical enclosures comply to code. Required customer wiring is minimal, but should be done by a qualified electrician in compliance with OSHA, National Electric Code and any other applicable local electrical code concerning switches, fused disconnects, etc. DEKKER includes a wiring diagram in the control panel for use by the installer. DEKKER recommends that a main disconnect switch be fitted between the vacuum system and the incoming power.

Wire Size Chart (AWG) by Vmax-VFD Horsepower
Recommended Wire Size and Disconnect Size for Vmax-VFD Systems

Vmax-VFD System Model No.	HP	Serv. Fact.	Full Load Amperage at 230V	Full Load Amperage at 460V	Volt. Tol.	Copper AWG (kcmil) 230V	Copper AWG (kcmil) 460V	Recommended Conduit Size in Inches 230V	Recommended Conduit Size in Inches 460V	Recommended Disconnect (Amps) 230V	Recommended Disconnect (Amps) 460V	Recommended Class J Fuse (Amps) 230V	Recommended Class J Fuse (Amps) 460V
VMX-VFD0063KA1	5	1.0	12.0	6.0	±10%	12	16	½"		20	15	15	10
VMX-VFD0083KA1	5	1.0	12.0	6.0	±10%	12	16			20	15	15	10
VMX-VFD0103KA1	7.5	1.0	19.0	9.5	±10%	10	14			30	20	25	15
VMX-VFD0153KA1	10	1.0	24.0	12.0	±10%	10	12			35	25	30	20
VMX-VFD0203KA1	15	1.0	39.0	19.5	±10%	8	10	¾"		60	30	50	25
VMX-VFD0303KA1	20	1.0	50.8	25.4	±10%	6	10	1"		60	35	60	30
VMX-VFD0453KA1	25	1.0	62.0	31.0	±10%	4	8			80	40	70	35
VMX-VFD0553KA1	40	1.0	99.0	49.5	±10%	1	6	1-1/4"	1"	125	70	125	60
VMX-VFD0753KA1	50	1.0	123.0	61.9	±10%	1/0	4			150	80	150	70
VMX-VFD1003KA1	60	1.0	146.8	73.4	±10%	2/0	4	2"		200	100	175	90
VMX-VFD1103KA1	75	1.0	174.0	87.0	±10%	3/0	2		1-1/4"	200	100	200	100
VMX-VFD1203KA1	100	1.0	232.0	116.0	±10%	250	1	2-1/2"		250	150	250	125

NOTES: 1. Based on no more than three single insulated conductors rated 0-2000 volts.

2. Conduit sizes shown does include ground conductor if required (over 60 amperes).
3. Wire sizes are based on THHN 75 deg. C rated conductors.
4. Approved trade size conduit or metal tubing.
5. Use the disconnect and fuse corresponding to the 230V or 460V range
6. Above information is general information. Please confirm actual motor full load amperage before proceeding.

VFD value , transducer voltage and vacuum level chart

VFD Value %	Transd. Voltage	Vac.lvl. Torr	Vac.lvl. "HgV		VFD Value %	Transd. Voltage	Vac.lvl. Torr	Vac.lvl. "HgV
10.00	1.00	0.00	29.92		56.00	5.60	349.60	16.16
11.00	1.10	7.60	29.62		57.00	5.70	357.20	15.86
12.00	1.20	15.20	29.32		58.00	5.80	364.80	15.56
13.00	1.30	22.80	29.02		59.00	5.90	372.40	15.26
14.00	1.40	30.40	28.72		60.00	6.00	380.00	14.96
15.00	1.50	38.00	28.42		61.00	6.10	387.60	14.66
16.00	1.60	45.60	28.12		62.00	6.20	395.20	14.36
17.00	1.70	53.20	27.83		63.00	6.30	402.80	14.06
18.00	1.80	60.80	27.53		64.00	6.40	410.40	13.76
19.00	1.90	68.40	27.23		65.00	6.50	418.00	13.46
20.00	2.00	76.00	26.93		66.00	6.60	425.60	13.16
21.00	2.10	83.60	26.63		67.00	6.70	433.20	12.87
22.00	2.20	91.20	26.33		68.00	6.80	440.80	12.57
23.00	2.30	98.80	26.03		69.00	6.90	448.40	12.27
24.00	2.40	106.40	25.73		70.00	7.00	456.00	11.97
25.00	2.50	114.00	25.43		71.00	7.10	463.60	11.67
26.00	2.60	121.60	25.13		72.00	7.20	471.20	11.37
27.00	2.70	129.20	24.83		73.00	7.30	478.80	11.07
28.00	2.80	136.80	24.53		74.00	7.40	486.40	10.77
29.00	2.90	144.40	24.24		75.00	7.50	494.00	10.47
30.00	3.00	152.00	23.94		76.00	7.60	501.60	10.17
31.00	3.10	159.60	23.64		77.00	7.70	509.20	9.87
32.00	3.20	167.20	23.34		78.00	7.80	516.80	9.57
33.00	3.30	174.80	23.04		79.00	7.90	524.40	9.28
34.00	3.40	182.40	22.74		80.00	8.00	532.00	8.98
35.00	3.50	190.00	22.44		81.00	8.10	539.60	8.68
36.00	3.60	197.60	22.14		82.00	8.20	547.20	8.38
37.00	3.70	205.20	21.84		83.00	8.30	554.80	8.08
38.00	3.80	212.80	21.54		84.00	8.40	562.40	7.78
39.00	3.90	220.40	21.24		85.00	8.50	570.00	7.48
40.00	4.00	228.00	20.94		86.00	8.60	577.60	7.18
41.00	4.10	235.60	20.64		87.00	8.70	585.20	6.88
42.00	4.20	243.20	20.35		88.00	8.80	592.80	6.58
43.00	4.30	250.80	20.05		89.00	8.90	600.40	6.28
44.00	4.40	258.40	19.75		90.00	9.00	608.00	5.98
45.00	4.50	266.00	19.45		91.00	9.10	615.60	5.68
46.00	4.60	273.60	19.15		92.00	9.20	623.20	5.39
47.00	4.70	281.20	18.85		93.00	9.30	630.80	5.09
48.00	4.80	288.80	18.55		94.00	9.40	638.40	4.79
49.00	4.90	296.40	18.25		95.00	9.50	646.00	4.49
50.00	5.00	304.00	17.95		96.00	9.60	653.60	4.19
51.00	5.10	311.60	17.65		97.00	9.70	661.20	3.89
52.00	5.20	319.20	17.35		98.00	9.80	668.80	3.59
53.00	5.30	326.80	17.05		99.00	9.90	676.40	3.29
54.00	5.40	334.40	16.76		100.00	10.00	684.00	2.99
55.00	5.50	342.00	16.46					

Pipe Connections and Sizing

Before installation, remove all protective inserts on the pump suction and discharge. Piping connected to the system must be installed without imposing any strain on the system components. Improperly installed piping can result in misalignment, general operating problems and pump failure. Use flexible connectors where necessary. Piping must be cleaned of debris before installation.

Inlet Piping

Note: Install a temporary screen at the pump inlet flange at first start-up to protect the unit against carry over of pipe debris and welding slag. The screen must be removed after the initial run in period.

Inlet piping should be at least the size of the pump inlet. Install the system as close as possible to the process to minimize losses due to the length of the suction line. If the system has to be installed further away from the process, be sure that the inlet piping is oversized accordingly to minimize the overall line pressure drop. For more information consult your dealer or call the factory.

Pump systems operating in parallel on a common manifold must each have a manual or automatic shut-off valve and a suitable check valve installed in the suction line close to the pump suction flange. This allows each individual system to be isolated when it is not in operation. The line size of the manifold should be a minimum equal to the sum of the individual system pipe areas.

Vmax systems are supplied with an inlet check valve as standard. This valve provides a minimum of resistance close to the pump suction flange to prevent back flow of process gas and seal fluid when the pump is stopped.

If the inlet gas pumped contains dust or foreign particles, a suitable 10 micron (or finer) inlet filter should be installed at the inlet port

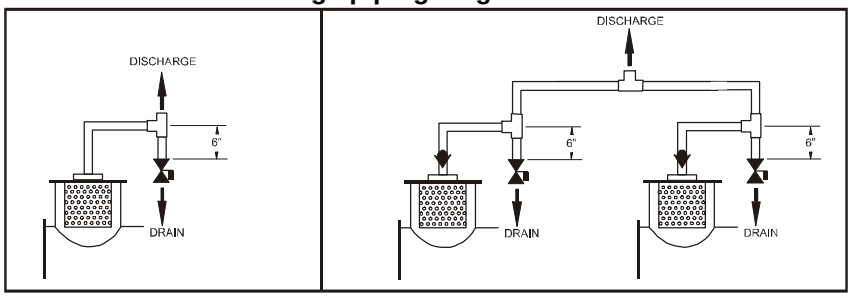
If the possibility exists that the pump inlet can become closed during operation it will be essential to install some type of vacuum relief valve (anti-cavitation valve) so that air can enter the pump inlet. **Never run a pump with a closed suction, which causes cavitation and will damage the pump.**

Discharge Piping

Discharge piping should be at least the size of the separator discharge. Do not discharge the exhaust gases from the pump system into the area where the system is installed. Vapors pulled over from the process could be hazardous. Install an exhaust line of at least the same diameter as the discharge connection on top of the separator reservoir leading outside. Install a dripleg with tee on the discharge line to prevent condensables from draining back into the separator reservoir. See the “Discharge piping diagram” on the next page.

For pump systems operating in parallel on a common discharge, we recommend the installation of a suitable check valve close to the separator discharge flange of each unit. When discharging more than one pump in a common discharge line and/or over a long distance, oversize pipe accordingly.

Discharge piping diagrams



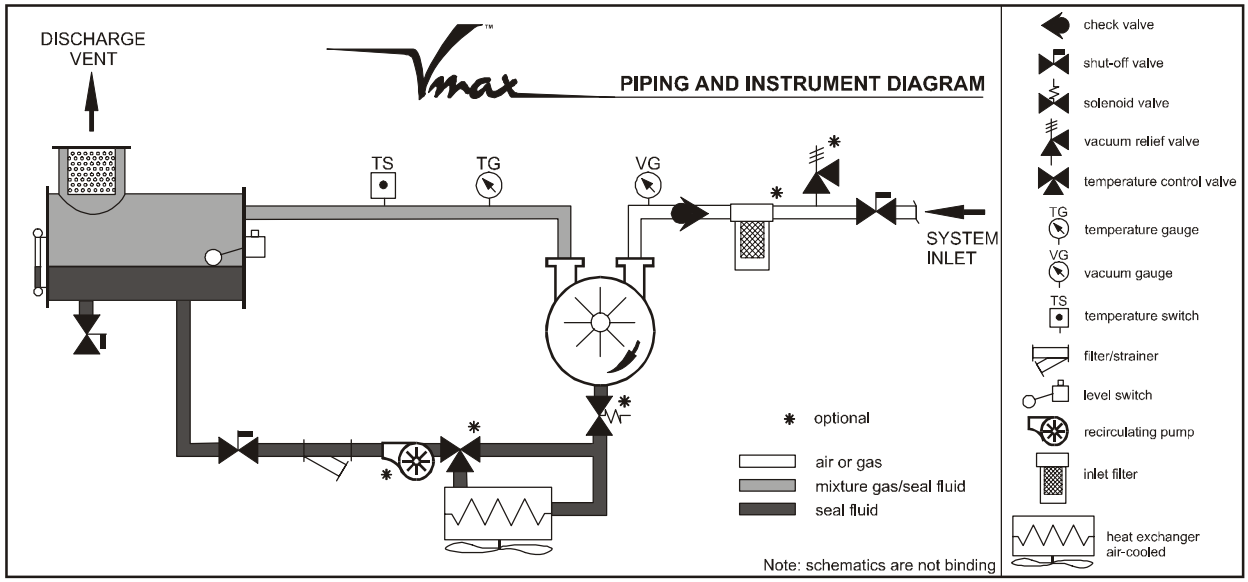
Cooling water piping (water cooled systems only)

Water-cooled systems require an adequate supply of cooling water at a maximum of 85°F and a minimum supply pressure of 20 psig. If the cooling water temperature is higher or available pressure lower, consult your dealer or call the factory.

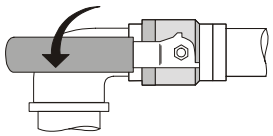
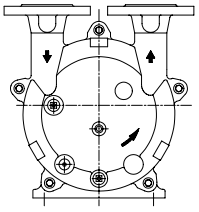
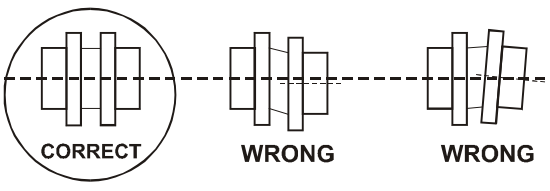
The cooling water outlet connection of the heat exchanger may be fitted with an optional automatic temperature control valve, which regulates the cooling water flow rate depending on pump operating temperature. The valve is preset at the factory. To raise the system operating temperature, turn the valve-adjusting screw counter-clockwise. To lower operating temperature, turn clockwise. Normal system operating temperature is between 140° - 185° F. The valve will only open when the system operating temperature is reached.

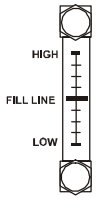
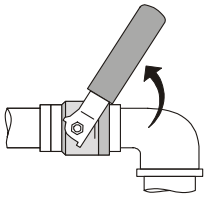
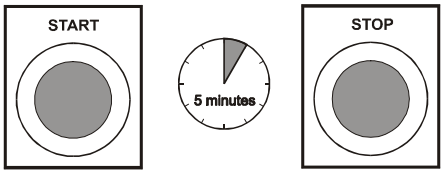
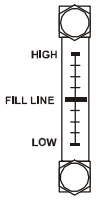
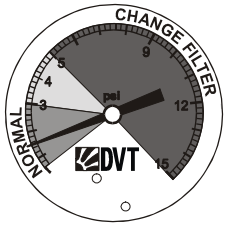
THEORY OF OPERATION

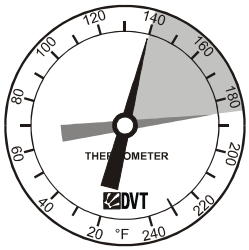
The DEKKER ***Vmax*** oil-sealed liquid ring vacuum pump system includes our high efficiency liquid ring vacuum pump. The liquid ring vacuum pump is known for its simplicity in design and low maintenance requirements, due to the absence of wearing parts such as pistons, sliding vanes and internal bearings. The impeller assembly is the only moving part, which rotates freely in the casing without metal-to-metal contact. This means that no internal lubrication is required. The function of the sealing liquid is to create a liquid piston action *used to produce vacuum* and to remove the heat of compression. The seal fluid in the system circulates in a closed loop passing through an air- or water-cooled heat exchanger that removes the heat of compression. The discharge separator/reservoir holds the seal fluid and incorporates the DEKKER patented high-efficiency separator arrangement to separate the seal fluid from the air or gases discharged by the pump. See "Piping and Instrument Diagram" of the ***Vmax*** oil-sealed liquid ring vacuum pump system below.



START UP PROCEDURES

1	Ensure seal fluid isolation valve is open. This valve is located below the separator and/or before the strainer.	
2	Jog the motor briefly and check direction of rotation. The correct direction of rotation is marked by an arrow on the motor or pump housing. If direction is incorrect switch any two of the three leads at the power connection. The correct direction of rotation is clockwise facing the pump from the drive end and counter-clockwise if viewed from the non-drive end.	
3A	Check drive coupling alignment. Angular alignment should be within .035" - .175". Parallel alignment should be within .010" - .025". Consult the factory for specific system size alignment. Mono-block units do not require any field adjustment (motors are C-face mounted).	

3B	For units utilizing V-belt drives, make sure the sheaves are properly installed and aligned before attempting to tension the drive. The V-belts should be placed over the sheaves and in the grooves without forcing them over the sides of the grooves. The tensioning steps 1, 2, 3 and 4 can be used for all types of V-belts, all cross sections and number of belts and all types of construction. **Avoid excessive heat** (140°F and higher); belt life will be shortened. **Never switch** or mix **belts** from one groove to another on the sheaves. **Do not use belt dressing.** Sheaves should remain free of oil and grease. **When replacing belts install an identical set.** For more specific V-belt tensioning guidelines consult factory.	1. With all belts in their grooves, adjust centers to take up the slack until they are fairly taut. Use standard V-belt tensioning guidelines. 2. Start the drive and continue to adjust until the belts have only a slight bow on the slack side while operating **with load conditions.** 3. After several days of operation, the belts will seat themselves in the sheave grooves. Further tensioning may be necessary to the point that the drive shows a slight bow in the slack side. Insufficient tension is often evidenced by slipping (squealing) at start-up. 4. If the unit is idle for an extended period of time, the tension on the belts should be removed.
4	Check fluid level in separator reservoir. The fluid level should be at the FILL LINE on the sight gauge. Add oil if necessary.	
5	If your system contains an inlet valve, set it to approximately 3/4 closed, and start pump. If valve is not supplied, one should be installed.	
6	Run the pump for a few minutes, then turn it off.	
7	With the pump shut off, check fluid level again. The fluid level should be at the FILL LINE on the sight gauge. Add fluid if necessary. **Warning: never remove the oil fill plug while the pump is running.**	
8	Start pump again and check that discharge pressure on the separator pressure gauge does not exceed 2 psig when operating under vacuum conditions. A pressure higher than 2 psig is a sign of high back-pressure in the discharge pipe system. Pressure gauge might show a higher pressure at start-up at low vacuum (0-10" Hg).	

9	Check the voltage and motor current, they should be within the specifications for the motor. Standard motors have a 1.15 S.F. (Service Factor). **Note:** This test should also be performed under normal system operating conditions.	**DANGER: HIGH VOLTAGE!** **Lethal shock hazard present.** **USE EXTREME CAUTION!**
10	After 15-30 minutes of operation, check pump operating temperature, which should be in the 140° to 185° F range. Some smaller units may run cooler.	

SHUT DOWN PROCEDURE

To stop the pump system follow the procedure as lined out below.

Push the STOP button, or turn switch to the OFF position. The inlet check valve will prevent fluid from the system being sucked back into the inlet manifold.

Note: If inlet piping could be under vacuum for an extended period of time without the pump running, inlet piping should be vented to atmosphere.

Note: Close the seal fluid isolation valve and the pump inlet isolation valve during extended periods of storage or when transporting. Open valves before starting system.

SEQUENCE OF OPERATION

The following sequence of operation is a description of how the ***Vmax*** oil-sealed vacuum pump system should operate. The description is general to cover simplex to multiplex (more than one pump) systems. It is assumed that all start-up procedures have been followed. Ensure that pump reservoirs are filled with oil (See “Start-up Procedures”, page 5). Make sure that the seal fluid isolation valve is in the open position. If unsure about the function of one of the electrical controls mentioned below, see the "Electrical Controls" section (page 10) for a description of the component. If any of the below do not occur, see the "Trouble-shooting " section (page 12).

Once the power connection to the system has been made, the following should occur:

- If disconnects or circuit breakers are installed on the control panel, and are turned to the ON position, the system will be energized. If POWER ON indicating lights are installed on the panel, the lights will be illuminated.
- If any other lights are illuminated, see the "Trouble-shooting" section (page 12).
- If HAND-OFF-AUTO selector switches are installed and are turned to the HAND mode, the pump(s) will immediately start. If PUMP ON light(s) are installed on the panel, they should light up to indicate pump operation. We suggest that each pump be tested ("bump started") in the HAND mode initially to check rotation of the pump. When facing the drive end of the pump, the correct rotation is clockwise. When in HAND mode, the pumps will run continuously unless an alarm condition is triggered. If such a condition occurs, see the "Trouble-shooting " section.
- When the HAND-OFF-AUTO selector switch is placed in the AUTO mode, the pumps will operate from vacuum switches (if installed). In multiplex pump systems, each vacuum switch is set with a differential as well as an offset relative to the next switch. The switches should not be set identically. The differential is usually between 3 to 6” Hg. For details on setting the vacuum switches, see the “Accessories and Protective Devices” section on page 11. Below is an example for a duplex system. The differential for each switch is 4"Hg, the offset between the two switches is 2"Hg.

PUMP	PUMP ON	PUMP OFF
Pump 1 (lead pump)	@ 21"Hg	@ 25"Hg
Pump 2 (lag pump)	@ 19"Hg	@ 23"Hg

- The switches are set in this manner so that if pump 1 (lead pump) cannot satisfy demand and the vacuum level drops below 21"Hg, the lag pump (2) will start-up when the vacuum level reaches 19"Hg and stops at 23" Hg.
- All multiplex systems are supplied with "Automatic alternation" and "Frequent stop/start protection" unless otherwise specified.
- "**Automatic alternation**" allows the pumps to operate equally (even run time) by alternating each pump whenever the pump(s) shut down. When alternation occurs, the "lead" pump becomes the "lag" pump and the "lag" pump becomes the "lead" pump.
- "**Frequent stop/start protection**" is used to allow the pump(s) to operate a minimum amount of time. The time period is factory-set at 10 minutes. This allows the pump(s) to warm up and eliminate frequent starting of the pump(s) which can cause premature coupling failure and breakdown of electrical components. The pump(s) will continue to operate after the vacuum level has been satisfied. If the possibility exists that the pump could work with a closed suction, a relief valve must be installed to prevent cavitation.
- If the pump(s) are not alternating and/or are frequent starting, one of the electrical components may be defective. Contact the factory for more information.

SYSTEM ALARM CONDITIONS

The following is a description of how alarm conditions will affect the operation of the system.

- If a **"Lag pump in operation"** alarm is installed in the panel, observe the following. Such an alarm is usually only supplied with medical packages. The alarm consists of a warning light and an audible alarm. The alarm will trigger when the "lag" pump starts up. The alarm will not affect the operation of the system. The light will illuminate and the alarm will sound. The audible alarm can only be silenced by physically (or remotely) pushing the ALARM SILENCE button. This will not stop the LAG PUMP ON light from illuminating. The light can be reset by physically (or remotely) pressing the ALARM RESET button.

  Note: If the lag pump is still operating when the ALARM SILENCE or ALARM RESET buttons are pressed, the alarm will continue to sound. The alarm will only reset if the lag pump is not running.
- **"Transformer failure"** light (optional). Only installed if more than one control voltage transformer is supplied. If the TRANSFORMER FAILURE light is illuminated, one of the transformers has malfunctioned and the second one has picked up. As long as a back-up transformer is available, the above alarm will not affect the operation of the system. If both transformers fail, the system will shut down.
- **"High temperature"** light. If the HIGH TEMPERATURE light illuminates, the affected pump will shut down unless otherwise specified at time of purchase of the equipment. The back-up pump(s) will continue to operate unless a high temperature (or other) alarm occurs in those pump(s).
- **"Low level"** light (optional). If the LOW OIL LEVEL light is illuminated, the affected pump will shut down. The back-up pump(s) will continue to operate unless a similar condition occurs in those pump(s).

MAINTENANCE

As you proceed in reading this section, it will become clear that the "Maintenance Schedule" for DVT ***Vmax*** oil-sealed liquid ring vacuum pump systems is quite minimal. The use of the service gauges will alert you when service is required.

WARNING: Before attempting any maintenance such as changing the fluid, disconnect all power from the system by switching off the main breaker or disconnect switch. This will prevent the system from automatically starting from a vacuum switch.

Bearing Lubrication - Pump

The .25 – 20 HP Titan-series single-stage liquid ring vacuum pumps are installed with sealed bearings that require no field lubrication.

The 25 – 40 HP Titan-series single-stage liquid ring vacuum pumps which are belt-driven, the 50 – 100 HP Titan-series single-stage pumps and the 2 – 60 HP two-stage Titan-series pumps require lubricating every 3000 hours. Extreme operating conditions may require more frequent lubricating. Grease fittings are located on the top of each bearing housing.

For Titan-series two-stage pumps 100 HP and up, please consult Factory.

The Maxima-K series of large capacity single-stage liquid ring vacuum pumps require lubricating every 1500 hours of operation. Grease fittings are located on the top of each bearing housing.

Use a good quality high temperature lithium based grease of #2 consistency. Typical products are Texaco Premium RB and Chevron SR1 #2.

Pump bearing lubricating schedule

Pump type	Pump HP	Greasing schedule
Titan-series single-stage	.25 - 20	none required
Titan-series single-stage	25 – 100	every 3000 hours
Titan-series two-stage	2 – 60	every 3000 hours
Titan-series two-stage	100 - up	consult factory
Maxima-K-series large capacity	50 - up	every 1500 hours

Bearing Lubrication – Motor (where required)

The motors are shipped from the factory with the bearings properly packed with grease. During extended storage of 6 months or greater, the ball-bearings should be re-lubricated prior to starting with a good quality high temperature lithium based grease of #2 consistency. Typical products are Texaco Premium RB and Chevron SR1 #2. Roller-bearings (V-belt drive systems) use the Texaco Premium RB or Chevron Black Pearl EP #2.

The bearings may be lubricated with the motor running or stationary. Stationary with the motor warm is preferred. Locate the grease inlets – there is one on each end of the motor.

Note: This is generally the case with domestic motors. European motors use sealed bearings and do not require lubrication. Consult Factory with any questions.

Clean the area and replace the pipe plug with a grease fitting as generally they are not equipped with a grease fitting. Remove the grease drain plug, located at the lower portion of each motor face (typically a plastic plug), and loosen any hardened grease that may block the drain. Add the recommended volume of the previously described grease using a hand operated grease gun. Run the motor for two hours. Replace the pipe plug in grease drain.

Mixing of lubricants is not recommended due to possible incompatibility. Signs of incompatibility are extreme soupiness from the grease relief drain or from the shaft opening. If changing a lubricant, grease and then re-grease after 100 hours of service.

Frequency/volume of greasing is based on service conditions, speed and frame size. See table below.
Standard conditions: 8 hour day operation, normal or light loading, clean environment at a 100 ºF maximum ambient temperature.
Severe conditions: 24 hour operation or shock loading, vibration, dirty or dusty environment, running at a 100 ºF to 120 ºF ambient temperature.
Extreme conditions: heavy shock, vibration, or dust.

See table below for lubricating details.

Motor bearing lubricating schedule

Lubrication Frequency – Ball Bearings

Roller bearings – divide time by 2

Speed (RPM)	NEMA Frame	Standard Conditions	Severe Conditions	Extreme Conditions
1800	182-215	3 years	1 year	6 months
1800	254-365	2 years	6-12 months	3 months
1800	404-449	1 year	6 months	1-3 months
3600	ALL	6 months	3 months	1 month

Lubrication Volume

NEMA Frame	Volume (Cubic inches)
182-215	0.5
254-286	1.0
324-365	1.5
404-449	2.5

Inlet Filter (if installed)

Check after first 8 hours of operation. Clean or replace inlet filter element every 1000 to 3000 hours depending on application or if excessive pressure drop is noticed. In some applications it may be necessary to clean inlet filter more often.

CAUTION: Be careful not to allow accumulated foreign material to fall in the pump suction opening when removing the filter cartridge. Horizontal filter installation is recommended to prevent this. Filters must be disposed of properly as they might contain toxic substances carried over from the process.

Seal Fluid

The system(s) are shipped with our especially formulated ***Vmaxol*** seal fluid. These fluids are specifically designed for use in our ***Vmax*** systems, providing low viscosity, excellent water separating qualities, anti-foaming and low oxidation. We recommend that our ***Vmaxol*** sealing fluids be used for obtaining ultimate performance from your ***Vmax*** vacuum pump system and to guarantee the extended 3-year warranty period.

Container Size	Standard *Vmaxol* (10,000 hours of operation)	Synthetic/Food grade Long-life *Vmaxol* (15,000 hours of operation)
5 Gallon Container	5220-0050-000	5220-0050-001
55 Gallon Drum	5220-0550-000	5220-0550-001

Material Safety Data Sheets available upon request

When using **Standard Vmaxo**l it is recommended that the seal fluid be changed every 10,000 hours of operation or once a year, whichever comes first. When using **Synthetic/Food grade Long-life Vmaxol**, seal fluid may be changed every 15,000 hours of operation or once a year, whichever comes first. Extreme operating conditions may require more frequent changes.

To change the fluid, first make sure there is no power to the system and the pump is off. Drain the fluid reservoir, vacuum pump and heat exchanger using the drain valves. We recommend that the fluid be changed when the system is at operating temperature.

When charging the system with new fluid, make sure that the pump is filled with oil to the shaft centerline level. **Do not fill the pump above the shaft centerline**. Starting the pump with oil level above the shaft centerline may result in shaft or impeller damage or failure. You can add oil by removing the suction or discharge flange and pouring oil through pump suction or discharge port.

Fill the reservoir to the FILL LINE on the sight gauge. Open the air bleed valve on the heat exchanger to remove all air from the system. Run the pump for a few minutes, stop and check fluid level again. If required, add additional fluid to the reservoir. **Be sure not to overfill.**

Check seal fluid level in the reservoir. A high fluid level could mean a build-up of water in the reservoir, which should be drained. Check every 500 hours.

Devarnishing

The operating life of the unit is greatly enhanced based on the quality of the seal fluid. Oxidized or darkened seal fluid is a sign of trouble. Plugged filters reduce performance and may damage pump. Periodic maintenance will offer the best protection for your equipment.

DEKKER offers a specially formulated devarnishing compound **Proclean 39V** for oil-sealed liquidring pumps and systems. Procedure for using Proclean 39V and MSDS sheet are included with the product. The compound is available in the following quantities:

Proclean 39V (part no.: 5230-0010-000) – 1 gallon
Proclean 39V (part no.: 5230-0050-000) – 5 gallon
Proclean 39V (part no.: 5230-0055-000) – 55 gallon

NOTE: Varnished pumps are not covered under warranty.

Seal Fluid Strainer

After the first 50 hours of operation, clean the strainer in the seal fluid line. This is done to remove any debris carried over into the system from the process. Clean and inspect the strainer every 1000-3000 hours depending on application or if excessive oil discharge temperature (above 185°F) is indicated. An increase in pump discharge oil temperature is an indication of low oil flow and normally is an indication of

strainer blockage. If cleaning of strainer does not decrease temperature check the seal fluid line for blockage.

Spin-on Oil Filter (if installed)

If you notice that the operating temperature of your system steadily increases, change the spin-on filter.

Separator Element

The separator elements are located in the separator reservoir. Its purpose is to remove the oil from the discharge air. Replace the element every 10,000 hours or once a year. Earlier replacement may be necessary when the back-pressure is higher than 4 psig. High back-pressure is a result of dirt build-up on the separator element due to oil varnish, or contaminated inlet gas stream. Replacement may vary depending on application.

NOTE: Thread-in style filters are installed hand-tight as an oil filter. Do not over-tighten with a wrench.

Separator Element Oil Return Line

The separator element oil return lines are 1/4" to 3/8" transparent tubing. The purpose of these lines is to remove excessive oil build-up from inside the separator and separator element. If excessive smoking or oil mist is present, check the oil return lines for blockage and replace if necessary. Also check that the steel section of oil return line located on top of the separator reservoir is cut at a 45° angle and is touching the bottom of the separator element.

Mechanical Shaft Seals

All DEKKER oil-sealed liquid ring vacuum pumps are fitted with mechanical shaft seals. Mechanical seals do not require maintenance unless there is more than a small amount of leakage. To define this we differentiate between the following:

Weepage: Mechanical seals work by having two flat surfaces pushed together by axial force from the closing mechanism and by product pressure in the seal chamber. When the seal is in operation, the seal fluid lubricates the tow faces. This thin film of lubrication protects the faces of the seal from heat and excessive wear, but it can also allow for a small amount of leakage across the seal face. This small leakage is called a "weep". While a weep has rather arbitrary limits, it is commonly considered to be a leakage rate of less than one drop of liquid every minute. Seal weeps are not covered under warranty.

Leakage: a leakage rate of more than one drop per minute is considered to be a "leak". Seal leakage is normally a result of a build-up of abrasive particles carried over in the pump suction. These particles cause excessive wear on the seal faces. Leakage caused by wear and tear is not covered under warranty.

Seal replacement is addressed in the assembly and disassembly instruction for the specific pump model used. Consult factory for assistance.

MAINTENANCE SCHEDULE

To help ensure trouble free system operation, a basic maintenance schedule consisting of the following system checks is recommended.

First 8 hours operation

Check oil level and inlet filter element if installed. Clean strainers and remove temporary inlet screen. Check for water in sight gauge and drain if necessary. Check piping for signs of oil leakage and tighten if necessary.

500 hours operation

Under normal operating conditions repeat 8 hour check procedure as described above

1000 hours operation

Check back-pressure on separator element; it should not exceed 4 psig. Change separator element if back-pressure exceeds 4 psig. Also check discharge pipe system for blockage.

Clean or replace inlet filter element every 1000 to 3000 hours depending on application or if excessive pressure drop is noticed.

Remove debris from pump housing, motor fan guard and heat exchanger.

1,000-3,000 hours of operation

Applicable to pumps equipped with grease fittings located on each bearing housing. Grease bearings with a #2 quality lithium grease. Do not over-grease, 3 to 4 pumps with a grease gun is sufficient under normal conditions.

10,000 hours of operation

Or once per year, change seal fluid. Use DEKKER ***Vmaxol*** seal fluid. Life of **Standard Vmaxol** is **10,000** hours of operation. **Synthetic/Food grade Long-life Vmaxol** may be changed every **15,000** hours of operation or once a year, whichever comes first.

Change separator element if back- pressure exceeds 4 psig.

Check coupling element for wear. Replace if worn.

Clean strainer in seal fluid line.

30,000 hours of operation

Or every 5 years, it is recommended that you replace the vacuum pump's mechanical seals and bearings as preventative maintenance. This should be done by a DEKKER authorized distributor or properly trained service technician.

ELECTRICAL CONTROLS (if included)

- **Disconnect Handles**: must be turned on to energize the system. The handles must be turned off to open control panel.
- **CAUTION: High voltage, main disconnect must be off when servicing panel.**
- **HOA (Hand-Off-Auto) Selector Switches:** are supplied only if vacuum switches are supplied. Pump units will start in HAND mode (unless units are in a shutdown alarm condition). The pumps will bypass vacuum switches. AUTO mode, allows units to start upon contact closure of the vacuum switch.
- **Stop/Start Push Buttons:** are included if HOA selector switch is not installed.
- **Reset Button:** is used to reset the starter overloads.
- **Power On Light:** indicates that power is on in panel.
- **Pump Running Light:** indicates a pump is operating.
- **High Temperature Overload Light:** indicates a pump has overheated and shuts the pump down. The ALARM RESET button needs to be pressed to reset the alarm condition. If high temperature condition has not been fixed, the alarm will not reset.
- **High Back-pressure Light:** indicates the exhaust filter element in the vacuum pump needs to be replaced. Alarm does not shut down the pump. Replace element as soon as possible.
- **Transformer Failure Light:** indicates transformer failure. If alternate transformers are included in the panel, the alternate transformer will pick up. The pump will shut down if only one transformer is present and fails.

- **Lag Pump In Operation Light:** When the light illuminates, the lag pump is in operation.
- **Audible Alarm:** signals that the lag pump is in operation. The alarm can be silenced by pressing the ALARM SILENCE button. The audible alarm may also be used to signal other alarm conditions, such as high temperature, low oil level or high back pressure.
- **Alarm Silence Button:** is used to silence the audible alarm, but the light will remain on unless alarm condition has been corrected.
- **Alarm Reset Button:** is used to reset an alarm condition when the condition has been rectified. The ALARM RESET button will stop the light and alarm if alarm condition has been corrected.
- **Hour Meter:** is a running clock that indicates how many hours each pump has been operating. It should be used to determine when the oil in the pump and the discharge filter element needs to be replaced. See Maintenance Schedule (page 9) for oil life.

ACCESSORIES AND PROTECTIVE DEVICES (if included)

Accessories

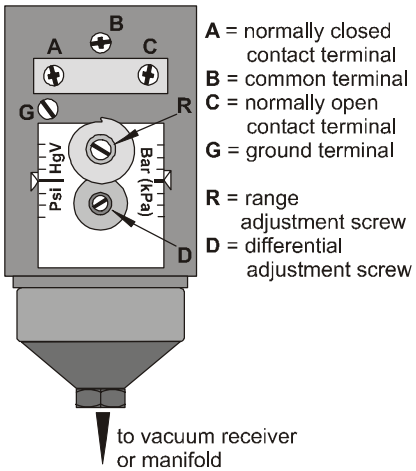
The following accessories are available for ***Vmax*** oil-sealed liquid ring vacuum pump systems.

- **Flexible Connectors (optional):** are used in piping systems to eliminate vibration transmission from machinery throughout the piping network. If ordered, DEKKER uses braided flexible connectors on the ***Vmax*** oil-sealed vacuum pump systems.

- **Vibration Isolators (optional):** are used to eliminate vibrations, noise and shock transmission from machinery to the floor. Floor-mount type vibration isolators are used for ***Vmax*** vacuum pump systems. The vibration isolators have a steel top plate, threaded insert and steel base, both totally imbedded in an oil-resistant neoprene. The isolators bolt onto a tank or base-frame with one bolt and have two mounting bolts to mount to the foundation or floor.
- **System Isolation Valve (optional):** may be installed on the vacuum receiver tank or vacuum pump manifold. Usually the valve is used to isolate the vacuum system from the piping network.
- **Inlet Filter (optional):** An inlet filter may be installed on the ***Vmax*** oil-sealed vacuum pump systems to prevent carry-over of particles into the pump.
- **Vacuum Relief Valve (optional):** This valve may be installed on the pump suction manifold or on the receiver. The vacuum relief valve is used to protect the vacuum pump from closed suction which can damage the pump.
- **Vacuum Switch (optional):** is used to automatically switch the vacuum pump ON and OFF, based on demand. This switch is standard on all multiplex systems.

  Switches are factory preset for your application and it is NOT RECOMMENDED to adjust the vacuum switch. Each switch is labeled as LEAD or LAG and is marked with the corresponding PUMP ON and PUMP OFF points.

  If the vacuum switch must be adjusted, please follow these instructions:



1. To increase the point at which the vacuum pump turns ON, turn the RANGE ADJUSTMENT SCREW (R) counter-clockwise. See the range scale on switch for approximation. Use vacuum gauge to observe actual PUMP ON and PUMP OFF point.
2. To increase the differential, which is the difference between the PUMP ON and PUMP OFF point, turn the DIFFERENTIAL ADJUSTMENT SCREW (D) counter-clockwise. To obtain the correct PUMP OFF point observe the physical opening of the contact switch as compared to the vacuum gauge reading. The vacuum pump will not stop running, because all systems are equipped with “10 minute mimum run” timers.
3. Remember you will need to vary the vacuum level in the receiver or manifold to see a change in the vacuum level, and to adjust the switches.

- **Microprocessing Controller (optional):** system may be equipped with this very reliable and compact Controller module for controlling and monitoring basic machinery functions. The following instructions should help guide the end user to perform simple changes to the Controllers’ pre-programmed settings. The specific preset areas that may be modified are outlined below.

  Set the Internal Clock:

  Upon powering the system control panel, the installation technician must ensure that the internal clock in the Controller has been set to the current military time setting. The Controller is equipped with an internal capacitor that will hold the time for approximately 80 hrs. If your system has not been installed within the allotted time frame, the alternation of the automatic mode will not occur and only one of the pumps will function until the time parameter has been updated. Refer to the following instructions for access to and changing of the parameters.

  Sequence of Operation Automatic Mode:

  The switch on the front of the system control panel must be placed in the automatic mode before the Controller program will initiate. Upon starting the system, all pumps should come on line and run for a minimum of 10 minutes each. As the demand for the vacuum pumps change, the individual units will turn off and on as required, each time running for a minimum of 10 minutes after initial start. If all the individual pumps are not placed in automatic mode simultaneously, there may be a pump that does not ramp up to speed with the lead pump. This does not mean that there is a problem with your vacuum system. The reason for this can be the switch settings for lead and lag pumps. When the system is started and individual units are placed in automatic mode at different times, the demand for lag pump may not be present due to the time lapse between placing the various pumps in automatic mode.

After 24 hours of operation (1 calendar day), the lead pump will become the lag pump and the remaining pumps will shift one spot forward, keeping the same on and off switch settings as before. The alternation of the vacuum pumps will allow equal usage of the equipment and will increase the life expectancy of the system. If the demand for the remaining pumps needs to change, you must enter the necessary value in the Controller for the level of vacuum you wish to maintain as a minimum/maximum for each on/off switch point. If there is not a demand for the lag pump(s) they will never run with the lead pump. Every day the lead pump will change.

When the lead pump cannot handle the demand of the system, the remaining pump(s) will turn on. For medical packages: when the last pump in the system is required to operate, the alarm condition will trigger the audio or visual signal that the lag pump is operating, and the system is near full capacity. The alarm reset button should be pressed and the light or audible sound will stop.

Manual Modes:

Any pump can be independently started manually by placing the system in manual mode. All high temperature and low/high level switches will still be monitoring the equipment, thus ensuring the safe operation of your Vacuum system. The Controller program will not initiate and the automatic alternation will not function. The cost of operating the system will be considerably higher than in automatic mode.

Switching to parameterization mode:

In order to change **any** of the preset values in the Controller, the initial procedure is the same:

1. Turn on power to the Controller.
2. Place pump(s) in manual (Hand) mode. This is done so vacuum will be maintained, otherwise when saving changes, the pump(s) will shut down.
3. Press **ESC**, then scroll down to "Set Param", then push **OK**.

The Controller switches to parameterization mode and displays the parameterization menu. The operator can now access the various menus by using the **up** or **down** arrows to toggle to desired menu.

Selecting a parameter:

The following can be parameters:

- The delay times of a time relay.
- The switching times of an alternation time switch.
- The threshold value of a counter.
- The monitoring time of an operating hours counter (internal clock).
- The switching thresholds of a vacuum switch.

To select a parameter, proceed as follows:

1. Select the "Set Param" option from the parameterization menu. (**UP** or **DOWN** arrows)
2. Once you have the cursor (>) on the desired parameter, press **OK**.

The Controller displays the first parameter. If parameters cannot be set or modified, you can use **ESC** to return to the parameterization menu. The **ESC** key can be used at any time to leave the parameterization mode and return to the running mode.

3. Select the desired parameter by using the **UP** or **DOWN** arrows to toggle through until the desired parameter is displayed in the window.
4. To change a parameter, you must select it and press **OK**.

Changing a parameter:

To change a parameter, you first must select it as shown above. Once you have selected the desired parameter, you can change the value by moving the cursor to the desired location with the **<** or **>** arrows. The actual value is changed by using the **UP** or **DOWN** arrow. The steps are as follows:

1. Move the cursor to the point at which you want to make the change. (**<** or **>** arrows)
2. Change the value. (**UP** or **DOWN** arrows)
3. Accept the value. (**OK**)

Once all parameters are modified, you'll need to exit the "Set Param" mode by followings these steps:

1. Press **ESC** until you reach the screen that has **STOP**.
2. Arrow up to **STOP** and press **OK**.
3. When prompted **Stop Prg**, use arrow **UP** or **DOWN** to **Yes** and press **OK**.
4. Arrow down to **Start** and press **OK**. (This will save the changes)
5. Turn pump(s) to Automatic mode.

Vacuum pump ON/OFF settings for Microprocessing Controller (Vacuum in "Hg):

When setting the ON and OFF switch points in your Controller, use the following table for reference:

Inches of HgV	PLC Setting
29	234
28	488
27	742
26	996
25	1250
24	1504
23	1758
22	2012
21	2266
20	2520
19	2775
18	3028
17	3282
16	3536
15	3790
14	4044
13	4298
12	4552
11	4806
10	5060

This table will apply to all single and multiplex systems equipped with a Controller after 5/15/02 (all units supplied with a Controller prior to this date must contact the Service or Engineering department with serial number of supplied equipment for assistance). These values are entered directly into the Controller in the appropriate block number for lead and lag pumps. Refer to the specific instruction set provided with the IOM for block number identification.

- The correct value can also be determined by the following formula:

  7600 – (Inches of HgV x 254) = Controller setting

  Example: SW↑ = 3282 – switch pump on at 17"HgV (7600 – (17 x 254) = 3282)

  SW↓ = 2520 – switch pump off at 20"HgV (7600 – (20 x 254) = 2520)

- To determine the vacuum point displayed on the LED of the Controller unit use the following formula:

  "HgV = 29.92 – (Displayed Value/254)

Please note that the values you are working with are Torr values multiplied by 10.
A perfect vacuum is approaching a setting of 0 and at atmospheric pressure at sea-level the setting is at 7600 (760 Torr x 10).

Settings for Simplex Systems:

- Unless otherwise noted, the standard switch points for a Simplex System will be set at:
  Lead pump ON at 17"HgV – OFF at 20"HgV
- Specific block numbers for Simplex Controller Program:
  Lead pump =B15

Setting for Duplex Systems:

- Unless otherwise noted, the standard switch points for a Duplex System will be set at:
  Lead pump ON at 17"HgV – OFF at 20"HgV
  Lag pump ON at 16"HgV – OFF at 19"HgV
- Specific block numbers for Duplex Controller Program:
  Lead pump =B15
  Lag pump =B16
  Alarm visual/audible =B13 (Typically set to come on and off with lag pump settings)

Setting for Triplex Systems:

- Unless otherwise noted, the standard switch points for a Triplex System will be set at:
  Lead pump ON at 17"HgV – OFF at 20"HgV
  Mid pump ON at 16"HgV – OFF at 19"HgV
  Lag pump ON at 15"HgV – OFF at 18"HgV
- Specific Block number for Triplex Controller Program:
  Lead Pump =B15
  Mid pump =B16
  Lag pump =B23
  Alarm visual/audible =B13 (Typically set to come on and off with lag pump settings)

Protective Devices

The following protective devices are available to protect the unit from being damaged and to help with maintenance.

- **High Temperature Switch (standard except on Vmax^{LT}):** will signal when the temperature of the oil is exceeding the shut-down level. The switch will shut the unit down. The unit will not restart until the alarm condition is acknowledged and is reset. The switch is a "snap disc" type of switch that is normally closed. When the temperature reaches the maximum setpoint, the switch will open. Once the switch has opened, there is a 10-20^{o}F differential that the temperature will need to drop to, in order for the switch to close.
- **High Back-pressure Switch (optional):** is installed on the discharge of the separator. When the back-pressure reaches a pre-determined level (4 psi), the switch will signal the control panel. A high back-pressure light may be installed on the control panel, which, when illuminated, signals that the exhaust element in the vacuum pump needs to be replaced. Note that the high back-pressure switch will not shut the unit down, but the exhaust element must be replaced as soon as possible.
- **Lag Pump On Alarm (optional):** An NFPA 99 requirement on medical systems. This is an audio/visual alarm that signals lag pump operation. Once the alarm triggers, the alarm must be acknowledged and reset. The alarm will not reset if the lag pump is still in operation. This alarm indicates vacuum is greater than the supply of the lead pump only.
- **Transformer Failure Light (optional):** All standard medical NFPA 99 oil-sealed liquidring vacuum pump systems are supplied with two (2) control voltage transformers (one primary and one for backup). If indication is desired in the event that the primary transformer fails and the backup transformer picks up, a TRANSFORMER FAILURE light will be necessary. The defective transformer should be replaced as soon as possible. When the primary transformer fails, the operation of the system will not be interrupted. If the backup transformer also fails, the system will shut down.
- **Low Oil Level Switch (optional):** This switch is installed in the separator/reservoir of the liquidring vacuum pump. It is a float type of switch. If the level switch is triggered, the affected pump will shut down. The LOW OIL LEVEL light on the control panel will be illuminated. The low level switch will be wired into the main alarm of the panel. The alarm will have to be reset to restart the pump. **When filling the system with oil, make sure that the power to the pump is off because if the alarm reset button has been reset and the level switches contacts close while filling the pump, the pump will start-up automatically.**
- **Frequent Stop/Start Protection (standard on multiplex systems):** Allows each pump to run a minimum amount of time. Frequent stopping/starting can reduce coupling life and is also less efficient from a power consumption standpoint.
- **Automatic Alternation (standard on multiplex systems unless otherwise specified):** Allows the pumps to alternate. The primary feature of automatic alternation is to equalize the running time on all the pumps.

TROUBLE-SHOOTING

Following is a basic trouble-shooting guide. We recommended that you consult your local dealer for service. Each ***Vmax*** system is tested and checked at the factory. Always indicate system model and serial number when calling.

WARNING: Before attempting any repairs, disconnect all power from the system by switching off the main breaker or disconnect switch. This will prevent the system from automatically starting from a vacuum switch.

TROUBLE SHOOTING FAQS (Frequently Asked Questions)

VMAX OIL-SEALED LIQUID RING VACUUM PUMP SYSTEMS

START-STOP PROBLEMS:

System will not start in HAND or AUTO position: (Vmax)

1. Check if the disconnect or circuit breaker is switched on.
2. Check the overload setting on the starter and fuses.
3. Check alarm reset, light should be off.
4. Ensure that the proper voltage is supplied and that the wire size is correct.
5. Check electrical control panel (if installed). Make sure that all wires are tight. Wires may vibrate loose during shipment or operation.
6. Check low oil level switch (if installed). Add oil to reservoir if needed.
7. Check if the pump has seized by rotating the coupling by hand (**disconnect power first**). If a rubbing noise or binding is observed, contact authorized dealer.
8. Check the high temperature switch, which should be set for 225^{o}F.
9. Check if pump operates against high back-pressure (> 4 psig), if so replace oil separator element.
10. Check vacuum switch (if installed).

System shuts down while running: (Vmax)

1. Check oil temperature gauge for operating temperature.
2. Check the overload setting on the starter and fuses.
3. Ensure that the proper voltage is supplied and that the wire size is correct.
4. Check for loose electrical connections.
5. Check the vacuum switch setting (if installed).
6. Check low oil level switch (if installed), add oil to reservoir if needed.
7. Check if the pump has seized by rotating the coupling by hand (**disconnect power first**). If a rubbing noise or binding is observed, contact authorized dealer.
8. Check high temperature switch, which should be set for 225^{o}F.
9. Clean oil strainer.
10. Check if pump operates against high back-pressure (> 4 psig), if so replace oil separator element.
11. Check the overload setting on the starter and fuses.

VACUUM PROBLEMS:

System operates, but does not achieve desired vacuum level: (Vmax)

1. Stop system and disconnect power.
2. Check if the inlet valve is open and inlet filter is clean.
3. Ensure that no lines are open to the atmosphere, causing loss of vacuum.
4. Check for leaks in piping systems, using conventional leak detection methods.
5. Ensure that the oil level is correct and that the pump is primed and filled with oil to the shaft centerline only.
6. Check if the oil isolation valve is open.
7. Check if the oil solenoid valve (if installed) is working.
8. Check the vacuum switch setting (if installed).
9. Check setting of vacuum relief valve (if installed) and adjust as needed.
10. Check if the motor rotation is correct. Rotation should be clockwise (facing pump from motor side) and marked by an arrow on the motor or pump housing. If incorrect, switch any two of the three main power leads on the contactor inside the control panel.

OVERHEATING PROBLEMS:

System overheats or operates above 200^{o}F: (Vmax)

1. Stop system and disconnect power.
2. Check the oil cooler and fan. Clean cooler externally with compressed air. Ensure that 12" of space is available in front of the cooler and that the ambient temperature is below 110° F.
3. Check if the oil isolation valve is open.
4. Check if the oil solenoid valve (if installed) is working.
5. Ensure that the oil level is correct and that the pump is primed and filled with oil to the shaft centerline only.
6. Check if the temperature control valve (if installed) is working and that oil is flowing through the cooler. **Caution, hot oil!**
7. Clean oil strainer.
8. Check if oil cooler is blocked internally with solids passed through from the process, clean if necessary.

Unit overheats on start-up in low ambient temperatures: (Vmax)

1. Stop system and disconnect power
2. Oil tends to thicken in temperatures of 50^{o}F and below. Place heat tape and insulation on the fluid seal line from the heat- exchanger to the pump inlet.
3. Also insulate the seal-fluid solenoid valve (if installed).

NOISE AND VIBRATION PROBLEMS:

The system is making an abnormal noise or sound: (Vmax)

1. Stop system and disconnect power.
2. Check the coupling and/or element for proper alignment. If worn or damaged, replace.
3. Check if the bearings are greased. Rotate the coupling by hand, which should rotate freely. If a rubbing noise or binding is observed, contact authorized dealer.
4. Ensure that the oil level is correct and that the pump is primed and filled with oil to the shaft centerline only.
5. Check vacuum relief valve (if installed), check the setting and adjust as needed.
6. Check the inlet filter and clean if necessary. Pump will cavitate if filter is blocked.
7. Check if the inlet valve is closed. The pump will cavitate if inlet is closed.
8. Check vacuum level on vacuum gauge. Pump could cavitate as a result of a too high vacuum level.

System is vibrating excessively: (Vmax)

1. Stop system and disconnect power.
2. Check the coupling and/or element for proper alignment. If worn or damaged, replace.
3. Check if the bearings are greased. Rotate the coupling by hand, which should rotate freely. If a rubbing noise or binding is observed, contact authorized dealer.
4. Check if baseplate is properly supported. Uneven floor will distort baseplate, which could cause vibrating problems.
5. Check that the mounting bolts of pump, coupling, fan and cooler are not loose. Tighten as required.
6. Check belt alignment on belt drive systems.

OIL PROBLEMS:

System uses excessive oil or produces an oil-mist: (Vmax)

1. Stop system and disconnect power.
2. Check the oil return line from the separator for blockage to ensure that oil flows from separator to vacuum pump.
3. Check if pump operates against high back-pressure (> 4 psig), if so replace oil separator element.
4. Vacuum level should be 15” Hg or higher. If not, consult authorized dealer.
5. Check for an excessive amount of water vapor carried over from the process.

CUSTOMER SERVICE

DEKKER
VACUUM TECHNOLOGIES, INC.

935 SOUTH WOODLAND AVENUE, MICHIGAN CITY, IN 46360-5672
TEL.: 219-861-0661 – FAX: 219-861-0662 – TOLL-FREE: 888-925-5444

Business hours: 7.30 a.m. – 4.30 p.m. CST

Website: www.dekkervacuum.com

E-mail: Info@dekkervacuum.com

Sales@dekkervacuum.com

Techsupport@dekkervacuum.com

Order information

When calling for service, parts or system information always have the pump or system model number and serial number(s) ready. Refer to the bill of lading or the gold-colored system information plate attached to the system.

Parts should be purchased from the nearest authorized DEKKER representative or from the vacuum pump system supplier. If for any reason parts cannot be obtained in this manner, contact the factory directly.

H:\Sales\OperatingManuals\VMAX.DOC
June2006/ado/13

WARRANTY POLICY

Warranty policy for DEKKER vacuum pumps and systems: April 2006

DEKKER Vacuum Technologies, Inc. (hereafter referred to as the Company) warrants that the products hereunder shall be free of defects in material and workmanship and conform to the specifications given in connection with the sale of the product.

Vmax **systems:** full **3-year warranty** from date of shipment, provided the system is operated exclusively with DEKKER ***Vmaxol*** sealing liquid and is operated during the full warranty period as per the instructions given in the Operation and Maintenance Manual. If purchaser elects not to use DEKKER seal-fluids, system warranty shall be 2 years if fluid is approved by DEKKER.

Vmax^{MTH} **systems: 1-year warranty** from date of shipment, provided the system is operated exclusively with DEKKER ***Vmaxol*** sealing liquid and is operated during the full warranty period as per the instructions given in the Operation and Maintenance Manual. If purchaser elects not to use DEKKER seal-fluids, system warranty shall be 1 year if fluid is approved by DEKKER.

DuraVane pumps, systems and compressors: 2-year warranty from date of shipment, provided the pump(s) are operated during the full warranty period as per the instructions given in the Operation and Maintenance Manual, and where applicable are operated exclusively with DEKKER **Duratex** oil. If purchaser elects not to use DEKKER oil, pump and system warranty shall be 18 months if oil is approved by DEKKER.

TiTan and Maxima-K liquid ring vacuum pumps and compressors and AquaSeal and ChemSeal systems: 2-year warranty from date of shipment, provided the pump or system is operated during the full warranty period as per the instructions given in the Operation and Maintenance Manual.

All other systems not specified above and all custom-engineered systems: 1-year warranty from date of shipment, provided the pump or system is operated during the full warranty period as per the instructions given in the Operation and Maintenance Manual.

Rebuilt pumps and systems: 6 months warranty from date of shipment if operated as per the instructions given in the Operation and Maintenance Manual.

All 3rd party components are subject to Manufacturers' warranty.

Mechanical shaft seals are warranted for a period of **ninety (90) days** from date of shipment.

The replacement of **maintenance items** including, but not limited to oil, seals, bearings, filters, vanes in rotary vane pumps, etc., made in connection with normal maintenance service are **not covered** under this warranty.

No warranty shall apply to products that have been misused or neglected, which includes operation in excessive ambient temperatures, dirty environments or the pumping of corrosive, erosive or explosive liquids or gasses or for problems caused by a build-up of material on the internal parts of the product.

Under this warranty the purchaser is entitled to the repair or replacement (whichever DEKKER elects) of any part or parts of the product that do not conform to specifications. This warranty shall be void unless said nonconformance is discovered before the expiration of this warranty. For repairs, the Company has to be notified in writing, a return authorization has to be obtained and the nonconforming part or parts need to be returned to the Company, transport charges prepaid, within thirty (30) days of discovery. Repairs shall be made at the Company's facility without charge, except for return transport charges. Replacement parts provided under the terms of this warranty are warranted for the remainder of the warranty period applicable to the product in which they are installed, as if such parts were original components of that product.

No allowance will be granted for repairs or alterations made by the purchaser without the Company's written consent.

In lieu of the foregoing remedy, the company may (if the Company so elects), redesign and/or replace the product or refund the full purchase price thereof.

If purchaser disassembles the product for any reason without the written consent of the Company, this warranty shall be void.

Limitation of liability for DEKKER vacuum pumps and systems:
The Company's obligations are limited to repair, redesign, replacement or refund of the purchase price, at the Company's option. In no event shall the purchaser be entitled to recover incidental, special or consequential damages arising out of any defect, failure or malfunction of the product.

This warranty and the company's obligation there under is expressly in lieu of all other warranties, including but not limited to the implied warranties of merchantability and fitness for a particular purpose. All warranties, which exceed the aforementioned obligations are hereby disclaimed by the company and excluded from this warranty. No other person is authorized to give any other warranty or to assume any other liability on the company's behalf without written authorization.

SERVICE AND PARTS MANUAL FOR BLOWER MODEL

EN707 – EN808 THREE PHASE

Technical & Industrial Products
627 Lake Street, Kent, Ohio 44240 U.S.A.
Telephone: 330-673-3452 Fax: 330-677-3306
e-mail: rotronindustrial@ametek.com
internet: www.ametektip.com

Your Choice. Our Commitment.™

WARRANTY, INSTALLATION, MAINTENANCE AND TROUBLESHOOTING INSTRUCTIONS

TECHNICAL AND INDUSTRIAL PRODUCTS
627 Lake Street, Kent, Ohio 44240 USA
Telephone: 330-673-3452 Fax: 330-677-3306
e-mail: rotronindustrial@ametek.com web site: www.ametektip.com

1. AMETEK Rotron DR, EN and HiE regenerative direct drive blowers are guaranteed for one full year from the date of installation (limited to 18 months from the date of shipment) to the original purchaser only. Should the blower fail we will evaluate the failure If failure is determined to be workmanship or material defect related, we will at our option repair or replace the blower.

2. AMETEK Rotron Minispiral, Revaflow, Multiflow, Nautilair, remote drive blowers, moisture separators, packaged units, CP blowers, Nasty Gas™ models and special built (EO) products are guaranteed for one full year from date of shipment for workmanship and material defect to the original purchaser only. Should the blower fail, If failure is determined to be workmanship or material defect related, we will at our option repair or replace the blower.

3. **Parts Policy** - AMETEK Rotron spare parts and accessories are guaranteed for three months from date of shipment for workmanship and material defect to the original purchaser only. If failure is determined to be workmanship or material defect related we will at our option repair or replace the part.

Corrective Action - A written report will be provided indicating reason(s) for failure, with suggestions for corrective action. Subsequent customer failures due to abuse, misuse, misapplication or repeat offense will not be covered. AMETEK Rotron will then notify you of your options. Any failed unit that is tampered with by attempting repair or diagnosis will void the warranty, unless authorized by the factory.

Terms and Conditions - Our warranty covers repairs or replacement of regenerative blowers only, and will not cover labor for installation, outbound and inbound shipping costs, accessories or other items not considered integral blower parts. Charges may be incurred on products returned for reasons other than failures covered by their appropriate warranty. Out-of-warranty product and in warranty product returned for failures determined to be caused by abuse, misuse, or repeat offense will be subject to an evaluation charge. Maximum liability will in no case exceed the value of the product purchased. Damage resulting from mishandling during shipment is not covered by this warranty. It is the responsibility of the purchaser to file claims with the carrier. Other terms and conditions of sale are stated on the back of the order acknowledgement.

Installation Instructions for SL, DR, EN, CP, and HiE Series Blowers

1. **Bolt It Down** - Any blower must be secured against movement prior to starting or testing to prevent injury or damage. The blower does not vibrate much more than a standard electric motor.

2. **Filtration** - All blowers should be filtered prior to starting. Care must be taken so that no foreign material enters the blower. If foreign material does enter the blower, it could cause internal damage or may exit at extremely high velocity.

   Should excessive amounts of material pass through the blower, it is suggested that the cover(s) and impeller(s) be removed periodically and cleaned to avoid impeller imbalance. Impeller

imbalance greatly speeds bearing wear, thus reducing blower life. Disassembling the blower will void warranty, so contact the factory for cleaning authorization.

3. **Support the Piping** - The blower flanges and nozzles are designed as connection points only and are not designed to be support members.

   Caution: Plastic piping should not be used on blowers larger than 1 HP that are operating near their maximum pressure or suction point. Blower housing and nearby piping temperatures can exceed 200°F. Access by personnel to the blower or nearby piping should be limited, guarded, or marked, to prevent danger of burns.

4. **Wiring** - Blowers must be wired and protected/fused in accordance with local and national electrical codes. All blowers must be grounded to prevent electrical shock. Slo-Blo or time delay fuses should be used to bypass the first second of start-up amperage.

5. **Pressure/Suction Maximums** - The maximum pressure and/or suction listed on the model label should not be exceeded. This can be monitored by means of a pressure or suction gage (available from Rotron), installed in the piping at the blower outlet or inlet. Also, if problems do arise, the Rotron Field representative will need to know the operating pressure/suction to properly diagnose the problem.

6. **Excess Air** - Bleed excess air off. DO NOT throttle to reduce flow. When bleeding off excess air, the blower draws less power and runs cooler.

   Note: Remote Drive (Motorless) Blowers - Properly designed and installed guards should be used on all belts, pulleys, couplings, etc. Observe maximum remote drive speed allowable. Due to the range of uses, drive guards are the responsibility of the customer or user. Belts should be tensioned using belt gauge.

Maintenance Procedure

When properly piped, filtered, and applied, little or no routine maintenance is required. Keep the filter clean. Also, all standard models in the DR, EN, CP, and HiE series have sealed bearings that require no maintenance. Bearing should be changed after 15,000 to 20,000 hours, on average. Replacement bearing information is specified on the chart below.

Bearing Part Number	Size	Seal Material	Grease	Heat Stabilized
510217 510218 510219	205 206 207	Polyacrylic	Nye Rheotemp 500 30% +/- 5% Fill	Yes – 325 F
510449 516440 516648	203 202 307	Buna N	Exxon Polyrex Grease	NO
516840 516841 516842 516843 516844 516845 516846 516847	206 207 208 210 309 310 311 313	Buna N	Exxon Polyrex Grease	NO

Troubleshooting

		POSSIBLE CAUSE	OUT OF WARRANTY REMEDY ***
IMPELLER DOES NOT TURN	Humming Sound	1. * One phase of power line not connected 2. * One phase of stator winding open 3. Bearings defective 4. Impeller jammed by foreign material 5. Impeller jammed against housing or cover 6. ** Capacitor open	1. Connect 2. Rewind or buy new motor 3. Change bearings 4. Clean and add filter 5. Adjust 6. Change capacitor
	No Sound	1. * Two phases of power line not connected 2. * Two phases of stator winding open	1. Connect 2. Rewind or buy new motor
IMPELLER TURNS	Blown Fuse	1. Insufficient fuse capacity 2. Short circuit	1. Use time delay fuse of proper rating 2. Repair
	Motor Overheated Or Protector Trips	1. High or low voltage 2. * Operating in single phase condition 3. Bearings defective 4. Impeller rubbing against housing or cover 5. Impeller or air passage clogged by foreign material 6. Unit operating beyond performance range 7. Capacitor shorted 8. * One phase of stator winding short circuited	1. Check input voltage 2. Check connections 3. Check bearings 4. Adjust 5. Clean and add filter 6. Reduce system pressure/vacuum 7. Change capacitor 8. Rewind or buy new motor
	Abnormal Sound	1. Impeller rubbing against housing or cover 2. Impeller or air passages clogged by foreign material 3. Bearings defective	1. Adjust 2. Clean and add filter 3. Change bearings
	Performance Below Standard	1. Leak in piping 2. Piping and air passages clogged 3. Impeller rotation reversed 4. Leak in blower 5. Low voltage	1. Tighten 2. Clean 3. Check wiring 4. Tighten cover, flange 5. Check input voltage

* 3 phase units

** 1 phase units

*** Disassembly and repair of new blowers or motors will void the Rotron warranty. Factory should be contacted prior to any attempt to field repair an in-warranty unit.

Blower Disassembly:

WARNING: Attempting to repair or diagnose a blower may void Rotron's warranty. It may also be difficult to successfully disassemble and reassemble the unit.

1) Disconnect the power leads. **CAUTION:** Be sure the power is disconnected before doing any work whatsoever on the unit.

2) Remove or separate piping and/or mufflers and filters from the unit.

3) Remove the cover bolts and then the cover. **NOTE:** Some units are equipped with seals. It is mandatory that these seals be replaced once the unit has been opened.

4) Remove the impeller bolt and washers and then remove the impeller. **NOTE:** Never pry on the edges of the impeller. Use a puller as necessary.

5) Carefully note the number and location of the shims. Remove and set them aside. NOTE: If the disassembly was for inspection and cleaning the unit may now be reassembled by reversing the above steps. If motor servicing or replacement and/or impeller replacement is required the same shims may not be used. It will be necessary to re-shim the impeller according to the procedure explained under assembly.

6) Remove the housing bolts and remove the motor assembly (arbor/.housing on remote drive models).

7) Arbor disassembly (Applicable on remote drive models only):
   a) Slide the bearing retraining sleeve off the shaft at the blower end.
   b) Remove the four (4) screws and the bearing retaining plate from the blower end.
   c) Lift the shaft assembly far enough out of the arbor to allow removal of the blower end snap ring.
   d) Remove the shaft assembly from the arbor.
   e) If necessary, remove the shaft dust seal from the pulley end of the arbor.

Muffler Material Replacement:

1) Remove the manifold cover bolts and them manifold cover.

2) The muffler material can now be removed and replaced if necessary. On blowers with fiberglass acoustical wrap the tubular retaining screens with the fiberglass matting before sliding the muffler pads over the screens.

3) Reassemble by reversing the procedure.

NOTE: On DR068 models with tubular mufflers it is necessary to remove the cover and impeller accessing the muffler material from the housing cavity.

Blower Reassembly:

1) Place the assembled motor (assembled arbor assembly for remote drive models) against the rear of the housing and fasten with the bolts and washer.

2) To ensure the impeller is centered within the housing cavity re-shim the impeller according to the procedure outlined below.

3) If blower had a seal replace the seal with a new one.

4) Place the impeller onto the shaft making sure the shaft key is in place and fasten with the bolt, washer and spacer as applicable. Torque the impeller bolt per the table below. Once fastened carefully rotate the impeller to be sure it turns freely.

5) Replace the cover and fasten with bolts.

6) Reconnect the power leads to the motor per the motor nameplate.

Bolt Size	Torque Pound-Force-Foot
1/4-20	6.25 +/- 0.25
5/16-18	11.5 +/- 0.25
3/8-16	20.0 +/- 0.5
½-13	49.0 +/- 1
5/8 –11	90.0 +/- 2

Impeller Shimming Procedure:

WARNING: This unit may be difficult to shim. Extreme care may be exercised.

Tools Needed: Machinist's Parallel Bar
Vernier Caliper with depth measuring capability
Feeler gauges or depth gauge

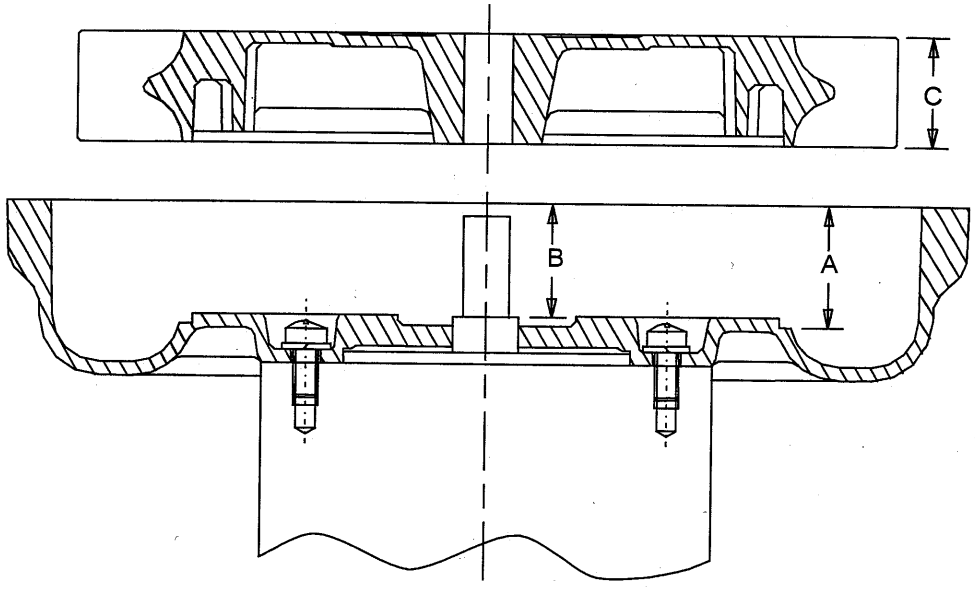
Measure the Following:

Distance from the flange face to the housing (A)
Distance from the flange face to the motor shaft shoulder (B)
Impeller Thickness (C)

Measurements (A) and (B) are made by laying the parallel bar across the housing flange face and measuring to the proper points. Each measurement should be made at three points, and the average of the readings should be used.

Shim Thickness = B – (A+C)/2

After the impeller installation (step #4 above) the impeller/cover clearance can be checked with feeler gauges, laying the parallel bar across the housing flange face. This clearance should nominally be (A-C)/2.



AMETEK®
ROTRON TECHNICAL MOTOR DIVISION
REGENERATIVE BLOWER GROUP

75 North Street
Saugerties, New York 12477
Phone: (845) 246-3401
Fax: (845) 246-3802

EXPLOSION-PROOF BLOWERS

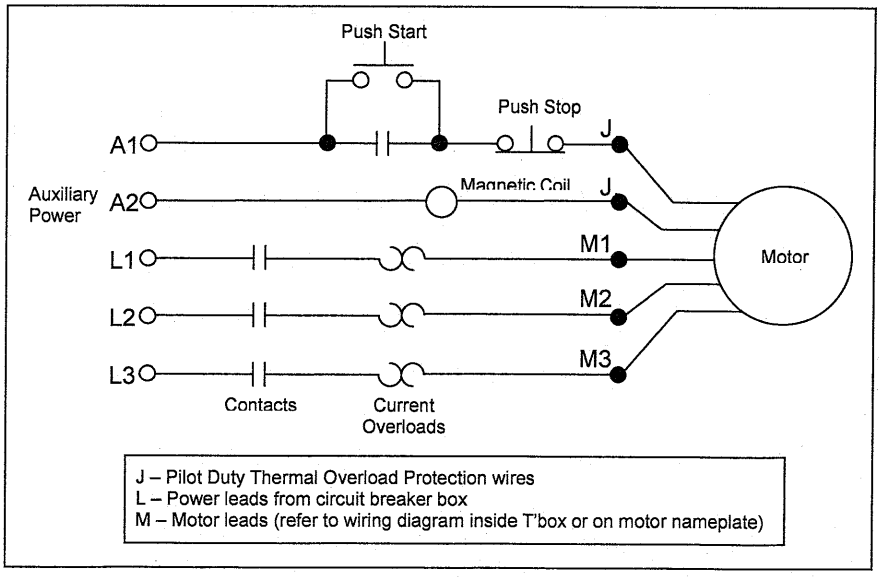
IMPORTANT: Read before wiring this Explosion-proof Blower

This AMETEK Rotron Explosion-proof Regenerative Blower may be equipped with Pilot Duty Thermal Overload (PDTO) or Automatic Thermal Overload (ATO) protection. When properly wired to a motor starter, this protection limits the motor winding temperature rise per the National Electric Code (NEC) article 500. Failure to properly wire this blower is an NEC violation and could cause an explosion. AMETEK Rotron assumes no responsibilities for damages incurred by negligent use of this product, and will not warranty a blower on which the PDTO is not properly connected. Some blowers 1 HP and under do not require PDTO and have built in ATO. Consult the factory if verification of wiring connections is required.

In all cases, follow the motor controller manufacturer's instructions. The following schematic is for conceptual understanding only, and may not apply to all motor/controller combinations.

The manufacturer's wiring diagram found on the motor takes precedent over reference diagrams supplied by AMETEK Rotron Technical Motor Division.

Schematic



The schematic is shown for a three phase motor. For a single phase motor disregard L3 and M3. Pushing the START button completes the auxiliary control circuit, allowing current to flow through the magnetic coil. The contacts are magnetically closed, starting the motor and latching the auxiliary circuit. The motor will continue to run until the STOP push button is depressed, the motor reaches the overload temperature, or the current sensing overloads trip out.

If you have any questions, contact AMETEK Rotron at 914-246-3401 for the location of your area representative.

POLICY REGARDING INSTALLATION OF AMETEK ROTRON REGENERATIVE BLOWERS IN HAZARDOUS LOCATIONS

AMETEK Rotron will not knowingly specify, design or build any regenerative blower for installation in a hazardous, explosive location without the proper NEMA motor enclosure. AMETEK Rotron does not recognize sealed blowers as a substitute for explosion-proof motors. Sealed units with standard TEFC motors should never be utilized where local, state, and/or federal codes specify the use of explosion-proof equipment.

AMETEK Rotron has a complete line of regenerative blowers with explosion-proof motors. Division 1 & 2, Class I, Group D; Class II, Groups F & G requirements are met with these standard explosion-proof blowers.

AMETEK Rotron will not knowingly specify, design or build any regenerative blower for installation in a hazardous, corrosive environment without the proper surface treatment and sealing options.

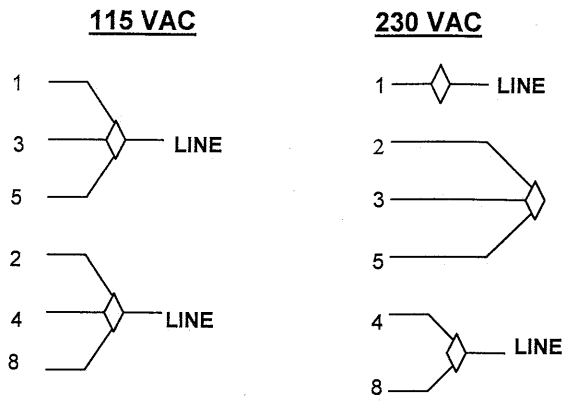
AMETEK Rotron has a complete line of Chemical Processing and Nasty Gas™ regenerative blowers with Chem-Tough™, stainless steel parts, and seals.

AMETEK Rotron offers general application guidance; however, suitability of the particular blower selection is ultimately the responsibility of the purchaser, not the manufacturer of the blower.

FS2 Rev B 3/10/98

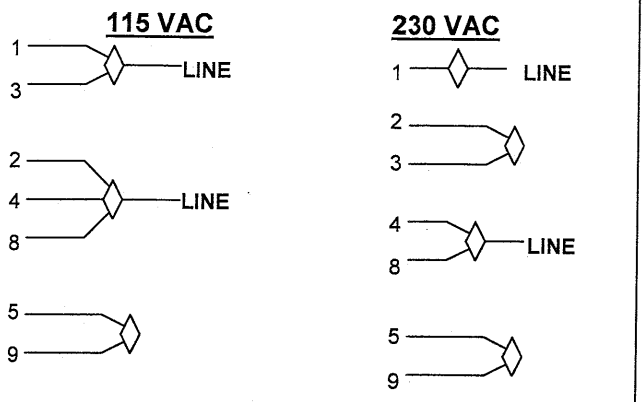
WIRING DIAGRAMS, XP MOTORS

H. 1∅, 6 WIRE



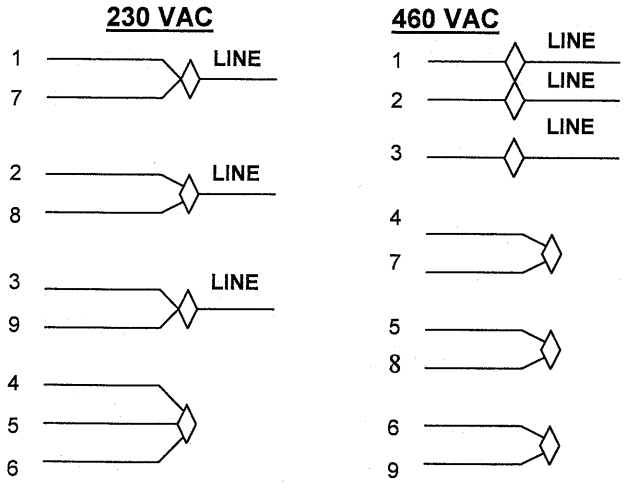
INTERCHANGE LEADWIRES 5 & 8 to REVERSE ROTATION

I. 1∅, 7 WIRE



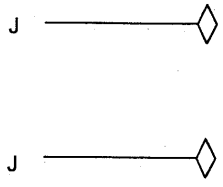
INTERCHANGE LEADWIRES 5 & 8 to REVERSE ROTATION

K. 3∅, 9 WIRE



INTERCHANGE ANY TWO LEAD LINES TO REVERSE ROTATION

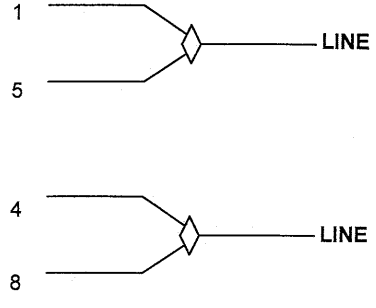
L. PILOT DUTY THERMAL OVERLOADS



HOOK J LEADS TO CONTROL CIRCUITRY

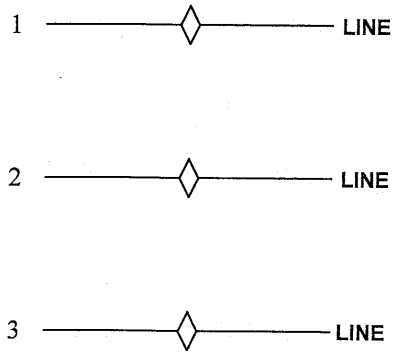
M. 1∅ 230 VAC

SINGLE VOLTAGE



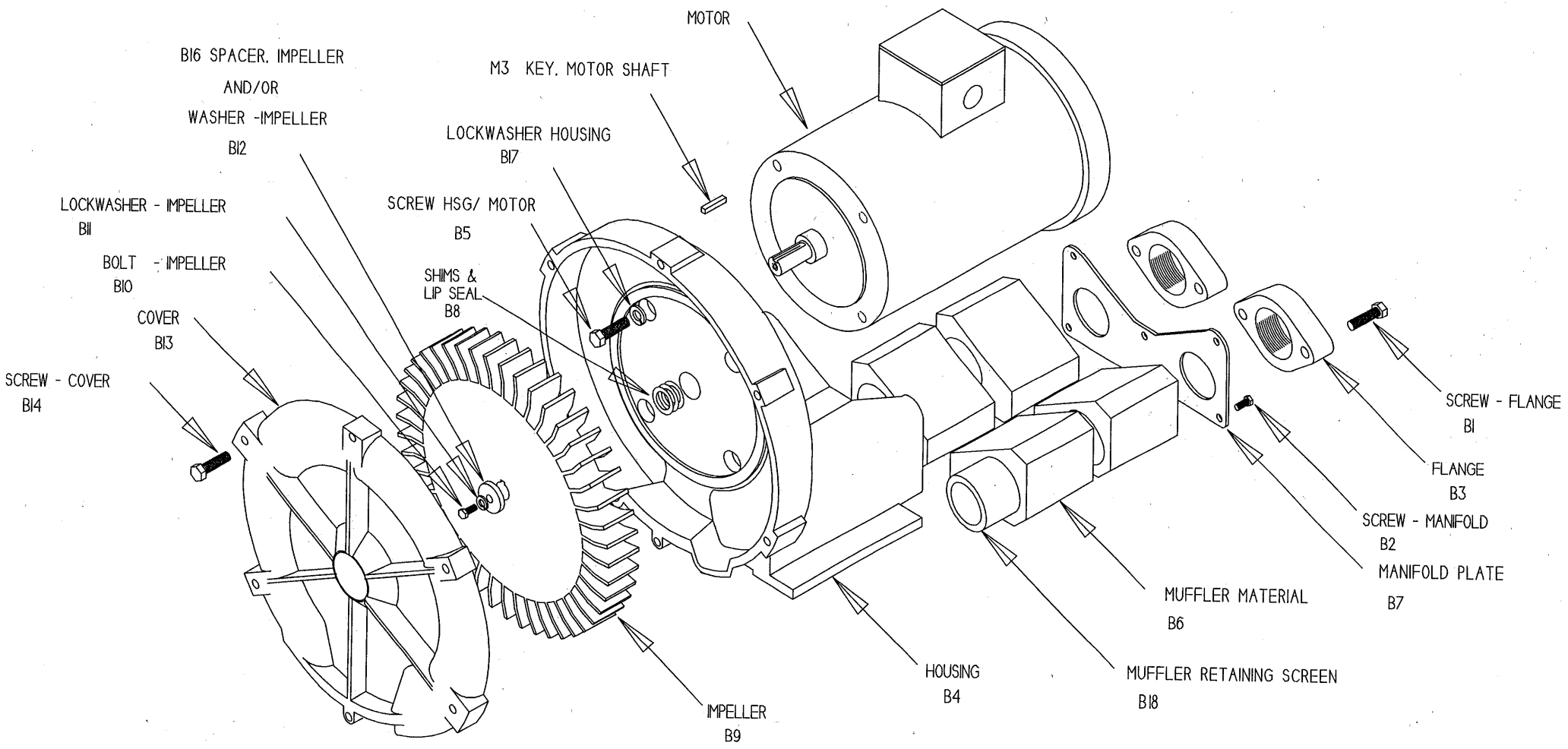
INTERCHANGE LEADWIRES 5 & 8 TO REVERSE ROTATION

N. 3∅ 575 VAC



INTERCHAGE ANY TWO LEAD LINES TO REVERSE ROTATION

ASSEMBLY DIAGRAM
DR/EN/CP/HiE X0X



EN 707/808 3 Phase
Service and Parts Manual

Parts Breakdown

		EN707	EN808	EN707F_MXL	EN757	EN757	EN808BA_MXL	EN808BA__MXL
	Model:			038710	081176	081174	*038729*	081229
	Part No.:	*038181*	*038182*					
		038439	*038440*	038711	081177		*038731*	081230
		OBSOLETE	***OBSOLETE***				***OBSOLETE***	

Item No.	Qty. Req'd	Description							
M3	1	Key Motor Shaft	510212	511532	510212	510629	510212	511532	511532
B1	4	Screw, Flange	155095	155025	155067	155067	155067	155067	155067
B2		Screw, Manifold	(13 pcs) 120214	120214	Not Used	Not Used	Not Used	Not Used	Not Used
B3	2	Flange	511480	511614	511614	511614	511614	511614	511614
		Screen, Flange Guard	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used
B4	1	Housing	516752	516758	516752	552021	552037	550081	516764
B5	4	Screw, Hsg /Motor	251792	140014	251792	251791	251792	140014	155034
B6	36	Muffler Material (Gray)	(40 pcs) 515493	515405	(7) 551720 14 pcs) 552044		14 pcs) 552044	551736	551736
	1	Muffler Material (White)	Not Used	Not Used	551721 (2 pcs) 552045		(2 pcs) 552045	(2) 551737	(2) 551737
B7		Manifold Plate	551264	523432	Not Used	Not Used	Not Used	Not Used	Not Used
B8	*	Shim .002"	272703	511547	272703	510356	272703	511547	511547
	*	Shim .005"	272704	511548	272704	510357	272704	511548	511548
	*	Shim .010"	272705	511549	272705	510358	272705	511549	511549
	*	Shim .020"	272706	511550	272706	510359	272706	511550	511550
	*	Shim .030"	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used
B9	1	Impeller	515461	516452	515461	552035	552036	550071	552062
B10	1	Bolt, Impeller	251791	155068	251791	120215	120007	155068	120210
B11	1	Lockwasher, Impeller	251787	251788	251787	120203	251787	251788	251788
B12		Washer, Impeller	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	511529
B13	1	Cover	515462	516447	515462	552023	552023	516447	552061
B14	7	Screw, Cover	(7 pcs) 120215	140016	155236 (9 pcs)		155236 (9 pcs)	155236	(8 pcs) 140016
B15		Eye Bolt	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used
B16	1	Spacer, Impeller Bolt	478336	511529	478336	510355	478336	511529	515555
B17		Lockwasher, Housing	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used
B18	1	Screen, Muffler Retaining, Right (**)	515492	515408	551723	552046	552046	551723	551723
	1	Screen, Muffler Retaining, Left (**)	515491	515407	551723	552046	552046	551723	551723
B19	6	Bolt, Muffler Hsg/Hsg	120251	155025	120251	120007	120007	155025	155025
B19A	4	Bolt, Muffler Hsg/Hsg	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	120214
B20	1	Muffler Housing	515480	515370	550023	552017	552017	550017	550017
		Muffler Discrete	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used
	2	Bolt, Motor/Muffler	Not Used	120325	Not Used	Not Used	Not Used	Not Used	Not Used
	2	Lockwasher, Motor/Muffler	Not Used	120203	Not Used	Not Used	Not Used	Not Used	Not Used
	2	Washer, Motor/Muffler	Not Used	155029	Not Used	Not Used	Not Used	Not Used	Not Used
B25		Nut, Rail	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used
B26		Rail Mounting	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used
	1	Lip Seal	516691	516693	516691	516587	516693	516693	516693

*As needed **Viewed looking at inlet/outlet ports

Model	Part No.	Motor	Wiring Diagram	Specific Parts	Bearing, Rear (M1)	Bearing, Impeller End (M2)
EN707F72MXL	038710	515552	K + L		510217	510218
EN707F86MXL	038711	529633	N + L			
EN757M72XL	081176	516687	K + L		510449	510217
EN757M86XL	081177	529630	N + L			
EN757F72XL	081174	515552	K + L		510217	510218
EN808BA86MXL	081230	529626	N + L		516840	516844
EN808BA72MXL	081229	515558	K + L			
Discontinued						
EN707F72XL	038181	515552	K + L		510217	510218
EN707F86XL	038439	529633	N + L			
EN808BA72XL	038182	515558	K + L		510840	516844
EN808BA86XL	038440	529626	N + L		Call Factory	Call Factory
EN808BA86MXL	038731	529626	N + L		516840	516844
EN808BA72MXL	038729	515558	K + L			

*As needed **Viewed looking at inlet/outlet ports

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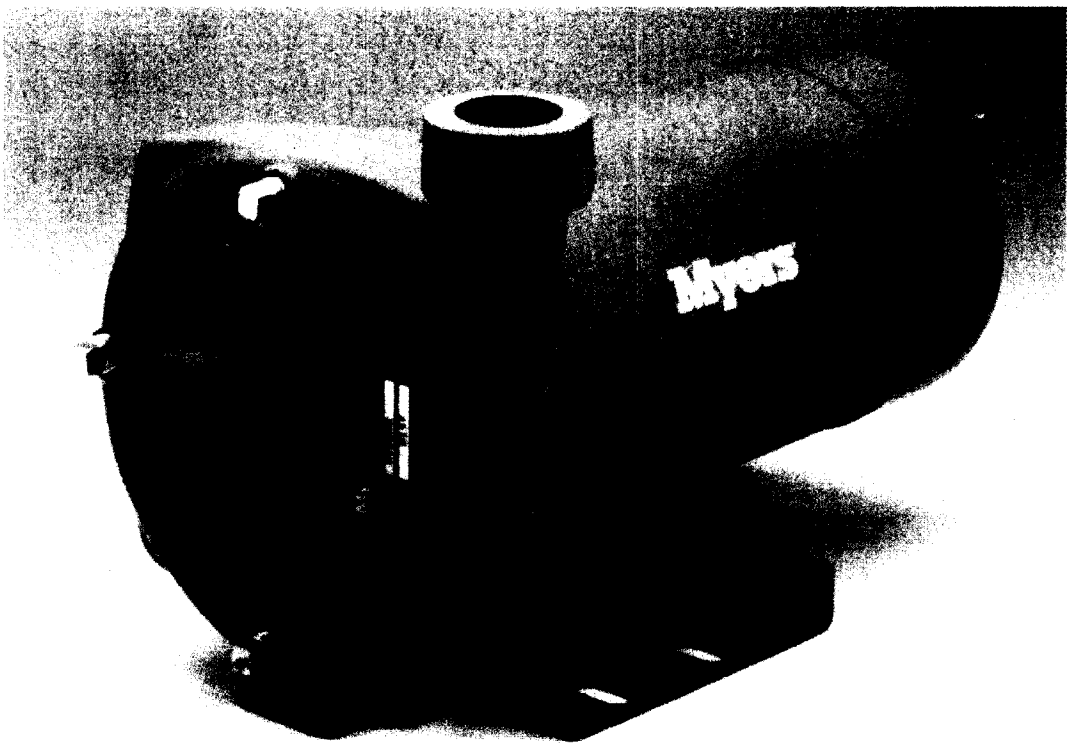
Pentair Pump Group

Installation and Service Instructions

Centri-Thrift Pumps

CT Series



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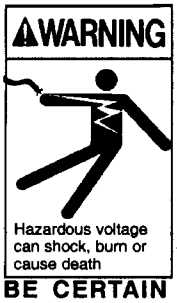
WARNING! IMPORTANT SAFETY INSTRUCTIONS! READ CAREFULLY BEFORE INSTALLATION



FAILURE TO FOLLOW THESE INSTRUCTIONS AND COMPLY WITH ALL CODES MAY CAUSE SERIOUS BODILY INJURY AND/OR PROPERTY DAMAGE

⚠ 1) Before installing or servicing your pump, **BE CERTAIN THE PUMP POWER SOURCE IS TURNED OFF AND DISCONNECTED.**

⚠ **2)** All installation and electrical wiring must adhere to state and local codes. Check with appropriate community agencies, or contact your local electrical and pump professionals for help.

⚠ **3)** CALL AN ELECTRICIAN WHEN IN DOUBT. Pump must be connected to a separate electrical circuit directly from the entrance box. There must be an appropriately sized fuse or circuit breaker in this line. Tying into existing circuits may cause circuit overloading, blown fuses, tripped circuit breakers, or a burned up motor.

⚠ **4)** Do not connect pump to a power supply until the pump is grounded. For maximum safety, a ground fault interrupter should be used. **CAUTION: FAILURE TO GROUND THIS UNIT PROPERLY MAY RESULT IN SEVERE ELECTRICAL SHOCK.**

⚠ **5) WARNING**: Reduced risk of electric shock during operation of this pump requires the provision of acceptable grounding if the means of connection to the supply-connection box is other than grounded metal conduit, ground the motor back to the service by connecting a copper conductor, at least the size of the circuit conductors supplying the motor, to the ground screw provided within the wiring compartment of the motor.

⚠ **6)** The voltage and phase of the power supply must match the voltage and phase of the pump motor.

⚠ **7)** Do not use an extension cord.

⚠ **8)** Do not work on this pump or switch while the power is on.

⚠ **9)** Never operate a pump with a frayed or brittle power cord, and always protect it from sharp objects, hot surfaces, oil and chemicals. Avoid kinking the cord.

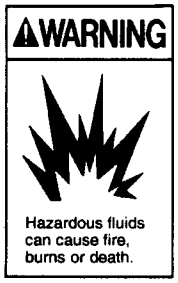
⚠ **10)** Never service a motor or power cord with wet hands or while standing in or near water or damp ground.

⚠ **11)** The three phase units must be wired by a qualified electrician, using an approved starter box and switching device.

⚠ **12)** Do not use this pump in or near a swimming pool, pond, lake or river.

⚠ **13)** Single phase motors are equipped with automatic resetting thermal protectors. The motor may restart unexpectedly causing the leads to energize or pump to turn. Three phase motors should be protected by proper, thermal and amperage protection. (Check local codes.)

⚠ **14)** Do not pump gasoline, chemicals, corrosives, or flammable liquids; they could ignite, explode, or damage the pump, causing injury and voiding the warranty.



⚠ **15)** Do not run this pump with the discharge completely closed this will create superheated water, which could damage the seal, and shorten the life of the motor. This superheated water could also cause severe burns.

⚠ **16)** The following may cause severe damage to the pump and void warranty. It could also result in personal injury:

- Running the pump dry.
- Failure to protect the pump from below freezing temperatures.
- Running the pump with the discharge completely closed.
- Pumping chemicals or corrosive liquids.

⚠ **17)** Never work on the pump or system without relieving the internal pressure.

⚠ **18)** Do not pump water above 120° Fahrenheit.

⚠ **19)** Never exceed the pressure rating of any system component.

INSTALLATION

PACKAGE CONTENTS - 1. Each pump is carefully tested and packaged at the factory.
2. The catalog lists all parts included with package. A packing list packed with pump, also lists contents.
3. Be sure all parts have been furnished and that nothing has been damaged in shipment.
4. OPEN PACKAGES AND MAKE THIS CHECK BEFORE GOING ON JOB.

PIPING - Pipes must line up and not be forced into position by unions. **Piping should be independently supported near the pump so that no strain will be placed on the pump casing**. Where any noise is objectionable, pump should be insulated from the piping with rubber connections. Always keep pipe size as large as possible and use a minimum of fittings to reduce friction losses.

SUCTION PIPING - Suction pipe should be direct and as short as possible. It should be at least one size larger than suction inlet tapping and should have a minimum of elbows and fittings. The piping should be laid out so that it slopes upward to pump without dips or high points so that air pockets are eliminated. The highest point in the suction piping should be the pump inlet except where liquid flows to the pump inlet under pressure. A foot valve must be used to keep pump primed. Where liquid flows to the pump, it may be desirable to use a check valve in the suction line or discharge line to keep pump primed.

To prevent air from being drawn into suction pipe due to a suction whirlpool, the foot valve should be submerged at least three feet below the low water level. The suction pipe must be tight and free of air leaks or pump will not operate properly.

DISCHARGE PIPING - Discharge piping should never be smaller than pump tapping and should preferably be one size larger. A gate valve should always be installed in discharge line for throttling if capacity is not correct. To protect the pump from water hammer and to prevent backflow, a check valve should be installed in the discharge line between the pump and gate valve.

ELECTRICAL CONNECTIONS - Be sure motor wiring is connected for voltage being used. Unit should be connected to a separate circuit, direct from main switch. A fused disconnect switch or circuit breaker must be used in this circuit. Wire of sufficient size should be used to keep voltage drop to a maximum of 5%. All motors, unless provided with built-in overload protection, must be protected with an overload switch, either manual or magnetic. Single phase ½-2½ HP motors have built-in overload protection. **Never install a pump without proper overload protection.** When motor is mounted on a base plate or on slide rails for adjustment, flexible metallic conduit should be used to protect the motor leads.

PRIMING - The pump must be primed before starting. The pump casing and suction piping must be filled with water before starting motor. Remove vent plug in top of casing while pouring in priming water. A hand pump or ejector can be used for priming when desired. When water is poured into pump to prime, use care to remove all air before starting motor.

If pump does not start immediately, stop and reprime.

STARTING - It is good practice to close the discharge valve when starting the pump as it puts less starting load on the motor. When the pump is up to operating speed, open the discharge valve to obtain desired capacity or pressure. Do not allow the pump to run for long periods with the discharge valve tightly closed. If the pump runs for an extended period of time without liquid being discharged, the liquid in the pump case can get extremely hot.

ROTATION - The pump must run in direction of arrow on pump case. All single phase motors are single rotation and leave factory with proper rotation. Three phase motors may run either direction. If rotation is wrong when first starting motor, interchange any two line leads to change rotation.

STOPPING - Before stopping pump, close the discharge valve. This will prevent water hammer and is especially important on high head pumps.

FREEZING - Care should be taken to prevent the pump from freezing during cold weather. It may be necessary, when there is any possibility of this, to drain the pump casing when not in operation. Drain by removing the pipe plug in the bottom of the casing.

ROTARY SEAL - Centri-Thrift pumps are fitted only with a rotary seal. This seal is recommended for water free from abrasives. If liquid contains abrasives, the Centri-Thrift pump should not be used.

BEARINGS - The pump motor uses sealed ball bearings that are factory lubricated and require not further lubrication.

DISASSEMBLY INSTRUCTIONS

All pumping parts can be removed from case without disturbing the piping.

POWER SUPPLY - Open the power supply switch contacts and remove fuses. Disconnect the electrical wiring from the motor.

VOLUTE CASE

(a) Drain pump case by removing drain plug.
(b) Remove the cap screws securing volute case to pump bracket.
(c) Pry volute case from seal plate with a screwdriver.

IMPELLER

(a) Remove motor end cover.
(b) Loosen clamp holding start capacitor and swing capacitor off to one side, do not disconnect wires.
(c) Wrench flats are on the shaft just behind the centrifugal switch that is screwed into the end of the shaft. Do not remove this switch. A 7/16" open end wrench can then be used to hold the shaft from turning.
(d) Grasp the impeller and turn counterclockwise (as viewed from the pump end).

SEAL

(a) Remove the rotating part of the seal by pulling it off the shaft.
(b) The stationary seat can be pressed from the seal plate.

ASSEMBLY INSTRUCTIONS

All pump parts should be cleaned thoroughly before being reassembled.

MOTOR

(a) Assure that the rubber slinger is in place on the motor shaft.

SEAL

(a) A new pump seal should always be used when rebuilding a pump.
(b) Apply some light oil to the rubber which surrounds the ceramic stationary seat. Insert the seal seat into the seal plate using finger pressure to press firmly and squarely until it bottoms. Care must be taken to keep grease and dirt off face areas of the seal. Be sure the seal faces are not damaged during assembly (cracked, scratched, or chipped) or the seal will leak.
(c) Position the seal plate into the motor flange. use care not to chip the stationary seal seat by hitting the motor shaft.
(d) By hand, carefully press the rotating seal assembly onto the motor shaft. The smooth face of the carbon ring must contact the ceramic seat. The rubber ring must seal against the shaft.

IMPELLER

(a) Hold the motor shaft with a 7/16" open end wrench.
(b) Check that the rubber ring of the seal is positioned on the shaft.
(c) Turn the impeller clockwise onto the shaft.
(d) Replace the capacitor taking care not to pinch any wires and tighten capacitor clamp.
(e) Replace motor end cover taking care not to pinch any wires.

VOLUTE

(a) Assure that a new or good condition gasket is in place on the seal plate.
(b) Carefully position the volute in alignment over the impeller and seal plate.
(c) Assemble the components with four 3/8-16UNC cap screws. The bottom two cap screws must also pass through the bracket.

RESTARTING OPERATION

(a) The pump must be primed before starting. The pump volute and suction piping must be filled with water before starting motor. A hand pump or ejector can be used for priming when desired.
(b) Reconnect electric power.
(c) After a few minutes of operation, check that there is no leakage from the pump or piping.

PARTS LIST
CENTRI-THRIFT CT SERIES
½, ¾, 1, 1½ HP

ITEM NO.	DESCRIPTION	QUANTITY REQUIRED	PART NUMBER
1	Motor		
	1/2 HP, 115/230V, 1 Phase	1	26452A000
	1/2 HP, 208-230/460V, 3 Phase	1	26452A001
	3/4 HP, 115/230V, 1 Phase	1	26453A000
	3/4 HP, 208-230/460V, 3 Phase	1	26453A001
	1 HP, 115/230V, 1 Phase	1	26454A000
	1 HP, 208-230/460V, 3 Phase	1	26454A001
	1-1/2 HP, 115/230V, 1 Phase	1	26455A000
	1-1/2 HP, 208-230/460V, 3 Phase	1	26455A001
3	Seal, Rotary 5/8 Shaft		
	Standard Seal with Polycarbonate Impeller	1	14525A010
	Hi-Temp Seal with Brass Impeller	1	21181A021
4	Plate, Seal - Cast Iron	1	26442C000
5	Case, Volute - Cast Iron		
	BSPP Threads	1	26443D000
	NPT Threads	1	26443D001
6	Impeller		
	Polycarbonate, 1/2 HP, 1 Phase	1	26441B003
	Polycarbonate, 1/2 HP, 3 Phase	1	26441B005
	Polycarbonate, 3/4 HP, 1 Phase	1	26440B003
	Polycarbonate, 3/4 HP, 3 Phase	1	26440B005
	Polycarbonate, 1 HP, 1 Phase	1	26439B007
	Polycarbonate, 1 HP, 3 Phase	1	26439B011
	Polycarbonate, 1-1/2 HP, 1 Phase	1	26439B004
	Polycarbonate, 1-1/2 HP, 3 Phase	1	26439B010
	Bronze, 1/2 HP, 1 Phase	1	26441B000
	Bronze, 1/2 HP, 3 Phase	1	26441B004
	Bronze, 3/4 HP, 1 Phase	1	26440B000
	Bronze, 3/4 HP, 3 Phase	1	26440B004
	Bronze, 1 HP, 1 Phase	1	26439B001
	Bronze, 1 HP, 3 Phase	1	26439B009
	Bronze, 1-1/2 HP, 1 Phase	1	26439B000
	Bronze, 1-1/2 HP, 3 Phase	1	26439B008
7	Tube	1	26238A000
8	Bracket	1	25383B002
9	Cap Screw, 3/8-16 UNC x 1 1/8 Lg.	4	19101A016
11	Gasket, 6-3/8 x 5-19/32 x 1/32 Vellumoid	1	05059A446
12	Plug, 1/8 NPT - Galvanized	3	05022A021
13	Plate, Name	1	17908A000
26	Cap Screw, 1/4-28 UNF x 7/8 Lg. (3 Phase)	1	19099A032
27	Washer, 11/16 O.D. Bronze (3 Phase)	1	10186A000

PARTS LIST
CENTRI-THRIFT CT SERIES
2 and 2½ HP

ITEM NO.	DESCRIPTION	QUANTITY REQUIRED	PART NUMBER
1	Motor		
	2 HP, 115/230V, 1 Phase	1	26489A000
	2 HP, 208-230/460V, 3 Phase	1	26489A001
	2-1/2 HP, 115/230V, 1 Phase	1	26490A000
	2-1/2 HP, 208-230/460V, 3 Phase	1	26490A001
3	Seal, Rotary 5/8 Shaft		
	Standard Seal with Polycarbonate Impeller	1	14525A010
	Hi-Temp Seal with Brass Impeller	1	21181A021
4	Plate, Seal - Cast Iron	1	26485D000
5	Case, Volute - Cast Iron		
	2 HP - BSPP Threads	1	26484D001
	2 HP - NPT Threads	1	26484D003
	2-1/2 HP - BSPP Threads	1	26484D000
	2-1/2 HP - NPT Threads	1	26484D002
6	Impeller		
	Polycarbonate, 2 HP, 1 Phase	1	26487C005
	Polycarbonate, 2 HP, 3 Phase	1	26487C009
	Polycarbonate, 2-1/2 HP, 1 Phase	1	26487C004
	Polycarbonate, 2-1/2 HP, 3 Phase	1	26487C008
	Bronze, 2 HP, 1 Phase	1	26487C001
	Bronze, 2 HP, 3 Phase	1	26487C007
	Bronze, 2-1/2 HP, 1 Phase	1	26487C000
	Bronze, 2-1/2 HP, 3 Phase	1	26487C006
7	Tube	1	26238A000
8	Bracket	1	26488C000
9	Cap Screw, 3/8-16 UNC x 1-1/8 Lg.	4	19101A016
11	Gasket, 6.58 x 6.13, Vellumoid	1	05059A447
12	Plug, 1/8 NPT - Galvanized	3	05022A021
13	Plate, Name	1	17908A000
26	Cap Screw, 1/4-28 UNF x 1-1/8 Lg. (3 Phase)	1	19099A031
27	Washer, 11/16 O.D. Bronze (3 Phase)	1	10186A000

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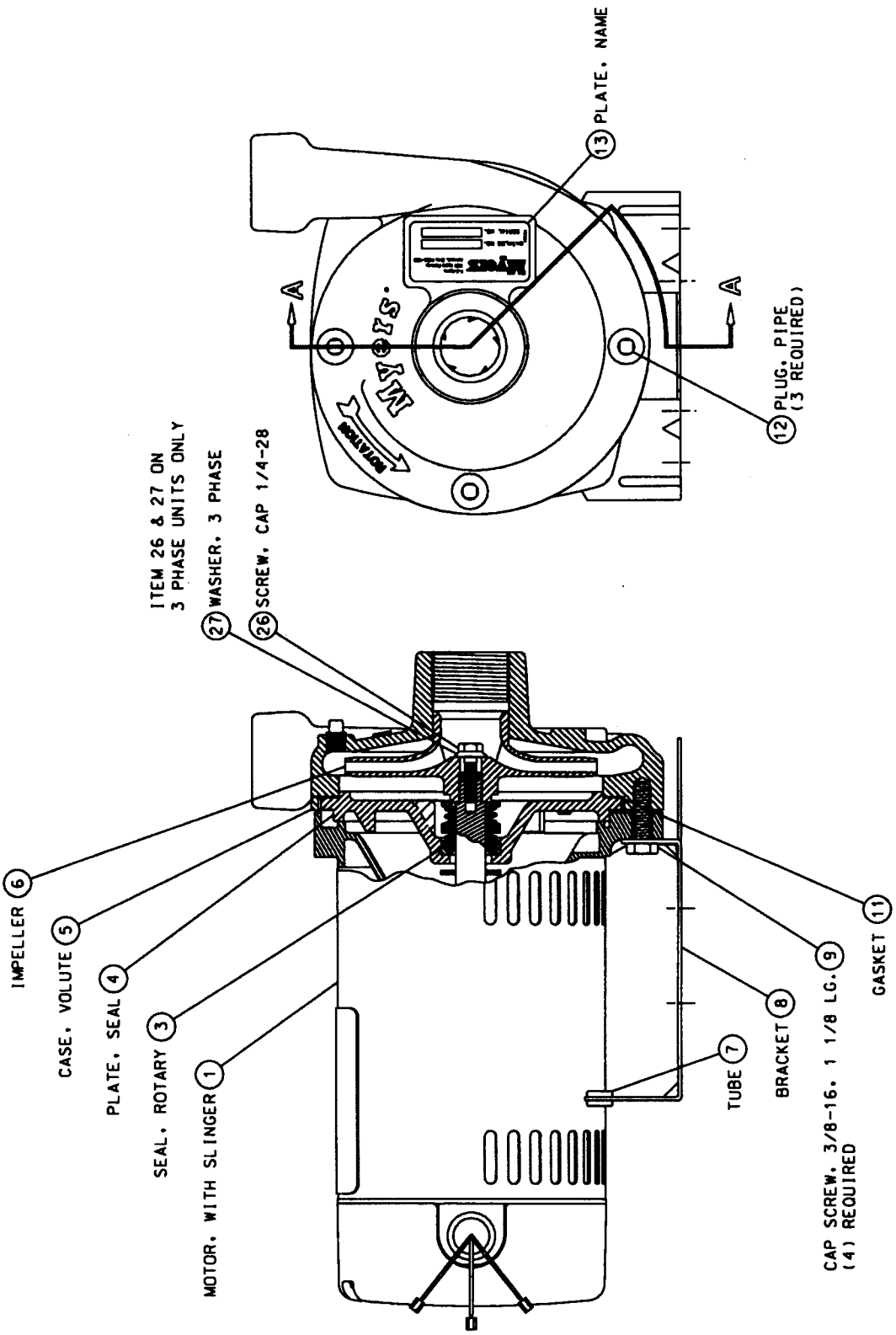
13 PLATE, NAME
A
A
12 PLUG, PIPE (3 REQUIRED)
ITEM 26 & 27 ON 3 PHASE UNITS ONLY
27 WASHER, 3 PHASE
26 SCREW, CAP 1/4-28
6 IMPELLER
5 CASE, VOLUTE
4 PLATE, SEAL
3 SEAL, ROTARY
1 MOTOR, WITH SLINGER
7 TUBE
8 BRACKET
9 CAP SCREW, 3/8-16, 1 1/8 LG. (4) REQUIRED
11 GASKET

SERVICE

TROUBLE SHOOTING GUIDE

A	No water delivered				
B	Not enough water delivered				
C	Not enough pressure				
D	Pump runs for short while; then loses prime				
	POSSIBLE CAUSE OF PROBLEM	**D**	**C**	**B**	**A**
1.	Pump not properly primed; repeat priming operation				X
2.	Discharge head too high. Check total head with gauge at pump inlet and discharge. (With no water, the gauge at discharge would show shut-off pressure.)			X	X
3.	Excessive volume being discharged. Throttle discharge valve.		X		
4.	Suction lift too high. Check with vacuum gauge. This should not exceed 15 feet.	X		X	X
5.	Air leak in suction line. Check line under pressure to find leak.	X	X	X	X
6.	Air pocket in suction line. Check line for proper slope.	X			X
7.	Impeller or suction line plugged.		X	X	x
8.	Impeller and volute case badly worn. Disassemble pump if clearance on diameter is over .030", replace worn impeller and worn volute case.		X	X	
9.	Suction strainer plugged. Clean strainer.	X			
10.	Impeller diameter too small for condition required.		X	X	
11.	Seal leaking - seal is worn or seal face cocked. Replace with new seal and carefully follow directions.				

23833A378 1/02
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Myers
Pentair Pump Group

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CONTINENTAL®
PROGRESSING CAVITY PUMPS

BULLETIN NO. CP-8000

APPLICATION, INSTALLATION AND OPERATION

Speed, temperature, viscosity, suction lift, discharge pressure, abrasive content and corrosive action of the liquid to be handled should all be considered in applying these pumps. Pump should always be filled with the liquid to be handled before running. The liquid serves as a lubricant and is easily poured into pump through the discharge port before final assembly of the piping or hose connections. A filling tee with a plug or valve can be installed above the discharge port for ease in filling.

Liquid to be pumped should never exceed 190°F temperature. Maximum speed that any of these pumps should be run is 2,800 rpm and then only in handling thin, abrasive-free liquids. Preferably the speed should be 1,750 rpm for longest life. When liquid contains abrasive material or is viscous, the speed should be reduced.

For various viscosities of abrasive-free liquids, the maximum operating speed of the pump is set forth below:

SUGGESTED MAXIMUM OPERATING SPEED OF PUMP							
2800 RPM	1750 RPM	1150 RPM	870 RPM	580 RPM	435 RPM	180 RPM	100 RPM
VISCOSITY (Centipoises)							
1	1 to 100	100 to 500	500 to 1000	1000 to 3000	3000 to 5000	5000 to 10,000	10,000 to 20,000
Water	Cleaned Milk	30 Weight Oil	Table Syrup	Honey	Molasses	Paste	Peanut Butter
ABRASIVE FLUIDS							
None	None	None	Light	Medium	Medium	Heavy	Heavy
Clear Water Gasoline			Dirty Water	Clay Slurries Porcelain Enamel		Lapping Compounds Mill Scale in Water	

Capacity and life of these pumps will depend upon the liquid being handled.

Piping to pump should be properly selected and should not be smaller in size than the suction and discharge ports of the pump. All pipe and hose fitting joints should be tight. Discharge lines should be open or if pump is operated in an enclosed system, provision should be made for pressure relief when the pump pressure exceeds the limits as set forth for each model pump.

Pump bearings do not require lubrication as they are pre-lubricated.

We recommend that the pump be flushed after its use.

PUMP SHOULD NOT BE RUN DRY.

We will be glad to collaborate on any proposed applications.

Fill in CONTINENTAL PUMP DATA Sheet and return for a prompt recommendation. Request copies if not with this Bulletin.

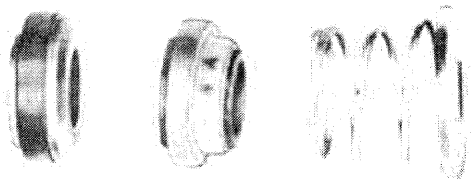
When necessary to dismantle pump, disconnect pipe or hose at suction and discharge ports. Remove bolts which connect Suction Housing to Discharge Housing. Rotor can be removed by turning it in opposite direction to pump rotation. Grip Rotor with wrench, whose teeth have been protected, and hold Shaft externally—hold Motor Shaft with Screwdriver on CPM Models. To replace Rotary Seal, unscrew Flexible Joint with 3/16" hexagonal wrench. Rotary Seals can be easily removed from shaft.

To replace Pump Bearings remove Retaining Ring and then tap shaft at threaded end. Protect threaded end with wood or rubber block.

If any parts of the Rotary Seal are worn or broken, replace complete Rotary Seal. The parts of each Rotary Seal are precision matched and are not interchangeable. Illustration below shows how Rotary Seal is installed by parts and how it looks after it is complete. Part A is pressed into the Discharge Housing. Care should be taken to assure that rubbing surfaces of Part A and B are not scratched. Moisten rubber sleeve of Part B with water to permit easy fitting over Shaft. Part B is then slipped down Shaft until face fits firmly against face of Part A. Part C is placed against Part B. Flexible Joint should then be screwed into Shaft against Part C. Use hexagonal wrench to tighten Flexible Joint, then screw Rotor onto Flexible Joint. It is not necessary to tighten Rotor with a wrench as it is self-tightening when pump starts.

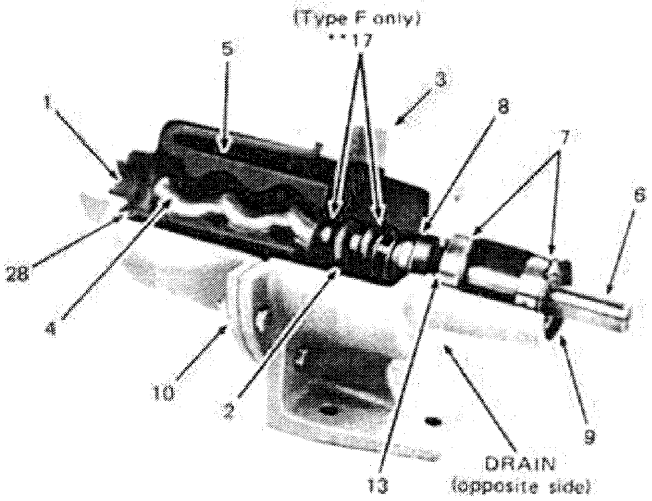
Moisten inside of Stator with water and slip it over Rotor. Mount Suction Housing to Discharge Housing and fasten with body screws. Refill pump with liquid to be handled, connect pipe or hose to suction and discharge ports and pump is ready to run.

ROTARY SEAL ASSEMBLY

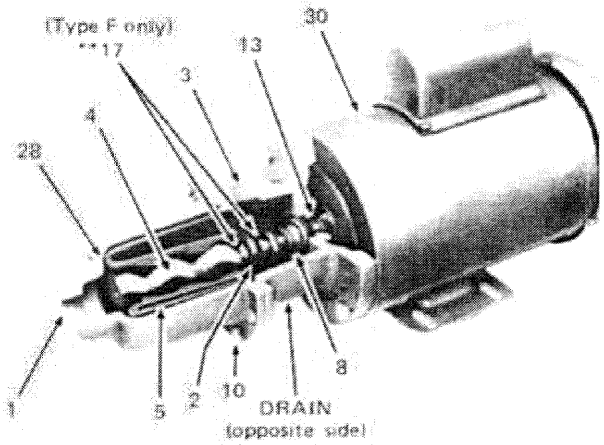


PART A PART B PART C

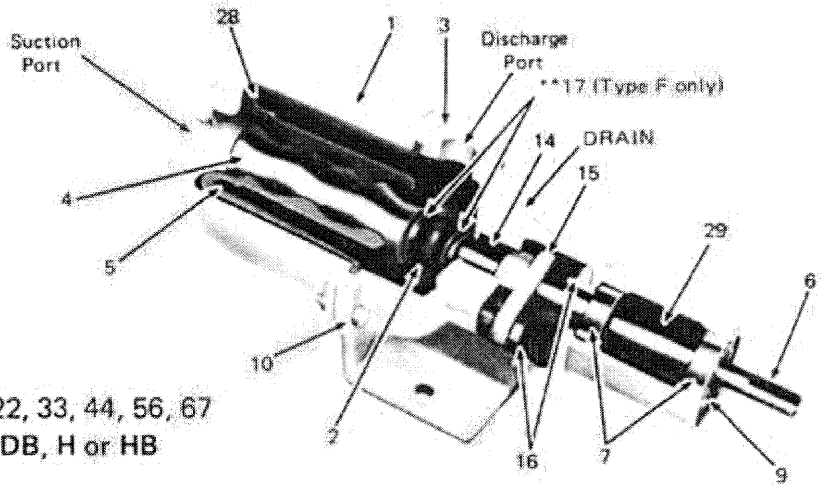
MOTOR SHAFT FLEXIBLE JOINT ROTOR



*Models CP-15, 22, 33, 44, 56, 67
TYPES A or AB, C or CB, F or FB, G or GB



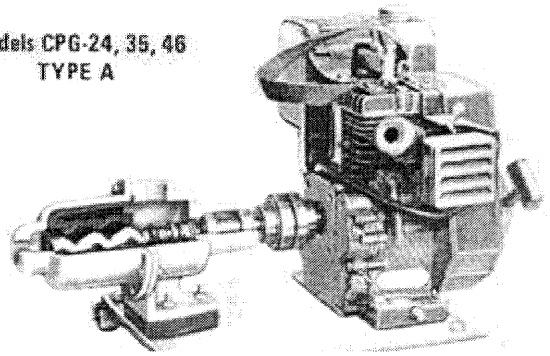
*Models CPM-15, 22, 33, 44, 56, 67
TYPES C or CB, F or FB, G or GB



*Models CP-15, 22, 33, 44, 56, 67
TYPES D or DB, H or HB

ITEM NO.	DESCRIPTION	ITEM NO.	DESCRIPTION	ITEM NO.	DESCRIPTION
1	Suction Housing	7	Pump Bearing	15	Packing Gland
2	Flexible Joint	8	Rotary Seal	16	Packing Gland Bolt
3	Discharge Housing	9	Retaining Ring	17	Roll Pins
4	Rotor	10	Screws and Nuts	28	Stator Ring
5	Stator	13	Slinger Ring	29	Bearing Spacer
6	Shaft	14	Packing	30	Motor

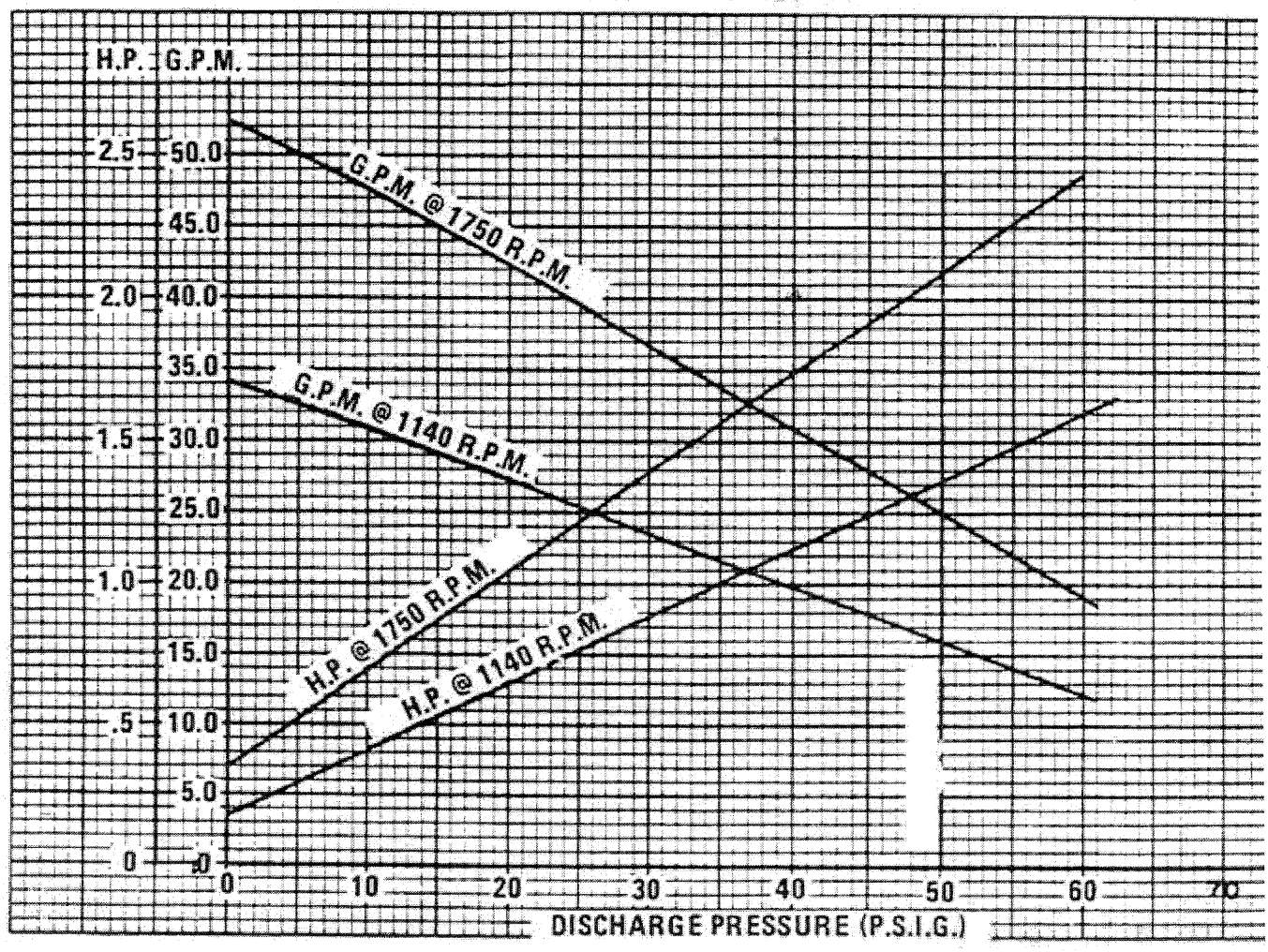
Models CPG-24, 35, 46
TYPE A



OPERATION OF GASOLINE ENGINE DRIVEN UNITS

This unit comes to you ready for operation with the excep
of the gasoline and engine oil. A complete book of instructi
is furnished with each Gasoline Engine Model and shoulc
thoroughly read and followed. After gasoline engine is m
ready by filling with engine oil in crank case and gasolin
tank, fill Discharge Housing of the pump with the liquic
be handled. Complete suction and discharge port connecti
of pump and start engine with rope provided. We recomm
that the pump be drained and flushed after each use.

MODEL CP-67



Test Liquid - Water at 70°F

HYDRO QUIP
Water Treatment Equipment

NEEP ShallowTray
low profile air strippers

OIL WATER SEPARATOR OPERATION AND MAINTENANCE MANUAL

for

Model AGM-3SS-90V HCR

PURCHASE ORDER # 309927-1715005

Seneca Environmental

Des Moines, IA 50313

108 Pond Street· Seekonk, MA 02771
Phone 508-399-5771 · Fax 508-399-5352

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108 Pond Street· Seekonk, MA 02771
Phone 508-399-5771 · Fax 508-399-5352

1.0) INTRODUCTION

Hydro Quip, Inc. (HQI) Oil Water Separator (OWS) Model AGM-3SS-90V will remove essentially all free and dispersed, non-emulsified oil, and settleable solids from the oil water mixture at a flow rate of 25 GPM at a temperature of 55 degrees F. The design utilizes the difference in specific gravity between oil and water (buoyancy force) enhanced by the use of 6 cubic feet of HD Q-PAC coalescing plates. The separator is designed to receive oily water by gravity/pumped flow that will not mechanically emulsify the oil and will process it on a once through basis. The tank will be a single wall, rectangular unit installed above grade. It will be constructed of stainless steel. The HD Q-PAC coalescing plates are manufactured of UV-Resistant Polypropylene material.

2.0 SYSTEM DESCRIPTION AND REQUIREMENTS

2.1 *FABRICATION:* The oil water separator is a special purpose prefabricated parallel corrugated plate, rectangular, gravity displacement, type oil water separator. The separator shall be comprised of a tank containing an inlet compartment, separation chamber, sludge chamber, and clean water outlet chamber.

2.2 *TANK:* The tank shall be a single wall construction of 12 gauge stainless steel conforming to ASTM A240, type 304 stainless steel. Welding will be in accordance with AWS D1.1 to provide a watertight tank that will not warp or deform under load. Pipe connections to the exterior shall be as follows:

2.2.1 *PIPE CONNECTIONS*: All connections 3” and smaller are FNPT couplings. All connections 4“ and larger are flat face flanges with ANSI 150 pound standard bolt circle. Use flanged piping connections that conform to ANSI B16.5.

2.3 *SEPARATOR CORROSION PROTECTION*: (For Carbon Steel Only) after shop hydrostatic test has been successfully completed, a coating system will be applied to the interior and exterior surfaces of the separator. Interior and exterior shall be sandblasted to SSPC-SP10 & SSPC-SP6; Interior lined with Tnemec Series 61 liner to 9 mils MDFT; Exterior coated with polyamide epoxy to 6 mils MDFT.

2.4 *LIFTING LUGS*: The tank shall be provided with properly sized lifting lugs for handling and installation.

2.5 *COVERS:* The tank will be provided with vapor tight covers for vapor control. Gas vents and suitable access openings to each compartment will be provided. The covers shall be constructed of marine grade aluminum and will be fastened in place. A gasket shall be provided for vapor tightness. 3/8-16 bolts and threaded knobs will be provided for cover attachment.

2.6 *INLET COMPARTMENT*: The inlet chamber shall be comprised of a non-clog diffuser to distribute the flow across the width of the separation chamber. The inlet compartment shall be of sufficient volume to effectively reduce influent suspended solids, dissipate energy and begin separation. The media will sit elevated on top of a sludge baffle. The sludge baffle will be provided to retain settleable solids and sediment from entering the separation chamber.

2.7 *SEPARATION CHAMBER*: The oil separation chamber shall contain HD Q-PAC Coalescing Media containing a minimum of 132 square feet per cubic foot of effective coalescing surface area. The medias needle like elements (plates) shall be at 90 degrees to the horizontal or longitudinal axis of the separator. Spacing between these elements shall be spaced 3/16" apart for the removal of a minimum of 99.9% of free droplets 20 micron in size or greater. The elements are positioned to create an angle of repose of 90 degrees to facilitate the removal of solids that may tend to build up on the coalescing surfaces, which would increase velocities to the point of discharging an unacceptable effluent. Laminar flow with a Reynolds Number of less than 500 at a maximum designed flow rate shall be maintained throughout the separator packed bed including entrance and exit so as to prevent re-entrainment of oils with water. Flow through the polypropylene coalescing media shall be crossflow perpendicular to the vertical media elements such that all 132 square feet/cubic foot of coalescing media is available for contact with the coalescing surfaces. None of the coalescing media surfaces shall be pointing upward so as not to be available for contact with the crossflowing oily water. The media shall have a minimum of 87% void volume to facilitate sludge and dirt particles as they fall off the vertical elements and settle in the sludge compartment. The media when installed in crossflow OWS shall meet US EPA Method 413.2 and also European Standard 858-1.

2.8 *BAFFLES:* An oil retention & underflow weir, and overflow weir. Position underflow weir to prevent resuspension of settled solids.

2.9 *SLUDGE CHAMBER*: The sludge chamber shall be located prior to the coalescing compartment for the settling of any solids. It shall also prevent any solids from entering the clean water chamber.

2.10 *OIL SKIMMER*: The oil separation chamber will be provided with a rotatable pipe skimmer for gravity decanting of the separated oil to a product storage tank.

2.11 *CLEAN WATER CHAMBER:* The tank will be provided with a 90-gallon clean water chamber that allows the water to leave the separator by pumped flow through the clean water outlet port.

2.12 VENTS: 2" vents will be provided with vent piping to atmosphere.

3.0 SAFETY AND ENVIRONMENTAL CONSIDERATIONS

3.1 All normal safety precautions should be taken with this equipment to prevent accidents and fires.

3.2 Normal fire prevention measures must be taken to prevent fire danger from separated oil.

3.3 Care should be taken to keep the area around the separator clean to prevent accidents.

3.4 Disposal of the separated oil and solids, which may contain hazardous material, must comply with the regulations of the authority having jurisdiction.

3.5 Safety and environmental protection are the responsibility of the user. HQI assumes no liability for misuse of this separator or for use outside the purpose for which it is designed.

4.0 INSPECTION AND OFFLOADING

4.1 *INSPECTION*: Inspect the oil water separator upon delivery for any damage, which may have occurred in shipment. Areas most susceptible to damage are connections and cover openings. If the separator is damaged, HQI should be notified immediately. The off loading personnel should note the extent of damage and sign and date the bill of lading. A claim should be filed with the delivering carrier.

4.2 *OFF LOADING*: The separator must be carefully removed from the truck so the unit is not damaged. Components for the separator are often supplied in a separate carton. Proper rigging practices should be observed at all times. Hoisting equipment operators should attach a guide line to prevent the separator from swinging out of control. Do not drop the separator or allow it to fall hard in the process of inverting, turning, or moving. Do not slide the separator.

4.3 *COATINGS*: All damaged coatings should be touched up immediately ! Please contact the factory if more specific information is required. Under no conditions should chains or cables be put around the separator. Use spreader bars, and the lifting eyes on the unit.

4.4 *STORAGE*: If the equipment is not to be installed at the time of delivery, it should be stored in an area away from traffic. The ground should be level and free sharp objects that might damage the coatings. All equipment should be stored off the ground on timbers. All factory packing should remain intact until the unit is ready for installation. Equipment should be stored indoors. If not, care should be taken that tanks do not fill up with water and debris. Covering all of the equipment with a tarp is strongly recommended.

5.0 SYSTEM INSTALLATION

When placing the separator for system operation, be sure it is installed in a concrete foundation, which provides adequate support under full load operating conditions. Even if a mounting skid is used, a concrete pad or other properly designed structure must be installed as a foundation. The length and width of this pad are dependent upon the footprint of the unit. Thickness of the concrete pad depends on local soil and frost conditions. A local qualified civil engineer should be contacted to determine these dimensions.

5.1 *FOR EQUIPMENT SUBJECT TO TRAFFIC LOADS*

1. A concrete slab must be installed around the equipment if the separator is going to be subject to traffic loads. It should be designed to carry the load and transmit the load into adjacent, undisturbed soil, not onto the tank side walls!
2. If a concrete pad is not installed and the equipment is subject to traffic loads, deformation or in some cases total collapse of the equipment may occur. HQI cannot be held responsible for equipment subjected to such loads!

5.2 *LEVELING*

1. At this point the equipment should be set exactly in place and the anchor bolts should be installed.

2. Remove any lids.

3. The tankage should now be made as level as possible. The absolute minimum requirements being, within +/- 1/16“ per foot from inlet to outlet end of tank and +/- 1/16” per foot from side to side, maximum of +/- 1/4“ total. Shim the tank, if necessary, until these parameters are met. We recommend the use of stainless steel shim stock. When installing shims, make sure to locate them under all vertical tank supports.

NOTE: We cannot stress enough the leveling process. It is better to invest a little time at this point than to try to correct an improperly leveled tank later. A level installation functions better, has a better appearance and will give you fewer problems in the future.

The next step toward system start involves the plumbing and electrical connections. Any valves and/or piping should be adequately supported and accepted piping and valve practices must be followed for proper system

operation. Any pump or level probe wiring and conduit connections should be made at this time. If the unit includes internal level detection, insert the level detection probe into the port indicated on the drawing. Be sure to lower the probe to the correct level indicated on the drawing.

PLUMBING

1. When making connections to the equipment do not use the equipment as a pipe support. All plumbing should stand on its own if disconnected from equipment. HQI cannot be held responsible for damage caused by using this equipment to support your plumbing.

2. Connections do not have to be made in the order listed below. Review your situation and make the connections in the most convenient order for your particular application.

3. Connect the outlet plumbing. The effluent plumbing must be the same size or larger than the nozzle size of the equipment. Do not reduce the size of the effluent piping as this might cause hydraulic overloading of the equipment. Also, try to run the discharge piping through as few changes as possible, as short a distance as possible and at a pitch of not less than 1/16” per foot. On gravity flow units it may be necessary to vent exterior piping to prevent air locks in discharge pipe.

4. Connect the inlet plumbing. The influent must be the same size or smaller than the nozzle size on the equipment. Do not increase the size of the influent piping as this might cause hydraulic overloading of the equipment. Also, the pitch of the pipe should not exceed 1/16" per foot.

5. On most units, vents will have been provided. These vents have been supplied to prevent air locks during surge conditions. For both indoor and outdoor applications the vents should be run to a location where noxious and sometimes volatile gas would pose no hazard. Follow all applicable fire codes with regards to size of vent pipe.

Warning: Do not plug or otherwise obstruct air flow through the vents. Obstructing air flow through the vents could damage the unit and/or create a hazardous condition.

6.0 SEPARATOR SET UP AND START UP PROCEDURES

6.1 *SEPARATOR SET UP PROCEDURES*:

The inlet flow to the separator must be by gravity or a positive displacement pump upstream. Centrifugal pumps greatly agitate the oil and water and tend to make a stable emulsion that is very difficult, if not impossible, to separate by gravity settling.

Separator flow should be controlled upstream to ensure even, steady flow, and stable conditions in the separator. Unstable flows tend to reduce efficiency and may cause high oil concentration at the outlet.

6.1.1 The separator tank is atmospheric in design and must be vented to the atmosphere. Consult the OWS drawing for location of all vents.

6.1.2 To achieve the desired flow, excessive throttling of the input must be avoided as this will also cause emulsification of the oil, adversely effecting separator performance. Especially avoid the use of globe type or other valves with high-pressure drops.

6.1.3 It is recommended that the effluent water flows by gravity flow from the separator. The pressure loss for the water effluent pipe shall not exceed the drop elevation of the customer lines. External piping should be separately supported. The separator is not designed to support piping.

6.1.4 To install the separator, follow these steps:
(Please refer to attached installation drawing)

1. Ensure that the source of the water to be treated is properly regulated and not provided with a centrifugal pump or other device, which will cause emulsification such as a high-pressure drop valve.

2. Ensure that the separator is securely installed per installation drawing.

6.2 *SEPARATOR START-UP PROCEDURES*:

6.2.1 Initial start-up.

This procedure is to be followed after the installation of the separator or after the separator has been drained for maintenance and is ready to be restarted.

1. Ensure that the owner supplied upstream influent flow regulating valve is closed.

2. Before starting the flow to the unit, remove the coalescer access cover and ensure that the HD Q-PAC packs have not shifted and are securely fastened. The separator should contain plate packs, polishing pack and adjustable oil skimmer pipe tube. **(Slot of skimmer to be turned upward away from water)**

3. Ensure that there are not obstructions in the water outlet piping.

4. With the coalescer access cover off, **fill the tank with clean water**, establishing flow from the effluent opening. Check for leaks, both external and internal remedy any found.

5. Allow the influent oil water mixture into the OWS tank.

6. Replace the coalescer access cover and bolt down liquid tight.

6.2.2 Normal operation:

Carefully maintain flow at the rate set when flow was established. Once a sufficient quantity of oil has accumulated in the separator, turn the slot of the skimmer into the oil layer (The oil will then be decanted into an integral oil storage compartment or to a separate tank outside of the separator). Disposal of the oil must comply with regulations of the authority having jurisdiction.

7.0 QUALITY ASSURANCE

7.1 *INSPECTION*: Examine each component of the separator for compliance with requirements indicated in Section 2 - System Description & Requirements. This element of inspection shall encompass visual examination.

7.2 *PRETEST PROCEDURES*: After separator has been leveled, hydrostatically test unit for (4) hours by filling full with potable water, provided by customer, with means of getting it from the nearest source by the installer. Acceptance criteria for this test is no leakage after four (4) hours.

7.3 *TESTS*: - After hydrostatic test has been successfully completed and unit has been properly connected to influent and effluent piping, allow influent oil water mixture of 100 ppm, to flow into separator filled with potable water. After injection, operate unit for a minimum of ten tank volume changes prior to testing for contaminant removal.

7.4 *TEST FOR CONTAMINANTS*: The installer shall test the effluent to ensure that it meets oil concentration levels described in Section 2 - System Description & Requirements. Test shall be performed by an independent certified testing laboratory.

7.5 *ANALYTICAL METHODS:* Test and sample preservation methods for test contaminants shall be in accordance with the latest revision of EPA Methods for Chemical Analysis of Water and Wastes. Effluent oil concentration shall be measured by gravimetric, Separatory Funnel Extraction Method API 413.1.

8.0 MAINTENANCE

8.1 The separator should be checked periodically to determine if excessive amounts of solids and debris have accumulated. If this happens the solids may accumulate enough to plug the lower part of the HD Q-PAC plates. In this case, efficiency will be reduced and oil in the outlet water may exceed specified effluent limits.

8.2 After the first 6 months of operation, the inlet area should be inspected and cleaned as follows:

1. Stop the flow of influent to the separator.
2. Remove separator cover.
3. Dispose of separated oil per regulatory procedures.
4. Remove water from separator through drain or hose.

8.3 Measure and record the depth of the solids. Use this measurement as the timing basis for the next solids inspection and clean out. Consult OWS drawing for depth of sludge baffle. Solids should not exceed this depth.

8.4 The HD Q-PAC plates can be either cleaned in place or removed and cleaned .

1. For cleaning in place, connect a pressure water hose (1-15 psig) and insert in plate spacing on top of the plate packs. As the water flushes the dirt out of the plate packs it should be removed by the vacuum hose.

2. For removing plate packs outside of separator. Flush with garden hose (10-15 psig) over an area to prevent discharge of flushed water into groundwater. It is only necessary to remove all sludge from between the plates and any very heavy oil coating.

8.5 Examine tank interior for damage and repair any damage to internal coating.

8.6 To restart separator, reinstall HD Q-PAC plate packs and polishing pack in original position. Make sure that both are securely in place so that they do not float when unit is operational.

8.7 For start up, repeat steps in section 6 of these instructions.

9.0 TROUBLESHOOTING

Regularly monitor the quality of the effluent leaving the separator. If any loss in effluent quality is observed, steps should be taken to correct the problem immediately. Some things to check if effluent quality has deteriorated are:

1. Have you exceeded the separators rated flow? If so, return the flow rate to the design flow rate.

2. Have you allowed the sludge to accumulate to a point where it has started to affect the performance of the separator? If so, take steps to have the sludge removed immediately. If it cannot be pumped out, you will have to drain the separator and remove the accumulated sludge.

3. Check the influent for surfactants or chemical emulsifiers. If any are present, you may need additional treatment in order to meet discharge requirements.

4. Are you pumping into the separator? If so, you may be mechanically emulsifying the influent oil. Sample the oil water from both before and after the pump. There should be no differences between the two samples. If you are mechanically emulsifying the oil you may have to change your influent pump to a low RPM positive displacement pump or similar pump that will cut down on shearing.

5. Check to make sure that the oil depth in the separator is not too great, a deep layer of product will reduce the efficiency of the separator. Free product should be removed and the separator put back in service.

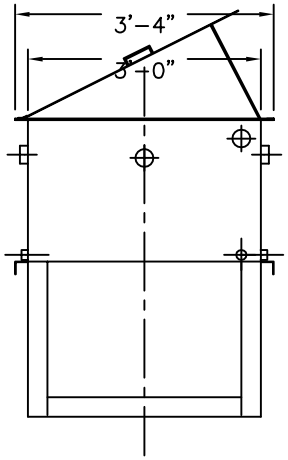
9.1 TROUBLESHOOTING GUIDELINE

PROBLEM	POSSIBLE CAUSE	DIAGNOSTIC TECHNIQUE	CORRECTIVE ACTION
EFFLUENT CONCENTRATION TOO HIGH	Oil Concentration too Great for Design	Sample Influent	Decrease the Flow Rate
	Flow Too Great For Design	Check Flow	Decrease the Flow Rate
	Plates Blocked	Inspect, Remove Plates if Necessary	Clean Per Par. 8.4 Instructions and Reinstall.
	Solids have Accumulated Into Coalescer Plates	Check Depth of Solids In Coalescer Compartment	Remove Solids From Compartment See Par. 8.3.
TANK IS OVERFLOWING	Output Line Restricted	Check Flow	Remove Restriction

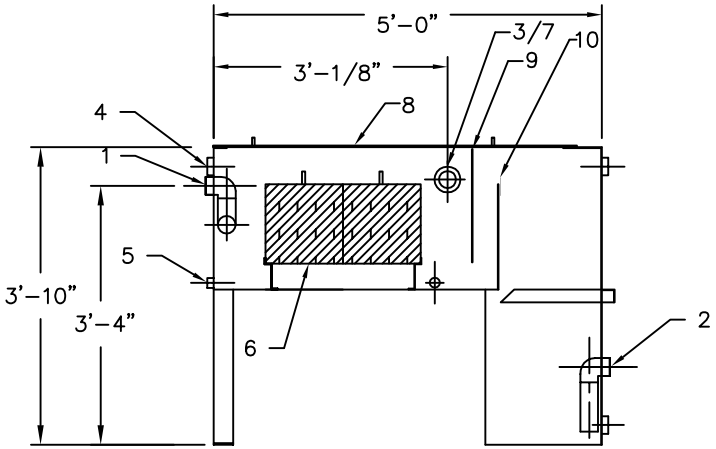
Note: For proper operation, outlet line should be as large as outlet nozzle unless unit is to be operated at very large flows.

ITEM	QTY	DESCRIPTION	ITEM	QTY	DESCRIPTION
1	1	2" FNPT INLET	8	1	HINGED COVER
2	1	2" FNPT OUTLET	9	1	OIL STOP WEIR
3	2	2" FNPT OIL OUTLET	10	1	ADJ. OVERFLOW WEIR
4	2	2" FNPT VENT	11	1	2" NPT DRAIN
5	3	1" FNPT DRAIN	12	0	OPT. SIGHT GLASS PORTS
6	1	COALESCING PLATES	13	0	OPTIONAL PRODUCT TANK
7	1	PVC OIL SKIMMER	14	1	2" NPT FLOAT SWITCH

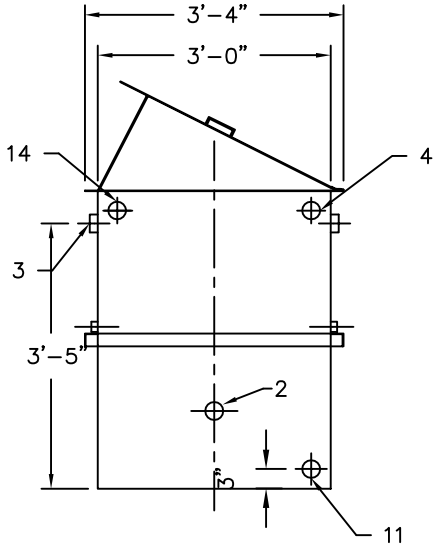
SHIPPING WEIGHT	450 LBS
OPERATING WEIGHT	2682 LBS
SEPARATOR VOLUME	279 GALLONS
EFFLUENT TANK VOLUME	90 GALLONS
SLUDGE VOLUME	6 GALLONS
COALESCING AREA	6 FT^3
OPT. PRODUCT TANK VOL	60 GALLONS



LEFT SIDE VIEW



ELEVATION



RIGHT SIDE VIEW

NOTES

1. MATERIAL: 12 GAUGE 304SS.
2. GASKET: NEOPRENE.
3. HARDWARE: 18-8 STAINLESS STEEL
4. INTERNAL PIPE SCH 80 PVC

REV.	DESCRIPTION	DATE	INIT.

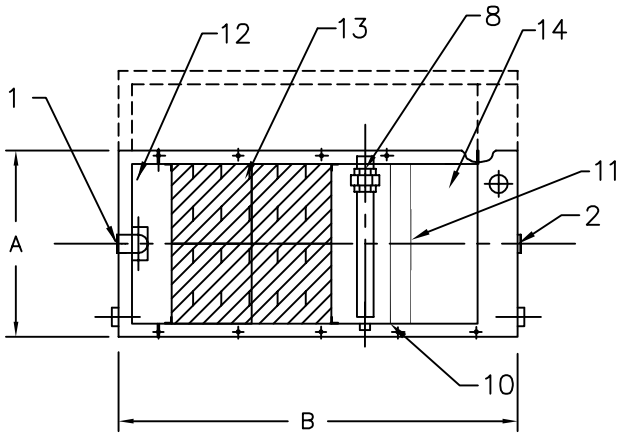
HYDRO QUIP. INC.

Water Treatment Systems

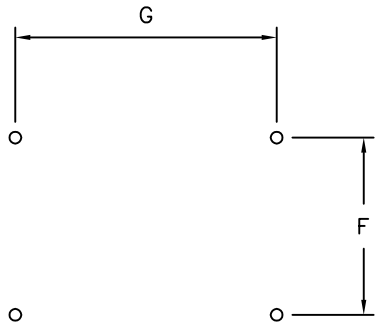
GENERAL ARRANGEMENT
MODEL AGM-3SS-90V HCR

DRN. BY: PND
CHKD.BY:
PROJECT:
DATE: 6/20/12
REF:
FILE: AGM-3SS-90V HCR
SCALE: 1/2" = 1'

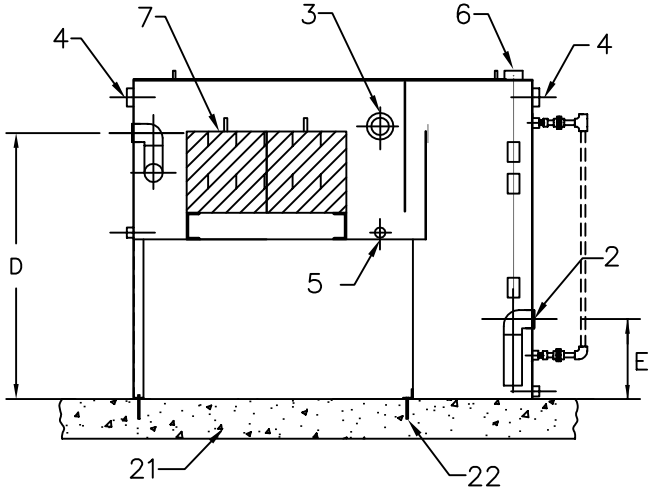
REV: 0



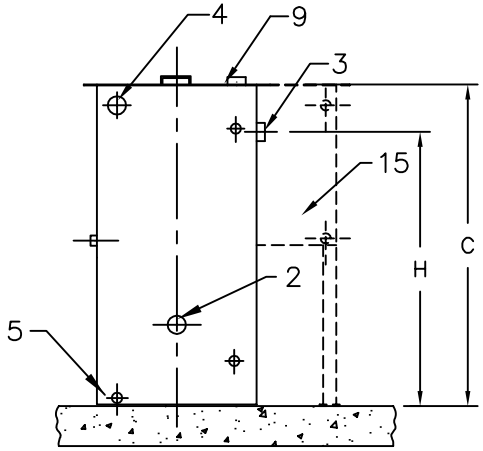
PLAN



ANCHOR BOLT LAYOUT



ELEVATION



RIGHT SIDE VIEW

ITEM	QTY	DESCRIPTION
1	1	INLET NOZZLE (SEE TABLE)
2	1	OUTLET NOZZLE (SEE NOZZLE)
3	1	OIL OUTLET 2" NPT
4	2	VENT 2" NPT
5	3	DRAIN 1" NPT
6	1	LEVEL SENSOR PORT 2" NPT
7	A/R	PARALLEL PLATE MEDIA
8	1	OIL SKIMMER
9	A/R	VAPOR TIGHT COVER
10	1	OIL STOP WEIR
11	1	OVERFLOW WEIR
12	1	SEDIMENT CHAMBER
13	1	SEPARATOR CHAMBER
14	1	CLEAN WATER CHAMBER
ITEM	QTY	OPTIONAL EQUIPMENT
15	1	OIL RESERVOIR (SEE TABLE)
16	1	LEVEL CONTROLS NEMA ENG
17	A/R	IMMERSION HEATERS
18	A/R	POLISHING MEDIA
19	A/R	INFLUENT & EFFLUENT PUMPS
20	1	OIL PUMPS
ITEM	QTY	CUSTOMER SUPPLIED EQUIPMENT
21	1	CONCRETE PAD
22	A/R	ANCHOR BOLTS
23	A/R	EXTERNAL PIPING

NOTES

MATERIAL:
304SS (SS)
CARBON STEEL (CS)
INTERIOR TNENEC SERIES 61 LINER TO 9 MILS.
EXTERIOR POLYAMIDE EPOXY 6 MDFT.

COVER GASKET: NEOPRENE
GASKET: NEOPRENE.
HARDWARE: 18-8 STAINLESS STEEL
SKIMMER SCHEDULE 80 PIPE
CONNECTION ARE NPT FITTINGS
ANCHOR BOLT TO BE 3/8" DIA. MIN. WITH 4" INBEDMENT & 2" PROJECTION

MODEL AGM	INLET OUTLET DIA.	METAL THK.	A WIDTH	B LENGTH	C HEIGHT	D INLET HEIGHT	E OUTLET HEIGHT	F ANCHOR DIM.	G ANCHOR DIM.	H OIL OUTLET HEIGHT	OPTION OIL RES. (GAL.)	CAPACITY (GAL.)	CLEAN WATER CHAMBER CAPACITY	SHIP WEIGHT (LBS)	OPER. WEIGHT (LBS)
1SS-30V	2"	12	16"	60"	46"	40"	12"	8"	38.5"	41"	60	105	30	245	1085
2SS-60V	2"	12	28"	60"	46"	40"	12"	18"	38.5"	41"	60	210	60	325	2005
3SS-90V	2"	12	40"	60"	46"	40"	12"	30"	38.5"	41"	60	279	90	450	2682
1SS-36V-1H	2"	12	16"	60"	58"	52"	12"	8"	38.5"	53"	90	142	36	273	1409
2SS-90V-1H	2"	12	28"	60"	58"	52"	12"	18"	38.5"	53"	90	217	90	367	2103
3SS-150V-1H	2"	12	40"	60"	58"	52"	12"	30"	38.5"	53"	90	325	150	510	3110

REV.	DESCRIPTION	DATE	INIT.

HYDRO QUIP. INC.

Water Treatment Systems

OIL/WATER SEPARATOR MODEL AGM-SS-V

DRN. BY: PMD

CHKD.BY:

PROJECT:

DATE: 01/20/08

REF:

FILE: AGMSV

SCALE: NONE

REV: 0

Water Treatment Equipment

LIMITED WARRANTY

Products manufactured by Hydro Quip are warranted to the original purchaser only to be free of defects in material and workmanship. Should the equipment or any parts prove defective within sixty (60) months from the date of shipment, it will be replaced F.O.B. destination without charge, provided the part (or parts) is returned transportation charges prepaid.

No allowance will be made for labor, transportation, or other charges incurred in the replacement or repair of defective parts by the customer. This warranty does not apply when damage is caused by conditions such as sand or abrasive materials pumped with the fluids, lightning, improper voltage supply, careless handling, improper installation, stray electrical interference, or due to substances or factors that were unknown to Hydro Quip at the time of purchase. Buyer shall have no claim, and no product or part shall be deemed defective, by reason of failure to resist erosive or corrosive action, nor for problems resulting from buildup of material within the equipment.

This warranty applies only to seller's equipment, under use and service in accordance with the seller's written instructions, recommendations and ratings for installation, operating and maintenance, and service. All claims for defective products, parts, or work under this warranty must be made in writing immediately upon discovery and, in any event, within five years.

Products which are sold but not manufactured by Hydro Quip will be covered under the original manufacturer's warranty and not by this warranty. In the event there is a need for repair or replacement of an item produced by another equipment manufacturer, then the warranty guidelines of that manufacturer must be followed.

HYDRO QUIP WILL NOT BE LIABLE FOR ANY INICIDENTAL OR CONSEQUENTIAL DAMAGES, LOSSES, OR EXPENSES ARISING FROM INSTALLATION, USE, OR ANY OTHER CAUSES. THERE ARE NO EXPRESSED OR IMPLIED WARRANTIES, INCLUDING MARCHANTIBILITY OR FITNESS FOR A PARTICULAR PURPOSE, WHICH EXTEND BEYOND THOSE WARRANTIES DESCRIBED OR REFERRED TO ABOVE.

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SOLBERG

Filter Silencers and Inlet Filters Maintenance Manual

www.solbergmfg.com

Note: Please read the maintenance instructions given by the OEM for the machinery first. The OEM's manual should be adhered to in order to protect the equipment. Solberg Manufacturing, Inc has made every effort to make sure that these instructions are accurate but is not responsible for any typos, slight variations or for human errors that may occur.

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Maintenance Manual

Solberg Air Inlet Filters and Filter Silencers

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**For Further Information Please Call: 630-773-1363*

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SOLBERG

Section A

INTRODUCTION

The purpose of this manual is instruction on the proper assembly and care of Solberg inlet air filters.

WARNING

This manual must be read and thoroughly understood before using and caring for this air filter. Failure to comply could result in explosion, product/system contamination or personal injury.

This manual should be used as a supplement to the user's understanding of the proper care needed to maintain a safe and dependable air filter. It is the responsibility of the user to interpret and explain all instructions to persons who do not read or understand English BEFORE they are allowed to maintain and use this filter.

This manual should be readily available to all operators responsible for operation and maintenance of the inlet air filters.

We thank you for selecting products from Solberg Manufacturing, Inc. We are confident that our superior filter designs will meet your application requirements.

Section B

GENERAL INFORMATION

1. Identification of Solberg Inlet Air Filters.

All Solberg inlet air filters should have an identification label/nameplate that gives the following information:

Assembly Model #
Replacement Element #

(The exception is OEM supplied units. In this case, please enter the OEM part numbers below.)
Fill in the actual nameplate data from your new Solberg inlet filter(s):

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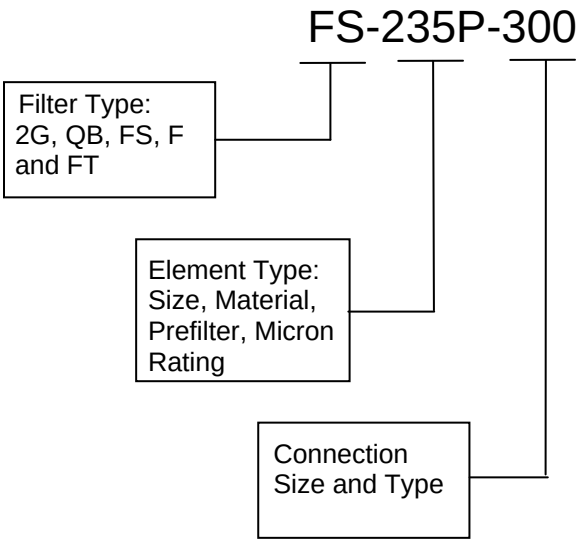
No.	Filter Model Number	Replacement Element	Initial Delta P Readings
1			
2			
3			
4			
5			

Table 1

The model number designates the filter type, the original element configuration and housing connection size. For example, the following part number identifies the filter as being a 'FS' design filter with a 235 element with prefilter and 3" MPT connection size:



2. Filtration Rules of Thumb

General: For peak output performance from a compressor, blower, vacuum pump, engine, or any other machine that consumes air, one must have clean, unrestricted air. Proper filtration can help stabilize the working environment within rotating equipment even when the external conditions may be quite severe. A critical component in creating the right working conditions is filter sizing. With the properly sized filter, equipment will run smoothly over its entire expected operating life.

A major factor in filtration and filter sizing is air velocity through the filter media. Generally, the slower the velocity of air through a media the higher the filter efficiency and, conversely, the lower the pressure drop. Therefore, the primary

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goal in filter sizing is to optimize the velocity of air through the media (sometimes called face velocity).

Rule of Thumb #1: Always begin with the filter cartridge requirements when sizing a filter. Once the appropriate element has been selected then move on to the housing requirements.

Rule of Thumb #2: Always ask or specify a filter based on a micron rating ***with filtration efficiencies***. As an example, stating a requirement for a 1-micron filter is misleading because no efficiency rating has been specified. A 1-micron filter at 95% efficiency may be less efficient than a 5-micron filter at 99% efficiency. For proper air system performance in light and industrial duty environments, a filter with a minimum of 99% filtration efficiency at 5 microns is required.

Rule of Thumb #3: Size your filter correctly by understanding the impact air velocity through a media has on efficiency and pressure drop. Maintain the suggested Air-to-Media ratios listed below based on the external environment listings and Filtration efficiency needs.

Filtration Efficiency Requirements (99%+ efficiency)	**Environmental Conditions**	**Air to Media Ratio**	
Industrial Grade 2-micron **Paper**	Industrial Duty (clean, office/warehouse-like)	30 CFM/ft^2	(51m^3/h)/cm^2
	Severe Duty (workshop, factory-like)	15 CFM/ft^2	(25.5m^3/h)/cm^2
	Extreme Duty (Foundry, Construction-like)	10 CFM/ft^2	(17m^3/h)/cm^2
Industrial Grade 5-micron **Polyester**	Industrial Duty (clean, office/warehouse-like)	50 CFM/ft^2	(85m^3/h)/cm^2
	Severe Duty (workshop, factory-like)	40 CFM/ft^2	(68m^3/h)/cm^2
	Extreme Duty (Foundry, Construction-like)	25 CFM/ft^2	(42.5m^3/h)/cm^2
Industrial Grade 1-micron **Polyester**	Severe Duty (Foundry, Construction-like)	10 CFM/ft^2	(17m^3/h)/cm^2
Industrial Grade 0.3-micron **HEPA** Glass @ 99.97% Efficiency	Industrial Duty (Pre-filtered Applications)	10 CFM/ft^2	(17m^3/h)/cm^2
	Severe Duty (workshop, factory-like)	7 CFM/ft^2	(12m^3/h)/cm^2
	Extreme Duty (Foundry, Construction-like)	5 CFM/ft^2	(8.5m^3/h)/cm^2

Table 2

Rule of Thumb #4: Pressure drop is also caused by the dirt holding capacity of the element. As the element fills up with dirt, the pressure drop increases. It is

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important to document the pressure drop across a given filter when it is new and then clean or replace it when the pressure drop increases by 10” to 15” / 250-280mm H_2O over the original reading.

Rule of Thumb #5: The inlet connection greatly influences the overall pressure drop of the filter system. To minimize the restriction contributed by an inlet filter, a velocity of 6,000 ft/min (10200m^3/h) or less is suggested through the outlet pipe. The table below lists the suggested flows based on pipe size:

Pipe Size (inches)	Max Airflow		Pipe Size (inches)	Max Airflow		Pipe Size (inches)	Airflow	
1/4"	6 CFM	10m^3/h	1 ¼"	60 CFM	102m^3/h	6"	1,100 CFM	1870m^3/h
3/8"	8 CFM	14m^3/h	1 ½"	80 CFM	136m^3/h	8"	1,800 CFM	3060m^3/h
1/2"	10 CFM	17m^3/h	2"	135 CFM	230m^3/h	10"	3,300 CFM	5610m^3/h
3/4"	20 CFM	34m^3/h	2 ½"	195 CFM	332m^3/h	12"	4,700 CFM	7990m^3/h
1"	35 CFM	60m^3/h	3"	300 CFM	510m^3/h	14"	6,000 CFM	10200m^3/h
			4"	520 CFM	884m^3/h			
			5"	800 CFM	1360m^3/h			

Table 3 **Note: This information is for general use only. A qualified engineer must properly design each system.*

3. Element Specifications

Temperature Range: -15° to 220°F / -26° to 105°C
Filter Change-Out Differential: 10” to 15” / 250-380mm H_2O Over Initial Delta P

Media	Micron Rating
Standard Paper	99+% @ 2 micron
Standard Polyester	99+% @ 5 micron
“S” Series Wire Mesh	Epoxy Coated Wire Mesh
“Z” Series Polyester	99+% @ 1 micron
“HE” Series HEPA	99.97% @ 0.3 microns
“U” Series Polyester	99+% @ 25 micron
“W” Series Polyester	99+% @ 100 micron
“S2” Series	Stainless Steel Wire Mesh
“AC” & “ACP” Series	N/A
“Y” Series Polypropylene	99+% @ 5 micron

Table 4

Temperature Range: -15° to 385°F / -26° to 196°C
Filter Change-Out Differential**:** 10” to 15”/ 250-380mm H_2O Over Initial Delta P

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Media	Micron Rating
“MX” & “MXD” Series – Nomex Cloth	99+% @ 5 micron

Table 5

4. **Element Cleaning - Inlet Filtration**

Solberg elements should be cleaned or replaced, once the pressure drop reaches 15 to 20-inches water column (380 - 500mm WC) above the initial pressure drop of the installation.

The decision to clean the element rather than replace it is left to the discretion of the operator. Any damage which results from by-pass or additional pressure drop created by element cleaning is the sole responsibility of the operator.

WARNING

The overall performance of a filter element is altered once cleaned.

The initial pressure drop after cleaning will be greater than the original, clean pressure drop of the element.

After each subsequent cleaning, the initial pressure drop will continue to increase.

Under all circumstances, the initial pressure drop of the element needs to be maintained at less than 20-inches water column (500mm WC).

Cleaned elements that exceed 20-inches water column (500mm WC) at start-up should be replaced with new elements.

With many types of equipment, the maximum pressure drop allowed will be dictated by the ability of the equipment to perform to its rated capacity. Under all circumstances, the operator should avoid exceeding the manufacturer’s recommended maximum pressure drop for their specific equipment.

A. ***Polyester Element***: The polyester element may be washed in warm soapy water, vacuumed, gently blown out or replaced. The element

should be dry before reinstallation. The element should be replaced after a maximum of three cleanings.

B. ***Paper Element***: The paper element may be lightly blown with low pressure air. It is disposable and in most cases should be replaced with a new element.
C. ***Polyurethane Prefilter***: The prefilter may be washed as a sponge or replaced to give the element a longer service life.
D. ***Epoxy Coated Wire Mesh and Stainless Steel Wire Mesh Elements***: Cleaning instructions similar to polyester, except mild solvents may be used.
E. ***Activated Carbon Element***: Not cleanable
F. ***Polypropylene Element***: Cleaning instructions similar to polyester
G. ***Nomex Cloth Element***: Cleaning instructions similar to polyester

If you are not confident that the integrity of the element was maintained during cleaning, it is recommended that a new element be installed. Also, spare parts such as gaskets, wing nuts and washers can be supplied upon request.

Section C

PROCEDURES

1. Installation.

A. Maximum operating temperature for most Solberg inlet air filter products is 220°F / 105°C. Temperatures in excess of this could cause damage to elements, media and elastomers. High temperature products are available.

B. Direction of flow is typically from the outside of the element to the inside of the element. Most products have arrows indicating direction of flow on the inlet and outlet ports.

C. Ensure that pipe/flange connections are adequately sealed so the potential for leaks is reduced to a minimum.

2. Disconnecting canister top from canister base.

A. FS-04-06-10 *(or 05-07-11):* Twist top housing to open. Use care to support bottom housing while removing top housing. Fitting damage can occur if fitting is torqued in the wrong direction.

B. Small QB/FS/F/FT*:* Remove weather hood or top plate by loosening hex nut or wing nut and lifting off.

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C. Large 2Q/QB/FS/F/FT: Remove cover by loosening hex nut or wing nut and lifting off.

3. Removing element for service/maintenance.

A. Carefully remove retaining hex head/wing-nut and washer over top plate, and then remove element. Note: Model “04-06-10” elements should be free when housing tops are removed.

B. Clean sealing surfaces of housing, top plates and element endcaps so that they are free of dirt or any other particulate.

WARNING

Failure to comply with these instructions may result in system or equipment contamination.

4. Securing Element.

A. Place new or cleaned element evenly on base plate. Be sure element seats properly on base and there is no dirt or particulate present on sealing surfaces. With multiple element stacks place elements in line with base element and ensure elements seat properly.

B. Place top plate (if necessary) on element by centering on tap bolt.

C. Secure washer and wing nut to end cap (or top plate) and tap bolt. Element must be tightly secured. Note: Do NOT over tighten!

WARNING

Defective installation may cause system or pump contamination. Use only genuine Solberg replacement parts.

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5. **Securing canister top to canister base.**

   A. Make sure all surfaces are free from dust and other particulate.

   B. Small QB/FS/F/FT: Replace top plate and/or weather hood if necessary. Feed threaded rod into corresponding bolthole and tighten. Note: Do NOT over tighten!

   C. Large 2G/QB/FS/F/FT: Replace cover. Feed threaded rod into corresponding bolt hole(s) and tighten. Note: Do NOT over tighten!

   D. FS-04-06-10 (or 05-07-11): Reassemble top housing to bottom housing by aligning tabs and turning into place.

6. **Equipment Startup.**

   A. Be sure to read the instructions on installation or element replacement as listed above before starting equipment.

WARNING

If at any time the operator is unable to verify the integrity of the element or any housing feature, the factory or a regional representative should be contacted prior to start-up.

   B. Please check the listed steps prior to startup.

      1. Check element to make sure it is seated properly on element base or sealing surface.

WARNING

Failure to seat the element properly may result in contaminant by-pass resulting in damage to equipment.

      2. Check element top plate or cover to make sure it is seated properly on element.

      3. Check housing cover (if applicable) that it is installed correctly onto housing.

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4. Be sure all fasteners and hardware (if applicable) have been tightened.

WARNING

If the air flow is reversed through a Solberg filter unit, be sure to check the element and housing internals for damage. Failure to do so may result in damage to equipment.

Section D

MAINTENANCE RECOMMENDATIONS

1. Pressure drop readings are recommended to have an effective air filter. Always document initial pressure drop during start-up when element is clean. Replacement cartridge is needed when system experiences 10" to 15" / 250-380mm H^2O above drop above the initial reading. Refer to page 4 for initial values.

2. Always check replacement cartridge gaskets to insure they are adhered uniformly along the end caps during handling. If not, contact Solberg Manufacturing, Inc. immediately. Do not modify or change!

3. Always check inlets/outlets, element base and its components when replacing element to insure cleanliness. Wipe clean if necessary.

4. Operate only when a proper seal exists.

SPARE PARTS LIST:

Contact your Solberg Representative for spare part model numbers.

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SOLBERG

Inlet Vacuum Filters
Maintenance Manual

www.solbergmfg.com

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Note: Please read the maintenance instructions given by the OEM for the machinery first. The OEM's manual should be adhered to in order to protect the equipment. Solberg Manufacturing, Inc has made every effort to make sure that these instructions are accurate but is not responsible for any typos, slight variations or for human errors that may occur.

Maintenance Manual

SOLBERG Inlet Vacuum Filters

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Rev: MMVF-910

Section A

INTRODUCTION

The purpose of this manual is instruction on the proper assembly and care of Solberg inlet vacuum filters.

WARNING

This manual must be read and thoroughly understood before using and caring for this air filter. Failure to comply could result in explosion, product/system contamination or personal injury.

This manual should be used as a supplement to the user's understanding of the proper care needed to maintain a safe and dependable air filter. It is the responsibility of the user to interpret and explain all instructions to persons who do not read or understand English BEFORE they are allowed to maintain and use this filter.

This manual should be readily available to all operators responsible for operation and maintenance of the vacuum inlet filters.

We thank you for selecting products from Solberg Manufacturing, Inc. We are confident that our superior filter designs will exceed your application requirements.

Section B

GENERAL INFORMATION

1. Identification of Solberg Vacuum Inlet Filters.

All Solberg inlet vacuum air filters should have an identification label/nameplate that gives the following information:

Assembly Model #
Replacement Element #

(The exception is OEM supplied units. In this case please enter the OEM part numbers below.)

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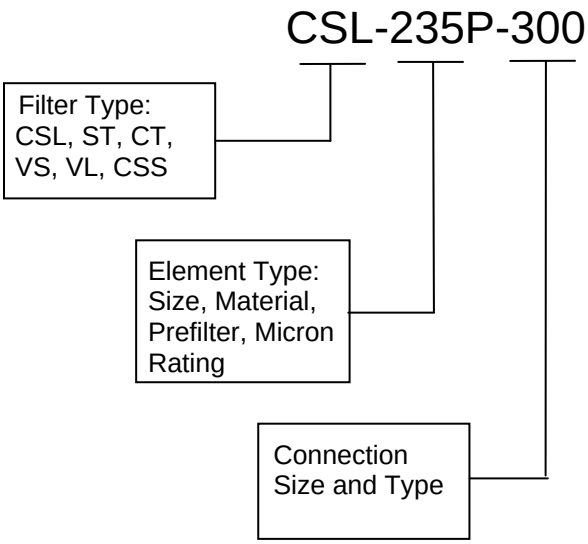
Fill in the actual nameplate data from your new Solberg inlet filter(s):

No.	Filter Model Number	Replacement Element
1		
2		
3		
4		
5		

Table 1

The model number designates the filter type, the original element configuration and housing connection size. For example, the following part number identifies the filter as being a 'CSL' design filter with a 235 element with prefilter and 3" MPT connection size:



2. Filtration Rules of Thumb

General: For peak output performance from a compressor, blower, vacuum pump, engine, or any other machine that consumes air, one must have clean, unrestricted air. Proper filtration can help stabilize the working environment within rotating equipment even when the external conditions may be quite severe. A critical component in creating the right working conditions is filter sizing. With the properly sized filter, equipment will run smoothly over its entire expected operating life.

A major factor in filtration and filter sizing is air velocity through the filter media. Generally, the slower the velocity of air through a media the higher the filter efficiency and, conversely, the lower the pressure drop. Therefore, the primary

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goal in filter sizing is to optimize the velocity of air through the media (sometimes called face velocity).

Rule of Thumb #1: Always begin with the filter cartridge requirements when sizing a filter. Once the appropriate element has been selected then move on to the housing requirements.

Rule of Thumb #2: Always ask or specify a filter based on a micron rating **with** filtration efficiencies. As an example, stating a requirement for a 1-micron filter is misleading because no efficiency rating has been specified. A 1-micron filter at 95-% efficiency may be less efficient than a 5-micron filter at 99% efficiency. For proper air system performance in light and industrial duty environments, a filter with a minimum of 99% filtration efficiency at 5 microns is required.

Rule of Thumb #3: Size your filter correctly by understanding the impact air velocity through a media has on efficiency and pressure drop. Maintain the suggested Air-to-Media ratios listed below based on the external environment listings and Filtration efficiency needs.

Filtration Efficiency Requirements (99+% efficiency)	**Environmental Conditions**	**Air to Media Ratio**	
Industrial Grade 2-micron **Paper**	Industrial Duty (clean, office/warehouse-like)	30 CFM/ft^2	$(51m^3/h)/cm^2$
	Severe Duty (workshop, factory-like)	15 CFM/ft^2	$(25.5m^3/h)/cm^2$
	Extreme Duty (Foundry, Construction-like)	10 CFM/ft^2	$(17m^3/h)/cm^2$
Industrial Grade 5-micron **Polyester**	Industrial Duty (clean, office/warehouse-like)	50 CFM/ft^2	$(85m^3/h)/cm^2$
	Severe Duty (workshop, factory-like)	40 CFM/ft^2	$(68m^3/h)/cm^2$
	Extreme Duty (Foundry, Construction-like)	25 CFM/ft^2	$(42.5m^3/h)/cm^2$
Industrial Grade 1-micron **Polyester**	Severe Duty (Foundry, Construction-like)	10 CFM/ft^2	$(17m^3/h)/cm^2$
Industrial Grade 0.3-micron **HEPA** Glass @ 99.97% efficiency	Industrial Duty (clean office/warehouse-like)	10 CFM/ft^2	$(17m^3/h)/cm^2$
	Severe Duty (workshop, factory-like)	7 CFM/ft^2	$(12m^3/h)/cm^2$
	Extreme Duty (Foundry, Construction-like)	5 CFM/ft^2	$(8.5m^3/h)/cm^2$

Table 2

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Rule of Thumb #4: Pressure drop is also caused by the dirt holding capacity of the element. As the element fills up with dirt, the pressure drop increases. It is important to document the pressure drop across a given filter when it is new and then clean or replace it when the pressure drop increases by 10" to 15" / 250-380mm H_2O from the original reading.

Rule of Thumb #5: The inlet connection greatly influences the overall pressure drop of the filter system. To minimize the restriction contributed by an inlet filter, a velocity of 6,000 ft/min (10200m^3/h) or less is suggested through the outlet pipe. The table below lists the suggested flows based on pipe size:

Pipe Size (inches)	Max Airflow		Pipe Size (inches)	Max Airflow		Pipe Size (inches)	Airflow	
1/4"	6 CFM	10m^3/h	1 ¼"	60 CFM	102m^3/h	6"	1,100 CFM	1870m^3/h
3/8"	8 CFM	14m^3/h	1 ½"	80 CFM	136m^3/h	8"	1,800 CFM	3060m^3/h
1/2"	10 CFM	17m^3/h	2"	135 CFM	230m^3/h	10"	3,300 CFM	5610m^3/h
3/4"	20 CFM	34m^3/h	2 ½"	195 CFM	332m^3/h	12"	4,700 CFM	7990m^3/h
1"	35 CFM	60m^3/h	3"	300 CFM	510m^3/h	14"	6,000 CFM	10200m^3/h
			4"	520 CFM	884m^3/h			
			5"	800 CFM	1360m^3/h			

Table 3 **Note: This information is for general use only. A qualified engineer must properly design each system.*

3. Element Specifications

Temperature Range: -15° to 220°F / -26° to 105°C
Filter Change-Out Differential: 10" to 15" / 250-380mm H_2O Over Initial Delta P

Media	Micron Rating
Standard Paper	99+% @ 2 micron
Standard Polyester	99+% @ 5 micron
"S" Series Wire Mesh	Epoxy Coated Wire Mesh
"Z" Series Polyester	99+% @ 1 micron
"HE" Series HEPA	99.97% @ 0.3 microns
"U" Series Polyester	99+% @ 25 micron
"W" Series Polyester	99+% @ 100 micron
"S2" Series	Stainless Steel Wire Mesh
"AC" & "ACP" Series	N/A
"Y" Series Polypropylene	99+% @ 5 micron

Table 4

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Temperature Range: -15° to 385°F / -26° to 196°C
Filter Change-Out Differential: 10” to 15” / 250-380mm H_2O Over Initial Delta P

Media	Micron Rating
“MX” & “MXD” Series – Nomex Cloth	99+% @ 5 micron

Table 5

4. **Element Cleaning - Inlet Filtration**

Solberg elements should be cleaned or replaced, once the pressure drop reaches 15 to 20-inches water column (380 - 500mm WC) above the initial pressure drop of the installation.

The decision to clean the element rather than replace it is left to the discretion of the operator. Any damage which results from by-pass or additional pressure drop created by element cleaning is the sole responsibility of the operator.

WARNING

The overall performance of a filter element is altered once cleaned.

The initial pressure drop after cleaning will be greater than the original, clean pressure drop of the element.

After each subsequent cleaning, the initial pressure drop will continue to increase.

Under all circumstances, the initial pressure drop of the element needs to be maintained at less than 20-inches water column (500mm WC).

Cleaned elements that exceed 20-inches water column (500mm WC) at start-up should be replaced with new elements.

With many types of equipment, the maximum pressure drop allowed will be dictated by the ability of the equipment to perform to its rated capacity. Under all

circumstances, the operator should avoid exceeding the manufacturer's recommended maximum pressure drop for their specific equipment.

A. ***Polyester Element***: The polyester element may be washed in warm soapy water, vacuumed, gently blown out or replaced. The element should be dry before reinstallation. The element should be replaced after a maximum of three cleanings.
B. ***Paper Element***: The paper element may be lightly blown with low pressure air. It is disposable and in most cases should be replaced with a new element.
C. ***Polyurethane Prefilter***: The prefilter may be washed as a sponge or replaced to give the element a longer service life.
D. ***Epoxy Coated Wire Mesh and Stainless Steel Wire Mesh Elements***: Cleaning instructions similar to polyester, except mild solvents may be used.
E. ***Activated Carbon Element***: Not cleanable
F. ***Polypropylene Element***: Cleaning instructions similar to polyester
G. ***Nomex Cloth Element***: Cleaning instructions similar to polyester

If you are not confident that the integrity of the element was maintained during cleaning, it is recommended that a new element be installed. Also, spare parts such as gaskets, wing nuts and washers can be supplied upon request.

Section C

PROCEDURES

1. Installation.

A. Maximum inlet gas stream temperature for most Solberg inlet vacuum filter products is 220°F / 105°C. Temperatures in excess of this could cause damage to elements, media and elastomers.

B. Direction of flow is typically from the outside of the element to the inside of the element. Most products have arrows indicating direction of flow on inlet and outlet ports.

C. Ensure that pipe/flange connections are adequately sealed so the potential for leaks is reduced to a minimum.

2. Disconnecting canister top from canister base.

A. ST/CT/Small CSL: Release wire-form clips or loosen wing nut on "claw" bolts.

B. Large CSL: Loosen wing nut or hex head on T-bolts.

C. CSS: Twist upper housing to release.

D. VS/VL: Remove V-clamp by loosening Hex Nut or T-bolt and releasing.

E. Lift off canister top.

3. Removing element for service/maintenance.

A. Remove retaining hex head/wing-nut and washer carefully, and then remove element. Some elements will have a top plate that should also be removed.

B. Clean sealing surfaces of housing, top & base plates, and element endcaps so that they are free of dirt or any other particulate.

WARNING

Failure to comply with these instructions may result in system or pump contamination.

4. Securing Element.

A. Place new or cleaned element evenly on base plate. Be sure element seats properly on base and there is no dirt or particulate present on sealing surfaces.

B. Place top plate (if necessary) on element by centering on tap bolt.

C. Secure washer and wing nut to end cap (or top plate) and tap bolt. Element must be tightly secured. Note: DO NOT over tighten!

WARNING

Defective installation may cause system or pump contamination. Use only genuine Solberg replacement parts.

5. Securing canister top to canister base.

A. Make sure all surfaces are free from dust and other particulate.

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B. Hemisphere o-ring must rest evenly along canister/casting base o-ring groove.

C. ST/CT/Small CSL: Hold canister housing against o-ring or sealing ring on main filter head. Re-fasten wire-form clips or “claw” bolts.

D. Large CSL: Replace housing top plate. Feed T-bolts into corresponding slots and tighten evenly around perimeter. Note: Do NOT over tighten!

E. VS/VL: Secure V-clamp by disconnecting hex nut or T-bolt portion and placing V-clamp along the diameter of canister o-ring groove. Fasten T-bolt and secure tightly. V-CLAMP LEGS MUST REST UNIFORMLY ALONG ENTIRE O-RING GROOVE.

F. CSS: Reassemble top housing to bottom housing by aligning tabs and turning into place.

Section D

MAINTENANCE RECOMMENDATIONS

1. Pressure drop readings are recommended to have an effective air filter. Always document initial pressure drop during start-up when element is clean. Replacement cartridge is needed when system experiences 10” to 15” / 250-380mm H_2O higher pressure drop above the initial reading. Refer to page 4 for instructions.

2. Always check replacement cartridge gaskets to insure they are adhered uniformly along the end caps during handling. If not, contact Solberg Manufacturing, Inc. immediately. Do not modify or change from Solberg specified parts!

3. Always check inlets/outlets, element base and its components when replacing element to insure cleanliness. Wipe clean if necessary.

4. Operate only when a proper seal exists.

5. VS/VL: Never operate without absolute assurance that V-clamp is secured correctly along entire diameter of canisters. Check along V-clamp for wear. Replace if any distortion occurs due to handling and usage.

SPARE PARTS

Contact your Solberg Representative for spare part model numbers.

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Rev: MMVF-910

SOLBERG

®

Replacement Filter Elements Maintenance Manual

www.solbergmfg.com

Note: Please read the maintenance instructions given by the OEM for the machinery first. The OEM's manual should be adhered to in order to protect the equipment. Solberg Manufacturing, Inc has made every effort to make sure that these instructions are accurate but is not responsible for any typos, slight variations or for human errors that may occur.

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1. Filtration Rules of Thumb

General: For peak output performance from a compressor, blower, vacuum pump, engine, or any other machine that consumes air, one must have clean, unrestricted air. Proper filtration can help stabilize the working environment within rotating equipment even when the external conditions may be quite severe. A critical component in creating the right working conditions is filter sizing. With the properly sized filter, equipment will run smoothly over its entire expected operating life.

A major factor in filtration and filter sizing is air velocity through the filter media. Generally, the slower the velocity of air through a media the higher the filter efficiency and, conversely, the lower the pressure drop. Therefore, the primary goal in filter sizing is to optimize the velocity of air through the media (sometimes called face velocity).

Rule of Thumb #1: Always begin with the filter cartridge requirements when sizing a filter. Once the appropriate element has been selected then move on to the housing requirements.

Rule of Thumb #2: Always ask or specify a filter based on a micron rating **with** filtration efficiencies. As an example, stating a requirement for a 1-micron filter is misleading because no efficiency rating has been specified. A 1-micron filter at 95-% efficiency may be less efficient than a 5-micron filter at 99% efficiency. For proper air system performance in light and industrial duty environments, a filter with a minimum of 99% filtration efficiency at 5 microns is required.

Rule of Thumb #3: Size your filter correctly by understanding the impact air velocity through a media has on efficiency and pressure drop. Maintain the suggested Air-to-Media ratios listed below based on the external environment listings and Filtration efficiency needs.

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Filtration Efficiency Requirements (99+% efficiency)	Environmental Conditions	Air to Media Ratio	
Industrial Grade 2-micron **Paper**	Industrial Duty (clean, office/warehouse-like)	30 CFM/ft^2	(51m^3/h)/cm^2
	Severe Duty (workshop, factory-like)	15 CFM/ft^2	(25.5m^3/h)/cm^2
	Extreme Duty (Foundry, Construction-like)	10 CFM/ft^2	(17m^3/h)/cm^2
Industrial Grade 5-micron **Polyester**	Industrial Duty (clean, office/warehouse-like)	50 CFM/ft^2	(85m^3/h)/cm^2
	Severe Duty (workshop, factory-like)	40 CFM/ft^2	(68m^3/h)/cm^2
	Extreme Duty (Foundry, Construction-like)	25 CFM/ft^2	(42.5m^3/h)/cm^2
Industrial Grade 1-micron **Polyester**	Severe Duty (Foundry, Construction-like)	10 CFM/ft^2	(17m^3/h)/cm^2
Industrial Grade 0.3-micron **HEPA** Glass @ 99.97% efficiency	Industrial Duty (clean office/warehouse-like)	10 CFM/ft^2	(17m^3/h)/cm^2
	Severe Duty (workshop, factory-like)	7 CFM/ft^2	(12m^3/h)/cm^2
	Extreme Duty (Foundry, Construction-like)	5 CFM/ft^2	(8.5m^3/h)/cm^2

Table 2

Rule of Thumb #4: Pressure drop is also caused by the dirt holding capacity of the element. As the element fills up with dirt, the pressure drop increases. It is important to document the pressure drop across a given filter when it is new and then clean or replace it when the pressure drop increases by 10” to 15” / 250-380mm H_2O from the original reading.

Rule of Thumb #5: The inlet connection greatly influences the overall pressure drop of the filter system. To minimize the restriction contributed by an inlet filter, a velocity of 6,000 ft/min (10200m^3/h) or less is suggested through the outlet pipe. The table below lists the suggested flows based on pipe size:

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Pipe Size (inches)	Max Airflow		Pipe Size (inches)	Max Airflow		Pipe Size (inches)	Airflow	
1/4"	6 CFM	10m^3/h	1 ¼"	60 CFM	102m^3/h	6"	1,100 CFM	1870m^3/h
3/8"	8 CFM	14m^3/h	1 ½"	80 CFM	136m^3/h	8"	1,800 CFM	3060m^3/h
1/2"	10 CFM	17m^3/h	2"	135 CFM	230m^3/h	10"	3,300 CFM	5610m^3/h
3/4"	20 CFM	34m^3/h	2 ½"	195 CFM	332m^3/h	12"	4,700 CFM	7990m^3/h
1"	35 CFM	60m^3/h	3"	300 CFM	510m^3/h	14"	6,000 CFM	10200m^3/h
			4"	520 CFM	884m^3/h			
			5"	800 CFM	1360m^3/h			

Table 3 **Note: This information is for general use only. A qualified engineer must properly design each system.*

Element Specifications

Temperature Range: -15° to 220°F / -26° to 105°C
Filter Change-Out Differential: 10" to 15" / 250-380mm H_2O Over Initial Delta P

Media	Micron Rating
Standard Paper	99+% @ 2 micron
Standard Polyester	99+% @ 5 micron
"S" Series Wire Mesh	Epoxy Coated Wire Mesh
"Z" Series Polyester	99+% @ 1 micron
"HE" Series HEPA	99.97% @ 0.3 microns
"U" Series Polyester	99+% @ 25 micron
"W" Series Polyester	99+% @ 100 micron
"S2" Series	Stainless Steel Wire Mesh
"AC" & "ACP" Series	N/A
"Y" Series Polypropylene	99+% @ 5 micron

Table 4

Temperature Range: -15° to 385°F / -26° to 196°C
Filter Change-Out Differential: 10" to 15" / 250-380mm H_2O Over Initial Delta P

Media	Micron Rating
"MX" & "MXD" Series – Nomex Cloth	99+% @ 5 micron

Table 5

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Element Cleaning

Some types of Solberg inlet filter elements can be cleaned and reused. However, damage can occur to an element during cleaning so it is imperative that care is taken during disassembly, cleaning and re-assembly. Damaged elements can allow particulate bypass, which will damage rotating equipment.

A. ***Polyester Element***: The polyester element may be washed in warm soapy water, vacuumed, gently blown out or replaced. The element should be dry before reinstallation.
B. ***Paper Element***: The paper element may be lightly blown with low pressure air. It is disposable and in most cases should be replaced with a new element.
C. ***Polyurethane Prefilter***: The prefilter may be washed as a sponge or replaced to give the element a longer service life.
D. ***Epoxy Coated Wire Mesh and Stainless Steel Wire Mesh Elements***: Cleaning instructions similar to polyester, except mild solvents may be used.
E. ***Activated Carbon Element***: Not cleanable
F. ***Polypropylene Element***: Cleaning instructions similar to polyester
G. ***Nomex Cloth Element***: Cleaning instructions similar to polyester

If you are not confident that the integrity of the element was maintained during cleaning, it is recommended that a new element be installed. Also, spare parts such as gaskets, wingnuts and washers can be supplied upon request.

Removing element for service/maintenance.

A. Remove retaining hex head/wing-nut and washer carefully, and then remove element. Some elements will have a top plate that should also be removed.

B. Clean sealing surfaces of housing, top & base plates, and element endcaps so that they are free of dirt or any other particulate.

WARNING

Failure to comply with these instructions may result in system or pump contamination.

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Securing Element.

A. Place new or cleaned element evenly on base plate. Be sure element seats properly on base and there is no dirt or particulate present on sealing surfaces.

B. Place top plate (if necessary) on element by centering on tap bolt.

C. Secure washer and wing nut to end cap (or top plate) and tap bolt. Element must be tightly secured. Note: DO NOT over tighten!

WARNING

Defective installation may cause system or pump contamination. Use only genuine Solberg replacement parts.

MAINTENANCE RECOMMENDATIONS

1. Pressure drop readings are recommended to have an effective air filter. Always document initial pressure drop during start-up when element is clean. Replacement cartridge is needed when system experiences 10” to 15” / 250-380mm H_2O higher pressure drop above the initial reading. Refer to page 4 for instructions.

2. Always check replacement cartridge gaskets to insure they are adhered uniformly along the end caps during handling. If not, contact Solberg Manufacturing, Inc. immediately. Do not modify or change from Solberg specified parts!

3. Always check inlets/outlets, element base and its components when replacing element to insure cleanliness. Wipe clean if necessary.

4. Operate only when a proper seal exists.

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Custom Service & Design, Inc.

P.O. Box 214923
Auburn Hills, MI 48321
Phone: 248.340.9005
Fax: 248.340.9002

INSTALLATION, OPERATION AND MAINTENANCE MANUAL

SINGLE BAG VESSEL

CSD MODELS 04, 06, 07, 08, L08

REPLACEMENT PARTS AVAILABLE

CALL CSD FOR SPECIFIC SPARE PARTS LIST

IMPORTANT!!

READ & UNDERSTAND ENTIRE MANUAL BEFORE OPERATING THIS VESSEL. THIS DOCUMENT SERVES AS AN OVERVIEW FOR WORKING WITH A CSD VESSEL.

ALL INDUSTRY SAFETY STANDARDS APPLY.

CSD FILTER VESSELS ARE DESIGNED TO BE USED SAFELY TO FILTER LIQUIDS UNDER PRESSURE IN ACCORDANCE WITH TEMPERATURE AND PRESSURE. RESTRICTIONS AS STAMPED ON THE NAME PLATE AFFIXED TO THE PRODUCT.

INSTALLATION

⇒ Remove all shipping and crating materials carefully.

⇒ Vessel can be lifted by means of a multi-legged sling chain with a safety hook attached to the end of each leg. Attach the hook of each leg to an eye nut and space legs around vessel equally.

⇒ Securely anchor the adjustable tripod stand to the floor or a base

⇒ Check the inter housing and pipe connections for foreign material and discard any items that have entered during shipping or unpacking

⇒ Piping material used should be the same as the base material of the vessel it should have a rating equal to or grater than the pressure and temperature rating of the vessel. Single bag models are capable of having several different piping variations based upon the outlet style of the unit. Plumb vessel with inlet / outlet pipe connections (NPT or Flanged).

⇒ After completing installation to be sure to double check connections for integrity. Your unit has been factory pressure tested leak free, therefore any seepage problems usually occur from improper installation connections.

⇒ NPT ports are provided for gauges, vents, pressure relieve valves, temperature and/or drains.

- ⇒ To install the filter basket and bag remove the cover by loosening the eye nuts (note: Eye nuts do not need to be fully removed from housing).
- ⇒ If your unit requires a basket seal, insert the basket seal into the basket collar groove.
- ⇒ Place the basket into the filter housing; make sure the basket flange is firmly seated into the basket collar.
- ⇒ Insert the bag into the bag basket making sure filter bag ring is firmly seated inside the basket flange. For best results, be sure the bag is installed fully extended to the bottom of the basket.

⇒ **It is the responsibility of the end-user to protect system components, such from being over pressurized. This can be achieved by installing a system relief valve.**

⇒ Filter inlet is above restrainer basket

INSTALLATION (CONT.)

⇒ Filter outlet is below the restrainer basket in vessel body or bottom

⇒ Shut off valves should be installed before & after vessel to allow element changes

⇒ Vessel bypass system may be desirable

⇒ CSD advises to pressurize system to check for any installation leaks

⇒ Make certain vessel is not bent or twisted when making piping connections in any way, leaks may occur.

General Rules:

Initial operating pressure with a clean filter bag installed in the vessel will remain constant until the filter is approximately 80% "blinded"

When the pressure differential increases by approximately 15 – 25 PSI, the filter bag should be changed. This figure can vary with the manufacturer of the filter bag. Actual pressure differential, pressure drops and frequency of filter bag changes can only be determined by experience in each individual application.

YOUR CSD HOUSING IS NOW READY FOR OPERATION

OPERATION

It is important that the directions below are followed when opening and closing a pressure bag filter.

⇒ IT IS CRITICAL TO RELIEVE PRESSURE BEFORE OPENING THE VESSEL. THIS CAN BE DONE BY OPENING EITHER THE VENT VALVE OR DRAIN VALVE.

The following instructions assume the drain valve is piped back to the holding tank.

TO START-UP

Before utilizing the vessel perform the following checks:

⇒ Ensure the filter basket and bag are in the housing and do not require cleaning or replacement.

OPERATION (CONT.)

Confirm the filter cover is securely fastened to housing. Slowly open the inlet service line 25% of the normal operation flow (so not to alter filter bag inside the housing. After filter unit is pressurized and vented, slowly open outlet service line unit valve until completely open. Complete opening of inlet service line until desired flow rate is reached.

TO CLEAN OR REPLACE FILTER MEDIA:

⇒ Close the flow from the inlet valve

⇒ Close the flow to the outlet valve

⇒ Relieve the pressure from the filter unit

⇒ Drain housing sufficiently to access filter basket

⇒ Loosen eye nuts to remove cover.

⇒ Remove filter basket and clean thoroughly, remove filter bag (if applicable) and throw away. (It is not recommended to reuse bag).

⇒ Remove debris and sludge from inside the inlet portion of housing as to not interference with cover seal or flow of fluid being filtered.

⇒ Remove basket seal and inspect, replace if necessary. Clean basket seal groove and replace basket seal.

⇒ Replace clean basket and install new filter bag. Place basket into the housing; ensure the basket flange is firmly seated in the basket collar. Insert bag into the bag basket making sure filter bag ring is firmly seated inside the basket flange. Fully extend the bag for optimum performance.

⇒ Inspect cover gasket integrity (cuts or general detioration)

⇒ Replace lid

NOTE: FOUR BOLT VESSELS: Position bolts & hand tighten rear bolts to vessel cover. Hand tighten the front bolts. Final torque should be done as above until cover is tight and evenly closed.

MAINTENANCE

MANUAL LIFTING DEVICE:

⇒ Keep threads clean and well lubricated with a lubricant acceptable for the customer's application.

⇒ Threads should be inspected periodically for wear and tear. Should the wear become excessive, parts should be replaced with authorized CSD parts.

⇒ Lubricate the support and swivel blocks of the davit arm.

GENERAL CARE

⇒ Gaskets are subject to wear and should be checked each time the filter lid is opened. Check for dirt, cuts abrasions or swelling. Replacements of the gaskets should be done prior to pressurization of the filter system. Be certain that the fluid to be filtered is chemically and thermally compatible with the filter vessel, o-ring and filter bag material. Fluid compatibility includes all materials in contact with the liquid under elevated temperature and pressure.

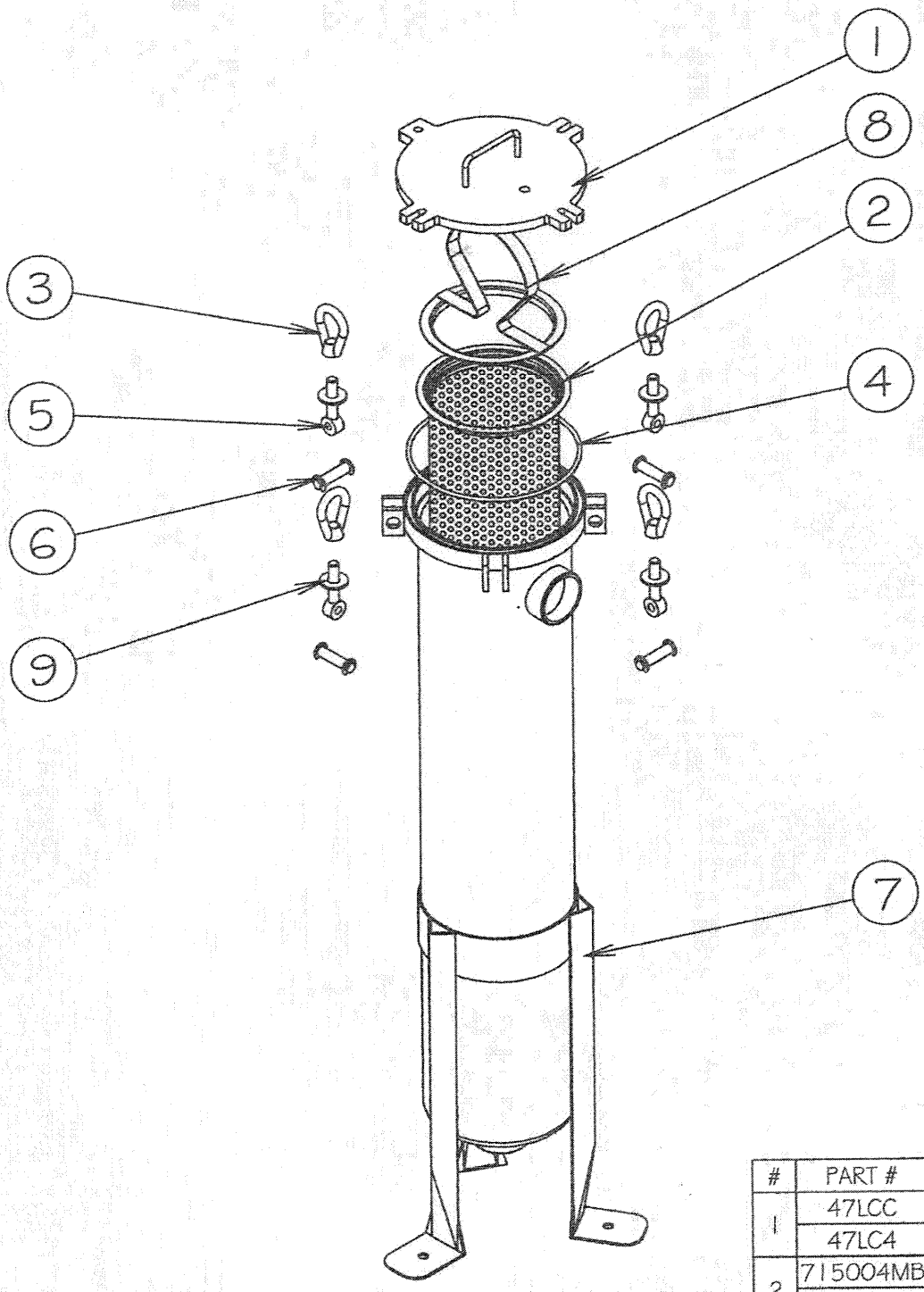
⇒ Keep vessel clean of excessive dirt that may impair the vessel, hindering optimum performance.

SAFETY

This manual has been prepared for the safe installation, operation and maintenance of Custom Service & Design, Inc. (CSD) pressure vessels. Note: Improper use of filter vessel may result in injury or property damage. Any misuse or modification of these products will void any warranties and/or responsibility of the manufacturer.

Warning: Before operating this vessel, operation should wear protective garments & eyewear. Before pressurizing a filter vessel, always make sure the connections and lid hardware are securely fastened. Always relieve the pressure to the filter system before loosening the hardware.

Note: A filter bag that has been used with a hazardous liquid may contain residual amounts of this material and should be handled with the same safeguards that would be used in handling any hazardous and/or toxic materials (i.e. gloves, respirators, protective eyewear, etc).



#	PART #	DESCRIPTION
1	47LCC	CARBON STEEL LID
	47LC4	304L STAINLESS STEEL LID
2	715004MB	15" S.S. BASKET
	730004MB	30" S.S. BASKET
3	4EN	EYE NUT
4	890*	GASKET
5	4RE	EYE BOLT
6	3CPA	CLEVIS PIN ASSY.
7	A7LGC	CARBON STEEL LEGS
	A7LG4	STAINLESS STEEL LEGS
8	A7054	OMEGA SPRING *OPTIONAL*
9	1/2 USS	FLAT WASHER

CSD

CUSTOM SERVICE & DESIGN INC.

PARTS LIST

CHK'D		PART NO. 007AI**4L	MATERIAL:	DESCRIPTION: 007A SIDE INLET SPARE PARTS LIST	TOLERANCE: FRAC ± 1/4, .000 ± .005, .0000 ± .000
DATE			DRN. TJT		
SCALE NTS			DATE 10/23/05		
NOTICE: SCALE ON "A" SIZE PLOTS ONLY					

Tetrasolv Filtration

Operation & Maintenance Manual

AFD • AF • HPP • HPAF SERIES

Tetrasolv Filtration Liquid Filters

Liquid & Vapor Filtration
Remedial • Industrial • Municipal

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1.0 GENERAL DESCRIPTION

The liquid series filters utilize fixed bed filtration to treat water. The filters employ a variety of medias to remove or catalyze contaminants. Flow through the filter may be either up flow or down flow depending upon the media supplied and the operation parameters. Generally inlet and outlet locations are indicated on the filter and or the filter drawings.

Product data sheets, drawings, MSDS, etc are available from www.tetrasolv.com or call the number below or email your request to support@tetrasolv.com.

2.0 SAFETY CONSIDERATIONS

It is important that the entire O&M manual be read prior to set up and operation of the carbon system.

- ***WARNING: We strongly recommend the use of a relief device in all installations. Exceeding the maximum pressure of the filter could result in catastrophic failure of the vessel.***

- Always adhere to "lockout/tagout" procedures when servicing the system.

- Wear appropriate safety equipment when operating system.

- Review the MSDS sheet for the installed media prior to working with the installed carbon.

- ***WARNING: Wet or dry activated carbon preferentially removes oxygen from air. In closed or partially closed containers, oxygen depletion may reach hazardous levels. If workers must enter a container containing carbon, appropriate sampling and work procedures should be followed for potentially low-oxygen spaces - including all applicable federal and state requirements.***

- Understand the potential hazards of the stream

being treated by the system. The media may contain higher concentrations of the contaminants being adsorbed than is in the influent stream. In addition the media may be considered hazardous material and therefore may require specific handling precautions unknown to Tetrasolv Filtration.

3.0 INSTALLATION

3.1 Shipment

Typically filters are shipped with media installed. However, in certain instances media is shipped to the site to be installed after installation. In very large systems it may be advisable to not install the media until adsorbers have been placed into final position and secured.

3.2 Unloading

Refer to the product data sheet for weight information for appropriate sizing information for the equipment to be used.

All components should be lifted either by crane or forklift as designated by the model.

- ***WARNING: Failure to follow the procedures outlined below can result in catastrophic damage to the system.***

Crane Lift - If a crane lift is to be used we recommend the following method. A "spreader" equaling 75% of the distance between the opposing lifting eyes on each adsorber should be used to insure proper lifting force direction. Attach an appropriately sized spreader beam and lifting cables to each lift eye of the component. The use of an experienced crane operator and quality equipment is highly recommended.

Fork-Lift - When using a forklift we recommend that the fork tubes on the filter be used or a pallet if the unit was shipped on a pallet.

- ***WARNING: Never attempt to pick up an adsorber which has wet carbon installed. The lifting eyes are designed only to lift the adsorber with dry carbon installed.***

3.3 Inspection

Perform the following inspections after un-loading the filter. Note any discrepancies and contact Tetrasolv Filtration immediately.

- Check the vessel exterior for damage which may have occurred during shipment. Inspect the support structures and piping support for damage.
- Inspect the piping system for damage. Insure the valves operate properly. Check installed instruments and instrument installation points for damage.
- Visually inspect the interior (if possible) of the vessel for loose laterals and or internal damage.
- Inspect the carbon discharge, drain and vent valves for damage.

3.4 Set Up

The filter should be placed on a level concrete pad of appropriate thickness to support the system at it's maximum operational weight. The filter should be secured to the pad using appropriately sized anchor bolts.

Connect the site piping to the filter inlet and outlet connection points. It is important that all piping connected to the filter should be self supported. We also recommend in hard pipe installation that a flexible joint be used to further insulate the filter from vibration and stress.

Connect any gauges and instrumentation shipped loose with the system.

The outlet piping should be designed to allow flooded operation of the Adsorber at all times to assure effective operation. If the outlet line does not provide for back pressure on the Adsorber unit, then the discharge piping should include an elevated piping loop to assure flooded operation.

Siphoning can occur when the discharge line allows suction to be placed on the process discharge. Siphoning can cause air pockets to occur in the adsorbers. If channeling is likely to occur we recommend the installation of an appropriately sized vacuum breaker.

If the supply pump is capable of producing pressure greater than the design limitation of the filter it is recommended that a rupture disk or pressure relief valve be installed prior to the influent connection.

If water conditions such as high suspended solids exist a filter should be installed prior to the Adsorber. A simple cartridge or screen filter helps prevent pressure buildup in the media bed. Many other water issues may effect Adsorber operation and we therefore recommend you discuss your specific installation with a representative.

Connect the process inlet and outlet to the site influent and effluent process lines.

3.5 Wetting and Deaeration

Dry carbon and other medias must be wetted and deaerated prior to use. This procedure displaces air from the internal structure of the carbon granule, thus assuring that the liquid to be treated is in contact with the carbon surface.

Prior to operation, the filter must be filled with clean, uncontaminated liquid. The recommended method for filling the vessel is through the outlet line. Open the inlet line to purge air from the system. Feed water into the outlet line until water flows from the inlet line. The wet carbon or media should be allowed to set for a minimum of 1 hours.

This is also a good time to inspect the system for leaks which may have been caused in transit and unloading the system. If leaks are spotted, tighten the fitting or flange bolts carefully until the leak stops. Do not overtighten the bolt or fitting. If the leak persists contact Tetrasolv Filtration for assistance.

After wetting, the carbon bed can be deaerated by draining the adsorber, and again filling the adsorber upflow with uncontaminated water. This procedure will eliminate any air pockets which may have formed between the carbon granules.

After completing the wetting and Dearation it is recommended that a backwash be performed. The backwash will remove media fines which can cause excess pressure drop in the system if not removed. In addition backwashing helps equalize the bed. Follow the directions outlined in Backwashing ***(refer to section 4.2)***.

After backwashing close the system valves and wait 1 hour.

The system is now ready for operation.

4.0 OPERATION

Flowrates to the filter should be determined based upon the required contact time between the liquid and the filtration media. The required contact time normally is determined prior to installation and operation of the filter.

It is important that the filters remain flooded at all times. If it is necessary to drain adsorbers while off-line it is recommend the procedures in section 3.5 "Wetting and Dearation" be repeated.

4.1 Modes of Operation

With certain applications (2) filters in series flow are utilized. Listed below are typical operational modes.

- Shutdown - Both filters completely off-line and isolated.
- Series Flow - Influent enters primary filter and exits through secondary adsorber (this is the preferred method of operation)
- Isolation Flow - Only one filter is receiving influent. This mode is typically used when the operator is maintaining the off-line filter.
- Parallel Flow - Both filters are receiving the influent as the primary. Flow is split equally between the filters. This mode is used when higher flow rates need to be achieved and contact times are not critical.
- Backwash Mode - Used when back-washing either filter.

4.2 Backwashing

IMPORTANT: Backwashing is not advisable with AFD or AF Series Filters. If a backwash is required please contact the number below or support@tetrasolv.com for assistance.

Usually backwashing is only performed in carbon adsorbers after new carbon has been installed or prior to removing the carbon from the adsorber. However, sometimes water conditions necessitate backwashing to remove suspended solids from the top of the carbon bed. Keep in mind that backwashing a carbon bed during normal service runs may cause the transfer zone to be disturbed leading to pre-mature breakthru of the carbon bed. Backwashing helps to reduce and equalize pressure drop across the media bed as well as removes

collected particulate from the top of the bed. Backwash rates for filters typically fall in the 5 to 20 gpm/ft^2. Backwash rates are dependent upon temperature of the backwash water, filter design and the media conditions. Refer to the data sheet for the supplied filter to obtain the cross sectional bed area. Refer to the data sheet for the supplied media to obtain the recommended backwash rate. Backwashing should begin at a low rate and proceed upwards.

Clean, uncontaminated, sediment free water is introduced to the filter through the outlet connection. This liquid flows upwards through the filter and exits through the inlet line - directed to a back-wash water collection point or drain. The flow rate should not be high enough to cause a significant quantity of media to exit.

IMPORTANT: Use only clean un-contaminated water free of sediments. If there is any question that sediments may be present the water should be filters through a 100 micron filter or smaller. Sediments introduced into the lateral system during backwash can cause excessive pressure build-up in the underdrain leading to underdrain failure.

If possible position an observer at the backwash discharge point. The adsorber should note excessive media loss and general appearance of the backwash effluent. If conditions warrant the observer should also instruct that the backwash be stopped.

Monitor the differential pressure for the filter being backwashed during the operation. If the differential pressure exceeds 30 PSIG discontinue the backwash and contact Tetrasolv Filtration.

IMPORTANT: Differential Pressure exceeding 30 PSIG during backwash may damage the vessel underdrain.

4.3 Monitoring

Filter units only require periodic monitoring if properly installed. The following items may be monitored:

- Pressure: Check inlet and outlet pressure. Increase in pressure differential may indicate build-up of filtered solids. Never exceed maximum design pressure of filter. If the differential pressure exceeds 20 PSIG it may become necessary to perform a backwash ***(see Backwashing Section 4.2)***

- Samples: Inlet and outlet sample points if provided for liquid analysis to determine system performance. Before pulling a sample the sample valve should be opened and allowed to flow freely for a few minutes to insure a fresh sample is obtained.

- Air: Check for trapped air by opening upper vent valve and allowing small amount of liquid to flow out. If your system was provided with automatic vent systems it is still necessary to periodically verify their operation.

- Inspect the discharge stream periodically for filtration media. If filter media is present in the exit stream shut down the system and contact Tetrasolv Filtration immediately.

Note: When the system if first started up small amounts of fines may be present. This is normal and should discontinue within a short period of time.

5.0 FILTRATION MEDIA REPLACEMENT

Prior to servicing the unit should be closed off from influent and effluent lines and any electrical devices or connections should be tagged off.

After removal of the filtration media is complete, it is recommended that the inside of the filter be washed to remove all contamination and any trace of spent media. After the filter has been washed, the filter should also be checked thoroughly and any minor maintenance conducted.

5.1 Media Loading - Dry Method

Fill the adsorber 1/4 full of clean water to protect the lower manifold and limit the amount of dust generated.

- ***WARNING - Dry activated carbon generates considerable dust. While activated carbon poses no health risk the dust can cause respiratory irritation and occasional skin rash. Therefore we recommended the use of proper clothing and dust mask during filling operation.***

Super Sacks - Hoist the bag over the manway and untie the outer bag exposing the inner chute. Untie the inner chute while clasping it shut. Remain holding the chute and carefully lower the chute into the manway. Un-clasp the chute and allow the carbon to discharge from the sack. The carbon should flow out very quickly and completely. When finished shake the bag and invert the chute into the bag.

If at any time you wish to stop the flow of carbon simply re-grasp the chute up high and cinch. Re-tie the bag.

5.2 Media Loading - Slurry Method

In this method dry-activated carbon will be delivered to the site in a slurry truck or slurry capable hoppers. To add the carbon to the filters use the following method:

- ***WARNING: Carbon slurry operation is a potentially hazardous operation which should only be performed by experienced operators with prior slurry experience. If you are un-trained do not attempt to perform a slurry without assistance.***

1. Use an appropriate sized hose connected to the carbon supply line for the adsorber. **Be sure the slurry line is adequately secured and the cam-lock mechanism is completely engaged. If the slurry line disconnects or fails large amounts of carbon will be expelled.**

2. Fill the adsorber 1/4 full of water to cushion the vessel internals from the entering carbon.

3. Completely cover the fresh carbon with clean water. Connect air source to the slurry container capable of producing 10 PSIG of air at 175 cfm.

4. Open the adsorber process outlet valve to allow excess water to escape the system (note: depending upon your discharge piping configuration this may not allow sufficient water drainage under non-pressure operation, consult Tetrasolv Filtration). Open the slurry in valve. Fresh carbon should begin flowing quickly into the filter. During this process it may become necessary to stop the slurry and allow excess water to drain from the adsorber.

5. When transfer is complete the transfer hose will begin blowing air only. It may be necessary to inspect the transfer hopper for carbon which did not transfer. If a sufficient quantity is present wash the carbon to the center using clean water and add enough water to re-cover the carbon and repeat the above procedures.

6. Close the valves and proceed to Section 3.5 "Wetting and Deaeration" then perform a backwash.

5.3 Media Removal - Slurry Method

This method can only be used with slurry equipped HPAF Series!

In this method spent activated carbon will be removed from the spent adsorber into a slurry truck or slurry capable hoppers. To remove the carbon from the filter use the following method:

- ***WARNING: Carbon slurry operation is a potentially hazardous operation which should only be performed by experienced operators with prior slurry experience. If you are un-trained do not attempt to perform a slurry without assistance.***

Backwashing the adsorber to be serviced for a few minutes prior to servicing will make the slurry occur more easily. It is important the the adsorber to be backwashed be full of water prior to attempting the slurry.

1. Connect the carbon discharge line to the carbon discharge connection on the adsorber to be emptied.

2. Connect an air source to the carbon fill line capable of producing 50 PSIG of air at 175 cfm.

- ***WARNING - The inlet air should be closely monitored to insure the pressure does not exceed the design pressure leading to rupture disc activation. If this can not be done the use of a pressure limiting device which still allows adequate air flow should be used.***

3. Open the air vent valve and pressurize the adsorber to 15 PSIG.

IMPORTANT: The initial pressure required for slurry transfer will be between 10 and 20 PSIG. Because of the compressibility of air the pressure should be reduced as the adsorber empties. If the operator supplying compressed air into the adsorber cannot see the pressure gauge there must be another operator who can call out the pressure reading during the transfer.

4. Open the slurry out valve. Spent carbon should begin flowing quickly out of the carbon vessel.

5. When transfer is complete the transfer hose will begin blowing air only. Bleed all air from the adsorber, remove the manway and inspect the adsorber for carbon which did not transfer. If a sufficient quantity is present wash the carbon to the center using clean water and add enough water to re-cover the carbon and repeat the above procedures.

6. Inspect the internals prior to refilling the adsorber.

Inspect the interior lining. Do not place the adsorber back into operation if any defects are noted.

6.0 MAINTENANCE

6.1 Extended Shut Down

If the filter will be shutdown for extended periods certain procedures should be taken to protect the filter.

If possible backflush the filter. Drain all water from the adsorber utilizing the effluent connection and the drain port if available. When draining allow air to enter the system by venting the influent line. Store the drained filter with system vented.

Caution should be taken during system startup following exposure to freezing conditions as the media may still be in a frozen state days or weeks after.

Prior to placing the adsorber back into service it is recommended the procedures outlined in section 3.5 "Wetting and Dearation" be followed.

Monitor the filter closely after extended shutdown for signs of potential problems such as interior manifold failure or leaking valves and gaskets.

6.2 Manway Opening & Closing

When it becomes necessary to open a manway the following methods should be closely followed:

- ***WARNING: Opening a manway while a vessel is pressurized can cause serious injury or death. Always verify pressure is relieved before attempting to remove a cover.***

- ***WARNING: Opening the lower manway on an filter which contains media can result in large quantities of media being discharged. Worse still the manway may not be able to be successfully sealed without removal of the media.***

Verify vessel is isolated and relieve pressure using filter vent valve.

Round T-Bolt Closures

1. Carefully loosen retaining nuts around manway ring. If while loosening the bolts you hear a hissing or any other indication of pressure immediately re-tighten the bolts and verify pressure has been relieved.

3. Swing all T-Bolts away from manway cover and slowly open cover. If gasket sticks to manway cover gently pry away to avoid tearing the gasket.

4. Clean O-Ring surface. Lubricate gasket with petroleum jelly.

5. Close manway and tighten bolts. It may be necessary to further tighten bolts after pressure has been applied to filter to prevent leaking.

Elliptical Closures

1. Slip a bent bar between the manway handle and the flange frame. ***This is to insure the manway does not fall into the vessel when the yokes are removed.***

2. Carefully loosen both large nuts holding the yokes to the manway. Remove the yokes.

3. Slide the bar out of the handle while holding it. Push the manway in and tilt to allow the manway to be pulled out of the filter.

Closing the manways:

1. Clean the gasket surface and replace if necessary. Apply tape to the gasket and the cover to hold the gasket in place while it is placed into position.

2. Slip a bent bar between the manway handle and the flange frame. ***This is to insure the manway does not fall into the vessel when the yokes are removed.***

3. Place the yoke into the manway cover slot and hand tighten. Carefully inspect the gasket to be sure it can be seen around the inside surface of the manway opening.

4. Wrench tighten nuts.

7.0 Troubleshooting

The following situations are typical problems which may arise during the operation of filters. If these problems cannot be resolved by using this guide or problems occur which are not addressed in this guide please contact TetraSolv Filtration at the number listed below or e-mail **support@tetrasolv.com**

Situation:

High pressure drop or inadequate flow through filters at expected pressure drop levels.

Probable Cause:

a) Verify effluent and influent lines to and from adsorber are not restricted.

b) Sediments or solids may have clogged the surface of the media. Remove the top manway cover and inspect the surface of the media. Backwashing the media should resolve this issue. Explore the possibility of pre-filtration ahead of the media filter to limit future problems.

c) Air is trapped in the top of the filter or the system piping. Relieve air using vent valves.

d) Underdrain collection baskets clogged. Contact Tetrasolv Filtration for recommendations.

Situation:

Manways failing to seal. Water leaking from.

Probable Cause:

a) Manway not installed properly.

b) Missing or damaged gasket

c) Debris trapped between gasket and ring

Solution:

Tighten the bolts on the manway first. If this does not solve the problem remove and reinstall manway as outlined in 6.4 if possible. If problem persists contact TetraSolv Filtration for further assistance.

Situation:

Premature filter exhaustion.

Probable Cause:

a) Inadequate contact time between the media and the liquid stream.

b) Contaminants in stream not originally accounted for in initial design or higher levels of contaminants than originally accounted for.

c) Trapped air or solids on bed causing channeling.

Solution:

Sample and analyze the influent water stream. Verify proper conditions exist. Also look closely at suspended and dissolved solids.

Verify contact time sufficient for contaminate being adsorbed. Decrease flow rate or install additional media.

Inspect surface of filter for fouling.

Release excess air from top of filter through filter vent line.

Situation:

Activated Carbon bed discharge stream has higher level of contaminants than influent stream.

Probable Cause:

Carbon bed has reached saturation. Carbon beds will often release larger amounts of contaminants than they are adsorbing as the mechanical bonds are broken when the carbon has reached it's saturation point.

Also, activated carbon will preferentially exchange more easily adsorbed compounds for ones already trapped in the carbon surface releasing the compounds trapped in unpredictable levels.

QTY	DESCRIPTION	MANUFACTURER	PART NUMBER
	Panel Hardware		
1	Enclosure - PLC Panel	Hoffman	CSD363612
1	Sub Panel	Hoffman	CP3636
1	Swing Panel	Hoffman	A36P36
1	Hinge Kit	Hoffman	ANADFK
1	Drawing Pocket	Hoffman	ADP2
1	Door Handle	Hoffman	CWHK
1	Cooling Fan Thermostat	Hoffman	ATEMNO
1	Cooling Fan 4"	Hoffman	A4AXFN
1	Cooling Fan 4" Finger Guard	Hoffman	AGARD4
2	Fan Shrouds 4"	Hoffman	T4S3R
3	Vents 4"	Hoffman	AFLT44
1	Mini Circuit Breaker 1.0A 1P Exhaust Fan	Square-D	60101
	480 Volt Panel Hardware		
1	Enclosure 480V	Hoffman	CSD36288
1	Sub Panel	Hoffman	CP3624
1	Door Handle	Hoffman	CWHK
	480V Panel Disconnect		
1	Main Breaker 600V 100A	Square-D	HDL36100C
	Panel Switches		
5	Hand-Off-Auto Switch Maintain - Illuminated	Telemecanique	ZB4BK1333
5	Contact Block	Telemecanique	ZB4BZ103
	Panel Lights-Meters		
5	Pilot Light Assembly-Lens White 24vdc	Telemecanique	XB4BVB1
1	Pilot Light Assembly-Lens Blue 24vdc	Telemecanique	XB4BVB6
	Panel Labels		
5	Legend Plate Hand/Off/Auto	Telemecanique	ZBY2387
	Motor Starters-Overloads-Breakers		
	Liquid Ring Pump		
1	Contactor 20HP 480V 3Ph 27FLA	Square-D	LC1D40AG7
1	Overload Module 23-32A	Square-D	LRD332
1	Auxiliary Contacts	Square-D	LAD8N20
1	Surge Suppressor	Square-D	LAD4RC3U
1	Circuit Breaker 480V 3P 60A	Square-D	GV7RE80
	SVE Blower		
1	Contactor 7.5HP 480V 3Ph 11.0FLA	Square-D	LUB32
1	Overload Module 4.5-18A	Square-D	LUCA18FU
1	Auxiliary Contacts	Square-D	LUFN20
1	Auxillary Contacts - Overload	Telemecanique	LUA1C20
1	Incoming Line Barrier	Telemecanique	LU9SPO
	Heat Exchanger		
1	Contactor 0.5HP 480V 3Ph 1.1FLA	Square-D	LUB32
1	Overload Module 1.25-5A	Square-D	LUCA05FU
1	Auxiliary Contacts	Square-D	LUFN20
1	Auxillary Contacts - Overload	Telemecanique	LUA1C20
1	Incoming Line Barrier	Telemecanique	LU9SPO
	KO Tank Transfer Pump		
1	Contactor 1.0HP 480V 3Ph 2.1FLA	Square-D	LUB32
1	Overload Module 1.25-5A	Square-D	LUCA05FU
1	Auxiliary Contacts	Square-D	LUFN20
1	Auxillary Contacts - Overload	Telemecanique	LUA1C20
1	Incoming Line Barrier	Telemecanique	LU9SPO
	Discharge Pump		
1	Contactor 1.5HP 480V 3Ph 3.0FLA	Square-D	LUB32
1	Overload Module 1.25-5A	Square-D	LUCA05FU
1	Auxiliary Contacts	Square-D	LUFN20
1	Auxillary Contacts - Overload	Telemecanique	LUA1C20
1	Incoming Line Barrier	Telemecanique	LU9SPO
	Heater		

1	Contactor	Square-D	LC1D12G7
1	Fuses Holder, Heater 600V 2P 30A	Ferraz/Shawmut	US3J3I
2	Fuses, Heater 600V 15A	Ferraz/Shawmut	AJT15
	Exhaust Fan		
2	Mini Circuit Breaker Lights 240VAC 15A 2P	Square-D	60146
	PLC		
1	PLC - TWIDO 40 I/O 120-230VAC Pwr	Telemecanique	TWDLCAE40DRF
1	Digital Input Module 8Pt.	Telemecanique	TM2DDI8DT
0	Digital Output Module 8Pt.	Telemecanique	TM2DRA8RT
1	Analog Input Module 2Ch 4-20mA	Telemecanique	TM2AMI2HT
1	Battery	Telemecanique	TSXPLP01
1	Mini Circuit Breaker 1.5A 1P PLC	Square-D	60102
	HMI		
1	HMI 5.7" Color w/Ethernet, Compact Flash	Square-D	HMISTU855
1	Flash Drive 8GB	Kingston	DTMCK/8GB
1	Mini Circuit Breaker 1.0A 1P HMI	Square-D	60101
	Ethernet Switch		
1	Ethernet Switch 4 Port	N-Tron	104TX
1	Circuit Breaker 1P 1A Ethernet Switch	Square-D	60101
	Ethernet Cables		
1	1' Ethernet Cable	3E	QTN530100001
1	2' Ethernet Cable	3E	QTN530100002
1	6' Ethernet Cable	3E	QTN27250
1	Panel Mount Ethernet Port 22mm	WAG	51205068
	Intrinsic/Isolation Barriers		
7	Discrete Barriers	Turk	IM1-22EX-R/24VDC
	Panel Protection		
1	Surge Arrestor	Ferraz/Shawmut	ST1201PG
1	Circuit Breaker Phase Monitor 1P 4A	Square-D	MGN61326
1	Phase Monitor	SymCom	460
	Misc. Panel Items		
1	Power Supply 24VDC 4.2A	Puls	ML100100
1	Mini Circuit Breaker Primary 120vac 3A	Square-D	60104
1	Mini Circuit Breaker Secondary 4.0A 1P	Square-D	60105
1	Mini Circuit Breaker Analog Devices 24vdc 1A	Telemecanique	60101
1	Auxillary Relay 120vac	Telemecanique	RXM4AB2F7
7	Auxillary Relay 24vdc	Telemecanique	RXM4AB2BD
8	Relay Socket	Telemecanique	RXZE2S114M
1	120Vac Relay Varistor	Telemecanique	RXM021FP
7	24Vdc Relay Varistor	Telemecanique	RXM021BN
1	Flashing Beacon - Red	Federal Signal	SLM100R
1	Flashing Beacon - Green	Federal Signal	SLM100G
1	Wall Mount Base Dual	Federal Signal	SLMBT120-240/GY
2	Grounding Bus Bar	Square-D	PK15GTAL
6	Din Rail	IDEC	BNDN1000
36	Din Rail Retainers	IDEC	BNL5
1	Din Rail Retainers	Allen-Bradley	1492-EAJ35
4	Terminal Blocks 2 Conductor	Allen-Bradley	1492-JD3
1	End Barrier	Allen-Bradley	1492-EBJD3
67	Terminal Blocks	Square-D	9080GR6
31	Terminal Blocks	Square-D	9080GM6
7	End Barrier	Square-D	9080GM6B
2	Terminal Block Green	WAGO	2002-1307
2	End Barrier	WAGO	2002-1391
1	Terminal Block 3 Conductor	WAGO	2002-3218
1	End Barrier	WAGO	2002-3291
3	Power Distribution 480vac	Ferraz/Shawmut	FSPDB3A
3	Power Distribution 240/120vac	Ferraz/Shawmut	FSPDB2A
8	Distribution Block Pins	Ferraz/Shawmut	FSPIN1
1	Mini Circuit Breaker Control Pwr 120VAC 10A	Square-D	60110

1	Mini Circuit Breaker Lights 120VAC 15A	Square-D	60112
1	Mini Circuit Breaker GFI 120VAC 20A	Square-D	60113
2	Fuses Holder, Control Transformer 600V 2P 30A	Ferraz/Shawmut	US3J2I
4	Fuses, Control Transformer 600V 20A	Ferraz/Shawmut	AJT20
	Other Items		
3	Thermostat	Columbus Electric	EP-ETD-8D
1	Emergency Stop Switch - Exp	Appleton	EFKBUM1
1	Emergency Stop Switch Box - Exp	Appleton	EFDC175NLQ
3	Light	Appleton	VXHA1075G
1	Light Switch Box - Exp	Killark	SWB-2
1	Light Switch Cover - Exp	Killark	XNS-2C
1	Light Switch	P&S	PS20AC1-W
1	GFI Receptacle	P&S	2095-TRWRW
1	GFI Cover	Intermatic	CKMUV
1	WP Box 1G 3 Hole 1/2" Hubs	Raco	5385-0
1	Distribution Transformer 5.0KVA 480-120/240V 1Ph	Hammond	C1F005LES
1	Surge Arrestor 480/277V 3Ph 40kA Per Phase	Square-D	SDSA3650D

TwidoSuite
Kinder Morgan Bellingham Site

Project Information

Print date	7/8/2015
Author	RR
Department	SES
Index	
Industrial Property	

Comment

Job # 1715005

1009 East Smith Road

Bellingham, WAshington 98226

HMI

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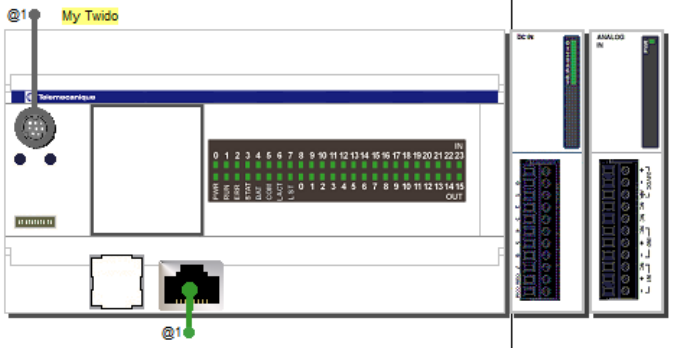

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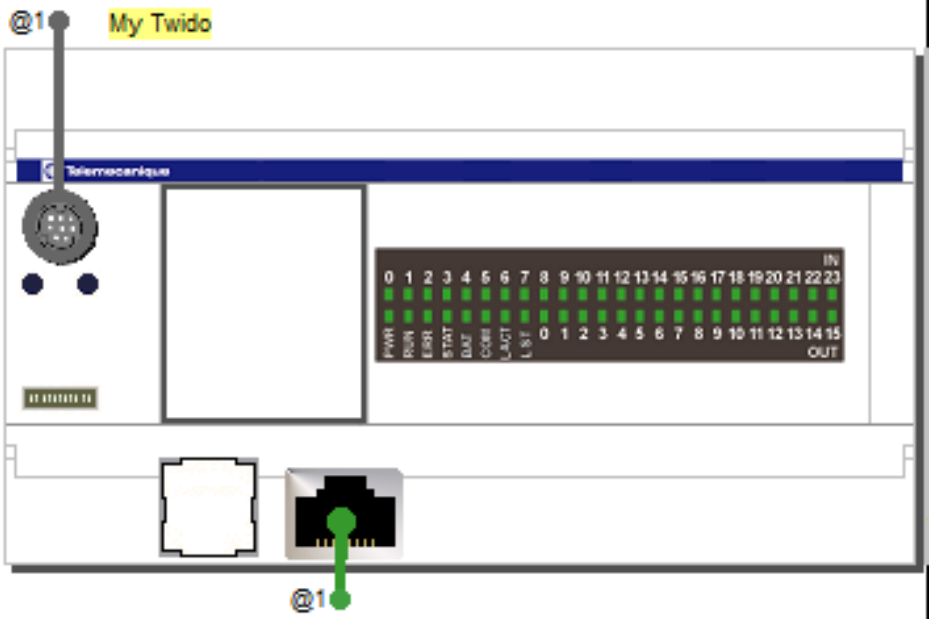
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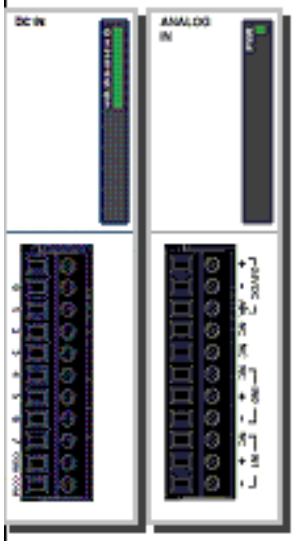

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Properties

Ethernet Port :

IP address configuration

IP address :
Subnet mask :
Gateway address :

Marked IP

Marked IP address :

Idle time

Time (min) : 10

Remote devices

Index	IP	Unit ID	Timeout

Bill of material

Family	Reference number	Quantity
Twido	TWDLCAE40DRF	1
Twido	TM2DDI8DT	1
Twido	TM2AMI2HT	1

Hardware configuration

Base

TWDLCAE40DRF

Expansion bus modules

1 : TM2DDI8DT

2 : TM2AMI2HT

Memory objects configuration

Timer configuration (%TM)

Used	%TM	Symbol	Type	Adjustable	Time Base	Preset
Yes	%TM0	KO_TNK_HLIM_DLY_TMR	TON	Yes	1 min	20
Yes	%TM1	OW_SEP_TNK_HLIM_DLY_TMR	TON	Yes	1 min	20
Yes	%TM2	LRP_LOIL_LEV_DLY_TMR	TON	Yes	1 s	5
Yes	%TM3	LRP_HOIL_LEV_DLY_TMR	TON	Yes	1 s	5
Yes	%TM4	LRP_HTEMP_DLY_TMR	TON	Yes	1 s	5
Yes	%TM5	LRP_LAC_DLY_TMR	TON	Yes	1 s	15
Yes	%TM6	KO_PMP_HPRES_DLY_TMR	TON	Yes	1 s	5
Yes	%TM7	DC_PMP_HPRES_DLY_TMR	TON	Yes	1 s	5
Yes	%TM8	HT_EXCHG_HPRES_DLY_TMR	TON	Yes	1 s	5
Yes	%TM9	HT_EXCHG_DISCHG_HTEMP_LTCH	TON	Yes	1 s	5
Yes	%TM10	ETM_MIN_TMR	TON	Yes	1 min	6
Yes	%TM11	HT_EXCHG_ETM_REST_TIMR	TON	Yes	1 s	10
Yes	%TM12	SVE_BLW_ETM_REST_TMR	TON	Yes	1 s	10
Yes	%TM13	LRP_ETM_REST_TMR	TON	Yes	1 s	10

Counter configuration (%C)

Register configuration (%R)

Drum configuration (%DR)

Scheduler block configuration (%SCH)

Fast counters configuration (%FC)

Very fast counters configuration (%VFC)

Memory words (%MD)

Used	%MD	Symbol	Allocated
Yes	%MD100	HT_EXCHG_ETM	Yes
Yes	%MD102	SVE_BLW_ETM	Yes
Yes	%MD104	LRP_ETM	Yes

Memory words (%MW)

Used	%MW	Symbol	Allocated
Yes	%MW0	HT_EXCHG_DISCHG_TEMP	Yes
Yes	%MW1	HT_EXCHG_DISCHG_HTEMP_ST_PT	Yes
Yes	%MW701	DIALOG_TABLE_RTC1	Yes
Yes	%MW702	DIALOG_TABLE_RTC2	Yes
Yes	%MW703	DIALOG_TABLE_RTC3	Yes
Yes	%MW704	DIALOG_TABLE_RTC4	Yes
Yes	%MW705	DIALOG_TABLE_CALC	Yes

Memory words (%MF)

Memory bits (%M)

Used	%M	Symbol	Allocated
Yes	%M0	E_STOP_REST_BIT	Yes
Yes	%M1	E_STOP_BIT	Yes

Used	%M	Symbol	Allocated
Yes	%M2	PWR_MON_BIT	Yes
Yes	%M3	PWR_MON_LTCH	Yes
Yes	%M4	KO_TNK_HLIM_BIT	Yes
Yes	%M5	KO_TNK_HLIM_LTCH	Yes
Yes	%M6	OW_SEP_TNK_HLIM_BIT	Yes
Yes	%M7	OW_SEP_TNK_HLIM_LTCH	Yes
Yes	%M8	PRD_TNK_HLIM_LTCH	Yes
Yes	%M9	LRP_LOIL_LEV_LTCH	Yes
Yes	%M10	LRP_HOIL_LEV_LTCH	Yes
Yes	%M11	LRP_HTEMP_LTCH	Yes
Yes	%M12	LRP_LVAC_LTCH	Yes
Yes	%M13	KO_PMP_HPRES_LTCH	Yes
Yes	%M14	DC_PMP_HPRES_LTCH	Yes
Yes	%M15	HT_EXCHG_DISCHG_HPRES_LTCH	Yes
Yes	%M16	KO_PMP_MTR_OL_LTCH	Yes
Yes	%M17	DC_PMP_MTR_OL_LTCH	Yes
Yes	%M18	HT_EXCHG_MTR_OL_LTCH	Yes
Yes	%M19	SVE_BLW_MTR_OL_LTCH	Yes
Yes	%M20	LRP_MTR_OL_LTCH	Yes
Yes	%M21	KO_PMP_AUX_BIT	Yes
Yes	%M22	DC_PMP_AUX_BIT	Yes
Yes	%M23	HT_EXCHG_AUX_BIT	Yes
Yes	%M24	SVE_BLW_AUX_BIT	Yes
Yes	%M25	LRP_AUX_BIT	Yes
Yes	%M26	SYSTM_OK_BIT	Yes
Yes	%M27	SYSTM_ALRM_BIT	Yes
Yes	%M28	KO_TNK_LEV_CNTRL_BIT	Yes
Yes	%M29	OW_SEP_TNK_LEV_CNTRL_BIT	Yes
Yes	%M30	HT_EXCHG_ETM_REST_BIT	Yes
Yes	%M31	SVE_BLW_ETM_REST_BIT	Yes
Yes	%M32	LRP_ETM_REST_BIT	Yes
Yes	%M33	SYSTM_REST_BIT	Yes
Yes	%M34	HT_EXCHG_HTEMP_LTCH	Yes
Yes	%M35	KO_PMP_CNTRL_CONTINU	Yes
Yes	%M36	SVE_BLW_CNTRL_CONTINU	Yes
Yes	%M37	LRP_CNTRL_CONTINU	Yes
Yes	%M38	ETM_MIN_TMR_REST_BIT	Yes
Yes	%M39	SYSTM_CNTRL_CONTINU	Yes

PID configuration (PID)

Constant configuration (%KD)

Constant configuration (%KW)

Constant configuration (%KF)

PLS/PWM configuration (%PLS/%PWM)

Configuration of external objects Comm

Configuration of external objects Drive

Configuration of external objects Tesys

Configuration of external objects Advantys OTB

Memory

Memory usage statistic

User data			
Memory bits	:	40 Bits	0.1%
Memory words	:	706 Words	20.5%
Backed up	:	343 Words	
RAM = EEPROM	:	???	
Constants	:	0 Words	0.0%
Configuration	:	502 Words	14.6%
Avail. mem. data	:	2146 Words	62.1%

User program			
Executable code	:	926 Words	6.0%
Prog. data	:	4 Words	0.1%
Online modif.	:	0 Words	0.0%
Avail. code mem.	:	14168 Words	91.8%

Other			
Execution data	:	88 Words	2.6%
:	88 Words	2.6%	

Configure the behavior

Functional levels

Functional levels management

Management :	Automatic
Level :	The highest possible

Scan mode

Scan mode

Mode :	Normal
Duration (ms) :	-

Watchdog

Duration (ms) :	250

Periodic event

Not used :	Yes

Startup

Parameters

Automatic start in Run :	Yes
Run/Stop Input:	None

Autosave

Parameters

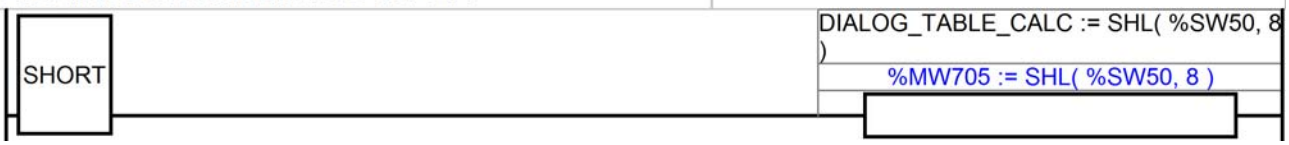
Autosave RAM=>EEPROM :	Yes

Program lists and diagrams

1 LD HMI Real-Time Clock Synchronization

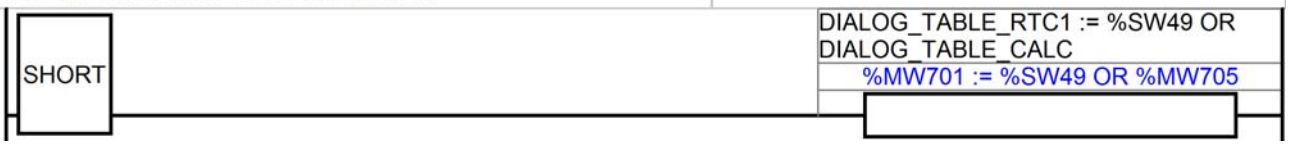
COPT RTC TO MW FOR HMI DIALOG TABLE

Rung 0



SECONDS BYTE OR WITH DAY OF WEEK

Rung 1



HOUR, MINUTE

Rung 2

MONTH, DAY

Rung 3

CENTURY, YEAR

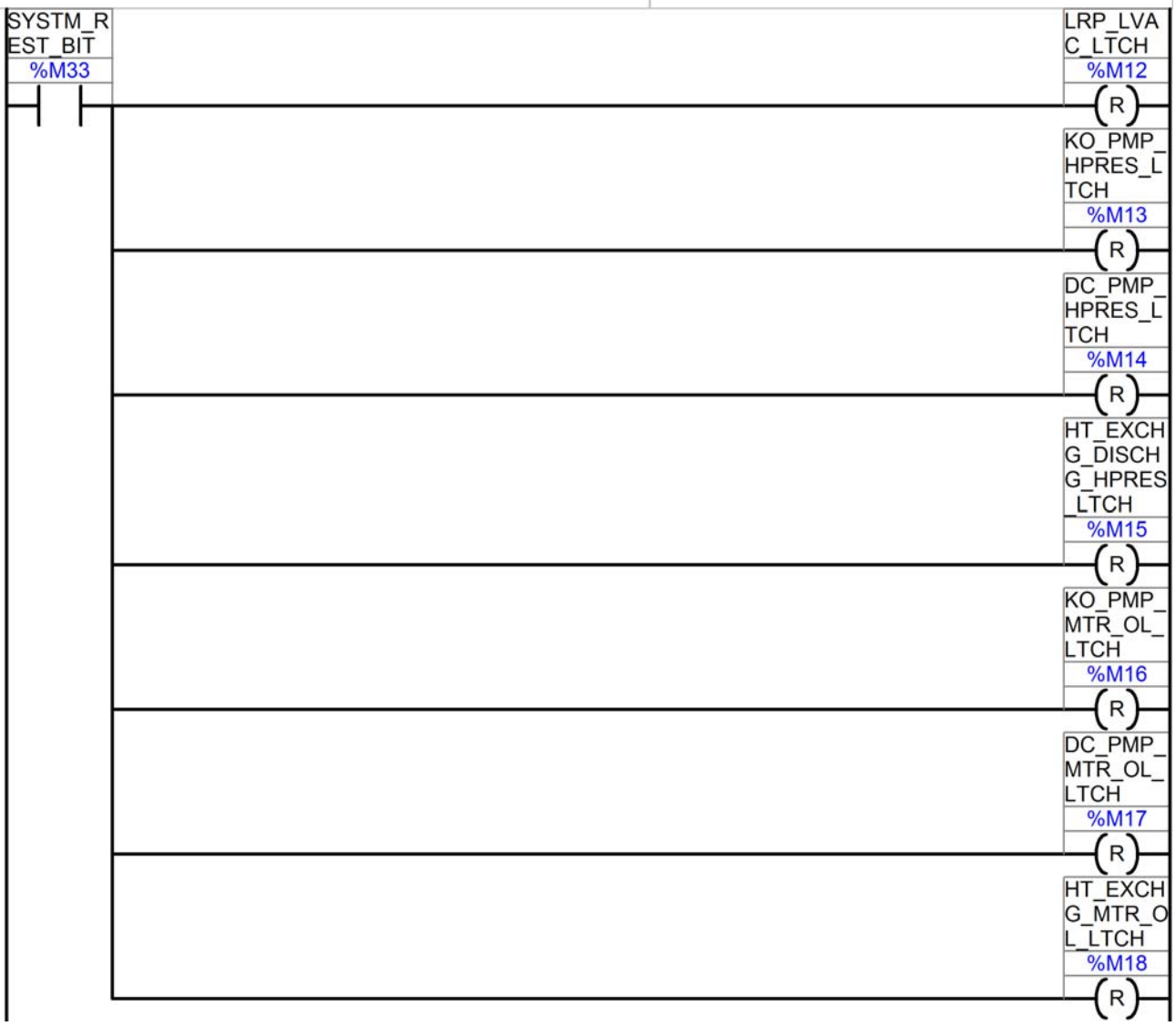
Rung 4

2 LD System Alarm's and Resets

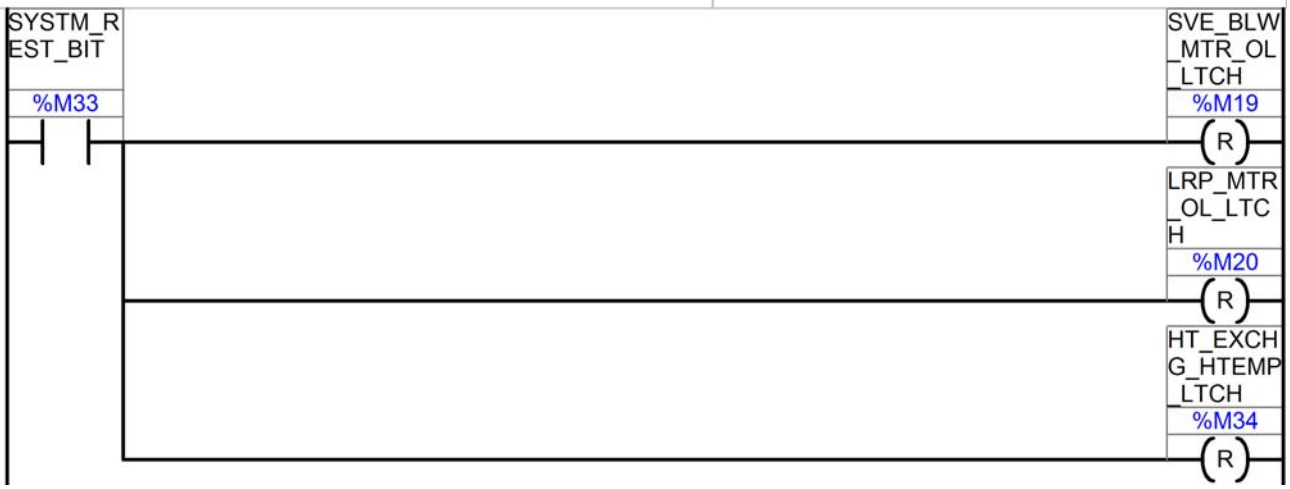
SYSTEM ALARMS

Rung 0

Rung 1


SYSTM_REST_BIT
%M33
LRP_LVAC_LTCH
%M12
R
KO_PMP_HPRES_LTCH
%M13
R
DC_PMP_HPRES_LTCH
%M14
R
HT_EXCHG_DISCHG_HPRES_LTCH
%M15
R
KO_PMP_MTR_OL_LTCH
%M16
R
DC_PMP_MTR_OL_LTCH
%M17
R
HT_EXCHG_MTR_OL_LTCH
%M18
R

Rung 2

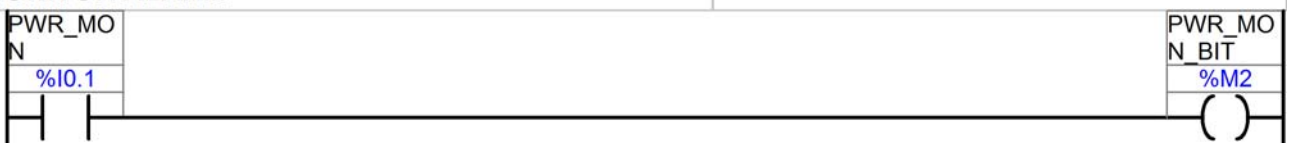

SYSTM_REST_BIT
%M33
SVE_BLW_MTR_OL_LTCH
%M19
R
LRP_MTR_OL_LTCH
%M20
R
HT_EXCHG_HTEMP_LTCH
%M34
R

EMERGENCY STOP RESET

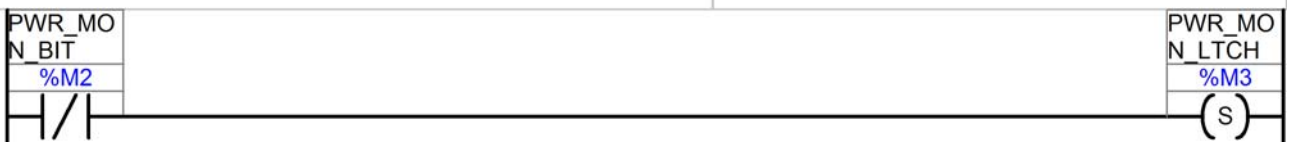
Rung 3

POWER MONITOR ALARM

Rung 4



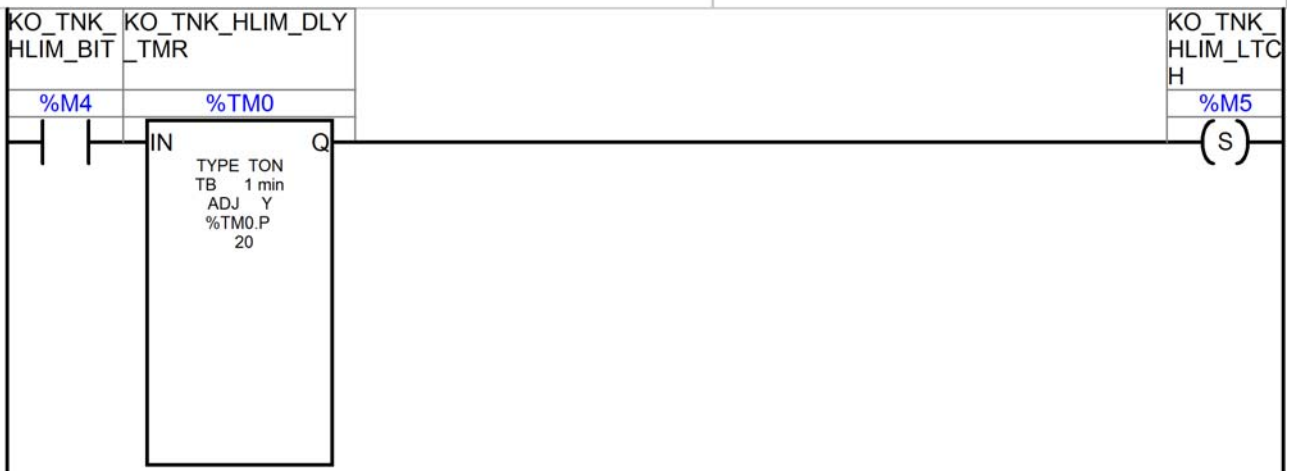
Rung 5



KO TANK HIGH LIMIT ALARM

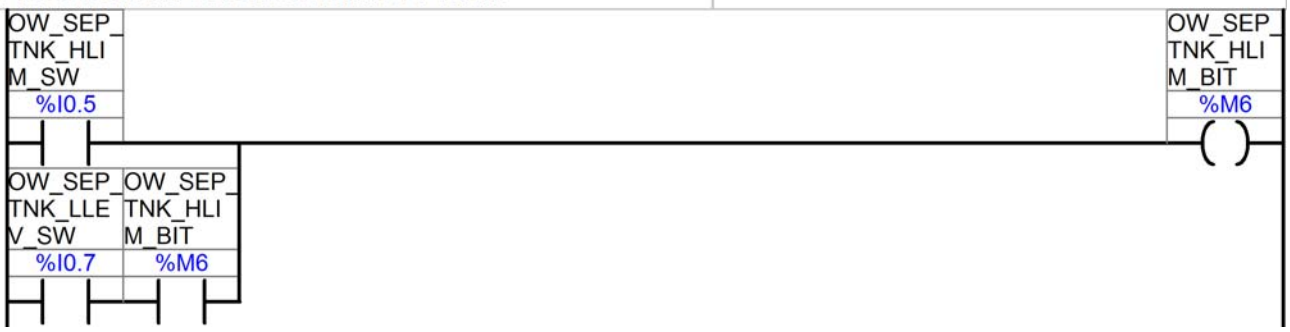
Rung 6

Rung 7

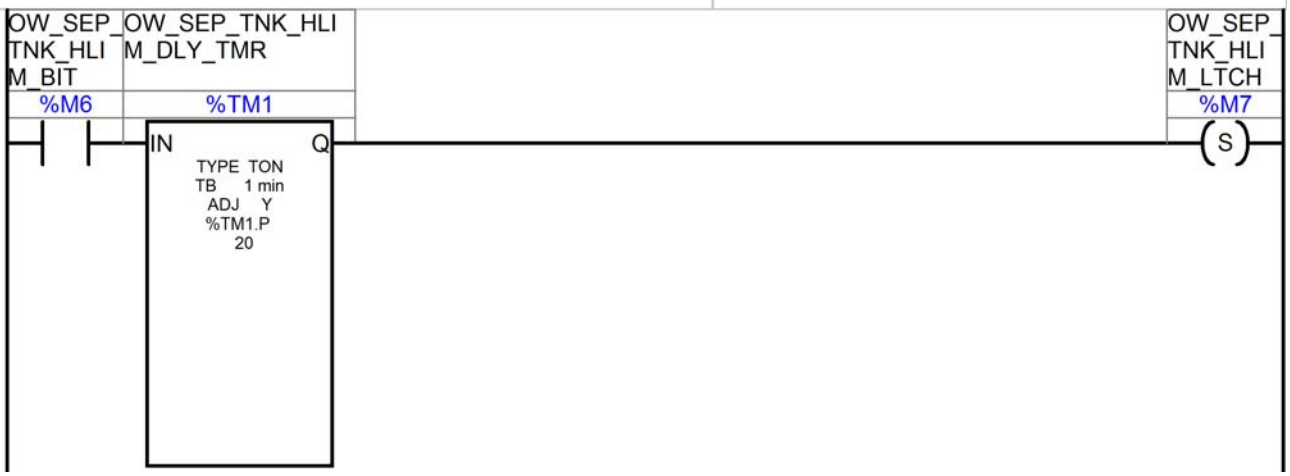


OIL / WATER SEPARATOR HIGH LIMIT ALARM

Rung 8



Rung 9

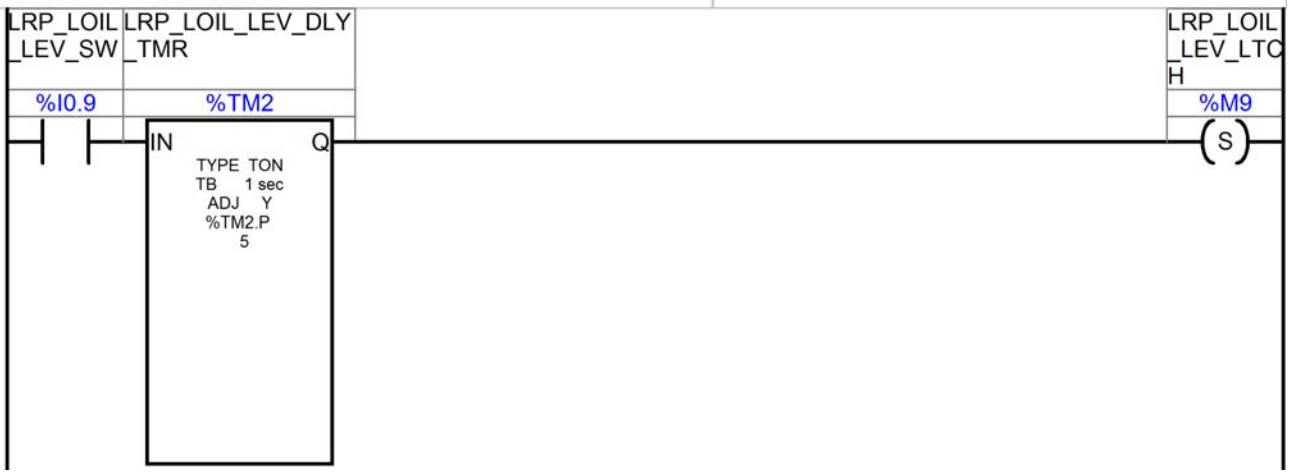


PRODUCT TANK HIGH LIMIT ALARM

Rung 10

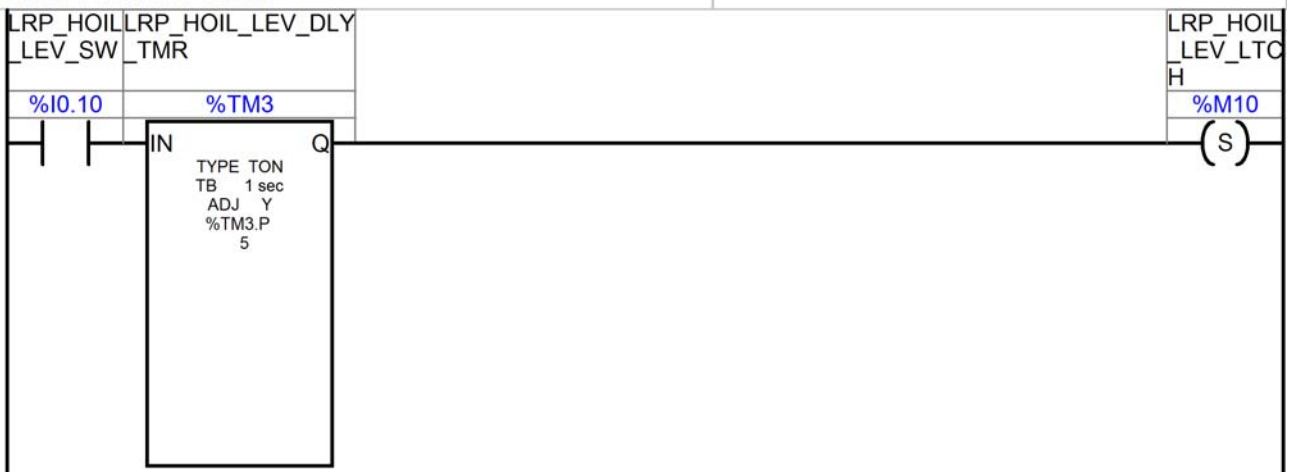
LRP LOW OIL LEVEL ALARM

Rung 11



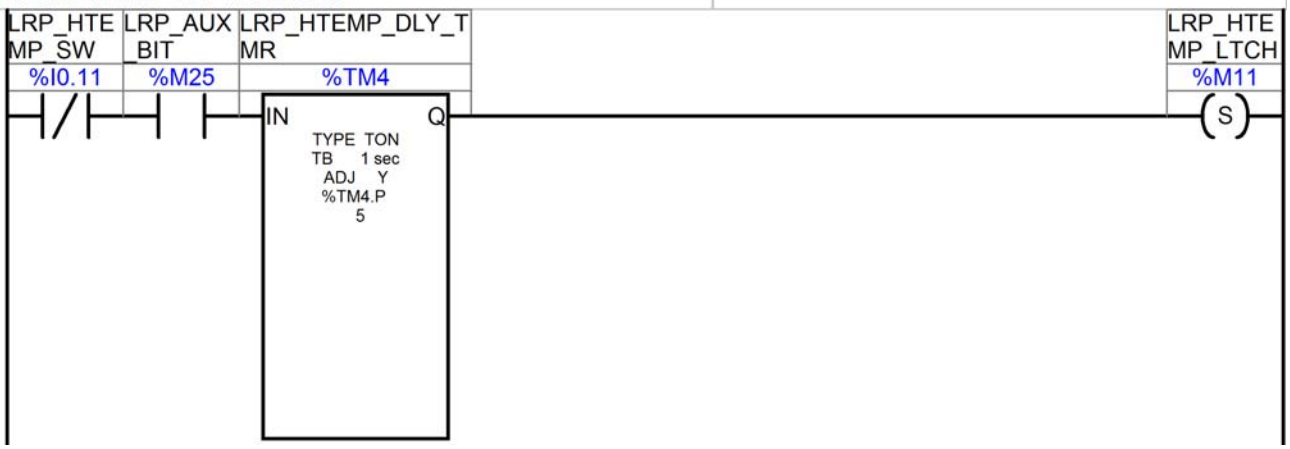
LRP HIGH OIL LEVEL ALARM

Rung 12



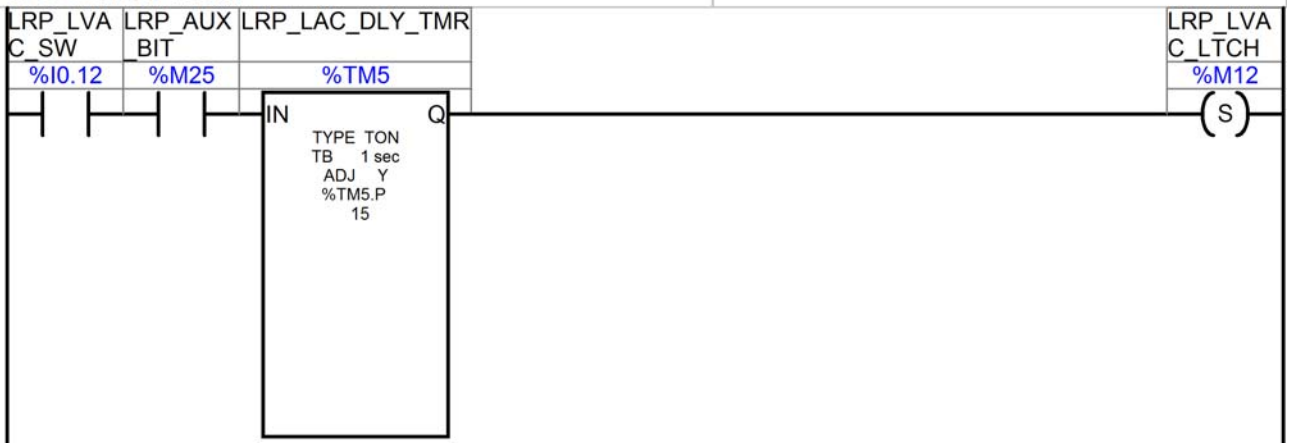
LRP HIGH TEMPERATURE ALARM

Rung 13



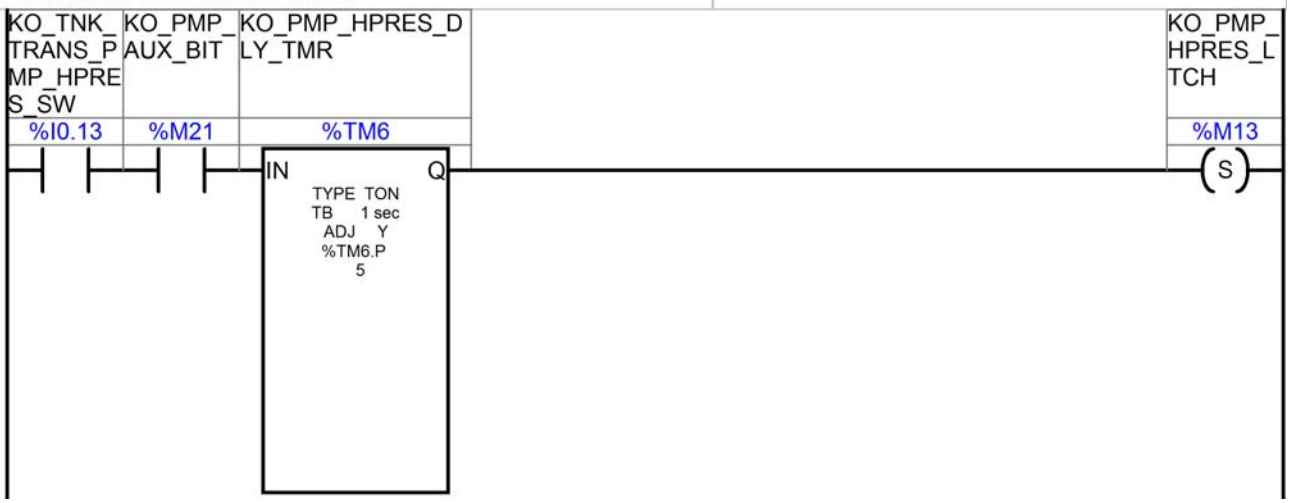
LRP LOW VACUUM ALARM

Rung 14



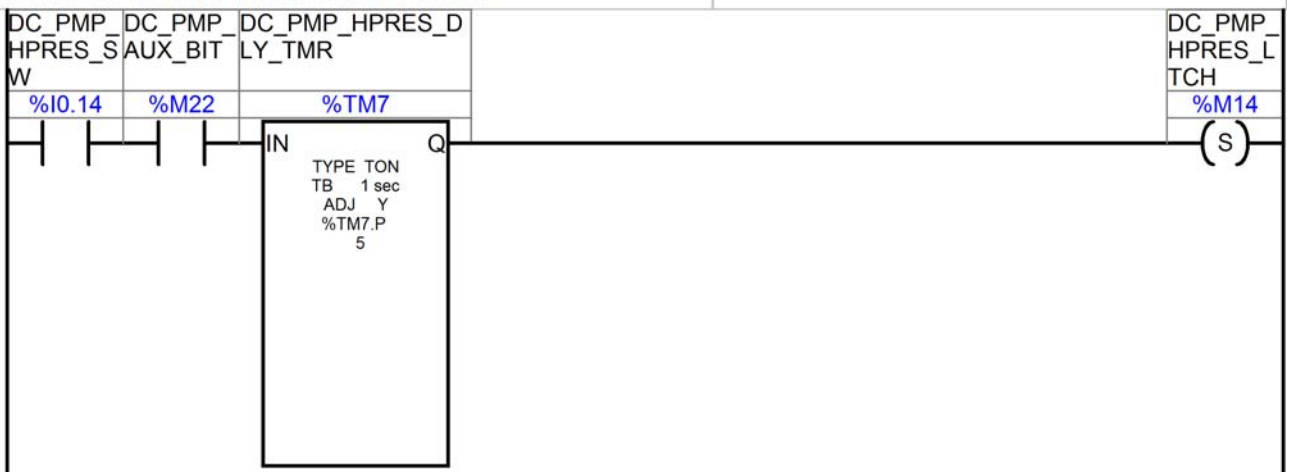
KO PUMP HIGH PRESSURE ALARM

Rung 15



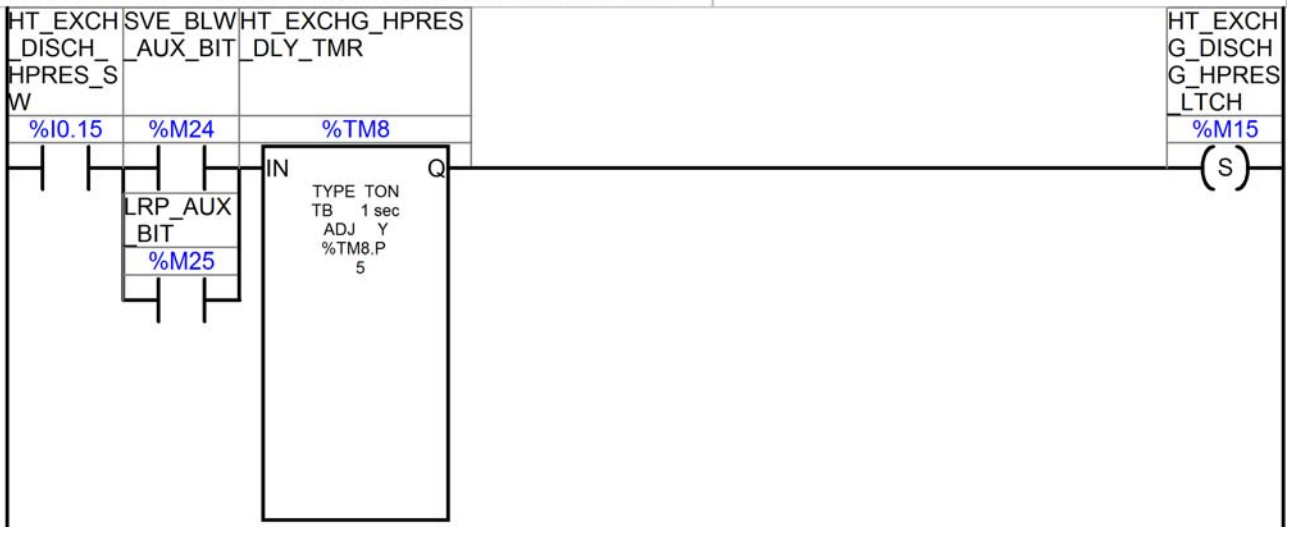
DISCHARGE PUMP HIGH PRESSURE ALARM

Rung 16



HEAT EXCHANGER DISCHARGE HIGH PRESSURE ALARM

Rung 17

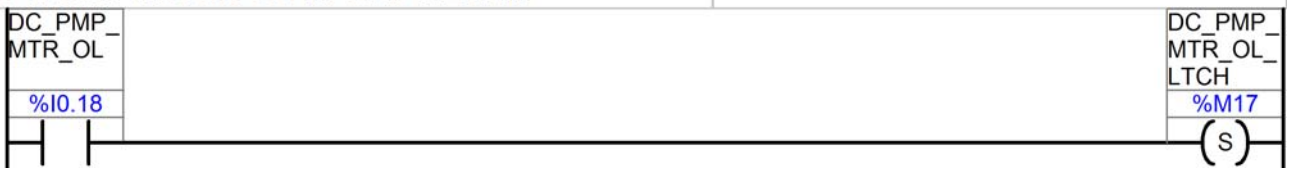


KO PUMP MOTOR OVERLOAD ALARM

Rung 18

DISCHARGE PUMP MOTOR OVERLOAD ALARM

Rung 19



HEAT EXCHANGER MOTOR OVERLOAD ALARM

Rung 20

SVE BLOWER MOTOR OVERLOAD ALARM

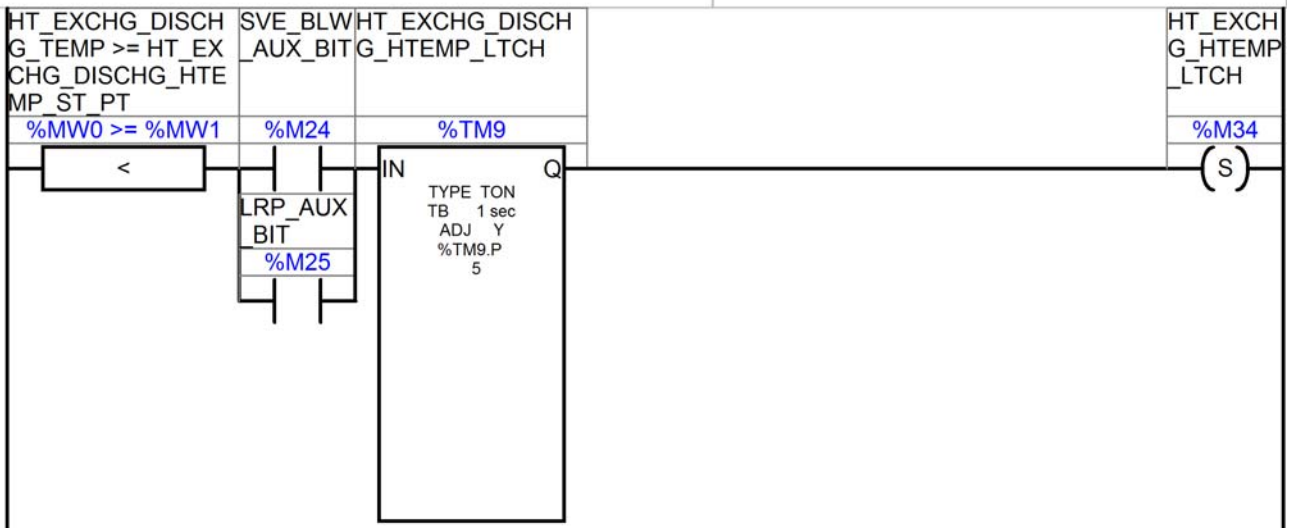
Rung 21

LRP MOTOR OVERLOAD ALARM

Rung 22

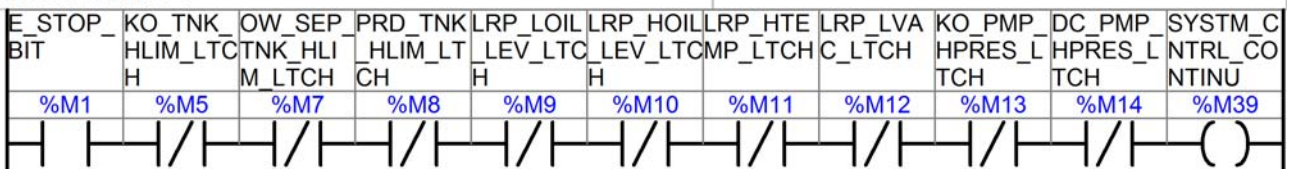
HEAT EXCHANGER DISCHARGE HIGH TEMPERATURE ALARM

Rung 23

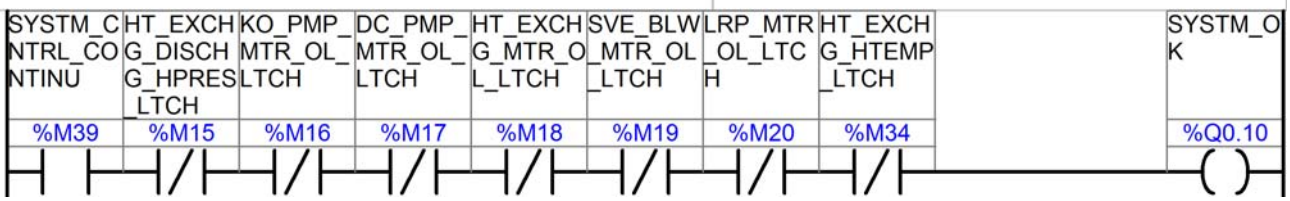


SYSTEM OK CONTROL

Rung 24

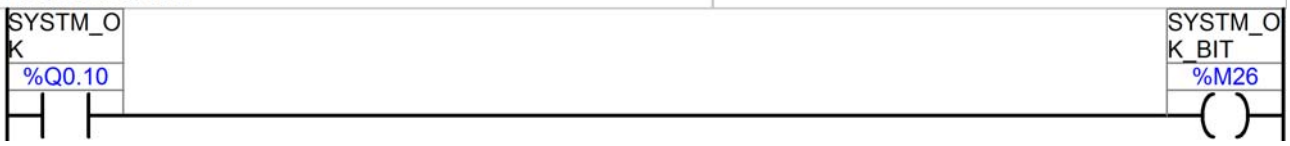


Rung 25



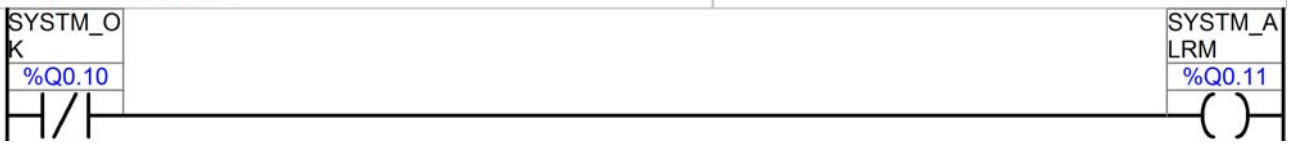
SYSTEM OK AUXILIARY

Rung 26



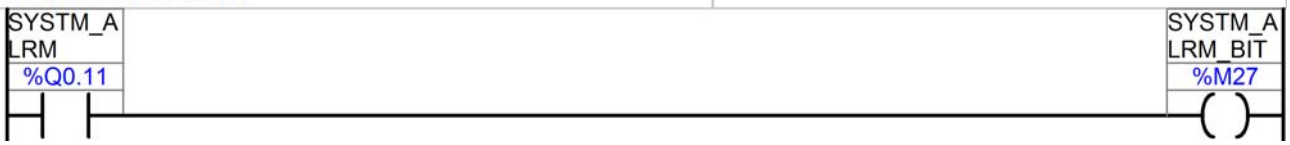
SYSTEM ALARM CONTROL

Rung 27



SYSTEM ALARM AUXILIARY

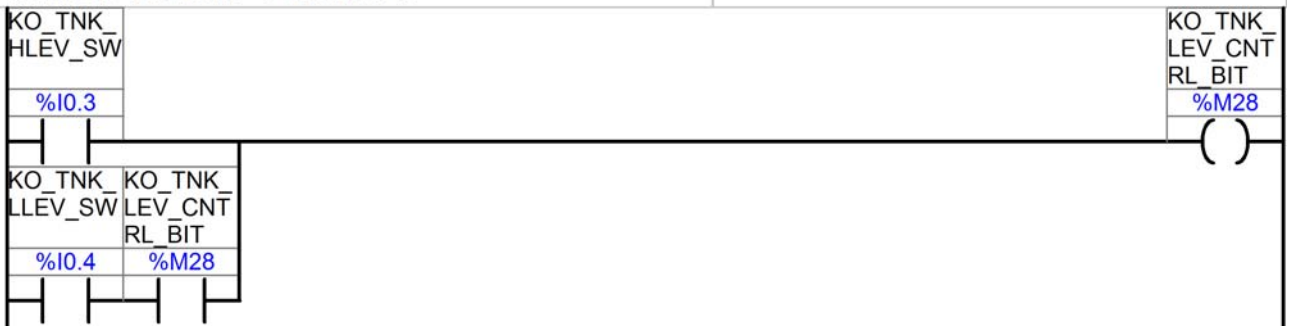
Rung 28



3 LD Motor Controls

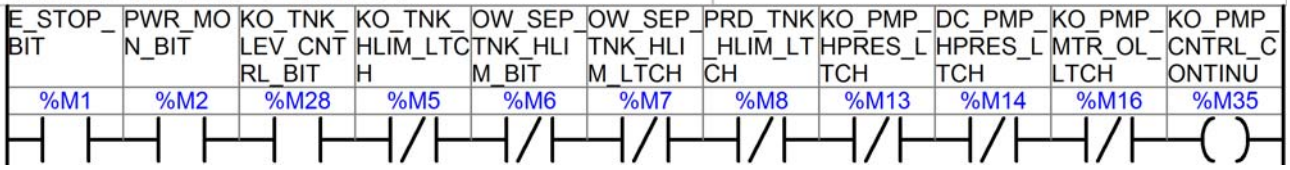
KO TANK TRANSFER PUMP CONTROLS

Rung 0



KO TANK TRANSFER PUMP CONTROL

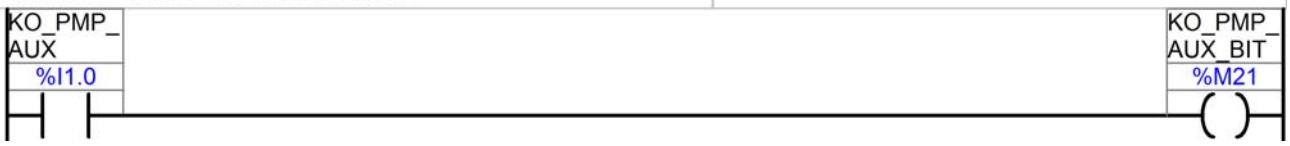
Rung 1



Rung 2

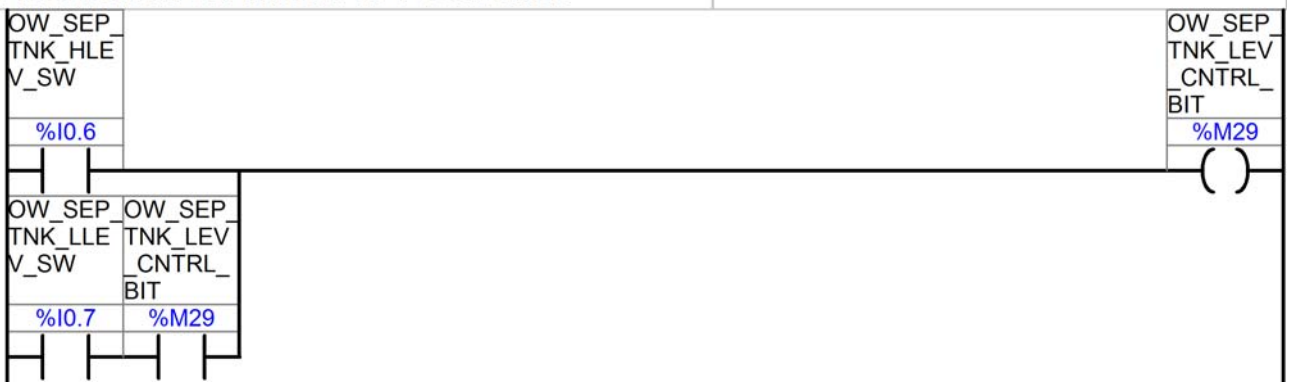
KO TANK TRANSFER PUMP AUXILIARY

Rung 3



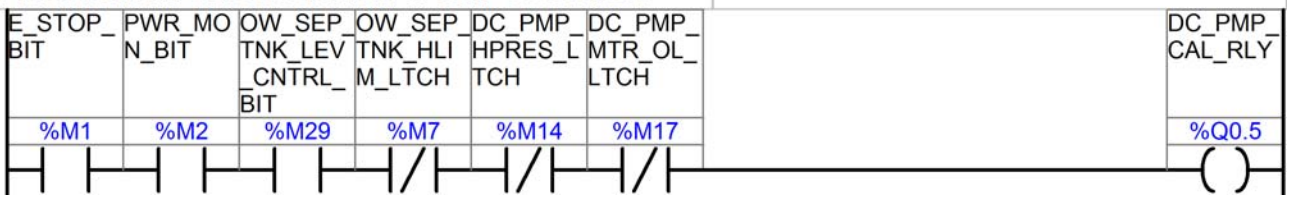
OIL / WATER SEPARATOR TANK LEVEL CONTROL

Rung 4



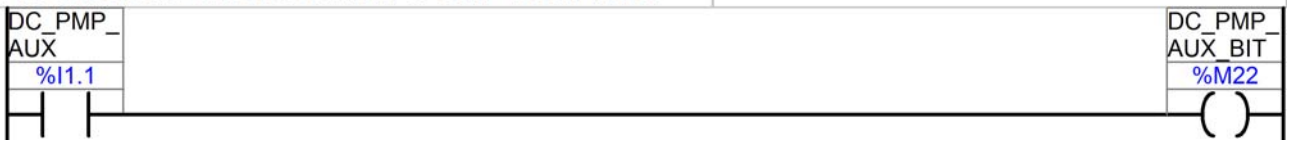
OIL / WATER SEPARATOR DISCHARGE PUMP CONTROL

Rung 5



OIL / WATER SEPARATOR DISCHARGE PUMP AUXILIARY

Rung 6



HEAT EXCHANGER CONTROL

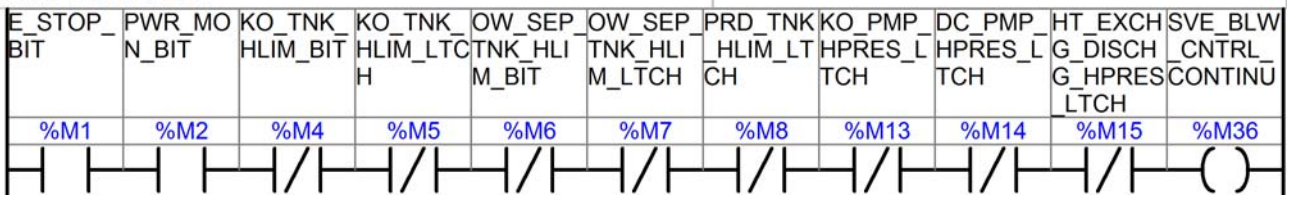
Rung 7

HEAT EXCHANGER AUXILIARY

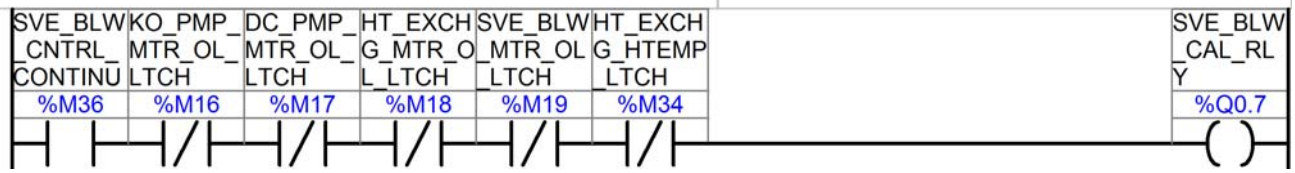
Rung 8

SVE BLOWER CONTROL

Rung 9

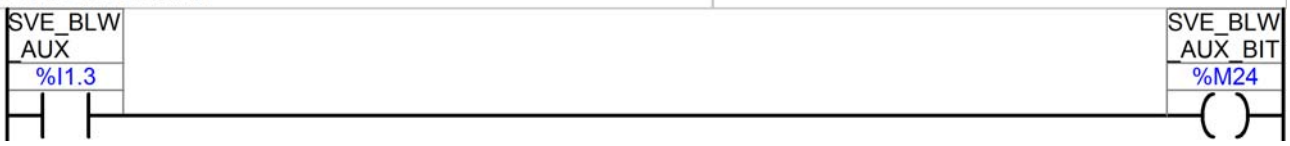


Rung 10



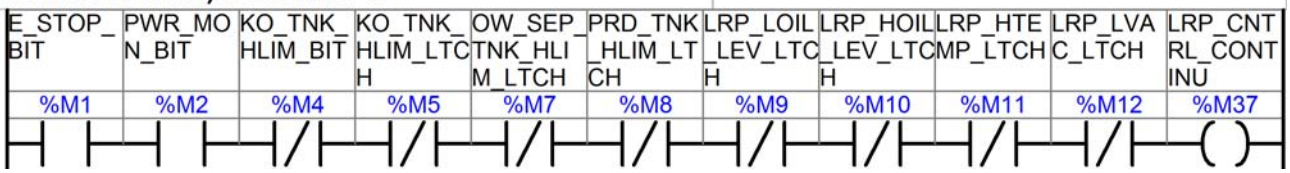
SVE BLOWER AUXILIARY

Rung 11

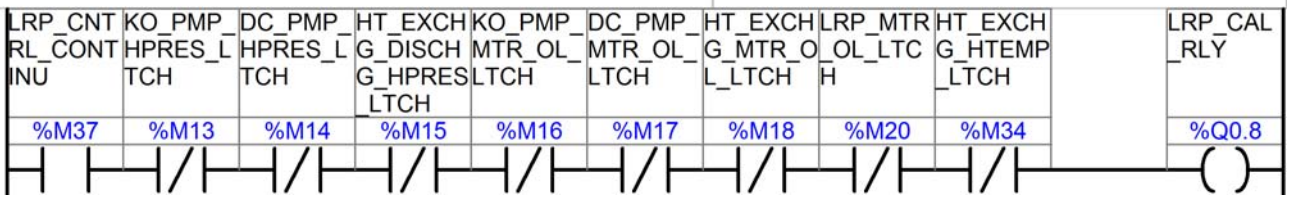


LRP (LIQUID RING PUMP) CONTROLS

Rung 12

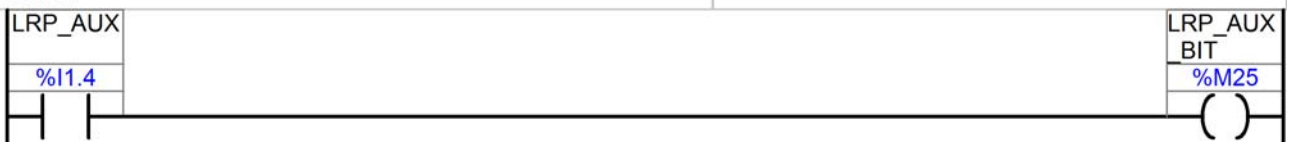


Rung 13



LRP AUXILIARY

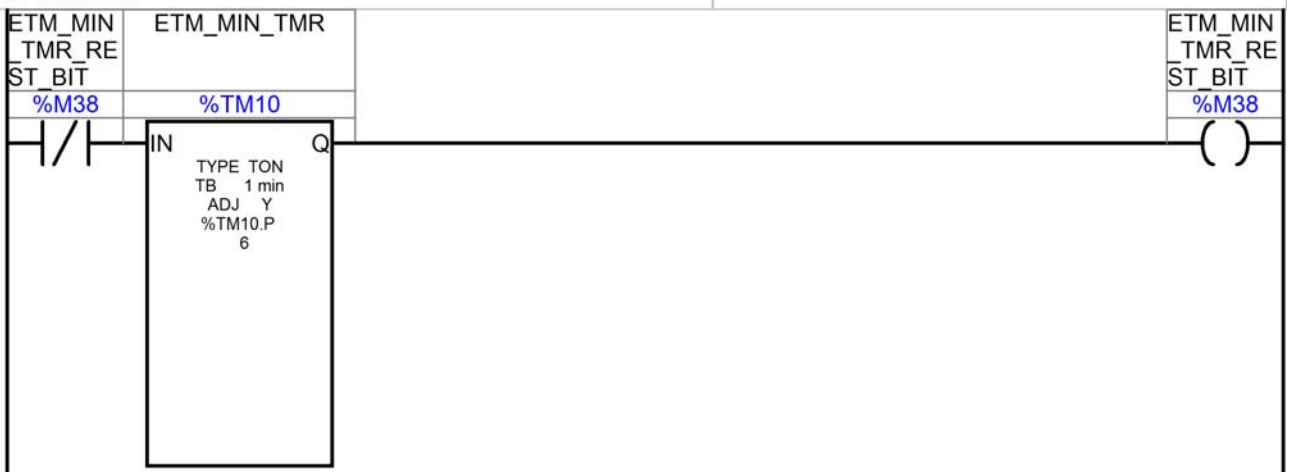
Rung 14



4 LD	Elapse Time Meter (ETM)	

ETM MINUTE TIMER

Rung 0

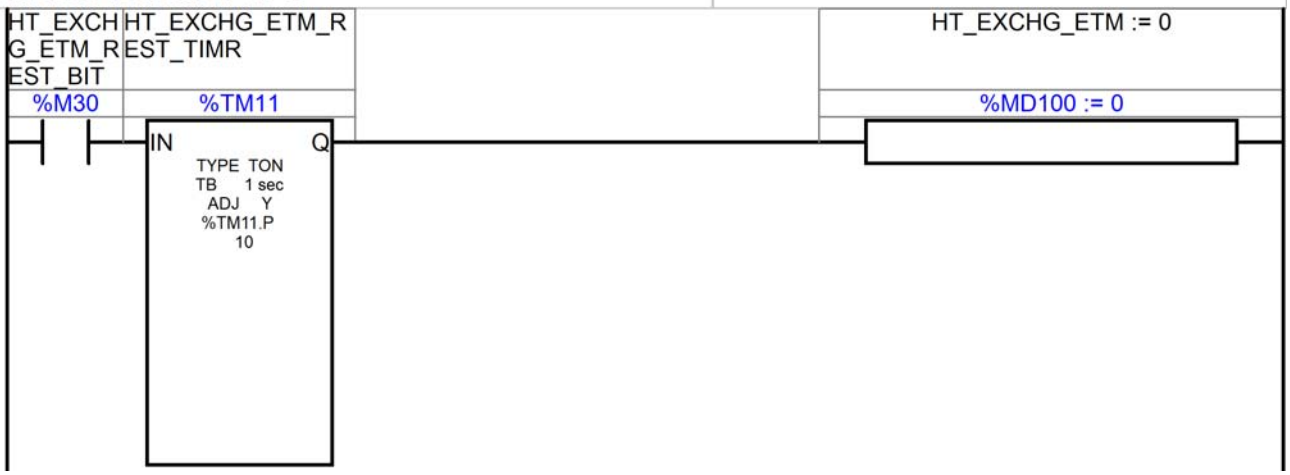


HEAT EXCHANGER ETM

Rung 1

HEAT EXCHANGER ETM RESET

Rung 2

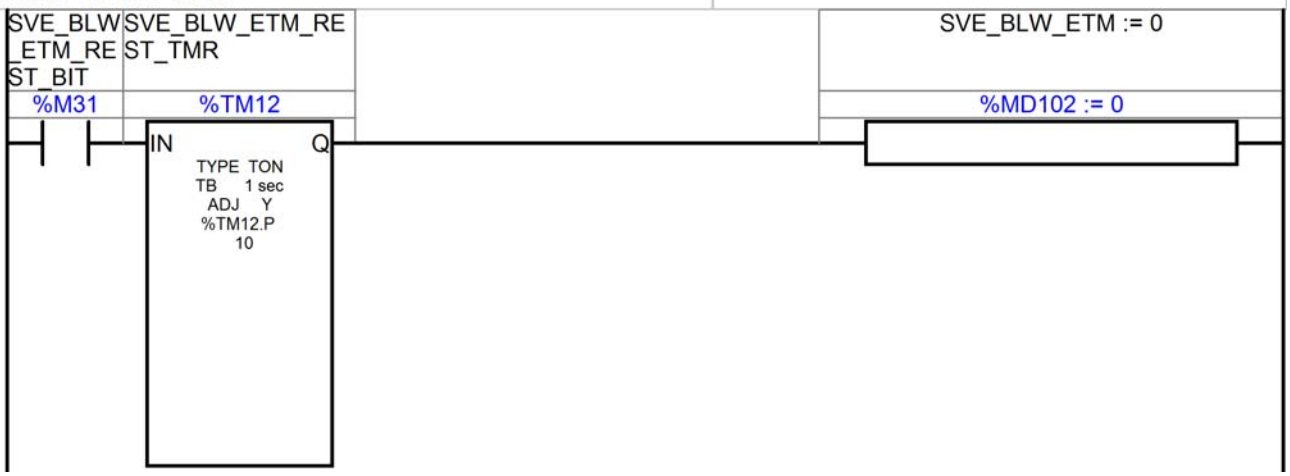


SVE BLOWER ETM

Rung 3

SVE BLOWER ETM RESET

Rung 4

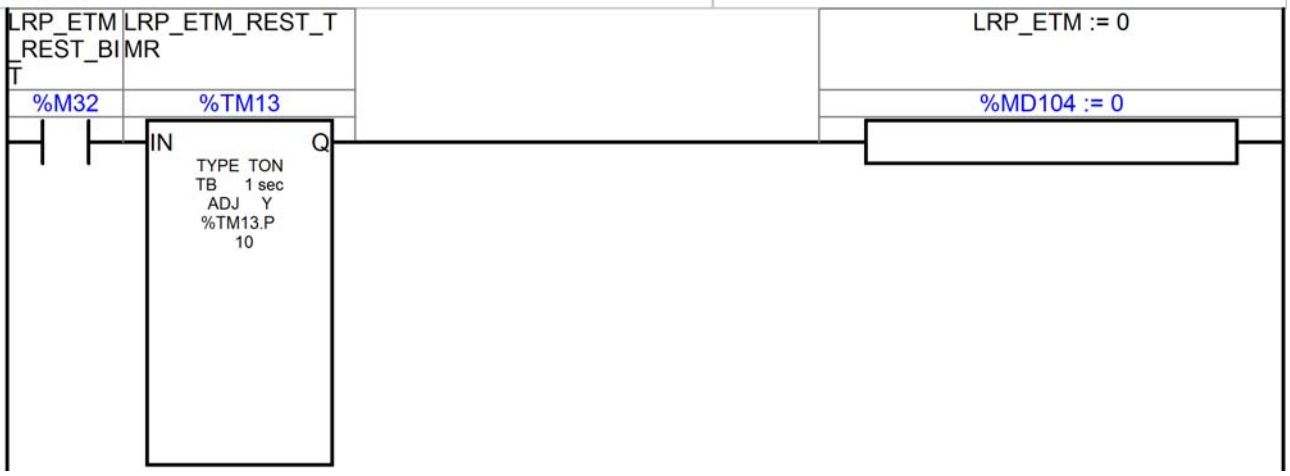


LRP ETM

Rung 5

LRP ETM RESET

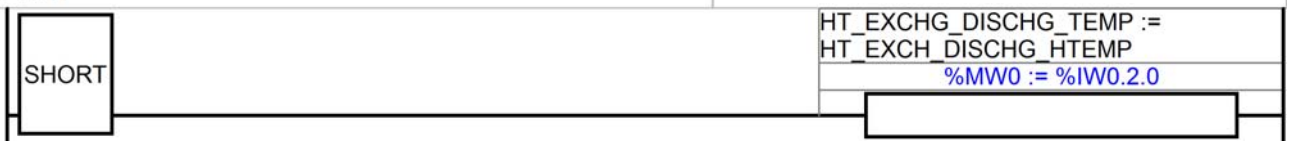
Rung 6



5 LD Analog Devices

HEAT EXCHANGER DISCHARGE TEMPERATURE TRANSMITTER

Rung 0



Symbols

Used	Address	Symbol	Comment
Yes	%I1.1	DC_PMP_AUX	Discharge Pump Auxiliary
Yes	%M22	DC_PMP_AUX_BIT	Discharge Pump Auxiliary Bit
Yes	%Q0.5	DC_PMP_CAL_RLY	Discharge Pump Call Relay
Yes	%TM7	DC_PMP_HPRES_DLY_TMR	DC Pump High Pressure Delay Timer
Yes	%M14	DC_PMP_HPRES_LTCH	DC Pump High Pressure Latch
Yes	%I0.14	DC_PMP_HPRES_SW	Discharge Pump High Pressure Switch
Yes	%I0.18	DC_PMP_MTR_OL	Discharge Pump Motor Overload
Yes	%M17	DC_PMP_MTR_OL_LTCH	Discharge Pump Motor Overload Latch
Yes	%MW705	DIALOG_TABLE_CALC	Dialog Table Calc
Yes	%MW701	DIALOG_TABLE_RTC1	Dialog Table RTC1
Yes	%MW702	DIALOG_TABLE_RTC2	Dialog Table RTC2
Yes	%MW703	DIALOG_TABLE_RTC3	Dialog Table RTC3
Yes	%MW704	DIALOG_TABLE_RTC4	Dialog TAble TRC4
Yes	%TM10	ETM_MIN_TMR	ETM Minute Timer
Yes	%M38	ETM_MIN_TMR_REST_BIT	ETM Minute Timer Reset Bit
Yes	%I0.0	E_STOP	Emergency Stop Switch
Yes	%M1	E_STOP_BIT	Emergency Stop Bit
Yes	%M0	E_STOP_REST_BIT	Emergency Stop Reset Bit
Yes	%M23	HT_EXCHG_AUX_BIT	Heat Exchanger Auxiliary Bit
Yes	%M15	HT_EXCHG_DISCHG_HPRES_LTCH	Heat Exchanger Discharge High Pressure Latch
Yes	%TM9	HT_EXCHG_DISCHG_HTEMP_LTCH	Heat Exchanger Discharge High Temperature Latch
Yes	%MW1	HT_EXCHG_DISCHG_HTEMP_ST_PT	Heat Exchanger Discharge Temperature High Set Point
Yes	%MW0	HT_EXCHG_DISCHG_TEMP	Heat Exchanger Discharge Temperature
Yes	%MD100	HT_EXCHG_ETM	Heat Exchanger ETM
Yes	%M30	HT_EXCHG_ETM_REST_BIT	Heat Exchanger ETM Reset Bit
Yes	%TM11	HT_EXCHG_ETM_REST_TIMR	Heat Exchanger ETM Reset Timer
Yes	%TM8	HT_EXCHG_HPRES_DLY_TMR	Heat Exchanger High Pressure Delay Timer
Yes	%M34	HT_EXCHG_HTEMP_LTCH	Heat Exchanger Discharge High Temperature Latch
Yes	%M18	HT_EXCHG_MTR_OL_LTCH	Heat Exchanger Motor Overload Latch
Yes	%I1.2	HT_EXCH_AUX	Heat Exchanger Auxiliary
Yes	%Q0.6	HT_EXCH_CAL_RLY	Heat Exchanger Call Relay
Yes	%IW2.0	HT_EXCH_DISCHG_HTEMP	Heat Exchanger Discharge High Temperature
Yes	%I0.15	HT_EXCH_DISCH_HPRES_SW	Heat Exchanger Discharge High Pressure Switch
Yes	%I0.19	HT_EXCH_MTR_OL	Heat Exchanger Motor Overload
Yes	%I1.0	KO_PMP_AUX	KO Pump Auxiliary
Yes	%M21	KO_PMP_AUX_BIT	KO Pump Auxiliary Bit
Yes	%Q0.4	KO_PMP_CAL_RLY	KO Pump Call Relay
Yes	%M35	KO_PMP_CNTRL_CONTINU	KO Pump Control Continued
Yes	%TM6	KO_PMP_HPRES_DLY_TMR	KO Pump High Pressure Delay Timer
Yes	%M13	KO_PMP_HPRES_LTCH	KO Pump High Pressure Latch
Yes	%I0.17	KO_PMP_MTR_OL	KO Pump Motor Overload
Yes	%M16	KO_PMP_MTR_OL_LTCH	KO Pump Motor Overload Latch
Yes	%I0.3	KO_TNK_HLEV_SW	KO Tank High Level switch
Yes	%M4	KO_TNK_HLIM_BIT	KO Tank High Limit Bit
Yes	%TM0	KO_TNK_HLIM_DLY_TMR	KO Tank High Limit Delay Timer

Used	Address	Symbol	Comment
Yes	%M5	KO_TNK_HLIM_LTCH	KO Tank High Limit Latch
Yes	%I0.2	KO_TNK_HLIM_SW	KO Tank High Limit Switch
Yes	%M28	KO_TNK_LEV_CNTRL_BIT	KO Tank Level Control Bit
Yes	%I0.4	KO_TNK_LLEV_SW	KO Tank Low Level Switch
Yes	%I0.13	KO_TNK_TRANS_PMP_HPRES_SW	KO Pump High Pressure Switch
Yes	%I1.4	LRP_AUX	LRP Auxiliary
Yes	%M25	LRP_AUX_BIT	LRP Auxiliary Bit
Yes	%Q0.8	LRP_CAL_RLY	LRP Call Relay
Yes	%M37	LRP_CNTRL_CONTINU	LRP Controls Continued
Yes	%MD104	LRP_ETM	LRP ETM
Yes	%M32	LRP_ETM_REST_BIT	LRP ETM Reset Bit
Yes	%TM13	LRP_ETM_REST_TMR	LRP ETM Reset Timer
Yes	%TM3	LRP_HOIL_LEV_DLY_TMR	LRP High Ol Level Delay Timer
Yes	%M10	LRP_HOIL_LEV_LTCH	LRP High Oil Level Latch
Yes	%I0.10	LRP_HOIL_LEV_SW	LRP High Oil Level Switch
Yes	%TM4	LRP_HTEMP_DLY_TMR	LRP High Temperature Delay Timer
Yes	%M11	LRP_HTEMP_LTCH	LRP High Temperature Latch
Yes	%I0.11	LRP_HTEMP_SW	LRP High Temperature Switch
Yes	%TM5	LRP_LAC_DLY_TMR	LRP Low Vacuum Delay imer
Yes	%TM2	LRP_LOIL_LEV_DLY_TMR	LRP Low Oil Level Delay Timer
Yes	%M9	LRP_LOIL_LEV_LTCH	LRP Low Oil Level Latch
Yes	%I0.9	LRP_LOIL_LEV_SW	LRP Low Oil Level Switch
Yes	%M12	LRP_LVAC_LTCH	LRP Low Vacuum Latch
Yes	%I0.12	LRP_LVAC_SW	LRP Low Vacuum Switch
Yes	%I0.21	LRP_MTR_OL	LRP Motor Overload
Yes	%M20	LRP_MTR_OL_LTCH	LRP Motor Overload Latch
Yes	%I0.6	OW_SEP_TNK_HLEV_SW	Oil/Water Separator Tank High Level Switch
Yes	%M6	OW_SEP_TNK_HLIM_BIT	OW Separator Tank High Limit Bit
Yes	%TM1	OW_SEP_TNK_HLIM_DLY_TMR	OW Separator Tank High Limit Delay Timer
Yes	%M7	OW_SEP_TNK_HLIM_LTCH	OW Separator Tank High Limit Latch
Yes	%I0.5	OW_SEP_TNK_HLIM_SW	Oil/Water Separator Tank High Limit Switch
Yes	%M29	OW_SEP_TNK_LEV_CNTRL_BIT	OW Separator Tank Level Control Bit
Yes	%I0.7	OW_SEP_TNK_LLEV_SW	Oil/Water Separator Tank Low Level Switch
Yes	%M8	PRD_TNK_HLIM_LTCH	Product Tank High Limit Latch
Yes	%I0.8	PRD_TNK_HLIM_SW	Product Tank High Limit Switch
Yes	%I0.1	PWR_MON	Power Monitor
Yes	%M2	PWR_MON_BIT	Powr Monitor Bit
Yes	%M3	PWR_MON_LTCH	Power Monitor Latch
No	%MW700	REAL_TM_STRT	Start Real Time Clock
Yes	%I1.3	SVE_BLW_AUX	SVE Blower Auxiliary
Yes	%M24	SVE_BLW_AUX_BIT	SVE Blower Auxiliary Bit
Yes	%Q0.7	SVE_BLW_CAL_RLY	SVE Blower Call Relay
Yes	%M36	SVE_BLW_CNTRL_CONTINU	SVE Blower Control Continued
Yes	%MD102	SVE_BLW_ETM	SVE Blower ETM
Yes	%M31	SVE_BLW_ETM_REST_BIT	SVE Blower ETM Reset Bit
Yes	%TM12	SVE_BLW_ETM_REST_TMR	SVE Blower ETM Reset Timer
Yes	%I0.20	SVE_BLW_MTR_OL	SVE Blower Motor Overload
Yes	%M19	SVE_BLW_MTR_OL_LTCH	SVE Blower Motor Overload Latch
Yes	%Q0.11	SYSTM_ALRM	System Alarm
Yes	%M27	SYSTM_ALRM_BIT	System Alarm Bit
Yes	%M39	SYSTM_CNTRL_CONTINU	System OK Control Continued
Yes	%Q0.10	SYSTM_OK	System OK
Yes	%M26	SYSTM_OK_BIT	System OK Bit

Used	Address	Symbol	Comment
Yes	%M33	SYSTM_REST_BIT	System Reset Bit

Cross references

Address	Symbol	Section	Lines/Networks	Operator
%MW701	DIALOG_TABLE_RTC1	1	1	[:= OR]
%MW702	DIALOG_TABLE_RTC2	1	2	[:=]
%MW703	DIALOG_TABLE_RTC3	1	3	[:=]
%MW704	DIALOG_TABLE_RTC4	1	4	[:=]
%MW705	DIALOG_TABLE_CALC	1	1	[:= OR]
%SW49		1	1	[:= OR]
%SW51		1	2	[:=]
%SW52		1	3	[:=]
%SW53		1	4	[:=]
1		1	1	LD
		1	2	LD
		1	3	LD
		1	4	LD

Animation table

My animation table 1

Used	Address	Symbol	Units
Yes	%TM0.P	KO_TNK_HLIM_DLY_TMR.P	Decimal
Yes	%TM0.V	KO_TNK_HLIM_DLY_TMR.V	Decimal
Yes	%TM0.Q	KO_TNK_HLIM_DLY_TMR.Q	Decimal
Yes	%TM1.P	OW_SEP_TNK_HLIM_DLY_TMR.P	Decimal
Yes	%TM1.V	OW_SEP_TNK_HLIM_DLY_TMR.V	Decimal
Yes	%TM1.Q	OW_SEP_TNK_HLIM_DLY_TMR.Q	Decimal

Twido programmable controllers
Hardware Reference Guide

TWD USE 10AE eng Version 2.5

a brand of Schneider Electric

Telemecanique

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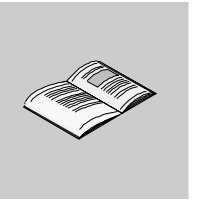

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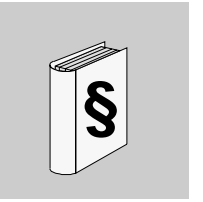
Safety Information



Important Information

NOTICE

Read these instructions carefully, and look at the equipment to become familiar with the device before trying to install, operate, or maintain it. The following special messages may appear throughout this documentation or on the equipment to warn of potential hazards or to call attention to information that clarifies or simplifies a procedure.

The addition of this symbol to a Danger or Warning safety label indicates that an electrical hazard exists, which will result in personal injury if the instructions are not followed.

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

DANGER

DANGER indicates an imminently hazardous situation, which, if not avoided, **will result** in death, serious injury, or equipment damage.

WARNING

WARNING indicates a potentially hazardous situation, which, if not avoided, **can result** in death, serious injury, or equipment damage.

CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

PLEASE NOTE

Electrical equipment should be serviced only by qualified personnel. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material. This document is not intended as an instruction manual for untrained persons. Assembly and installation instructions are provided in the Twido Hardware Reference Manual, TWD USE 10AE.

Additional Safety Information

Those responsible for the application, implementation or use of this product must ensure that the necessary design considerations have been incorporated into each application, completely adhering to applicable laws, performance and safety requirements, regulations, codes and standards.

General Warnings and Cautions

WARNING

EXPLOSION HAZARD

- Substitution of components may impair suitability for Class I, Div 2 compliance.
- Do not disconnect equipment unless power has been switched off or the area is known to be non-hazardous.

Failure to follow this precaution can result in death, serious injury, or equipment damage.

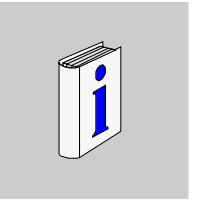
WARNING

UNINTENDED EQUIPMENT OPERATION

- Turn power off before installing, removing, wiring, or maintaining.
- This product is not intended for use in safety critical machine functions. Where personnel and or equipment hazards exist, use appropriate hard-wired safety interlocks.
- Do not disassemble, repair, or modify the modules.
- This controller is designed for use within an enclosure.
- Install the modules in the operating environment conditions described.
- Use the sensor power supply only for supplying power to sensors connected to the module.
- Use an IEC60127-approved fuse on the power line and output circuit to meet voltage and current requirements. Recommended fuse: Littelfuse 5x20 mm slowblow type 218000 series/Type T.

Failure to follow this precaution can result in death, serious injury, or equipment damage.

About the Book



At a Glance

Document Scope	This manual provides parts descriptions, specifications, wiring schematics, installation, set up, and troubleshooting information for all Twido products.
Validity Note	The information in this manual is applicable only for Twido products.
Product Related Warnings	Schneider Electric assumes no responsibility for any errors that appear in this document. No part of this document may be reproduced in any form or means, including electronic, without prior written permission of Schneider Electric.
User Comments	We welcome your comments about this document. You can reach us by e-mail at TECHCOMM@modicon.com

Twido Overview

1

At a Glance

Introduction

This chapter provides an overview of the Twido products, the maximum configurations, the main functions of the controllers, and an overview of the communication system.

What's in this Chapter?

This chapter contains the following topics:

Topic	Page
About Twido	14
Maximum Hardware Configuration	20
Main Functions of the Controllers	24
Communication Overview	27

About Twido

Introduction

The Twido controller is available in two models:
- Compact
- Modular

The Compact controller is available with:
- 10 I/Os
- 16 I/Os
- 24 I/Os
- 40 I/Os

The Modular controller is available with:
- 20 I/Os
- 40 I/Os

Additional I/O can be added to the controllers using expansion I/O modules. They are:
- 15 expansion modules of the digital I/O or relay type
- 4 expansion modules of the analog I/O type

Connecting to an AS-Interface bus interface module also allows you to manage up to 62 slave devices. Use the following module:
- AS-Interface V2 bus interface master module: TWDNOI10M3.

There are also several options that can be added to the base controllers:
- Memory cartridges
- Real-Time Clock (RTC) cartridge
- Communication adapters
- Communication expansion modules (Modular controller only)
- Operator display module (Compact controller only)
- Operator display expansion module (Modular controller only)
- Input simulators
- Programming cables
- Digital I/O cables
- TeleFast cable system kits with I/O interfaces

Advanced integrated features are provided on the TWDLCAA40DRF and TWDLCAE40DRF series compact base controllers:
- Built-in 100Base-TX Ethernet network port: TWDLCAE40DRF only
- Onboard Real-Time Clock (RTC): TWDLCAA40DRF and TWDLCAE40DRF
- A fourth Fast Counter (FC):TWDLCAA40DRF and TWDLCAE40DRF
- External battery support:TWDLCAA40DRF and TWDLCAE40DRF

Controller Models

The following table lists the controllers:

Controller Name	Reference	Channels	Channel type	Input/Output type	Power supply
Compact 10 I/O	TWDLCAA10DRF	6	Inputs	24 VDC	100/240 VAC
		4	Outputs	Relay	
Compact 10 I/O	TWDLCDA10DRF	6	Inputs	24 VDC	24 VDC
		4	Outputs	Relay	
Compact 16 I/O	TWDLCAA16DRF	9	Inputs	24 VDC	100/240 VAC
		7	Outputs	Relay	
Compact 16 I/O	TWDLCDA16DRF	9	Inputs	24 VDC	24 VDC
		7	Outputs	Relay	
Compact 24 I/O	TWDLCAA24DRF	14	Inputs	24 VDC	100/240 VAC
		10	Outputs	Relay	
Compact 24 I/O	TWDLCDA24DRF	14	Inputs	24 VDC	24 VDC
		10	Outputs	Relay	
Compact 40 I/O	TWDLCAA40DRF TWDLCAE40DRF	24	Inputs	24 VDC	100/240 VAC
		16	Outputs	Relay X 14 Transistors X 2	
Modular 20 I/O	TWDLMDA20DUK	12	Inputs	24 VDC	24 VDC
		8	Outputs	Transistor sink	
Modular 20 I/O	TWDLMDA20DTK	12	Inputs	24 VDC	24 VDC
		8	Outputs	Transistor source	
Modular 20 I/O	TWDLMDA20DRT	12	Inputs	24 VDC	24 VDC
		6 2	Outputs Outputs	Relay Transistor source	
Modular 40 I/O	TWDLMDA40DUK	24	Inputs	24 VDC	24 VDC
		16	Outputs	Transistor sink	
Modular 40 I/O	TWDLMDA40DTK	24	Inputs	24 VDC	24 VDC
		16	Outputs	Transistor source	

Digital Expansion I/O Modules

The following table lists the digital and relay expansion I/O modules:

Module Name	Reference	Chan-nels	Channel type	Input/Output type	Terminal type
Input modules					
8-point input	TWDDDI8DT	8	Inputs	24 VDC	Removable terminal block
8-point input	TWDDAI8DT	8	Inputs	120 VAC	Removable terminal block
16-point input	TWDDDI16DT	16	Inputs	24 VDC	Removable terminal block
16-point input	TWDDDI16DK	16	Inputs	24 VDC	Connector
32-point input	TWDDDI32DK	32	Inputs	24 VDC	Connector
Output Modules					
8-point output	TWDDD08UT	8	Outputs	Transistor sink	Removable terminal block
8-point output	TWDDD08TT	8	Outputs	Transistor source	Removable terminal block
8-point output	TWDDRA8RT	8	Outputs	Relay	Removable terminal block
16-point output	TWDDRA16RT	16	Outputs	Relay	Removable terminal block
16-point output	TWDDDO16UK	16	Outputs	Transistor sink	Connector
16-point output	TWDDDO16TK	16	Outputs	Transistor source	Connector
32-point output	TWDDDO32UK	32	Outputs	Transistor sink	Connector
32-point output	TWDDDO32TK	32	Outputs	Transistor source	Connector
Mixed modules					
4-point input/4-point output	TWDDMM8DRT	4	Inputs	24 VDC	Removable terminal block
		4	Outputs	Relay	
16-point input/ 8-point output	TWDDMM24DRF	16	Inputs	24 VDC	Non-removable terminal block
		8	Outputs	Relay	

Analog Expansion I/O Modules

The following table lists the analog expansion I/O modules:

Module name	Reference	Channel	Channel type	Details	Terminal type
2 high level inputs	TWDAMI2HT	2	Inputs	12 bits 0-10 V, 4-20 mA	Removable terminal block
1 high level output	TWDAM01HT	1	Outputs	12 bits 0-10 V, 4-20 mA	Removable terminal block
2 high level inputs/1 output	TWDAMM3HT	2 1	Inputs Outputs	12 bits 0-10 V, 4-20 mA	Removable terminal block
2 low level inputs/1 high level output	TWDALM3LT	2 1	Inputs Outputs	12 bits 0-10V, 4-20mA, RTD, thermocouple	Removable terminal block

AS-Interface V2 bus master module

The following table lists the specifications of the AS-Interface V2 bus master module:

Module name	Reference	Number of slaves	Maximum number of channels	Power supply	Terminal type
AS-Interface master	TWDNOI10M3	Maximum 62	248 inputs 186 outputs	30 VDC	Removable terminal block

Options

The following table lists the options:

Option name	Reference
Operator display module	TWDXCPODC
Operator display expansion module	TWDXCPODM
Real Time Clock (RTC) cartridge	TWDXCPRTC
32 Kb EEPROM memory cartridge	TWDXCPMFK32
64 Kb EEPROM memory cartridge	TWDXCPMFK64
Communication adapter, RS485, miniDIN	TWDNAC485D
Communication adapter, RS232, miniDIN	TWDNAC232D
Communication adapter, RS485, terminal	TWDNAC485T
Communication expansion module, RS485, miniDIN	TWDNOZ485D
Communication expansion module, RS232, miniDIN	TWDNOZ232D
Communication expansion module, RS485, terminal	TWDNOZ485T
6-point input simulator	TWDXSM6
9-point input simulator	TWDXSM9
14-point input simulator	TWDXSM14
5 mounting strips	TWDDXMT5
2 terminal blocks (10 positions)	TWDFTB2T10
2 terminal blocks (11 positions)	TWDFTB2T11
2 terminal blocks (13 positions)	TWDFTB2T13
2 terminal blocks (16 positions)	TWDFTB2T16T
2 connectors (20 pins)	TWDFCN2K20
2 connectors (26 pins)	TWDFCN2K26

Cables

The following table lists the cables:

Cable name	Reference
Programming cables	
PC to controller programming cable: Serial	TSXPCX1031
PC to controller programming cable: USB	TSXPCX3030
Mini-DIN to free wire communication cable	TSXCX100
Digital I/O Cables	
3 meter, connector for controller to free wire	TWDFCW30M
5 meter, connector for controller to free wire	TWDFCW50M
3 meter, connector for expansion I/O module to free wire	TWDFCW30K
5 meter, connector for expansion I/O module to free wire	TWDFCW50K
AS-Interface Cables	
Standard two-wire AS-Interface ribbon cable for sending data and power to slave devices	see AS-Interface Wiring System catalog available from your local Schneider representative
Standard two-wire round cable for sending data and power to slave devices	see AS-Interface Wiring System catalog available from your local Schneider representative
TeleFast Cable System Kits with I/O Interfaces	
Cabling kit, 16 input TeleFast base, 1 meter cable	TWDFST16D10
Cabling kit, 16 input TeleFast base, 2 meter cable	TWDFST16D20
Cabling kit, 16 output TeleFast base, 1 meter cable	TWDFST16R10
Cabling kit, 16 output TeleFast base, 2 meter cable	TWDFST16R20
Cabling kit, 16 input/8 output relay TeleFast base, 1 meter cable	TWDFST20DR10
Cabling kit, 16 input/8 output relay TeleFast base, 2 meter cable	TWDFST20DR20
Ethernet Connection Cable	
SFTP Cat5 RJ45 Ethernet cable	490NTW000••

Maximum Hardware Configuration

Introduction

This section provides the maximum hardware configurations for each controller.

Maximum Hardware Configurations - Compact Controllers

The following table lists the maximum number of configuration items for each compact controller:

Controller Item	**Compact controller**			
TWD...	**LCAA10DRF LCDA10DRF**	**LCAA16DRF LCDA16DRF**	**LCAA24DRF LCDA24DRF**	**LCAA40DRF LCAE40DRF**
Standard digital inputs	6	9	14	24
Standard digital outputs	4	7	10	16 (14 Relay + 2 Transistor outputs)
Max expansion I/O modules (Digital or analog)	0	0	4	7
Max digital inputs (controller I/O + exp I/O)	6	9	14+(4x32)=142	24+(7x32)=248
Max digital outputs (controller I/O + exp I/O)	4	7	10+(4x32)=138	16+(7x32)=240
Max digital I/O (controller I/O + exp I/O)	10	16	24+(4x32)=152	40+(7x32)=264
Max AS-Interface bus interface modules	0	0	2	2
Max I/O with AS-Interface modules (7 I/O per slave)	10	16	24+(2x62x7) =892	40+(2x62x7) =908
Max relay outputs	4 base only	7 base only	10 base + 32 expansion	14 base + 96 expansion
Potentiometers	1	1	2	2
Built-in analog inputs	0	0	0	0

Controller Item	**Compact controller**			
TWD...	**LCAA10DRF LCDA10DRF**	**LCAA16DRF LCDA16DRF**	**LCAA24DRF LCDA24DRF**	**LCAA40DRF LCAE40DRF**
Max analog I/O (controller I/O + exp I/O)	0 in / 0 out	0 in / 0 out	8 in / 4 out	15 in / 7 out
Remote controllers	7	7	7	7
Serial ports	1	2	2	2
Ethernet port	0	0	0	1 (TWDLCA-E40DRF only)
Cartridge slots	1	1	1	1
Largest application/ backup size (KB)	8	16	32	64
Optional memory cartridge (KB)	32[1]	32[1]	32[1]	32 or 64[2]
Optional RTC cartridge	yes[1]	yes[1]	yes[1]	RTC onboard[3]
Optional Operator Display	yes	yes	yes	yes
Optional 2nd port	no	yes	yes	yes

Note:
1. A Compact controller can have either a memory cartridge or an RTC cartridge.
2. Memory cartridge only, for RTC is already onbaord.
3. Both TWDLCA40DRF and TWDLCAE40DRF compact controllers have a built-in RTC. Therefore, no RTC cartridge can be added on those controllers, but only a memory cartridge.

Maximum Hardware Configurations - Modular Controllers

The following table lists the maximum number of configuration items for each modular controller:

Controller Item	Modular controller		
TWD...	**LMDA20DUK LMDA20DTK**	**LMDA20DRT**	**LMDA40DUK LMDA40DTK**
Standard digital inputs	12	12	24
Standard digital outputs	8	8	16
Max expansion I/O modules (Digital or analog)	4	7	7
Max digital inputs (controller I/O + exp I/O)	12+(4x32)=140	12+(7x32)=236	24+(7x32)=248
Max digital outputs (controller I/O + exp I/O)	8+(4x32)=136	8+(7x32)=232	16+(7x32)=240
Max digital I/O (controller I/O + exp I/O)	20+(4x32)=148	20+(7x32)=244	40+(7x32)=264
Max AS-Interface bus interface modules	2	2	2
Max I/O with AS-Interface modules (7 I/O per slave)	20+(2x62x7)=888	20+(2x62x7)=888	40+(2x62x7)=908
Max relay outputs	64 expansion only	6 base + 96 expansion	96 expansion only
Potentiometers	1	1	1
Built-in analog inputs	1	1	1
Max analog I/O (controller I/O + exp I/O)	9 in / 4 out	15 in / 7 out	15 in / 7 out
Remote controllers	7	7	7
Serial ports	2	2	2
Cartridge slots	2	2	2

Controller Item	Modular controller		
TWD...	**LMDA20DUK LMDA20DTK**	**LMDA20DRT**	**LMDA40DUK LMDA40DTK**
Largest application/ backup size (KB)	32	64	64
Optional memory cartridge (KB)	32	32 or 64	32 or 64
Optional RTC cartridge	yes	yes	yes
Optional Operator Display	yes[2]	yes[2]	yes[2]
Optional 2nd port	yes[2]	yes[2]	yes[2]

Note:
1. A Compact controller can have either a memory cartridge or an RTC cartridge.
2. A Modular controller can have either an Operator Display expansion module (with an optional communication adapter) or a communication expansion module.

Main Functions of the Controllers

Introduction

By default all I/O on the controllers are configured as digital I/O. However, certain I/O can be assigned to specific tasks during configuration such as:

- RUN/STOP input
- Latching inputs
- Fast counters:
  - Single up/down counters: 5 kHz (1-phase)
  - Very fast counters: Up/down counters - 20 kHz (2-phase)
- Controller status output
- Pulse Width Modulation (PWM)
- Pulse (PLS) generator output

Twido controllers are programmed using TwidoSoft which enables the following functions to be used on:

- PWM
- PLS
- Fast counters and very fast counters
- PID and PID Auto-Tuning

Main Functions

The following table lists the main functions of the controllers:

Function	Description
Scanning	Normal (cyclical) or periodic (constant) (2 to 150 ms)
Execution time	0.14 µs to 0.9 µs for a list instruction
Memory capacity	Data: 3000 memory words for all controllers, 128 memory bits for TWDLCAA10DRF and TWDLCAA16DRF, 256 memory bits for all other controllers.
	Program: 10 I/O compact controller: 700 list instructions 16 I/O compact controller: 2000 list instructions 24 I/O compact, and 20 I/O modular controllers: 3000 list instructions 20 I/O modular and 40 I/O modular controllers, and 40 I/O compact controllers: 6000 list instructions (with a 64 Kb cartridge, otherwise 3000 list instructions)
RAM backup	• All controllers: By lithium internal battery. Backup duration is approximately 30 days (typical) at 25°C (77°F) after battery is fully charged. The charging time is 15 hours for charging from 0 to 90% of full charge. Battery life is 10 years when charging for 9 hours and discharging for 15 hours. The battery cannot be replaced. • 40DRF compact controllers: By user-replaceable lithium external battery (in addition to internal battery onboard). Backup duration is approximately 3 years (typical) at 25°C (77°F) under normal operating condition of the controller (typically, no long-term powering off of the controller). BAT LED on front-panel provides indication of status for battery-power.
Programming port	• All controllers: EIA RS-485 • 40DRF compact controllers: Built-in RJ45 Ethernet communications port
Expansion I/O modules	10 and 16 I/O compact controllers: no expansion modules 24 I/O compact and 20 I/O modular controllers: up to 4 expansion I/O modules 20 I/O modular and 40 I/O relay controllers: up to 7 expansion I/O modules
AS-Interface V2 bus interface modules	10 and 16 I/O compact controllers: no AS-Interface bus interface module 24 I/O and 40 I/O compact, 20 I/O and 40 I/O modular controllers: up to 2 AS-Interface bus interface modules
Remote link communication	Maximum 7 slaves by remote I/O or peer controllers. Maximum length of entire network: 200 m (650 feet).
Modbus communication	Non-isolated EIA RS-485 type, maximum length limited to 200 m. ASCII or RTU mode.
Ethernet communication	TWDLCAE40DRF compact controller only: 100Base-TX auto-negotiated type Ethernet communications over TCP/IP protocol, via built-in RJ45 port.

Function	Description	
ASCII communication	Half-duplex protocole to a device.	
Dedicated function blocks	PWM/PLS	All Modular controllers: 2
	Fast counters	TWDLCA•40DRF Compact controllers: 4 All other compact controllers: 3 All Modular controllers: 2
	Very fast counters	TWDLCA•40DRF Compact controllers: 2 All other Compact controllers: 1 All Modular controllers: 2
Analog potentiometers	24 I/O and 40 I/O compact controllers: 2 All other controllers: 1	
Built-in analog channel	Compact controllers: none Modular controllers: 1 input	
Programmable input filter	Input filter time can be changed during configuration No filtering or filtering at 3 ms or 12 ms I/O points are configured in groups	
Special I/O	Inputs	RUN/STOP: Any one of the base inputs
		Latching: up to 4 inputs (%I0.2 to %I0.5)
		Built-in analog input connected to %I0.0 according to frequency meter
		Fast counters: 5 kHz maximum Very fast counters: 20 kHz maximum Frequency meter: 1 kHz to 20 kHz maximum
	Outputs	Controller status output: 1 of 3 outputs (%Q0.1 to %Q0.3)
		PLS: 7 kHz maximum
		PWM: 7 kHz maximum

Communication Overview

Introduction

Twido controllers have one, or an optional second, serial port that is used for real-time or system management services. The real-time services provide data distribution functions for exchanging data with I/O devices and messaging functions for communicating to external devices. System management services manage and configure the controller through TwidoSoft. Either serial port is used for any of these services but only serial port 1 is for communicating with TwidoSoft.
To provide these services, there are three protocols available on each controller:

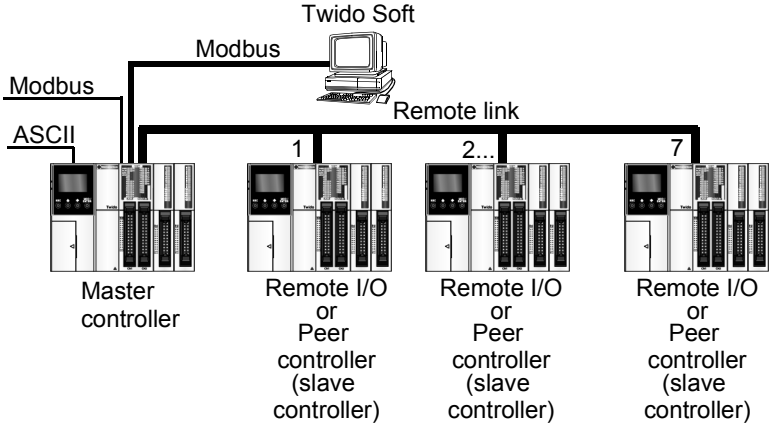
- Remote Link
- Modbus
- ASCII

In addition, the TWDLCAE40DRF compact controller features a built-in RJ45 Ethernet communications port allowing to perform all real-time communications and system management tasks via the network. Ethernet communications implements the following protocol:

- Modbus TCP/IP

Communications Architecture

The following diagram shows a communication architecture with all three protocols.



Note: Communication between the "Modbus" and "Remote Link" protocols cannot occur at the same time.

Remote Link Protocol

The Remote Link protocol is a high-speed master/slave bus designed to communicate a small amount of data between the Master controller and up to seven Remote Slave controllers. Application or I/O data is transferred, depending on the configuration of the Remote controller. A combination of Remote controller types is possible where some can be Remote I/O and some can be Peer controllers.

Modbus Protocol

The Modbus protocol is a master/slave protocol that allows for one master to request responses from slaves or to take action based on the request. The master can address individual slaves or can initiate a broadcast message to all slaves. Slaves return a message (response) to queries that are addressed to them individually. Responses are not returned to broadcast queries from the master.
Modbus Master Mode - The Modbus master mode allows the controller to initiate a Modbus query transmission, with a response expected from a Modbus slave.
Modbus slave mode - Modbus slave mode enables the controller to respond to Modbus queries from a master. This is the default communications mode if no communication is configured.

Modbus TCP/IP Protocol

Note: Modbus TCP/IP is solely supported by TWDLCAE40DRF series of compact controllers with built-in Ethernet network interface.

The following information describes the Modbus Application Protocol (MBAP).
The Modbus Application Protocol (MBAP) is a layer-7 protocol providing peer-to-peer communication between programmable logic controllers (PLCs) and other nodes on a LAN.
The Twido controller TWDLCAE40DRF implements Modbus TCP/IP Client/Server communications over the Ethernet network. Modbus protocol transactions are typical request-response message pairs. A PLC can be both client and server depending on whether it is querying or answering messages. A Modbus TCP/IP Client is equivalent to a Modbus Master controller in legacy Modbus, while a Modbus TCP/IP Server would correspond to a legacy Modbus Slave controller.

ASCII Protocol

The ASCII protocol allows communication between the controller and a simple device such as a printer.

Descriptions, Specifications, and Wiring

2

At a Glance

Introduction

This chapter provides wiring rules and recommendations, overviews, parts descriptions, specifications, and wiring schematics for the Twido products.

What's in this Chapter?

This chapter contains the following sections:

Section	Topic	Page
2.1	Wiring Rules and Recommendations	31
2.2	Compact Controller	35
2.3	Modular Controller	58
2.4	Digital I/O Modules	79
2.5	Analog I/O Modules	107
2.6	AS-Interface V2 bus master module	118
2.7	Communication Options	138
2.8	Operator Display Options	143
2.9	Options	148
2.10	TeleFast Cable Systems	151

2.1 Wiring Rules and Recommendations

Wiring Rules and Recommendations

Introduction

There are several rules that must be followed when wiring a controller or module. Recommendations, when needed, are provided on how to comply with the rules.

DANGER

ELECTRIC SHOCK

- Be sure to remove ALL power from ALL devices before connecting or disconnecting inputs or outputs to any terminal or installing or removing any hardware.
- Be sure to connect the grounding wire to a proper ground.

Failure to follow this precaution will result in death, serious injury, or equipment damage.

WARNING

FAILURE OF OUTPUTS

If outputs should fail, outputs may remain on or off. Where personnel and or equipment hazards exist, use appropriate hard-wired safety interlocks.

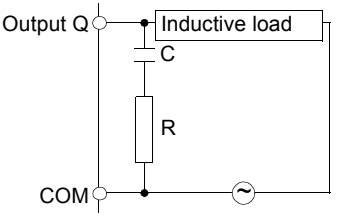
Failure to follow this precaution can result in death, serious injury, or equipment damage.

Rules

- Each terminal accepts up to two 18 AWG (0.82 mm^2) through 28 AWG (0.08 mm^2) fitted with cable ends or tags.
- Output module fusing is the responsibility of the user. It is not within the Twido product itself. Select a fuse appropriate for the load with respect to the electrical codes.
- Depending on the load, a protection circuit may be needed for relay outputs on modules.
- The power supply wire should be between 18 AWG (0.82 mm^2) and 22 AWG (0.33 mm^2). Use the shortest wire length possible.
- The grounding wire should be 16 AWG (1.30 mm^2).
- Power supply wires routed inside the panel must be kept separate from I/O and communication wiring. Route wiring in separate cable ducting.
- Take care when wiring output modules that are designed to work as either source or sink. Incorrect wiring can cause equipment damage.
- Make sure that the operating conditions and environments are within the specification values.
- Use proper wire size to meet voltage and current requirements.

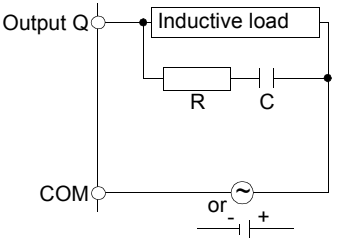
Contact Protection Circuit for Relay and Transistor Outputs

Depending on the load, a protection circuit may be needed for the relay output on the controllers and certain modules. Choose a protection circuit, from the following diagrams, according to the power supply. Connect the protection circuit to the outside of the controller or relay output module.
Protective circuit A: this protection circuit can be used when the load impedance is smaller than the RC impedance in an AC load power circuit.



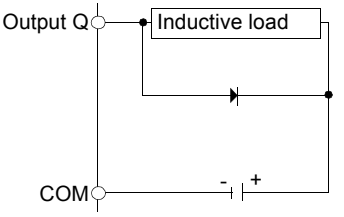
- C represents a value from 0.1 to 1 µF.
- R represents a resistor of approximately the same resistance value as the load.

Protective circuit B: this protection circuit can be used for both AC and DC load power circuits.



- C represents a value from 0.1 to 1 μF.
- R represents a resistor of approximately the same resistance value as the load.

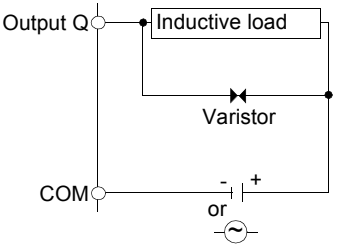
Protective circuit C: this protection circuit can be used for DC load power circuits.



Use a diode with the following ratings:

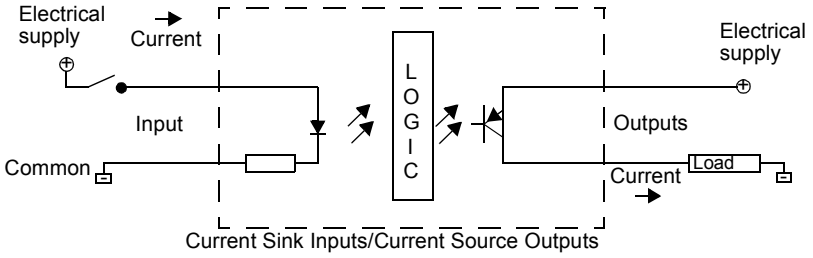
- Reverse withstand voltage: power voltage of the load circuit x 10.
- Forward current: more than the load current.

Protective circuit D: this protection circuit can be used for both AC and DC load power circuits.



Explanation of Source Inputs/ Sink Outputs

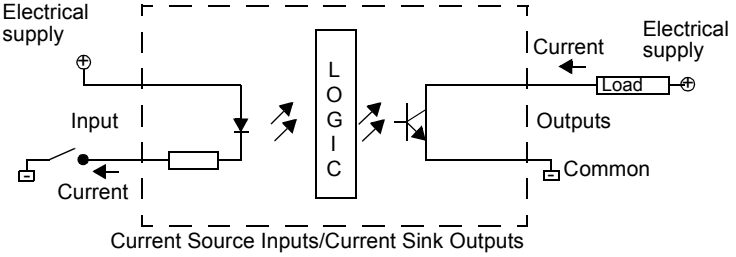
Note: Sink corresponds to the sensors' common on the (+) terminal of the power supply.



Input side COM field terminal connects to the "-" terminal or common of the field power supply. Output side COM field terminal connects to +24V field power supply.

Explanation of Sink Inputs/ Source Outputs

Note: Source corresponds to the sensors' common on the (-) terminal of the power supply.



Input side COM field terminal connects to +24V field power supply. Output side COM field terminal connects to the "-" terminal or common of the field power supply.

2.2 Compact Controller

At a Glance

Introduction

This section provides an overview, parts description, specifications, and wiring schematics of the Compact controllers.

What's in this Section?

This section contains the following topics:

Topic	Page
Overview of Compact Controllers	36
Description of Analog Potentiometers	38
Parts Description of a Compact Controller	39
General Specifications for the Compact Controllers	41
Functional Specifications for the Compact Controllers	45
I/O Specifications for the Compact Controller	47
Compact Controller Wiring Schematics	53

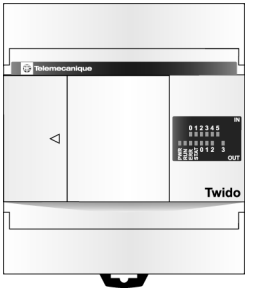
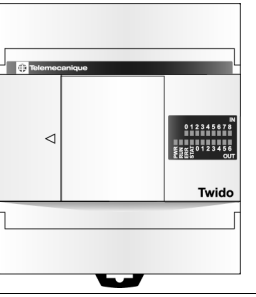
Overview of Compact Controllers

Introduction

The information in this section describes the main features of the Compact controllers.

Illustrations

The following illustrations are the Compact controllers:

Controller Type	Illustration
The Compact 10 I/O controller: ● has 6 digital inputs and 4 relay outputs ● has 1 analog potentiometer ● has 1 integrated serial port ● accepts one optional cartridge (RTC or memory - 32 KB only) ● accepts an optional operator display module	TWDLCAA10DRF TWDLCDA10DRF 
The Compact 16 I/O controller: ● has 9 digital inputs and 7 relay outputs ● has 1 analog potentiometer ● has 1 integrated serial port ● has a slot for an additional serial port ● accepts one optional cartridge (RTC or memory - 32 KB only) ● accepts an optional operator display module	TWDLCAA16DRF TWDLCDA16DRF 

Controller Type	Illustration
The Compact 24 I/O controller: ● has 14 digital inputs and 10 relay outputs ● has 2 analog potentiometers ● has 1 integrated serial port ● has a slot for an additional serial port ● accepts up to 4 expansion I/O modules ● accepts up to 2 AS-Interface V2 bus interface modules ● accepts one optional cartridge (RTC or memory - 32 KB only) ● accepts an optional operator display module	TWDLCAA24DRF TWDLCDA24DRF 
The Compact 40 I/O controllers. Features shared by both TWDLCAA40DRF and TWDLCAE40DRF series are as follows: ● has 24 digital inputs, 14 relay and 2 transistor outputs ● has 2 analog potentiometers ● has 1 integrated serial port ● has a slot for an additional serial port ● has RTC onboard ● has battery compartment for user-replaceable external battery ● accepts up to 7 expansion I/O modules ● accepts up to 2 AS-Interface V2 bus interface modules ● accepts one optional memory cartridge (32 KB or 64 KB) ● accepts an optional operator display module TWDLCAE40DRF-specific feature: ● has 1 built-in Ethernet RJ-45 port	TWDLCAA40DRF  TWDLCAE40DRF 

Description of Analog Potentiometers

Introduction

The following section describes the analog potentiometer on the Compact controllers.

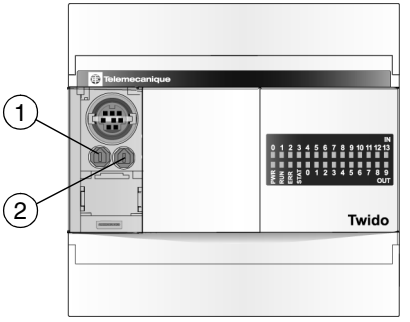
Description

The TWDLC•A10DRF[1] and TWDLC•A16DRF[1] controllers have one analog potentiometer. The TWDLC•A24DRF[1] and TWDLCA•40DRF[2]controllers has two analog potentiometers. The first analog potentiometer can be set to a value between 0 and 1023. On the TWDLC•A10DRF[1], the second analog potentiometer can be set to a value between 0 and 511. The value is stored in a system word and is updated in every scan. For more information on setting the analog potentiometer, see the TwidoSoft Software Reference Manual.

Note:
1. • = D as in 24 VDC power supply
• = A as in 110/240 VAC power supply
2. • = A as in standard model (no Ethernet port)
• = E as in built-in Ethernet communications interface

Analog Potentiometer on a Compact Controller

The following figure shows the analog potentiometers on a TWDLCAA10DRF Compact controller.



Legend

Label	Description
1	Analog potentiometer 1
2	Analog potentiometer 2

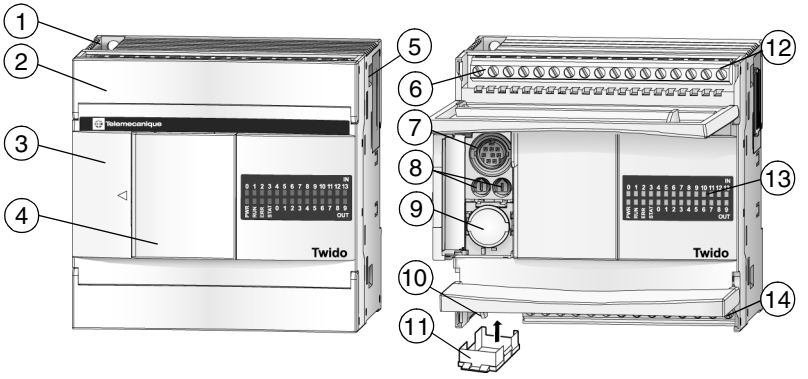
Parts Description of a Compact Controller

Introduction

The following section describes the parts of a Compact controller. Your controller may differ from the illustrations but the parts will be the same.

Parts Description of a Compact Controller

The following figure shows the parts of a Compact controller. This figure is the TWDLCAA24DRF controller.

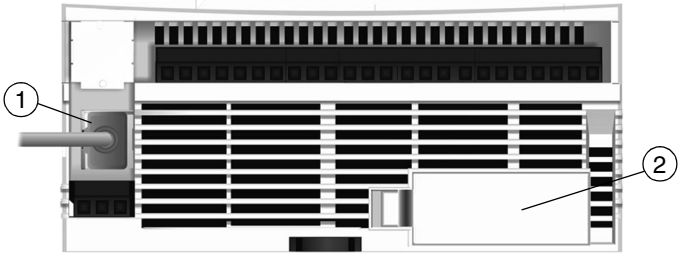


Legend

Label	Description
1	Mounting hole
2	Terminal cover
3	Hinged lid
4	Removable cover to operator display connector
5	Expansion connector - On both 24DRF and 40DRF series compact bases
6	Sensor power terminals
7	Serial port 1
8	Analog potentiometers - TWDLCAA10DRF and TWDLCAA16DRF have one
9	Serial port 2 connector - TWDLCAA10DRF does not have one
10	100-240 VAC power supply terminals on TWDLCA•••DRF series 24 VDC power supply terminals on TWDLCD•••DRF series
11	Cartridge connector - located on the bottom of the controller
12	Input terminals
13	LEDs
14	Output terminals

Rear Panel of a 40DRF Compact Controller

The following figure shows the rear panel of a 40 I/O Compact controller. This figure is the TWDLCAE40DRF controller.



Legend

Label	Description
1	RJ-45 100Base-TX Ethernet port (only TWDLCAE40DRF has one)
2	External user-replaceable battery compartment (both TWDLCAA40DRF and TWDLCAE40DRF have one)

General Specifications for the Compact Controllers

Introduction

This section provides general specifications for the Compact controllers.

Normal Operating Specifications

Compact controller TWDLC...	AA10DRF DA10DRF	AA16DRF DA16DRF	AA24DRF DA24DRF	AA40DRF AE40DRF
Operating temperature	0 to 55°C (32°F to 131°F) operating ambient temperature			
Storage temperature	-25°C to +70°C (-13°F to 158°F)			
Relative humidity	Level RH1, 30 to 95% (non-condensing)			
Degree of pollution	2 (IEC60664)			
Degree of protection	IP20			
Corrosion immunity	Free from corrosive gases			
Altitude	Operation: 0 to 2,000 m (0 to 6,560 ft) Transport: 0 to 3,000 m (0 to 9,840 ft)			
Resistance to vibration	When mounted on a DIN rail: 10 to 57 Hz amplitude 0.075 mm, 57 to 150 Hz acceleration 9.8 ms^2 (1G), 2 hours per axis on each of three mutually perpendicular axes. When mounted on a panel surface: 2 to 25 Hz amplitude 1.6 mm, 25 to 100 Hz acceleration 39.2 ms^2 (4G) Lloyd's 90 min per axis on each of three mutually perpendicular axes.			
Impact strength	147 ms^2 (15G), 11 ms duration, 3 shocks per axis, on three mutually perpendicular axes (IEC 61131)			
Weight	230 g	250 g	305 g	522 g

Specifications for the Backup Internal Battery

All compact base controllers have one non-removable internal battery

Compact backed up elements	Internal RAM: internal variables, internal bits and words, timers, counters, shift registers, etc.
Time	Approximately 30 days at 25°C (77°F) after battery fully charged.
Battery type	Non-interchangeable lithium accumulator
Charging time	Approximately 15 hours for 0% to 90 % of total load
Service life	10 years

Specifications for the Backup External Battery

Only TWDLCAAA40DRF and TWDLCAE40DRF series compact controllers have one external battery compartment.

Compact backed up elements	Internal RAM: internal variables, internal bits and words, timers, counters, shift registers, etc.
Time	Approximately 3 years at 25°C (77°F) under following conditions: ● Internal backup battery is fully charged. ● The Twido compact base is constantly powered. It has had no (or minor) down-time.
Battery type	$^1/_2$ AA, 3.6V, lithium battery Note that the external battery must be provided by user. No external battery is included with the Twido controller's package.

Electrical Specifications

Compact controller TWDLC...	AA10DRF	AA16DRF	AA24DRF	AA40DRF AE40DRF
Rated power voltage	100 to 240 VAC			
Allowable voltage range	85 to 264 VAC			
Rated power frequency	50/60 Hz (47 to 63 Hz)			
Maximum input current	0.25 A (85 VAC)	0.30 A (85 VAC)	0.45 A (85 VAC)	0.79 A (85 VAC)
Maximum power consumption	30 VA (264 VAC), 20 VA (100 VAC) This controller's power consumption includes 250 mA sensor power.	31 VA (264 VAC), 22 VA (100 VAC) This controller's power consumption includes 250 mA sensor power.	40 VA (264 VAC), 33 VA (100 VAC) This controller plus 4 I/O modules' power consumption includes 250 mA sensor power.	77 VA (264 VAC), 65 VA (100 VAC) This controller plus 7 I/O modules' power consumption includes 400 mA sensor power.
Allowable momentary power interruption	20 ms (at the rated inputs and outputs) (IEC61131)			
Dielectric strength	Between power and ground terminals: 1,500 VAC, 1 min Between I/O and ground terminals: 1,500 VAC, 1 min			
Insulation resistance	Between power and ground terminals: 10 MΩ minimum (500 VDC) Between I/O and ground terminals: 10 MΩ minimum (500 VDC)			
Noise resistance	AC power terminals: 1.5 kV, 50 ns to 1 μs I/O terminals (coupling clamp): 1.5 kV, 50 ns to 1 μs			
Inrush current	35 A maximum	35 A maximum	40 A maximum	35 A maximum
Ground wiring	UL1007 16 AWG (1.30 mm^2)			
Power supply wiring	UL1015 22 AWG (0.33 mm^2), UL1007 18 AWG (0.82 mm^2)			
Effect of improper power supply connection	Reverse polarity: normal operation Improper voltage or frequency: permanent damage may be caused Improper lead connection: permanent damage may be caused			

Compact controller TWDLC...	**DA10DRF**	**DA16DRF**	**DA24DRF**
Rated power voltage	24 VDC		
Allowable voltage range	from 19.2 to 30 VDC (including ripple)		
Maximum input current	Controller	Controller	Controller plus 4 I/O Modules
	3.9 W (@ 24 VDC	4.6 W (@ 24 VDC	5.6 W (@ 24 VDC
Allowable momentary power interruption	10 ms (@ 24VDC)		
Dielectric strength	Between power and ground terminals: 500 VAC, 1 min Between I/O and ground terminals: 1500 VAC, 1 min		
Insulation resistance	Between power and ground terminals: 10 MΩ minimum (500 VDC) Between I/O and ground terminals: 10 MΩ minimum (500 VDC)		
Noise resistance	DC power terminals: 1 kV, 50 ns to 1 µs I/O terminals (coupling clamp): 1.5 kV, 50 ns to 1 µs		
Inrush current	35 A maximum (@ 24 VDC)	35 A maximum (@ 24 VDC)	40 A maximum (@ 24 VDC)
Ground wiring	UL1015 22 AWG (0.33 mm^2), UL1007 18 AWG (0.82 mm^2)		
Power supply wiring	UL1015 22 AWG (0.33 mm^2), UL1007 18 AWG (0.82 mm^2)		
Effect of improper power supply connection	Reverse polarity: no operation, no damage Improper voltage or frequency: permanent damage may be caused Improper lead connection: permanent damage may be caused		

Functional Specifications for the Compact Controllers

Introduction This section provides functional specifications for the Compact controllers.

Communication Function Specifications

Communication Port	Port 1 (RS485)	Port 2 (RS232C) Communication Adapter: TWDNAC232D	Port 2 (RS485) Communication Adapters: TWDNAC485D TWDNAC485T	Ethernet Port (RJ45) (TWDLCAE40DRF controller only)
Standards	RS485	RS232	RS485	100Base-TX, RJ45
Maximum baud rate	PC Link: 19,200 bps Remote Link: 38,400 bps	19,200 bps	PC Link: 19,200 bps Remote Link: 38,400 bps	100 Mbps, depending on network speed.
Modbus communication (RTU master/ slave)	Possible	Possible	Possible	TCP/IP Modbus Client/ Server
ASCII communication	Possible	Possible	Possible	-
Remote communication	7 links possible	Not possible	7 links possible	up to 16 remote nodes configured per controller
Maximum cable length	Maximum distance between the base controller and the remote controller: 200 m	Maximum distance between the base controller and the remote controller: 10 m	Maximum distance between the base controller and the remote controller: 200 m	Maximum distance between network nodes (depending on network architecture)
Isolation between internal circuit and communication port	Not isolated	Not isolated	Not isolated	Not isolated
Telephone communication	Possible Possible to connect from a receive only modem.	Not possible	Not possible	Not possible

Built-in Function Specifications

Sensor power supply	Output voltage/current	24 VDC (+10% to -15%), 250 mA
	Overload detection	Not available
	Isolation	Isolated from the internal circuit
Counting	Number of channels	4
	Frequency	3 channels at 5kHz (FCi), 1 channel at 20kHz (VFCi)
	Capacity	16 bits (0..65535 pulses) 32 bits (0..4294967295 pulses)
Analog potentiometers	1 adjustable from 0 through to 1023 pulses	
	1 adjustable from 0 through to 511 pulses	

I/O Specifications for the Compact Controller

Introduction This section provides I/O specifications for the Compact controllers.

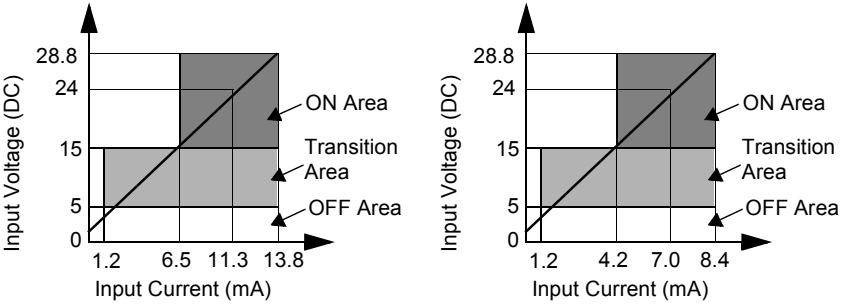
DC Input Specifications

Compact controller	**TWDLCAA10DRF TWDLCDA10DRF**	**TWDLCAA16DRF TWDLCDA16DRF**	**TWDLCAA24DRF TWDLCDA24DRF**	**TWDLCAA40DRF TWDLCAE40DRF**
Input points	6 points in 1 common line	9 points in 1 common line	14 points in 1 common line	24 points in 2 common lines
Rated input voltage	24 VDC sink/source input signal			
Input voltage range	from 20.4 to 28.8 VDC			
Rated input current	I0 and I1: 11 mA I2 to I13: 7 mA/point (24 VDC)			I0, I1, I6, I7: 11 mA I2 to I5, I8 to I23: 7 mA/ point (24 VDC)
Input impedance	I0 and I1: 2.1 kΩ I2 to I13: 3.4 kΩ			I0, I1, I6, I7: 2.1 kΩ I2 to I5, I8 to I23: 3.4 kΩ
Turn on time	I0 to I1: 35 µs + filter value I2 to I13: 40 µs + filter value			I0, I1, I6, I7: 35 µs + filter value I2 to I5, I8 to I23: 40 µs + filter value
Turn off time	I0 and I1: 45 µs + filter value I2 to I13: 150 µs + filter value			I0, I1, I6, I7: 45 µs + filter value I2 to I5, I8 to I23: 150 µs + filter value
Isolation	Between Input Terminals: not isolated Internal Circuit: photocoupler isolated			
Input type	Type 1 (IEC 61131)			
External load for I/O interconnection	Not needed			
Signal determination method	Static			
Effect of improper input connection	The input signals can be both sink and source. But if any input exceeding the rated value is applied, permanent damage may be caused.			
Cable length	3m (9.84 ft) for compliance with electromagnetic immunity.			

Input Operating Range

The input operating range of the Type 1 (IEC 61131-2) input module is shown below.

Inputs I0 and I1 <- (10, 16 and 24 I/O controllers) -> Inputs I0, I1, I6, I7
Inputs I0, I1, I6, I7 <- (40 I/O controllers) -> Inputs I2 to I5, I8 to I23



Input Internal Circuit

The input internal circuit is shown below.

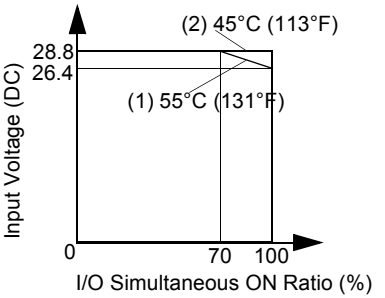
Latching or High Speed Sink or Source Inputs

Standard Sink or Source Input

Inputs I0 and I1 <- (10, 16 and 24 I/O controllers) -> Inputs I0, I1, I6, I7
Inputs I0, I1, I6, I7 <- (40 I/O controllers) -> Inputs I2 to I5, I8 to I23

I/O Usage Limits

When using TWDLC•AA16DRF, TWDLC•A24DRF and TWDLCA•40DRF at an ambient temperature of 55°C (131°F) in the normal mounting direction, limit the inputs and outputs, respectively, which turn on simultaneously along line (1).



Also, when using the above-mentionned controllers at 45°C (113°F), all I/O can be turned on simultaneously at input voltage 28.8 VDC as indicated with line (2).
When using the TWDDMM8DRT controller, all inputs and outputs can be turned on simultaneously at 55°C (131°F), input voltage 28.8 VDC.
For other possible mounting directions, see *Controller, Expansion I/O Module and AS-Interface Bus Master Module Mounting Positions, p. 178*.

Relay Output Specifications

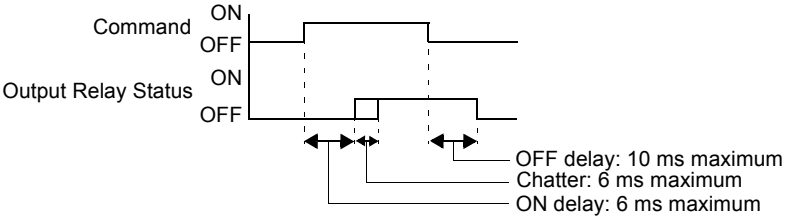
Compact controller	TWDLCAA10DRF TWDLCDA10DRF	TWDLCAA16DRF TWDLCDA16DRF	TWDLCAA24DRF TWDLCDA24DRF	TWDLCAA40DRF TWDLCDAE40DRF
Output points	4 output	7 output	10 output	14 output
Output points per common line: COM0	3 NO contacts	4 Normally Open	4 NO contacts	—
Output points per common line: COM1	1 NO contact	2 NO contacts	4 NO contacts	—
Output points per common line: COM2	—	1 NO contact	1 NO contact	4 NO contact
Output points per common line: COM3	—	—	1 NO contact	4 NO contact
Output points per common line: COM4	—	—	—	4 NO contact
Output points per common line: COM5	—	—	—	1 NO contact
Output points per common line: COM6	—	—	—	1 NO contact
Maximum load current	2 A per output 8 A per common line			
Minimum switching load	0.1 mA/0.1 VDC (reference value)			
Initial contact resistance	30 mΩ maximum			
Electrical life	100,000 operations minimum (rated load 1,800 operations/h)			
Mechanical life	20,000,000 operations minimum (rated load 18,000 operations/h) Internal Circuit: photocoupler isolated			
Rated load (resistive/inductive)	240 VAC/2 A, 30 VDC/2 A			
Dielectric strength	Between output to internal circuit: 1500 VAC, 1 min Between output to terminals (COMs): 1500 VAC, 1 min			

Transistor Source Output Specifications

Compact controller	TWDLCAA40DRF and TWDLCAE40DRF
Output type	Source output
Number of digital output points	2
Output points per common Line	1
Rated load voltage	24 VDC
Maximum load current	1 A per common line
Operating load voltage range	from 20.4 to 28.8 VDC
Voltage drop (on voltage)	1 V maximum (voltage between COM and output terminals when output is on)
Rated load current	1 A per output
Inrush current	2.5 A maximum
Leakage current	0.25 mA maximum
Clamping voltage	n/a
Maximum lamp load	8 W
Inductive load	L/R = 10 ms (28.8 VDC, 1 Hz)
External current draw	12 mA maximum, 24 VDC (power voltage at the +V terminal)
Isolation	Between output terminal and internal circuit: photocoupler isolated Between output terminals: not isolated
Output delay - turn on/off time	Q0, Q1: 5 µs maximum ($I \geq 5mA$)

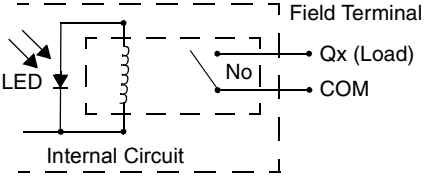
Output delay

The output delay is shown below.



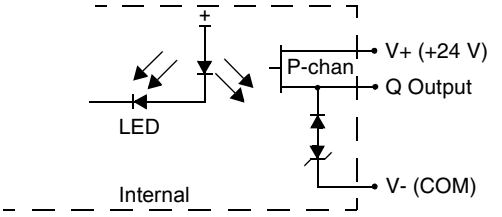
Relay Output Contact

The relay output contact is shown below.



Transistor Source Output Contact

The transistor source output contact applicable to TWDLCA•40DRF series compact controllers is shown below.



Compact Controller Wiring Schematics

Introduction

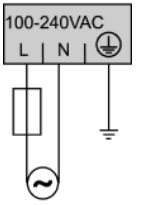
This section shows examples of wiring schematics for Compact controllers.

Note: These schematics are for external wiring only.

Note: The shaded boxes are markings on the controller. The I and Q numbers are the input and output points.

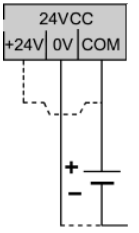
AC Power Supply Wiring Schematic

The following AC power supply wiring schematic is for the TWDLCA•••DRF series controllers.



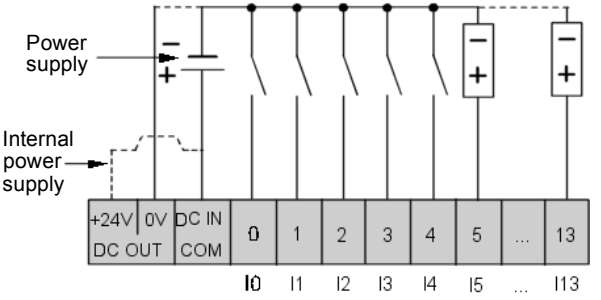
DC Power Supply Wiring Schematic

The following AC power supply wiring schematic is for the TWDLCDA••DRF series controllers. (Note that TWDLCA•40DRF series controllers have AC power supply only.)

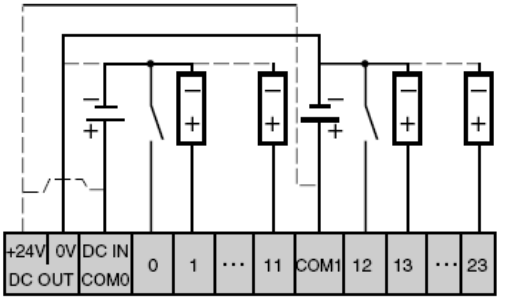


DC Source Input Wiring Schematic

The following schematic is for the TWDLC•A10DRF, TWDLC•A16DRF, and TWDLC•A24DRF controllers.

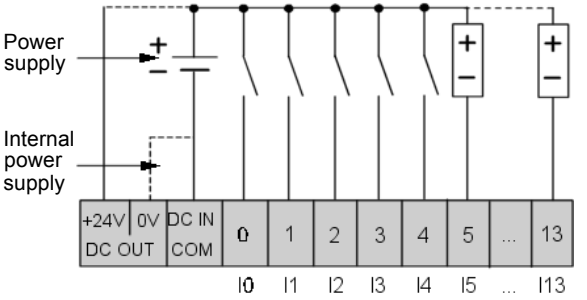


The following DC source input wiring schematic is for the TWDLCA•40DRF series controllers.

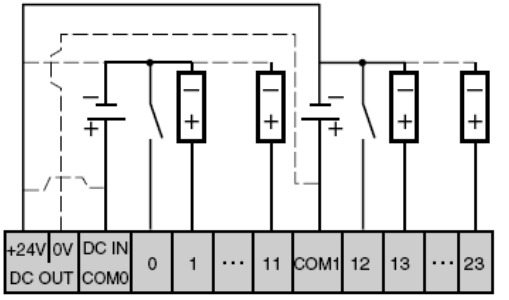


DC Sink Input Wiring Schematic

This schematic is for the TWDLC•A10DRF, TWDLC•A16DRF, and TWDLC•A24DRF controllers.

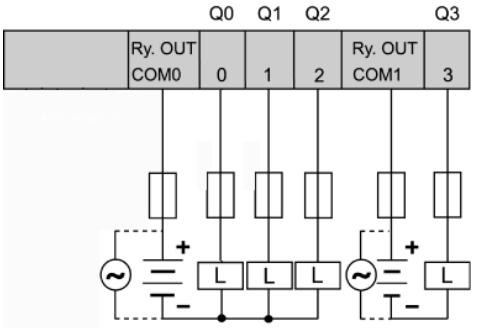


The following DC sink input wiring schematic is for the TWDLCA•40DRF series controllers.

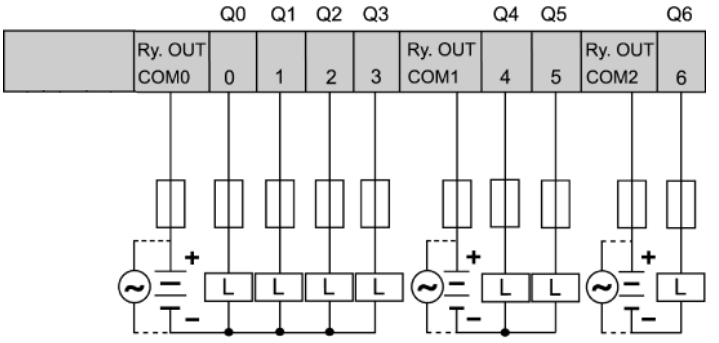


AC Power and Relay Output Wiring Schematic

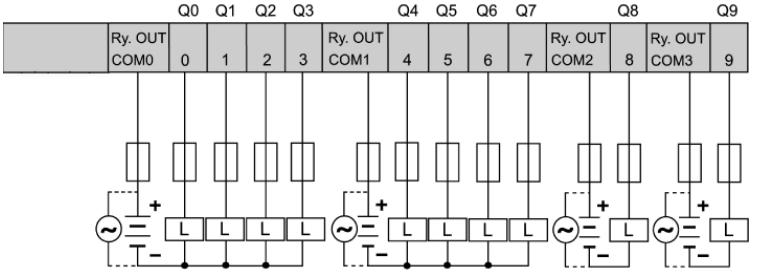
This schematic is for the TWDLC•A10DRF series controllers.



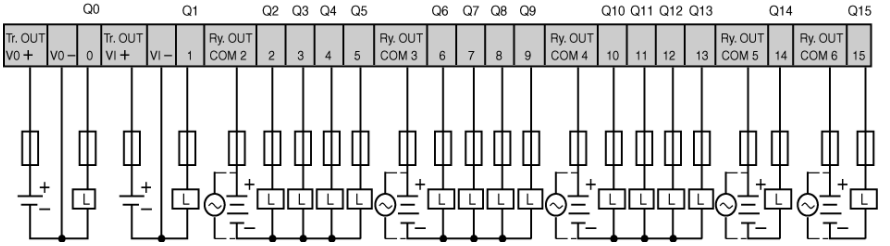
This schematic is for the TWDLC•A16DRF series controllers.



This schematic is for the TWDLC•A24DRF series controllers.



This schematic is for the TWDLCA•40DRF series controllers.



2.3 Modular Controller

At a Glance

Introduction

This section provides an overview, parts description, specifications, and wiring schematics of the Modular controllers.

What's in this Section?

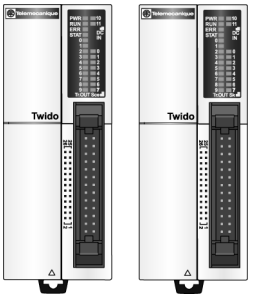
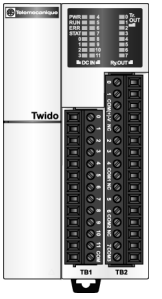
This section contains the following topics:

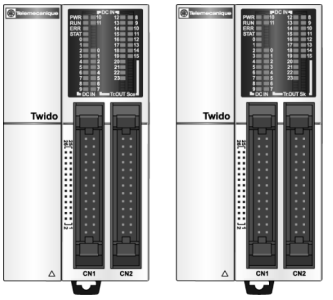
Topic	Page
Overview of Modular Controllers	59
Description of Analog Potentiometers	61
Overview of Analog Voltage Input	62
Parts Description of a Modular Controller	63
General Specifications for the Modular Controllers	64
Functional Specifications for the Modular Controllers	66
I/O Specifications for the Modular Controllers	68
Modular Controller Wiring Schematics	74

Overview of Modular Controllers

Introduction The following section provides an overview of the Modular controllers.

Illustrations The following illustrations are the Modular controllers.

Controller Type	Illustration
The Modular 20 I/O controllers: ● are available in two models: with transistor source outputs (TWDLMDA20DTK) or with transistor sink outputs (TWDLMDA20DUK) ● have 12 digital inputs and 8 transistor source or sink outputs ● have 1 analog voltage input connector ● have 1 analog potentiometer ● have 1 integrated serial port ● have a connector for wiring ● accept up to 4 expansion I/O modules ● accept up to 2 AS-Interface V2 bus interface modules ● accept both optional cartridges (RTC and memory - 32 KB or 64 KB) ● accept either an optional operator display expansion module or an optional communication expansion module	TWDLMDA20DTK TWDLMDA20DUK 
The Modular 20 I/O controller: ● has 12 digital inputs, 6 relay outputs, and 2 transistor source outputs ● has 1 analog voltage input connector ● has 1 analog potentiometer ● has 1 integrated serial port ● has a terminal block for wiring ● accepts up to 7 expansion I/O modules ● accepts up to 2 AS-Interface V2 bus interface modules ● accepts both optional cartridges (RTC and memory - 32 KB or 64 KB) ● accepts either an optional operator display expansion module or an optional communication expansion module	TWDLMDA20DRT 

Controller Type	Illustration
The Modular 40 I/O controller: ● is available in two models: with transistor source outputs (TWDLMDA40DTK) or with transistor sink outputs (TWDLMDA40DUK) ● has 24 digital inputs and 16 transistor source or sink outputs ● has 1 analog voltage input connector ● has 1 analog potentiometer ● has 1 integrated serial port ● has a connector for wiring ● accepts up to 7 expansion I/O modules ● accepts up to 2 AS-Interface V2 bus interface modules ● accepts both optional cartridges (RTC and memory - 32 KB or 64 KB) ● accepts either an optional operator display expansion module or an optional communication expansion module	TWDLMDA40DTK TWDLMDA40DUK 

Description of Analog Potentiometers

Introduction

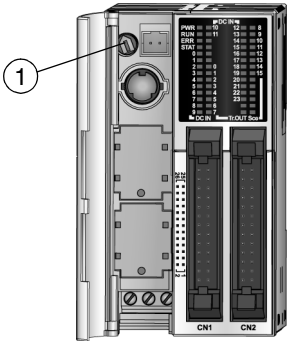
The following section describes the analog potentiometer on the Modular controllers.

Description

The TWDLMDA20DUK, TWDLMADA20DTK, TWDLMDA20DRT, TWDLMDA40DUK, and TWDLMADA40DTK controllers have one analog potentiometer. The analog potentiometer can be set to a value between 0 and 1024. The value is stored in a system words and is updated in every scan. For more information on setting the analog potentiometer, see the TwidoSoft Software Reference Manual.

Analog Potentiometer on a Compact Controller

The following figure shows the analog potentiometer on a Modular controller, the TWDLMDA40DUK.



Legend

Label	Description
1	Analog potentiometer 1

Overview of Analog Voltage Input

Introduction

The following section describes the analog voltage input on the Modular controllers.

Description

All Modular controllers have one analog voltage input. The analog voltage input connects an analog voltage source of 0 through 10 VDC. The analog voltage is converted to a value of 0 through 512 and is stored in a system word.

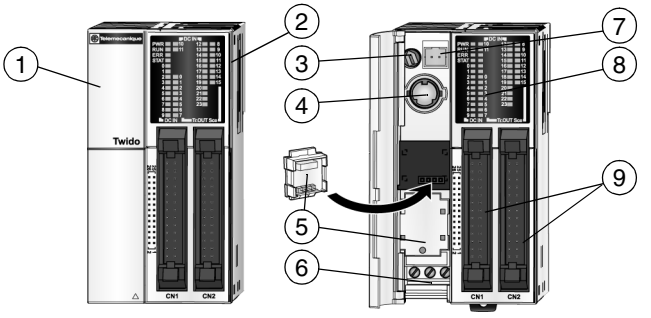
Parts Description of a Modular Controller

Introduction

The following section describes the parts of a Modular controller. Your controller may differ from the illustrations but the parts will be the same.

Parts Description of a Modular Controller

The following figure shows the parts of a Modular controller. This figure is the Modular 40 I/O controller.



10 not shown, left side of controller

Legend

Label	Description
1	Hinged lid
2	Expansion connector
3	Analog potentiometer
4	Serial port 1
5	Cartridge covers
6	24 VDC power supply terminals
7	Analog voltage input connector
8	LEDs
9	I/O terminals
10	Communication connector

General Specifications for the Modular Controllers

Introduction

This section provides general specifications for the Modular controllers.

Normal Operating Specifications

Modular controller	TWDLMDA20DTK TWDLMDA20DUK	TWDLMDA20DRT	TWDLMDA40DTK TWDLMDA40DUK
Operating temperature	0 to 55°C (32°F to 131°F) operating ambient temperature		
Storage temperature	-25°C to +70°C (-13°F to 158°F)		
Relative humidity	from 30 to 95% Rh (non-condensing)		
Pollution degree	2 (IEC60664)		
Degree of protection	IP20		
Corrosion immunity	Free from corrosive gases		
Altitude	Operation: from 0 to 2000 m Transport: from 0 to 3000 m		
Resistance to Vibration	When mounted on a DIN rail: from 10 to 57 Hz amplitude 0.075 mm, from 57 to 150 Hz acceleration 9.8 ms^2 (1G), 2 hours per axis on each of three mutually perpendicular axes. When mounted on a panel surface: from 2 to 25 Hz amplitude 1.6 mm, from 25 to 100 Hz acceleration 39.2 ms^2 (4G) Lloyd's 90 min per axis on each of three mutually perpendicular axes.		
Impact strength	147 ms^2 (15G), 11 ms duration, 3 shocks per axis, on three mutually perpendicular axes (IEC 61131).		
Weight	140 g	185 g	180 g

Specifications for the Backup Battery

Compact backed up elements	Internal RAM: internal variables, internal bits and words, timers, counters, shift registers, etc.
Time	Approximately 30 days at 25°C (77°F) after battery fully charged.
Battery type	Non-interchangeable lithium accumulator
Charging time	Approximately 15 hours for 0% to 90 % of total load
Service life	10 years

Electrical Specifications

Modular controller	**TWDLMDA20DTK TWDLMDA20DUK**	**TWDLMDA20DRT**	**TWDLMDA40DTK TWDLMDA40DUK**
Rated power voltage	24 VDC		
Allowable voltage range	from 20.4 to 26.4 VDC (including ripple)		
Maximum input current	Controller plus 4 I/O Modules	Controller plus 7 I/O Modules	
	15 W (26.4 VDC)	19 W (26.4 VDC)	19 W (26.4 VDC)
Allowable momentary power interruption	10 ms (@ 24VDC)		
Dielectric strength	Between power and ground terminals: 500 VAC, 1 min Between I/O and ground terminals: 1500 VAC, 1 min		
Insulation resistance	Between power and ground terminals: 10 MΩ minimum (500 VDC) Between I/O and ground terminals: 10 MΩ minimum (500 VDC)		
Noise resistance	DC power terminals: 1 kV, 50 ns to 1 µs I/O terminals (coupling clamp): 1.5 kV, 50 ns to 1 µs		
Inrush current	50 A maximum (24 VDC)		
Ground wiring	UL1015 22 AWG (0.33 mm^2), UL1007 18 AWG (0.82 mm^2)		
Power supply wiring	UL1015 22 AWG (0.33 mm^2), UL1007 18 AWG (0.82 mm^2)		
Effect of improper power supply connection	Reverse polarity: no operation, no damage Improper voltage or frequency: permanent damage may be caused Improper lead connection: permanent damage may be caused		

Functional Specifications for the Modular Controllers

Introduction

This section provides functional specifications for the Modular controllers.

Communication Function Specifications

Communication Port	Port 1 (RS485)	Port 2 (RS232C) Communication Expansion Module (TWDNOZ232D) or Operator Display Expansion Module (TWDXCPODM) with Communication Adapter (TWDNAC232D)	Port 2 (RS485) Communication Expansion Modules (TWDNOZ485D) or (TWDNOZ485T) or Operator Display Expansion Module (TWDXCPODM) with Communication Adapter (TWDNAC485D) or (TWDNAC485T)
Standards	RS485	RS232	RS485
Maximum baud rate	PC Link: 19,200 bps Remote Link: 38,400 bps	19,200 bps	PC Link: 19,200 bps Remote Link: 38,400 bps
Modbus communication (RTU master/ slave)	Possible	Possible	Possible
ASCII communication	Possible	Possible	Possible
Remote communication	7 links possible	Not possible	7 links possible
Maximum cable length	Maximum distance between the base controller and the remote controller: 200 m	Maximum distance between the base controller and the remote controller: 200 m	Maximum distance between the base controller and the remote controller: 200 m
Isolation between internal circuit and communication port	Not isolated	Not isolated	Not isolated

Communication Port	Port 1 (RS485)	Port 2 (RS232C) Communication Expansion Module (TWDNOZ232D) or Operator Display Expansion Module (TWDXCPODM) with Communication Adapter (TWDNAC232D)	Port 2 (RS485) Communication Expansion Modules (TWDNOZ485D) or (TWDNOZ485T) or Operator Display Expansion Module (TWDXCPODM) with Communication Adapter (TWDNAC485D) or (TWDNAC485T)
Telephone communication	Possible Possible to connect from a receive only modem.	Not possible	Not possible

Built-in Function Specifications

Analog voltage input	Number of channels	1
	Input voltage range	from 0 to 10 VDC
	Input impedance	100 kΩ
	Resolution	9 bits (0 to 511 pulses)
	Input error	+/- 5%
	Sample duration time	5 ms
	Sample repeat time	5 ms
	Total input transfer time	5 ms + 1 cycle time
Movement	Number of channels	2
	Frequency	7 kHz
	Functions	PWM - Pulse Width Modulation output PLS - Pulse generator output
Counting	Number of channels	4
	Frequency	2 channels at 5kHz (FCi), 2 channel at 20kHz (VFCi)
	Capacity	16 bits (0..65535 pulses)
Analog potentiometers	1 adjustable from 0 through to 1023 pulses	

I/O Specifications for the Modular Controllers

Introduction

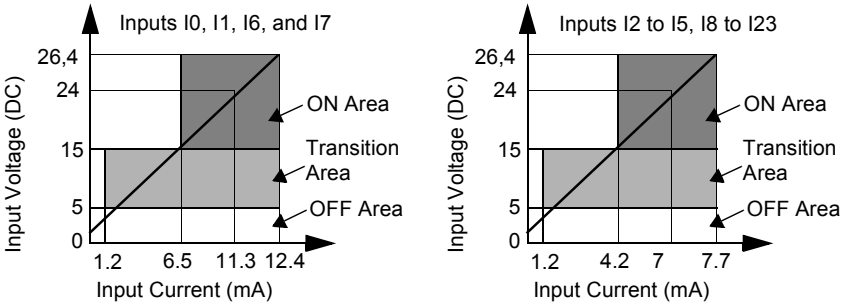
This section provides I/O specifications for the Modular controllers.

DC Input Specifications

Modular controller	TWDLMDA20DUK TWDLMDA20DTK	TWDLMDA20DRT	TWDLMDA40DUK TWDLMDA40DTK
Input points	12 points in 1 common line	12 points in 1 common line	24 points in 1 common line
Rated input voltage	24 VDC source/sink input signal		
Input voltage range	from 20.4 to 26.4 VDC		
Rated input current	I0, I1, I6, I7: 5 mA/input (24 VDC) I2 to I5, I8 to I23: 7 mA/input (24 VDC)		
Input impedance	I0, I1, I6, I7: 5.7 kΩ I2 to I5, I8 to I23: 3.4 kΩ		
Turn on time (ON Time)	I0 to I7: 35 µs + filter value I8 to I23: 40 µs + filter value		
Turn off time (OFF Time)	I0, I1, I6, I7: 45 µs + filter value I2 to I5, I8 to I23: 150 µs + filter value		
Isolation	Between input terminals: not isolated Internal circuit: photocoupler isolated		
Filtering: 3 possibilities • none • 3 ms • 12 ms	I0 to I11	I0 to I11	I0 to I7
Input type	Type 1 (IEC 61131)		
External load for I/O interconnection	Not needed		
Signal determination method	Static		
Effect of improper input connection	The input signals can be both sink and source. But if any input exceeding the rated value is applied, permanent damage may be caused.		
Cable length	3m (9.84 ft) for compliance with electromagnetic immunity		
Connector insertion/ removal durability	100 times minimum		

Input Operating Range

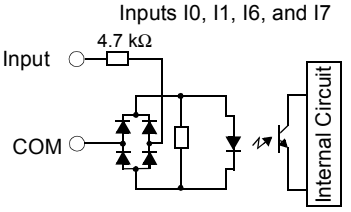
The input operating range of the Type 1 (IEC 61131-2) input module is shown below.



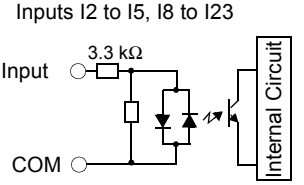
Input Internal Circuit

The input internal circuit is shown below.

Latching or High Speed Sink or Source Inputs

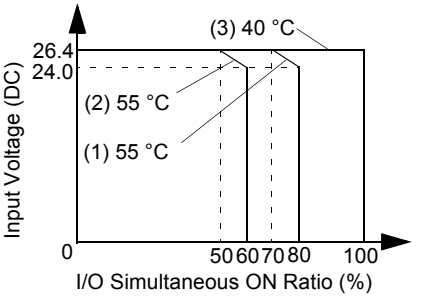


Standard Sink Or Source Input



I/O Usage Limits

When using TWDLMDA20DUK and TWDLMDA20DTK at an ambient temperature of 55°C (131°F) in the normal mounting direction, limit the inputs and outputs, respectively, which turn on simultaneously along line (1).



When using TWDLMDA40DUK and TWDLMDA40DTK limit the inputs and outputs, respectively, which turn on simultaneously along line (2).
At 40°C (104°F), all inputs and outputs can be turned on simultaneously at 26.4 VDC as indicated with line (3).

When using the TWDLMDA20DRT controller, all inputs and outputs can be turned on simultaneously at 55°C (131°F), input voltage 26.4 VDC.

Transistor Sink and Source Output Specifications

Modular controller TWDLMDA...	**20DUK**	**40DUK**	**20DRT**	**20DTK**	**40DTK**
Output type	Sink output	Sink output	Source output	Source output	Source output
Output points per common Line	8	2	2	8	16
Rated load voltage	24 VDC				
Maximum load current	1 A per common line				
Operating load voltage range	from 20.4 to 28.8 VDC				
Voltage drop (on voltage)	1 V maximum (voltage between COM and output terminals when output is on)				
Rated load current	0.3 A per output				
Inrush current	1 A maximum				
Leakage current	0.1 mA maximum				
Clamping voltage	39 V +/-1 V				
Maximum lamp load	8 W				
Inductive load	L/R = 10 ms (28.8 VDC, 1 Hz)				
External current draw	100 mA maximum, 24 VDC (power voltage at the +V terminal)		100 mA maximum, 24 VDC (power voltage at the -V terminal)		
Isolation	Between output terminal and internal circuit: photocoupler isolated Between output terminals: not isolated				
Average number of connector insertions/ removals	100 times minimum				

Modular controller TWDLMDA...	20DUK	40DUK	20DRT	20DTK	40DTK
Output delay - turn on time	Q0, Q1: 5 µs maximum Q2 to Q15: 300 µs maximum				
Output delay - turn off time	Q0, Q1: 5 µs maximum Q2 to Q15: 300 µs maximum				

Relay Output Specifications

Modular controller	TWDLMDA20DRT
Number of outputs	8 digital inputs consisting of 6 relay outputs and 2 transistor source outputs
Output points per common line - COM0	2 outputs
Output points per common line - COM1	3 NO contacts
Output points per common line - COM2	2 NO contacts
Output points per common line - COM3	1 NO contact
Maximum load current	2 A per output 8 A per common line
Minimum switching load	0.1 mA/0.1 VDC (reference value)
Initial contact resistance	30 mΩ maximum
Mechanical life	20,000,000 operations minimum (rated load 18,000 operations/h)
Dielectric strength	Between output to internal circuit: 1500 VAC, 1 min Between output to terminals (COMs): 1500 VAC, 1 min
Connector insertion/removal durability	100 times minimum

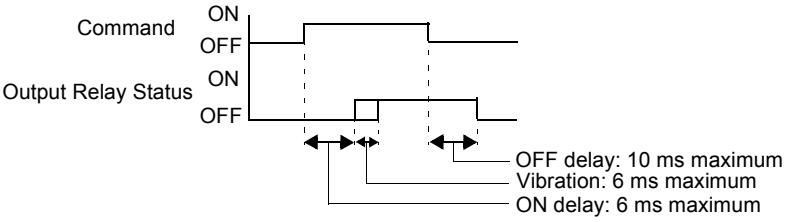
Usage category	Rated load	Electrical life (number of operations)
AC1 Resistive load command	500 VA(*)	10^5
AC14 Weak solenoid load	250 VA	10^5
AC15 Solenoid	200 VA	10^5

Usage category	Rated load	Electrical life (number of operations)
DC1 Resistive load command	60 W(*)	10^5
DC13 Solenoid L/R=150ms	30 W	10^5

(*) for AC1 & DC1 the outputs indicated here take the maximum per point on Twido (2A) into account.

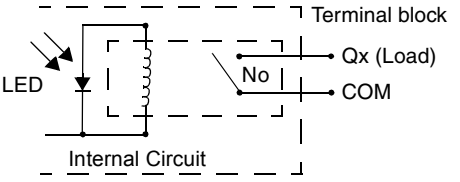
Output delay

The output delay is shown below.



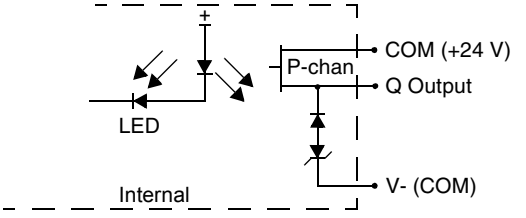
Relay Output Contact

The relay output contact is shown below.



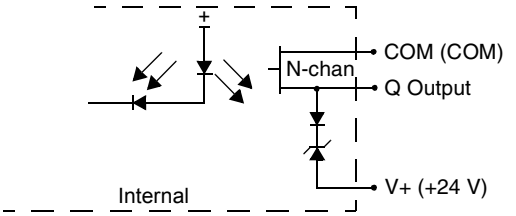
Transistor Source Output Contact

The transistor source output contact is shown below.



Transistor Sink Output Contact

The transistor sink output contact is shown below.



Modular Controller Wiring Schematics

Introduction

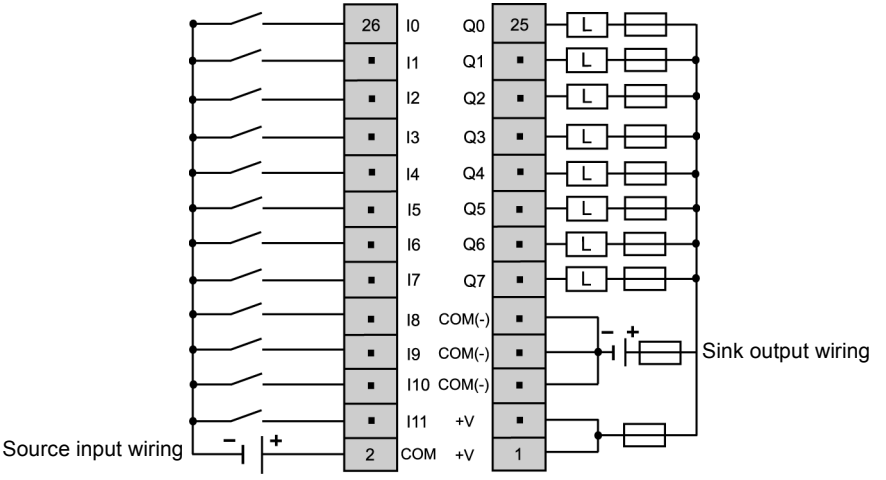
This section shows examples of wiring schematics for the Modular controllers.

Note: These schematics are for external wiring only.

Note: The shaded boxes are markings on the controller. The I and Q numbers are the input and output points.

TWDLMDA20-DUK Wiring Schematic

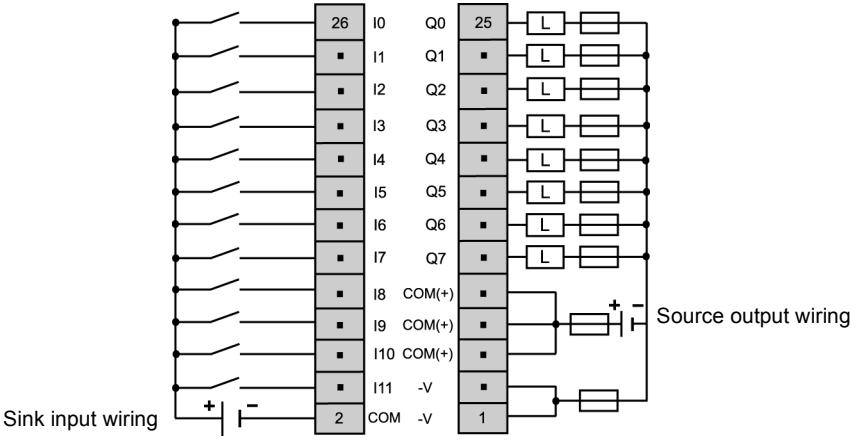
This schematic is for the TWDLMDA20DUK controller with connector.



- The COM(-) terminals are connected together internally.
- The COM and COM(-) terminals are **not** connected together internally.
- The +V terminals are connected together internally.
- Connect an appropriate fuse for the load.

TWDLMDA20-DTK Wiring Schematic

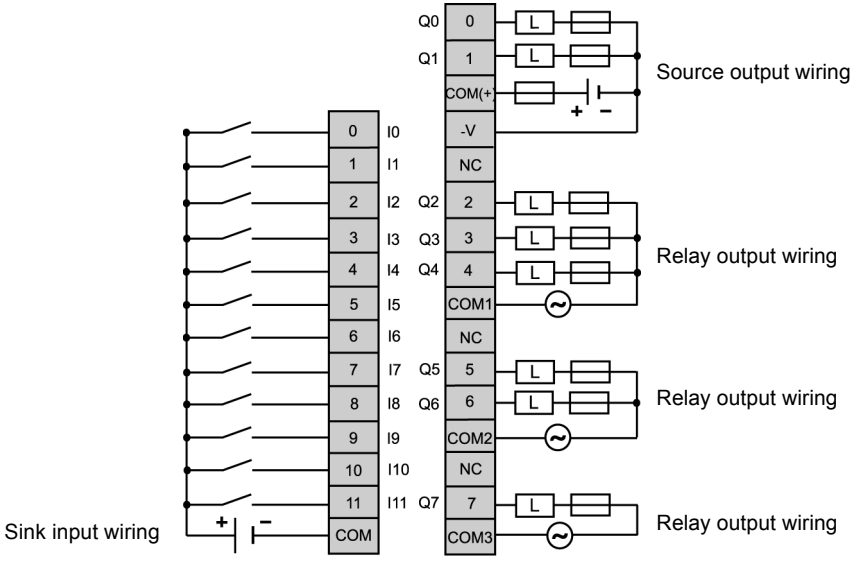
This schematic is for the TWDLMDA20DTK controller with connector.



- The COM(+) terminals are connected together internally.
- The COM and COM(+) terminals are **not** connected together internally.
- The -V terminals are connected together internally.
- Connect an appropriate fuse for the load.

TWDLMDA20-DRT Wiring Schematic

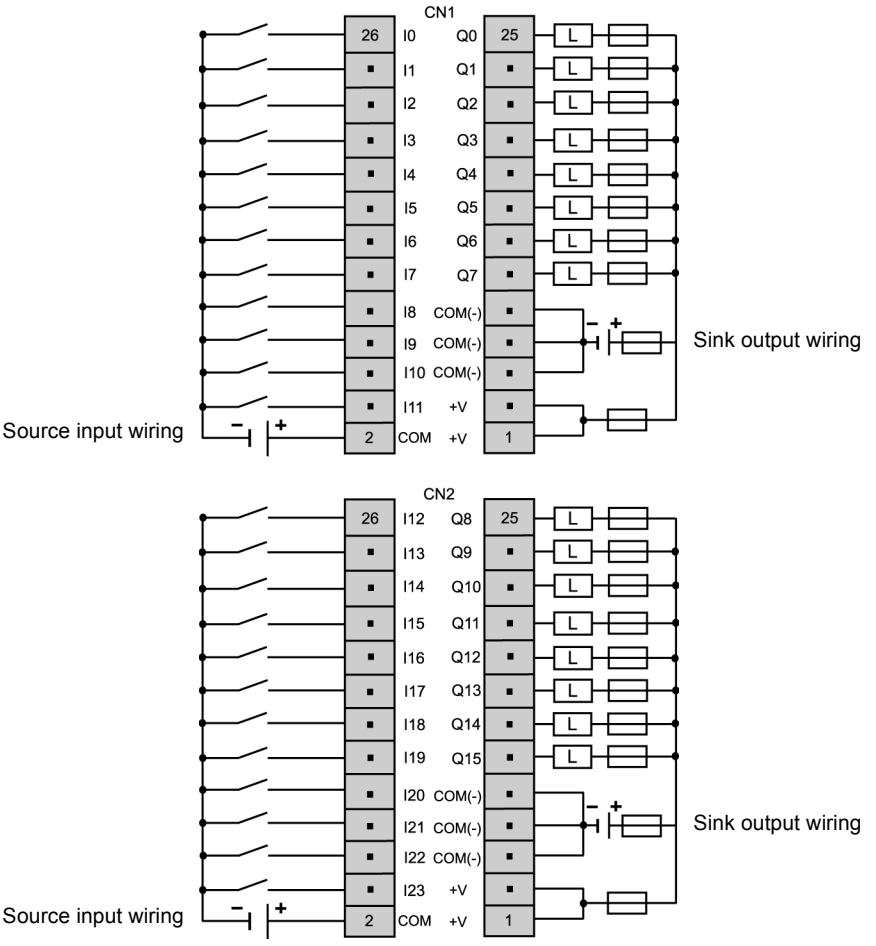
This schematic is for the TWDLMDA20DRT controller with terminal block.



- Output points 0 and 1 are transistor source outputs, all other output points are relay.
- The COM terminals are **not** connected together internally.
- Connect an appropriate fuse for the load.

TWDLMDA40-DUK Wiring Schematic

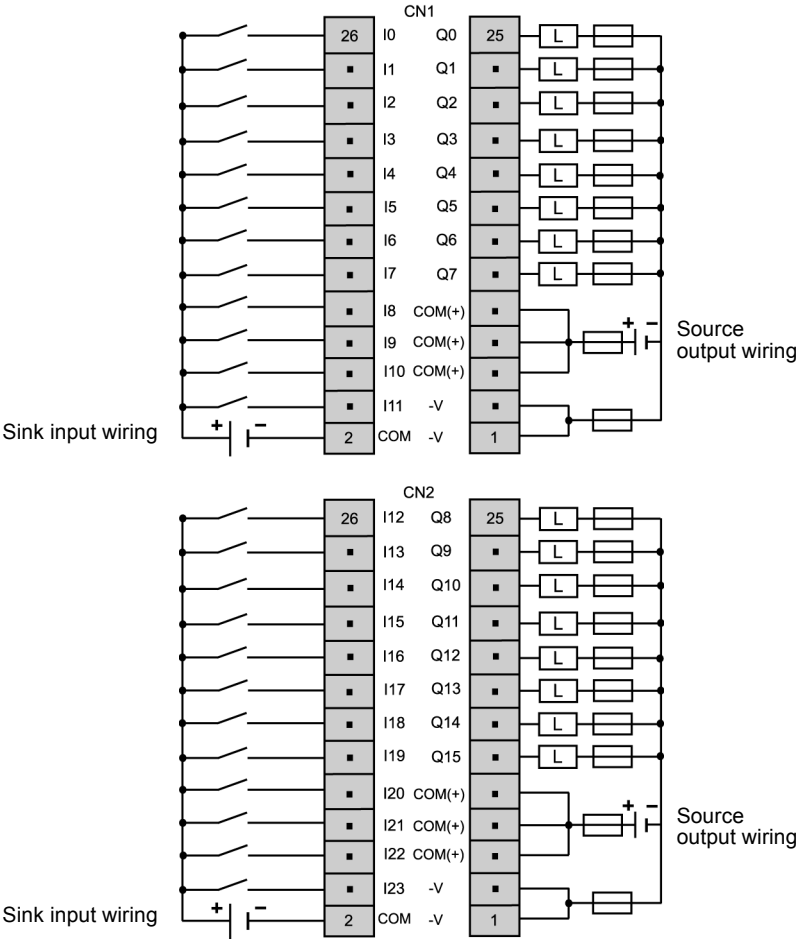
This schematic is for the TWDLMDA40DUK controller with connector.



- The terminals on CN1 and CN2 are **not** connected together internally.
- The COM(-) terminals are connected together internally.
- The COM and COM(-) terminals are **not** connected together internally.
- The +V terminals are connected together internally.
- Connect an appropriate fuse for the load.

TWDLMDA40-DTK Wiring Schematic

This schematic is for the TWDLMDA40DTK controller with connector.



- The terminals on CN1 and CN2 are **not** connected together internally.
- The COM(+) terminals are connected together internally.
- The COM and COM(+) terminals are **not** connected together internally.
- The -V terminals are connected together internally.
- Connect an appropriate fuse for the load.

2.4 Digital I/O Modules

At a Glance

Introduction

This section provides an overview, specifications, and wiring schematics of the digital I/O modules.

What's in this Section?

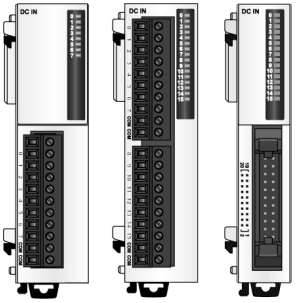
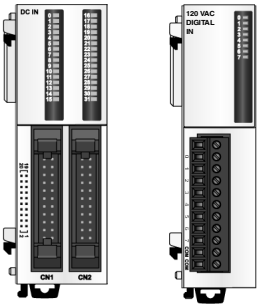
This section contains the following topics:

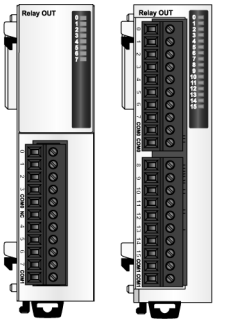
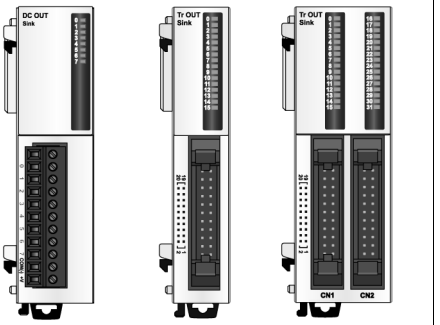
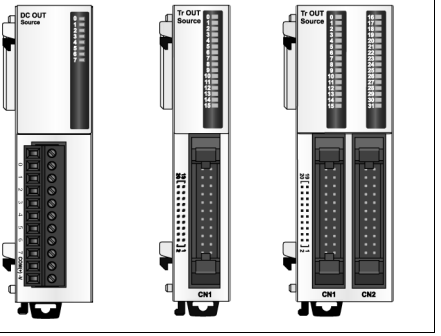
Topic	Page
Overview of Digital I/O Modules	80
Parts Description of Digital I/O Modules	83
Specifications for the Digital I/O Modules	85
Digital I/O Module Wiring Schematics	97

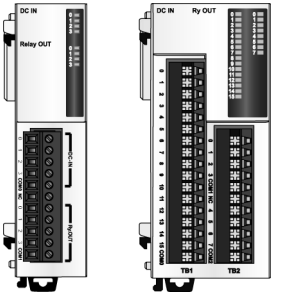
Overview of Digital I/O Modules

Introduction The following section provides an overview of the digital I/O modules.

Illustrations The following illustrations are the digital input, output, and mixed I/O modules.

Model Type	Illustration
There are 4 digital input modules: • 8-point module with a terminal block (TWDDDI8DT) • 16-point module with a terminal block (TWDDDI16DT) • 16-point module with a connector (TWDDDI16DK) • 32-point module with a connector (TWDDDI32DK) • 8-point, 120 VAC input module with a terminal block (TWDDAI8DT) These modules can be attached to any controller except the Compact 10 I/O and 16 I/O controllers.	TWDDDI8DT TWDDDI16DK TWDDDI16DT  TWDDDI32DK TWDDAI8DT 

Model Type	Illustration
There are 8 digital output modules: ● 8-point relay output module with a terminal block (TWDDRA8RT) ● 16-point relay output module with a terminal block (TWDDRA16RT) ● 8-point transistor sink module with a connector (TWDDDO8UT) ● 16-point transistor sink module with a connector (TWDDDO16UK) ● 32-point transistor sink module with a connector (TWDDDO32UK) ● 8-point transistor source module with a terminal block (TWDDDO8TT) ● 16-point transistor source module with a connector (TWDDDO16TK) ● 32-point transistor source module with a connector (TWDDDO32TK) These modules can be attached to any controller except the Compact 10 I/O and 16 I/O controllers.	TWDDRA8RT TWDDRA16RT  TWDDDO8UT TWDDDO16UK TWDDDO32UK  TWDDDO8TT TWDDDO16TK TWDDDO32TK 

Model Type	Illustration
There are 2 digital mixed input and output modules: ● 4-point input/4-point output module with a terminal block (TWDDMM8RT) ● 16-point input/8-point output module with a wire-clamp terminal block (TWDDMM24DRF) These modules can be attached to any controller except the Compact 10 I/O and 16 I/O controllers.	TWDDMM8RT TWDDMM24DRF 

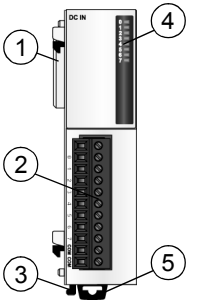
Parts Description of Digital I/O Modules

Introduction

The following section describes the parts of a digital I/O module with a terminal block and with a connector. Your I/O module may differ from the illustrations but the parts will be the same.

Parts Description of a Digital I/O Module with a Terminal Block

The following figure shows the parts of a digital I/O module with a terminal block. This figure is the TWDDDI8DT module.

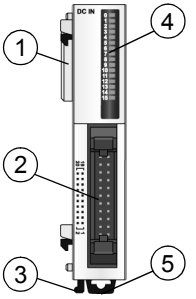


Legend

Label	Description
1	Expansion connector - one on each side, right side not shown
2	Terminal block
3	Latch button
4	LEDs
5	Clamp

Parts Description of a Digital I/O Module with a Connector

The following figure shows the parts of a digital I/O module with a connector. This figure is the TWDDDO16TK module.



Legend

Label	Description
1	Expansion connector - one on each side, right side not shown
2	Connector
3	Latch button
4	LEDs
5	Clamp

Specifications for the Digital I/O Modules

Introduction

This section presents the specifications for the digital I/O modules.

TWDDDI8DT, TWDDDI16DT, TWDDDI16DK, TWDDDI32DK and TWDDAI8DT Specifications

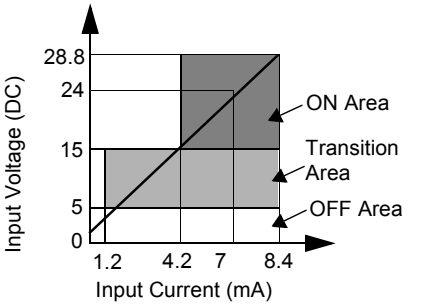
Reference number	Digital I/O Modules TWDD...				
	DI8DT	**DI16DT**	**DI16DK**	**DI32DK**	**AI8DT**
Input points	8	16	16	32	8
Common lines	1	1	1	2	2
Rated input voltage	24 VDC source/sink input signal				120 VAC
Input voltage range	from 20.4 to 28.8 VDC				132 VAC max
Rated input current	7 mA/input (24 VDC)		5 mA/input (24 VDC)		7.5 mA/input (100 VAC)
Input impedance	3.4 kΩ		4.4 kΩ		11 kΩ
Turn on time	8 ms (24 VDC)				25 ms (120 VAC)
Turn off time	8 ms (24 VDC)				30 ms (120 VAC)
Isolation	Between input terminals: not isolated Internal circuit: photocoupler isolated				
External load for I/O interconnection	Not needed				
Signal determination method	Static				
Effect of improper input connection	The input signals can be both sink and source.				The input signals must be of AC type.
	But if any input exceeding the rated value is applied, permanent damage may be caused.				
Cable length	3m (9.84 ft.) in compliance with electromagnetic immunity				
Connector insertion/ removal durability	100 times minimum				
Internal current draw - all inputs on	25 mA (5 VDC) 0 mA (24 VDC)	40 mA (5 VDC) 0 mA (24 VDC)	35 mA (5 VDC) 0 mA (24 VDC)	65 mA (5 VDC) 0 mA (24 VDC)	55 mA (5 VDC) 0 mA (24 VDC)

Reference number	Digital I/O Modules TWDD...				
	DI8DT	**DI16DT**	**DI16DK**	**DI32DK**	**AI8DT**
Internal current draw - all inputs off	5 mA (5 VDC) 0 mA (24 VDC)	5 mA (5 VDC) 0 mA (24 VDC)	5 mA (5 VDC) 0 mA (24 VDC)	10 mA (5 VDC) 0 mA (24 VDC)	25 mA (5 VDC) 0 mA (24 VDC)
Weight	85 g	100 g	65 g	100 g	81 g

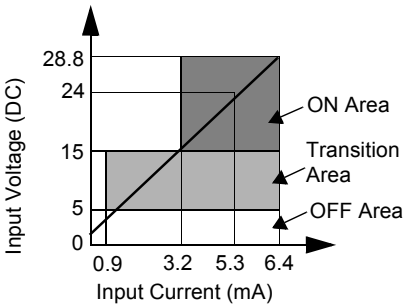
TWDDDI8DT, TWDDDI16DT, TWDDDI16DK, TWDDDI32DK and TWDDAI8DT Operating Range

The operating range of the Type 1 (IEC 61131-2) input module is shown below.

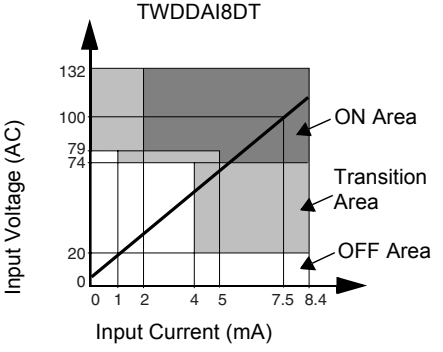
TWDDDI8DT and TWDDDI16DT



TWDDDI16DK and TWDDDI32DK



TWDDAI8DT

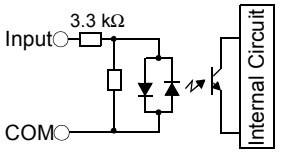


TWDDDI8DT, TWDDDI16DT, TWDDDI16DK, TWDDDI32DK and TWDDAI8DT Internal Circuit

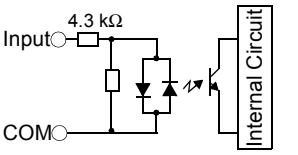
The input internal circuit is shown below.

Standard Sink or Source Input

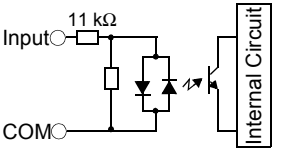
TWDDDI8DT and TWDDDI16DT



TWDDDI16DK and TWDDDI32DK

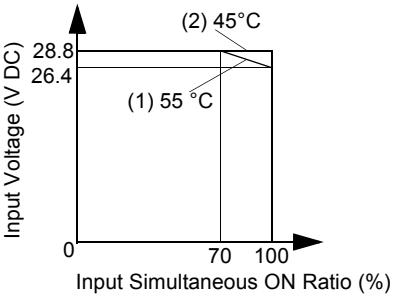


TWDDAI8DT

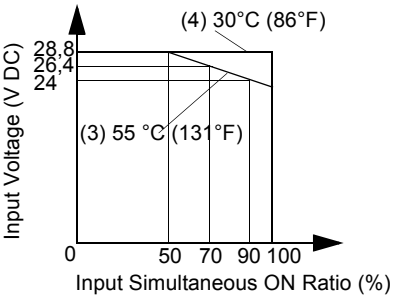


TWDDDI8DT, TWDDDI16DT, TWDDDI16DK, TWDDDI32DK and TWDDAI8DT Usage Limits

When using TWDDDI16DT at 55°C (131°F) in the normal mounting direction, limit the inputs which turn on simultaneously along line (1). At 45°C (113°F), all inputs can be turned on simultaneously at 28.8 VDC as indicated with line (2).



When using TWDDDI16DK and TWDDDI32DK at 55°C (131°F), limit the inputs which turn on simultaneously on each connector along line (3). This limitation applies per connecteur. At 30°C (86°F), all inputs can be turned on simultaneously at 28.8 VDC as indicated with line (4).



When using TWDDDI8DT, all inputs can be turned on simultaneously at 55°C (131°F), input voltage 28.8 VDC.

TWDDRA8RT and TWDDRA16RT Specifications

CAUTION

Possible current overload

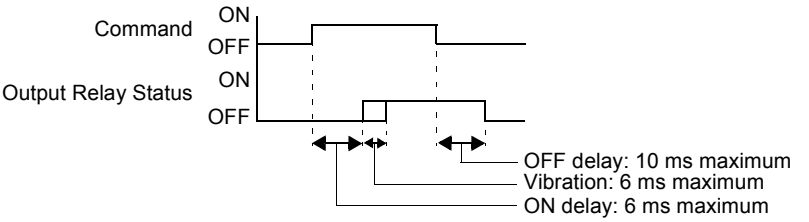
Size wire accordingly

Failure to follow this precaution can result in injury or equipment damage.

Reference number	TWDDRA8RT	TWDDRA16RT
Output points and common lines	8 NO contacts in 2 common lines	16 NO contacts in 2 common lines
Maximum load current	2 A per output	
	7 A per common line	8 A per common line
Minimum switching load	0.1 mA/0.1 VDC (reference value)	
Initial contact resistance	30 mΩ maximum	
Electrical life	100,000 operations minimum (rated load 1,800 operations/h)	
Mechanical life	20,000,000 operations minimum (rated load 18,000 operations/h)	
Rated load (resistive/inductive)	240 VAC/2 A, 30 VDC/2 A	
Dielectric strength	Between output to terminals: 1,500 VAC, 1 minute Between output terminal and internal circuit: 1,500 VAC, 1 minute Between output terminals (COMs): 1,500 VAC, 1 minute	
Connector insertion/removal durability	100 times minimum	
Internal current draw - all outputs on	30 mA (5 VDC) 40mA (24 VDC)	45 mA (5 VDC) 75 mA (24 VDC)
Internal current draw - all outputs off	5 mA (5 VDC) 0 mA (24 VDC)	5 mA (5 VDC) 0 mA (24 VDC)
Weight	110 g	145 g

TWDDRA8RT and TWDDRA16RT Delay

The output delay is shown below.



TWDDDO8UT, TWDDDO16UK, and TWDDDO32UK Specifications

Reference number	TWDDDO8UT	TWDDDO16UK	TWDDDO32UK
Output type	Transistor sink output		
Output points per common Line	8 points in 1 common line	16 points in 1 common line	32 points in 2 common lines
Rated load voltage	24 VDC		
Operating load voltage range	from 20.4 to 28.8 VDC		
Rated load current	0.3 A per output	0.1 A per output	
Maximum load current	0.36 A per output 3 A per common line	0.12 A per output 1 A per common line	
Voltage drop (on voltage)	1 V maximum (voltage between COM and output terminals when output is on)		
Inrush current	1 A maximum		
Leakage current	0.1 A maximum		
Clamping voltage	39 V +/-1 V		
Maximum lamp load	8 W		
Inductive load	L/R = 10 ms (28.8 VDC, 1 Hz)		
External current draw	100 mA maximum, 24 VDC (power voltage at the +V terminal)		
Isolation	Between output terminal and internal circuit: photocoupler isolated Between output terminals: not isolated		
Connector insertion/removal durability	100 times minimum		
Internal current draw - all outputs on	10 mA (5 VDC) 20 mA (24 VDC)	10 mA (5 VDC) 40mA (24 VDC)	20 mA (5 VDC) 70 mA (24 VDC)
Internal current draw - all outputs off	5 mA (5 VDC) 0 mA (24 VDC)	5 mA (5 VDC) 0 mA (24 VDC)	10 mA (5 VDC) 0 mA (24 VDC)
Output delay	Turn on time: 300 µs maximum Turn off time: 300 µs maximum		
Weight	85 g	70 g	105 g

TWDDDO8TT, TWDDDO16TK, and TWDDDO32TK Specifications

Reference number	TWDDDO8TT	TWDDDO16TK	TWDDDO32TK
Output type	Transistor source output		
Output points per common Line	8 points in 1 common line	16 points in 1 common line	32 points in 2 common lines
Rated load voltage	24 VDC		
Operating load voltage range	from 20.4 to 28.8 VDC		
Rated load current	0.3 A per output	0.1 A per output	
Maximum load current	0.36 A per output 3 A per common line	0.12 A per output 1 A per common line	
Voltage drop (on voltage)	1 V maximum (voltage between COM and output terminals when output is on)		
Inrush current	1 A maximum		
Leakage current	0.1 mA maximum		
Clamping voltage	39 V +/-1 V		
Maximum lamp load	8 W		
Inductive load	L/R = 10 ms (28.8 VDC, 1 Hz)		
External current draw	100 mA maximum, 24 VDC (power voltage at the +V terminal)		
Isolation	Between output terminal and internal circuit: photocoupler isolated Between output terminals: not isolated		
Connector insertion/removal durability	100 times minimum		
Internal current draw - all outputs on	10 mA (5 VDC) 20 mA (24 VDC)	10 mA (5 VDC) 40mA (24 VDC)	20 mA (5 VDC) 70 mA (24 VDC)
Internal current draw - all outputs off	5 mA (5 VDC) 0 mA (24 VDC)	5 mA (5 VDC) 0 mA (24 VDC)	10 mA (5 VDC) 0 mA (24 VDC)
Output delay	Turn on time: 300 µs maximum Turn off time: 300 µs maximum		
Weight	85 g	70 g	105 g

TWDDMM8DRT and TWDDMM24DRF Input Specifications

WARNING

Effect of improper input connection

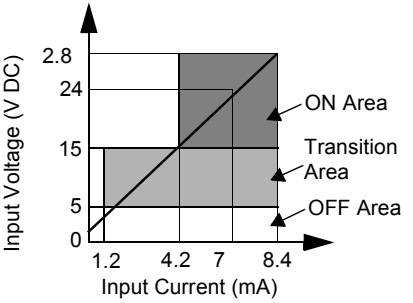
If any input exceeding the rated value is applied, permanent damage may be caused.

Failure to follow this precaution can result in death, serious injury, or equipment damage.

Reference number	TWDDMM8DRT	TWDDMM24DRF
I/O points	4 inputs and 4 outputs	16 inputs and 8 outputs
Rated input voltage	24 VDC source/sink input signal	
Input voltage range	from 20.4 to 28.8 VDC	
Rated input current	7 mA/input (24 VDC)	
Input impedance	3.4 kΩ	
Turn on time (24 VDC)	4 ms (24 VDC)	
Turn off time (24 VDC)	4 ms (24 VDC)	
Isolation	Between input terminals: not isolated Internal circuit: photocoupler isolated	
External load for I/O interconnection	Not needed	
Signal determination method	Static	
Effect of improper input connection	Both sinking and sourcing input signals can be connected.	
Cable length	3m (9.84 ft.) in compliance with electromagnetic immunity	
Connector insertion/removal durability	100 times minimum	Not removable
Internal current draw - all I/O on	25 mA (5 VDC) 20 mA (24 VDC)	65 mA (5 VDC) 45 mA (24 VDC)
Internal current draw - all I/O off	5 mA (5 VDC) 0 mA (24 VDC)	10 mA (5 VDC) 0 mA (24 VDC)
Weight	95 g	140 g

TWDDMM8DRT and TWDDMM24DRF Input Operating Range

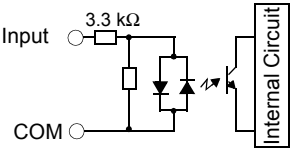
The input operating range of the Type 1 (IEC 61131-2) input module is shown below.



TWDDMM8DRT and TWDDMM24DRF Input Internal Circuit

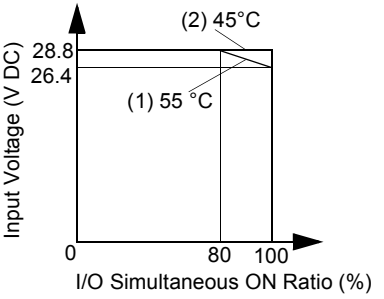
The input internal circuit is shown below.

Standard Sink or Source Input



TWDDMM8DRT and TWDDMM24DRF Usage Limits

When using TWDDMM24DRF at an ambient temperature of 55°C (131°F) in the normal mounting direction, limit the inputs and outputs, respectively, which turn on simultaneously along line (1). At 45°C (113°F), all inputs and outputs can be turned on simultaneously at 28.8 VDC as indicated with line (2).



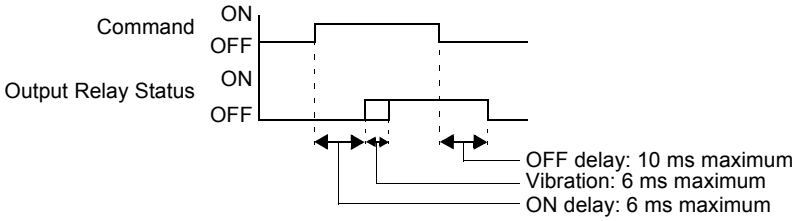
When using TWDDMM8DRT, all inputs and outputs can be turned on simultaneously at 55°C (131°F), input voltage 28.8 VDC.

TWDDMM8DRT and TWDDMM24DRF Output Specifications

Reference number	TWDDMM8DRT	TWDDMM24DRF
Output points and common lines	4 NO contacts in 1 common line	8 NO contacts in 2 common lines
Maximum load current	2 A per output 7 A per common line	
Minimum switching load	0.1 mA/0.1 VDC (reference value)	
Initial contact resistance	30 mΩ maximum	
Electrical life	100,000 operations minimum (rated load 1,800 operations/h)	
Mechanical life	20,000,000 operations minimum (rated load 18,000 operations/h)	
Rated load (resistive/inductive)	240 VAC/2 A, 30 VDC/2 A	
Dielectric strength	Between the output and ground terminals: 1,500 VAC, 1 minute Between output terminal and internal circuit: 1,500 VAC, 1 minute Between output terminals (COMs): 1,500 VAC, 1 minute	

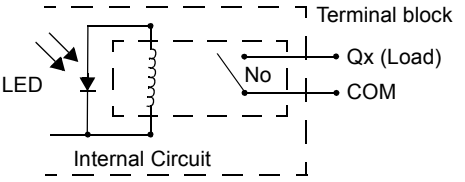
TWDDMM8DRT and TWDDMM24DR Output Delay

The output delay is shown below.



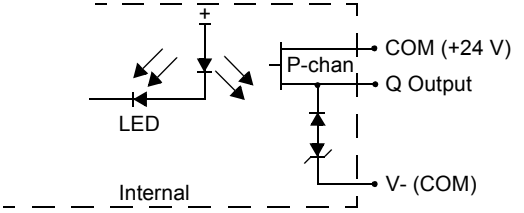
Relay Output Contact

The relay output contact is shown below.



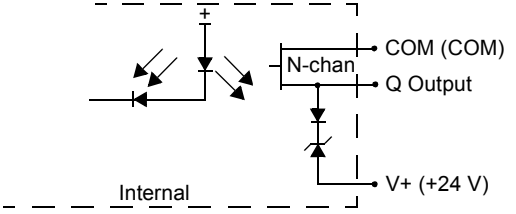
Transistor Source Output Contact

The transistor source output contact is shown below.



Transistor Sink Output Contact

The transistor sink output contact is shown below.



Digital I/O Module Wiring Schematics

Introduction

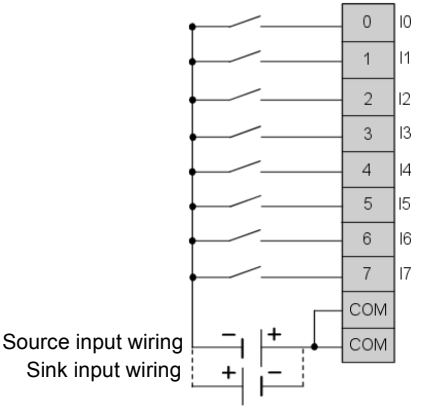
This section shows examples of wiring schematics for the digital I/O modules.

Note: These schematics are for external wiring only.

Note: The shaded boxes are markings on the digital I/O modules. The I and Q numbers are the input and output points.

TWDDDI8DT Wiring Schematic

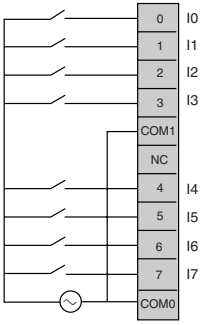
This schematic is for the TWDDDI8DT module.



- The two COM terminals are connected together internally.

TWDDAI8DT Wiring Schematic

This schematic is for the TWDDAI8DT module.

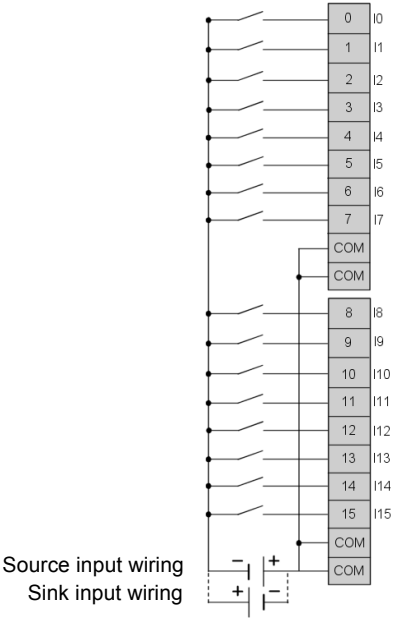


120 VAC input wiring

- The two COM terminals are **not** connected together internally.

TWDDDI16DT Wiring Schematic

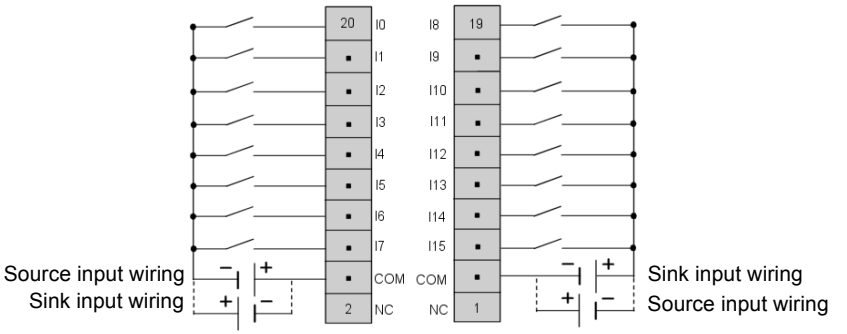
This schematic is for the TWDDDI16DT module.



- The four COM terminals are connected together internally.

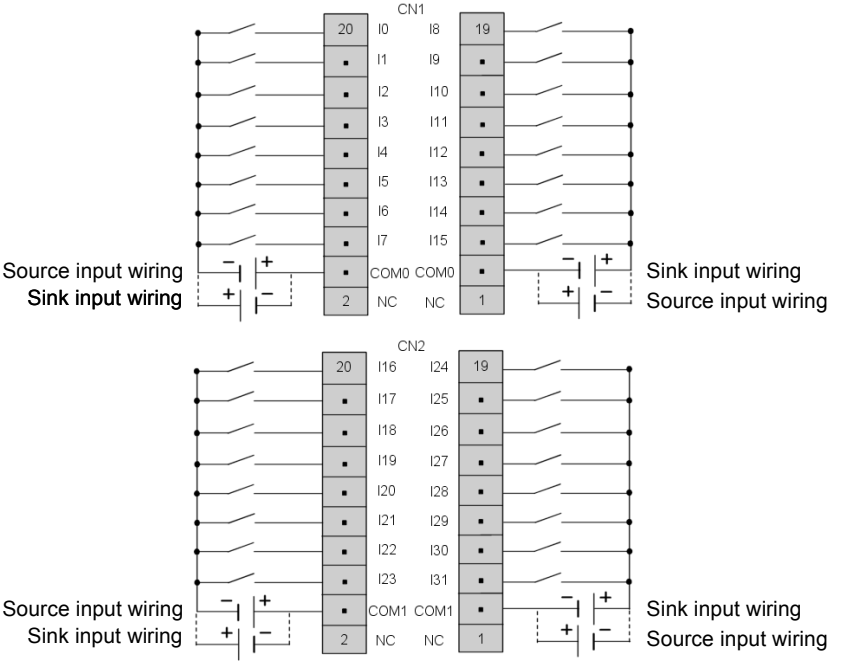
TWDDDI16DK Wiring Schematic

This schematic is for the TWDDDI16DK module.



TWDDDI32DK Wiring Schematic

This schematic is for the TWDDDI32DK module.



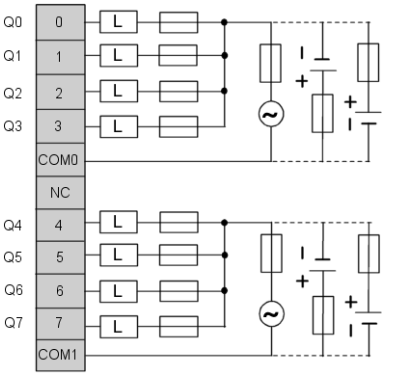
- The COM0 terminals are connected together internally.
- The COM1 terminals are connected together internally.

- The COM0 and COM1 terminals are **not** connected together internally.

TWDDRA8RT Wiring Schematic

This schematic is for the TWDDRA8RT module.

Relay output wiring

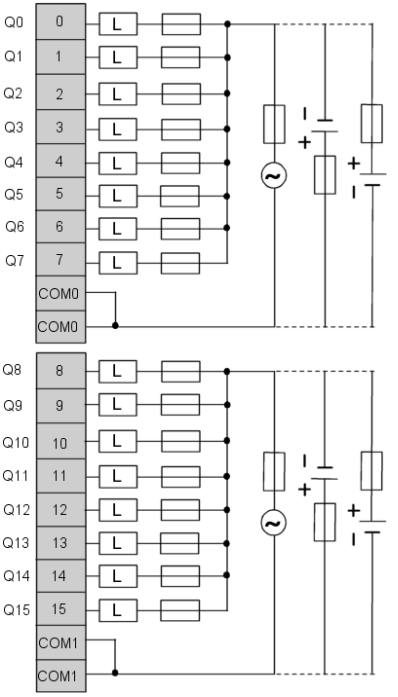


- The COM0 and COM1 terminals are **not** connected together internally.
- Connect an appropriate fuse for the load.

TWDDRA16RT Wiring Schematic

This schematic is for the TWDDRA16RT module.

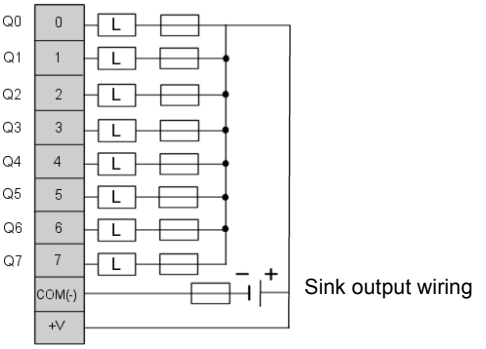
Relay output wiring



- The COM0 terminals are connected together internally.
- The COM1 terminals are connected together internally.
- The COM0 and COM1 terminals are **not** connected together internally.
- Connect an appropriate fuse for the load.

TWDDDO8UT Wiring Schematic

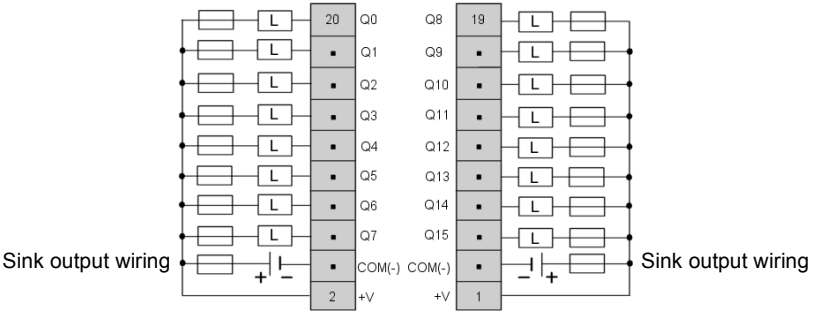
This schematic is for TWDDDO8UT module.



- Connect an appropriate fuse for the load.

TWDDDO16UK Wiring Schematic

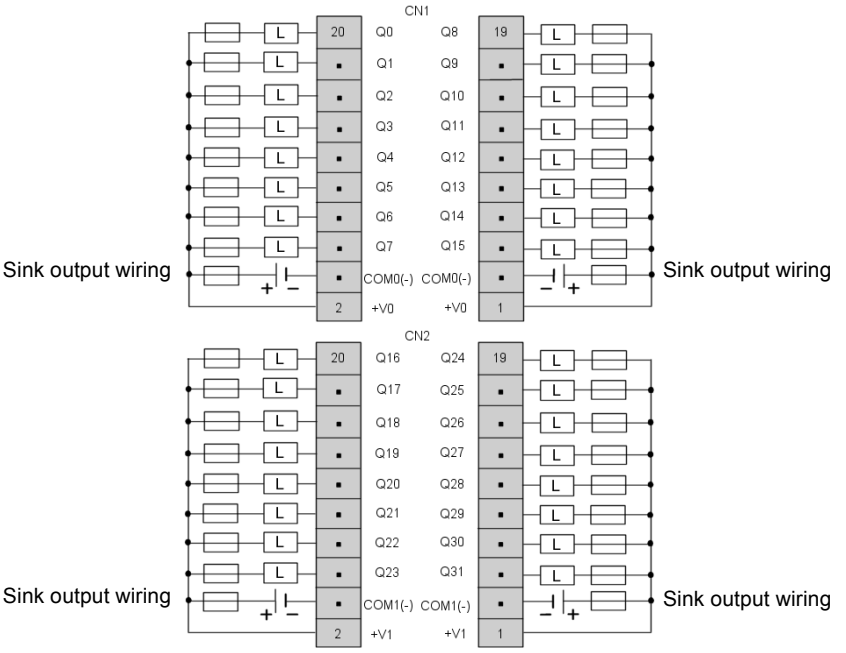
This schematic is for the TWDDDO16UK module.



- The COM(-) terminals are connected together internally.
- The +V terminals are connected together internally.
- Connect an appropriate fuse for the load.

TWDDDO32UK Wiring Schematic

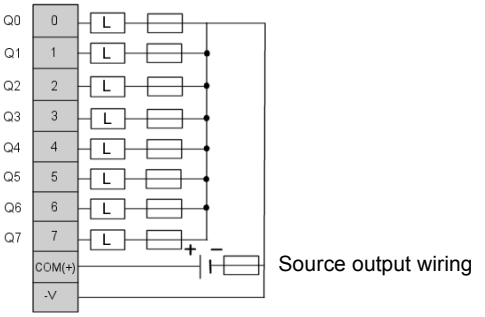
This schematic is for the TWDDDO32UK module.



- Terminals on CN1 and CN2 are **not** connected together internally.
- The COM0(-) terminals are connected together internally.
- The COM1(-) terminals are connected together internally.
- The +V0 terminals are connected together internally.
- The +V1 terminals are connected together internally.
- Connect an appropriate fuse for the load.

TWDDDO8TT Wiring Schematic

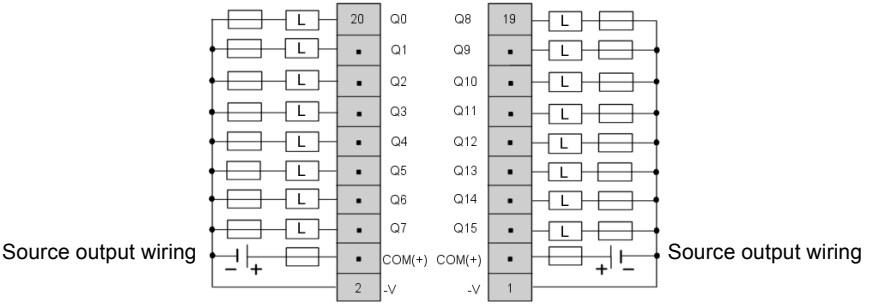
This schematic is for the TWDDDO8TT module.



- Connect an appropriate fuse for the load.

TWDDDO16TK Wiring Schematic

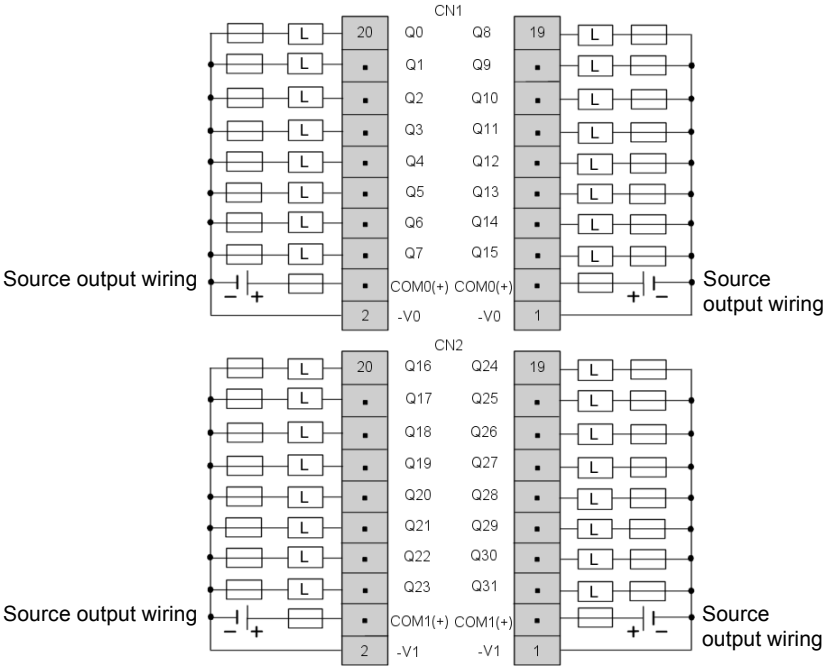
This schematic is for the TWDDDO16TK module.



- The COM(+) terminals are connected together internally.
- The -V terminals are connected together internally.
- Connect an appropriate fuse for the load.

TWDDDO32TK Wiring Schematic

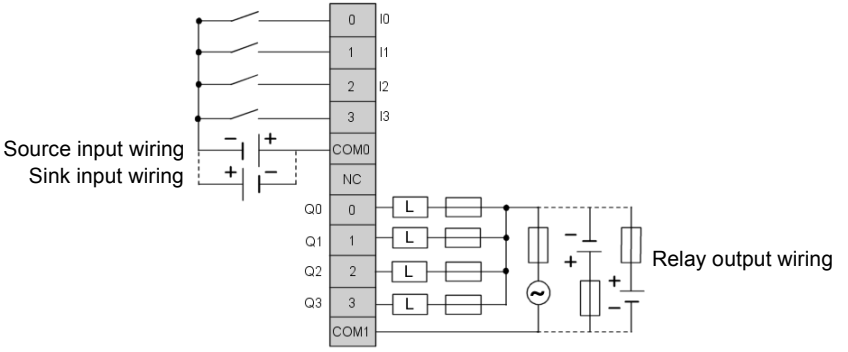
This schematic is for the TWDDDO32TK module.



- Terminals CN1 and CN2 are **not** connected together internally.
- The COM0(+) terminals are connected together internally.
- The COM1(+) terminals are connected together internally.
- The -V0 terminals are connected together internally.
- The -V1 terminals are connected together internally.
- Connect an appropriate fuse for the load.

TWDDMM8DRT Wiring Schematic

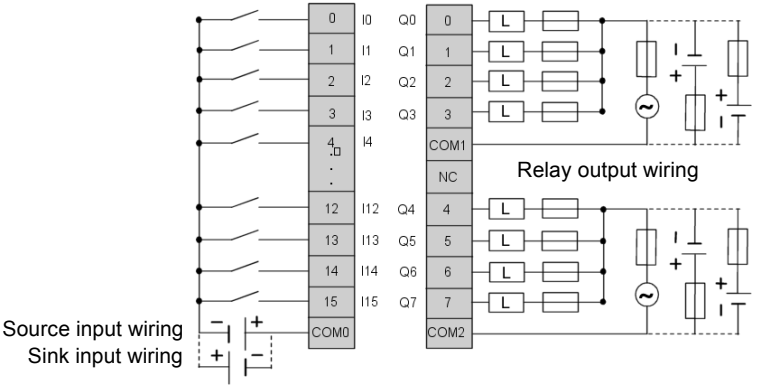
This schematic is for the TWDDMM8DRT module.



- The COM0 and COM1 terminals are **not** connected together internally.

TWDDMM24DRF Wiring Schematic

This schematic is for the TWDDMM24DRF module.



- The COM0, COM1 and COM2 terminals are **not** connected together internally.
- Connect an appropriate fuse for the load.

2.5 Analog I/O Modules

At a Glance

Introduction

This section provides an overview, specifications, and wiring schematics of the analog I/O modules.

What's in this Section?

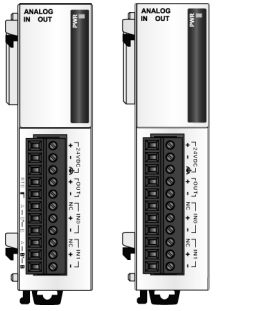
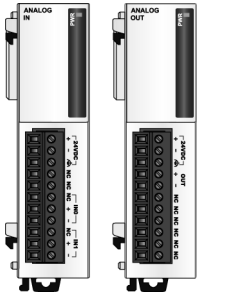
This section contains the following topics:

Topic	Page
Overview of Analog I/O Modules	108
Parts Description of Analog I/O Modules	109
General Specifications for the Analog I/O Module	110
I/O Specifications for the Analog I/O Module	111
Analog I/O Modules Wiring Schematics	115

Overview of Analog I/O Modules

Introduction The following section provides an overview of the analog I/O modules.

Illustrations TheThe following illustrations are the analog I/O modules.

Controller Type	Illustration
These 2 analog I/O modules are: • 2-point input/1-point output module with a terminal block, accepts thermocouple and resistance thermometer signals (TWDALM3LT) • 2-point input/1-point output module with a terminal block (TWDAMM3HT) These modules can be attached to any controller except the Compact 10 I/O and 16 I/O controllers.	TWDALM3LT TWDAMM3HT 
These 2 analog I/O modules are: • 2-point input module with a terminal block (TWDAMI2HT) • 1-point output module with a terminal block (TWDAMO1HT) These modules can be attached to any controller except the Compact 10 I/O and 16 I/O controllers.	TWDAMI2HT TWDAMO1HT 

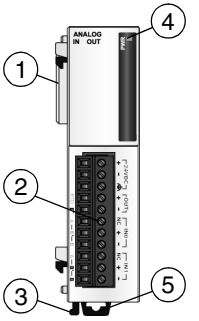
Parts Description of Analog I/O Modules

Introduction

The following section describes the parts of an analog I/O module. Your I/O module may differ from the illustrations but the parts will be the same.

Parts Description of an Analog I/O Module

The following figure shows the parts of an analog I/O module. This figure is the TWDALM3LT module.



Legend

Label	Description
1	Expansion connector - one on each side, right side not shown
2	Removable terminal block
3	Latch button
4	LEDs
5	Clamp

General Specifications for the Analog I/O Module

Introduction

This section is general specifications for analog I/O modules.

General Specifications

Reference	TWDALM3LT	TWDAMM3HT	TWDAMI2HT	TWDAMO1HT
Rated power voltage	24 VDC			
Allowable voltage range	from 20.4 to 28.8 VDC			
Average number of connector insertions/ removals	100 times minimum			
Internal current draw - internal power	50mA (5 VDC) 0 mA (24 VDC)			
Internal current draw - external power	40mA (24 VDC)			
Weight	85 g			

I/O Specifications for the Analog I/O Module

Introduction

This section is I/O specifications for the analog I/O modules.

Input Specifications

Analog Input Specifications	Voltage Input	Current Input	Thermocouple	Resistance Thermometer
Input range	from 0 to 10 VDC	from 4 to 20 mA DC	Type K (0 to 1300 °C) (32 to 2372 °F) Type J (0 to 1200 °C) (32 to 2192 °F) Type T (0 to 400 °C) (32 to 742 °F)	Pt 100 3-wire type (-100 to 500 °C) (-148 à 932 °F)
Input impedance	1 MΩ min.	10 Ω	1 MΩ min.	1 MΩ min.
Sample duration time	16 ms max.		50 ms max.	
Sample repetition time	16 ms max.		50 ms max.	
Total input system transfer time	32 ms + 1 scan time[1]		100 ms + 1 scan time[1]	
Input type	Single-ended input	Differential input		
Operating mode	Self-scan			
Conversion mode	ΣΔ type ADC			
Input error - maximum error at 25°C (77°F)	±0.2 % of full scale		±0.2% of full scale plus reference junction compensation accuracy ±4°C max	±0.2 % of full scale
Input error - temperature coefficient	±0.006% of full scale/°C			
Input error - repeatable after stabilization time	±0.5 % of full scale			
Input error - nonlinear	±0.2 % of full scale			
Input error - maximum error	±1 % of full scale			

Analog Input Specifications	Voltage Input	Current Input	Thermocouple	Resistance Thermometer
Digital resolution	4096 increments (12 bits)			
Input value of LSB	2.5 mV	4 µA	K: 0.325 °C J: 0.300 °C T: 0.100 °C	0.15 °C
Data type in application program	0 to 4095 (12 bit data) -32768 to 32767 (optional range designation)[2]			
Monotonicity	Yes			
Input data out of range	Detectable[3]			
Noise resistance - maximum temporary deviation during electrical noise tests	±3% maximum when a 500 V clamp voltage is applied to the power and I/O wiring			Accuracy is not assured when noise is applied
Noise resistance - common mode characteristics	Common mode reject ration (CMRR): -50 dB			
Noise resistance - common mode voltage	16 VDC			
Noise resistance - input filter	No			
Noise resistance - cable	Twisted-pair shielded cable is recommended for improved noise immunity		—	
Noise resistance - crosstalk	2 LSB maximum			
Dielectric strength	500 V between input and power circuit			
Type of protection	Photocoupler between input and internal circuit			
Maximum permanent allowed overload (no damage)	13 VDC	40 mA DC	—	
Selection of analog input signal type	Using software programming			
Calibration or verification to maintain rated accuracy	Approximately 10 years			

Note:
1. Total input system transfer time = sample repetition x 2 + 1 scan time.
2. The 12-bit data (0 to 4095) processed in the Analog I/O module can be linear-converted to a value between -32768 and 32767. The optional range designation and analog I/O data minimum and maximum values can be selected using data registers allocated to analog I/O modules.
3. When an error is detected, a corresponding error code is stored to a data register allocated to analog I/O operating status.

Output Specifications

Analog Input Specifications	Voltage output	Current Output
Output range	from 0 to 10 VDC	from 4 to 20 mA DC
Load impedance	2 kΩ max	300 Ω maximum
Application load type	Resistive load	
Settling time	20 ms	
Total output system transfer Time	20 ms + 1 scan time	
Output error - maximum error at 25°C (77°F)	±0.2 % of full scale	
Output error - temperature coefficient	±0.015% of full scale/°C	
Output error - repeatable after stabilization time	±0.5 % of full scale	
Output error - output voltage drop	±1 % of full scale	
Output error - nonlinear	±0.2 % of full scale	
Output error - output ripple	1 LSB maximum	
Output error - overshoot	0%	
Output error - total error	±1 % of full scale	
Digital resolution	4096 increments (12 bits)	
Output value of LSB	2.5 mV	4 μA
Data type in application program	0 to 4095 (12 bit data) -32768 to 32767 (optional range designation)[1]	
Monotonicity	Yes	
Current loop open	—	Detectable[2]

Analog Input Specifications	Voltage output	Current Output
Noise resistance - maximum temporary deviation during electrical noise tests	±3% maximum when a 500 V clamp voltage is applied to the power and I/O wiring	
Noise resistance - cable	Twisted-pair shielded cable is recommended for improved noise immunity	
Noise resistance - crosstalk	No crosstalk because of 1 channel output	
Dielectric strength	500 V between output and power circuit	
Type of protection	Photocoupler between output and internal circuit	
Selection of analog input signal type	Using software programming	
Calibration or verification to maintain rated accuracy	Approximately 10 years	

Note:

1. The 12-bit data (0 to 4095) processed in the Analog I/O module can be linear-converted to a value between -32768 and 32767. The optional range designation and analog I/O data minimum and maximum values can be selected using data registers allocated to analog I/O modules.
2. When an error is detected, a corresponding error code is stored to a data register allocated to analog I/O operating status.

Analog I/O Modules Wiring Schematics

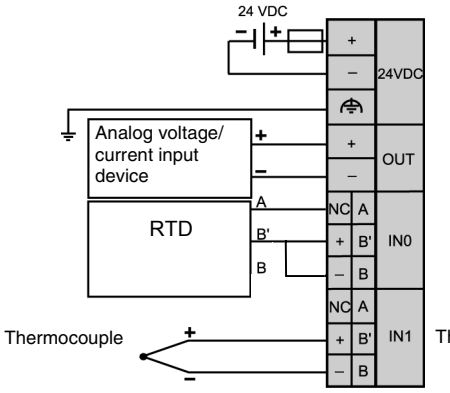
Introduction

This section shows examples of wiring schematics for the Analog I/O modules.

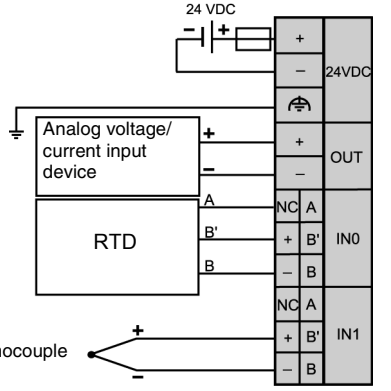
TWDALM3LT Wiring Schematic

This schematic is for the TWDALM3LT module.

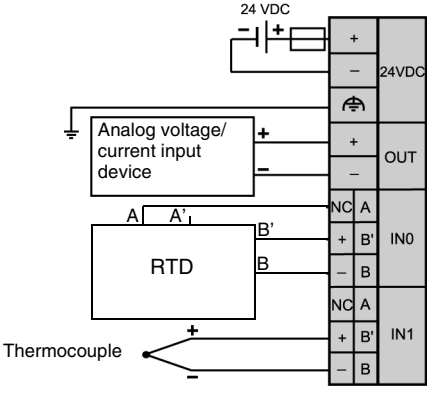
2-wire cabling:



3-wire cabling:



4-wire cabling:



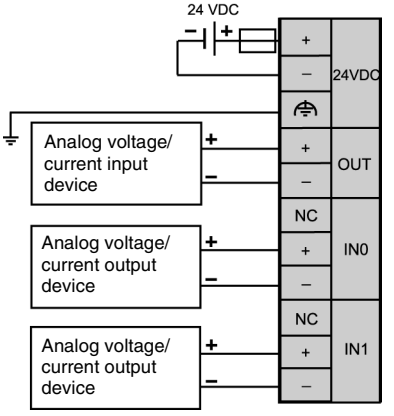
Note: For 4-wire cabling, output A' is not connected.

- Connect a fuse appropriate for the applied voltage and current draw, at the position shown in the diagram.
- When connecting an RTD, connect the three wires to terminals A, B', and B of input channel 0 or 1.

- When connecting a thermocouple, connect the two wires to terminals B' and B of input channel 0 or 1.
- Do not connect any wiring to unused channels.
- Do not connect the thermocouple to a hazardous voltage (60 VDC or 42.4 V peak or higher)

TWDAMM3HT Wiring Schematic

This schematic is for the TWDAMM3HT module.

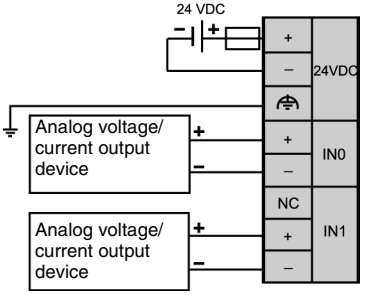


- Connect a fuse appropriate for the applied voltage and current draw, at the position shown in the diagram.
- Do not connect any wiring to unused channels.

Note: The (-) poles of inputs IN0 and IN1 are connected internally.

TWDAMI2HT Wiring Schematic

This schematic is for the TWDAMI2HT module.

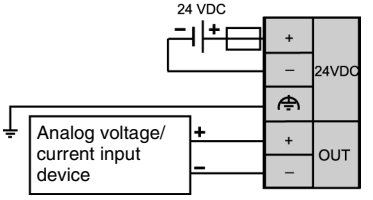


- Connect a fuse appropriate for the applied voltage and current draw, at the position shown in the diagram.
- Do not connect any wiring to unused channels.

Note: The (-) poles of inputs IN0 and IN1 are connected internally.

TWDAMO1HT Wiring Schematic

This schematic is for the TWDAMO1HT module.



- Connect a fuse appropriate for the applied voltage and current draw, at the position shown in the diagram.
- Do not connect any wiring to unused channels.

2.6 AS-Interface V2 bus master module

At a Glance

Introduction

This section provides a review of the AS-Interface bus, presents the description, specifications and use of the AS-Interface master module**TWDNOI10M3**.

What's in this Section?

This section contains the following topics:

Topic	Page
Reminder about the AS-Interface bus	119
Presentation of the main constituent elements of the AS-Interface bus	122
Main specifications of the AS-Interface V2 Bus	124
Parts description of an AS-Interface master module: TWDNOI10M3	127
Technical specifications of the TWDNOI10M3 module and the AS-Interface V2 bus	128
Wiring and connections	130
TWDNOI10M3 Operating Modes and Push Buttons	133
AS-Interface module TWDNOI10M3 display panel	135

Reminder about the AS-Interface bus

General

The AS-Interface (abbreviation for Actuator-Sensor-Interface) bus is a field bus (level 0), and can be used to connect sensors/actuators. This allows "discrete" or analog type information to run between a bus "master" and sensor/actuator type "slave" devices.

AS-Interface is made up of three major basic elements:
- a specific supply providing a 30 VDC voltage,
- a bus master,
- one or more slave devices (sensors, actuators and others).

These components are interconnected by a two-wire cable dedicated to data transmission and power supply.

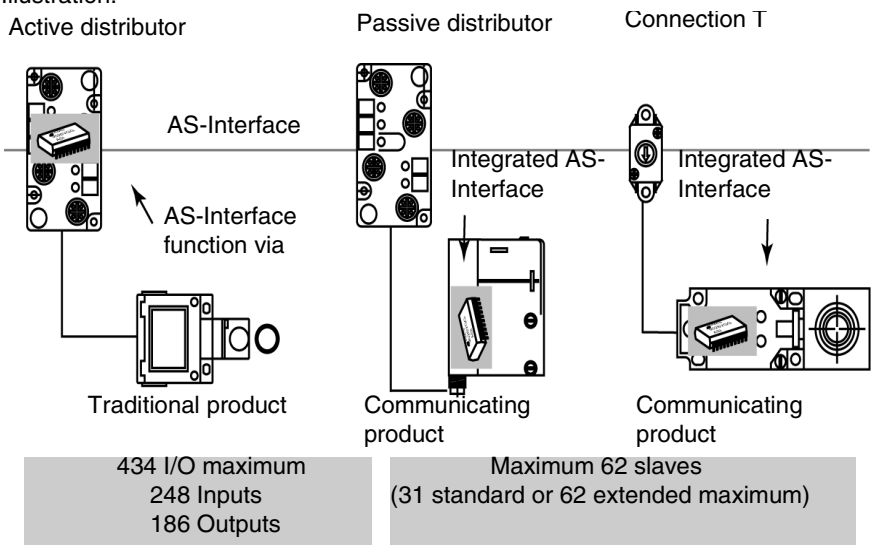
The main types of sensors/ actuators

Table of the main types of sensors:

Type of sensor	Description
Communicating sensors/ actuators (compatible with AS-Interface)	Thanks to the integrated AS-Interface feature, they connect directly to the AS-Interface bus via a passive dispatcher or a connection T.
Traditional sensors/actuators (not compatible with AS-Interface)	They connect to the bus via an AS-Interface interface (active dispatcher). These interfaces connect the sensors and traditional actuators to the AS-Interface bus and provide them with dialog capacity on the bus.

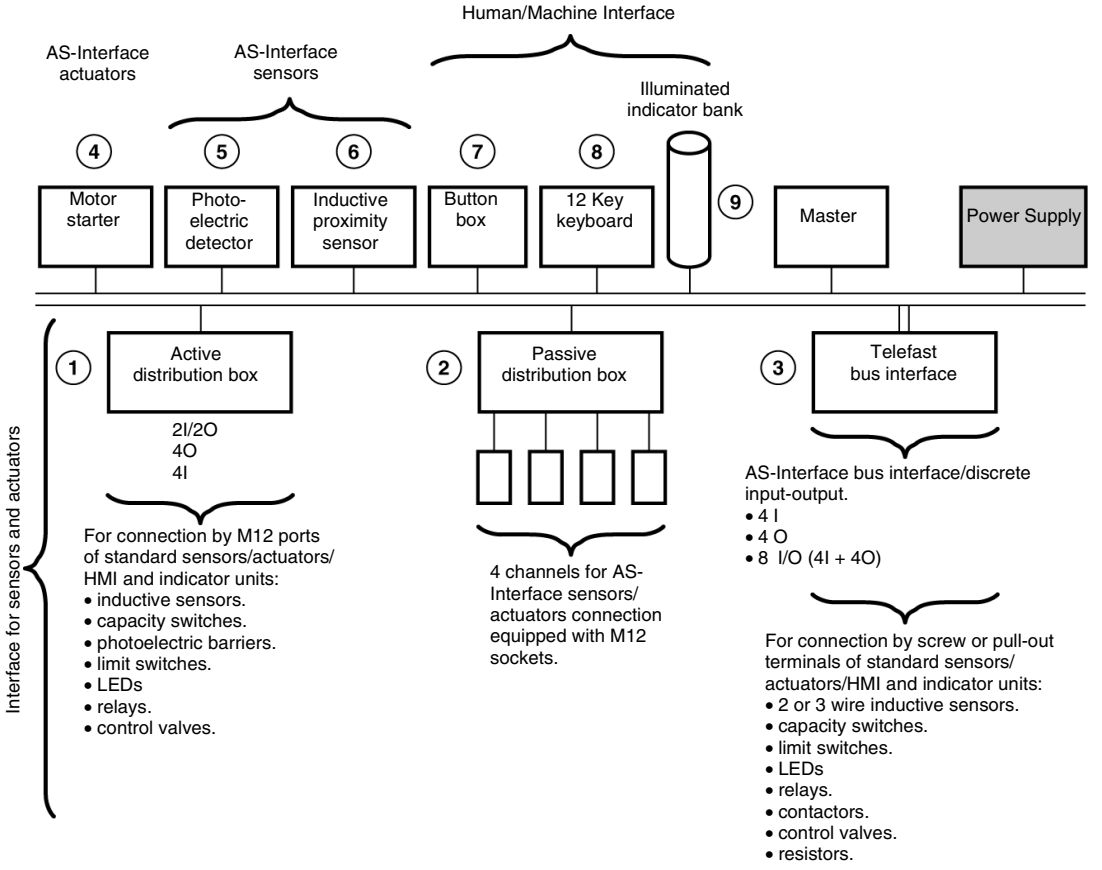
Illustration

Illustration:



Overview of AS-Interface Products from the Schneider Catalog

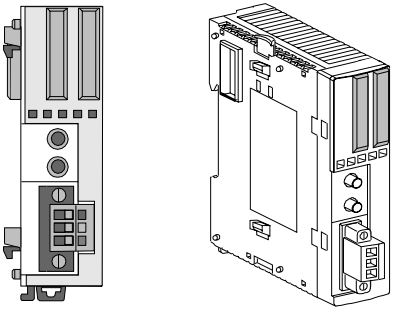
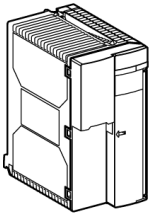
Non-exhaustive list of AS-Interface products from the Schneider catalog:

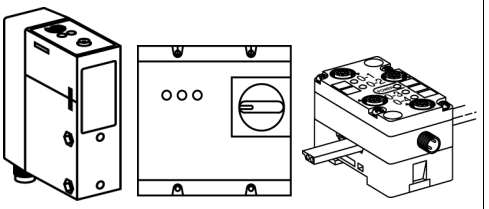


Presentation of the main constituent elements of the AS-Interface bus

Introduction to the Main Constituent Elements

The following table lists the main constituent elements of an AS-Interface bus:

Part	Illustration
AS-Interface bus master Connected to a modular controller or a compact TWDLC•A24DRF or TWDLCA•40DRF series, it manages all exchange of data on the AS-Interface network. It also enables slave status to be monitored.	 Module TWDNOI10M3
AS-Interface Power Supply Specific AS-Interface power supplies, dedicated to 30 VDC, designed to supply the constituents connected to the AS-Interface bus. The power supply is distributed with the same medium used for data exchange.	 Alimentation 30 Vcc
Cable This transmits data and carries the power. It can be made up from: • Either a standard two-wire AS-Interface yellow ribbon cable, unshielded and polarized, • Or a standard round, shielded or unshielded two-wire cable.	 Guiding ribbon cable  Round cable

Part	Illustration
Slaves Different types of slaves can be connected to the AS-Interface, bus, including the sensors, actuators and splitters, as well as the analog slaves. Slaves are available as slaves with standard address settings, or as slaves with extended address settings (A/B).	 Sensor Actuator Passive

Main specifications of the AS-Interface V2 Bus

Overview

AS-Interface is a system in which exchange management is ensured by a single master which, by scanning the bus, calls each detected slave in succession and awaits a response. The master manages the inputs/outputs, parameters and identity codes of each slave, as well as their addressing.

For slaves with AS-Interface V2 standard addressing, the serial communications frame carries:

- 4 data bits (D0 to D3), which are the image of inputs or outputs according to the type of interface,
- 4 parametering bits (P0 to P3), which are used to set the operating modes of the interface.

Communication series frame for slaves with extended addressing settings:

- 4 data bits (D0 to D3), which are the image of inputs or outputs according to the type of interface,
- 3 parametering bits (P0 to P2), which are used to set the operating modes of the interface.

All slave devices connected to the AS-Interface bus are identified by at least one "I/O Code" and one "ID code" which completes the functional identification of the slave.

Some slaves have an ID2 and ID1 code, which define the internal functions of the slave: on analog slaves, for example, ID2 shows the slave's analog channel number.

In the AS-Interface master request, outputs are positioned and AS-Interface input devices are sent back in the slave's response.

Table of Main Specifications

The following table provides the main specifications of the AS-Interface V2 bus:

Specifications	Description
Slave Addressing	Each slave connected to the AS-Interface bus must have an address between 1 and 31, accompanied by "bank" /A or "bank" /B for extended addressing. The slaves delivered from the factory have the address 0 (the address of the slave is memorized in a non-volatile format). Addresses are programmed using a specialized addressing terminal.
Identification of Slaves	All slave devices connected to the AS-Interface bus are identified by: • an ID identity code (coded on 4 bits) that specifies the type of slave (sensor, extended slave, etc.). For example, the ID code of an extended slave is 0xA, • an I/O code (coded on 4 bits) that shows input/output distribution. For example, the I/O code of a slave with 4 inputs is 0, with 4 inputs is 8 and with 2 I/2O is 4, • an ID2 code (coded on 4 bits) that specifies the internal functionalities of the slave, • an ID1 code (coded on 4 bits) that specifies an additional slave identity, These identifications allow the AS-Interface master to recognize the configuration present on the bus. These different profiles have been developed by the AS-Interface association. They are used to distinguish between input, output and mixed modules, "intelligent" device families, etc.
Maximum number of slaves and inputs/outputs	On the same bus, an AS-Interface bus can support a maximum of: • 31 slaves with standard address settings; each slave can have a maximum of 4 inputs and/or 4 outputs, with addresses from 1 to 31, • 62 slaves with extended address settings; each slave can have a maximum of 4 inputs and/or 3 outputs, with addresses from 1 A/B to 31A/B. This makes it possible to manage a maximum of 248 inputs +186 outputs (thus 434 inputs/outputs) when all extended slaves have 4 inputs and 3 outputs.
Topology and Maximum Length of AS-Interface Bus	The topology of the AS-Interface bus is flexible. It can be perfectly adapted to meet the user's needs (point to point, on line, tree structure etc.). In every case, the total length of all the branches of the bus must not exceed 100 meters without a relay.

Specifications	Description
AS-Interface Bus Cycle Time	This is the cycle time between slave(s) and the master module. The AS-Interface system always transmits information, which is the same length to each slave on the bus. The AS-Interface cycle time depends on the number of active slaves connected to the bus. The scan time **t** represents the exchange time between a master and **n** active slaves (a maximum of 31 on /A or /B). So, for: ● up to 19 active slaves, **t** = 3ms ● 20 to 31 active slaves t = (1+**n**) * 0.156ms When two slaves A and B have the same address, each slave in the pair is scanned every two cycles. This means that for 31 extended address setting slaves configured in /A, + 31 extended address setting slaves configured in /B. the scan time will be 10 ms. Maximum cycle time: ● maximum 5 ms for 31 standard or extended address setting slaves, ● maximum 10 ms for 62 extended address setting slaves.
Reliability, Flexibility	The transmission process used (current modulation and Manchester code) guarantees dependable operation. The master monitors the line supply voltage and the data sent. It detects transmission errors as well as slave failures, and sends the information to the PLC. The exchange of a slave or connection of a new slave during operations does not disrupt communications with the other slaves.

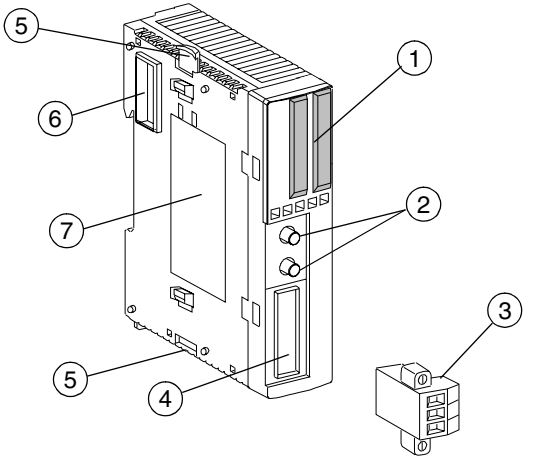
Note: When a faulty slave is replaced, the update of the replacement slave's address can be automatically carried out if the automatic addressing function is allowed on the master module.

Note: When there is mixed use of slaves with standard and extended address settings, a standard address setting slave only use an address from 1(A) to 31(A). The same address accompanied by "bank" /B can only be used by an extended address setting slave.

Parts description of an AS-Interface master module: TWDNOI10M3

Parts Description

The following diagram shows the different parts of the AS-Interface TWDNOI10M3 master module:



Legend

The module is made up of the following elements:

No.	Part	Description
1	Display screens	• Status display LEDs: show AS-Interface bus status, • I/O LEDs: show the I/O status of a slave specified by the address LEDs, • Address LEDs: show slave addresses.
2	Push Buttons	Allow selection of a slave's address and change of mode.
3	Client terminal	Is connected to the AS-Interface cable.
4	AS-Interface cable connector	To install the terminal.
5	Latch button	Holds/releases the module from a controller.
6	Expansion Connector	Enables connection to the Twido module and connection to another I/O module.
7	Module name	Shows the module reference and specification.

Technical specifications of the TWDNOI10M3 module and the AS-Interface V2 bus

AS-Interface V2 Bus

Technical specifications:

Specification	Value
Maximum cycle time of AS-Interface bus:	• from 1 to 19 slaves = 3ms, • from 20 to 62 slaves = (1+n) x 0.156ms where n = number of active slaves. 5 ms pour 31 standard or extended address setting slaves, 10 ms pour 62 extended address setting slaves.
Maximum number of slaves on the bus:	31 standard address setting slaves or, 62 extended address setting slaves.
Maximum length of AS-Interface bus cables:	all branches without relay: 100 meters with two relays: 300 meters
Maximum number of I/O managed by the bus	standard address setting slaves: 124 inputs + 124 outputs extended address setting slaves: 248 inputs + 186 outputs
Nominal bus supply voltage	30 VDC

AS-Interface TWDNOI10M3 module

Technical specifications:

Specification	Value
Operating temperature	0 to 55°C (32°F to 131°F) operating ambient temperature
Storage temperature	-25°C to +70°C (-13°F to 158°F)
Relative humidity	from 30 to 95% Rh (non-condensing)
Pollution degree	2 (IEC60664)
Degree of protection	IP20
Corrosion immunity	Free from corrosive gases
Altitude	Operation: from 0 to 2000 m Transport: from 0 to 3000 m

Specification	Value
Resistance to Vibration	When mounted on a DIN rail: from 10 to 57 Hz amplitude 0.075 mm, from 57 to 150 Hz acceleration 9.8 ms^2 (1G), 2 hours per axis on each of three mutually perpendicular axes. When mounted on a panel surface: from 2 to 25 Hz amplitude 1.6 mm, from 25 to 100 Hz acceleration 39.2 ms^2 (4G) Lloyd's 90 min per axis on each of three mutually perpendicular axes.
Resistance to Shock	147 ms^2 (15G), 11 ms duration, 3 shocks per axis, on three mutually perpendicular axes (IEC 61131).
Allowable voltage range	from 29.5 to 31.6 VDC
Current consumed on the AS-Interface bus	Typically 65 mA / 110 mA maximum
Protection against polarity inversion on bus inputs	Yes
Connector on mother board	MSTB2.5/3-GF-5.08BK (Phoenix contact)
Average number of connector insertions/removals	100 times minimum
Power consumption	At 5 VDC: 80 mA At 24 VDC: 0 mA
Power dissipation	540 mW (24 VDC)
Weight	85 g

CAUTION

Connection of Other Expansion Modules

- When an AS-Interface module is connected to a Twido module, do not connect more than five I/O expansion modules (if Twido can usually accept seven) because of the amount of heat that is generated.
- The AS-Interface master module can accept a maximum of seven analog I/O slaves; otherwise the AS-Interface system will not operate correctly.

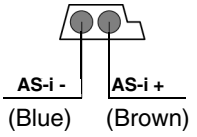
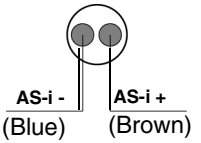
Failure to follow this precaution can result in injury or equipment damage.

Wiring and connections

Different Cable Types

The AS-Interface bus cables carry the signals and provide a 30 VDC power supply to the sensors and actuators connected to this bus.

Types of AS-Interface cables:

Cable type	Specifications	Illustration
Polarized AS-Interface ribbon cable	Jacket color: yellow Wire cross-section: 1.5 mm^2	
Standard round cable or separated cables	Wire cross-section: - multifiliment: from 0.5 mm^2 to 1.0 mm^2 - solids: from 0.75 mm^2 to 1.5 mm^2 AWG: from 16 to 20	

Procedure for Connecting the AS-Interface Master Module to the Bus

The following table describes the connection procedure:

Steps	Description
1	Remove the terminal from the module bus connector.
2	Respecter the polarities of the AS-Interface cable: brown cable for the AS-i+ pole and blue cable for the AS-i– pole. Connect the cable according to the colors shown on the terminal.
3	Connect the AS-Interface ground terminal block to the DIN rail (see diagram).
4	Using a screwdriver, tighten the screws on the terminal between 0.5 to 0.6 Newton meters of torque. The use of end ferrules crimped at the multifilament or solid wires terminators will prevent the cable from slipping out of the terminal.
5	Insert the terminal into the module connector on the module. Using a screwdriver, tighten the mounting screws on the terminal between 0.3 to 0.5 Newton meters of torque.

CAUTION

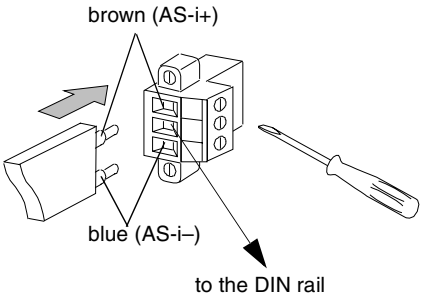
Electric shock hazard

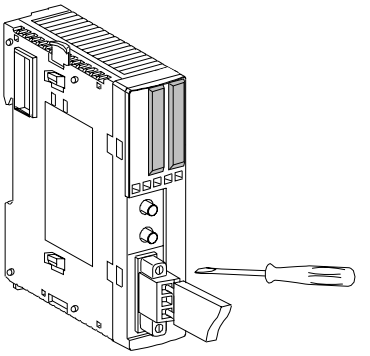
Do not touch the cable terminators, including immediately after the module has been switched off.

Failure to follow this precaution can result in injury or equipment damage.

Illustration of Connection

Illustration of Connection:





	**CAUTION** **AS-Interface V2 bus supply** Use an AS-Interface TBTS (Very Low Safety Voltage) supply, with nominal voltage of 30VDC. **Failure to follow this precaution can result in injury or equipment damage.**

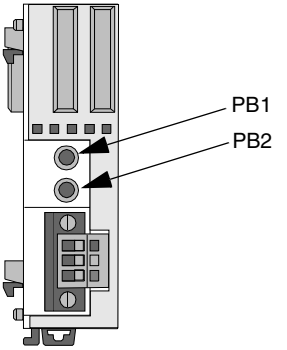
TWDNOI10M3 Operating Modes and Push Buttons

At a Glance

The actions performed using the push buttons PB1 and PB2 on the front panel of the AS-Interface module depend on the length of time for which they are pressed. A "long press" selects the operating mode and a "short press" selects the address of the slave on which you wish to perform diagnostics. If the length for which the buttons are pressed does not correspond to either of those mentioned above or the two buttons are pressed simultaneously, the status of the module remains unchanged.

Illustration

The following illustration shows the position of the buttons:



Pressing Buttons

The following table describes the function of the buttons:

Action	Description
Long press	A "long press" is effective when the button is pressed for 3 seconds or more. Use a long press to change the operating mode of the AS-Interface master.
Short press	A "short press" corresponds to pressing the button for not more than 0.5 seconds. Use a short press to change the address of the slave for which you wish to view the I/O status via the LEDs on the AS-Interface master. Pressing PB1 increments the slave address, and PB2 decrements it. When the last address 31B is reached, pressing PB1 returns you to the first address 0A.

AS-Interface Master Module Operating Modes

As soon as it is powered up, the AS-Interface module goes into online mode. The Twido module can then communicate with the AS-Interface master to allow viewing and checking of the status of each slave. Online mode consists of the three following modes:

- **Normal protected mode:**
  On power up, the AS-Interface master initially goes into this mode if no error occurs. This is the normal operating mode in which the AS-Interface master exchanges communication data with slaves connected to it.
- **Normal protected mode - Offline (software not connected):**
  To enter this mode from the previous mode, press and hold down ("long press") the push button PB2. The AS-Interface master then stops all communication with slaves allowing you to perform operations such as the initialization of the master module. In this mode, the Twido module cannot display the status of slaves. The OFF LED (See *Display of AS-Interface Master Operating Modes, p. 137*) of the AS-Interface master illuminates to indicate that the module is in Offline mode. To return to the previous mode, press and hold down ('long press") push button PB2 a second time.
- **Normal protected mode - Data Exchange Off:**
  This mode can be entered and exited only by a user program in TwidoSoft. In this mode all forms of communication with slaves is prohibited.

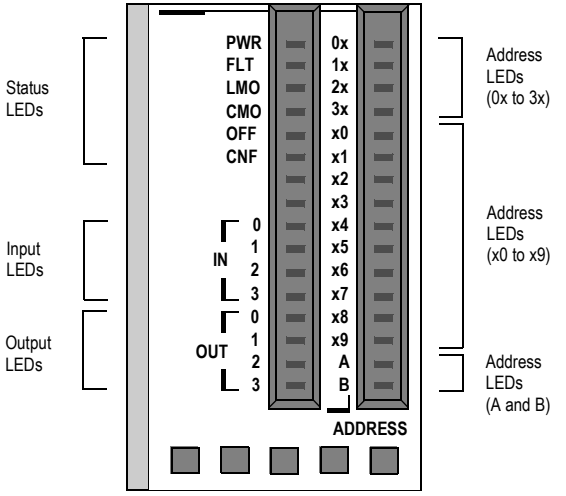
AS-Interface module TWDNOI10M3 display panel

At a Glance

The AS-Interface master module **TWDNOI10M3** is equipped with a display screen consisting of status LEDs, input/output LEDs and address LEDs.

Illustration

Illustration of display panel:



Display of Module Status

Module status is displayed by the status LEDs on the module which provide information depending on their state (indicator extinguished or illuminated) on the module operating mode.

Status LED descriptions

LED	Status	Description
PWR	●	Indicates that the AS-Interface module is not powered up.
	○	Indicates that insufficient power is being delivered to the AS-Interface module.
FLT	●	Indicates that the configuration loaded onto the AS-Interface master is not correct or that an error has occurred on the AS-Interface bus.
	○	Module OK.
LMO	○	Indicates that the module is not in offline mode (the module is online from power up). Note: Flickers on power up.
CMO	●	Indicates that the module is in online mode.
OFF	●	Indicates that the module is in offline normal protected mode.
	○	Indicates that the module is in another operating mode.
CNF	○	This indicator is no longer used. Note: Flickers on power up.
○ Extinguished ● Illuminated		

Display of AS-Interface Master Operating Modes

The operating modes of the AS-Interface module can be changed using the push buttons or TwidoSoft programming software. The status LEDs also allow you to determine what mode the AS-Interface module is in.
Mode display table

Operating modes	PWR	FLT	LMO	CMO	OFF	CNF
Normal Protected Mode	●	○	○	●	○	○
Normal Protected Mode (Offline)	●	●	○	●	●	○
Normal Protected Mode (Data Exchange OFF)	●	●	○	●	○	○
○ Extinguished ● Illuminated						

Diagnostics of the AS-Interface Bus

The input/output LEDs and address LEDs can be used to view slaves on the AS-Interface bus and determine their operating status.
Diagnostics table:

State of address LEDs	State of IN/ OUT LEDs	Description
●	or ● / ○	There is a slave at this address and its inputs/outputs are on and active.
●	⊠	There is a slave at this address, but an error has occurred.
⊠	○	No slave is assigned to this address.
○	○	Communication on the AS-Interface bus has been interrupted because no power is being supplied or because the AS-Interface module is offline normal protected mode.
○ Extinguished	⊠ Flashing	● Illuminated

The slave address is selected using the buttons PB1 and PB2. An address with an assigned slave can be read using the address LEDs as shown in the following example:
If LEDS 2x, x5 and B are illuminated, this indicates that there is a slave assigned to address 25B.

2.7 Communication Options

At a Glance

Introduction

This section provides an overview, parts description, and specifications of the communication options.

What's in this Section?

This section contains the following topics:

Topic	Page
Overview of Communication Adapters and Expansion Modules	139
Parts Description of Communication Adapters and Expansion Modules	140
Specifications for Communication Adapters and Expansion Modules	142

Overview of Communication Adapters and Expansion Modules

Introduction

The following section provides an overview of the TWDNAC232D, TWDNAC485D, and TWDNAC485T communication adapters and the TWDNOZ232D, TWDNOZ485D, and TWDNOZ485T communication expansion modules.

Overview

All Twido controllers have one RS485 communication serial port 1. Moreover, TWDLC•A16DRF, TWDLC•A24DRF and TWDLCA•40DRF controllers have a serial port 2 connector for an optional second RS485 or RS232 serial port. An optional communication adapter (TWDNAC232D, TWDNAC485D, and TWDNAC485T) is available to install on the serial port 2 connector. Note that the TWDLCAA10DRF series does not have a serial port 2 connector.

In addition, the TWDLCAE40DRF series compact controllers have a built-in RJ-45 Ethernet network communications port.

A communication expansion module (TWDNOZ232D, TWDNOZ485D, and TWDNOZ485T) is available to attach to any Modular controller for an optional second RS485 or RS232 serial port. Also, an operator display expansion module (TWDXCPODM) is available to attach to a Modular controller where an optional communication adapter (TWDNAC232D, TWDNAC485D, and TWDNAC485T) can be installed to the serial port 2 connector on the operator display expansion module.

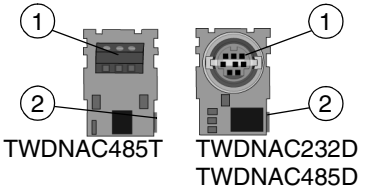
Parts Description of Communication Adapters and Expansion Modules

Introduction

The following section describes the parts of the TWDNAC232D, TWDNAC485D, and TWDNAC485T communication adapters and the TWDNOZ232D, TWDNOZ485D, and TWDNOZ485T communication expansion modules.

Parts Description of a Communication Adapter

The following figure shows the parts of the TWDNAC232D, TWDNAC485D, and TWDNAC485T communication adapters.

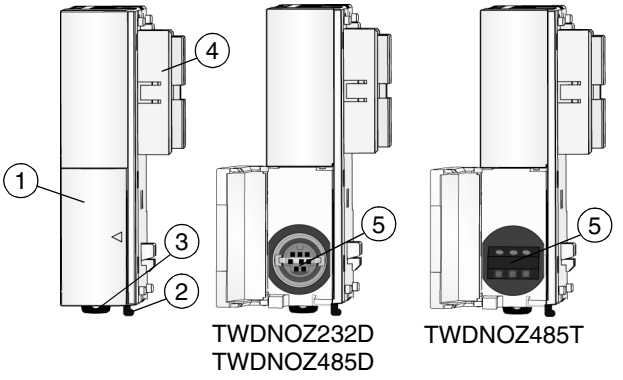


Legend

Label	Part	Description
1	Serial port 2	Adds an optional second RS485 or RS232 serial port.
2	Connector	Connects to the serial port 2 connector on TWDXCPODM operator display expansion module or TWDLCAA16DRF and TWDLCAA24DRF controllers.

Parts Description of a Communication Expansion Module

The following figure shows the parts of the TWDNOZ232D, TWDNOZ485D, and TWDNOZ485T communication expansion modules.



Legend

Label	Part	Description
1	Hinged door	Opens to access the serial port 2.
2	Clamp	Secures the module to a DIN rail.
3	Latch button	Holds/releases the module from a controller.
4	Communication connector	Connects to a Modular controller.
5	Serial port 2	Adds an optional second RS485 or RS232 serial port to a Modular controller.

Specifications for Communication Adapters and Expansion Modules

Introduction

This section presents the specifications for the TWDNAC232D, TWDNAC485D, and TWDNAC485T communication adapters and the TWDNOZ232D, TWDNOZ485D, and TWDNOZ485T communication expansion modules.

Communication Adapter and Expansion Module Specifications

The following table describes the communication adapter and expansion module specifications.

Reference number	**TWDNAC232D TWDNOZ232D**	**TWDNAC485D TWDNOZ485D**	**TWDNAC485T TWDNOZ485T**
Standards	RS232	RS485	RS485
Maximum baud rate	19,200 bps	PC Link: 19,200 bps Remote Link: 38,400 bps	PC Link: 19,200 bps Remote Link: 38,400 bps
Communication Modbus (RTU master/slave)	Possible	Possible	Possible
ASCII communication	Possible	Possible	Possible
Remote link communication:	Not possible	7 links possible	7 links possible
Maximum cable length	Maximum distance between the base controller and the remote controller: 10 m	Maximum distance between the base controller and the remote controller: 200 m	Maximum distance between the base controller and the remote controller: 200 m
Isolation between internal circuit and communication port	Not isolated	Not isolated	Not isolated

2.8 Operator Display Options

At a Glance

Introduction

This section provides an overview, parts description, and specifications of the operator display options.

What's in this Section?

This section contains the following topics:

Topic	Page
Overview of Operator Display Modules and Expansion Modules	144
Parts Description of Operator Display Module and Expansion Module	145
Specifications for Operator Display Modules and Expansion Modules	147

Overview of Operator Display Modules and Expansion Modules

Introduction

The following section provides an overview of the TWDXCPODC operator display module and the TWDXCPODM operator display expansion module.

Overview

The operator display is an optional module that can be added to any of the controllers. It is installed into a Compact controller as a operator display module (TWDXCPODC) and it is assembled to a Modular controller using the operator display expansion module (TWDXCPODM). See *How to Install the Operator Display Module and Operator Display Expansion Module, p. 184*.

The operator display provides the following services:

- Displays the controller state information
- Allows the user to control the controller
- Allows the user to monitor and tune application data objects

The operator display has two states:

- Display state - Displays data
- Edit state - Allows the user to change data

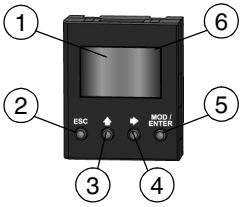
Parts Description of Operator Display Module and Expansion Module

Introduction

The following section describes the parts of the TWDXCPODC operator display module and the TWDXCPODM operator display expansion module.

Parts Description of a Operator Display Module

The following figure shows the parts of the TWDXCPODC operator display module.

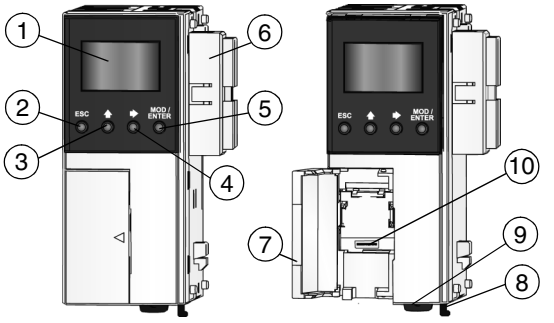


Legend

Label	Part	Description
1	Display screen	Shows menus, operands, and data.
2	ESC button	In Edit state - Returns to the previous display state and rejects changes made by the user.
3	Up arrow button	In Edit state - Changes the current edit element to the next value.
4	Right arrow button	In Display state - Advances to the next display state. In Edit state - Advances to the next editing element. The current editing element blinks.
5	MOD/ENTER button	In Display state - Works in MOD function, goes to the corresponding edit state. In Edit state - Works in ENTER function, returns to previous display state and accepts changes made by the user.
6	Operator display connector	Connects to the Compact controller.

Parts Description of a Operator Display Expansion Module

The following figure shows the parts of the TWDXCPODM operator display expansion module.



Legend

Label	Part	Description
1	Display screen	Shows menus, operands, and data.
2	ESC button	In Edit state - Returns to the previous display state and rejects changes made by the user.
3	Up arrow button	In Edit state - Changes the current edit element to the next value.
4	Right arrow button	In Display state - Advances to the next display state. In Edit state - Advances to the next editing element. The current editing element blinks.
5	MOD/ENTER button	In Display state - Works in MOD function, goes to the corresponding edit state. In Edit state - Works in ENTER function, returns to previous display state and accepts changes made by the user.
6	Operator display connector	Connects to a Modular controller.
7	Hinged door	Opens to access the serial port 2.
8	Latch button	Holds/releases the module from a controller.
9	Clamp	Secures the module to a DIN rail.
10	Serial port 2 connector	Connects to the connector on an optional TWDNAC232D, TWDNAC485D, or TWDNAC485T communication adapter.

Specifications for Operator Display Modules and Expansion Modules

Introduction

This section is specifications for the TWDXCPODC operator display module and the TWDXCPODM operator display expansion module.

Operator Display Module Specifications

The following table describes the operator display module specifications.

Part Number	TWDXCPODC
Power voltage	5 VDC (supplied from the controller)
Internal current draw	200 mA DC
Weight	20 g

Operator Display Expansion Module Specifications

The following table describes the operator display expansion module specifications.

Part Number	TWDXCPODM
Weight	78 g
Internal current draw	200 mA DC

2.9 Options

At a Glance

Introduction

This section provides an overview and specifications of the options.

What's in this Section?

This section contains the following topics:

Topic	Page
Overview of the Options	149
Specifications for the Options	150

Overview of the Options

Introduction

The following section provides an overview of the TWDXCPMFK32 and TWDXCPMFK64 memory cartridges, the TWDXCPRTC Real Time Clock (RTC) cartridge, and the TWDXSM6, TWDXSM9, and TWDXSM14 input simulators.

Overview of the Memory Cartridges

There are two optional memory cartridges, 32 KB (TWDXCPMFK32) and 64 KB (TWDXCPMFK64), available. The memory cartridges provide additional memory for application storage. The memory cartridges are used to:

- Provide a removable backup of the application.
- Load an application into a controller if certain conditions exist.
- Increase the program memory capacity.

The following table presents the available memory cartridge for each controller.

Memory Cartridge	Compact 10 I/O	Compact 16 I/O	Compact 24 I/O	20 I/O modular	40 I/O modular
TWDXCPMFK32	yes	yes	yes	yes	yes
TWDXCPMFK64	no	no	no	yes	yes

The TWDXCPMFK32 memory cartridge is for back up only. The TWDXCPMFK64 memory cartridge is for back up and expansion.

Overview of the Real Time Clock (RTC) Cartridge

An optional Real Time Clock cartridge (TWDXCPRTC) is available for all controllers. The Real Time Clock cartridge provides the controller with the current time and date. The RTC is required for the Schedule Blocks to operate.
When the controller is powered down, the Real Time Clock (RTC) will keep time for 1000 hours at 25 °C (77°F) or 300 hours at 55°C (131°F) when using a fully charged battery.

Overview of the Input Simulators

There are three input simulators: 6, 9, and 14 point. These are used only on the three Compact controllers. Used for debugging, you can control the inputs to test your application logic.

Specifications for the Options

Introduction

This section is specifications for the TWDXCPMFK32 and TWDXCPMFK64 memory cartridges and the TWDXCPRTC RTC cartridge.

Memory Cartridge Specifications

The following table describes the memory cartridge specifications.

Memory Type	EEPROM
Accessible memory capacity	32 KB: TWDXCPMFK32 64 KB: TWDXCPMFK64
Hardware for storing data	Twido controller
Software for storing data	Twido Soft
Quantity of stored programs	One user program is stored on one memory cartridge.
Program execution priority	When a memory cartridge is installed and enabled, the external user program will be loaded and executed if it differs from the internal program.

Real Time Clock Cartridge Specifications

The following table describes the Real Time Clock cartridge specifications.

Accuracy	30 s/month (typical) at 25°C (77°F)
Backup duration	Approximately 30 days (typical) at 25°C (77°F) after backup battery fully charged
Battery	Lithium secondary battery
Charging time	Approximately 10 hours for charging from 0% to 90% of full charge
Replaceable	Not possible

2.10 TeleFast Cable Systems

At a Glance

Introduction

This section provides an overview, specifications, base wiring schematics, and cable wiring specifications of the TeleFast cable systems.

What's in this Section?

This section contains the following topics:

Topic	Page
Overview of the Twido TeleFast Cable System Kits	152
Specifications for the TeleFast Bases	154
Twido TeleFast Wiring Schematics	155
Wiring Specifications for the TeleFast Cables	157

Overview of the Twido TeleFast Cable System Kits

Introduction

The following section provides an overview of the TWDFST16D10, TWDFST16D20, TWDFST16R10, TWDFST16R20, TWDFST20DR10, and TWDFST20DR20 Fast Cable Systems.

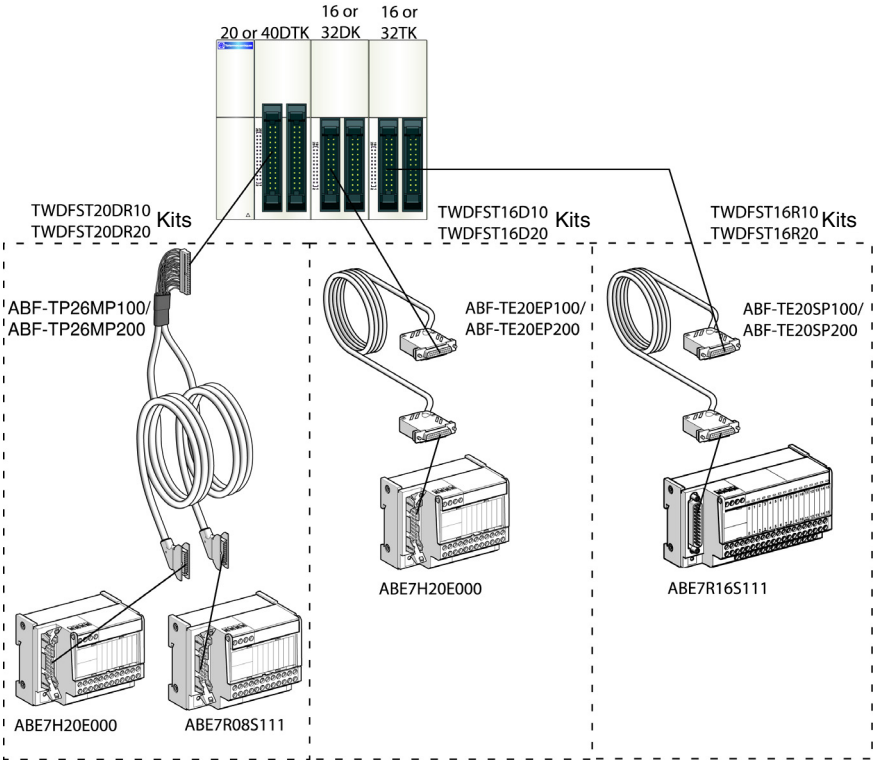
Overview of the Fast Cable Systems

The following table lists the TeleFast Cable System kits and their contents.

Fast Cable System Kits	Cable Part Number	Cable Description	TeleFast Base	TeleFast Base Description
Kit for TWDDDI16DK or TWDDDI32DK - 16 Input Sink				
TWDFST16D10	ABF-TE20EP100	1 meter interconnect	ABE7H20E000	16-point Input
TWDFST16D20	ABF-TE20EP200	2 meter interconnect	ABE7H20E000	16-point Input
Kit for TWDDDO16TK or TWDDDO32TK - 16 Output Source				
TWDFST16R10	ABF-TE20SP100	1 meter interconnect	ABE7R16S111	16-point Output Relay
TWDFST16R20	ABF-TE20SP200	2 meter interconnect	ABE7R16S111	16-point Output Relay
Kit for TWDLMDA20DTK or TWDLMDA40DTK - 16 Input Sink/8 Output Source				
TWDFST20DR10	ABF-TP26MP100	1 meter interconnect	ABE7H20E000 ABE7R08S111	16-point Input 8-point Output Relay
TWDFST20DR20	ABF-TP26MP200	2 meter interconnect	ABE7H20E000 ABE7R08S111	16-point Input 8-point Output Relay

Illustration

The following illustration shows the Twido TeleFast cable system kits.



Specifications for the TeleFast Bases

Introduction

This section provides specifications for the ABE7R08S111, ABE7R16S111, and ABE7H20E000 TeleFast bases.

ABE7H20E000 Specifications

Passive Input TeleFast Base	ABE7H20E000
Number of channels	16
Input type	Sink Input
Base power supply	20.4 - 26.4 VDC
Supply protection	1 A Fast Blow
Input current	7 mA
Number of inputs per COM	16
Isolation	None (passive)

See Catalog 8501CT9801, "TeleFast 2 Prewiring System" for more specifications on this Telefast bases.

ABE7R08S111 and ABE7R16S111 Specifications

Relay Output TeleFast Base	ABE7R08S111	ABE7R16S111
Number of channels	8	16
Base DC power	20.4 - 28.8 VDC	
Supply protection	1 A Fast Blow	
Output contacts	8 NO	16 NO
Maximum VAC	250 VAC @ 50-60 Hz	
Maximum VDC	30 VDC	
Number of channels per COM	4	8
Max contact current	2 A	
Max current per module	12 A	
Isolation outputs to internal circuitry	2 K VAC	

See Catalog 8501CT9801, "TeleFast 2 Prewiring System" for more specifications on these Telefast bases.

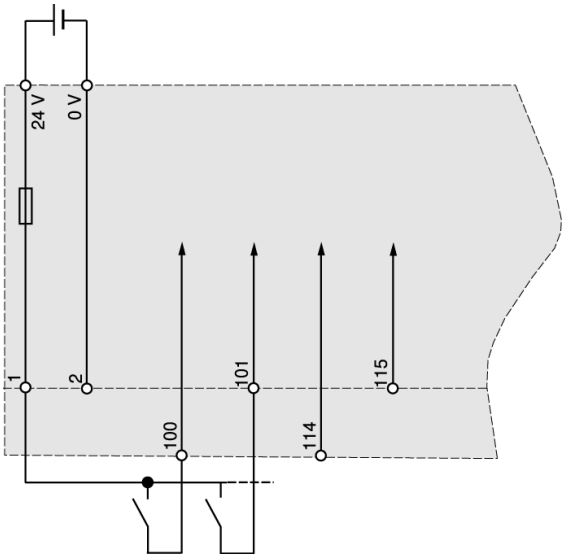
Twido TeleFast Wiring Schematics

Introduction

This section shows examples of wiring schematics for the TeleFast bases.

ABE7H20E00 Wiring Schematic

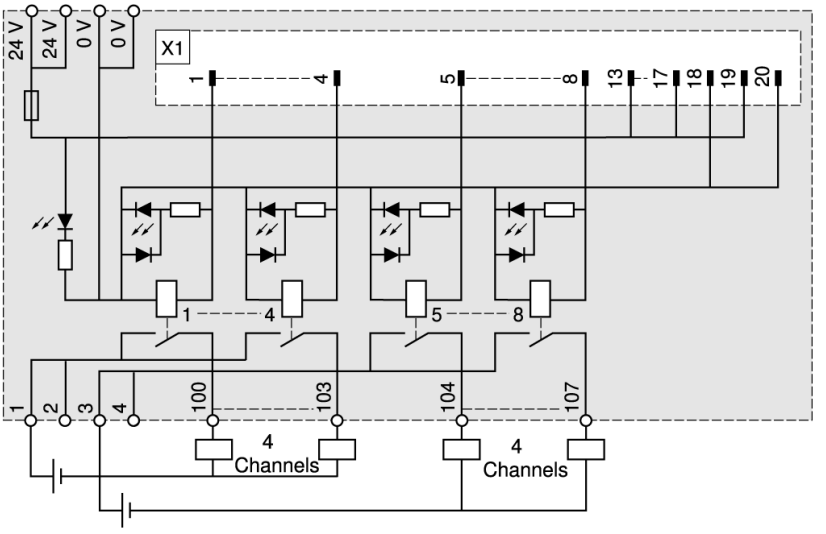
This schematic is for the ABE7H20E000 TeleFast base.



Note: Load is inductive.

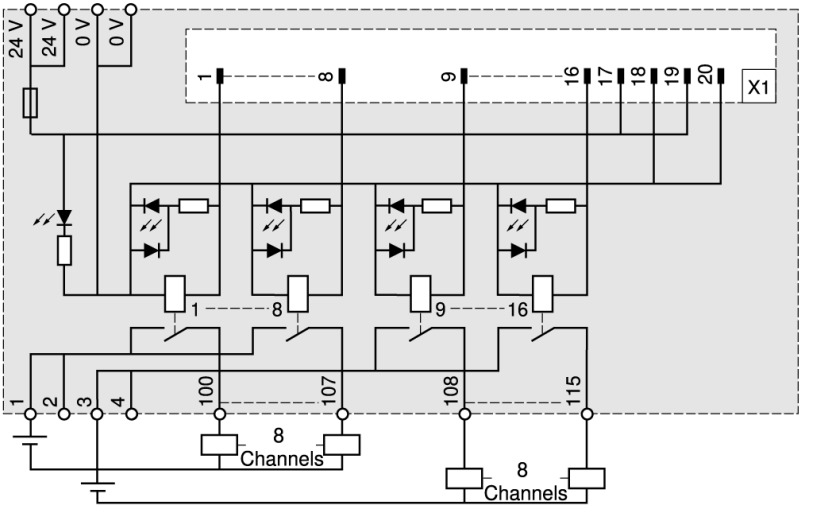
ABE7R08S111 Wiring Schematic

This schematic is for the ABE7R08S111 TeleFast base.



ABE7R16S111 Wiring Schematic

This schematic is for the ABE7R16S111 TeleFast base.



Wiring Specifications for the TeleFast Cables

Introduction

This section provides cable wiring specifications for the ABF-TE20EP100/200, ABF-TE20SP100/200, ABF-TP26MP100/200, TWDFCW30K/50K, and TWDFCW30M/50M TeleFast cables.

ABF-TE20EP100/200

The following table provides specifications for the ABF-TE20EP100/200 sink input cable wiring.

Twido Signal Name	Twido Pin Number	ABE7H20E000 Pin Number	ABE7H20E200 Signal Name
NC	1		NC
NC	2		NC
COM	3	20	COM
COM	4	18	COM
I15	5	16	I15
I7	6	8	I7
I14	7	15	I14
I6	8	7	I6
I13	9	14	I13
I5	10	6	I5
I12	11	13	I12
I4	12	5	I4
I11	13	12	I11
I3	14	4	I3
I10	15	11	I10
I2	16	3	I2
I9	17	10	I9
I1	18	2	I1
I8	19	9	I8
I0	20	1	I0

ABF-TE20SP100/ 200

The following table provides specifications for the ABF-TE20SP100/200 source cable wiring.

Twido Signal Name	Twido Pin Number	ABE7R16S111 Pin Number	ABE7R16S111 Signal Name
V+	1	20	COM
V+	2	18	COM
COM	3	I7	V+
COM	4	19	V+
Q15	5	16	Q15
Q7	6	8	Q7
Q14	7	15	Q14
Q6	8	7	Q6
Q13	9	14	Q13
Q5	10	6	Q5
Q12	11	13	Q12
Q4	12	5	Q4
Q11	13	12	Q11
Q3	14	4	Q3
Q10	15	11	Q10
Q2	16	3	Q2
Q9	17	10	Q9
Q1	18	2	Q1
Q8	19	9	Q8
Q0	20	1	Q0

ABF-TP26MP100/200

The following table provides specifications for the ABF-TP26MP100/200 sink/source cable wiring.

Twido Signal Name	Twido Pin Number	ABE7R08S111 Pin Number	ABE7R08S111 Signal Name	ABE7R08S111 Pin Number	ABE7R08S111 Signal Name
V+	1	18	COM		
COM	2			18 or 20	COM
V+	3	20	COM		
I11	4			12	I11
COM	5	17	V+		
I10	6			11	I10
COM	7	19	V+		
I9	8			10	I9
COM	9	--	--	--	--
I8	10			10	I9
Q7	11	8	Q7		
I7	12			8	I7
Q6	13	7	Q6		
I6	14			7	I6
Q5	15	6	Q5		
I5	16			6	I5
Q4	17	5	Q4		
I4	18			5	I4
Q3	19	4	Q3		
I3	20			4	I3
Q2	21	3	Q2		
I2	22			3	I2
Q1	23	2	Q1		
I1	24			2	I1
Q0	25	1	Q0		
I0	26			1	I0

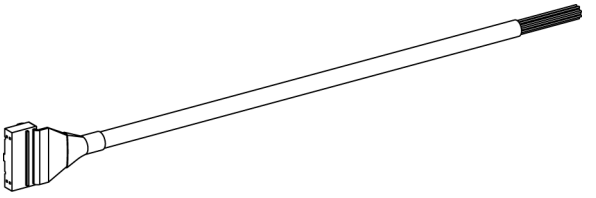
TWDFCW30K/ 50K

The following table provides specifications for the TWDFCW30K/50K with free wires for 20-pin Modular controller.

Pin Connector A Twido Connector Side	Wire Color
1	White
2	Brown
3	Green
4	Yellow
5	Grey
6	Pink
7	Blue
8	Red
9	Black
10	Violet
11	Grey/Pink
12	Red/Blue
13	White/Green
14	Brown/Green
15	White/Yellow
16	Yellow/Brown
17	White/Grey
18	Grey/Brown
19	White/Pink
20	Pink/Brown

Illustration

Illustration of a TWDFCW30K cable:



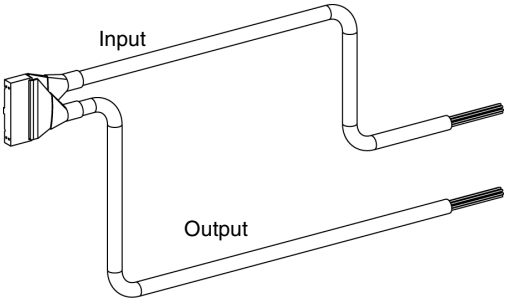
TWDFCW30M/ 50M

The following table provides specifications for the TWDFCW30M/50M cable with free wires for 26-pin Modular controller.

Pin Connector A Twido Connector Side	Wire Color for Input	Wire Color for Output
26	Brown/Black	
24	Brown/Red	
22	Brown/Blue	
20	Pink/Brown	
18	Grey/Brown	
16	Yellow/Brown	
14	Brown/Green	
12	Red/Blue	
10	Violet	
8	Red	
6	Pink	
4	Yellow	
2	Brown	
25		White/Black
23		White/Red
21		White/Blue
19		White/Pink
17		White/Grey
15		White/Yellow
13		White/Green
11		Grey/Pink
9		No Connect
7		Blue
5		Grey
3		Green
1		White

Illustration

Illustration of a TWDFCW30M cable:



Installation

3

At a Glance

Introduction

This chapter provides dimensions, installation, and mounting instructions for the controllers, digital and analog expansion I/O modules, and options.

What's in this Chapter?

This chapter contains the following topics:

Topic	Page
Dimensions of the Compact Controllers	165
Dimensions for the Modular Controllers	167
Dimensions for the Digital and Analog I/O Modules	169
Dimensions of AS-Interface V2 bus master module: TWDNOI10M3	172
Dimensions for the Operator Display Module, Operator Display Expansion Module, and Communication Expansion Modules	173
Dimensions of the TeleFast Bases	175
Installation Preparation	177
Controller, Expansion I/O Module and AS-Interface Bus Master Module Mounting Positions	178
Assembling an expansion I/O or AS-Interface bus master module to a controller	180
Disassembling an Expansion I/O or AS-Interface Bus Master Module from a Controller.	182
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How to Install and Remove a Controller and Expansion I/O Module or an AS-Interface Bus Interface Module from a DIN Rail	195
How to Direct Mount on a Panel Surface	198
Minimum Clearances for Controllers and Expansion I/O Modules in a Control Panel	203
How to Connect the Power Supply	205
How to Install and Replace an External Battery	208

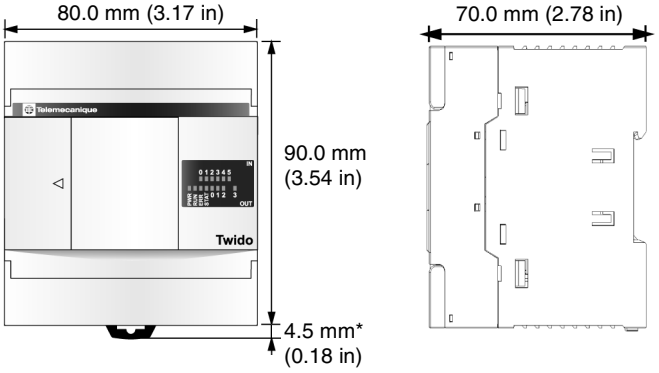
Dimensions of the Compact Controllers

Introduction

The following section shows the dimensions for all Compact controllers.

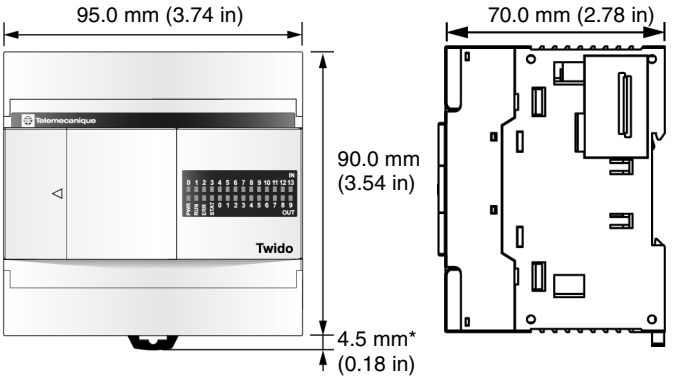
TWDLC•A10-DRF and TWDLC•A16-DRF

The following diagrams show the dimensions for the TWDLC•A10DRF and TWDLC•A16DRF series Compact controllers.
Illustration showing TWDLC•A10DRF series controller:



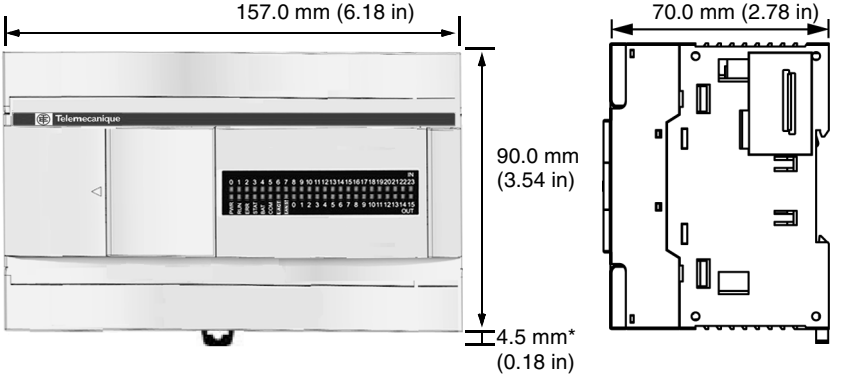
Note: * 8.5 mm (0.33 in) when the clamp is pulled out.

TWDLC•A24-DRF The following diagrams show the dimensions for the TWDLC•A24DRF series Compact controller.



Note: * 8.5 mm (0.33 in) when the clamp is pulled out.

TWDLCA•40-DRF The following diagrams show the dimensions for the TWDLCA•40DRF series Compact controller.



Note: * 8.5 mm (0.33 in) when the clamp is pulled out.

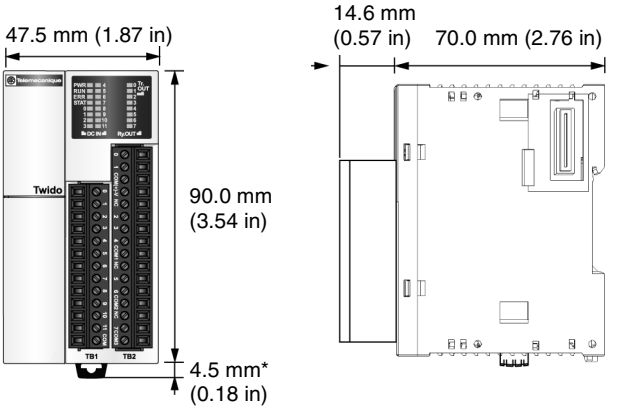
Dimensions for the Modular Controllers

Introduction

The following section shows the dimensions for all Modular controllers.

TWDLMDA20-DRT Dimensions

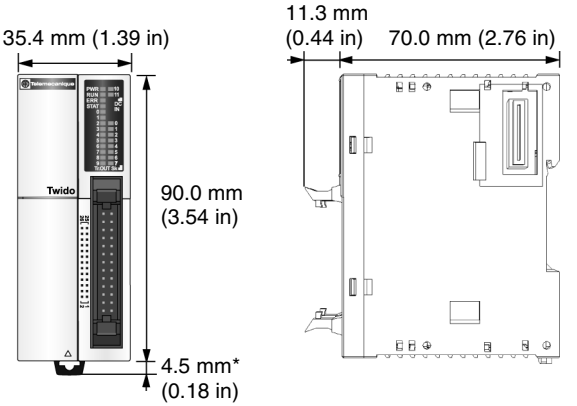
The following diagrams show the dimensions for the TWDLMDA20DRT Modular controller.



Note: * 8.5 mm (0.33 in) when the clamp is pulled out.

TWDLMDA20-DUK and TWDLMDA20-DTK Dimensions

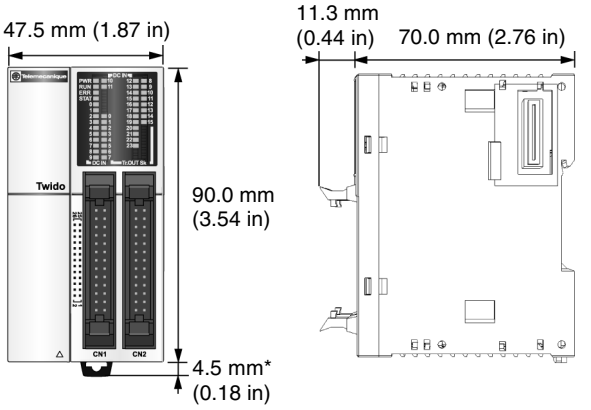
The following diagrams show the dimensions for the TWDLMDA20DUK and TWDLMDA20DTK Modular controllers.



Note: * 8.5 mm (0.33 in) when the clamp is pulled out.

TWDLMDA40-DUK and TWDLMDA40-DTK Dimensions

The following diagrams show the dimensions for the TWDLMDA40DUK and TWDLMDA40DTK Modular controllers.



Note: * 8.5 mm (0.33 in) when the clamp is pulled out.

Dimensions for the Digital and Analog I/O Modules

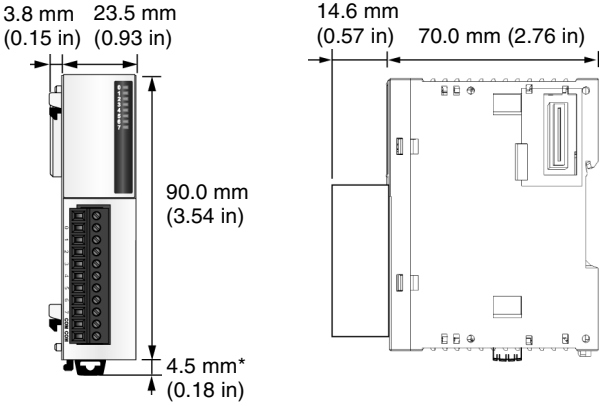
Introduction

The following section shows the dimensions for all digital and analog I/O modules.

Digital I/O and Analog Modules

The following diagrams show the dimensions for the TWDDDI8DT, TWDDAI8DT, TWDDRA8RT, TWDDDO8TT, TWDDDO8UT, TWDDMM8DRT digital I/O modules and TWDALM3LT, TWDAMM3HT, TWDAMI2HT, and TWDAMO1HT analog I/O modules.

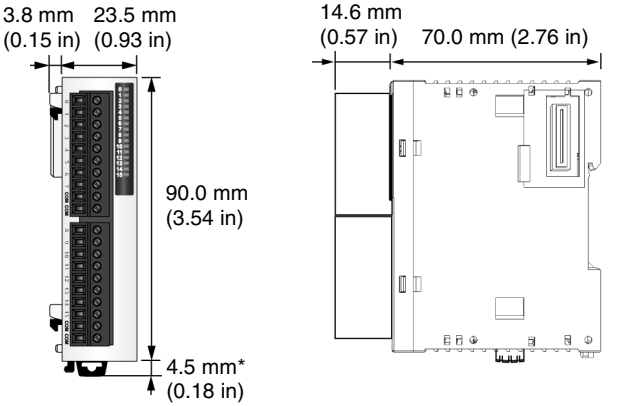
Illustrations showing a TWDDDI8DT or TWDDAI8DT module:



Note: * 8.5 mm (0.33 in) when the clamp is pulled out.

Digital I/O Modules

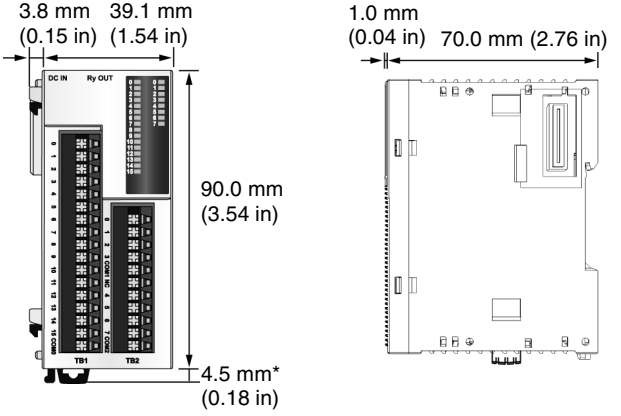
The following diagrams show the dimensions for the TWDDDI16DT and TWDDRA16RT digital I/O modules.
Illustrations showing a TWDDDI16DT module:



Note: * 8.5 mm (0.33 in) when the clamp is pulled out.

Digital I/O Modules

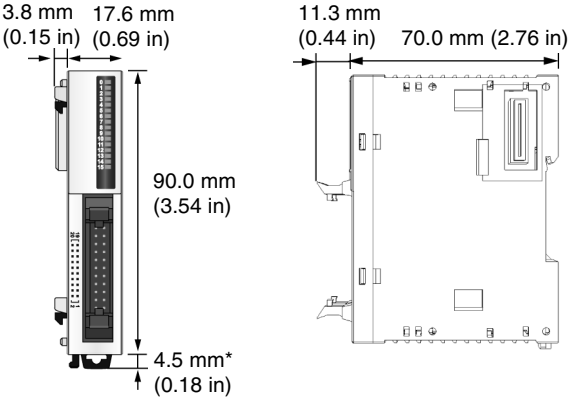
The following diagram show the dimensions for the TWDDMM24DRF digital I/O module.



Note: * 8.5 mm (0.33 in) when the clamp is pulled out.

Digital I/O Modules

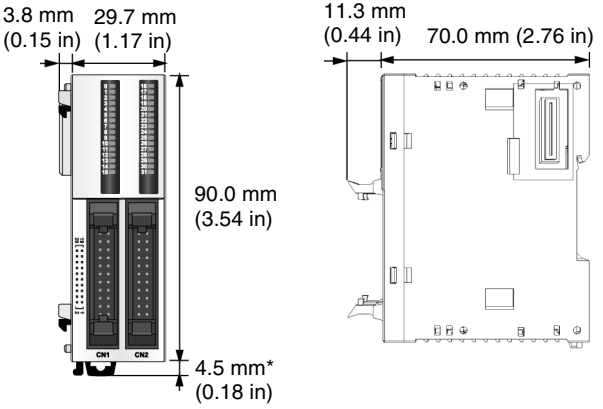
The following diagrams show the dimensions for the TWDDDI16DK, TWDDDO16TK, and TWDDDO16UK digital I/O modules.
Illustrations showing a TWDDDI16DK module:



Note: * 8.5 mm (0.33 in) when the clamp is pulled out.

Digital I/O Modules

The following diagrams show the dimensions for the TWDDDI32DK, TWDDDO32TK, and TWDDDO32UK digital I/O modules.
Illustrations showing a TWDDDI32DK module:

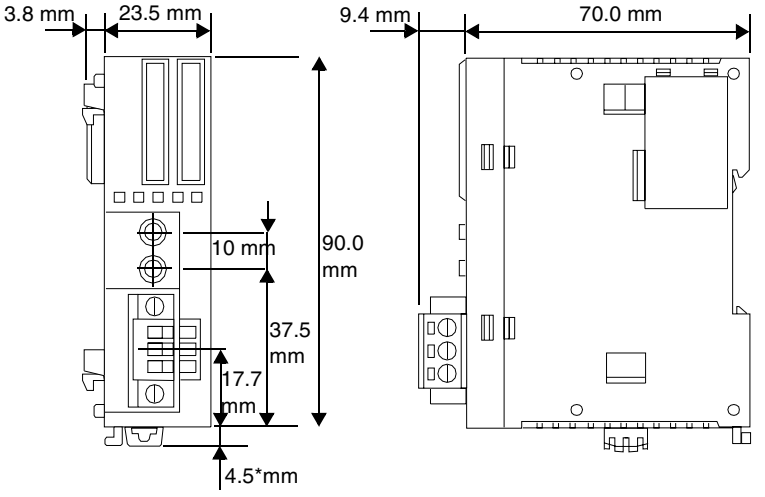


Note: * 8.5 mm (0.33 in) when the clamp is pulled out.

Dimensions of AS-Interface V2 bus master module: TWDNOI10M3

AS-Interface Master Module Dimensions

The following diagram shows the dimensions of the AS-Interface Master module TWDNOI10M3:



Note: * 8.5 mm (0.33 in) when the clamp is pulled out.

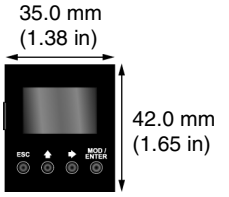
Dimensions for the Operator Display Module, Operator Display Expansion Module, and Communication Expansion Modules

Introduction

The following section shows the dimensions for the operator display module (TWDXCPODC), operator display expansion module (TWDXCPODM), and for all communication expansion modules (TWDNOZ232D, TWDNOZ485T, and TWDNOZ485D).

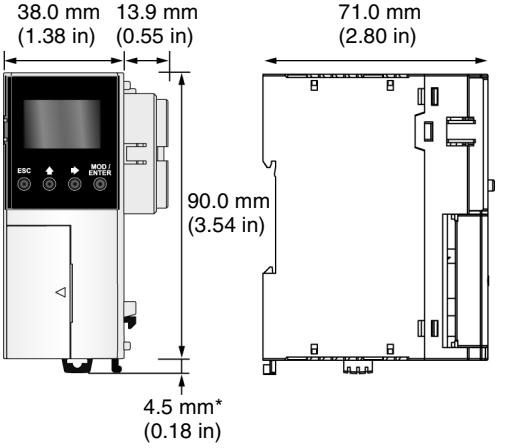
Operator Display Module Dimensions

The following diagram shows the dimensions for the operator display module (TWDXCPODC).



Operator Display Expansion Module Dimensions

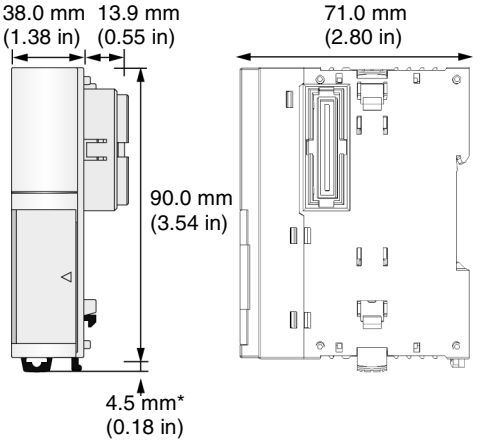
The following diagram shows the dimensions for the operator display expansion module (TWDXCPODM).



Note: * 8.5 mm (0.33 in) when the clamp is pulled out.

Communication Expansion Module Dimensions

The following diagram shows the dimensions for all communication expansion modules (TWDNOZ232D, TWDNOZ485T, and TWDNOZ485D).
Illustration of the TWDNOZ485T module:



Note: * 8.5 mm (0.33 in) when the clamp is pulled out.

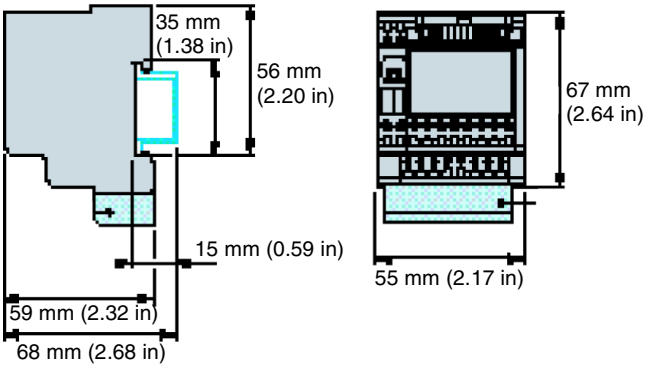
Dimensions of the TeleFast Bases

Introduction

The following section shows the dimensions for the TeleFast bases.

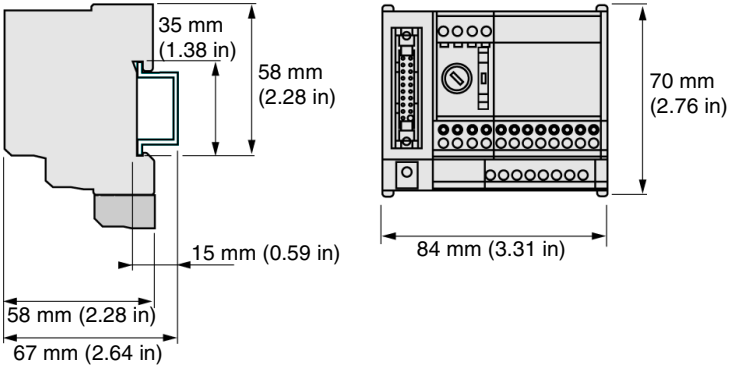
ABE7H20E000

The following diagrams show the dimensions for the ABE7H20E000 Input TeleFast base.



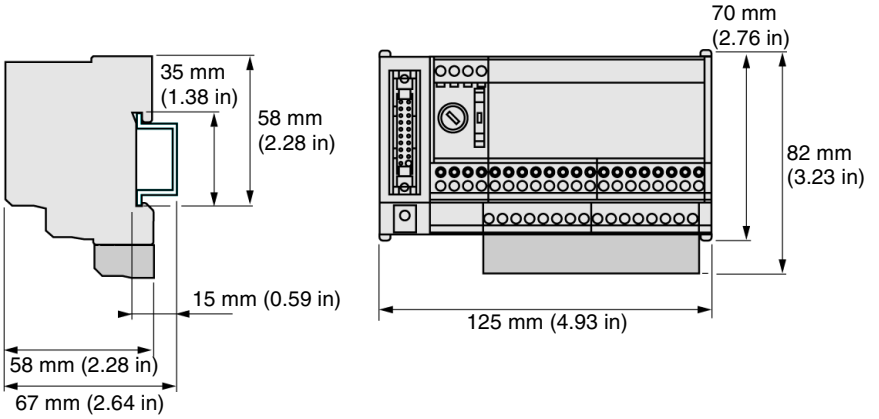
ABE7R08S111

The following diagrams show the dimension for the ABE7R08S111 Relay TeleFast base.



ABE7R16S111

The following diagrams show the dimensions for the ABE7R16S111 Relay TeleFast base.



Installation Preparation

Introduction

The following section provides information on preparation for all Twido controllers, expansion I/O and AS-Interface bus interface modules.

Before Starting

Before installing any of the Twido products read the Safety Information at the begging of this book.

	**CAUTION**
	EQUIPMENT DAMAGE Before adding/removing any module or adapter, turn off the power to the controller. Otherwise, the module, adapter, or controller may be damaged, or the controller may not operate correctly. **Failure to follow this precaution can result in injury or equipment damage.**

Note: All options, expansion I/O and AS-Interface bus interface modules should be assembled before installing a Twido system on a DIN rail, onto a mounting plate, or in a control panel. The Twido system should be removed from a DIN rail, a mounting plate, or a control panel before disassembling the modules.

Controller, Expansion I/O Module and AS-Interface Bus Master Module Mounting Positions

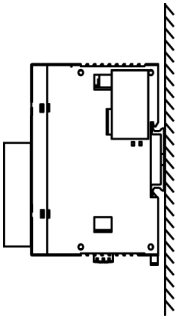
Introduction

This section shows the correct and incorrect mounting positions for all controllers, expansion I/O modules and AS-Interface bus master modules.

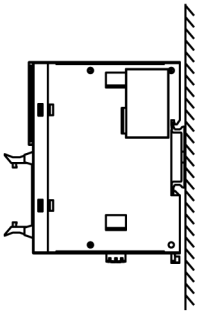
Note: Keep adequate spacing for proper ventilation and to maintain an ambient temperature between 0°C (32°F) and 55°C (131°F).

Correct Mounting Position for all Controllers, Expansion I/O Modules and AS-Interface Bus Master Modules

Controllers, expansion I/O modules and AS-Interface bus interface modules must be mounted horizontally on a vertical plane as shown in the figures below.



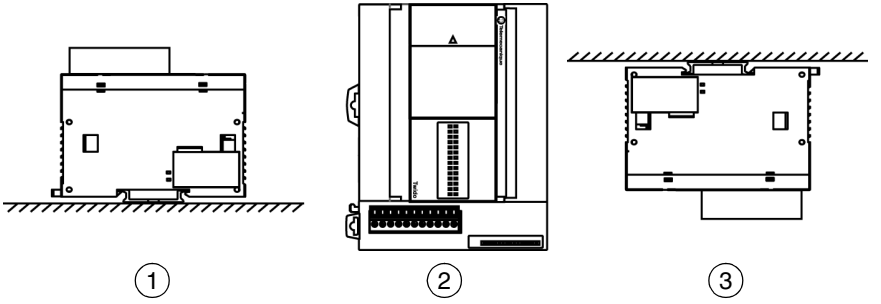
Compact controller with an expansion I/O module



Modular controller with an expansion I/O module

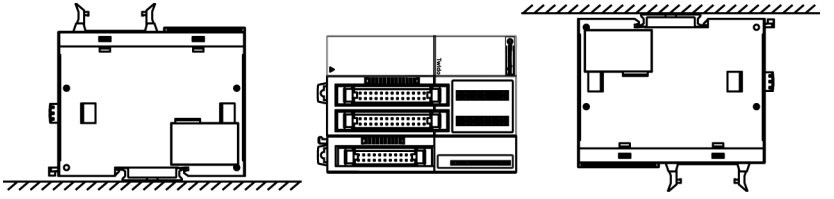
Correct and Incorrect Mounting Positions for the Compact Controller

A Compact controller should only be positioned as shown in "Correct Mounting Position for all Controllers, Expansion I/O Modules and AS-Interface Bus Master Modules" figure. When the ambient temperature is 35°C (95°F) or below, the Compact controller can also be mounted upright on a horizontal plane as shown in (1). When the ambient temperature is 40°C (113°F) or below, the Compact controller can also be mounted sideways on a vertical place as shown in figure (2). Figure (3) shows an incorrect mounting position.



Incorrect Mounting Positions for the Modular Controllers

A Modular controller should only be positioned as shown in "Mounting Position for all Controllers, Expansion I/O Modules and AS-Interface Bus Master Modules" figure. The figures below show the incorrect mounting positions for all Modular controllers.



	CAUTION
	Placing heat generating devices near the controller system Do not place heat generating devices such as transformers and power supplies underneath the controllers or expansion I/O modules. **Failure to follow this precaution can result in injury or equipment damage.**

Assembling an expansion I/O or AS-Interface bus master module to a controller

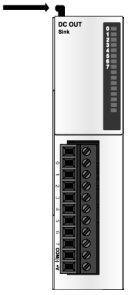
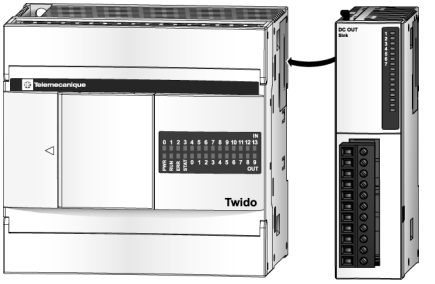
Introduction

This section shows how to assemble an expansion I/O or AS-Interface bus master module to a controller. This procedure is for both Compact and Modular controllers. Your controller, expansion I/O module, or AS-Interface bus master module may differ from the illustrations in this procedure.

	**CAUTION** **UNEXPECTED EQUIPMENT OPERATION** • If you change the hardware configuration of the I/O expansion bus or AS-Interface master and do not update the software to reflect that change, the expansion bus will no longer operate. • Be advised that the local base inputs and outputs will continue to operate. **Failure to follow this precaution can result in injury or equipment damage.**

Assembling an Expansion I/O or AS-Interface Bus Master Module to a Controller.

The following procedure shows how to assemble a controller and an expansion I/O or AS-Interface bus master module together.

Step	Action
1	Remove the expansion connector cover from the controller.
2	Make sure the black latch button on the I/O or AS-Interface module is in the up position. 
3	Align the connector on the left side of the Expansion I/O module or the AS-Interface master module with the connector on the right side of the controller. 
4	Press the expansion I/O or AS-Interface bus master module to the controller until it "clicks" into place.
5	Push down the black latch button on the top of the expansion I/O or AS-Interface bus master module to lock the module to the controller.

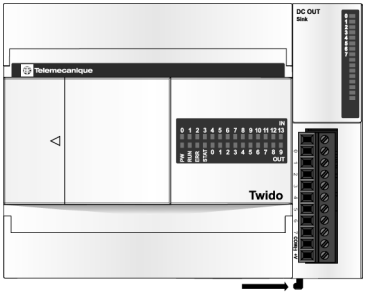
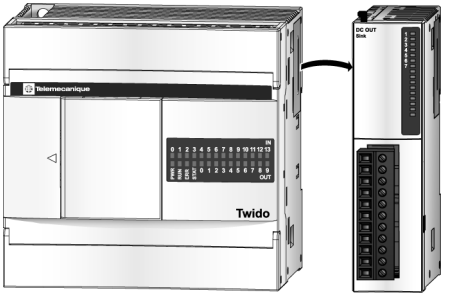
Disassembling an Expansion I/O or AS-Interface Bus Master Module from a Controller

Introduction

This section shows how to disassemble an expansion I/O or AS-Interface bus master module from a controller. This procedure is for both Compact and Modular controllers. Your controller, expansion I/O module or AS-Interface bus master module may differ from the illustrations in these procedures but the basic mechanism procedures are still applicable.

Disassembling an Expansion I/O or AS-Interface Bus Master Module from a Controller.

The following procedure shows how to disassemble an expansion I/O or AS-Interface bus master module from a controller.

Step	Action
1	Remove the assembled controller and module from the DIN rail before disassembling them. See *How to Install and Remove a Controller and Expansion I/O Module or an AS-Interface Bus Interface Module from a DIN Rail, p. 195*.
2	Push up the black latch from the bottom of the expansion I/O module or AS-Interface bus master to disengage it from the controller. 
3	Pull apart the controller and module. 

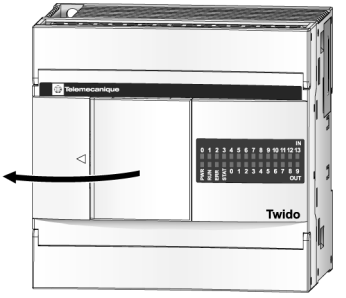
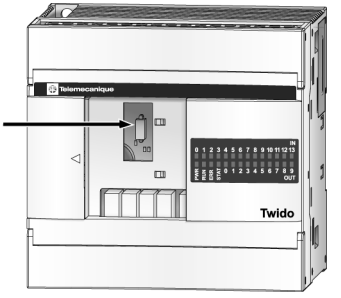
How to Install the Operator Display Module and Operator Display Expansion Module

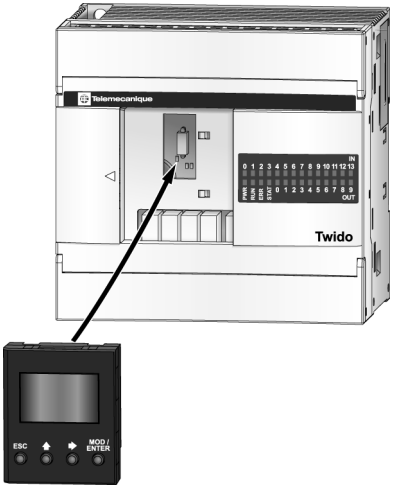
Introduction

This section describes installation of the operator display module TWDXCPODC, as well as installation and removal of the operator display expansion module TWDXCPODM.

Installing the Operator Display Module into a Compact Controller

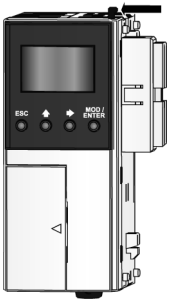
The following procedure shows how to install the TWDXCPODC operator display module into a Compact controller.

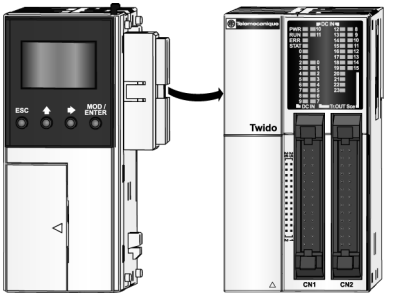
Step	Action
1	Remove the operator display connector cover on the Compact controller. 
2	Locate the operator display connector inside the Compact controller. 

Step	Action
3	Push the operator display module into the operator display connector in the Compact controller until it "clicks". 

Assembling the Operator Display Expansion Module to a Modular Controller

The following procedure shows how to assemble the TWDXCPODM operator display expansion module to a Modular controller.

Step	Action
1	Remove the communication connector cover on the left side of the Modular controller.
2	Make sure the black latch button on the operator display expansion module is in the up position. 

Step	Action
3	Align the connector opening on the left side of the Modular controller to the connector on the right side of the operator display expansion module. 
4	Press the operator display expansion module to the Modular controller until it "clicks" into place.
5	Push down the black latch button on the top of the operator display expansion module to lock the module to the Modular controller.

Disassembling an Operator Display Expansion Module from a Modular Controller

To remove the TWDXCPODM operator display expansion module from a Modular controller, see *Disassembling an Expansion I/O or AS-Interface Bus Master Module from a Controller., p. 182*.

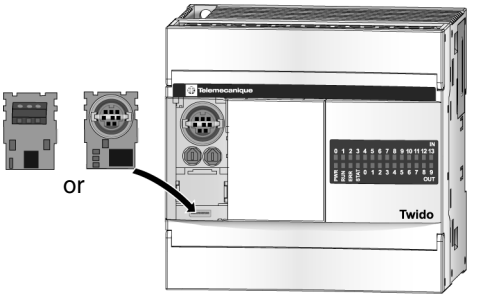
Installing a Communication Adapter and an Expansion Module

Introduction

This section shows how to install the TWDNAC232D, TWDNAC485D, or TWDNAC485T communication adapter into a Compact controller's port 2 and in a TWDXCPODM operator display expansion module. This section also shows how to assemble and disassemble the TWDNOZ232D, TWDNOZ485D, and TWDNOZ485T communication expansion module to a Modular controller. Your controller may differ from the illustrations in these procedures but the basic mechanism procedures are applicable.

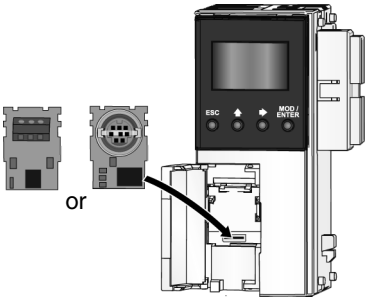
Installing the Communication Adapter into a Compact Controller's Port 2

The following procedure shows how to install the TWDNAC232D, TWDNAC485D, or TWDNAC485T communication adapter into a Compact controller's port 2.

Step	Action
1	Open the hinged lid.
2	Remove the cartridge cover located on the bottom of the Compact controller.
3	Push the communication adapter's connector into the Compact controller's port 2 connector until it "clicks". 
4	Look in the opening at the bottom of the Compact controller where the cartridge cover resided and make sure the communication adapter's connector is seated in the Compact controller's port 2 connector. Adjust the adapter if it is not seated correctly.
5	Attach the cartridge cover.

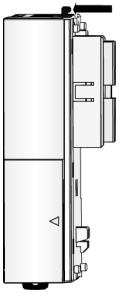
Installing a Communication Adapter in the Operator Display Expansion Module

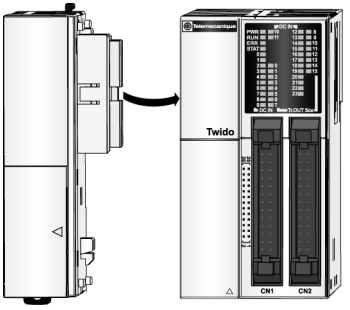
The following procedure shows how to install the TWDNAC232D, TWDNAC485D, or TWDNAC485T communication adapter in a TWDXCPODM operator display expansion module.

Step	Action
1	Open the hinged lid.
2	Push the communication adapter's connector into the operator display expansion module's connector until it "clicks". 
3	Close the hinged lid.

Assembling a Communication Expansion Module to a Modular Controller

The following procedure shows how to assemble the TWDNOZ485D, TWDNOZ232D, or TWDNOZ485T communication expansion module to a Modular controller.

Step	Action
1	Remove the communication connector cover on the left side of the Modular controller.
2	Make sure the black latch button on the communication expansion module is in the up position. 

Step	Action
3	Align the connector opening on the left side of the Modular controller to the connector on the right side of the communication expansion module. 
4	Press the communication expansion module to the Modular controller until it "clicks" into place.
5	Push down the black latch button on the top of the communication expansion module to lock the module to the Modular controller.

Disassembling a Communication Expansion Module from a Modular Controller

To disassemble a communication expansion module from a Modular controller, see *Disassembling an Expansion I/O or AS-Interface Bus Master Module from a Controller., p. 182*.

How to Install a Memory or RTC Cartridge

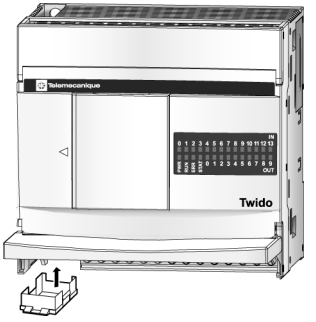
Introduction

This section shows how to install the TWDXCPMFK32 memory cartridge in a Compact controller, the TWDXCPMFK32 or TWDXCPMFK64 memory cartridge in a Modular controller, and the TWDXCPRTC RTC cartridge in a Compact controller and Modular controller.

Installing a Cartridge in a Compact Controller

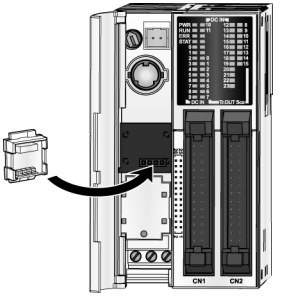
The following procedure shows how to install the TWDXCPMFK32 memory or the TWDXCPRTC RTC cartridge in a Compact controller. Only one of these cartridges can be installed in the Compact controller.

	**CAUTION** **EQUIPMENT DAMAGE** When handling the cartridges, do not touch the pins. The cartridge's electrical elements are sensitive to static electricity. Use proper ESD procedures when handling a cartridge. **Failure to follow this precaution can result in injury or equipment damage.**

Step	Action
1	Open bottom terminal cover.
2	Remove the cartridge cover.
3	Push the cartridge into the cartridge connector until it "clicks". 
4	Close the terminal cover.

Installing a Cartridge in a Modular Controller

The following procedure shows how to install the TWDXCPMFK32 or TWDXCPMFK64 memory cartridge or the TWDXCPRTC RTC cartridge in a Modular controller. Only one RTC cartridge can be installed. A memory cartridge and an RTC cartridge can be installed at the same time.

Step	Action
1	Open the hinged door.
2	Remove the cartridge cover by holding and pulling the opposite edges of the cover until it is out.
3	Push the cartridge into the Modular controller's connector until it "clicks". 
4	Close the hinged door.

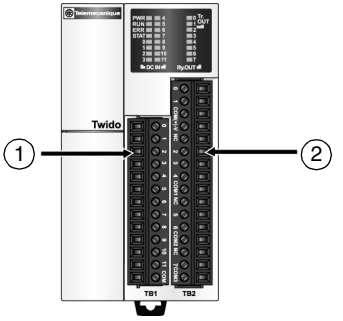
Removing a Terminal Block

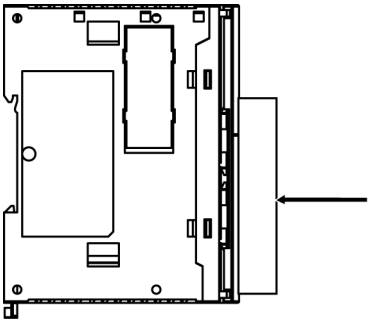
Introduction

This section shows how to remove a terminal block from the TWDLMDA20DRT Modular controller.

Removing a Terminal Block

The following procedure shows how to remove a terminal block from the TWDLMDA20DRT Modular controller.

Step	Action
1	Power off to the Modular controller and disconnect all wires. **Note:** The terminal block on the left (1) must be removed before the terminal block on the right (2). 

Step	Action
2	Remove the terminal block by holding the center of the terminal block and pulling it out straight. 

	CAUTION
	**Pulling the terminal block out from the top or bottom of the block** Do not pull the terminal block out from the top or bottom of the block. **Failure to follow this precaution can result in injury or equipment damage.**

How to Install and Remove a Controller and Expansion I/O Module or an AS-Interface Bus Interface Module from a DIN Rail

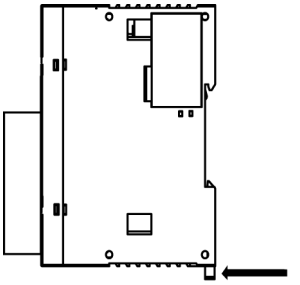
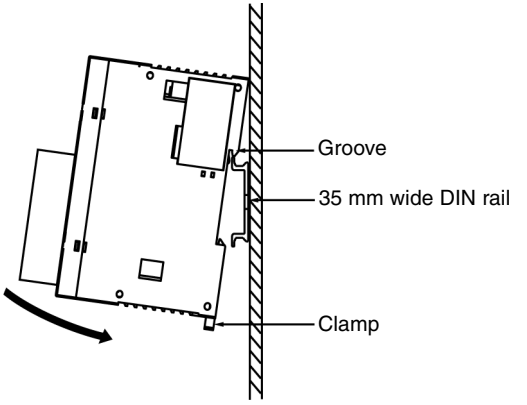
Introduction

This section describes how to install and remove controllers and expansion I/O modules or AS-Interface bus interface modules from a DIN rail. Your controller, expansion I/O module and AS-Interface bus interface module may differ from the illustrations in these procedures but the basic mechanism procedures are applicable.

Note: When mounting controllers on a DIN rail, use two end stops, type AB1-AB8P35 or equivalent.

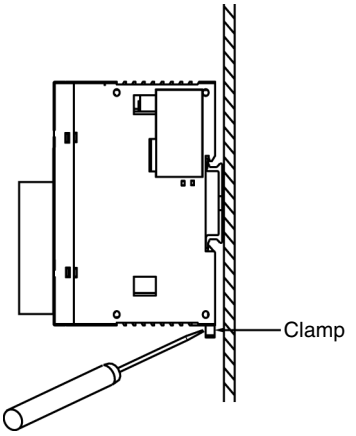
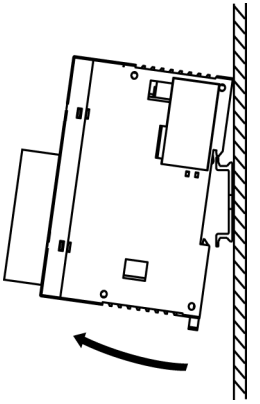
How to Install a Controller and Expansion I/O Module or AS-Interface Bus Interface Module on a DIN Rail

The following procedure shows how to install a controller and expansion I/O module or AS-Interface bus interface module on a DIN rail.

Step	Action
1	Fasten the DIN rail to a panel using screws.
2	Pull out the clamp at the bottom of the controller and module assembly. 
3	Put the top groove of the controller and module on the DIN rail and press the modules toward the DIN rail. 
4	Push the clamp into the DIN rail.
5	Place mounting clips on both sides of the modules to prevent the system from moving sideways.

How to Remove a Controller and Expansion I/O Module or AS-Interface Bus Interface Module from a DIN Rail

The following procedure shows how to remove a controller and expansion I/O module from a DIN rail.

Step	Action
1	Insert a flat screwdriver into the slot in the clamp. 
2	Pull out the clamp.
3	Pull the controller and the associated module off the DIN rail from the bottom. 

How to Direct Mount on a Panel Surface

Introduction

This section shows how to install mounting strips directly on modular controllers, expansion I/O modules, the AS-Interface bus interface module, the operator display expansion module, and communication expansion modules. This section also provides mounting hole layouts for each controller and module. Your controller or module may differ from the illustrations in these procedures but the basic mechanism procedures are applicable.

Installing a Mounting Strip

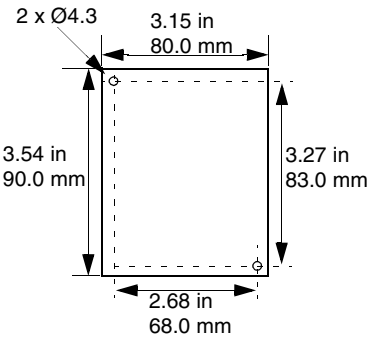
The following procedure shows how to install a mounting strip.

Step	Action
1	Remove the clamp from the back side of the module by pushing the clamp inward.
2	Insert the mounting strip, with the hook entering last, into the slot where the clamp was removed.
3	Slide the mounting strip into the slot until the hook enters into the recess in the module.

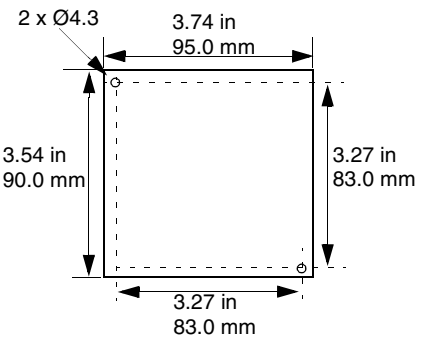
Mounting Hole Layout for Compact Controllers

The following diagram shows the mounting hole layout for all the Compact controllers.

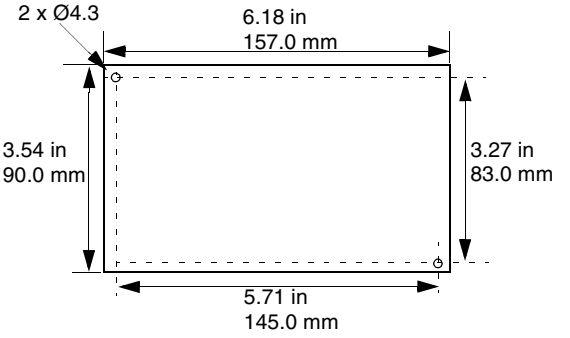
TWDLC•A10DRF
TWDLC•A16DRF



TWDLC•A24DRF



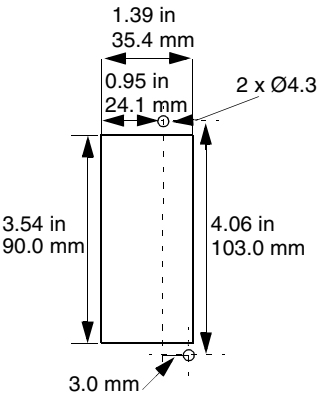
TWDLCA•40DRF



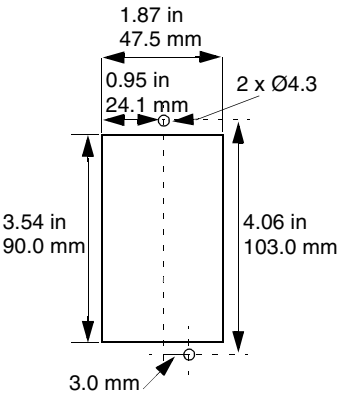
Mounting Hole Layout for Modular Controllers

The following diagram shows the mounting hole layout for all the Modular controllers.

TWDLMDA20DUK
TWDLMDA20DTK



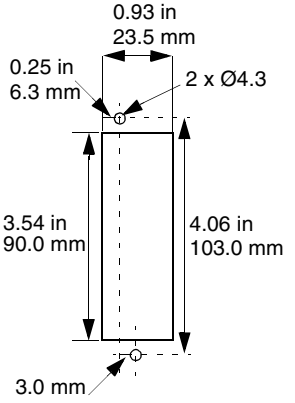
TWDLMDA20DRT
TWDLMDA40DUK
TWDLMDA40DUK



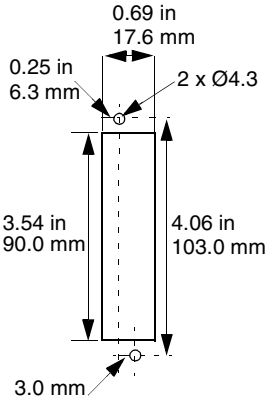
Mounting Hole Layout for Expansion I/O Modules

The following diagram shows the mounting hole layout for the expansion I/O modules.

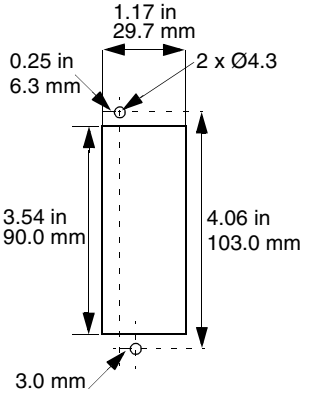
TWDDDI8DT
TWDDAI8DT
TWDDDI16DT
TWDDRA8RT
TWDDRA16RT
TWDDDO8UT
TWDDDO8TT
TWDDMM8DRT
TWDALM3LT
TWDAMM3HT
TWDAMI2HT
TWDAMO1HT



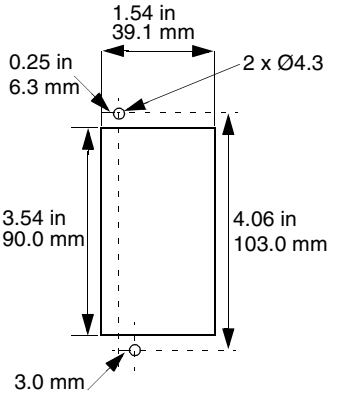
TWDDDI16DK
TWDDDO16TK
TWDDDO16UK



TWDDDI32DK
TWDDDO32TK
TWDDDO32UK

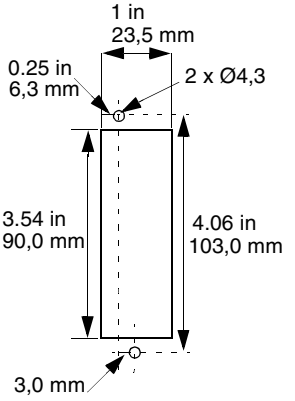


TWDDDO32UK



Mounting Hole Layout for the AS-Interface Bus Interface Module

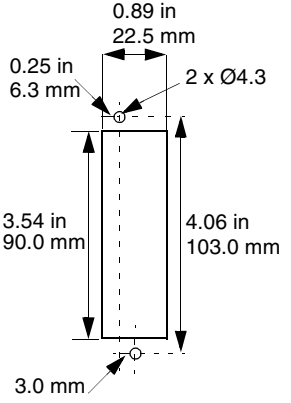
The following diagram shows the mounting hole layout for the TWDNOI10M3 AS-Interface bus interface module:



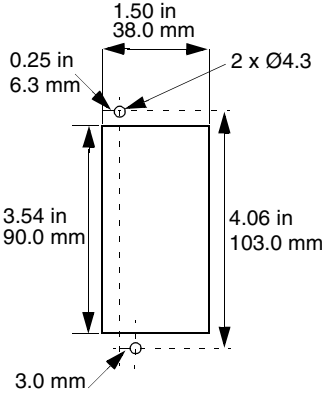
Mounting Hole Layout for Communication Expansion and Operator Display Expansion Modules

The following diagram shows the mounting hole layout for the communication expansion and operator display expansion modules.

TWDNOZ485D
TWDNOZ232D
TWDNOZ485T



TWDXCPODM



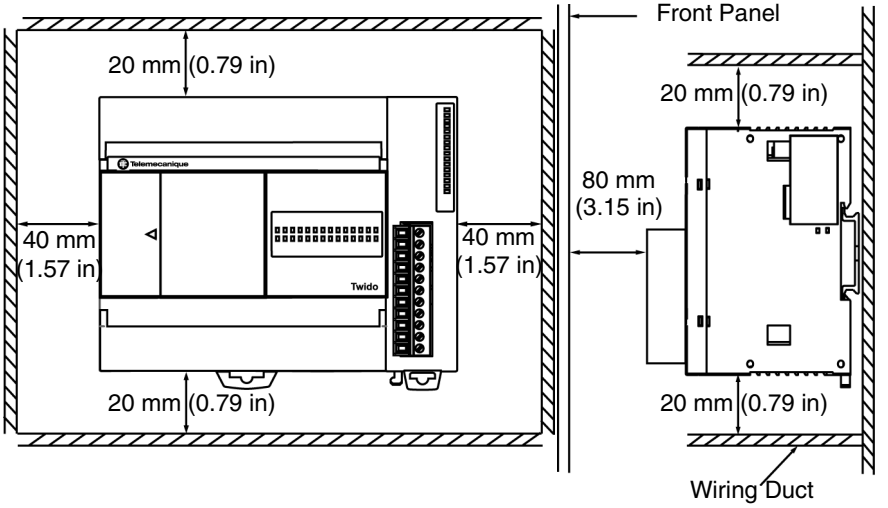
Minimum Clearances for Controllers and Expansion I/O Modules in a Control Panel

Introduction

This section provides the minimum clearances for controllers and expansion I/O modules in a control panel.

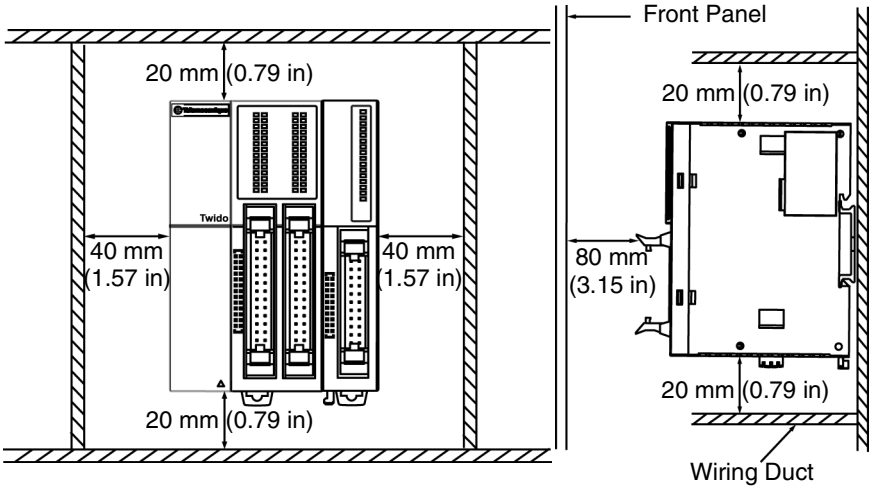
Minimum Clearances for a Compact Controller and Expansion I/O Modules

In order to maintain a natural circulation of air around the Compact controller and expansion I/O modules in a control panel, observe the minimum clearances shown in the figures below.



Minimum Clearances for a Modular Controller and Expansion I/O Modules

In order to maintain a natural circulation of air around the Modular controller and expansion I/O modules in a control panel, observe the minimum clearances shown in the figures below.



How to Connect the Power Supply

Introduction

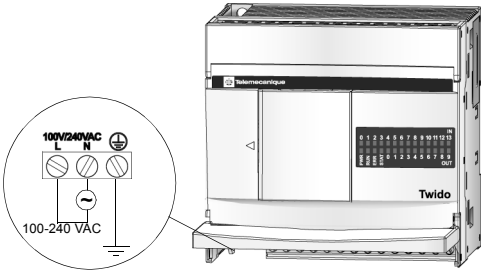
This section describes how to connect the power supply to the Compact and Modular controllers.

Note: When operating outside of the specified voltage range, outputs may not switch accordingly. Use appropriate hard-wired safety interlocks and voltage monitoring circuits.

	**CAUTION** **Make proper power supply connections** • Make sure that proper voltage and frequency is applied to the device. • Verify that you have made proper lead connections to the power supply terminal block. **Failure to follow this precaution can result in injury or equipment damage.**

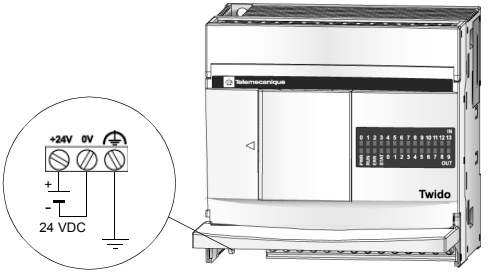
Connect an AC Power Supply to a Compact Controller

The following diagram shows how to connect an AC power supply to a TWDLCA•••DRF series Compact Controller.



Connect a DC Power Supply to a Compact Controller

The following diagram shows how to connect a DC power supply to a TWDLCD••DRF series Compact Controller.



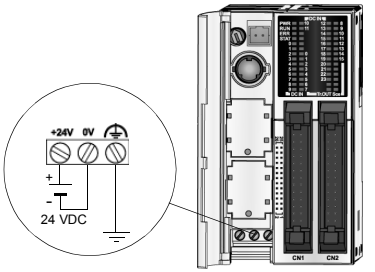
Compact Controller Power Supply Specifications

The following table provides power supply information for the Compact controller.

Item	AC Specifications	DC Specifications
Power supply voltage	Rated power voltage: from 100 to 240 VAC	Rated power voltage: 24 VDC
	Allowable range: from 85 to 264 VAC	Allowable range: from 19.2 to 30 VDC
	The detection of the absence of a power supply depends on the number of inputs and outputs used. Usually the absence of a power supply is detected when voltage drops to less than 85 VAC, stopping the current operation to prevent malfunction.	The detection of the absence of a power supply depends on the number of inputs and outputs used. Usually the absence of a power supply is detected when voltage drops to below 14 VDC, stopping the current operation to prevent malfunction.
	Note: Momentary power interruption for 20 ms or less at 100 to 240 VAC is not recognized as power failure.	**Note:** Momentary power interruption for 10 ms or less at 24 VDC is not recognized as failure.
Inrush current flow at power-up	TWDLCAA10DRF and TWDLCAA16DRF: 35 A maximum TWDLCAA24DRF: 40 A maximum	
Power supply wiring	0.64 mm^2 (UL1015 AWG22) or 1.02 mm^2 (UL1007 AWG18) Make the power supply wiring as short as possible.	
Ground wiring	1.30 mm^2 (UL1007 AWG16) Do not connect ground wire in common with ground wire of motor equipment.	

Connect a Power Supply to a Modular Controller

The following diagram shows how to connect a power supply to a Modular Controller.



Modular Controller Power Supply Specifications

The following table provides power supply information for the Modular controller.

Item	Specifications
Power supply voltage	Rated power voltage: 24 VDC Allowable range: from 20.4 to 26.4 VDC The detection of the absence of a power supply depends on the number of inputs and outputs used. Usually the absence of a power supply is detected when voltage drops to below 20.4 VDC, stopping the current operation to prevent malfunction. **Note:** Momentary power interruption for 10 ms or less at 24 VDC is not recognized as failure.
Inrush current flow at power-up	50 A maximum
Power supply wiring	0.64 mm^2 (UL1015 AWG22) or 1.02 mm^2 (UL1007 AWG18) Make the power supply wiring as short as possible.
Ground wiring	0.64 mm^2 (UL1015 AWG22) or 1.02 mm^2 (UL1007 AWG18) Do not connect ground wire in common with ground wire of motor equipment.

How to Install and Replace an External Battery

Note: The following information about the external battery applies to TWDLCAA40DRF and TWDLCAE40DRF series compact base controllers only.If you own another model of compact or modular controller, you may skip this section.

Introduction

In addition to the built-in internal battery used for RAM backup, each of the TWDLCAA40DRF and TWDLCAE40DRF compact base controllers is equipped with a battery compartment that can host a user-replaceable external battery. Note that for most applications, no external battery is required.
The external battery option provides extended backup duration to meet the needs for long-term backup for specific applications, such as HAVC applications.

Battery Type

Your compact base controller uses one 1/2 AA, 3.6 V, lithium battery to provide optional extended data storage duration of up to 3 years.

Note: The external battery is not included with your Twido controller.

Battery Power Status

The BAT LED indicator located on the front panel of your Twido compact controller serves as an indicator for low battery warning. The BAT LED state is described in the following table:

LED State	Description
Extinguished	Indicates that either: ● the external battery is functioning normally, or ● the BAT LED has been disabled by user by setting the %S66 system bit to 1.
Steady red	Indicates that either: ● the power of the external battery is low (voltage below 2.5V) (The external battery must be replaced within two weeks from the date the BAT LED was first lit.), or ● there is no external battery installed in the battery compartment.

Battery Installation Requirements

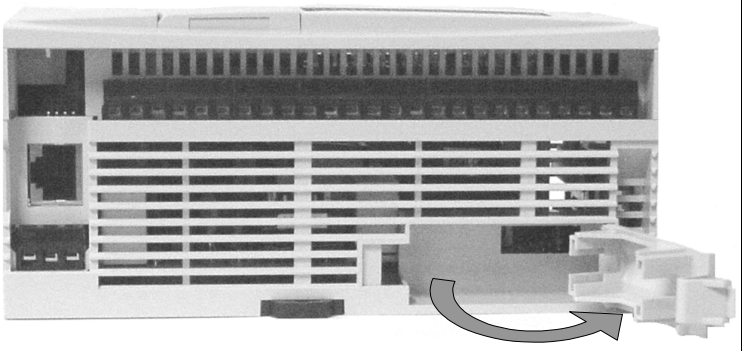
When installing or replacing the external battery, make sure the following two conditions are both met:

1. The internal battery of your Twido compact base must be fully charged.
2. After installing the external battery, you must power up your Twido controller immediately.

Note: Failure to meet any of the above two conditions will result in a significantly shorter battery life. The external battery life can be rapidly reduced to less than one month.

Installing and Replacing an External Battery

The battery compartment is located on the lower-panel of the Twido compact controller case. To install or replace an external battery, follow these steps:

Step	Action
1	Before installing or replacing the external battery, you must first make sure that the internal battery of your Twido controller is fully charged. This precaution is to ensure that the data stored in RAM memory are not lost when the external battery is removed from its compartment.
2	Press sideways on the small latch protruding from the compartment cover to unlock the door of the battery compartment.
3	Pull to open the compartment door, as shown in the figure below: 
4	Remove the used battery from the compartment, if any.
5	Insert the new battery in the compartment, observing the correct polarity, as indicated by the polarity marking located inside the battery compartment.
6	Close the door of the battery compartment (make sure the latch clicks into place to lock the compartment door).
7	Power up your Twido controller immediately to preserve battery life.

Battery Status Monitoring and Control via System Bits

The following information describes how the battery status can be monitored and how the battery LED management can be controlled via two system bits %S75 and %S66, respectively:

System Bit	Description
%S75	This is a read-only system bit that indicates the current battery status: • %S75 = 0: external battery is operating normally. • %S75 = 1: external battery power is low, or battery is absent from compartment.
%S66	This system bit is writable and allows you to turn on/off the BAT LED: • Set this bit to 1 to disable the BAT LED (LED is always off even if there is no battery inside the compartment). • Set this bit to 0 to enable the BAT LED indicator. Note that the %S66 system bit is reset to 0 as default at system start-up.

Special Functions

4

At a Glance

Introduction

This chapter provides an introduction and I/O assignments for the Twido controllers' special functions. For information on configuring and using these special functions see the Twido Software Reference Guide.

What's in this Chapter?

This chapter contains the following topics:

Topic	Page
RUN/STOP Input	212
Controller Status Output	213
Latching input	214
Fast Counting	215
Very Fast Counters	216
Pulse (PLS) Generator Output	219
Pulse Width Modulation (PWM) Output	220

RUN/STOP Input

Introduction

This section provides basic information on the RUN/STOP input special function.

Principle

The RUN/STOP input is a special function that can be assigned to any one of the base controller inputs. This function is used to start or stop a program.

Determining the State of Run/ Stop Input

At power up, if configured, the controller state is set by the Run/Stop input:

- if RUN/STOP input is at state 0, controller is in STOP mode.
- if RUN/STOP input is at state 1, controller is in RUN mode.

While the controller is powered, a rising edge on the RUN/STOP input state sets the controller to RUN. The controller is stopped if the RUN/STOP input is at 0. If the RUN/STOP input is at 0, a RUN command from a connected PC is ignored by the controller.

Controller Status Output

Introduction

This section provides basic information on the controller status output special function.

Principle

The controller status output is a special function that can be assigned to one of three outputs (%Q0.0.1 and %Q0.0.3) on a base or a remote controller.
At power up, if there is no controller error see *Troubleshooting Using the Controller's LEDs, p. 224*, the controller status output changes to 1. This function can be used in safety circuits external to the controller, for example, to control:

- The power supply to the output devices.
- The controller power supply.

Latching input

Introduction

This section provides basic information on the latching inputs special function.

Principle

The latching inputs is a special function that can be assigned to one of four inputs (%I0.0.2 to %I0.0.5) on a base or a remote controller. This function is used to memorize any pulse with a duration less than the controller scan time. When a pulse is shorter than one scan and has a value greater than or equal to 1 ms, the controller latches the pulse, which is then updated in the next scan.

Fast Counting

Introduction

This section provides basic information on the fast counting special function.

Principle

The base controllers have two fast counter types:
- A single up counter with a maximum frequency of 5 kHz.
- A single down counter with a maximum frequency of 5 kHz.

The single up counter and single down counter functions enable up counting or down counting of pulses (rising edges) on a digital I/O. The fast counter functions enable counting of pulses from 0 to 65535 in single-word mode and from 0 to 4294967296 in double-word mode.

Controllers Fast Counting Capabilities

Compact controllers can have up to 3 fast counters, with the exception of the TWDLCA•40DRF series compact controllers that have 4 fast counters. Modular controllers can have up to 2 fast counters. The availability of the double-word counting option depends on the controller model. The following table lists the fast counting capabilities of the Twido line Compact and Modular controllers.

Twido Line Controllers	**Compact controllers TWDLC••...**				**Modular controllers TWDLMDA...**	
	10DRF	**16DRF**	**24DRF**	**40DRF**	**20D••**	**40D••**
Fast Counters	3	3	3	4	2	2
Single-Word	Yes	Yes	Yes	Yes	Yes	Yes
Double-Word	No	Yes	Yes	Yes	Yes	Yes

Digital I/O Assignment for a Fast Counter

The digital I/O assignment for fast counters depends on whether digital I/O was assigned for the optional pre-set and catch inputs on the very fast counters. See *Very Fast Counters, p. 216* for more information.

Very Fast Counters

Introduction

This section provides basic information on the very fast counting special function.

Principle

The base controllers have five very fast counter types:
- An up/down counter with a maximum frequency of 20 kHz.
- An up/down 2-phase counter with a maximum frequency of 20 kHz.
- A single up counter with a maximum frequency of 20 kHz.
- A single down counter with a maximum frequency of 20 kHz.
- A frequency meter with a maximum frequency of 20 kHz.

The up/down counter, up/down 2-phase counter, single up counter, and single down counter functions enable counting of pulses from 0 to 65535 in single-word mode and pulses from 0 to 4294967296 in double-word mode. The frequency meter function measures the frequency of a periodic signal in Hz.

Controllers Very Fast Counting Capabilities

The number of very fast counters supported varies with the Twido controller models, as shown in the table below. Also, the availability of the double-word counting option depends on the controller model. The following table lists the very fast counting capabilities of the Twido line Compact and Modular controllers.

Twido Line Controllers	**Compact controllers TWDLC••...**				**Modular controllers TWDLMDA...**	
	10DRF	**16DRF**	**24DRF**	**40DRF**	**20D••**	**40D••**
Fast Counters	1	1	1	2	2	2
Single-Word	Yes	Yes	Yes	Yes	Yes	Yes
Double-Word	No	Yes	Yes	Yes	Yes	Yes

Digital I/O Assignment for a Very Fast Counter on all Controllers

The following tables lists the assigned I/O for one very fast counter on all controllers models.

Functions	First Input (pulses)	Second Input (pulses or Up/Down)	Pre-set Input	Catch Input	First Reflex Output	Second Reflex Output
Up/down counter	%I0.0.1 (pulses)	%I0.0.0*	%I0.0.2**	%I0.0.3**	%Q0.0.2**	%Q0.0.3**
Up/down 2-phase counter	%I0.0.1 (pulses Phase A)	%I0.0.0 (pulses Phase B)	%I0.0.2**	%I0.0.3**	%Q0.0.2**	%Q0.0.3**
Single Up Counter	%I0.0.1 (pulses)	Not used	%I0.0.2**	%I0.0.3**	%Q0.0.2**	%Q0.0.3**
Single Down Counter	%I0.0.1 (pulses)	Not used	%I0.0.2**	%I0.0.3**	%Q0.0.2**	%Q0.0.3**
Frequency Meter	%I0.0.1 (pulses)	Not used	Not used	Not used	Not used	Not used

Note:
- * Indicates up/down
- ** Optional use

Digital I/O Assignment for the Other Very Fast Counter on Modular Controllers

The following tables lists the assigned I/O for the other very fast counter on Modular controllers only.

Functions	First Input (pulses)	Second Input (pulses or Up/Down)	Pre-set Input	Catch Input	First Reflex Output	Second Reflex Output
Up/down counter	%I0.0.7 (pulses)	%I0.0.6*	%I0.0.5**	%I0.0.4**	%Q0.0.4**	%Q0.0.5**
Up/down 2-phase counter	%I0.0.7 (pulses Phase A)	%I0.0.6 (pulses Phase B)	%I0.0.5**	%I0.0.4**	%Q0.0.4**	%Q0.0.5**
Single Up Counter	%I0.0.7 (pulses)	Not used	%I0.0.5**	%I0.0.4**	%Q0.0.4**	%Q0.0.5**
Single Down Counter	%I0.0.7 (pulses)	Not used	%I0.0.5**	%I0.0.4**	%Q0.0.4**	%Q0.0.5**
Frequency Meter	%I0.0.7 (pulses)	Not used	Not used	Not used	Not used	Not used

Note:
- * Indicates up/down
- ** Optional use

Pulse (PLS) Generator Output

Introduction

This section provides basic information on the PLS special function.

Principle

The PLS is a special function that can be assigned to output %Q0.0.0 or %Q0.0.1 on a base or a peer controller. A user-defined function block generates a signal on output %Q0.0.0 or %Q0.0.1. This signal has a variable period but has a constant duty cycle, or on to off ratio of 50% of the period.

Controllers PLS Capabilities

The number of PLS generators supported varies with the Twido controller models, as shown in the table below. Note that all controllers that have a PLS generator support both single-word and double-word functions. The following table lists the PLS capabilities of the Twido line Compact and Modular controllers.

Twido Line Controllers	**Compact controllers TWDLC••...**				**Modular controllers TWDLMDA...**	
	10DRF	**16DRF**	**24DRF**	**40DRF**	**20D••**	**40D••**
PLS Generator	None	None	None	2	2	2
Single-Word	-	-	-	Yes	Yes	Yes
Double-Word	-	-	-	Yes	Yes	Yes

Pulse Width Modulation (PWM) Output

Introduction

This section provides basic information on the PWM special function.

Principle

The PWM is a special function that can be assigned to output %Q0.0.0 or %Q0.0.1 on a base or a peer controller. A user-defined function block generates a signal on output %Q0.00 or %Q0.0.1. This signal has a constant period with the possibility of varying the duty cycle, or on to off ratio.

Powering-Up and Troubleshooting

5

At a Glance

Introduction

This chapter provides the procedure for the first time a controller is powered-up, checking the I/O connections, and troubleshooting the controller using the LEDs.

What's in this Chapter?

This chapter contains the following topics:

Topic	Page
Procedure for First Time Power-Up of a Controller	222
Checking I/O Connections on the Base Controller	223
Troubleshooting Using the Controller's LEDs	224

Procedure for First Time Power-Up of a Controller

Introduction

This section explains powering-up a controller for the first time.

Power-Up Self Diagnostics

At power-up, the firmware will perform tests to ensure the proper functioning of the controller. Each major hardware component is tested for consistency. This includes the on-board PROM and RAM. Later in the booting sequence, the application is tested, using a checksum, before it can be executed.

First Time Power-Up Procedure

There are four status LEDs that signify the state and condition of the controller. The LED labeled PWR directly monitors the power supplied to the controller. It can not be changed by the application and can not be modified by the executive firmware. The first time the controller is powered up, it will be in a non-configured state with no application programming present. This state is indicated by a blinking ERR LED. If the ERR LED is not blinking or if any of the Input/Output LEDs are illuminated, without the presence of an external signal, see *Troubleshooting Using the Controller's LEDs, p. 224*.

Checking I/O Connections on the Base Controller

Introduction

This section provides a procedure for checking the I/O connections.

WARNING

Unintended operation of external equipment

To avoid unintended operation of external equipment, check that:
- Power fuses are removed from the motor controls.
- Pneumatic and hydraulic inputs are closed.

Failure to follow this precaution can result in death, serious injury, or equipment damage.

Checking I/O Connections Procedure

The following procedure ensures that the I/O connections are connected:

Step	Action
1	To test the I/O connections, the controller needs to be in the non-configured state. To accomplish this: ● If an Operator Display is attached, press and hold ESC and cycle the power on the controller. After the controller restarts, the Operator Display indicates "NCF". ● From TwidoSoft, issue the erase command from the Controller menu.
2	With the controller in the non-configured state, set system bit %S8 to 0. At state 0, the controller outputs are kept in their existing state.
3	Check the inputs by activating each external sensor. To accomplish this: ● Check that each of the input LEDs for the corresponding bit changes state. ● Using TwidoSoft's Operate Controller dialog, check that each of the input LEDs for the corresponding bit changes state.
4	Check the outputs by setting the bit corresponding to each output state to 1. To accomplish this: ● Check that each of the output LEDs for the corresponding bit changes state. ● Using TwidoSoft's Operate Controller dialog, check that each of the output LEDs for the corresponding bit changes state.
5	To complete this procedure, set system bit %S8 to 1. This is automatically accomplished by downloading a valid user application.

Troubleshooting Using the Controller's LEDs

Introduction

This section provides information on the controller's operating status and troubleshooting using the LEDs.

Controller state

The following table displays the different LED states on a base controller, peer controller, and remote controller.

LED state		Base Controller or Peer Controller	Remote I/O Controller
RUN green	○	Application not executed	Incorrectly or not connected
	⊗	Controller is in STOP mode or execution fault (HALT)	Same as base controller
	●	Controller is in RUN mode	Same as base controller
ERR red	○	OK	OK
	⊗	Application not executable, or execution error (HALT)	N/A
	●	Internal faults (watchdog, etc.)	Same as base controller
STAT green	○	Controlled by the user or application through system bit %S69	Same as base controller
	⊗	N/A	N/A
	●	Controlled by the user or application through system bit %S69	Same as base controller
BAT red	TWDLCAA40DRF and TWDLCAE40DRF Compact controllers. (For detailed information about the BAT LED status, please refer to *How to Install and Replace an External Battery, p. 208*.)		
	○	External battery power is OK or LED has been disabled. (Controlled by the user or system through system bit %S66)	N/A
	⊗	N/A	N/A
	●	No external battery or low battery power. Controlled by the user or system through system bit %S66	N/A

LED state		Base Controller or Peer Controller	Remote I/O Controller
LAN ACT green/ amber	TWDLCAE40DRF Compact controller. (For detailed information about the LAN ACT LED status, please refer to (See TwdoSOFT).)		
	◯	No Ethernet signal.	N/A
	⊗	green: communicating over 10Base-T link. amber: communicating over 100Base-TX link.	N/A
	●	green: 10Base-T network connection. amber: 100Base-TX network connection.	N/A
LAN ST green	TWDLCAE40DRF Compact controller. (For detailed information about the LAN ACT LED status, please refer to (See TwdoSOFT).)		
	◯	Base controller is powered OFF.	N/A
	⊗	Multiple, consecutive flashes of various numbers to provide a visual diagnostic tool of the Ethernet network connection status.	N/A
	●	Base controller is powered ON. Ethernet port is ready.	N/A
◯ Off		⊗ Flashing	● Illuminated

Status of the Digital I/O Module

LED state		Digital I/O Module
I/O LEDs	◯	I/O not active
	●	I/O active
◯ Off		● Illuminated

Status of AS-Interface bus interface module

The following table summarizes the problems that may occur on AS-Interface master module startup:

Problems		Causes and action to be taken
PWR	◯	Insufficient power is being delivered to the AS-Interface module. ● Check AS-Interface power supply and connections. ● Check the connection between the Twido module and the AS-Interface master.
FLT	●	The slave configuration on the AS-Interface bus is incorrect: ● Use TwidoSoft to check that the slaves are correctly connected. If the configuration is correct and the LED remains on: ● Disconnect and reconnect the AS-Interface connector, or switch off the power supply and switch it back on again.
OFF	●	A slave is connected at address 0 at power up: ● Change the slave's address and repeat power up:
Instable slave operation		If two slaves have the same address and the same identity codes, the AS-Interface master may fail to detect an error: ● Remove one of the slaves from the bus and perform readdressing using TwidoSoft.
◯ Off		● Illuminated

Agency Compliance

6

Agency Requirements

Introduction

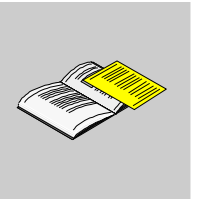
This section provides agency standards for the Twido products.

Standards

Twido controllers comply with the main national and international standards concerning electronic industrial control devices.
The following are specific controller requirements:

- EN61131-2 (IEC61131-2)
- UL508
- UL1604/CSA 213 Class I Division 2 Groups A, B, C, D

Appendices



At a Glance

Introduction

This appendix provides information on common IEC symbols used in this manual.

What's in this Appendix?

The appendix contains the following chapters:

Chapter	Chapter Name	Page
A	IEC Symbols	231

IEC Symbols

A

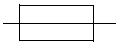
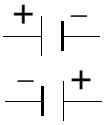
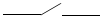
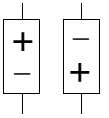
Glossary of Symbols

Introduction

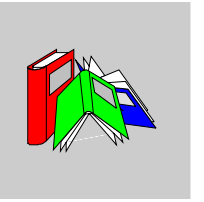
This section contains illustrations and definitions of common IEC symbols used in describing Twido wiring schematics.

Symbols

Common IEC symbols are illustrated and defined in the table below:

	Fuse
	Load
	AC power
	DC power
	Digital sensor/input, for example, contact, switch, initiator, light barrier, and so on.
	Earth ground
	2-wire sensor
	Thermocouple element

Glossary



A

Analog potentiometer — It can be used to preset a value for an analog timer. All Modular controllers and Compact 10 and 16 I/O controllers have one analog potentiometer. The Compact 24 I/O controller has two:

Analog Voltage Input Connector — Connects an analog voltage source of 0 through 10 VDC. The analog voltage is converted to a digital value and is stored in a system word.

C

Cartridge Connector — A connector to attach an optional memory cartridge or an RTC.

Catch Input — Makes sure to receive short input pulses (rising pulse of 40 µs or falling pulse of 150 µs minimum) from sensors without regard to the scan time.

Communication Adapter — An optional cartridge that can be attached to any Compact controller or Operator Display Expansion Module to provide an optional Serial Port 2.

Communication Expansion Module — An optional module that can be attached to any Modular controllers communications expansion bus to provide an optional Serial Port 2.

Controller status output	A special function. This function is used in safety circuits, external to the controller, to control the power supply to the output devices or the controller power supply.

E

ERR LED	An LED that illuminates when an error occurs in the controller.
Expansion connector	A connector to attach expansion I/O modules.
Expansion Connector Cover	A cover to protect the expansion connector.
Expansion I/O Module	Either a digital or analog module that adds additional I/O to the base controller.

F

Fast Counting	A special function, it is available as a single up counter and single down counter. These functions enable up counting or down counting of pulses (rising edges)on a digital I/O. Compact controllers can be equipped with three fast counters. Modular controllers can have two fast counters.
Free Wire	The end of a digital I/O cable whose wires do not have a connector. This scheme provides connectivity from Modular I/O to discrete I/O points.

I

I/O	Input/Output.
I/O terminals	Terminals on all Modular controllers and expansion I/O modules used to connect input and output signals. The input terminals accept both sink and source DC input signals. The output terminals are either transistor source or sink or relay contacts.
IN LED	An LED that illuminates when a corresponding input is on. All modules have IN LEDs.

Input Filter A special function that rejects input noises. This function is useful for eliminating input noises and chatter in limit switches. All inputs provide a level of input filtering using the hardware. Additional filtering using the software is also configurable through TwidoSoft.

Input Simulators An optional accessory for Compact controllers that is used for debugging. It can simulate input sensors to test application logic.

Input terminals Terminals on the top of all Compact controllers used to connect input signals from input devices such as sensors, push buttons, and limit switches. The input terminals accept both sink and source DC input signals.

L

Latching input A special function. This function is used to memorize any pulse with a duration less than the controller scan time. When a pulse is shorter than one scan and has a value greater than or equal to 100 µs, the controller latches the pulse, which is then updated in the next scan.

M

Memory Cartridge An optional cartridge available in two sizes: 32 KB and 64 KB (64 KB not available on Compact). It can be added to any controller for removable backup of applications or to load an application, if certain conditions exist. The 64 KB cartridge is also used to increase program memory.

Modbus Master Mode Allows the controller to initiate a Modbus query transmission, with a response expected from a Modbus slave.

Modbus Slave Mode Allows the controller to respond to Modbus queries from a Modbus master and is the default communications mode if no communication is configured.

O

Operator display expansion module An optional module that can be attached to any Modular controller to display program information.

Operator display module An optional module that can be attached to any Compact controller to display program information.

OUT LED An LED that illuminates when a corresponding output is on. All modules have OUT LEDs.

Output terminals Terminals on the bottom of all Compact controllers used to connect output signals from output devices such as electromechanical relays and solenoid valves. The internal output relay contact is rated up to 240 VAC/2A or 30 VDC/2A.

P

PLS A special function. This user-defined function block generates a signal on output %Q0.0.0 or %Q0.0.1. This signal has a variable period but has a constant duty cycle, or on to off ratio of 50% of the period.

Power Supply Terminals The power supply is connected to these terminals to provide power to the controller. The power voltage for a Compact controller is 100-240 VAC and 24 VDC for a Modular controller.

PWM A special function. This user-defined function block generates a signal on output %Q0.0.0 or %Q0.0.1. This signal has a constant period with the possibility of varying the duty cycle, or on to off ratio.

PWR LED An LED that illuminates when power is supplied to the controller.

R

Removable Cover A cover on all Compact controllers that can be removed to install an optional Operator Display.

RTC	Real Time Clock.
RTD	Temperature detector of type PT100, PT1000 etc. Resistor Temperature Detector.
RUN LED	An LED that illuminates when the controller is executing a program.

S

Sensor power terminals	Supplies power to the sensors (24 VDC, 250 mA). Output terminals are only intended for input devices and should not be used as a source for driving external loads.
Serial Port 1	An EIA RS-485 connector used to download and monitor the controller operation using TwidoSoft.
Serial port 2	An optional port that can be configured as either EIA RS-232 or EIA RS-485.
STAT LED	An LED that blinks on and off to indicate a specific status of the user program.

T

Terminal cover	A cover on all Compact controllers to protect the input and output terminals.

V

Very Fast Counting	A special function available as an up/down counter, an up/down 2-phase counter, a single up counter, a single down counter, and frequency meter. The counter functions enable counting of pulses from 0 to 65,535. The frequency meter function measures the frequency of a periodic signal in Hz.

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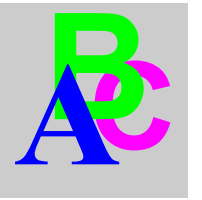

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09/2012

EIO0000000614.03

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The information provided in this documentation contains general descriptions and/or technical characteristics of the performance of the products contained herein. This documentation is not intended as a substitute for and is not to be used for determining suitability or reliability of these products for specific user applications. It is the duty of any such user or integrator to perform the appropriate and complete risk analysis, evaluation and testing of the products with respect to the relevant specific application or use thereof. Neither Schneider Electric nor any of its affiliates or subsidiaries shall be responsible or liable for misuse of the information that is contained herein. If you have any suggestions for improvements or amendments or have found errors in this publication, please notify us.

All pertinent state, regional, and local safety regulations must be observed when installing and using this product. For reasons of safety and to help ensure compliance with documented system data, only the manufacturer should perform repairs to components.

When devices are used for applications with technical safety requirements, the relevant instructions must be followed.

Failure to use Schneider Electric software or approved software with our hardware products may result in injury, harm, or improper operating results.

Failure to observe this information can result in injury or equipment damage.

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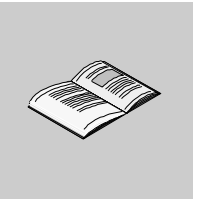

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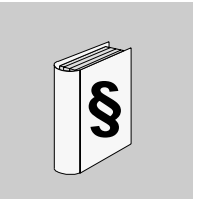
Safety Information



Important Information

NOTICE

Read these instructions carefully, and look at the equipment to become familiar with the device before trying to install, operate, or maintain it. The following special messages may appear throughout this documentation or on the equipment to warn of potential hazards or to call attention to information that clarifies or simplifies a procedure.

The addition of this symbol to a Danger safety label indicates that an electrical hazard exists, which will result in personal injury if the instructions are not followed.

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

⚠ DANGER

DANGER indicates an imminently hazardous situation which, if not avoided, **will result in** death or serious injury.

⚠ WARNING

WARNING indicates a potentially hazardous situation which, if not avoided, **can result in** death or serious injury.

⚠ CAUTION

CAUTION indicates a potentially hazardous situation which, if not avoided, **can result in** minor or moderate injury.

NOTICE

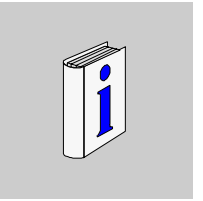
NOTICE is used to address practices not related to physical injury.

PLEASE NOTE

Electrical equipment should be installed, operated, serviced, and maintained only by qualified personnel. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material.

A qualified person is one who has skills and knowledge related to the construction and operation of electrical equipment and its installation, and has received safety training to recognize and avoid the hazards involved.

About the Book



At a Glance

Document Scope

This manual describes how to use the Magelis HMI STU 655/855 unit.

Validity Note

This documentation is valid for the HMI STU 655/855 when used with Vijeo Designer version 6.1 SP2 or later.

Product Related Information

⚠ WARNING

UNINTENDED EQUIPMENT OPERATION

The application of this product requires expertise in the design and programming of control systems. Only persons with such expertise should be allowed to program, install, alter, and apply this product.

Follow all local and national safety codes and standards.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

User Comments

We welcome your comments about this document. You can reach us by e-mail at techcomm@schneider-electric.com.

HMI STU 655/855 Panels

I

Overview

This part describes how to use HMI STU 655/855 Panels.

What Is in This Part?

This part contains the following chapters:

Chapter	Chapter Name	Page
1	HMI STU 655/855 Panels	11
2	Specifications	29
3	Installation and Wiring	45

HMI STU 655/855 Panels

1

Overview

This chapter describes the HMI STU 655/855 Panels and connectable devices.

What Is in This Chapter?

This chapter contains the following topics:

Topic	Page
HMI STU 655/855 Series of Panels	12
HMI STU 655/855 Package Contents	15
Accessories	16
Parts Identification and Functions	19
Certifications and Standards	23
System Design	25

HMI STU 655/855 Series of Panels

Introduction

The HMI STU 655/855 is a Human Machine Interface product that has an operating voltage of 24 VDC.

The following table describes the HMI STU 655/855 characteristics:

Part number	Screen size	Screen (pixel) resolution	Mono/Color	Screen technology	Serial port	Ethernet port
HMI STU 655	8.9 cm (3.5 in.)	320x240 (QVGA)	65 K colors and LED's backlight	TFT	Yes	Yes
HMI STU 855	14.48 cm (5.7 in.)	320x240 (QVGA)	65 K colors and LED's backlight	TFT	Yes	Yes
TFT: Thin-Film Transistor Technology.						

Critical systems, Detected Alarms and Handling Requirements

Critical detected alarm indicators and system functions require independent and redundant protection hardware and/or mechanical interlocks.

If the unit for any reason becomes inoperative (for example, an inoperative backlight) it may be difficult or impossible to identify a function. Functions that may present a hazard if not immediately executed, such as emergency stop, must be provided independently of the unit. The design of the control system must take into account an inoperative unit (backlight) and that the operator is unable to control the machine or respond to detected errors using the unit.

When the power is cycled, wait at least 10 seconds before restoring the power to the HMI unit. Switching the power OFF and ON quickly can damage the unit.

⚠ WARNING

LOSS OF CONTROL

- Consider the potential failure modes of control paths in the machine control system design, such as:
  - The possibility of backlight failure,
  - Unanticipated link transmission delays or failures,
  - The operator being unable to control the machine,
  - The operator making errors in the control of the machine.
- Provide a means to achieve a safe state during and after a path failure for critical control functions such as emergency stop and overtravel stop.
- Provide separate or redundant control paths for critical control functions.
- Test individually and thorougly each implementation of the HMI STU 655/855 for correct operation before service.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

⚠ WARNING

UNINTENDED EQUIPMENT OPERATION

- Do not use the unit as the only means of control for critical system functions such as motor start/stop or power control.
- Do not use the unit as the only notification device for critical alarms, such as device overheating or overcurrent.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

Handling the LCD Panel

The following characteristics are specific to the LCD unit and are considered normal behavior:

- LCD screen may show unevenness in the brightness of certain images or may appear different when seen from outside the specified viewing angle. Extended shadows, or cross-talk, may also appear on the sides of screen images.
- LCD screen pixels may contain black and white colored spots and color display may seem to have changed over time.
- When the same image is displayed on the screen for a long period, an after-image may appear when the image is changed. If this happens, turn off the unit, wait 10 seconds and then restart it.

NOTE: Do not display the same image for a long time, change the screen image periodically.

⚠ CAUTION

SERIOUS EYE AND SKIN INJURY

The liquid present in the LCD panel contains an irritant:

- Avoid direct skin contact with the liquid.
- Wear gloves when you handle a broken or leaking unit.
- Do not use sharp objects or tools in the vicinity of the LCD touch panel.
- Handle the LCD panel carefully to prevent puncture, bursting, or cracking of the panel material.

If the panel is damaged and any liquid comes in contact with your skin, immediately rinse the area with running water for at least 15 min.

If the liquid gets in your eyes, immediately rinse your eyes with running water for at least 15 minutes and consult a doctor.

Failure to follow these instructions can result in injury or equipment damage.

Using Touch Panel Correctly

⚠ WARNING

UNINTENDED EQUIPMENT OPERATION

- Operate the HMI STU 655/855 touch panel with only one finger.
- Do not activate two or more points of the touch panel simultaneously.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

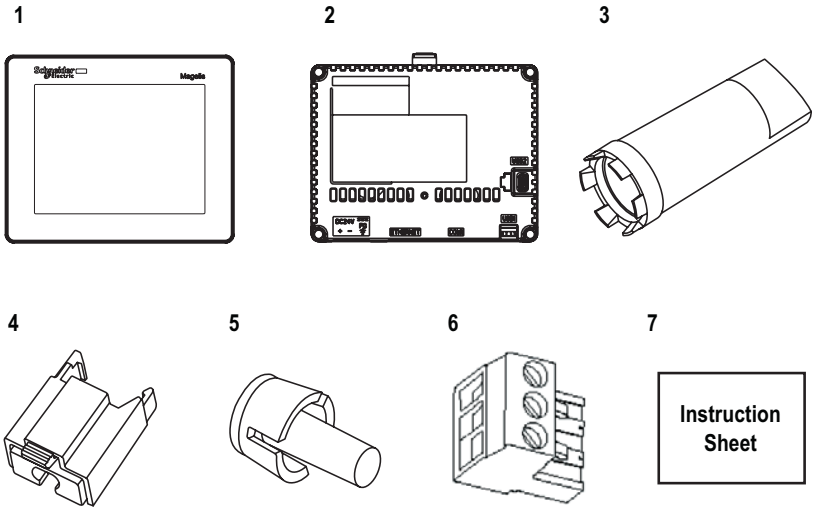
Use only one finger to select an object on the touch panel.

If the touch panel receives pressure at two or more points at the same time, an unintended object could be selected.

HMI STU 655/855 Package Contents

Package Contents

Verify all items listed here are present in your package:



1 Display Module
2 Rear Module
3 Tightening Wrench
4 USB Standard Type A Cable Holder
5 Anti-rotation Tee
6 Terminal Block
7 Quick Reference Guide

Revision

You can identify the product version (PV), revision level (RL) and the software version (SV) from the unit product label.

Accessories

Optional Accessories

Product Number	Description
HMI ZS61	Set of 5 Screen Protective Sheets
HMI ZSU62	Set of 5 Screen Protective Sheets for HMI STU 855
HMI ZSU KIT	Accessory Kit for HMI STU 655/855, contains: • USB standard Type A cable holder • USB mini B cable holder • Anti-rotation Tee • 2 Panel adaptors
ZB5AZ905	Tightening Wrench
ZB5AZ901	Kit of 10 display module fixing nuts
BMX XCA USB H018	Mini-B USB <-> PC download cable
HMI ZSUSBB	USB Front Cable (MiniB)
HMI ZURS	USB-232C Converter Cable
XBT ZGPWS1	Set of 5 Power Connectors
HMI S65	Front module 8.9 cm (3.5 in.)
HMI S85	Front module 14.48 cm (5.7 in.)
HMI S5T	Rear module

NOTE: Only HMI S5T supports both front module sizes without any new configuration.

Rear Module Label	Front Module Compatibility	
	HMI S65	**HMI S85**
HMI STU655	OK	–
HMI STU855	–	OK
HMI S5T	OK	OK

⚠ DANGER

RISK OF EXPLOSION IN HAZARDOUS LOCATIONS

Do not substitute a rear module labeled HMI STU655 by a rear module labeled HMI S5T when installed in hazardous locations.

Failure to follow these instructions will result in death or serious injury.

Serial Interface Items

Product Number	Description
XBT Z9780 (2.5 m/8.20 ft) **XBT Z9782** (10 m/32.80 ft)	Connects COM1 to Premium, Micro or Twido PLC.
XBT Z9980 (2.5 m/8.20 ft) **XBT Z9982** (10 m/32.8 ft)	Connects COM1 to Modicon M340
VW3A8306	Connects COM1 to derivation box TSXSCA62
VW3A8306R10	Connects COM1 to ATV Drives, a Hub LU9GC3 or Fieldbus Taps TWDXCAT3RJ or TWDXCAISO
XBT ZG939 + **XBT Z988**	Connects COM1 port to Advantys STB
XBT ZG939	Cable adapter COM1, RJ45
XBT Z968 **XBT Z9680** **XBT Z9681**	Connects COM1 port with XBTZ adapter to Premium, Micro or Twido PLC
XBT Z9710	Connects COM1 port with XBTZ adapter to Quantum PLC
XBT Z9711	Connects COM1 port with XBTZ adapter to Momentum PLC
XBT Z908	Connects COM1 port with XBTZ adapter to derivation box TSXSCA62
XBT Z938	Connects COM1 port with XBTZ adapter to ATV drives, a Hub LU9GC3 or Fieldbus Taps TWDXCAT3RJ or TWDXCAISO
XBT Z918	Connects COM1 port with XBTZ adapter to Premium SCY
XBT Z988	Connects COM1 port with XBTZ adapter to Advantys STB
XBT Z9733	Connects COM1 to Rockwell DF1 Logix PLC
XBT Z9734	Connects COM1 to Rockwell DH485 Logix PLC
XBT Z9743	Connects COM1 to Omron PLC Sysmac Link series
XBT Z9730 **XBT Z9731**	Connects COM1 with XBT Z adapter to Rockwell DF1 PLC
XBT Z9732	Connects COM1 with XBT Z adapter to Rockwell DH485 PLC
XBT Z9740	Connects COM1 with XBT Z adapter to Omron PLC Sysmac Link series

USB Interface Items

Product Number	Description
XBT ZG935	Connects the panel to a personal computer to transfer screen data and user program
XBT ZGUSB	Extends a USB host interface on a waterproofing cabinet
BMX XCAUSB018	Connects the panel to a: • personal computer to transfer screen data and user program • USB terminal port of a PLC (Modicon M340)
HMI ZSUSBB	Extends a USB device interface on a waterproofing cabinet
HMI ZURS	Connects the panel to a serial printer

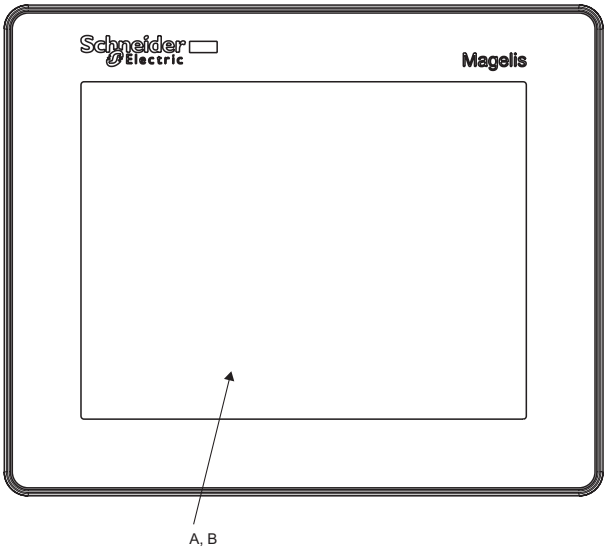
Software

Product name	Description
Vijeo Designer (Version 5.1 or later for HMI STU 655)	Software installed on a PC for creating HMI unit project data
Vijeo Designer (Version 5.1 SP2 or later for HMI STU 855)	Software installed on a PC for creating HMI unit project data

Parts Identification and Functions

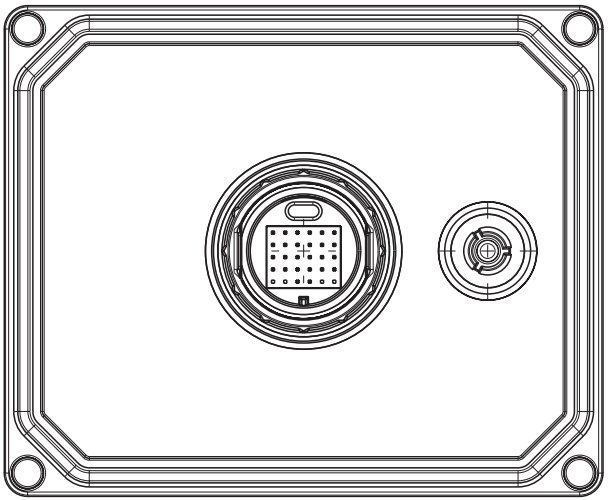
Display Module

Front:



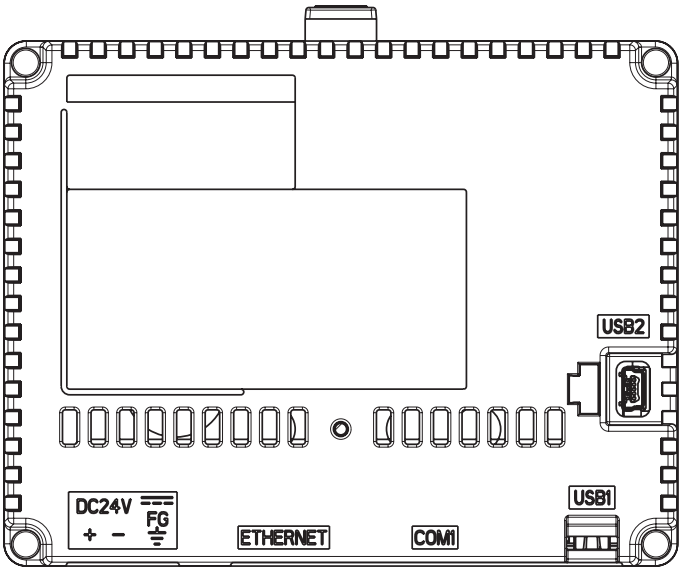
A Display: displays user created screens and remote equipment variables.
B Touch panel: performs screen change operations and sends data to the host (PLC).

Rear:

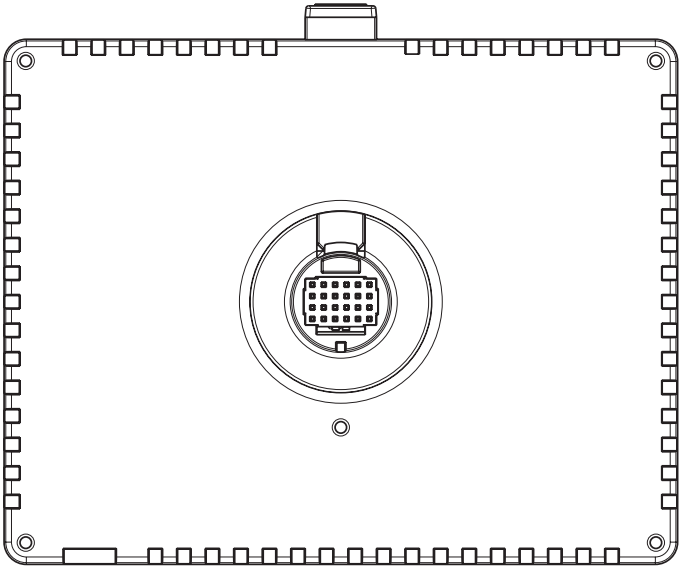


Rear Module

Front:

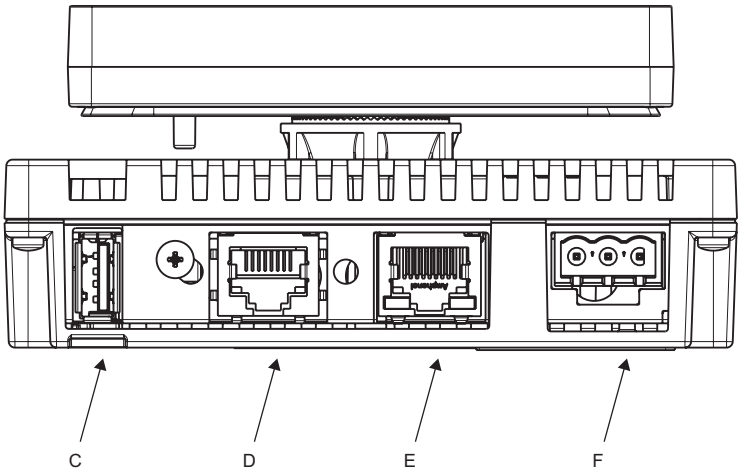


Rear:



Connectors:

Bottom:



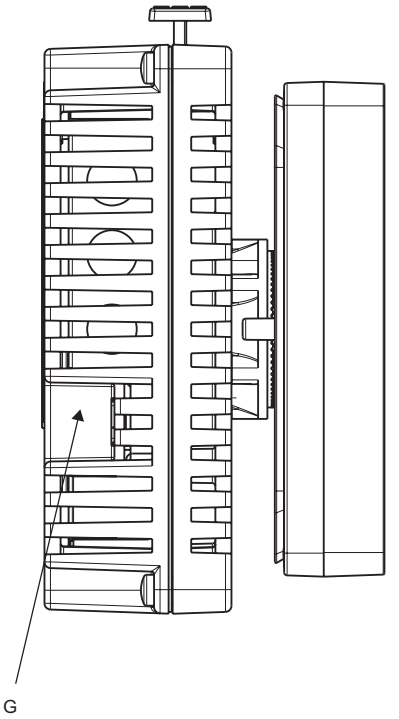
C Standard A USB port connector: connects the data transfer cable or memory stick to the unit.

D Serial I/F (host I/F 8 pin RJ45): connects a RS-232C or RS-485 (serial) cable (from the host/PLC) to the unit (Y port).

E Ethernet Interface (LAN): connects an Ethernet cable (from the host/PLC) to the unit (X port).

F Power input Terminal block: connects the power input and ground wires to the unit.

Side:



G Mini-B USB port connector: connects the data transfer PC cable to the unit.

Certifications and Standards

Introduction

Schneider Electric submitted this product for independent testing and qualification by third-party listing agencies. These agencies have certified this product as meeting the following standards.

Agency Certifications for HMI STU 655/855 Unit

HMI STU 655/855 unit is certified by the Underwriters Laboratory according to:

- UL 508 and CSA C22.2 n° 142 for Industrial Control Equipment
- UL1604, ANSI/ISA 12.12.01 and CSA C22.2 n° 213 for Electrical Equipment for Use in Class I, Division 2 Hazardous Locations

ATEX certification by INERIS is ongoing, please refer to product label.

HMI STU 655/855 unit is designed to comply to merchant navy bridge and deck requirements (Refer to the Schneider Electric website for installation guidelines).

For detailed information, contact your local distributor or see the catalog & marking on the product.

Hazardous Substances

HMI STU 655/855 unit is designed for compliance with:

- WEEE, Directive 2002/96/EC
- RoHS, Directive 2002/95/EC
- RoHS China, Standard SJ/T 11363-2006

UL Conditions of Acceptability and Handling Cautions for HMI STU 655/855 Unit

The HMI STU 655/855 unit is suitable for use in hazardous locations in accordance with Class 1, Division 2 standards. All relevant local, state, and regional codes must be followed.

CE Markings

This product conforms to the necessary requirements of the following Directives for applying the CE label:

- 2006/95/EC Low Voltage Directive
- 2004/108/EC EMC Directive

This conformity is based on compliance with IEC61131-2.

⚠ WARNING

RISK OF EXPLOSION IN HAZARDOUS LOCATIONS

- Verify that the power, input and output (I/O) wiring are in accordance with Class I, Division 2 wiring methods.
- Do not substitute components that may impair compliance to Class I, Division 2.
- Do not connect or disconnect equipment unless power has been switched off or the area is known to be non-hazardous.
- Securely lock externally connected units and each interface before turning on the power supply.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

Interfaces are: COM1, ETHERNET, USB1 and USB2.

⚠ WARNING

RISK OF EXPLOSION IN HAZARDOUS LOCATIONS

- Do not disconnect while circuit is live.
- Potential electrostatic charging hazard: wipe the front panel of the terminal with a damp cloth before turning ON.

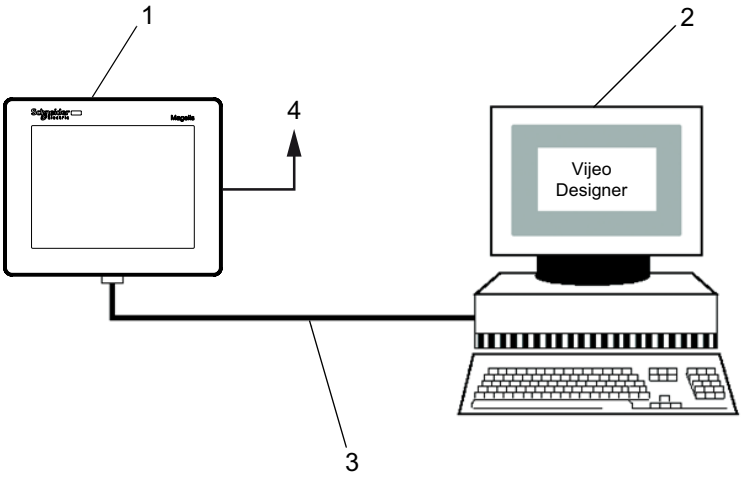
Failure to follow these instructions can result in death, serious injury, or equipment damage.

System Design

Introduction

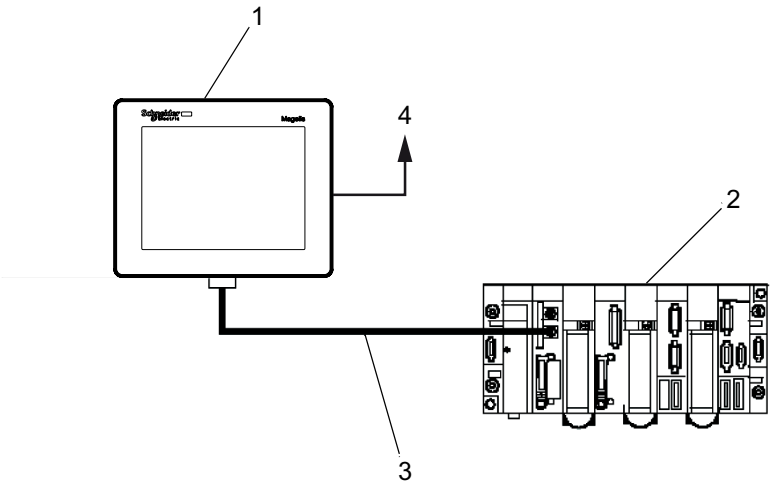
The following diagrams represent equipment that can be connected to the unit.

HMI STU 655/855 Edit Mode Peripherals



1 HMI STU 655/855 unit
2 Personal computer
3 **BMX XCA USB H018** cable
4 To Ethernet network

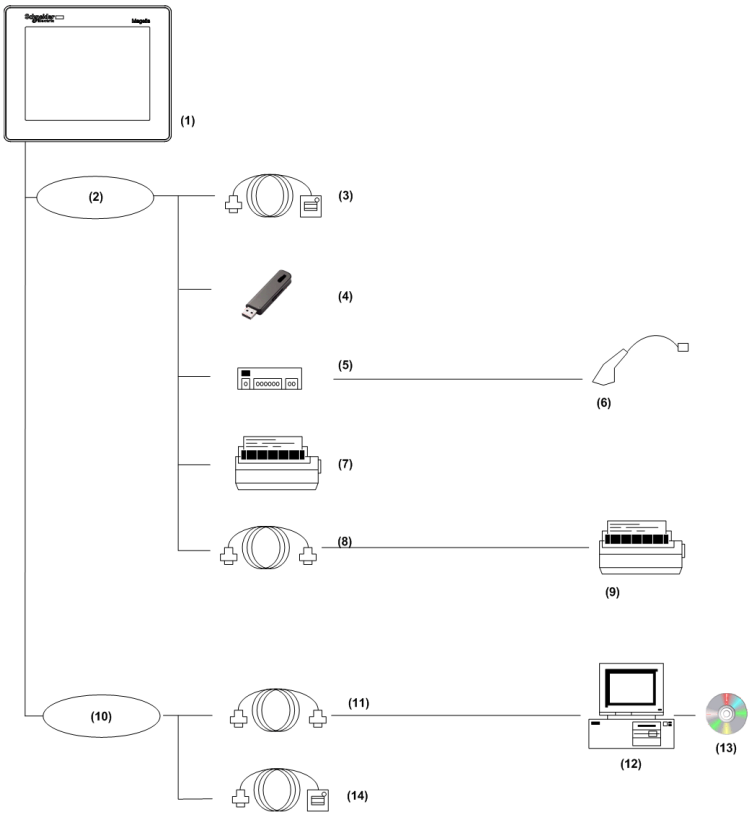
HMI STU 655/855 Run Mode Peripherals



1 HMI STU 655/855 unit
2 PLC
3 **HMI ZSUSBB** cable
4 To Ethernet network

Connecting Magelis HMI STU 655/855 unit to an external device

The following diagram represents a selection of equipment that can be connected to the HMI STU 655/855 unit.



1 HMI STU 655/855
2 USB HOST interface (TYPE-A)
3 USB Front Cable (A) 1 m (3.28 ft) **XBT ZGUSB**
4 USB Memory
5 USB HUB (Self Power Only)
6 Barcode Reader
7 Printer
8 USB-232C Converter Cable 0.5 m (1.64 ft) **HMI ZURS**
9 Printer (Commodity). NEC PC-PR201/PL Command Compatible, EPSON ESC/P24-J84© Command Compatible or HP Laser Jet PCL4 Command Compatible
10 USB DEVICE interface (TYPE-miniB)
11 Download Cable **BMX XCA USB H018**
12 PC
13 Vijeo-Designer
14 USB Front Cable **HMI ZSUSBB**

Specifications

2

Overview

This chapter presents the HMI STU 655/855 specifications.

What Is in This Chapter?

This chapter contains the following sections:

Section	Topic	Page
2.1	General Specifications	30
2.2	Functional Specifications	32
2.3	Interface Specifications	36
2.4	Dimensions	40

2.1 General Specifications

General Specifications

Electrical Specifications

The following table shows the electrical specifications of HMI STU 655/855:

Part Number	Rated Input Voltage	Input Voltage Limits	Acceptable Voltage Drop	Power Consumption	In-Rush Current	Voltage endurance between power terminal and frame ground (FG)	Insulation Resistance between power terminal and FG
HMI STU 655	24 Vdc	20.4 Vdc to 28.8 Vdc	≤10 ms	≤6.5 W	≤30 A	1000 Vac 20 mA for 1 minute	10 MΩ or higher at 500 Vdc
HMI STU 855	24 Vdc	20.4 Vdc to 28.8 Vdc	≤7 ms	≤6.8 W	≤30 A	1000 Vac 20 mA for 1 minute	10 MΩ or higher at 500 Vdc

Environmental Specifications

The following table shows the environmental specifications of HMI STU 655/855:

	Specification	HMI STU 655	HMI STU 855
Physical Environment	Ambient operating temperature (cabinet interior and panel face)	0 °C to +50 °C (32 °F to 122 °F)	0 °C to +50 °C (32 °F to 122 °F)
	Storage temperature	-20 °C to +60 °C (-4 °F to 140 °F)	-20 °C to +60 °C (-4 °F to 140 °F)
	Relative Humidity	85 % w/o condensation (Non-condensing, wet bulb temperature 39 °C (102.2 °F) or less)	85 % w/o condensation (Non-condensing, wet bulb temperature 39 °C (102.2 °F) or less)
	Air purity (dust)	≤0.1 mg/m^3 (10^{-7} oz/ft^3) (non-conductive levels)	≤0.1 mg/m^3 (10^{-7} oz/ft^3) (non-conductive levels)
	Corrosive gases	Free of corrosive gases	Free of corrosive gases
	Atmospheric pressure	800 hPa to 1,114 hPa (2000 m (6,561 ft) or lower)	800 hPa to 1,114 hPa (2000 m (6,561 ft) or lower)

	Specification	HMI STU 655	HMI STU 855
Mechanical Environment	Vibration immunity (operating)	IEC 61131-2 1gn 5Hz to 150Hz (maximum 3.5 mm (0.13 in.))	IEC 61131-2 1gn 5Hz to 150Hz (maximum 3.5 mm (0.13 in.))
	Protection (front panel)	IP 65 - (IEC 60529)	IP 65 - (IEC 60529)
	Protection structure	Type 4X indoor, installed on a panel	Type 4X indoor, installed on a panel
	Protection (rear panel)	IP 20 - (IEC 60529)	IP 20 - (IEC 60529)
	Shock immunity (operating)	IEC 61131-2 15gn 11 ms	IEC 61131-2 15gn 11 ms
	Cooling method	Natural air circulation	Natural air circulation
	Weight	0.25 kg (0.55 lb.) or less (main unit only)	0.25 kg (0.55 lb.) or less (main unit only)
	Color	Front bezel: dark gray	Front bezel: dark gray
	Material	PC/PBT	PC/PBT & PAA
Electrical Environment	Noise immunity	Noise voltage: 1000 Vp-p Pulse width: 1 µs Rising time: 1 ns	Noise voltage: 1000 Vp-p Pulse width: 1 µs Rising time: 1 ns
	High Energy Surges	1 kV CM, 0.5 kV DM on DC power supply 1 kV CM on shielded cables	1 kV CM, 0.5 kV DM on DC power supply 1 kV CM on shielded cables
	Electrical fast transient burst	2 kV CM, 2 kV DM on DC power supply. 1 kV on shielded cables	2 kV CM, 2 kV DM on DC power supply. 1 kV on shielded cables
	Radiated radio frequency electromagnetic field	10 V/m / 80 MHz to 2.7GHz Sinus amplitude modulated 80 % 1 kHz + Internal clock frequency	10 V/m / 80 MHz to 2.7GHz Sinus amplitude modulated 80 % 1 kHz + Internal clock frequency
	Electrostatic Discharge Immunity	6 kV direct contact 8 kV air contact	6 kV direct contact 8 kV air contact
	Grounding	D type grounding (SG-FG connected)	D type grounding (SG-FG connected)

CM Common Mode
DM Differential Mode

2.2 Functional Specifications

Overview

This section presents the HMI STU 655/855 functional specifications of the display, memory and interfaces.

What Is in This Section?

This section contains the following topics:

Topic	Page
Display	33
Memory, Clock, and Touch Panel	35

Display

Display Specifications

The following table shows the display specifications of the HMI STU 655/855:

Items	HMI STU 655	HMI STU 855
Type	Color TFT LCD	Color TFT LCD
Resolution (pixels)	320 x 240 (QVGA)	320 x 240 (QVGA)
Active Display Area (W x H)	70.56 x 52.92 mm (2.78 x 2.08 in.)	115.2 x 86.4 mm (4.53 x 3.40 in.)
Colors	65536 colors	65536 colors
Backlight	LED backlight:	LED backlight:
	Lifetime: 50000 hours before dimmed to 50% brightness. Ambient temperature = 25° C (77° F)	Lifetime: 50000 hours before dimmed to 50% brightness. Ambient temperature = 25° C (77° F)
	Non exchangeable	Non exchangeable
	LED ON / OFF control, adjustable screen saver activation time	LED ON / OFF control, adjustable screen saver activation time
Brightness adjustment	16 levels of adjustment available via touch panel in the Configuration menu.	16 levels of adjustment available via touch panel in the Configuration menu.
Brightness on LCD surface	White LED: 350 cd/m^2 (33 cd/ft^2) maximum	White LED: 350 cd/m^2 (33 cd/ft^2) maximum
View angle	• 60 degrees: left, right • 40 degrees: up • 60 degrees: down (Test condition: contrast ratio > 2)	• 80 degrees: left, right • 70 degrees: up • 70 degrees: down (Test condition: contrast ratio > 2)
System embedded language character sets	ASCII: (Code page 850) alphanumeric (including european characters) Chinese: (GB2312-80 codes) simplified Chinese fonts Japanese: ANK 158 Kanji: 6,962 (JIS Standards 1 & 2) (including 607 non-kanji characters) Korean: (KSC5601 - 1992 codes) Hangul fonts Taiwanese: (Big 5 codes) traditional Chinese fonts	ASCII: (Code page 850) alphanumeric (including european characters) Chinese: (GB2312-80 codes) simplified Chinese fonts Japanese: ANK 158 Kanji: 6,962 (JIS Standards 1 & 2) (including 607 non-kanji characters) Korean: (KSC5601 - 1992 codes) Hangul fonts Taiwanese: (Big 5 codes) traditional Chinese fonts
Character sizes (2)	8 x 8, 8 x 16, 16 x 16 and 32 x 32 pixels fonts	8 x 8, 8 x 16, 16 x 16 and 32 x 32 pixels fonts

Items	HMI STU 655	HMI STU 855
Font sizes	Width can be expanded 1 to 8 times. Height can be expanded 1/2 and 1 to 8 times.	Width can be expanded 1 to 8 times. Height can be expanded 1/2 and 1 to 8 times.
8 x 8 pixels	40 characters per row x 30 rows	40 characters per row x 30 rows
8 x 16 pixels	40 character per row x 15 rows	40 character per row x 15 rows
16 x 16 pixels	20 character per row x 15 rows	20 character per row x 15 rows
32 x 32 pixels	10 character per row x 7 rows	10 character per row x 7 rows

Memory, Clock, and Touch Panel

Memory

The following table shows the memory specifications of HMI STU 655/855:

Items	Specification
Application flash	32 MB
Data backup in FRAM	64 KB
Application run DRAM	64 MB

Memory Back-up Management in FRAM

Detected alarms data are saved:

- automatically every hour in the back-up memory.
- upon user request through Vijeo Designer application design.

Clock

Variations in operating conditions can cause a clock shift from -380 to +90 seconds per month.

Touch Panel

The following table shows the touch panel specifications of HMI STU 655/855:

Items	Specification
Type	Analog resistance film type (Metal Tab, Golden Plated)
Lifetime	1 million touches or more

2.3 Interface Specifications

Overview

This section presents the interface specifications of the HMI STU 655/855 units.

What Is in This Section?

This section contains the following topics:

Topic	Page
Interface Specifications	37
Specifications of Serial Interface COM1	38

Interface Specifications

Serial Interface COM1

The following table describes the serial interface COM1 of HMI STU 655/855 unit:

Interface	Description
Serial interface COM1 RJ45	
Asynchronous Transmission	RS-232C / RS-485
Data Length	7 or 8 bits
Stop Bit	1 or 2 bits
Parity	None, odd or even
Data Transmission Speed	2,400 to 115,200 bps
Maximum Transmission Distance	RS-232C 15 m (49.21 ft)/ RS-485 1200 m (3,937 ft) at 100 kbps

USB1 Interface (USB peripherals)

The following table describes the USB1 Interface of HMI STU 655/855 unit:

Interface		Description
HOST Interface		
Transmission Speed	High speed	480 Mbps
	Full speed	12 Mbps
	Low speed	1.5 Mbps
Maximum Current Supplied		250 mA
Maximum Transmission Distance		5 m (16.40 ft) at 12 Mbps
Connector		USB Type-A V2.0

USB2 Interface (application download)

USB Mini B V2.0 type connector is used for application download.

Ethernet Interface

The following table describes the LED colors and status:

LED	Contents
Green 1	Link state
Green 2	Activity

Specifications of Serial Interface COM1

Introduction

This interface is used to connect the HMI STU 655/855 to remote equipment via an RS-232C or RS-485 cable. The connector used is a RJ45-8 pin type connector.

When using a long PLC cable to connect the unit, a difference of electric potential can be observed between the cable and the unit, even if both are connected to ground.

The serial port is not isolated. The SG (signal ground) and the FG (frame ground) terminals are connected inside the unit.

NOTE: When setting up RS-485 communication, the cable diagram for some equipement may require polarization on the terminal side. This terminal does not require any special setting as it handles polarization automatically.

⚠ DANGER

ELECTRIC SHOCK

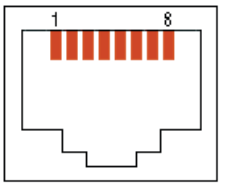
When using the SG terminal to connect an external device to the unit:

- Verify that a short-circuit loop is not created when you set up the system.
- Connect the #8 SG terminal to remote equipment when the host (PLC) unit is not isolated. Connect the #8 SG terminal to a known reliable ground connection to reduce the risk of damaging the RS-232C/RS-485 circuit.

Failure to follow these instructions will result in death or serious injury.

Serial Interface COM1

The following table describes the RJ45-8 pin connector on the HMI STU 655/855 units:

Pin Connection	Pin	Signal Name	Direction	Meaning
Front 	1	RXD	Input	Receive Data (RS-232C)
	2	TXD	Output	Send Data (RS-232C)
	3	Not connected	-	-
	4	D1	Output/Input	Transfer Data (RS-485)
	5	D0	Output/Input	Transfer Data (RS-485)
	6	RTS	Output	Request To Send
	7	Not connected	-	-
	8	SG	-	Signal Ground

RS-232C Type

The following table describes the 9-pin COM interface connector on the HMI STU 655/855:

RS-232C			
Label	**Signal Name**	**Direction**	**Meaning**
CI	CI(RI)	Input	Called status display
CD	CD	Input	Carrier detect
CS	CS(CTS)	Input	Send possible
RS	RS(RTC)	Output	Request to send
SG	SG	-	Signal ground
DR	DR(DSR)	Input	Data set ready
ER	ER(DTR)	Output	Data terminal ready
RD	RD(RXD)	Input	Receive data
SD	SD(TXD)	Output	Send data

Any excessive weight or stress on communication cables may cause a disconnection and unintended equipment operation.

⚠ CAUTION

LOSS OF COMMUNICATION

When using HMI STU 655/855:

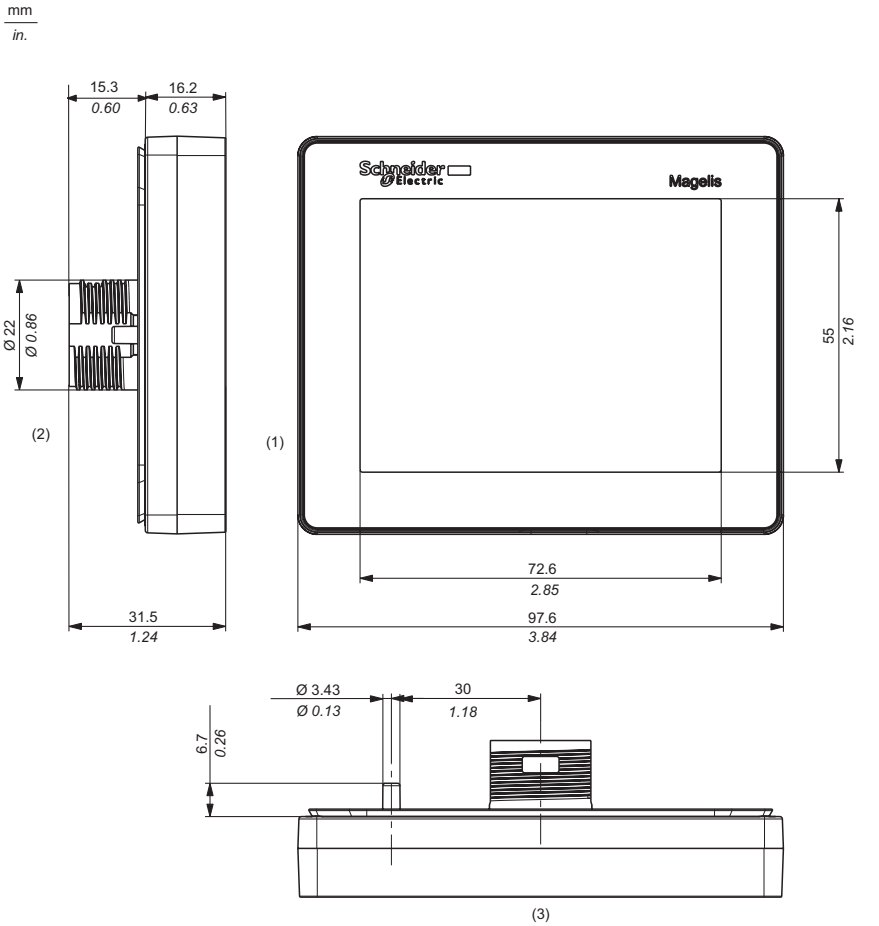
- All connections to the communication ports on the bottom and sides of the unit must not put excessive stress on the ports.
- Securely attach communication cables to the panel or cabinet.
- Use only RJ45 cables with a locking tab in good condition.

Failure to follow these instructions can result in injury or equipment damage.

2.4 Dimensions

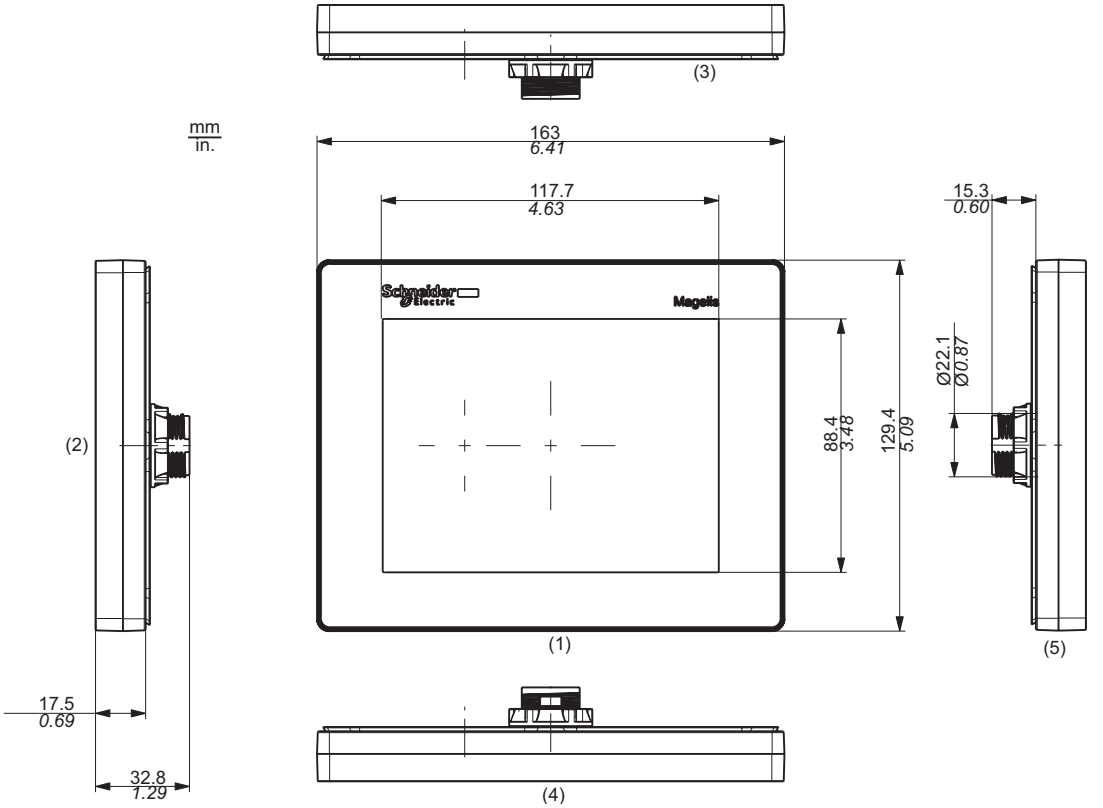
HMI STU 655/855

Display Module HMI STU 655



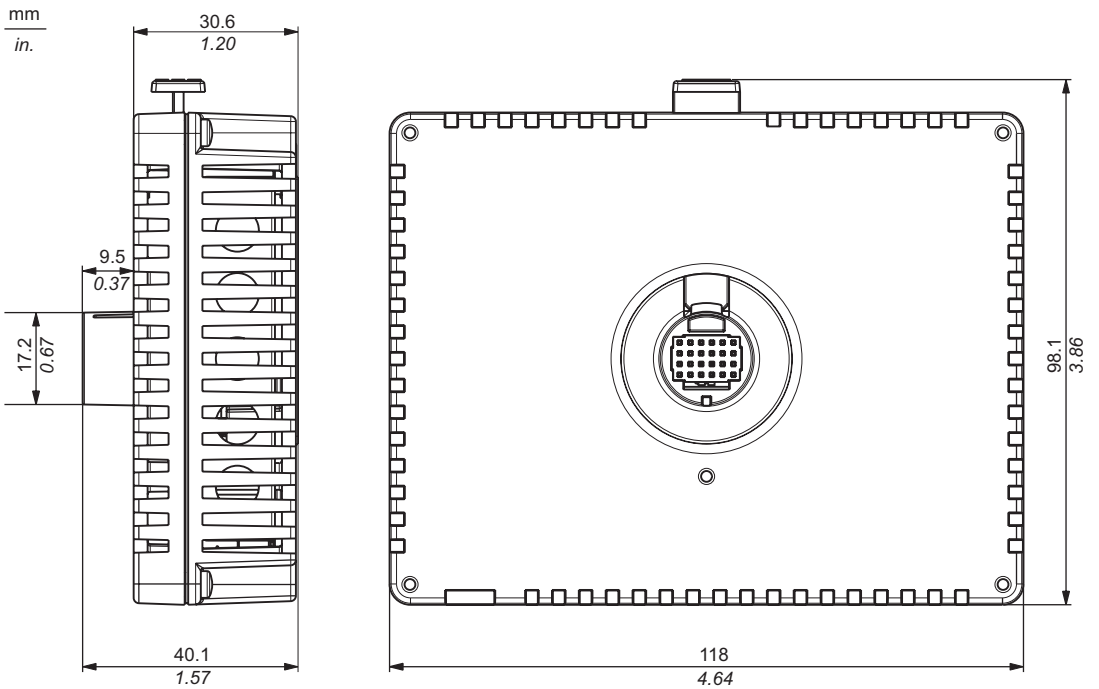
(1) Front
(2) Right Side
(2) Top

Display Module HMI STU 855



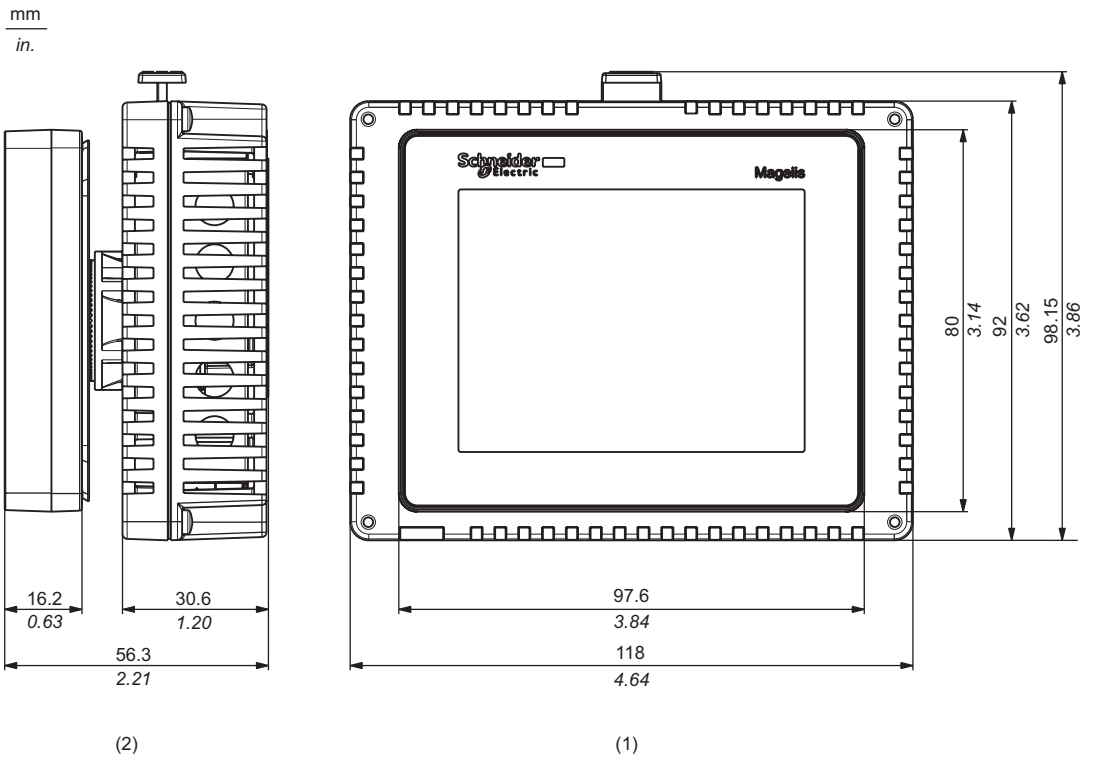
(1) Front
(2) Right Side
(3) Bottom
(4) Top
(5) Left Side

Rear Module HMI STU 655/855



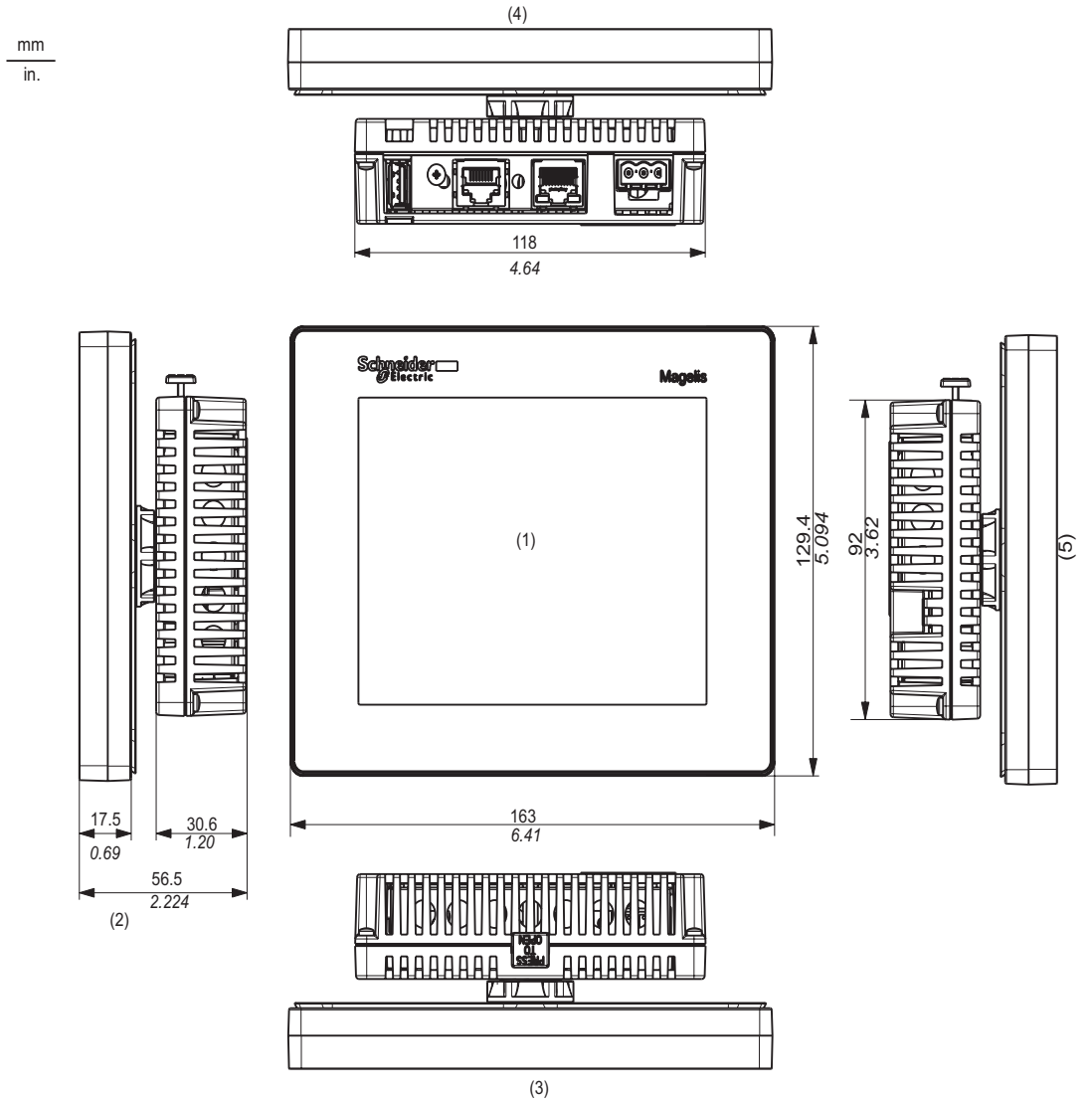
(1) Front
(2) Right Side

Display and Rear Modules HMI STU 655



(1) Right Side
(2) Front

Display and Rear Modules HMI STU 855



(1) Front
(2) Right side
(3) Top
(4) Bottom
(5) Left side

Installation and Wiring

3

Overview

This chapter describes the installation procedures and the wiring principles for HMI STU 655/855.

What Is in This Chapter?

This chapter contains the following sections:

Section	Topic	Page
3.1	Installation	46
3.2	Wiring Principles	55
3.3	USB Port	63
3.4	Ethernet Cable Connector	72

3.1 Installation

Overview

This section describes the installation Procedures for HMI STU 655/855.

What Is in This Section?

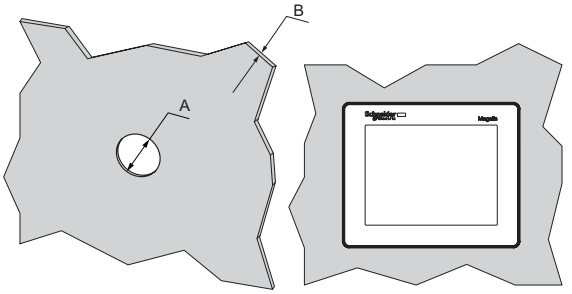
This section contains the following topics:

Topic	Page
Panel Cut-out Dimensions and Installation	47
Installation Procedures	51

Panel Cut-out Dimensions and Installation

Inserting a HMI STU 655/855 Without an Anti-rotation Tee

Create a panel cut-out and insert the display module of the unit into the panel from the front. The following illustration shows the panel cut-out for a HMI STU 655/855 unit without a tee:



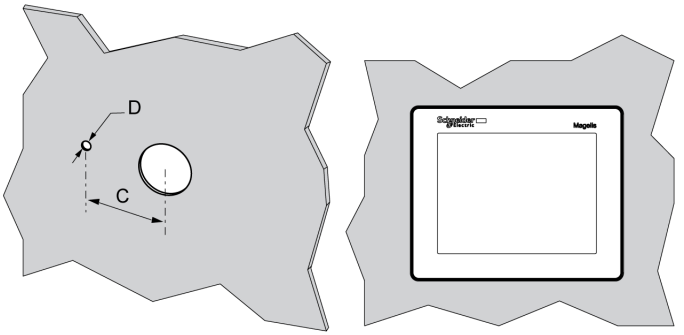
Dimensions

Unit	A (mm)	A (in.)	B (1)	B (2)
HMI STU 655/855	+0 22.50 -0.30	+0 0.88 -0.01	1.5...6 mm (0.06...0.23 in.)	3...6 mm (0.11...0.23 in.)
(1) Steel sheet **(2)** Glass fiber reinforced plastics (minimum GF30)				

NOTE: Without the tee option, the rotating torque that can be supported by the display module is 2.5 Nm (22.12 in-lb).

Inserting a HMI STU 655/855 With an Anti-rotation Tee

Create a panel cut-out and insert the display module of the unit into the panel from the front. The following illustration shows the panel cut-out for a HMI STU 655/855 unit using a tee:

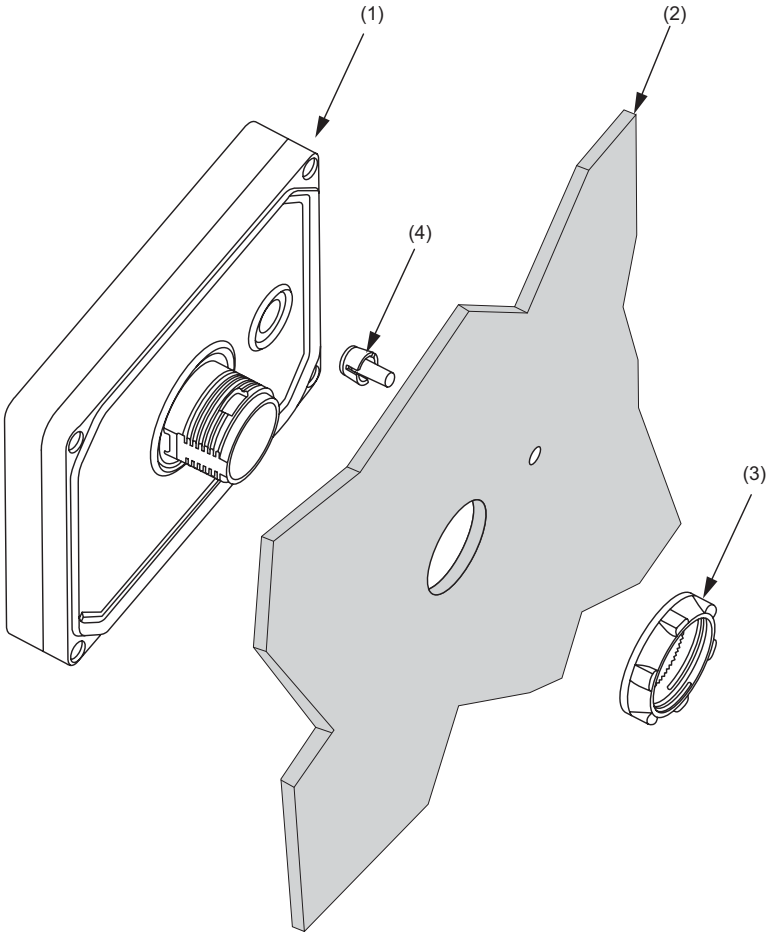


Dimensions

Unit	C (mm)	C (in.)	D (mm)	D (in.)
HMI STU 655/855	+0 30.00 -0.20	+0 1.18 -0.007	+0 4.00 -0.20	+0 0.15 -0.007

NOTE: With the tee option, the rotating torque that can be supported by the display module is 6 Nm (53.10 in-lb).

Illustration



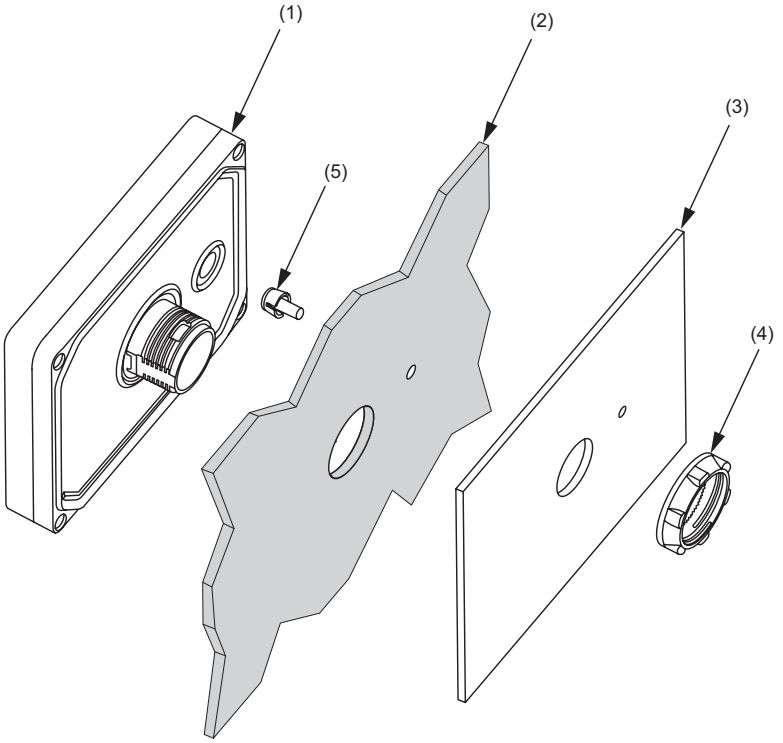
(1) Display module
(2) Support
(3) Nut
(4) Tee

Panel Adaptor

The Panel Adaptor, supplied in the accessory kit **HMI ZSU KIT** *(see page 16)*, allows mounting the product on a:

- Metallic support with a thickness between 1 and 1.5 mm (0.039 and 0.059 in.)
- Plastic support with a thickness between 1 and 3 mm (0.039 and 0.118 in.) for HMI STU 655
- Glass fiber reinforced plastic with a thickness between 2 and 3 mm (0.078 and 0.118 in.) for HMI STU 855

The following illustration shows the assembly with the panel adaptor:



(1) Display module
(2) Support
(3) Panel adaptor
(4) Nut
(5) Tee

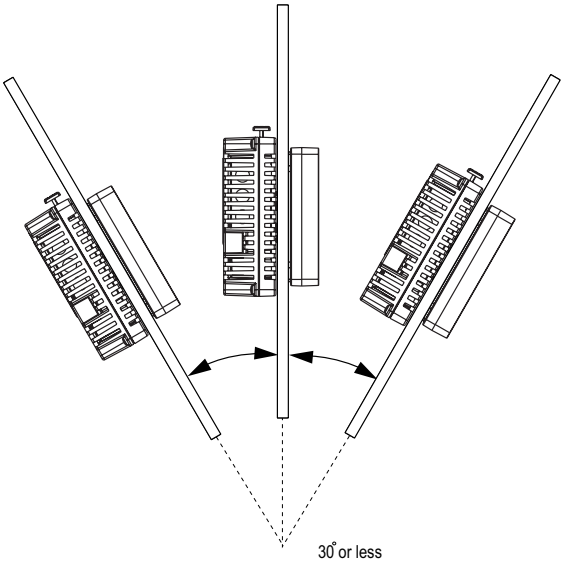
Installation Procedures

Panel Setup Procedure

Mount the unit in an enclosure that provides a clean, dry, robust and controlled environment (IP65 enclosure or UL50 4x, if indoors.) *(see page 30)*

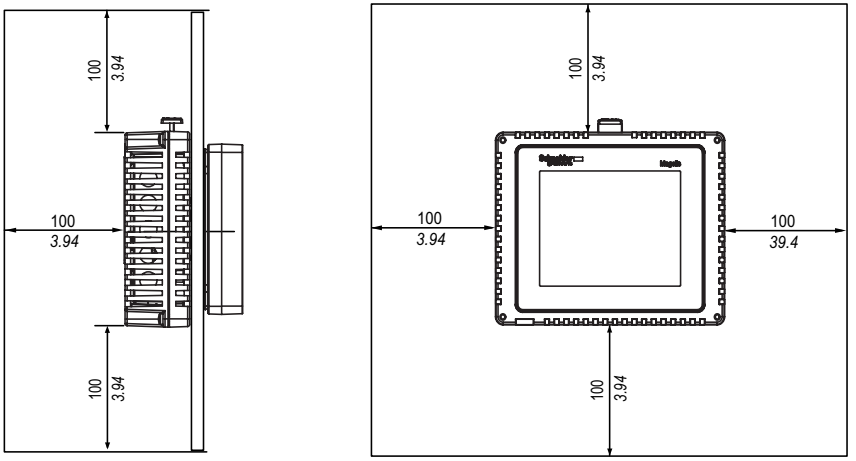
Before installing the HMI STU 655/855 verify that:

- The gasket is flat and not damaged.
- The installation panel or cabinet surface is flat (planarity tolerance: 0.5 mm (0.019 in.)), in good condition and has no jagged edges. Metal reinforcing strips may be attached to the inside of the panel, near the panel cut-out, to increase the rigidity.
- The panel must be designed to avoid any induced vibration resonance on the rear module exceeding a punctual factor of 10 and to avoid any induced permanent vibration resonance.
  To reduce the resonance use the panel adaptor accessory.
- The ambient operating temperature and the ambient humidity are within their specified ranges *(see page 30)*.
- The heat from surrounding equipment does not cause the unit to exceed its specified operating temperature *(see page 30)*.
- The panel face is not inclined more than 30° when installing the unit in a slanted panel:

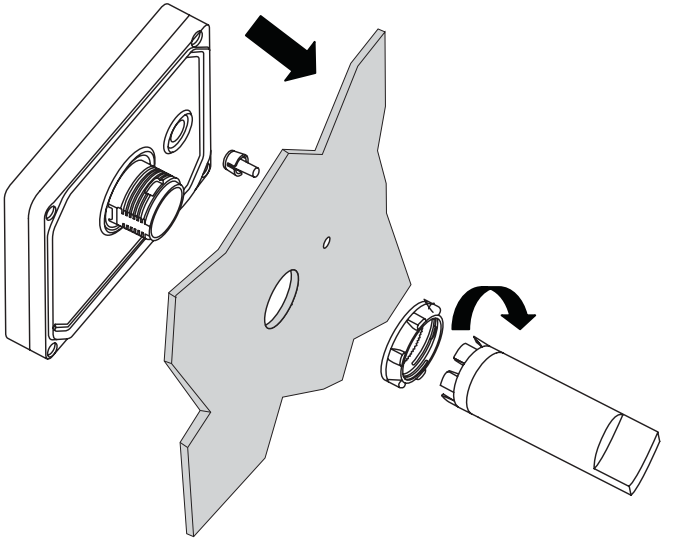


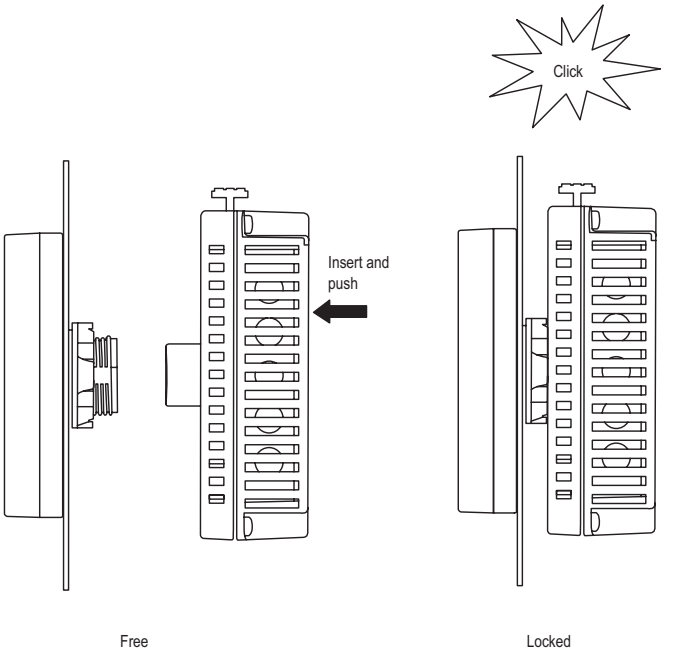
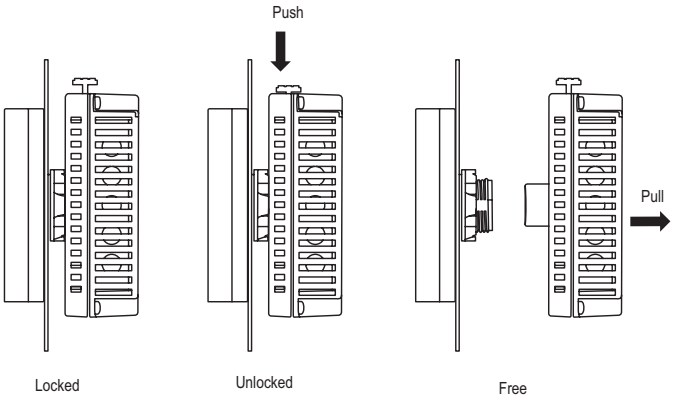
- the power plug is positioned vertically when the unit is vertically installed.
- the unit is at least 100 mm (3.94 in.) away from adjacent structures and other equipment for easier maintenance, operation and improved ventilation:

mm
in.



Step	Action
1	Place the unit on a clean and level surface with the display panel facing downward.
2	The support thickness depends on the material: ● Metallic: between 1.5 and 6 mm (0.059 and 0.236 in.) ● Plastic: between 3 and 6 mm (0.118 and 0.236 in.) If the thickness is between 1 and 1.5 mm (0.039 and 0.059 in.) for metallic support or 1 and 3 mm (0.039 and 0.118 in.) for plastic, use the panel adaptor supplied in accessory kit **HMI ZSU KIT** *(see page 16)*.
3	Create the correct sized holes required to install the unit, using the Panel Cut-out Dimension and Installation *(see page 47)*.

Step	Action
4	Insert the display module (with Tee, if used) into the panel hole:  Screw the nut with the tightening wrench with a torque between 1.2 and 2 Nm (10.62 and 17.70 in-lb.).

Step	Action
5	Insert and push the rear module until it locks into place: 
6	To remove the rear module, push the yellow button to unlock it, then pull the rear module out: 

3.2 Wiring Principles

Overview

This section presents HMI STU 655/855 wiring principles.

What Is in This Section?

This section contains the following topics:

Topic	Page
Connecting the Power Cord	56
Connecting the Power Supply	59
Grounding	61

Connecting the Power Cord

Introduction

Follow these instructions when supplying power to the unit:

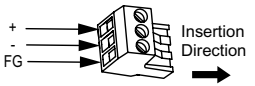
- When the frame ground (FG) terminal is connected, verify the wire is grounded. Not grounding the unit can result in excessive Electromagnetic Interference (EMI). Grounding is required to meet EMC level immunity.
- The shield ground (SG) and FG terminals are connected internally in the unit.
- Remove power before wiring to the power terminals of the unit.
- The unit uses only 24 Vdc power. Using any other level of power can damage both the power supply and the unit.
- Since the unit is not equipped with a power switch, connect a power switch to the unit's power supply.

Power Cord Preparation

Before using your power cord:

- Verify the ground wire is the same gauge or heavier than the power wires.
- Do not use aluminum wires for the power cord for power supply.
- If the conductor end (individual) wires are not twisted correctly, the end wires may either short loop to each other or against an electrode. To avoid this, use D25CE/AZ5CE cable ends.
- Use wires that are 0.2 to 2.5 mm^2 (24 - 12 AWG) for the power cord, and twist the wire ends before attaching the terminals.
- The conductor type is solid or stranded wire.
- To reduce electromagnetic noise, make the power cord as short as possible.

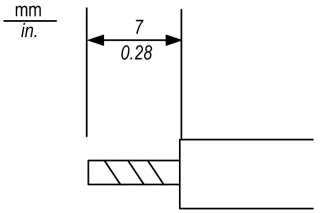
Power Plug Illustration



Connection	Wire
+	24 V
-	0 V
FG	Grounded terminal connected to the unit chassis

How to connect the Power Cord

The following table explains how to connect the power plug:

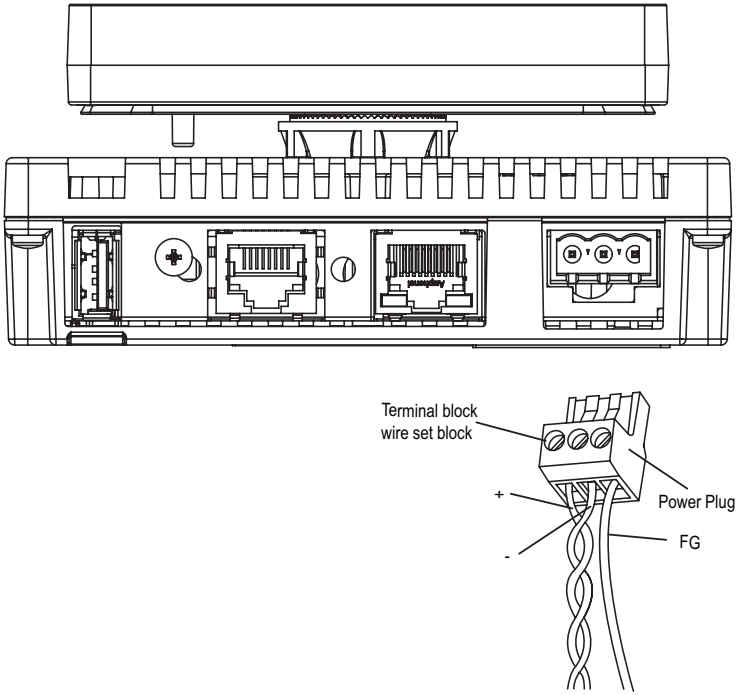
Step	Action
1	Remove the power cord from the power supply.
2	Remove the power plug from the unit.
3	Remove 7 mm (0.28 in.) of the vinyl cover of each of the power cord wires. 
4	If using stranded wire, twist the ends. Tinning the ends with solder reduces the risk of fraying and enhances electrical transfer.
5	Connect the wires to the power plug by using a flat-blade screwdriver (Size 0.6 x 3.5).
6	Torque the mounting screws: 0.5 to 0.6 Nm (4.4 to 5.2 lb-in).
7	Replace the power plug to the power connector.

NOTE:

- Do not solder the wire directly to the power receptable pin.
- The power supply cord must meet the specification shown above. Twist the power cords together, up to the power plug, for EMC cancellation. (See illustration as shown below).

Power Connection

The following illustration displays a connection of the power cord:



Connecting the Power Supply

Precautions

- Connect the power cord to the power connector on the side of the unit using the power plug.
- Use a regulated power supply with a Class 2 power supply between the line and the ground.
- Do not bundle the power supply cord with, or keep close to, main circuit lines (high voltage, high current), or input/output signal lines.
- Connect a lightning surge absorber to handle power surges.

Excessive stress on the power connection or attempting to install a unit with the power cables connected may disconnect or cause damage to the power connections. This can cause short circuits, fire or unintended equipment operation.

⚠ WARNING

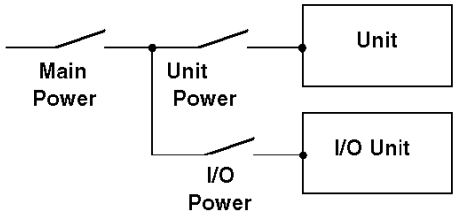
SHORT CIRCUITS, FIRE, OR UNINTENDED EQUIPMENT OPERATION

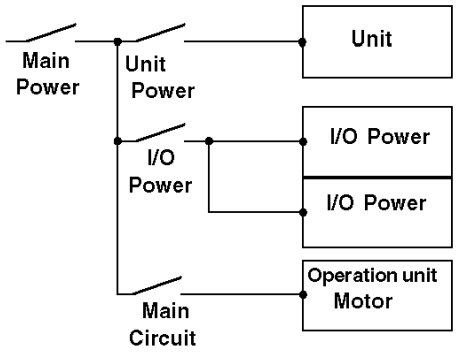
- Securely attach power cables to the panel or cabinet.
- Use the designated torque to tighten the unit terminal block screws.
- Install and fasten unit on installation panel or cabinet prior to connecting Power Supply and Communication lines.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

Power Supply Connections

For ease of maintenance, use the following optional connection diagram to set up your power supply connections.

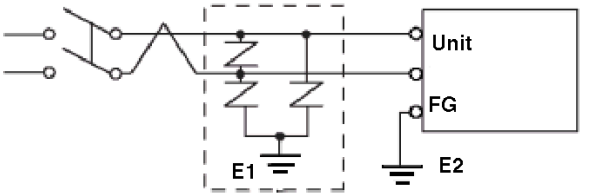




NOTE:

- Ground the surge absorber (E1) separately from the unit (E2).
- Select a surge absorber that has a maximum circuit voltage greater than the peak voltage of the power supply.

The following diagram displays a lightning surge absorber connection:



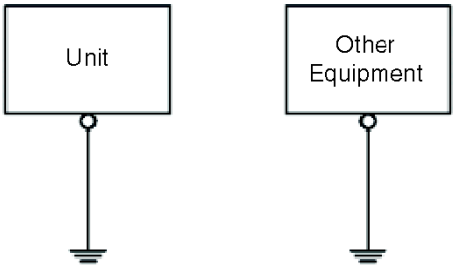
Grounding

Introduction

Take the following precautions for grounding the unit.

Exclusive Grounding

Connect the frame ground (FG) terminal on the power plug to an exclusive ground.



Grounding Procedure

Step	Action
1	Check that the grounding resistance is less than 100 Ω
2	Create the connection point as close to the unit as possible, and make the wire as short as possible. When using a long grounding wire, replace the thin wire with a thicker wire, and place it in a duct.

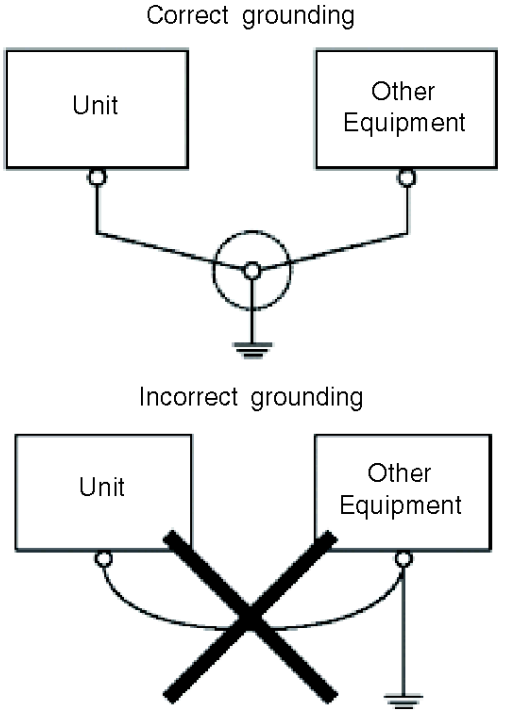
Common Grounding

Precautions:

Electromagnetic Interference (EMI) can be created if the devices are improperly grounded. Electromagnetic Interference (EMI) can cause loss of communication.

Do not use common grounding, except for the authorized configuration described below.

If exclusive grounding is not possible, use a common connection point.



3.3 USB Port

Overview

This section presents the USB port.

What Is in This Section?

This section contains the following topics:

Topic	Page
Important Considerations When Using the USB Port	64
USB Data Transfer Cable (BMX XCA USB H018) - USB Driver Installation	65
USB Standard A	67
USB Mini-B	70

Important Considerations When Using the USB Port

Introduction

Data transfer cable (BMX XCA USB H018) can be attached to the USB port to allow data transfer from the computer to the unit.

⚠ WARNING

RISK OF EXPLOSION IN HAZARDOUS LOCATIONS

In hazardous locations as described in UL1604 and ANSI/ISA - 12.12.01:

- confirm that the USB cable has been attached with the USB cable clamp before using the USB host interface.
- remove power before attaching or detaching any connector(s) to or from the unit.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

NOTICE

UNINTENTED EQUIPEMENT OPERATION

Do not use the 4.5 m USB cable BMX XCA USB H045.

Failure to follow these instructions can result in equipment damage.

USB Data Transfer Cable (BMX XCA USB H018) - USB Driver Installation

Important information

Follow the procedure described below to avoid damage to the cable connector or the unit:

- Do not connect the USB data transfer cable until told to do so in the instructions.
- Insert the connector at the correct angle when connecting the USB data transfer cable to the PC or to the unit.
- Hold the connector, not the cable itself when disconnecting the cable.
- Use the port designated during installation. If the cable is unplugged from the port designated during installation and connected to a different port, the OS (Operating System) will not recognize the new port.
- Restart the PC and quit all resident applications before re-installing the software if the installation does not complete successfully.

NOTE: Vijeo Designer must be installed before installing the USB driver.

Installation Procedure

Step	Action
1	Insert the Vijeo Designer Installation CR-ROM into your CR-ROM drive. The Setup window for Vijeo Designer opens automatically. If not, at the Windows **Start** menu, click **Run** and type **x:\install.exe** (where x is your CR-ROM drive name).
2	In the **install** menu, select **USB Driver**.
3	Select the driver you want to install from the window that appears. For the BMX XCA USB H018 USB cable, select **Install USB driver for...**.
4	A popup window appears stating the installation of the driver was successful.
5	Connect the USB cable to the computer. Windows automatically detects the cable and states that the device is ready to use.

Post-Installation Check

Perform the following check after installation:

Step	Action
1	On the target machine, verify the USB cable is physically connected to the USB port.
2	On the PC, verify the USB cable is physically connected to the USB port.
3	On the desktop, right-click **My Computer** and click **Properties**.
4	In **System Properties** dialog box, select **Hardware** tab, and then click **Device Manager**.
5	In **Device Manager**, the USB link cable (BMX XCA USB H018) is displayed below the USB controller.

Troubleshooting

Detected problem/Symptom	Solution
The USB cable is not recognized.	Connect the cable correctly, or restart your PC. Also, when connecting a USB hub, connect it directly to your PC USB port.
Overcurrent occurred.	
The Plug and Play is not functioning correctly.	
You are unable to use the USB cable after connecting it to a USB hub.	The power supplied from the hub may be insufficient. Verify the hub is self-powered.
	Connect the cable directly to the PC USB port.
After installation, a **?** is displayed when you try to confirm the cable's status via the Device Manager.	The driver has not been installed correctly. Uninstall the driver and re-install it.

Uninstalling the USB Driver

Step	Action
1	Click the USB device icon **Stop USB link cable** in the Windows task tray and then click **Stop USB link cable (BMX XCA USB H018)** for Windows 2000, or **Safely remove USB link cable (BMX XCA USB H018)** for Windows XP.
2	When the **Safe To Remove Hardware** message box appears, remove the USB download cable.
3	Click **OK** to close the message box.

USB Standard A

Introduction

When using a USB device, you can attach a USB holder to the USB interface on the side of the unit to prevent the USB cable from being disconnected.

⚠ WARNING

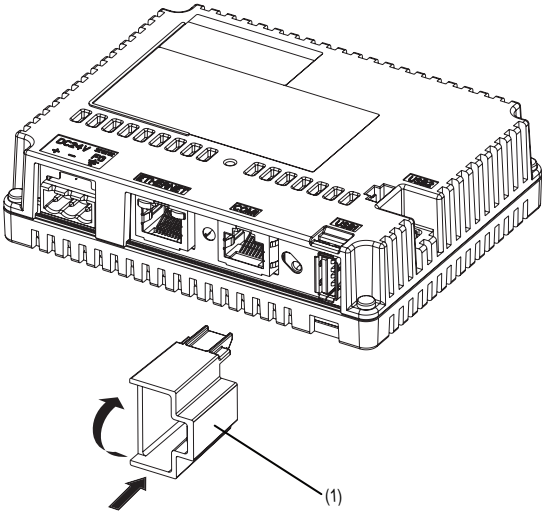
RISK OF EXPLOSION IN HAZARDOUS LOCATIONS

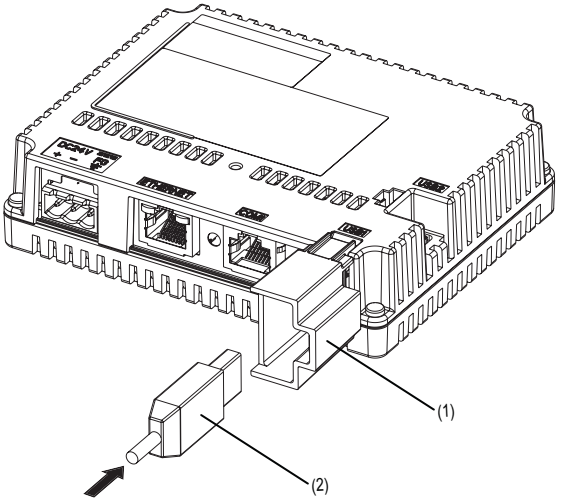
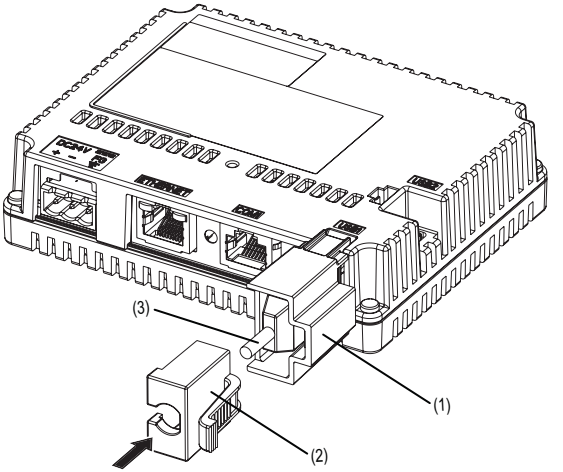
In hazardous locations as described in UL1604 and ANSI/ISA - 12.12.01:

- confirm that the USB cable has been attached with the USB cable clamp before using the USB host interface.
- remove power before attaching or detaching any connector(s) to or from the unit.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

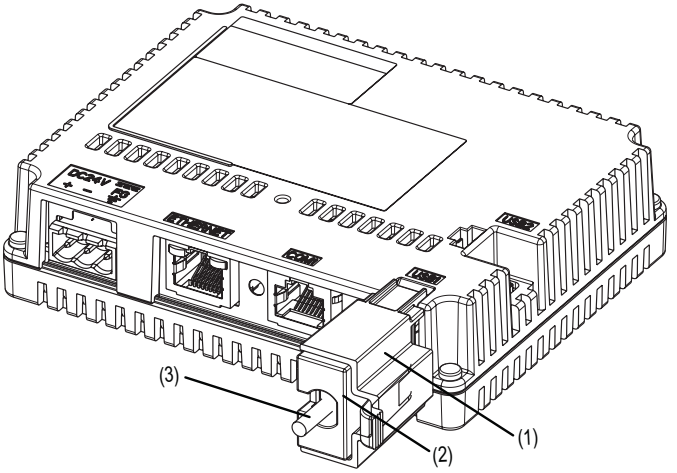
Attaching the USB Holder

Step	Action
1	Attach the USB holder to the USB Host Interface on the rear module. Hook the upper pick of the USB holder to the attachment hole of the main unit, and insert the lower pick as shown below to fix the USB holder.  **(1)** USB Holder

Step	Action
2	Insert the USB cable into the USB host interface.  **(1)** USB Holder **(2)** USB Cable
3	Attach the USB cover to fix the USB cable in place. Insert the USB cover into the tab of the USB holder.  **(1)** USB Holder **(2)** USB Cover **(3)** USB Cable

Removing the USB Holder

Push down the tab of the USB holder and then remove the USB cover.



(1) USB Holder
(2) USB Cover
(3) USB Cable

USB Mini-B

Introduction

When using a USB device, you can attach a USB holder to the USB interface on the side of the unit to prevent the USB cable from being disconnected.

⚠ WARNING

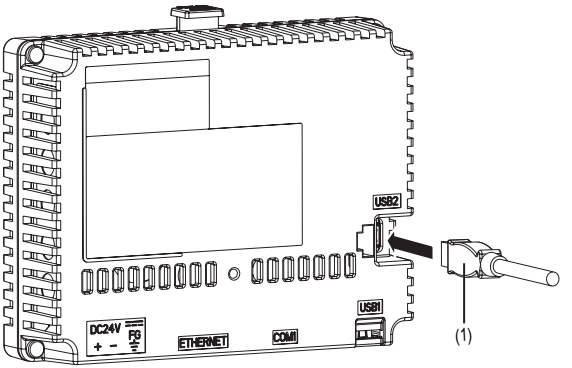
RISK OF EXPLOSION IN HAZARDOUS LOCATIONS

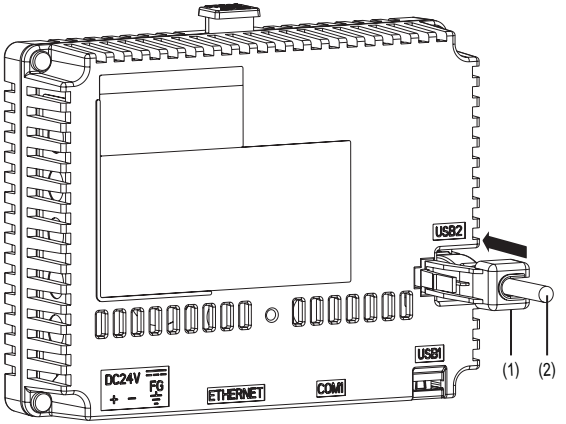
In hazardous locations as described in UL1604 and ANSI/ISA - 12.12.01:

- confirm that the USB cable has been attached with the USB cable clamp before using the USB host interface.
- remove power before attaching or detaching any connector(s) to or from the unit.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

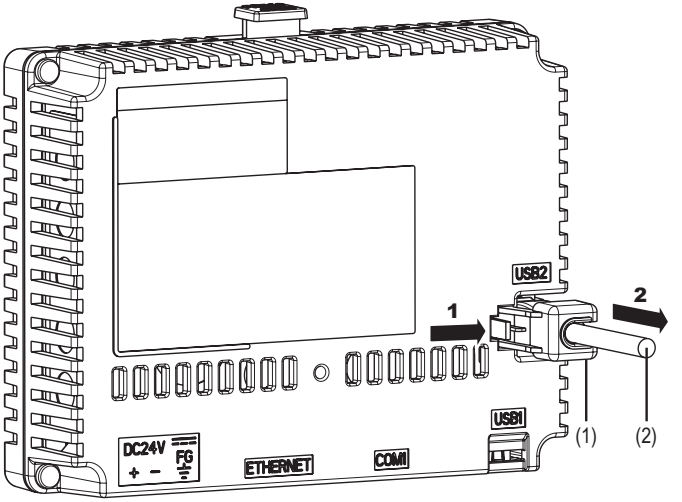
Attaching the USB Holder

Step	Action
1	Insert the USB cable into the USB host interface.  **(1)** USB Cable

Step	Action
2	Attach the USB holder to fix the USB cable in place.  **(1)** USB Holder **(2)** USB Cable

Removing the USB Holder

Push down the tab of the USB holder and then remove the USB holder.



(1) USB Holder
(2) USB Cable

3.4 Ethernet Cable Connector

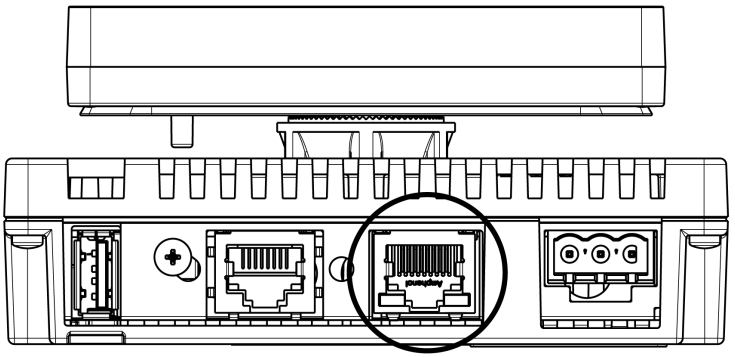
Presentation

Introduction

The HMI STU 655/855 comes equipped with an IEEE802.3 compliant Ethernet interface, that transmits and receives data at 10 Mbps or 100 Mbps.

Ethernet Cable Connector

The following illustration displays the location of the RJ45 Ethernet cable connector:



Do not confuse the RJ45 Ethernet connector with the RJ45 COM1/COM2 serial port.

NOTE: Ethernet networks must be installed by a trained and qualified person.

1:1 connections must be made with a hub or a switch. It is possible to use the 1:1 connection with a cross cable depending on the connected PCs and network cards.

Settings

II

Overview

This part describes the settings available on the target machine as well as how to debug the unit.

What Is in This Part?

This part contains the following chapters:

Chapter	Chapter Name	Page
4	Configuring the Unit	75
5	Troubleshooting	85
6	Maintenance	91

Configuring the Unit

4

Overview

This chapter presents the settings on the HMI STU 655/855 units.

What Is in This Chapter?

This chapter contains the following topics:

Topic	Page
Types of Settings	76
System Settings	77
Offline Settings	80
Diagnostics Settings	83

Types of Settings

Introduction

You can use the **Settings** menu to configure the unit.

Depending on how you use your HMI STU 655/855, you can display the **Settings** menu using three different methods:

- Use an action,
- Touch the top-left corner of the panel when powering up,
- Touch two corners of the panel successively while the application is running.

You can select which methods your application uses in the Vijeo Designer editor's Target properties.

Calling Up the Settings Menu

Step	Action
1	Set up any combination of the following methods for displaying the **Settings** menu. • Action: Create a switch and add the Configuration System Operation. See the Vijeo Designer online help for more information on creating a switch. • Top-Left Corner: In **Target** properties, set **To Configuration** to either **Top Left Corner** or **Top Left/2 Corner**. • Touch two corners successively: In **Target** properties, set **To Configuration** to either **2 Corner** or **Top Left/2 Corner**. If you set **To Configuration** to **None** and do not create a switch to display the **Settings** menu, then there is no way to configure the unit at runtime.
2	Connect the power supply.
3	Depending on what you set up in Step 1, you can display the **Configuration** menu using one of the following methods: • Action: Touch the switch set up with the Configuration system operation. • Top-Left Corner: Touch the top-left corner of the screen within ten seconds after the unit begins starting up. • Touch two corners successively: Touch successively the top left corner then the bottom right corner within half a second. The touch area is 50 dots by 50 dots. Vijeo Designer Runtime restarts and displays the Settings menu.
4	The **Settings** menu contains 3 tabs: **Offline**, **System**, **Diagnostics** and **To Run Mode**. Click a tab to display its settings.

System Settings

Introduction

You can change system settings while the user application is still running.

Stylus

Use the Stylus to calibrate the screen:

Step	Action
1	In the **Setting** menu, press the **System** tab.
2	Press the **Stylus** button.
3	Press the center of the cross several times to complete calibration of the screen.

Changing the Date/Time

Step	Action
1	In the **Setting** menu, press the **System** tab.
2	Press the **Date/Time** button.
3	Press any of the **Year**, **Month** or **Day** fields and a data entry keypad is displayed. Use this keypad to define the selected date setting.
4	Press any of the **Hour**, **Minutes** or **Seconds** fields and a data entry keypad is displayed. Use this keypad to define the selected time setting.
5	In the **Time Zone** tab press the up/down arrows to select the desired time zone.
6	Check the **Auto. adjust clock for daylight saving time** box to choose adjusting clock for daylight saving time changes automatically.
7	In the **DST** tab press the up/down arrows to select the desired daylight saving time type: ● **Date**: the DST is added, or subtracted, on the exact date chosen. ● **Rule**: the DST is added, or subtracted, on a specific weekday in the month.
8	Press the **Amount** field and a data entry keypad is displayed. Use this keypad to define the desired daylight saving time amount (minutes).
9	Press the **OK** button to validate your configuration or configure the parameters of daylight saving time by Date *(see page 78)* or by Rule *(see page 78)*.

Daylight Saving Time Setting by Date

If **Date** is selected in step 7 of Changing the Date/Time *(see page 77)*, follow this procedure to set the daylight saving time parameters:

Step	Action
1	Follow the procedure of Changing the Date/Time *(see Magelis Small Panels, HMI STO User Manual)* til step 9.
2	In **Add Time** press the up/down arrows to select the desired month and press the right field to display the keypad to define the desired day to add time. In **@** press any of the fields to display the keypad and define the hour to add time.
3	In **Subtract Time** press the up/down arrows to select the desired month and press the right field to display the keypad to define the desired day to subtract time. In **@** press any of the fields to display the keypad and define the hour to subtract time.

Daylight Saving Time Setting by Rule

If **Rule** is selected in step 7 of Changing the Date/Time *(see page 77)*, follow this procedure to set the daylight saving time parameters:

Step	Action
1	Follow the procedure of Changing the Date/Time *(see Magelis Small Panels, HMI STO User Manual)* til step 9.
2	In **Add Time** press the up/down arrows to select the desired day and the desired month to add tlme. In **@** press any of the fields to display the keypad and define the hour to add time.
3	In **Subtract Time** press the up/down arrows to select the desired day and the desired month to subtract time. In **@** press any of the fields to display the keypad and define the hour to subtract time.

Forcing a Restart

Step	Action
1	In the **Setting** menu, press the **System** tab.
2	Press the **Restart** button, the following message appears: **Are you sure you want to restart the operating system?**.
3	Press the **Restart** button to restart the unit or the **Cancel** button to return to the **System** menu.

Selecting a Language

The following table describes how to select the language used for the Settings menu, the run-time messages and user application.

Step	Action
1	In the **Setting** menu, press the **System** tab.
2	Press the **Language** button.
3	Press the up/down arrows to select the desired languages for: ● System, ● User Application, ● Keyboard Language. The languages available in the language settings are defined in the Vijeo Designer editor.
4	Press **OK** to validate.

Displaying Version Information

Step	Action
1	In the **Setting** menu, press the **System** tab.
2	Press the **Ver. Info** button, version information displays: ● Vijeo-Designer Runtime Version, ● Vijeo-Designer Version, ● build number.

Displaying Memory Statistics

Step	Action
1	In the **Setting** menu, press the **System** tab.
2	Press the **Memory** button. ● DRAM describes the amount of memory currently being used by the application. ● Main Flash indicates the amount of internal memory (flash memory) required to store the runtime system files and the user application.

Brightness Control

Step	Action
1	In the **Setting** menu, press the **System** tab.
2	Press the **Brightness** button.
3	Press the up/down arrows to adjust the brightness. **NOTE:** Reducing the brightness could increase the life span of the backlight.

Offline Settings

Introduction

The offline settings cannot be changed while a user application is running.

Changing the Network Settings

Step	Action
1	In the **Setting** menu press the **Offline** tab.
2	Press the **Network** button, the following message appears: **Working with Offline Settings will stop the user application and runtime. Continue?**
3	Press the **OK** button to restart the system or the **Cancel** button to return to the **System** menu.
4	In the **Static IP** tab, press any of **IP Address**, **Subnet Mask** or **Default Gateway** fields, a numerical keypad displays, enter the desired parameters and validate by pressing **Enter** button.
5	In the **DHCP** tab, press the **Enable DHCP** checkbox to obtain configuration information from the network. This reduces system administration workload, allowing devices to be added to the network with little or no manual intervention.
6	In the **MAC/DNS** tab: ● Press **Obtain DNS Setting** checkbox to translate names into IP addresses. ● Press any of **IP Address** fields, a numerical keypad displays, entry the desired IP address and validate by **Enter** button.
7	In **Static IP** tab press the **Ok** button to validate.

Changing the Buzzer Settings

Step	Action
1	In the **Setting** menu press the **Offline** tab.
2	Press the **Buzzer** button, the following message appears: **Working with Offline Settings will stop the user application and runtime. Continue?**
3	Press the **OK** button to restart the system or the **Cancel** button to return to the **System** menu.
4	Press the desired buzzer mode. The factory setting is **Pressing Touch Object**. ● **None**: Selecting this turns the buzzer off. ● **When Press Touch Object**: The buzzer only sounds when a Touch Object is pressed.

Changing Backlight Control

Step	Action
1	In the **Setting** menu press the **Offline** tab.
2	Press the **Backlight** button, the following message appears: **Working with Offline Settings will stop the user application and runtime. Continue?**
3	Press the **OK** button to restart the system or the **Cancel** button to return to the **System** menu.
4	In the **Backlight** control, define the backlight operations. • **Wait**: To extend the life of the backlight, you can set up the unit so that it turns off the backlight when the panel is inactive (idle) for the defined period of time, (Idle means the unit panel has not been pressed). The factory setting for this item is off. • **Enable Touch if Backlight Burned Out**: This setting defines whether the press panel is enabled or disabled when a backlight burnout is detected. When this feature is cleared and the backlight burns out, press inputs are ignored to prevent operation detected errors. The factory setting for this item is off.
5	To turn the **Backlight** off automatically after a specified period of time, press the **Wait** checkbox and then set the idle time.

Self Test

Step	Action
1	In the **Setting** menu, press the **Offline** tab.
2	Press the **Self Test** button, the following message appears: **Working with Offline Settings will stop the user application and runtime. Continue?**
3	Press the **OK** button to restart the system or the **Cancel** button to return to the **System** menu.
4	In the **Self Test** control, press: • **Char. Pattern**: to check the characters in each font set available on the unit. Use this test when characters (usually 2-byte characters) do not display properly. **Ok** appears if there is no detected error. **NG** appears if there is a detected error. • **Disp. Pattern**: to test your LCD screen with some graphical test patterns. • **Touch Panel**: to test the touch panel cells. Each cell highlights when it is pressed during the test. • **COM 1**: to test the COM 1 port connector. **Ok** appears if there is no detected error. **NG** appears if an error is detected. • **Video memory**: to test hardware memory.

Driver Configuration

Step	Action
1	In the **Setting** menu, press the **Offline** tab.
2	Press the **IO Manager** button, the following message appears: **Working with Offline Settings will stop the user application and runtime. Continue?**
3	Press the **OK** button to restart the system or the **Cancel** button to return to the **System** menu.
4	In the **IO Manager** control, press the **Driver Config** button.
5	In the **Driver Config** control: **Select Driver**: press the up/down arrow to select the desired driver.
6	Set the parameters of the selected driver.

Equipment Configuration

Step	Action
1	In the **Setting** menu, press the **Offline** tab.
2	Press the **IO Manager** button, the following message appears: **Working with Offline Settings will stop the user application and runtime. Continue?**
3	Press the **OK** button to restart the system, or the **Cancel** button to return to the **Setting** menu.
4	In the **IO Manager** control, press the **Equipment Config** button.
5	In the **Equipment Config** control: **Select Equipment**: press the up/down arrow to select the desired equipment.
6	Set the parameters of the selected equipment.

Diagnostics Settings

Introduction

The HMI STU 655/855 units are equipped with a number of diagnostic features that can be used to check the systems and the interfaces for any problems.

Diagnostics

See the Vijeo Designer online help for information on accessing the **Diagnostics Settings** menu.

Variables

Use the **Variable** menu to check that the application is running correctly. The following table describes how to get to the **Variable** menu:

Step	Action
1	In the **Settings** menu, press the **Diagnostics** tab.
2	Press the **Variable** button.
3	**Select Equipment**: press the up/down arrow to select the equipment whose variables you want to test.
4	In the **Variable** menu, press the **Go Offscan** button, the following message appears: **Warning: Entering the Variable Test screen pauses communication with all equipment. Continue?**
5	Press the **OK** button to restart the system, or the **Cancel** button to return to the **Variable** menu.
6	If the **Go Onscan** is pressed, the test reads the value for each variable associated with the selected equipment. If any of the variables detects a problem, because of a detected error in the equipment or a time-out, the event log displays a message with the name of the variable.
7	After you complete testing variables from one equipment, you can continue testing variables for other equipment connected to the target machine.
8	Alternatively, you can test all equipment at once by selecting **Test All** in the Select Equipment drop-down list.
9	Press the **Return** button to return to the **Diagnostics** menu.

Statistics

Use the **Statistics** menu to check the connection between equipment. The following table describes how to get to **Statistics** menu:

Step	Action
1	In the **Settings** menu, press the **Diagnostics** tab.
2	Press the **Statistics** button. **NOTE:** When you write any value to this system control word, press the **Rollover** button to: ● Copy the values in the current statistic variables to the previous statistic variables. ● Reset current statistic variables to zero.
3	In **Show Stats for:** press the up/down arrow to select the equipment whose variables you want to show statistics for.
4	Press the right arrow button to view the next display.
5	Press the **Go Offscan** button to start the test.
6	Press the right arrow button to view the next display.
7	**Total Good**: the total number of received variables without detected error. **Total Bad**: the total number of detected errors of all types. **Total Count**: Total Good + Total Bad. **No Reply**: no reply was received in response to the request. **Chksum Fail**: received a request or response **(1)** with an incorrect checksum. **Wrong Addr.**: received a request or response **(1)** with an incorrect address. **Error Resp.**: received a detected error response from the equipment. **(1)**: Master-type drivers send out requests and receive responses. Slave-type drivers receive requests and send responses.
8	Press the next arrow button to view the next display.
9	**Inv. Resp.**: received a response that contained a protocol detected error. **Init. Fail**: initializing communications with the equipment was unsuccessful. **Write Fail**: writing a new value to the equipment was unsuccessful. **Intrn Error**: internal driver detected error indicates improper driver configuration or driver problem. **Xmit Fail**: transmitting a request or response was unsuccessful. **Unsupp. Req.**: received a request for an unsupported service. **Inv. Request**: received a request that contained a protocol detected error.
10	Press the **Return** button to return to the **Diagnostics** menu or the previous arrow button to view the previous display.

Troubleshooting

5

Overview

This chapter describes how to find and resolve detected problems with the HMI STU 655/855 units.

What Is in This Chapter?

This chapter contains the following topics:

Topic	Page
Troubleshooting Checklists	86
Self Test List	89

Troubleshooting Checklists

Introduction

When there is a detected problem, go through the checklist and follow the instructions given.

Here are the main detected problems that may occur when using HMI STU 655/855 unit.

- Panel display is blank,
- Connected equipment cannot be used,
- Panel does not respond or responds very slowly,
- Panel beeps when powered on,
- Cannot change the date or time.

NOTE: Contact your local Schneider Electric vendor or your local distributor.

Panel Display is Blank

If the unit display is blank, perform the following check steps:

Step	Check/Operation	Solution
1	Are all Vijeo Designer screens downloaded?	You may have to download the screens again.
2	Is the Initial Panel ID set up correctly in Vijeo Designer?	Enter the Initial Panel ID in the Vijeo Designer editor and download again.
3	Is the unit using the correct rated voltage?	Verify the power supply connections and levels.
4	Is the power supply off or disconnected?	Follow the instructions in this manual for reconnecting the power supply.
5	Is the backlight lit?	Potential detected problem with the unit. Contact your local Schneider Electric distributor.
6	Is the detected problem resolved?	If none of the previous steps fixed the blank panel display detected problem, then verify the hardware.

Connected Equipment Cannot be Used

If the unit does not communicate with connected equipment, perform the following check steps:

Step	Check/Operation	Solution
1	Is the power supply off or disconnected?	Verify the power supply connections and levels.
2	Do the **Driver** and **Equipment** settings in Vijeo Designer match the actual equipment you are trying to communicate with?	In the Vijeo Designer editor Navigator window's **Project** tab, expand the I/O Manager node to enter the correct configuration settings for the Driver and Equipment nodes.
3	Is the communication cable connected correctly?	Refer to the associated protocol manual for information about cable diagrams.
4	Is the detected problem resolved?	If none of the previous steps fixed the communication detected problem, then verify the hardware.

Unit does not respond when pressed

If the unit is either not responding when pressed or if its response time is very slow, perform the following check steps:

Step	Check/Operation	Solution
1	Disconnect all the cables except the power cable.	-
2	In the **Settings** menu, press the **Offline** tab and then press the **Self Test** icon. Run the Touch Panel test.	If the test is unsuccessful, there is a detected problem with the hardware.
3	If touch response is slow, does it happen on a specific panel?	If the panel displays the values of a large number of equipment variables, you may want to redesign the panel and separate the variables into different panels and download again.

Step	Check/Operation	Solution
4	If touch response is slow, the target CPU may be very busy communicating with external equipment.	To resolve this detected problem, try each of the following in the Vijeo Designer editor and download again. • If you are using serial communication, verify the communication speed between the target and equipment is optimized. • In the equipment or scan group properties, reduce the Scan Rate to Slow. This will reduce the frequency of variable updates to 1000 ms. • If you use many equipment variables in application scripts, you may want to change the script to a panel script so that the variables are active only when the information is necessary. If none of the above works, then you may have to reduce the number of external variables in the project. If none of the proposed options work, contact your Schneider Electric Technical Support for optimizing your project.

Target beeps when powered ON

A continuous beep from the target means that system files are corrupted. To resolve this detected problem, go to the Vijeo Designer Start menu and run Recovery on the target machine.

Self Test List

Introduction

The HMI STU 655/855 units are equipped with a number of diagnostic features that can be used to check the systems and the interfaces for any detected s.

Self Test

From the **Settings** menu, press the **Offline** button and then the **Self Test** icon. **Self Test** menu appears. See the Vijeo Designer online help for information on accessing the **Offline** tab.

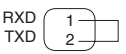
Self Tests

The following tests can be accessed from the **Self Test** menu.

Test	Description
Char. Pattern	Checks the characters in each font set available on the unit. Use this test when characters (usually 2-byte characters) are not displayed properly. **OK** appears if there is no detected error; **NG** appears if there is a detected error.
Disp. Pattern	Use this test when your drawings are not displayed properly.
Touch Panel	Tests the touch panel cells. Each cell highlights when it is pressed during the test.
COM 1	Checks that the serial port (RS-232C and RS-485) is working properly. To run the check, you may need to connect a loopback cable (see below). **OK** appears if there is no detected error; a detected error message appears if there is an error.
Video Memory	Use this test to check the video memory (memory used for screen display). Run this test when the screen does not display properly. **OK** appears if there is no detected error; **NG** appears if there is a detected error.

Wiring for COM 1 tests

When testing the serial port, depending on which port and which communication format you are testing, you may need to attach a loopback cable with wiring as defined below:

RS-232C	RS-485
HMI STU 655/855 in COM1 	Not available.

Maintenance

6

Overview

This chapter explains how to maintain your HMI STU 655/855 units.

What Is in This Chapter?

This chapter contains the following topics:

Topic	Page
Regular Cleaning	92
Periodic Check Points	94

Regular Cleaning

Cleaning the display

NOTICE
EQUIPMENT DAMAGE • Power off the unit before cleaning it. • Do not use hard or pointed objects to operate the touch panel, since it can damage the panel surface. • Do not use paint thinner, organic solvents, or a strong acid compound to clean the unit. **Failure to follow these instructions can result in equipment damage.**

When the surface or the frame of the display gets dirty, soak a soft cloth in water with a neutral detergent, wring the cloth tightly and wipe the display.

Chemical Substances

The products in the following table can be used when cleaning the unit:

Kinds of fluid	Company	Product designation	Concentration	Temperature °C(°F)	pH Value
Cleaning agents in the food and beverage industry	Ecolab	Topmaxx 422	5	40 (104)	1% : pH=13
	Ecolab	P3 Topax M 95	5	40 (104)	1% : pH=12.3
	Ecolab	P3 Oxonia Active	3	40 (104)	
	Ecolab	P3 Topax 52 FR	5	40 (104)	1% : pH=2
	Ecolab	P3 Topax 36	5	40 (104)	
	Ecolab	P3 Luboklar MH	0.7	40 (104)	
	Johnson Diversey	Divosan 2000	1	25 (77)	100% : pH=7
	Johnson Diversey	Diverfoam Septiplus	5	25 (77)	3% : pH=8.3
	Johnson Diversey	Acifoam	5	25 (77)	1% : pH=2.2
	Johnson Diversey	HD Plus Foam	5	25 (77)	1% : pH=12.9
	Johnson Diversey	Oxofoam	5	25 (77)	1% : pH=12.7
	Johnson Diversey	Endoroplus VE6	5	25 (77)	1% : pH=12.1
	Johnson Diversey	Endoroforce VE2	5	25 (77)	1% : pH=12.5
	Johnson Diversey	Endorocid VE10	5	25 (77)	1% : pH=2
Diverse		Water	100	50 (122)	
		Milk	100	25 (77)	
		Methanol	10	25 (77)	
Oils		ASTM 1	100	25 (77)	
		IRM 902	100	25 (77)	
		IRM 903	100	25 (77)	
		Cerechlor/IRM 903	50/50	25 (77)	
		Syntopon B	3	25 (77)	

Kinds of fluid	Company	Product designation	Concentration	Temperature° C(° F)	pH Value
Cutting oils	Ecocut	HBN 16LE	Pure	25 (77)	
	Quakercool	7101H	Emulsion	25 (77)	
	Quakercool	2769	Soluble / Synthetic	25 (77)	
	Quakercool	3750H	Micro-emulsion	25 (77)	

Periodic Check Points

Operation Environment

Refer to the Environmental Specifications *(see page 30)*.

Electrical Specifications

The input voltage must be within 20.4 to 28.8 Vdc.

Related Items

- Are all power cords and cables connected properly? Are there any loose cables?
- Are all mounting brackets holding the unit securely?
- Are there scratches or traces of dirt on the installation gasket?

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APPENDIX B

Well Completion Logs

Project: Kinder Morgan – Laurel Station
Project Location: Bellingham, Washington
Project Number: 33764823

Log of Boring DPE-1 (PV-2)

Sheet 1 of 1

Date(s) Drilled	**12/9/14-12/10/14**	Logged By	**C. Pearson**	Checked By	**DRR**
Drilling Method	**Sonic**	Drilling Contractor	**Cascade Drilling**	Total Depth of Borehole	**30 feet bgs**
Drill Rig Type	**Track Mounted, Sonic Drill Rig**	Drill Bit Size/Type	**8" Core Barrel with Casing**	Ground Surface Elevation (feet MSL)	**N/A**
Groundwater Level (feet bgs) **20'**		Sampling Method	**Grab**	Hammer Data	**N/A**
Borehole Backfill	**Passive Vent/Well Installed**	Location	**North end of pump station building**		

Elevation, feet	Downhole Depth, feet	SAMPLES Type	SAMPLES Number	Blows/ 6in.	Recovery (%)	PID/OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
	0							GP	Asphalt	
									Brown sandy fine GRAVEL/gravelly fine to coarse SAND (loose) (moist) (no odor, no sheen) (FILL)	Drilled at 30° angle Cleared to 4' with air knife
	5		PV-2-5			0.0		ML/SM	Light brown SILT with fine sand, low plasticity, slight mottling (very dense) (no odor, no sheen)	1350 PV-2-5 actual sample depth 4.3' bgs
									Grading interbedded fine sand lenses	
									Grading increasing clay (very dense) (dry)	
	10		PV-2-10			0.0			Grading gray, trace rounded cobbles and gravel	1405 PV-2-10 actual sample depth 8.7' bgs
	15		PV-2-15		100	0.0				1445 PV-2-15 actual sample depth 13.0' bgs
								SM	Gray silty very fine SAND (dense) (moist) (no odor, no sheen)	
								ML	Gray SILT, low plasticity (very dense) (no odor, no sheen)	
	20		PV-2-20			0.0			20 ft ▼	1505 PV-2-20 actual sample depth 17.3' bgs
								GP	Gray coarse GRAVEL with sand, well sorted (wet) (strong hydrocarbon odor, heavy sheen) Grading gray sandy fine to coarse GRAVEL, medium to coarse sand, poorly sorted (loose) (wet) (strong hydrocarbon odor, heavy sheen)	
	25		PV-2-25			18.0			Grading (no odor, no sheen)	1555 2/10/30 PV-2-25 actual sample depth 21.7' bgs
	30		PV-2-30			0.0				0830 PV-2-30 actual sample depth 26' bgs
									Boring was completed to 30' length at a 30° angle. Groundwater was encountered at 20' bgs. Boring was completed as passive vent/well.	
									Well construction details: 19.5-29.5 ft 4" Sch. 40 0.030" PVC screen 16-30 ft Clean silica sand 0-19.5 ft 4" Sch. 40 PVC riser 1.5-16 ft Bentonite 0-1.5 ft Concrete	
	35									
	40									
	45									

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Project: Kinder Morgan – Laurel Station
Project Location: Bellingham, Washington
Project Number: 33764823

Log of Boring DPE-2 (4)

Sheet 1 of 1

Date(s) Drilled	**12/11/14**	Logged By	**C. Pearson**	Checked By	**DRR**
Drilling Method	**Sonic**	Drilling Contractor	**Cascade Drilling**	Total Depth of Borehole	**30 feet bgs**
Drill Rig Type	**Track Mounted, Sonic Drill Rig**	Drill Bit Size/Type	**8" Core Barrel with Casing**	Ground Surface Elevation (feet MSL)	**N/A**
Groundwater Level (feet bgs) **N/A**		Sampling Method	**Grab**	Hammer Data	**N/A**
Borehole Backfill	**Dual Phase Extraction Well Installed**	Location	**East side of pump station building north of truck entrance**		

Elevation, feet	Downhole Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows/ 6in.	SAMPLES Recovery (%)	PID/OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
	0							GP/SP	Asphalt	Drilled at 35° angle
									Brown sandy fine to coarse rounded GRAVEL/gravelly fine to coarse SAND (loose) (moist) (no odor, no sheen)	Cleared to 4' bgs with air knife
	5		DPE-4-5			0.0		CL	Brown silty CLAY, low plasticity (very hard) (moist) (no odor, no sheen)	1350 DPE-2-5 actual sample depth 4.1' bgs
									Grading gray	
	10		DPE-4-10			0.0				1405 DPE-2-10 actual sample depth 8.2' bgs
	15		DPE-4-15		100	0.0				1430 DPE-2-15 actual sample depth 12.3' bgs
						0.0		GP	(slight iridescent sheen)	
	20		DPE-4-20			8.9			Brown coarse rounded GRAVEL with silt, well sorted (loose) (no odor, no sheen) Grading gray sandy fine to coarse GRAVEL, fine to coarse sand, poorly sorted (loose) (moderate hydrocarbon odor, moderate sheen) Grading increasing sand with depth	1445 DPE-2-20 actual sample depth 16.4' bgs
						2.4			Grading (no odor)	
	25		DPE-4-25			0.0		SP	Gray gravelly fine to coarse SAND, fine to coarse gravel, some cobbles, poorly sorted (loose) (no odor, no sheen)	1515 DPE-2-25 actual sample depth 20.5' bgs
	30		DPE-4-30			0.0				1540 DPE-2-30 actual sample depth 24.6' bgs
									Boring was completed to 30' length at a 35° angle. Groundwater was not encountered. Boring was completed as dual phase extraction well.	
	35								Well construction details: 25.5-30 ft Native soil 15.5-25.5 ft 4" Sch. 40 0.030" PVC screen 13-25.5 ft Clean silica sand 0-15.5 ft 4" Sch. 40 PVC riser 1-13 ft Bentonite 0-1 ft Concrete	
	40									
	45									

Project: Kinder Morgan – Laurel Station
Project Location: Bellingham, Washington
Project Number: 33764823

Log of Boring DPE-3

Sheet 1 of 1

Date(s) Drilled	**12/9/14**	Logged By	**C. Pearson**	Checked By	**DRR**
Drilling Method	**Sonic**	Drilling Contractor	**Cascade Drilling**	Total Depth of Borehole	**31 feet bgs**
Drill Rig Type	**Track Mounted, Sonic Drill Rig**	Drill Bit Size/Type	**8" Core Barrel with Casing**	Ground Surface Elevation (feet MSL)	**N/A**
Groundwater Level (feet bgs) **N/A**		Sampling Method	**Grab**	Hammer Data	**N/A**
Borehole Backfill	**Dual Phase Extraction Well Installed**	Location	**East side of pump station building closest to overhead piping**		

Elevation, feet	Downhole Depth, feet	SAMPLES Type	SAMPLES Number	Blows/ 6in.	Recovery (%)	PID/OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
	0							GP	Asphalt	Drilled at 30° angle
									Brown sandy fine GRAVEL/gravelly coarse to fine SAND (loose) (moist) (no odor, no sheen) (FILL)	Cleared to 4.5' with air knife
	5		DPE-3-5			0.0		CL	Brown silty CLAY, trace rounded gravel, low plasticity (very dense) (dry) (no odor, no sheen)	0830 DPE-3-5 actual sample depth 4.3' bgs
									Grading gray	
	10		DPE-3-10			0.0				0850 DPE-3-10 actual sample depth 8.7' bgs
	15		DPE-3-15		100	156.4		GP SP	Brown coarse rounded GRAVEL with silt, well sorted (wet) (slight to moderate hydrocarbon odor, no sheen)	0915 DPE-3-15 actual sample depth 13' bgs
									Gray gravelly medium to coarse SAND, poorly sorted, medium gravel (wet) (moderate hydrocarbon odor, moderate sheen) free product noted during sheen testing Grading trace sheen	
	20		DPE-3-20			15.9			Grading (moist) (very slight hydrocarbon odor, no sheen)	0940 DPE-3-20 actual sample depth 17.3' bgs
	25		DPE-3-25			0.0			Grading (possible slight hydrocarbon odor)	1025 DPE-3-25 actual sample depth 21.7' bgs
	30		DPE-3-30			0.0				1100 DPE-3-30 actual sample depth 26' bgs
									Boring was completed to 31' length at a 30° angle. Groundwater was encountered at 15' bgs. Boring was completed as dual phase extraction well.	
	35								Well construction details: 12.5-22.5 ft 4" Sch. 40 0.030" PVC screen; 23-31 ft Bentonite; 10-23 ft Clean silica sand; 0-12.5 ft 4" Sch. 40 PVC riser; 1-10 ft Bentonite; 0-1 ft Concrete	
	40									
	45									

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Project: Kinder Morgan – Laurel Station
Project Location: Bellingham, Washington
Project Number: 33764823

Log of Boring DPE-4 (2)

Sheet 1 of 1

Date(s) Drilled	**1/19/15**	Logged By	**C. Pearson**	Checked By	**DRR**
Drilling Method	**Sonic**	Drilling Contractor	**Cascade Drilling**	Total Depth of Borehole	**17 feet bgs**
Drill Rig Type	**Track Mounted, Sonic Drill Rig**	Drill Bit Size/Type	**8" Core Barrel with Casing**	Ground Surface Elevation (feet MSL)	**N/A**
Groundwater Level (feet bgs) **N/A**		Sampling Method	**Grab**	Hammer Data	**N/A**
Borehole Backfill	**Dual Phase Extraction Well Installed**	Location			

Elevation, feet / Downhole Depth, feet	SAMPLES Type Number	Blows/ 6in.	Recovery (%)	PID/OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
0				0.2		GP/SP	Asphalt Brown sandy fine to coarse GRAVEL/gravelly fine to coarse SAND (loose) (moist) (no odor, no sheen)	
				0.4				
5	DPE-4-5			0.3				0815
				0.3			Grading light gray (no odor)	
			100	1.0			Grading (slight hydrocarbon odor, no sheen)	
10	DPE-4-10			1.3				0820
				0.4			Grading (no odor)	
15	DPE-4-15			0.6				0910
20							Boring was completed to 17' bgs. Groundwater was not encountered. Boring was completed as dual phase extraction well. Well construction details: 6.5-16.5 ft bgs 4" Sch. 40 0.030" PVC screen 5-17 ft bgs Clean silica sand 0-6.5 ft bgs 4" Sch. 40 PVC riser 1-5 ft bgs Bentonite 0-1 ft bgs Concrete	
25								
30								
35								
40								
45								

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Project: Kinder Morgan – Laurel Station
Project Location: Bellingham, Washington
Project Number: 33764823

Log of Boring DPE-5

Sheet 1 of 1

Date(s) Drilled	**1/17/15**	Logged By	**C. Pearson**	Checked By	**DRR**
Drilling Method	**Sonic**	Drilling Contractor	**Cascade Drilling**	Total Depth of Borehole	**25 feet bgs**
Drill Rig Type	**Track Mounted, Sonic Drill Rig**	Drill Bit Size/Type	**8" Core Barrel with Casing**	Ground Surface Elevation (feet MSL)	**N/A**
Groundwater Level (feet bgs) **N/A**		Sampling Method	**Grab**	Hammer Data	**N/A**
Borehole Backfill	**Dual Phase Extraction Well Installed**	Location			

Elevation, feet	Downhole Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows/ 6in.	SAMPLES Recovery (%)	PID/OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
	0							GP/SP	Asphalt Brown sandy fine to coarse GRAVEL/gravelly fine to coarse SAND, subrounded gravel (loose) (moist) (no odor, no sheen)	Pea gravel on side walls during utility clearance
	5		DPE-5-5			0.0 38.2			Grading light gray, trace cobbles (moderate hydrocarbon odor, trace sheen)	1315
	10		DPE-5-10			120			Grading (slight hydrocarbon odor)	1320
					100	1.6				
	15		DPE-5-15			1.4 1.7 3.1			Grading (no odor, very slight sheen)	1340
	20									Drillers lost sample for 20' sample collection
	25		DPE-5-25			0.4 0.5			Grading brown (no odor, no sheen) Boring was completed to 25' bgs. Groundwater was not encountered. Boring was completed as dual phase extraction well. Well construction details: 14.5-24.5 ft bgs 4" Sch. 40 0.030" PVC screen 12-25 ft bgs Clean silica sand 0-14.5 ft bgs 4" Sch. 40 PVC riser 1-12 ft bgs Bentonite 0-1 ft bgs Concrete	1410
	30									
	35									
	40									
	45									

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Project: Kinder Morgan – Laurel Station
Project Location: Bellingham, Washington
Project Number: 33764823

Log of Boring DPE-6

Sheet 1 of 1

Date(s) Drilled	**1/14-15/15**	Logged By	**C. Pearson**	Checked By	**DRR**
Drilling Method	**Sonic**	Drilling Contractor	**Cascade Drilling**	Total Depth of Borehole	**35 feet bgs**
Drill Rig Type	**Track Mounted, Sonic Drill Rig**	Drill Bit Size/Type	**8" Core Barrel with Casing**	Ground Surface Elevation (feet MSL)	**N/A**
Groundwater Level (feet bgs) **N/A**		Sampling Method	**Grab**	Hammer Data	**N/A**
Borehole Backfill	**Dual Phase Extraction Well Installed**	Location			

Elevation, feet / Downhole Depth, feet	SAMPLES Type / Number	Blows/ 6in.	Recovery (%)	PID/OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
0						SW	Brown silty fine to medium SAND, trace gravel (FILL)	Drilled at 45° angle
							Soil, cement and bentonite (air knife to 3.5 ft bgs)	Cleared to 3.5' with air knife
				31.6		GP/SP	Brown sandy fine to coarse GRAVEL/gravelly fine to coarse SAND (loose) (moist) (strong hydrocarbon odor, heavy sheen)	
5	DPE-6-5						Grading light gray	1630 DPE-6-5 actual sample depth 3.5' bgs
				40.2				
10	DPE-6-10							1635 DPE-6-10 actual sample depth 7.1' bgs
				869				
				104				
				71.0			Grading free product noted, increasing sand (heavy sheen)	
15	DPE-6-15							1640 DPE-6-15 actual sample depth 10.6' bgs
			100	NA				
20	DPE-6-20							1705 DPE-6-20 actual sample depth 14.1' bgs 1/15/15
							Grading free product noted	
				589		SP	Gray fine to medium SAND trace gravel (loose) (moist) (strong hydrocarbon odor) free product	
				573		GP/SP	Brown sandy GRAVEL/gravelly SAND (loose) (moist) (moderate hydrocarbon odor, no sheen) (slight sheen)	0900 DPE-6-25 actual sample depth 17.7' bgs
25	DPE-6-25							
				33.1				
				36.3				
30	DPE-6-30							0905 DPE-6-30 actual sample depth 21.2' bgs
				7.0				
				129.9				
				140.1				
				4.1				
35	DPE-6-35						Grading (very slight odor)	1030 DPE-6-35 actual sample depth 24.7' bgs
							Boring was completed to 35' length at a 45° angle. Groundwater was not encountered. Boring was completed as dual phase extraction well. Well construction details: 14.5-34.5 ft 4" Sch. 40 0.030" PVC screen 12-35 ft Clean silica sand 0-14.5 ft 4" Sch. 40 PVC riser 1-12 ft Bentonite 0-1 ft Concrete	
40								
45								

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Project: Kinder Morgan – Laurel Station
Project Location: Bellingham, Washington
Project Number: 33764823

Log of Boring DPE-7

Sheet 1 of 1

Date(s) Drilled	**1/13-14/15**	Logged By	**C. Pearson**	Checked By	**DRR**
Drilling Method	**Sonic**	Drilling Contractor	**Cascade Drilling**	Total Depth of Borehole	**35 feet bgs**
Drill Rig Type	**Track Mounted, Sonic Drill Rig**	Drill Bit Size/Type	**8" Core Barrel with Casing**	Ground Surface Elevation (feet MSL)	**N/A**
Groundwater Level (feet bgs) **N/A**		Sampling Method	**Grab**	Hammer Data	**N/A**
Borehole Backfill	**Dual Phase Extraction Well Installed**	Location			

Elevation, feet	Downhole Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows/ 6in.	SAMPLES Recovery (%)	PID/OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
	0							GP/SP	Brown sandy fine to coarse GRAVEL/gravelly fine to coarse SAND, subrounded gravel (loose) (no odor, no staining) (FILL)	Drilled at 45° angle
									3 ft ▼	
	5		DPE-7-5			1.5		ML	SILT, low plasticity (dense) (moist) (organic odor, no sheen)	1620
						3.9		GP/SP	Sandy fine to coarse GRAVEL/gravelly fine to coarse SAND, subrounded gravel (loose) (moist) (moderate hydrocarbon odor) free product in top couple of feet	DPE-7-6 actual sample depth 4.2' bgs
	10		DPE-7-10			234.5				1630 DPE-7-10 actual sample depth 7.1' bgs
						207.1				
						45.5				
	15		DPE-7-15			41.7				1635 DPE-7-15 actual sample depth 10.6' bgs
						233				
					100					
						1.4				
	20		DPE-7-20			15.3		GP	Gray fine to coarse GRAVEL, trace fines (loose) (wet) (slight odor) ▼	1715 1/14/15
						238		GP/SP	Dark gray sandy fine to coarse GRAVEL/gravelly fine to coarse SAND (loose) (strong hydrocarbon odor, heavy sheen)	DPE-7-20 actual sample depth 14.1' bgs
						228				
	25		DPE-7-25			57.2				0850 DPE-7-25 actual sample depth 17.7' bgs
						10.7				
						919		SP	Gray fine to medium SAND (loose) (strong odor) free product	
	30		DPE-7-30						Grading (slight hydrocarbon odor)	1055 DPE-7-30 actual sample depth 21.2' bgs
	35		DPE-7-35						Grading increasing fine sand	1100 DPE-7-35 actual sample depth 24.7' bgs
									Boring was completed to 35' length at a 45° angle. Boring was completed as dual phase extraction well. Well construction details: 14.5-34.5 ft 4" Sch. 40 0.030" PVC screen 12-35 ft Clean silica sand 0-14.5 ft 4" Sch. 40 PVC riser 1-12 ft Bentonite 0-1 ft Concrete	
	40									
	45									

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Project: Kinder Morgan – Laurel Station
Project Location: Bellingham, Washington
Project Number: 33764823

Log of Boring DPE-8

Sheet 1 of 1

Date(s) Drilled	**1/12-13/15**	Logged By	**C. Pearson**	Checked By	**DRR**
Drilling Method	**Sonic**	Drilling Contractor	**Cascade Drilling**	Total Depth of Borehole	**37 feet bgs**
Drill Rig Type	**Track Mounted, Sonic Drill Rig**	Drill Bit Size/Type	**8" Core Barrel with Casing**	Ground Surface Elevation (feet MSL)	**N/A**
Groundwater Level (feet bgs) **N/A**		Sampling Method	**Grab**	Hammer Data	**N/A**
Borehole Backfill	**Dual Phase Extraction Well Installed**	Location			

Elevation, feet / Downhole Depth, feet	SAMPLES Type Number	Blows/ 6in.	Recovery (%)	PID/OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
0						GM	Light brown fine sandy gravelly SILT, fine sand with coarse angular to rounded gravel (FILL)	Drilled at 35° angle
						GP/SP	Brown sandy fine GRAVEL/gravelly coarse to fine SAND, subrounded gravel (loose) (moist) (no odor, no sheen)	
5	DPE-8-5			1.0				1440 DPE-8-5 actual sample depth 4.1' bgs
				1.2			Grading gray, increasing fines (strong hydrocarbon odor, moderate sheen)	
10	DPE-8-10			25.2			Grading (strong hydrocarbon odor, heavy sheen)	1540 DPE-8-10 actual sample depth 8.2' bgs
				9.9				
15	DPE-8-15			94.6			Grading silt nodules in part	1545 DPE-8-15 actual sample depth 12.3' bgs
			100				Grading (loose) (slight odor)	
20	DPE-8-20			362.4			Grading (decreasing moisture)	1615 DPE-8-20 actual sample depth 16.4' bgs 1/13/15
				88.3				
25	DPE-8-25			78.6			Grading (strong hydrocarbon odor, slight sheen)	0805 DPE-8-25 actual sample depth 20.5' bgs
				183.2				
30	DPE-8-30			530.2				0905 DPE-8-30 actual sample depth 24.6' bgs
				146.4				
				289.4			Grading increasing fines	
35	DPE-8-35			100.1			Grading decreasing fines	0950 DPE-8-35 actual sample depth 28.7' bgs
40							Boring was completed to 37' length at a 35° angle. Groundwater was not encountered. Boring was completed as dual phase extraction well.	
							Well construction details: 14.5-34.5 ft 4" Sch. 40 0.030" PVC screen; 12-37 ft Clean silica sand; 0-14.5 ft 4" Sch. 40 PVC riser; 1-12 ft Bentonite; 0-1 ft Concrete	
45								

ENV2 W/O WELL J:\PROJECTS\GRFX\AECOM PROJECTS\60440385 LAUREL STATION\DEC-JAN 2105 LOGS - COPY.GPJ URSSEA3B.GLB URSSEA3.GDT 12/3/15

URS

Project: Kinder Morgan – Laurel Station
Project Location: Bellingham, Washington
Project Number: 33764823

Log of Boring DPE-9

Sheet 1 of 1

Date(s) Drilled	**1/16/15**	Logged By	**C. Pearson**	Checked By	**DRR**
Drilling Method	**Sonic**	Drilling Contractor	**Cascade Drilling**	Total Depth of Borehole	**35 feet bgs**
Drill Rig Type	**Track Mounted, Sonic Drill Rig**	Drill Bit Size/Type	**8" Core Barrel with Casing**	Ground Surface Elevation (feet MSL)	**N/A**
Groundwater Level (feet bgs) **N/A**		Sampling Method	**Grab**	Hammer Data	**N/A**
Borehole Backfill	**Dual Phase Extraction Well Installed**	Location			

Elevation, feet / Downhole Depth, feet	SAMPLES Type Number	Blows/ 6in.	Recovery (%)	PID/OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
0						SP/GP	Dark brown silty fine to medium SAND with fine to medium subrounded gravel (loose) (no odor, no sheen) (FILL)	
							Soil, cement and bentonite (FILL)	
5								
10								
15			100					
20								
25				39.3 1.2		GP/SP	Light gray sandy fine to coarse GRAVEL/gravelly fine to coarse SAND (moist) (loose) (trace hydrocarbon odor, slight sheen) (no odor, no sheen)	
30	DPE-9-30			0.7			Grading increasing sand Grading decreasing sand (slight hydrocarbon odor)	1050
35	DPE-9-35						Boring was completed to 35' bgs. Groundwater was not encountered. Boring was completed as dual phase extraction well. Well construction details: 24.5-34.5 ft bgs 4" Sch. 40 0.030" PVC screen 22-35 ft bgs Clean silica and 0-24.5 ft bgs 4" Sch. 40 PVC riser 1-22 ft bgs Bentonite 0-1 ft bgs Concrete	1120
40								
45								

URS

Project: Kinder Morgan – Laurel Station
Project Location: Bellingham, Washington
Project Number: 33764823

Log of Boring DPE-10

Sheet 1 of 1

Date(s) Drilled	**1/15/15**	Logged By	**C. Pearson**	Checked By	**DRR**
Drilling Method	**Sonic**	Drilling Contractor	**Cascade Drilling**	Total Depth of Borehole	**26 feet bgs**
Drill Rig Type	**Track Mounted, Sonic Drill Rig**	Drill Bit Size/Type	**8" Core Barrel with Casing**	Ground Surface Elevation (feet MSL)	**N/A**
Groundwater Level (feet bgs) **N/A**		Sampling Method	**Grab**	Hammer Data	**N/A**
Borehole Backfill	**Dual Phase Extraction Well Installed**	Location			

Elevation, feet	Downhole Depth, feet	SAMPLES Type Number	Blows/ 6in.	Recovery (%)	PID/OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
	0						SP	Brown fine to medium SAND with SILT, trace gravel (loose) (FILL)	Drilled at 45° angle
								Soil, cement and bentonite (FILL)	
	5								
	10			100					
	15	DPE-10-15			0.0		ML/SM	Brown sandy SILT with fine to coarse subrounded gravel, fine sand, low plasticity (moist) (organic odor, no sheen)	1510 DPE-10-16 actual sample depth 11.3' bgs
	20	DPE-10-20			0.0 56.1		GP/SP	Gray sandy fine to coarse GRAVEL/gravelly fine to coarse SAND (loose) (moist) (strong hydrocarbon odor), free product	1515 DPE-10-20 actual sample depth 14.1' bgs
	25	DPE-10-25			446 268.8			(Heavy sheen)	1610 DPE-10-25 actual sample depth 17.7' bgs
								Boring was completed to 26' length at a 45° angle. Groundwater was not encountered. Boring was completed as dual phase extraction well. Well construction details: 5.5-25.5 ft 4" Sch. 40 0.030" PVC screen 5-26 ft Clean silica sand 0-5.5 ft 4" Sch. 40 PVC riser 1-5 ft Bentonite 0-1 ft Concrete	
	30								
	35								
	40								
	45								

URS

Project: Laurel Station Data Gap Investigation
Project Location: Bellingham, Washington
Project Number: 33762344

Log of Boring MW-3

Date(s) Drilled	**2/02/11**	Logged By	**IPV**	Checked By	**MTM**
Drilling Method	**Sonic**	Drilling Contractor	**Cascade Drilling, Inc.**	Total Depth of Borehole	**36 feet bgs**
Drill Rig Type	**Rotosonic 17-C**	Drill Bit Size/Type	**6" Core to 4" Core/6" Casing**	Ground Surface Elevation	**N/A**
Groundwater Level	**None Observed**	Sampling Method	**Core**	Hammer Data	**Not Used**
Borehole Backfill	**Completed as well**	Location	**Study Unit #1**		

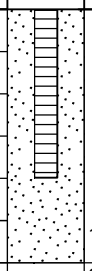
Elevation, feet	Downhole Depth, feet	SAMPLES Type	SAMPLES Number	Blows/ 6in.	Recovery (%)	OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	Well Completion Schematic	REMARKS AND WELL DETAILS
	0					0.8		SP	Asphalt surface Light brown gravelly fine to coarse SAND, fine to coarse subrounded gravel (moist) (no hydrocarbon odor)		0830
						1.2					
						0.6		CL	Bluish gray CLAY with silt and fine to coarse gravel (moist) (no hydrocarbon odor)		
	5		MW3-5			1.2		SM	SILT with clay, some woody debris (no hydrocarbon odor)		0855
								CL	Bluish gray CLAY with fine subrounded gravel and silt (hard) (moist) (no hydrocarbon odor)		
						1.4					
						1.2			Grading light brown		
	10		MW3-10			1.2					0905
						0.8					
						1.2			Grading light gray		0930
									Cobble in drill bit at 14'		
	15		MW3-15			1.1					
						0.7		SP	Gray fine SAND (loose) (moist) (no hydrocarbon odor)		
								CL	Gray CLAY with silt and trace fine to subrounded gravel (hard) (moist) (no hydrocarbon odor)		
						0.9					0940
	20		MW3-20			0.8					
						1.3					
								ML	Gray SILT with fine sand and clay (no hydrocarbon odor)		
								CL	Gray CLAY with silt and trace fine gravel (hard) (moist) (no hydrocarbon odor)		
						1.2					
	25		MW3-25			1.1		GP	Gray sandy fine to coarse subrounded GRAVEL with silt (dry) (no hydrocarbon odor)		0950
						0.9					1030
								GM	Gray silty fine to coarse GRAVEL (very dense) (moist to dry) (no hydrocarbon odor)		
						1.2					
	30										1055

ENV2 WITH WELL T:\ONEWORLD\33762344 LAUREL STATION\LAUREL STATION FEB 2011.GPJ URSSEA3B.GLB URSSEA3.GDT 3/30/11

URS

Project: Laurel Station Data Gap Investigation
Project Location: Bellingham, Washington
Project Number: 33762344

Log of Boring MW-3

Elevation, feet	Downhole Depth, feet	SAMPLES Type Number	Blows/ 6in.	Recovery (%)	OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION		REMARKS AND WELL DETAILS
	30	MW3-30			2.0		GP	Gray sandy fine to coarse subrounded GRAVEL with silt, fine to coarse sand (dense) (moist to dry) (no hydrocarbon odor)		
	35				1.0					1115
								Boring was completed to 36' bgs. Groundwater was not encountered. Boring was completed as monitoring well: 0'-2' bgs Concrete surface seal/flush monument 2'-23' bgs Bentonite chips 23'-36' bgs #2/12 Monterey sand 24'-34' bgs 0.010" slot PVC screen		Screen pulled up 1' while pulling up casing
	40									
	45									
	50									
	55									
	60									
	65									

Project: Laurel Station Data Gap Investigation
Project Location: Bellingham, Washington
Project Number: 33762344

Log of Boring MW-4

Date(s) Drilled	**2/02/11-2/03/11**	Logged By	**IPV**	Checked By	**MTM**
Drilling Method	**Sonic**	Drilling Contractor	**Cascade Drilling, Inc.**	Total Depth of Borehole	**30 feet bgs**
Drill Rig Type	**Rotosonic 17-C**	Drill Bit Size/Type	**6" Core to 4" Core/6" Casing**	Ground Surface Elevation	**N/A**
Groundwater Level	**20' bgs**	Sampling Method	**Core**	Hammer Data	**Not Used**
Borehole Backfill	**Completed as well**	Location	**Study Unit #1**		

Elevation, feet	Downhole Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows/ 6in.	SAMPLES Recovery (%)	OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	Well Completion Schematic	REMARKS AND WELL DETAILS
	0					1.2		SP	Gravel surface Brown gravelly fine to coarse SAND, fine to coarse subrounded gravel (moist) (no hydrocarbon odor)		1340
						0.8		CL	Light brown silty CLAY with trace fine to coarse gravel and cobbles (hard) (moist) (no hydrocarbon odor)		1345
	5		MW4-5			1.2					1355
						1.2			Grading decreasing silt		
						1.0					
	10		MW4-10			1.2					1400
						1.1			Grading blue gray, trace fine gravel		
						1.2					
	15		MW4-15			1.1					1415
						0.9					
	20		MW4-20			1.0			20 ft ▼		1445
						1.0		GP	Gray sandy fine to coarse subrounded GRAVEL with silt (moist) (no hydrocarbon odor)		
						8.0			Grading increasing sand, decreasing silt		
						4.2					
						6.5					1500
	25		MW4-25			3.7		GM	Gray silty fine to coarse subrounded GRAVEL (moist) (slight hydrocarbon odor)		1535
						5.4					
	30		MW4-30						Grading (no hydrocarbon odor)		

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URS

Project: Laurel Station Data Gap Investigation
Project Location: Bellingham, Washington
Project Number: 33762344

Log of Boring MW-4

Elevation, feet / Downhole Depth, feet	SAMPLES: Type Number	SAMPLES: Blows/ 6in.	SAMPLES: Recovery (%)	SAMPLES: OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION		REMARKS AND WELL DETAILS
30							Boring was completed to 30' bgs. Groundwater was encountered at 20' bgs. Boring was completed as monitoring well: 0'-2' bgs Concrete surface seal/flush monument 2'-18' bgs Bentonite chips 18'-30' bgs #2/12 Monterey sand 20'-30' bgs 0.010" slot PVC screen		1610 Done drilling for day Well installed 2/03/11
35									
40									
45									
50									
55									
60									
65									

Project: Laurel Station Data Gap Investigation
Project Location: Bellingham, Washington
Project Number: 33762344

Log of Boring MW-6 (SU1-B27)

Sheet 1 of 1

Date(s) Drilled	**2/04/11-2/07/11**	Logged By	**IPV**	Checked By	**MTM**
Drilling Method	**Sonic**	Drilling Contractor	**Cascade Drilling, Inc.**	Total Depth of Borehole	**26 feet bgs**
Drill Rig Type	**Rotosonic 17-C**	Drill Bit Size/Type	**6" Core to 4" Core/6" Casing**	Ground Surface Elevation	**N/A**
Groundwater Level	**13' bgs**	Sampling Method	**Core**	Hammer Data	**Not Used**
Borehole Backfill	**Completed as well**	Location	**Study Unit #1**		

Elevation, feet	Downhole Depth, feet	SAMPLES Type	SAMPLES Number	Blows/ 6in.	Recovery (%)	OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	Well Completion Schematic	REMARKS AND WELL DETAILS
	0					0.2		SP	Asphalt surface		0830
									Brown to gray gravelly fine to coarse SAND, fine to coarse subrounded gravel (moist) (no hydrocarbon odor)		
						0.1			Grading brown		
									Grading increasing gravel		
	5		MW6-5			0.1					0900
								CL	Blue gray CLAY with trace fine to medium subrounded gravel (very hard) (moist) (no hydrocarbon odor)		
						0.2					
						0.3					
	10		MW6-10						Grading gray		0910
						0.1					
								GP	Light brown fine to coarse sandy GRAVEL with silt (loose) (moist) (no hydrocarbon odor)		
						0.4			13 ft ▼		
									Wet from 13' to 14' bgs		
						0.6			Grading brown/gray mottled		
	15		MW6-15								0925 Slow drilling
									Grading increasing silt (dense)		
						1.1		GM	Gray silty fine to coarse subrounded GRAVEL (moist) (no hydrocarbon odor)		1030
								GP	Light gray fine to coarse SAND and fine to coarse GRAVEL with silt (moist) (no hydrocarbon odor)		
						1.3					
	20		MW6-20					GP/GM	Gray sandy fine to coarse subrounded GRAVEL with silt to silty fine to coarse subrounded GRAVEL with sand (moist) (no hydrocarbon odor)		1055
						0.6					
						0.2					
	25		MW6-25			1.5		GP	Gray sandy GRAVEL (loose) (moist) (no hydrocarbon odor)		1110
	30								Boring was completed to 26' bgs. Groundwater was encountered at 13' bgs. Boring was completed as monitoring well: 0'-2' bgs Concrete surface seal/flush monument 2'-9' bgs Bentonite chips 9'-26' bgs #2/12 Monterey sand 11'-26' bgs 0.010" slot PVC screen		02/04/11 - Left casing in ground to 26' bgs over weekend. 02/07/11 - Clean out to 26' bgs and install well

ENV2 WITH WELL T:\ONEWORLD\33762344 LAUREL STATION\LAUREL STATION FEB 2011.GPJ URSSEA3B.GLB URSSEA3.GDT 3/30/11

URS

Project: Laurel Station Data Gap Investigation
Project Location: Bellingham, Washington
Project Number: 33762344

Log of Boring MW-8

Date(s) Drilled	**2/10/11**	Logged By	**IPV**	Checked By	**MTM**
Drilling Method	**Sonic**	Drilling Contractor	**Cascade Drilling, Inc.**	Total Depth of Borehole	**40 feet bgs**
Drill Rig Type	**Rotosonic 17-C**	Drill Bit Size/Type	**6" Core to 4" Core/6" Casing**	Ground Surface Elevation	**N/A**
Groundwater Level	**None Observed**	Sampling Method	**Core**	Hammer Data	**Not Used**
Borehole Backfill	**Completed as well**	Location	**Study Unit #1**		

Elevation, feet	Downhole Depth, feet	SAMPLES Type	SAMPLES Number	Blows/ 6in.	Recovery (%)	OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	Well Completion Schematic	REMARKS AND WELL DETAILS
	0							SP	Asphalt surface		0805
						0.1			Brown gravelly fine to coarse SAND, fine to coarse subrounded gravel (loose) (moist) (no hydrocarbon odor)		
								CL	Dark brown CLAY with fine to coarse subrounded gravel, organics (moist) (no hydrocarbon odor)		
						0.3			Grading blue gray		0812
	5					0.2			Grading blue gray to light brown mottled		
						0.1			Grading to blue gray CLAY with silt		
						0.2			Grading increasing silt (hard) (moist to dry)		0820
	10					0.0			Grading decreasing silt		0830
						0.1					
	15					0.1					0845
						0.2			Grading blue gray with trace fine to subrounded gravel (moist)		
	20					0.2					0905
						0.1			Grading light brown		0935
								GP/GM	Silty fine to coarse GRAVEL to sandy fine to coarse GRAVEL with silt (dense) (moist) (no hydrocarbon odor)		
	25					0.1					0945
								GP	Sandy fine to coarse GRAVEL with silt (loose) (moist) (no hydrocarbon odor)		
						0.2					
	30										

ENV2 WITH WELL T:\ONEWORLD\33762344 LAUREL STATION\LAUREL STATION FEB 2011.GPJ URSSEA3B.GLB URSSEA3.GDT 3/30/11

URS

Project: Laurel Station Data Gap Investigation
Project Location: Bellingham, Washington
Project Number: 33762344

Log of Boring MW-8

Elevation, feet	Downhole Depth, feet	SAMPLES Type Number	Blows/ 6in.	Recovery (%)	OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION		REMARKS AND WELL DETAILS
	30						GP			1030
					2.1			Grading increasing silt (loose)		
								Grading increasing sand		
	35				1.3					
					1.2					1110
	40							Boring was completed to 40' bgs. Groundwater was not encountered. Boring was completed as monitoring well: 0'-2' bgs Concrete surface seal/flush monument 2'-23' bgs Bentonite chips 23'-40' bgs #2/12 Monterey sand 23'-38' bgs 0.010" slot PVC screen		Well casing came up 2' while pulling drill casing
	45									
	50									
	55									
	60									
	65									

Project: Kinder Morgan Laurel Station Data Gap Investigation
Project Location: Bellingham, Washington
Project Number: 33762778

Log of Boring MW-11

Date(s) Drilled	**6/7/11-6/8/11**	Logged By	**IPV**	Checked By	
Drilling Method	**Sonic**	Drilling Contractor	**Cascade Drilling, Inc.**	Total Depth of Borehole	**49 feet bgs**
Drill Rig Type	**Rotosonic 17-C**	Drill Bit Size/Type		Ground Surface Elevation	**N/A**
Groundwater Level	**25' bgs**	Sampling Method	**Core**	Hammer Data	**Not Used**
Borehole Backfill	**Completed as well**	Location			

Elevation, feet	Downhole Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows/ 6in.	SAMPLES Recovery (%)	OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	Well Completion Schematic	REMARKS AND WELL DETAILS
	0								Grass surface		
						0.2		ML	Reddish brown SILT with clay and fine sand, woody debris (moist) (no hydrocarbon odor)		
								CL	Light gray CLAY with silt and fine to coarse sand (moist) (no hydrocarbon odor)		
						0.3					
	5					0.1			Grading less sand (no hydrocarbon odor)		1400
						0.1			2" sand lense at 8'		
	10							GP	Brown to gray sandy fine to coarse GRAVEL with silt (moist) (no hydrocarbon odor)		1415
								GM	Gray silty fine to coarse subrounded GRAVEL with silt (dry) (no hydrocarbon odor)		
	15					0.2					1430
								GP	Gray sandy fine to coarse GRAVEL with silt (moist) (no hydrocarbon odor)		1445
						0.5					
								SP	Brown SAND with fine gravel (moist to wet) (no hydrocarbon odor)		
	20		MW11-20			2.3		GP	Gray sandy fine to coarse GRAVEL with silt (moist) (no hydrocarbon odor)		1530
						0.3					
	25		MW11-25						25 ft ▼ Grading less silt, more sand (wet)		1535
						1.4		GM	Gray silty fine to coarse GRAVEL with sand (moist) (no hydrocarbon odor)		1605 Finish for day
						0.1			Grading more sand		
	30										

ENV2 WITH WELL C:\DOCUMENTS AND SETTINGS\ANN_CAMPBELL\DESKTOP\WORK FILES\LAUREL STATION\33762778.GPJ URSSEA3B.GLB URSSEA3.GDT 6/26/11

URS

Project: Kinder Morgan Laurel Station Data Gap Investigation
Project Location: Bellingham, Washington
Project Number: 33762778

Log of Boring MW-11

Elevation, feet	Downhole Depth, feet	SAMPLES Type Number	Blows/ 6in.	Recovery (%)	OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	REMARKS AND WELL DETAILS
	30	MW11-30			1.8		GP	Brown to gray sandy fine to coarse GRAVEL with silt (moist) (no hydrocarbon odor)	0820
									0815
					1.7				0845
	35	MW11-35			1.2			Grading brown subrounded GRAVEL less silt (wet) (no hydrocarbon odor)	0910
								Grading less gravel	
							SP	Light brown gravelly fine to coarse SAND (wet) (no hydrocarbon odor)	
							GP	Light brown sandy GRAVEL (wet)	
	40	MW11-40					GM	Light brown silty GRAVEL (moist)	0920
							GP	Light brown sandy GRAVEL (wet)	
									1030
	45	MW11-45					GM	Gray silty fine to coarse GRAVEL with sand (moist) (no hydrocarbon odor)	1100
		MW11-49			1.2				
	50							Boring was completed to 49' bgs. Possible groundwater was encountered at 25' bgs. Boring was completed as monitoring well: 0'-2' bgs Concrete surface seal 2'-23' bgs Bentonite chips 23'-45' bgs #2/12 Monterey sand 25'-45' bgs 4" stainless steel Johnson type 304 screen +3'-25' bgs 4" stainless steel blank, stick-up monument	1110
	55								
	60								
	65								

Project: Kinder Morgan Laurel Station Data Gap Investigation
Project Location: Bellingham, Washington
Project Number: 33762778

Log of Boring MW-12

Sheet 1 of 2

Date(s) Drilled	**6/6/11-6/7/11**	Logged By	**IPV**	Checked By	
Drilling Method	**Sonic**	Drilling Contractor	**Cascade Drilling, Inc.**	Total Depth of Borehole	**54 feet bgs**
Drill Rig Type	**Rotosonic 17-C**	Drill Bit Size/Type		Ground Surface Elevation	**N/A**
Groundwater Level	**None Observed**	Sampling Method	**Core**	Hammer Data	**Not Used**
Borehole Backfill	**Completed as well**	Location			

Elevation, feet	Downhole Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows/ 6in.	SAMPLES Recovery (%)	OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	Well Completion Schematic	REMARKS AND WELL DETAILS
	0								Grass surface		0945
						1.9		CL	Brown gray mottled CLAY with silt, fine sand and trace fine gravel (moist) (no hydrocarbon odor)		
						2.1					
	5							ML	Gray SILT with fine sand, fine to medium gravel (moist) (no hydrocarbon odor)		1000
						2.2		GM	Gray silty fine to medium GRAVEL with fine to medium sand (moist) (no hydrocarbon odor)		1010
									Grading fine to coarse GRAVEL, increasing silt		
	10					1.9			(no hydrocarbon odor)		1040
						1.2			(no hydrocarbon odor)		1110
	15					1.4					1125
						2.1			(no hydrocarbon odor)		1153
	20								Grading fine to coarse sand (moist to dry)		
						1.6					1215
	25		MW12-25						(no hydrocarbon odor)		1340 Rough drilling - broke drill rod
											1350
						1.7		GP	Gray fine to coarse subrounded GRAVEL with silt (dry) (no hydrocarbon odor)		
	30										

URS

Project: Kinder Morgan Laurel Station Data Gap Investigation
Project Location: Bellingham, Washington
Project Number: 33762778

Log of Boring MW-12

Elevation, feet	Downhole Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows/ 6in.	SAMPLES Recovery (%)	SAMPLES OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	REMARKS AND WELL DETAILS
	30		MW12-30							1430
						1.1			Grading increasing sand (moist)	1455
	35		MW12-35							1510
						1.4			(no hydrocarbon odor)	
			MW12-39			0.4		SP	Gray gravelly fine to coarse SAND and GRAVEL (moist) (no hydrocarbon odor)	1525
	40							GM	Gray silty fine to coarse GRAVEL with sand (dry) (no hydrocarbon odor)	1607 Finish for day
	45		MW12-45					GP	Gray sandy fine to coarse subrounded GRAVEL with silt, fine to coarse sand (dry to moist) (no hydrocarbon odor)	0900 Soil dup 13 at 45'
						0.3				
	50		MW12-50			0.4				1015
			MW12-54			0.3			Grading increasing sand (no hydrocarbon odor)	
	55								Boring was completed to 54' bgs. Groundwater was not encountered. Boring was completed as monitoring well: 0'-2' bgs Concrete surface seal 2'-27' bgs Bentonite chips 27'-49' bgs #2/12 Monterey sand 29'-49' bgs 4" stainless steel Johnson type 304 screen +3'-29' bgs 4" stainless steel blank, stick-up monument Well casing pulled up when pulling casing.	1020
	60									
	65									

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URS

Project: Kinder Morgan Laurel Station Data Gap Investigation
Project Location: Bellingham, Washington
Project Number: 33762778

Log of Boring MW-13

Date(s) Drilled	**6/13/11-6/14/11**	Logged By	**IPV**	Checked By	
Drilling Method	**Sonic**	Drilling Contractor	**Cascade Drilling, Inc.**	Total Depth of Borehole	**60 feet bgs**
Drill Rig Type	**Rotosonic 17-C**	Drill Bit Size/Type		Ground Surface Elevation	**N/A**
Groundwater Level	**None Observed**	Sampling Method	**Core**	Hammer Data	**Not Used**
Borehole Backfill	**Completed as well**	Location			

Elevation, feet	Downhole Depth, feet	SAMPLES Type	SAMPLES Number	Blows/ 6in.	Recovery (%)	OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	Well Completion Schematic	REMARKS AND WELL DETAILS
	0								Grass surface		0830
						0.1		CL	Brown CLAY with silt and fine to medium subrounded GRAVEL (moist to wet) (no hydrocarbon odor)		
						0.2			Grading brown gray mottled (moist) (no hydrocarbon odor)		
	5										0840
						0.1		GM	Gray silty fine to coarse GRAVEL with SAND (moist) (no hydrocarbon odor)		
								GP	Gray fine to coarse sandy GRAVEL (moist) (no hydrocarbon odor)		
						0.1					
	10							ML	Gray gravelly SILT, fine to coarse gravel (moist to dry) (no hydrocarbon odor)		1000
						0.0					
											Slow drilling
								GM	Gray silty fine to coarse subrounded GRAVEL (moist to dry) (no hydrocarbon odor)		1100
						0.1					
	15										1116
						0.1			(no hydrocarbon odor)		
											1140
	20								Grading (moist)		
						0.1					
											1205
						0.3					
								GP	Gray sandy fine to coarse subrounded gravel (moist) (no hydrocarbon odor)		
	25		MW13-25								
						0.2		GM	Gray silty fine to coarse GRAVEL with sand (moist) (no hydrocarbon odor)		
						0.0					1347
	30										

ENV2 WITH WELL C:\DOCUMENTS AND SETTINGS\ANN_CAMPBELL\DESKTOP\WORK FILES\LAUREL STATION\33762778.GPJ URSSEA3B.GLB URSSEA3.GDT 6/26/11

URS

Project: Kinder Morgan Laurel Station Data Gap Investigation
Project Location: Bellingham, Washington
Project Number: 33762778

Log of Boring MW-13

Sheet 2 of 2

Elevation, feet	Downhole Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows/ 6in.	SAMPLES Recovery (%)	OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	REMARKS AND WELL DETAILS
	30		MW13-30			0.1			(no hydrocarbon odor)	1405
						0.3		GP	Light gray sandy fine to coarse GRAVEL with silt (moist) (no hydrocarbon odor)	
	35		MW13-35					SP	Gray gravelly fine to coarse SAND (moist) (no hydrocarbon odor)	1445 Soil dup 14
						0.2			4" silty gravel layer	
						2.4				
	40		MW13-40					GM	Gray silty fine to medium GRAVEL with sand (moist) (no hydrocarbon odor)	1530
						0.6				1550
	45		MW13-45						Grading light gray fine to coarse GRAVEL with fine to coarse sand (moist to dry)	Finish for day 0800 Start for day
						0.1		GP	Gray sandy GRAVEL with silt, fine to coarse gravel and sand (dry-from drilling?) (no hydrocarbon odor)	
						0.1		SP	Light brown fine to medium SAND with fine to coarse subrounded gravel (moist) (no hydrocarbon odor)	
	50		MW13-50			14.2			6" layer of material with sour odor (decay?)	Triple volume MD/MSD Small piece of coal at 50.5'
								GM	Light gray silty GRAVEL (dry-from drilling?) (no odor)	
								SP	Light brown fine to medium SAND with fine to coarse GRAVEL (moist) (no hydrocarbon odor)	
						0.2		GP	Gray silty GRAVEL with sand (dry) (no hydrocarbon odor)	
	55		MW13-55			1.2			(no hydrocarbon odor)	1005
			MW13-60			1.1		GM	Gray silty GRAVEL with sand (moist) (no hydrocarbon odor)	
	60								Boring was completed to 60' bgs. Groundwater was not encountered. Boring was completed as monitoring well: 0'-2' bgs Concrete surface seal 2'-36' bgs Bentonite chips 36'-59' bgs #2/12 Monterey sand 39'-59' bgs 4" stainless steel Johnson type 304 screen +3'-39' bgs 4" stainless steel blank, stick-up monument	1010
	65									

ENV2 WITH WELL C:\DOCUMENTS AND SETTINGS\ANN_CAMPBELL\DESKTOP\WORK FILES\LAUREL STATION\33762778.GPJ URSSEA3B.GLB URSSEA3.GDT 6/26/11

URS

Project: Kinder Morgan Laurel Station Data Gap Investigation
Project Location: Bellingham, Washington
Project Number: 33762778

Log of Boring MW-14

Date(s) Drilled	**6/14/11-6/15/11**	Logged By	**IPV**	Checked By	
Drilling Method	**Sonic**	Drilling Contractor	**Cascade Drilling, Inc.**	Total Depth of Borehole	**51 feet bgs**
Drill Rig Type	**Rotosonic 17-C**	Drill Bit Size/Type		Ground Surface Elevation	**N/A**
Groundwater Level	**None Observed**	Sampling Method	**Core**	Hammer Data	**Not Used**
Borehole Backfill	**Completed as well**	Location			

Elevation, feet	Downhole Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows/ 6in.	SAMPLES Recovery (%)	OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	Well Completion Schematic	REMARKS AND WELL DETAILS
	0								Grass surface		1315
						0.0		CL GP	Brown CLAY with silt and fine subrounded gravel (moist) (no hydrocarbon odor) Brown sandy fine to coarse subrounded GRAVEL (dry) (no hydrocarbon odor)		
						0.0			Grading light brown		
	5					0.0					1325
						0.1					
	10					0.2			Grading increasing silt		1345
						0.1		GM	Light gray silty fine to coarse subrounded GRAVEL with fine to coarse sand (dry-from drilling?) (no hydrocarbon odor)		1425
	15					0.0					
						1.4			Grading increasing sand (moist) (no hydrocarbon odor)		1500
						1.2			Grading decreasing sand		1520
	20		MW14 20			1.2					
						0.2		GP	Light brown sandy fine to coarse GRAVEL (moist) (no hydrocarbon odor)		1530
	25		MW14 25			0.1					1600 Finish for day 0800 Start for day
								GM	Gray silty fine to coarse subrounded GRAVEL with fine to coarse sand (moist) (no hydrocarbon odor)		
								GP	Light gray sandy fine to coarse GRAVEL (moist) (no hydrocarbon odor)		
	30					0.1					

ENV2 WITH WELL C:\DOCUMENTS AND SETTINGS\ANN_CAMPBELL\DESKTOP\WORK FILES\LAUREL STATION\33762778.GPJ URSSEA3B.GLB URSSEA3.GDT 6/26/11

URS

Project: Kinder Morgan Laurel Station Data Gap Investigation
Project Location: Bellingham, Washington
Project Number: 33762778

Log of Boring MW-14

Elevation, feet	Downhole Depth, feet	SAMPLES Type	SAMPLES Number	Blows/ 6in.	Recovery (%)	OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	REMARKS AND WELL DETAILS
	30		MW14 30							0830
						0.3		GM	Gray silty GRAVEL with sand (moist) (no hydrocarbon odor)	
						0.2				
						0.7		GP/GM	Gray sandy GRAVEL to silty GRAVEL with sand (moist) (no hydrocarbon odor)	
	35		MW14 35			0.1				0915
									(no hydrocarbon odor)	
	40		MW14 40			0.2				1000
						0.3			Grading increasing silt	
						2.9			Grading decreasing silt, increasing sand (no hydrocarbon odor)	
	45		MW14 45			0.3				1040
						1.2		GP	Grading increasing sand Gray sandy fine to coarse GRAVEL (moist) (no hydrocarbon odor)	
	50		MW14 50			0.4				1130
	55								Boring was completed to 51' bgs. Groundwater was not encountered. Boring was completed as monitoring well: 0'-2' bgs Concrete surface seal 2'-27' bgs Bentonite chips 27'-50' bgs #2/12 Monterey sand 30'-50' bgs 4" stainless steel Johnson type 304 screen +3'-30' bgs 4" stainless steel blank, stick-up monument	
	60									
	65									

Project: Kinder Morgan – Laurel Station
Project Location: Bellingham, Washington
Project Number: 33764823

Log of Boring MW-15

Sheet 1 of 1

Date(s) Drilled	**1/17/15**	Logged By	**C. Pearson**	Checked By	**DRR**
Drilling Method	**Sonic**	Drilling Contractor	**Cascade Drilling**	Total Depth of Borehole	**35 feet bgs**
Drill Rig Type	**Track Mounted, Sonic Drill Rig**	Drill Bit Size/Type	**8" Core Barrel with Casing**	Ground Surface Elevation (feet MSL)	**N/A**
Groundwater Level (feet bgs) **N/A**		Sampling Method	**Grab**	Hammer Data	**N/A**
Borehole Backfill	**Monitoring Well Installed**	Location			

Elevation, feet	Downhole Depth, feet	SAMPLES Type Number	Blows/ 6in.	Recovery (%)	PID/OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
	0						SP	Brown silty fine to medium SAND with gravel (loose) (no odor, no staining) (FILL)	
	5								
	8							Soil, cement and bentonite (FILL)	
	10								
	15			100					
	20								
	25								
	27						GP	Gray sandy fine to coarse GRAVEL/gravelly fine to medium SAND (loose) (moist) (no odor, no sheen)	
	30	MW-15-30			0.0				1010
	35	MW-15-35						Boring was completed to 35' bgs. Groundwater was not encountered. Boring was completed as monitoring well. Well construction details: 25-35 ft bgs 4" Sch. 40 0.030" PVC screen 21-35 ft bgs Clean silica sand 0-25 ft bgs 4" Sch. 40 PVC riser 1-21 ft bgs Bentonite 0-1 ft bgs Concrete	1100
	40								
	45								

URS

Project: Kinder Morgan – Laurel Station
Project Location: Bellingham, Washington
Project Number: 33764823

Log of Boring MW-16

Sheet 1 of 1

Date(s) Drilled	**1/16/15**	Logged By	**C. Pearson**	Checked By	**DRR**
Drilling Method	**Sonic**	Drilling Contractor	**Cascade Drilling**	Total Depth of Borehole	**35 feet bgs**
Drill Rig Type	**Track Mounted, Sonic Drill Rig**	Drill Bit Size/Type	**8" Core Barrel with Casing**	Ground Surface Elevation (feet MSL)	**N/A**
Groundwater Level (feet bgs) **N/A**		Sampling Method	**Grab**	Hammer Data	**N/A**
Borehole Backfill	**Monitoring Well Installed**	Location			

Elevation, feet	Downhole Depth, feet	SAMPLES Type	SAMPLES Number	Blows/ 6in.	Recovery (%)	PID/OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
	0							SW	Dark brown silty fine to medium SAND with fine to medium subrounded gravel (loose) (FILL)	
									Soil, cement and bentonite (FILL)	
	5									
	10									
	15				100					
	20									
	25							GP	Brown sandy fine to coarse GRAVEL/gravelly fine to medium SAND (loose) (no odor, no sheen)	
			MW-16-29							1540
	30								Soil, cement and bentonite (FILL)	Likely pulled in from side walls of boring
	35		MW-16-35					SP	Brown fine to coarse SAND with silt (loose) (moist) (no odor, no sheen)	1545
									Boring was completed to 35' bgs. Groundwater was not encountered. Boring was completed as monitoring well. Well construction details: 25-35 ft bgs 4" Sch. 40 0.030" PVC screen 22-35 ft bgs Clean silica sand 0-25 ft bgs 4" Sch. 40 PVC riser 1-22 ft bgs Bentonite 0-1 ft bgs Concrete	
	40									
	45									

ENV2 W/O WELL J:\PROJECTS\GRFX\AECOM PROJECTS\60440385 LAUREL STATION\DEC-JAN 2105 LOGS - COPY.GPJ URSSEA3B.GLB URSSEA3.GDT 12/3/15

URS

Project: Kinder Morgan – Laurel Station
Project Location: Bellingham, Washington
Project Number: 33764823

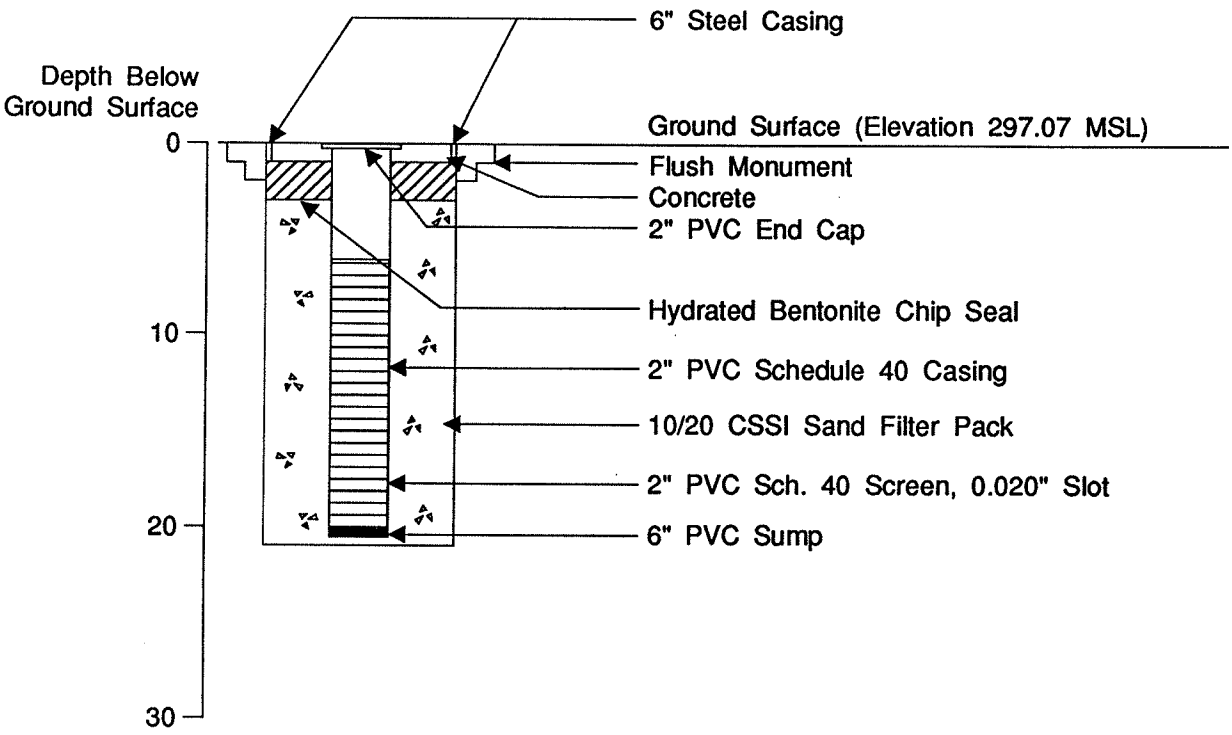
Log of Boring PV-1

Sheet 1 of 1

Date(s) Drilled	**12/10/14**	Logged By	**C. Pearson**	Checked By	**DRR**
Drilling Method	**Sonic**	Drilling Contractor	**Cascade Drilling**	Total Depth of Borehole	**30.8 feet bgs**
Drill Rig Type	**Track Mounted, Sonic Drill Rig**	Drill Bit Size/Type	**8" Core Barrel with Casing**	Ground Surface Elevation (feet MSL)	**N/A**
Groundwater Level (feet bgs) **N/A**		Sampling Method	**Grab**	Hammer Data	**N/A**
Borehole Backfill	**Passive Vent/Well Installed**	Location	**South end of pump station building**		

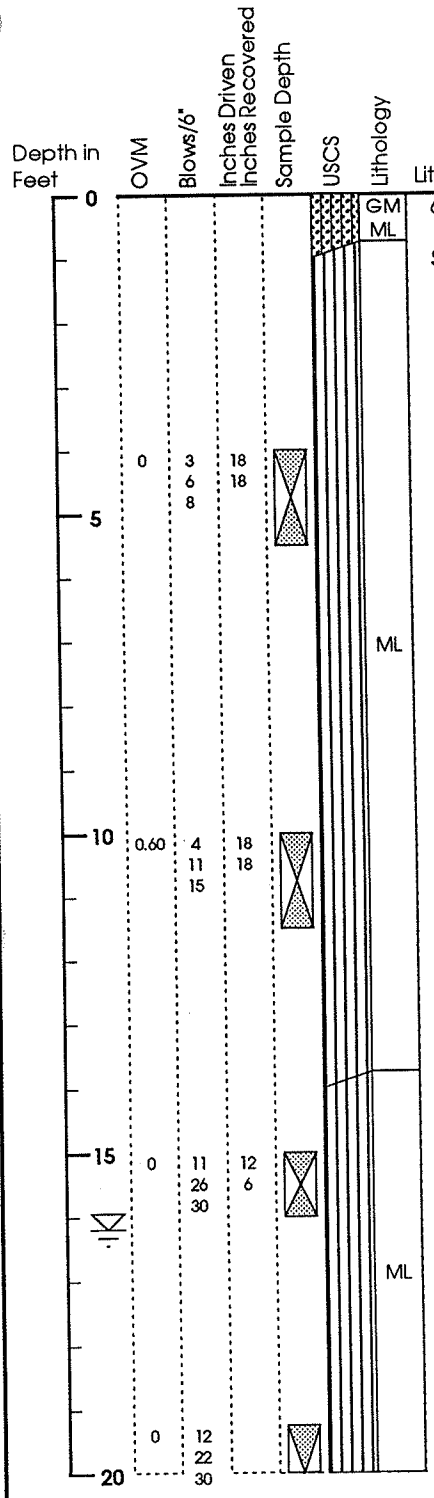
Elevation, feet	Downhole Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows/ 6in.	SAMPLES Recovery (%)	PID/OVM (ppm)	Graphic Log	USCS	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
	0							GP/SP	Asphalt	Drilled at 30° angle
									Brown sandy fine GRAVEL/gravelly fine to coarse SAND (loose) (moist) (no odor, no sheen) (FILL)	Cleared to 4' with air knife
	5		PV-1-5			0.0				1155 PV-1-5 actual sample depth 4.3' bgs
								CL	Light brown silty CLAY (dense) (moist) (no odor, no sheen)	
									Grading (very dense)	
	10		PV-1-10			0.0		GP	Light brown sandy fine to coarse rounded GRAVEL, trace silt, fine to coarse sand, trace rounded cobbles (loose) (strong hydrocarbon odor, heavy sheen and staining)	1205 PV-1-10 actual sample depth 8.7' bgs
	15		PV-1-15		100	47.5			Grading (slight hydrocarbon odor, no sheen)	1325 PV-1-15 actual sample depth 13.0' bgs
									Grading (no odor, no staining)	
									Grading light brown	
	20		PV-1-20			0.0			Grading no cobbles, decreasing gravel	1340 PV-1-20 actual sample depth 17.3' bgs
	25		PV-1-25			0.0				1410 PV-1-25 actual sample depth 21.7' bgs
	30		PV-1-30			0.0				1450 PV-1-30 actual sample depth 26' bgs
									Boring was completed to 30.8' length at a 35° angle. Groundwater was not encountered. Boring was completed as passive vent/well.	
									Well construction details: 19.5-29.5 ft 4" Sch. 40 0.030" PVC screen 17-30.8 ft Clean silica sand 0-19.5 ft 4" Sch. 40 PVC riser 1.5-17 ft Bentonite 0-1.5 ft Concrete	
	35									
	40									
	45									

URS



SW-1
Monitoring Well Construction Diagram
Dames & Moore

Geological Boring Log



Lithologic Description

6" dark brown topsoil, roots, organic, some gravel.

Silty GRAVEL; 50% silt, 50% gravel; moist, loose.

OVM: 0 | Blows/6": 3, 6, 8 | Inches Driven: 18 | Inches Recovered: 18

Clayey SILT; dark brown (7.5yr 3/2); scattered 1" well rounded gravels; moist, poorly graded, non plastic, medium stiff, small fragments of burnt wood, twigs, slightly organic (fill).

OVM: 0.60 | Blows/6": 4, 11, 15 | Inches Driven: 18 | Inches Recovered: 18

SILT; gray brown (5yr 5/2); scattered 1" well rounded gravels; moist, non plastic, poorly graded, very stiff, occasional wood chips.

Cuttings become saturated.

OVM: 0 | Blows/6": 11, 26, 30 | Inches Driven: 12 | Inches Recovered: 6

Gravely SILT; brown (7.5yr 4/2); 55% silt, 40% gravel with trace fine to medium sand; 1/2" subangular fragments of basalt and granite; saturated, non plastic, dense.

OVM: 0 | Blows/6": 12, 22, 30

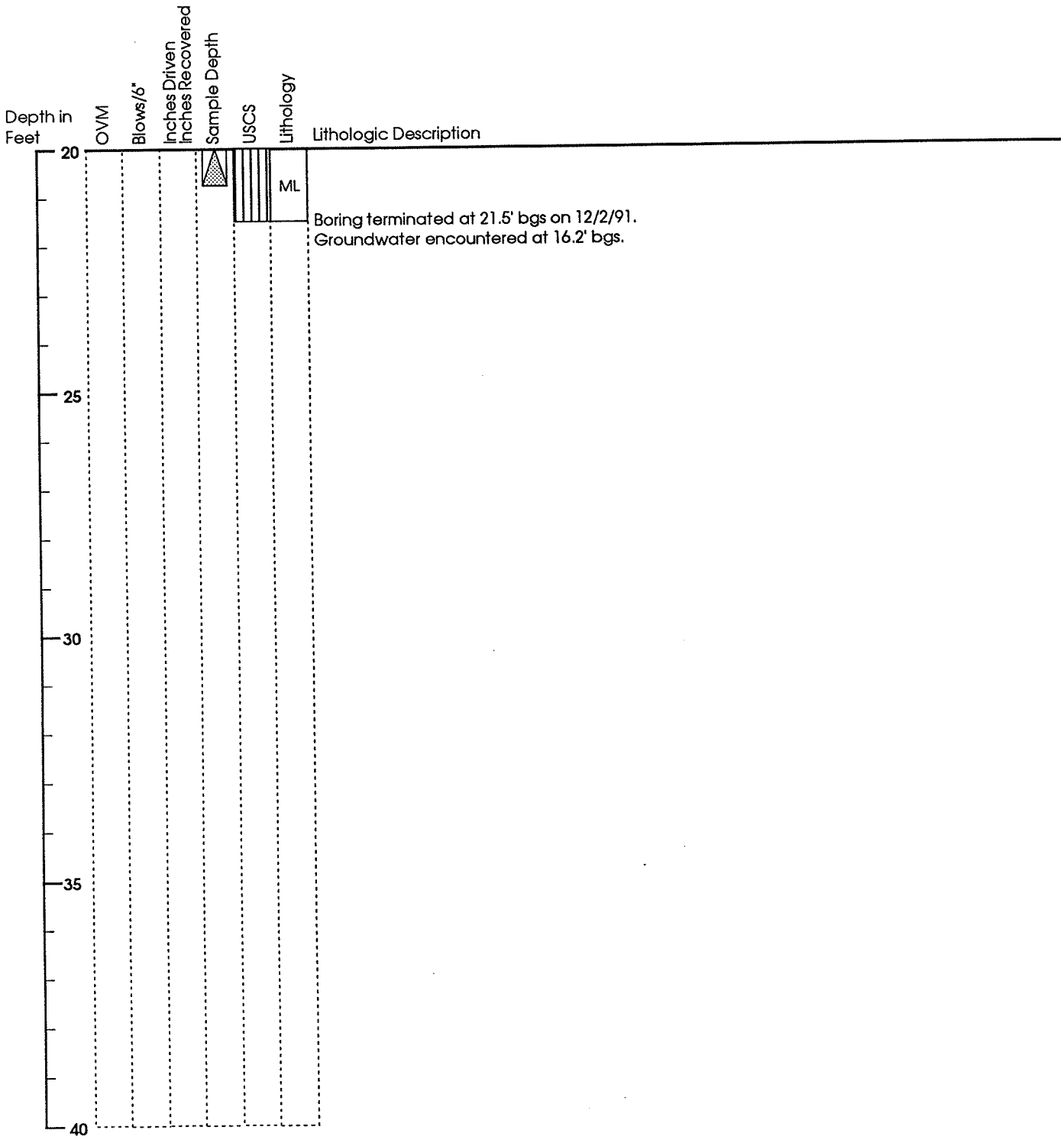
Gravely SILT; grayish brown (5yr 5/2); 55% silt, 40% gravel with trace fine to medium sand; moist, non plastic, very dense, gravel fragments include basalt and granite.

Client:	Trans Mountain Pipe Line Co.	Boring No:	TM-B2
Job No:	21199-032-005	Drilling Method:	6.25" O.D. Hollow Stem Auger
Location:	Bellingham, WA	Sample Method:	D&M U-type Split Spoon; 300# hammer with 30" drop
Geologist:	MAO	Drill Contractor:	Hays Drilling
		Drill Date:	12/2/91

Dames & Moore

FILENAME: TM-B2.DRW

Geological Boring Log

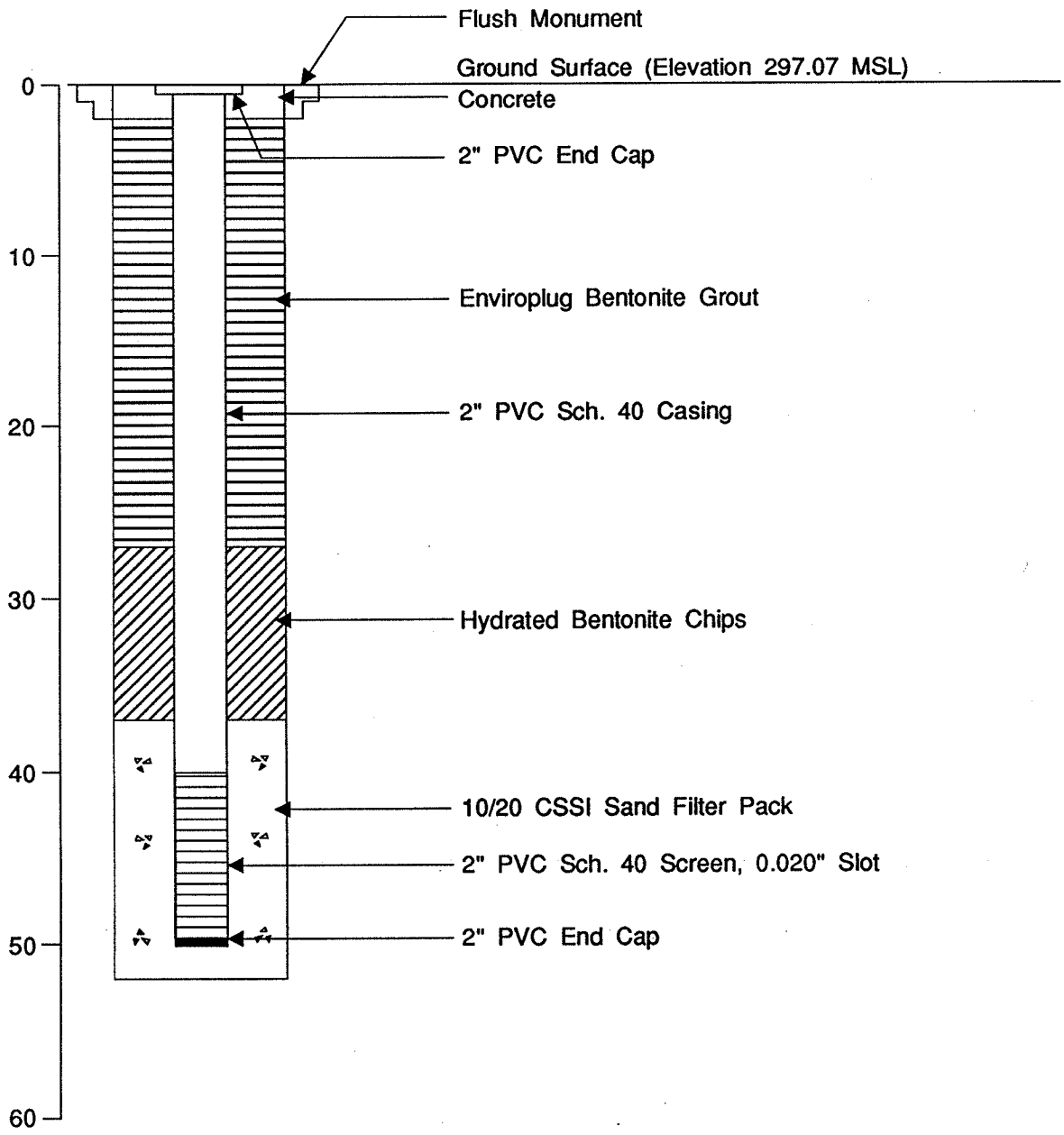


Client:	Trans Mountain Pipe Line Co.	Boring No:	TM-B2
Job No:	21199-032-005	Drilling Method:	6.25" O.D. Hollow Stem Auger
Location:	Bellingham, WA	Sample Method:	D&M U-type Split Spoon; 300# hammer with 30" drop
Geologist:	MAO	Drill Contractor:	Hays Drilling
		Drill Date:	12/2/91

Dames & Moore

FILENAME: TM-B2.DRW

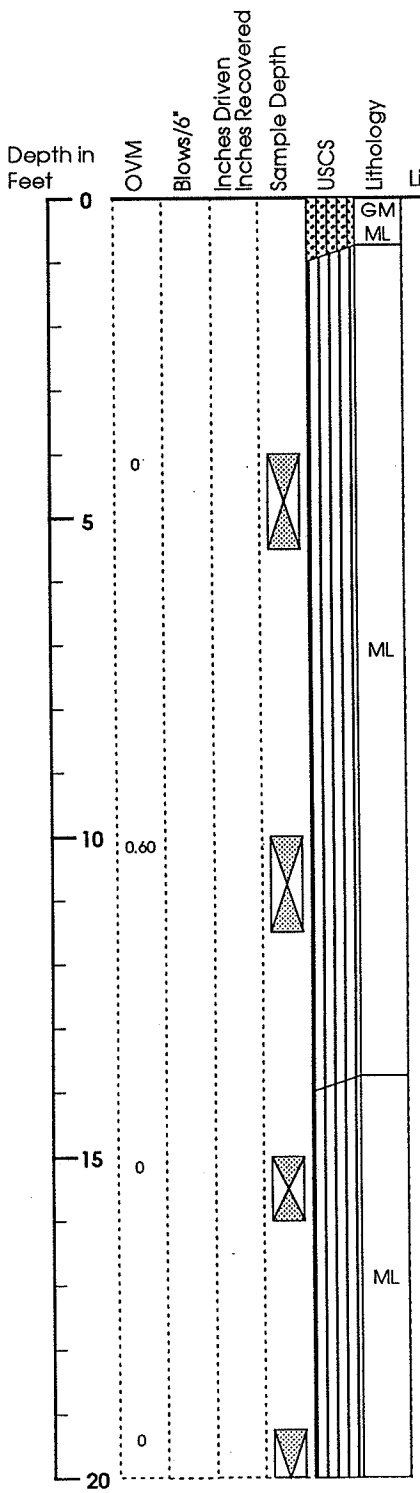
TMMW_04.CDR



Job No. 21 032-005

SW-2
Monitoring Well Construction Diagram
Dames & Moore

Geological Boring Log



Lithologic Description

6" dark brown topsoil, roots, organic, some gravel.

Silty GRAVEL; 50% silt, 50% gravel; moist, loose.

Clayey SILT; dark brown (7.5yr 3/2); scattered 1" well rounded gravels; moist, well sorted, non plastic, medium stiff, small fragments of burnt wood, twigs, slightly organic (fill).

SILT; gray brown (5yr 5/2); scattered 1" well rounded gravels; moist, non plastic, well sorted, very stiff, occasional wood chips.

Cuttings become saturated.

Gravely SILT; brown (7.5yr 4/2); 55% silt, 40% gravel with trace fine to medium sand; 1/2" subangular fragments of basalt and granite; saturated, non plastic, dense.

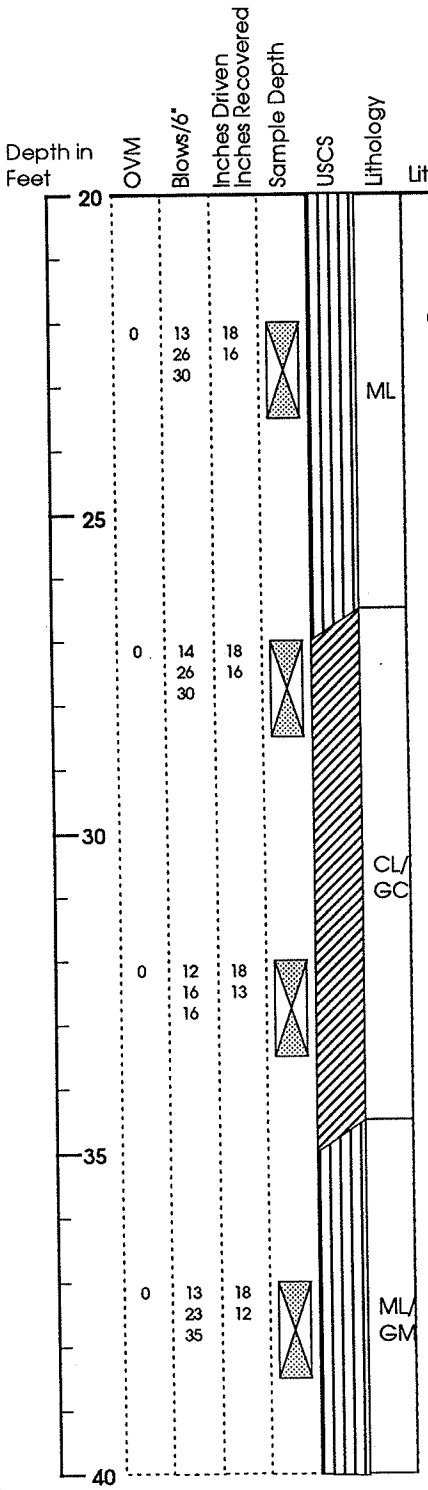
Gravely SILT; grayish brown (5yr 5/2); 55% silt, 40% gravel with trace fine to medium sand; moist, non plastic, very dense, gravel fragments include basalt and granite.

Client:	Trans Mountain Pipe Line Co.	Boring No:	TM-B3
Job No:	21199-032-005	Drilling Method:	6.25" O.D. Hollow Stem Auger
Location:	Bellingham, WA	Sample Method:	D&M U-type Split Spoon; 300# hammer with 30" drop
Geologist:	MAO	Drill Contractor:	Hays Drilling
		Drill Date:	12/3/91

Dames & Moore

FILENAME: TM-B3.DRW

Geological Boring Log



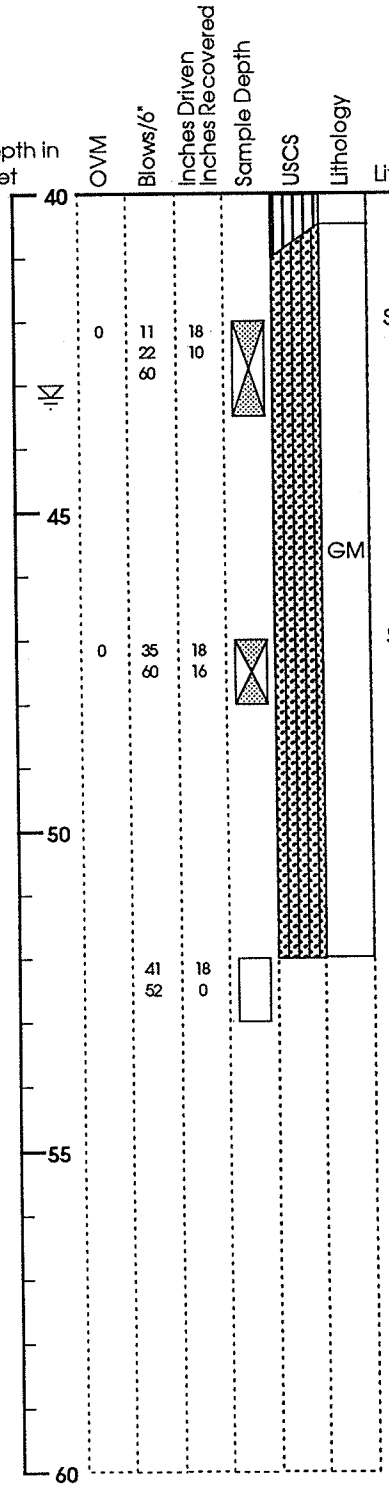
OVM	Blows/6"	Inches Driven	Inches Recovered	Lithologic Description
0	13 26 30	18	16	Gravelly clayey SILT; dark gray (2.5yr 4/0); 70% fines, 30% gravel; well sorted, moist, gravels fine to medium, subangular, very stiff.
0	14 26 30	18	16	Silty gravelly CLAY; dark gray (2.5 4/0); 10% gravel with trace of fine sand and well rounded clasts of granite; moist, slight plasticity, very stiff, some small wood splinters in nose of sample.
0	12 16 16	18	13	Silty CLAY; grayish brown (10yr 5/2); as above; very stiff.
				Drillers indicate gravel begins at 35.0' bgs.
0	13 23 35	18	12	Gravelly SILT; grayish brown (10yr 5/2); 50% silt, 45% gravel and 5% clay; moist, 1/4 to 3" angular gravels (granite), very dense; bottom 3" of sample contains poorly sorted gravels with fine to coarse sand; glacial drift.

Client:	Trans Mountain Pipe Line Co.	Boring No:	TM-B3
Job No:	21199-032-005	Drilling Method:	6.25" O.D. Hollow Stem Auger
Location:	Bellingham, WA	Sample Method:	D&M U-type Split Spoon; 300# hammer with 30" drop
Geologist:	MAO	Drill Contractor:	Hays Drilling
		Drill Date:	12/3/91

Dames & Moore

FILENAME: TM-B3.DRW

Geological Boring Log



Silty sandy GRAVEL; gray (2.5 yr 4/0); 50 - 55% gravel, 25% silt, 20% sand with trace clay; 1 - 2" subangular gravels (granite), sands fine to medium, saturated, poorly sorted, very dense.

Silty sandy GRAVEL; gray (2.5yr 5/0); 60% gravel, 30% silt, 10% sand; 1 - 2" angular basalt and granite clasts; saturated, well sorted, very dense.

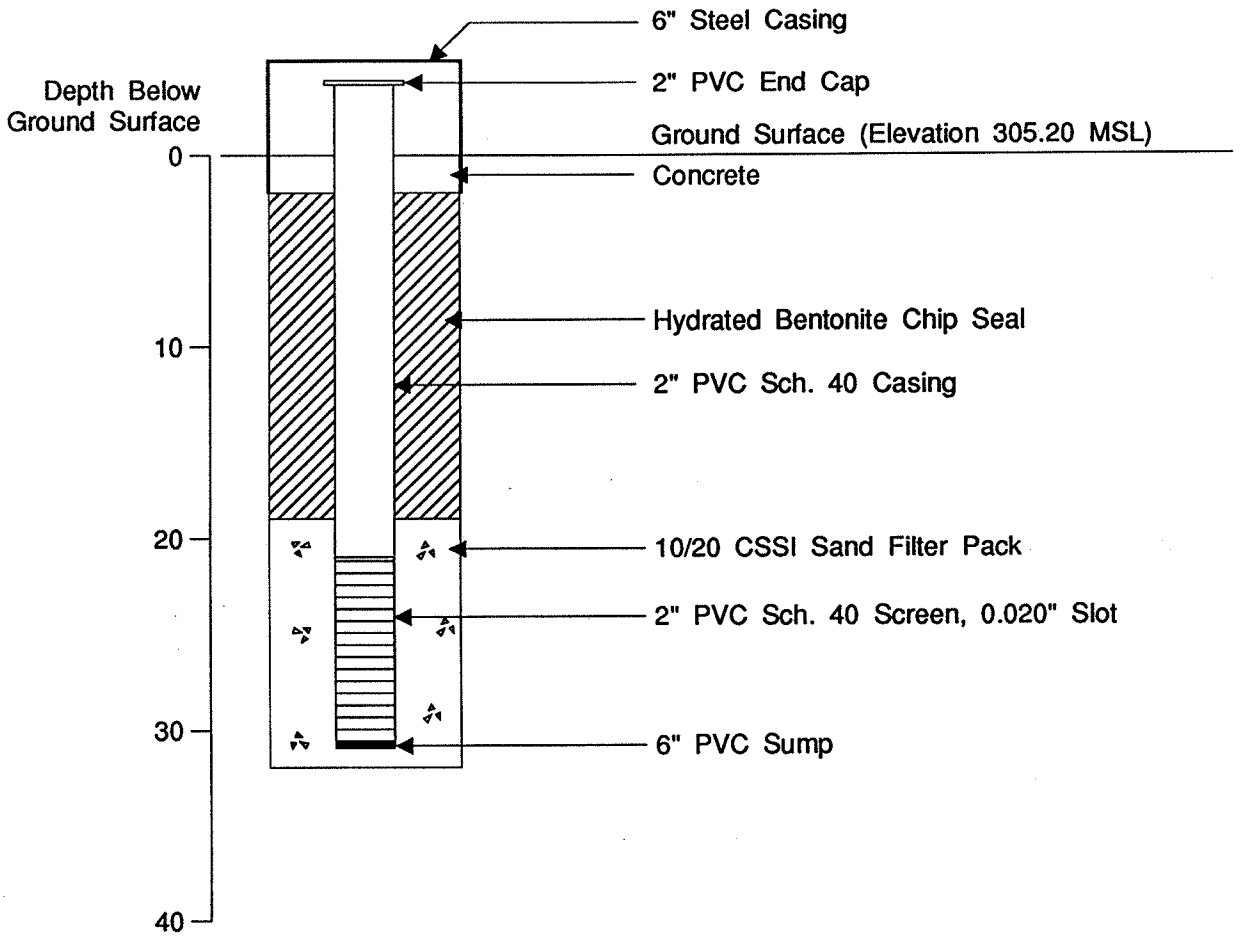
No recovery.
Boring terminated at 52.0' bgs on 12/3/91.
Groundwater encountered at 43.3' bgs.

Client:	Trans Mountain Pipe Line Co.	Boring No:	TM-B3
Job No:	21199-032-005	Drilling Method:	6.25" O.D. Hollow Stem Auger
Location:	Bellingham, WA	Sample Method:	D&M U-type Split Spoon; 300# hammer with 30" drop
Geologist:	MAO	Drill Contractor:	Hays Drilling
		Drill Date:	12/3/91

Dames & Moore

FILENAME: TM-B3.DRW

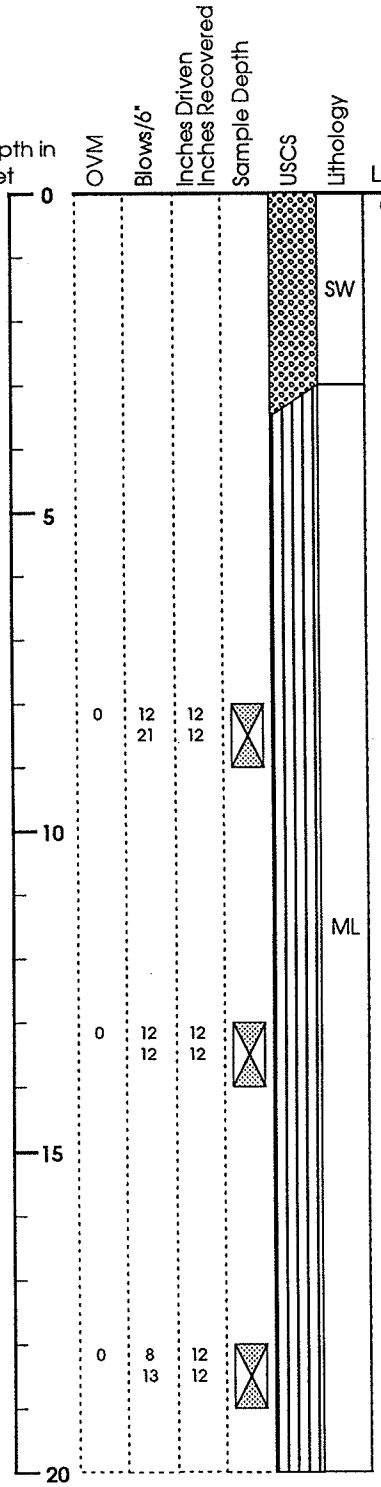
TMMW_03.CDR



Job No. 2; -032-005

SW-3
Monitoring Well Construction Diagram
Dames & Moore

Geological Boring Log



Gravelly SAND; 70% fine to coarse poorly sorted sand, 30% gravel with trace silt, 1 - 3" rounded gravels, scattered 6" cobbles (well rounded), loose, moist, no bedding (fill).

Sandy SILT; brown (10yr 5/3); moist.

OVM	Blows/6"	Inches Driven	Inches Recovered	Sample Depth
0	12	12	12	
	21		12	

Sandy SILT; brown (10yr 5/3); 70% silt, 30% sand with scattered 1/2" rounded gravels; well sorted, moist, non plastic, slightly organic, stiff, no bedding, small zones of oxidation staining.

OVM	Blows/6"	Inches Driven	Inches Recovered	Sample Depth
0	12	12	12	
	12		12	

Sandy SILT; brownish gray (2.5 5/2); 75% silt, 25% sand with scattered fine basalt clasts; dense, moist, well sorted, stiff, no bedding observed, non plastic.

OVM	Blows/6"	Inches Driven	Inches Recovered	Sample Depth
0	8	12	12	
	13		12	

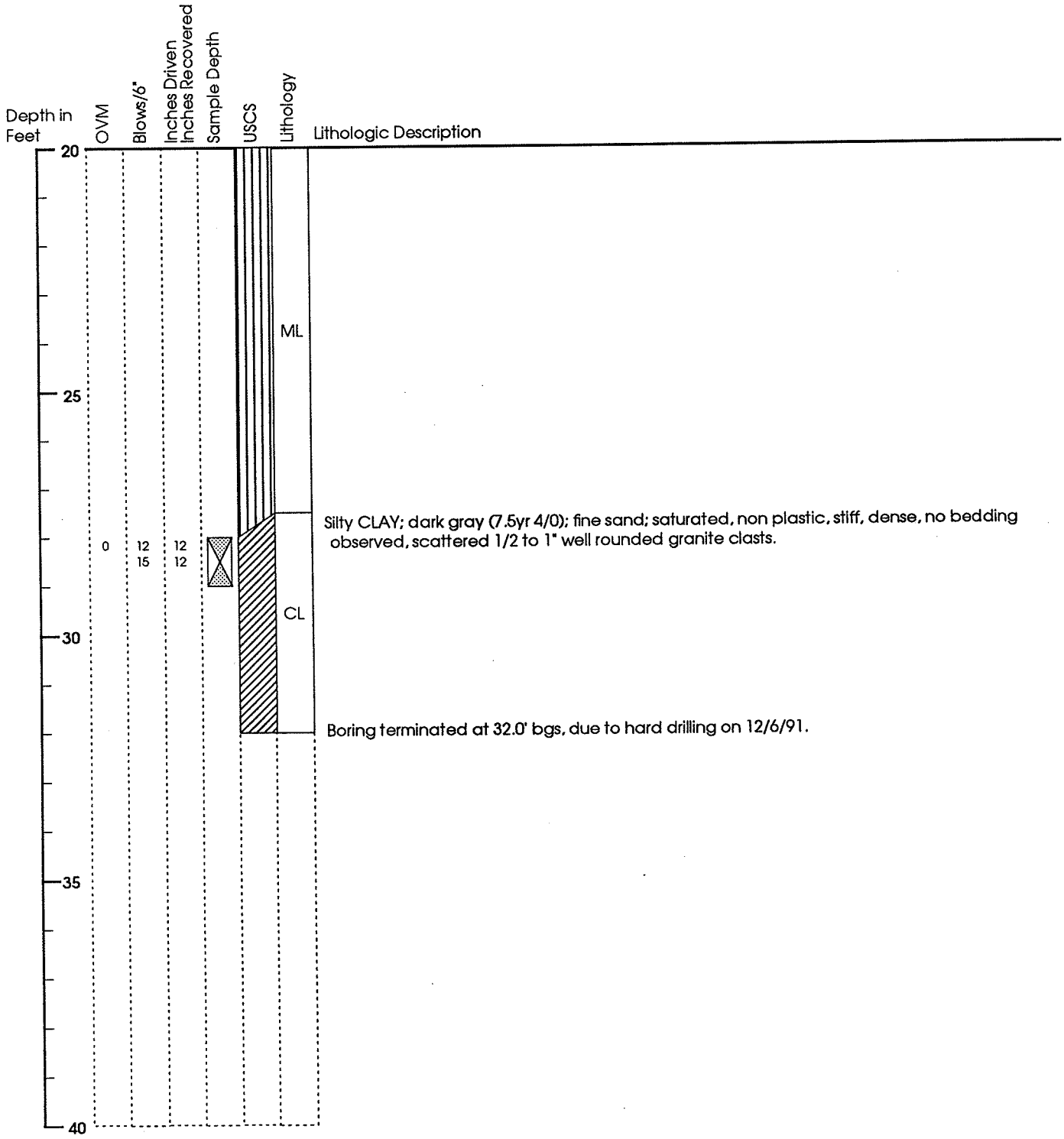
Sandy SILT; gray (7.5yr 4/0); 80% silt, 20% sand; moist, sampler saturated due to 2" of water in bottom of hole, non plastic, no bedding, stiff, scattered fine gravels of basalt.

Client:	Trans Mountain Pipe Line Co.	Boring No:	TM-B5
Job No:	21199-032-005	Drilling Method:	6.25" O.D. Hollow Stem Auger
Location:	Bellingham, WA	Sample Method:	D&M U-type Split Spoon; 300# hammer with 30" drop
Geologist:	MAO	Drill Contractor:	Hays Drilling
		Drill Date:	12/6/91

Dames & Moore

FILENAME: TM-B5.DRW

Geological Boring Log



Client:	Trans Mountain Pipe Line Co.	Boring No:	TM-B5
Job No:	21199-032-005	Drilling Method:	6.25" O.D. Hollow Stem Auger
Location:	Bellingham, WA	Sample Method:	D&M U-type Split Spoon; 300# hammer with 30" drop
Geologist:	MAO	Drill Contractor:	Hays Drilling
		Drill Date:	12/6/91

Dames & Moore

FILENAME: TM-B5.DRW

APPENDIX C

Updated As-Built Drawings

KINDER MORGAN

1009 EAST SMITH ROAD
BELLINGHAM, WA 98226
PROJECT #1715005

DESCRIPTION	SHEET NUMBER
TITLE DIAGRAM	01
SYMBOL & LEGEND DIAGRAM	02
PROCESS AND INSTRUMENTATION DIAGRAM - MPE SYSTEM	03
PROCESS AND INSTRUMENTATION DIAGRAM - WATER TREATMENT SYSTEM	04
PROCESS AND INSTRUMENTATION DIAGRAM - CARBON VESSELS	05
PROCESS AND INSTRUMENTATION DIAGRAM - WELL STUB/WELL VAULT DETAILS	06
EQUIPMENT LAYOUT	07
MAIN FLOOR PLAN	08
WALL SECTION	09
THREE LINE AC WIRING DIAGRAM - POWER DISTRIBUTION SYSTEM	E01
MAIN CONTROL PANEL - POWER WIRING	E02
MAIN CONTROL PANEL - PLC DISCRETE INPUTS - BASE UNIT	E03
MAIN CONTROL PANEL - PLC I/O LOGIC - EXPANSION UNIT #1	E04
MAIN CONTROL PANEL - PLC DISCRETE OUTPUTS - BASE UNIT	E05
MAIN CONTROL PANEL - PLC I/O LOGIC OUTPUTS - EXPANSION UNIT #2	E06
MAIN CONTROL PANEL - MOTOR CONTROLS	E07
MAIN CONTROL PANEL - INTRINSIC BARRIERS	E08
MAIN CONTROL PANEL - SWING/BACK PANEL LAYOUT	E09
MAIN CONTROL PANEL - BILL OF MATERIAL	E10

ASBUILT

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

Seneca Companies
The Complete Solution

JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
TITLE DIAGRAM

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: DAN NOLAN
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO. 01

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005501-06

SYMBOL SPECIFICATION

INSTRUMENT TYPE:

PS	PRESSURE SWITCH	SL	STATUS LAMP
PI	PRESSURE INDICATOR	PC	PRESSURE CONTROL
PT	PRESSURE TRANSDUCER	VI	VACUUM INDICATOR
FE	FLOW ELEMENT	TSH	TEMPERATURE SWITCH HIGH
FI	FLOW INDICATOR	DP	DIFFERENTIAL PRESSURE
FQI	FLOW METER (TOTALIZING)	PSL	PRESSURE SWITCH LOW
FT	FLOW TRANSMITTER	PSH	PRESSURE SWITCH HIGH
CI	CAPACITIVE SENSOR	LSHH	LEVEL SWITCH HIGH HIGH
TI	TEMPERATURE INDICATOR	LSH	LEVEL SWITCH HIGH
TT	TEMPERATURE TRANSDUCER	LSL	LEVEL SWITCH LOW
TS	TEMPERATURE SENSOR	HVS	HIGH VACUUM SWITCH
TSH	TEMPERATURE SWITCH	VSL	LOW VACUUM SWITCH
MJ	MECHANICAL JOINT	SOL	SOLENOID
LEL	EXPLOSIVITY METER		

LINE DESIGNATION:

2 - XXX - YY - Z

2 = SIZE IN INCHES

XXX: PROCESS LINE ABBREVIATION

AIR	AIR, ATMOSPHERIC PRESSURE
ASP	AIR SPARGE
BW	BACKWASH
CA	COMPRESSED AIR
CGW	CONTAMINATED GROUNDWATER
D	DRAIN
EFF	EFFLUENT
EXH	EXHAUST
GW	GROUNDWATER
NPW	NON-POTABLE WATER
P	PRODUCT
PW	POTABLE WATER
S	SANITARY
SL	SLUDGE
SP	SAMPLE PORT
SS	STORM SEWER
TF	TOTAL FLUIDS
V	VENT
VAP	VAPOR

YY: PIPING DESIGN TABLE ABBREVIATION

CPVC	CHLORINATED POLYVINYL CHLORIDE
CSP	CARBON STEEL PIPE
COP	COPPER PIPE
CMP	CORRUGATED METAL PIPE
CIP	CAST IRON PIPE
DIP	DUCTILE IRON PIPE
GAL	GALVANIZED STEEL PIPE
PE	POLYETHYLENE PIPE
PP	POLYPROPYLENE PIPE
PVC	POLYVINYL CHLORIDE PIPE
RCP	REINFORCED CONCRETE PIPE
RUB	RUBBER HOSE
SSP	STAINLESS STEEL PIPE
VCP	VITRIFIED CLAY PIPE
SG	SIGHT GLASS

VALVES, FITTINGS & PIPING

- HAND CONTROL
- BLOWDOWN
- GATE VALVE
- CLOSED VALVE
- GLOBE VALVE
- CHECK VALVE
- TRU UNION BALL/CHECK VALVE
- PLUG
- BALL VALVE
- TRU UNION BALL VALVE
- BUTTERFLY OR DAMPER
- NEEDLE VALVE
- DIAPHRAGM VALVE
- THREE WAY VALVE
- ELECTRIC CONTROL GATE
- ELECTRIC BUTTERFLY OR DAMPER
- BLEED OR PURGE CONNECTION
- AIR RELEASE VALVE
- SOLENOID VALVE
- VACUUM RELIEF VALVE
- PRESSURE RELIEF VALVE
- ANTI-SIPHON VALVE
- FOOT VALVE
- FLEXIBLE PIPE
- FLEXIBLE PIPE
- CROSSOVER
- FLANGED CONNECTION
- SCREWED CONNECTION
- UNION
- COUPLING

- EXPANSION JOINT/SLEEVE
- HOSE CONNECTION
- STRAINER
- PLUG
- PIPE CAP
- SLIP UPDRAFT VENT CAP
- ELBOW - TURNED UP
- ELBOW - TURNED DOWN
- ELBOW - 90°
- ELBOW - 45°
- ELBOW - LONG RADIUS
- REDUCING ELBOW
- QUICK CONNECT COUPLING
- BUSHING
- REDUCER (CONCENTRIC)
- TEE - REDUCING
- TEE - OUTLET UP
- TEE - OUTLET DOWN
- TEE
- SAMPLE PORT
- REGULATOR
- FLOW CONTROL VALVE (NONADJUSTABLE)
- FLOW CONTROL VALVE (ADJUSTABLE)
- SPECTACLE FLANGE

ARCHITECTURAL SYMBOL DESIGNATIONS

- 1 — KEY NOTE IDENTIFICATION
- A — SPECIAL CONSTRUCTION NOTES
- 3 — PLAN NOTE IDENTIFICATION
- 2 — VERTICAL GRID REFERENCE LINE
- A — HORIZONTAL GRID REFERENCE LINE
- 1/02 — INDICATES SECTION/DETAIL NUMBER; INDICATES DRAWING SHEET ON WHICH SECTION/DETAIL IS SHOWN
- [1/02] — INDICATES SECTION/DETAIL NUMBER; INDICATES DRAWING SHEET ON WHICH SECTION/DETAIL IS SHOWN
- 1/02 — INDICATES AREA SHOWN IN REFERENCED DETAIL
- 1/01 — ELEVATION REFERENCE DRAWING NUMBER
- B/01 — INDICATES SECTION / DETAIL NUMBER; SECTION CUT; INDICATES DRAWING SHEET ON WHICH SECTION IS SHOWN
- 1/02 — TITLE/TYPE OF DRAWING; SCALE OF DRAWING

INSTRUMENTATION CONTROLS & EQUIPMENT

- PUMP
- BLOWDOWN
- M — MOTOR
- MS — MOTOR STARTER
- I — INTERLOCK
- HOA — HAND, OFF, AUTO
- DISCONNECT SWITCH, UNFUSED
- DISCONNECT SWITCH, FUSED

- NORMALLY OPEN FLOAT SWITCH
- NORMALLY CLOSED FLOAT SWITCH
- NORMALLY OPEN CONTACT
- NORMALLY CLOSED CONTACT
- OPEN / CLOSED — TWO POSITION SWITCH
- MS — MOTOR STARTER / COIL
- OL — OVERLOAD RELAY/NORMALLY CLOSED
- MOTOR STARTER W/THERMAL OVERLOAD

ELECTRICAL SYMBOLS

- T_1 T_2 T_3 — THREE PHASE MOTOR
- T_1 T_2 — SINGLE PHASE MOTOR
- H_2 H_1 / X_2 X_1 — CONTROL TRANSFORMER
- CIRCUIT BREAKER
- INLINE FUSE
- FUSE (BOX)
- ISCM — INTRINSICALLY SAFE CONTROL MODULE
- SO — SEAL-OFF
- GROUND
- C — INDICATING LAMP (C = COLOR OF LENS)
- HM — HOUR METER
- ENCLOSURE
- NOT CONNECTED
- CONNECTED
- DEVICE TERMINAL
- CONTROL TERMINAL
- EXTERNAL TERMINAL
- HAZARDOUS AREA/CLASS 1

ASBUILT

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

Seneca Companies
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JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
SYMBOL AND LEGEND DIAGRAM

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: DAN NOLAN
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO. 02

MPE SYSTEM

ASBUILT

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

SUPPLY FAN
NYB #SN-122-M
0.25 HP, 240 V, 1900 CFM

SUPPLY FAN
NYB #SN-122-M
0.25 HP, 240 V, 1900 CFM

EMERGENCY STOP SWITCH (X2)

HEATER
CHROMALOX #CVEP-C-36-41-00-00
3.6 KW, 480V, 1 PHASE
XP

OUTSIDE ENCLOSURE
RED BEACON LIGHT
GREEN BEACON LIGHT
115V, 1 PHASE

FPI
STAINLESS STEEL

DILUTION AIR INTAKE
FILTER/SILENCER
SOLBERG #FS-30P-200

TO HIGH LEVEL ALARM LIGHT ON CONTROL PANEL LSHH

DISCHARGE PUMP ON LSH

DISCHARGE PUMP OFF LSL

WALL

2" SCH80PVC

DPI DWYER 2002

FI DWYER DS-300-2"

3" FLANGED OUTLET

12" FURNCO WITH STEEL PLATE

12"x5" THICK 304LSS MIST ELIMINATOR

4" SCH80PVC

4" FLANGE

4" PLAIN INLET

4" JOMAR BUTTERFLY VALVE

12"x24" STD BLACK PIPE

2.0" FEMALE THREADS

SITE TUBE

120 GALLON KO TANK
92-24-120-200

(0-30" HG) VI

SP 3/8"

8" CLEAN OUT FURNCO WITH STEEL PLATE

1.25" DRAIN

(0-30"HG) VI

2" FLANGED GLOBE VALVE

3" SCH80PVC

INLINE FILTER
SOLBERG #ST-235P-300C
3" INLET / OUTLET

INLINE FILTER
SOLBERG #CT-235P-300C
3" INLET / OUTLET

(0-30"HG) VI

SPILL CONTAINMENT

DWYER #1950P-15-2F
(3-15 PSID) SET @ 13" HG

LSH HM TSH MS LSL I HOA M SOL VSL

LIQUID RING PUMP
DEKKER #VMX0303KA1-01
20 HP, 230/460V. 3 PHASE
2.5" INLET / 3" OUTLET
300 ACFM @ 26" HG

3" GAL

(50-300°F) TI

PI (0-60"WCP) 3/8" SP

3" GAL

HM I MS HOA M

(0-100"WCV) VI

3" SCH80PVC

SVE BLOWER
AMETEK #EN808BA72MXL
7.5 HP, 230/460V. 3 PHASE
2.5" INLET / OUTLET
220 ACFM @ 4" HG

DWYER
TTE-104-W-LCD
SET @ 120°F

TS

DWYER
1950P-8-2F
SET @ 5 PSI

PSH

FILTER/SEPARATOR
SOLBERG #ST-235P-300C
3" INLET / OUTLET

0-30 PSI
(0-60"WCP)

PI

WALL

3" GAL

60"WCP
(0-30 PSI)

PI

TI (50-300°F)

3/8" SP

CONTINUED TO VAPOR PHASE CARBON ON SHEET 05

I MS HOA M

1" DRAIN

HEAT EXCHANGER
AMERICAN INDUSTRIAL #ACA-3301-3E
0.5 HP, 230/460V. 3 PHASE

BRASS

1" POLY FLEX RECURCULATION LINE

BRASS

PSB Header Pipe

Continued See Markups on sheet 6

WALL

1" DRAIN

PMS Header pipe

Continued See Markups on sheet 4D

2" SIGHT GLASS SG

2" SIGHT GLASS SG

1/4" VI

SP 3/8"

4" JOMAR BUTTERFLY VALVE

1/4" VI

SP 3/8"

SENECA INSTALL ON-SITE

I MS HOA M

(0-60PSI) PI

SP 1/4"

1.5" SCH80PVC

1.25" SCH80PVC

PROGRESSIVE CAVITY TRANSFER PUMP
CONTINENTAL #CP56C-CSQM
1.0 HP, 230/460V, 3 PHASE
15 GPM @ 25 PSI
1.5" INLET / 1.25" OUTLET

PSH

MERCOID
SA1111E-S5-K2
SET @ 25 PSI

DWYER
ROTOMETER
#VFC-143-EC

FI

CONTINUED TO OIL/WATER SEPARATOR ON SHEET 04

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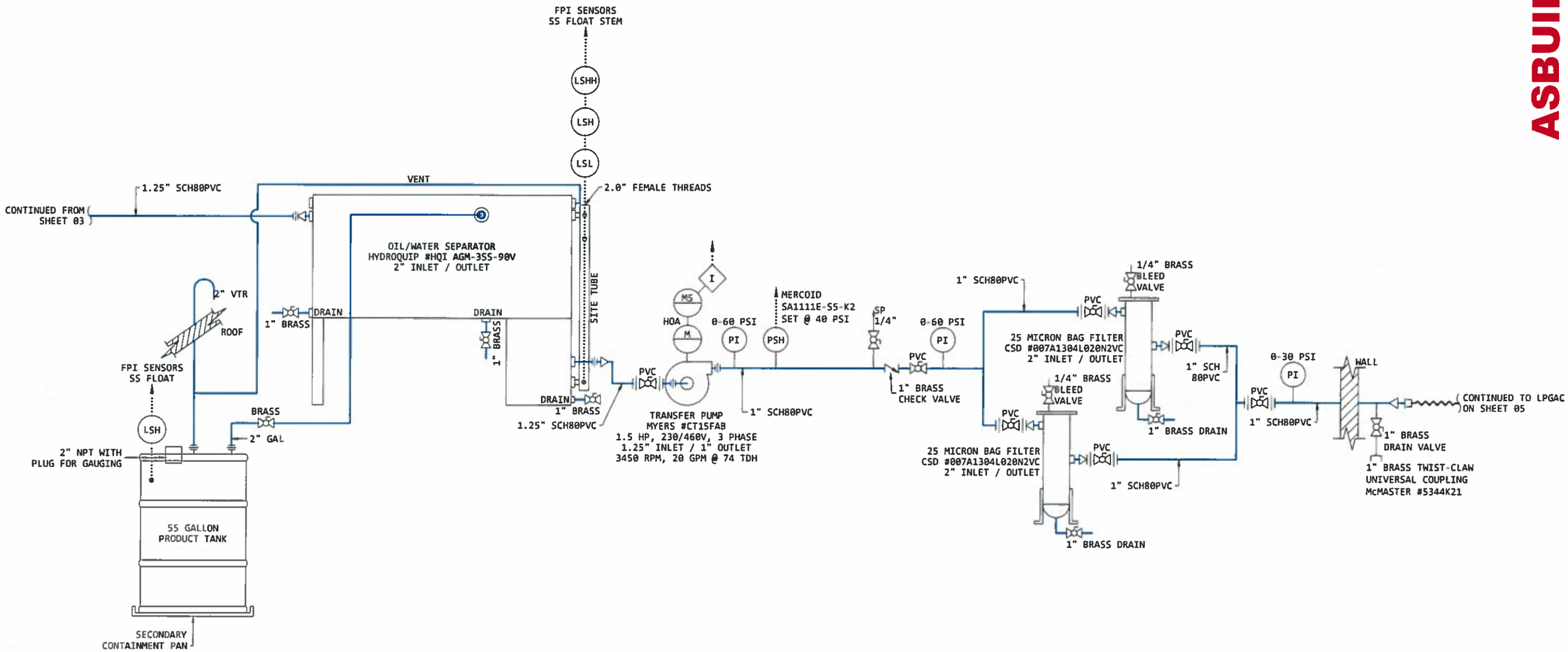
JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
PROCESS AND INSTRUMENTATION DIAGRAM

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: DAN NOLAN
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO: ~~03~~ 4A

FILE LOCATION: I:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005S01-06

WATER TREATMENT SYSTEM



No
Changes
needed

ASBUILT

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

Seneca Companies
The Complete Solution

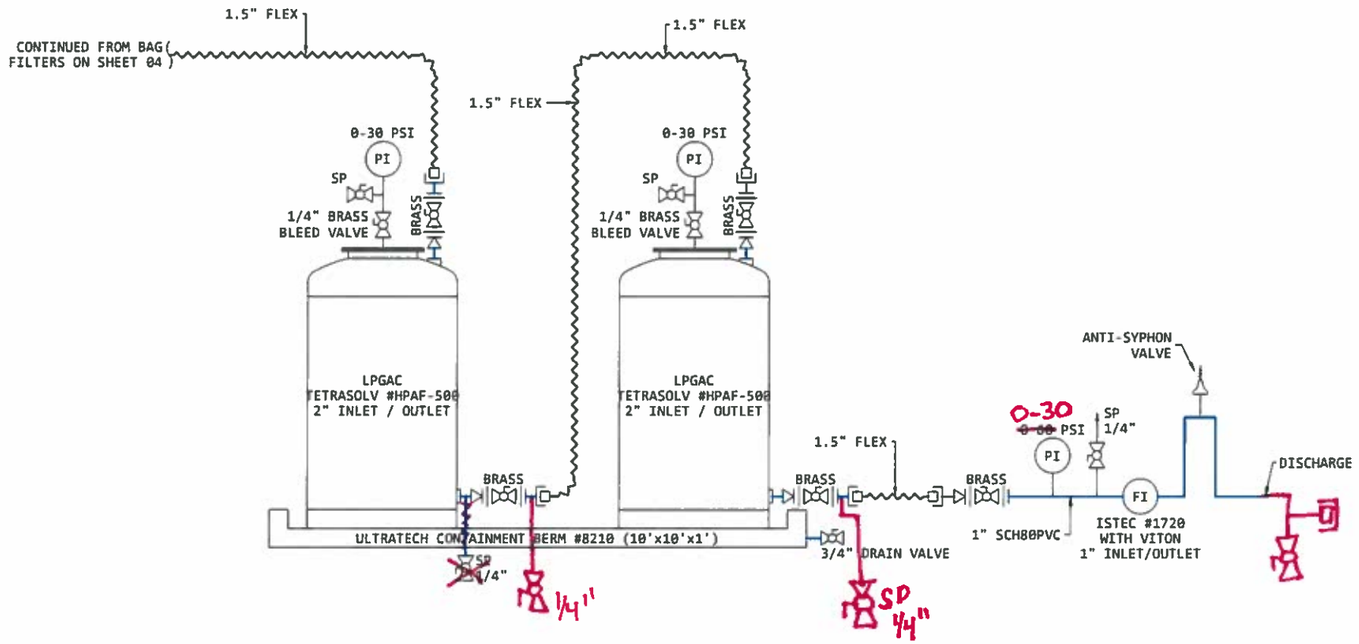
JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

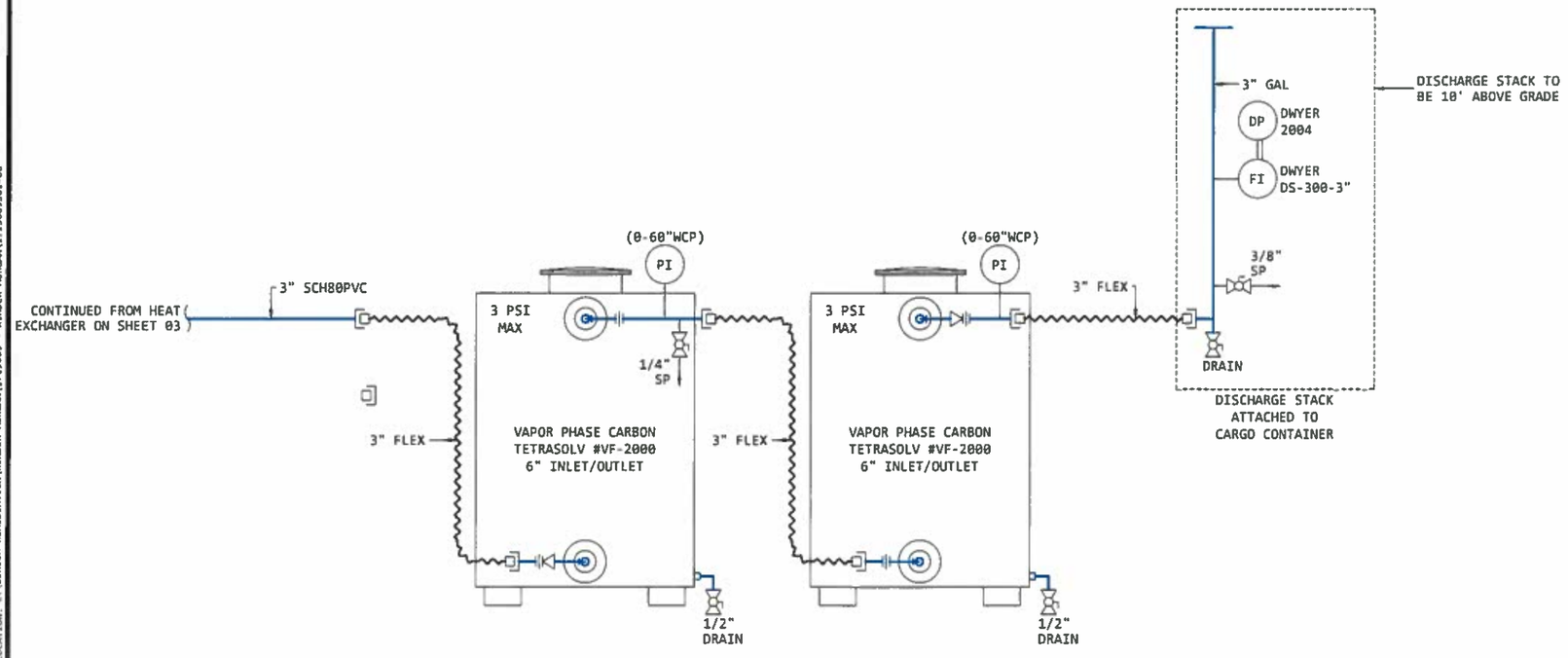
SHEET TITLE:
PROCESS AND INSTRUMENTATION DIAGRAM

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: DAN NOLAN
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO: 04 B

FILE LOCATION: I:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005S01-06

CARBON VESSELS





ASBUILT

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

Seneca Companies
The Complete Solution

JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
PROCESS AND INSTRUMENTATION DIAGRAM

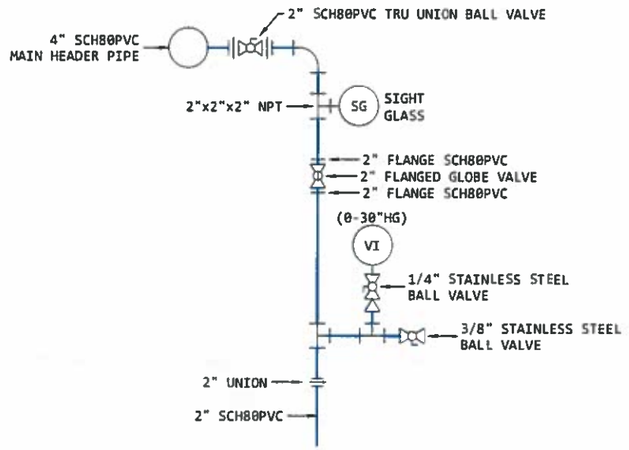
DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: DAN NOLAN
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO. ~~05~~ 4C

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005501.06

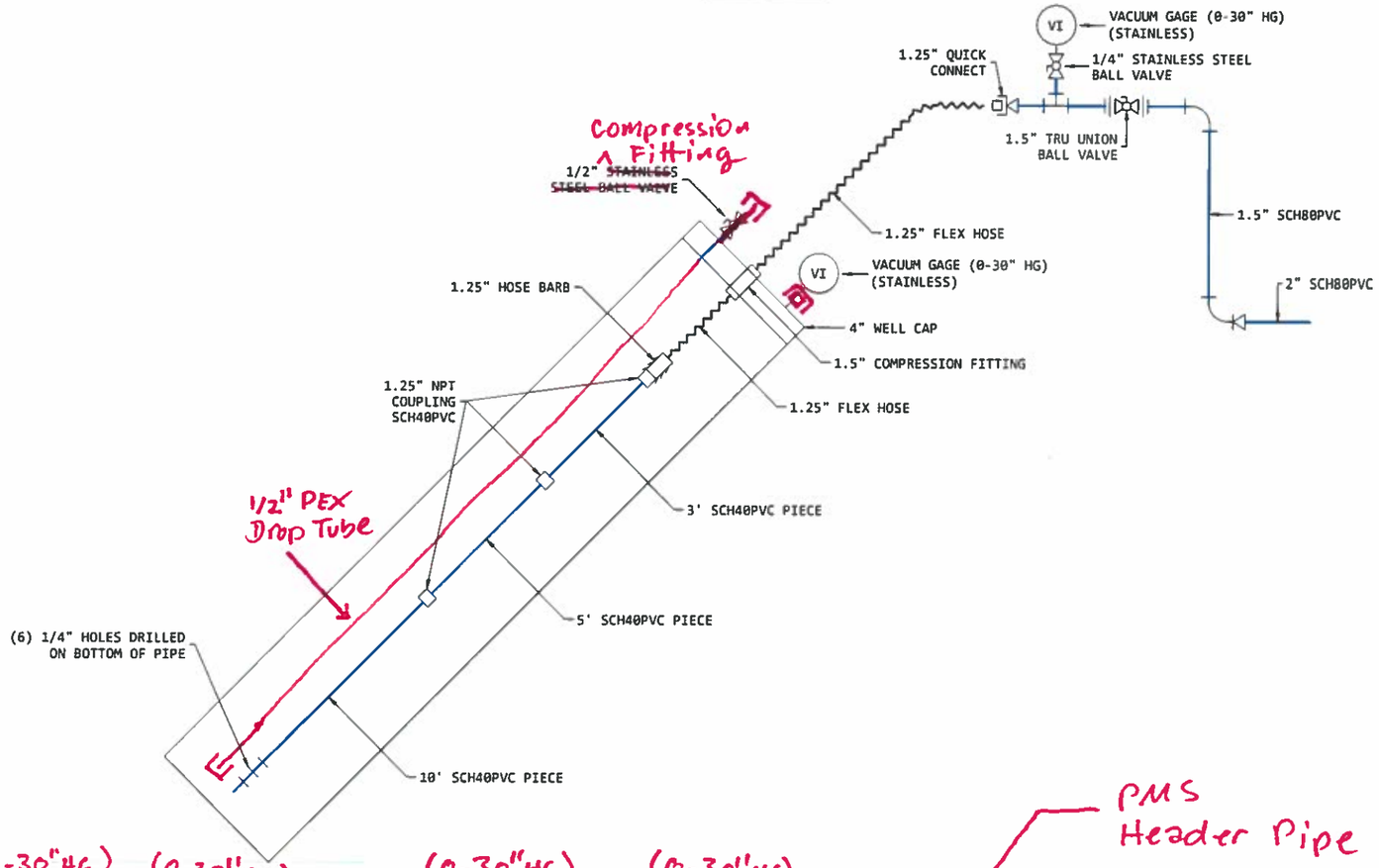
WELL STUB/WELL VAULT DETAILS

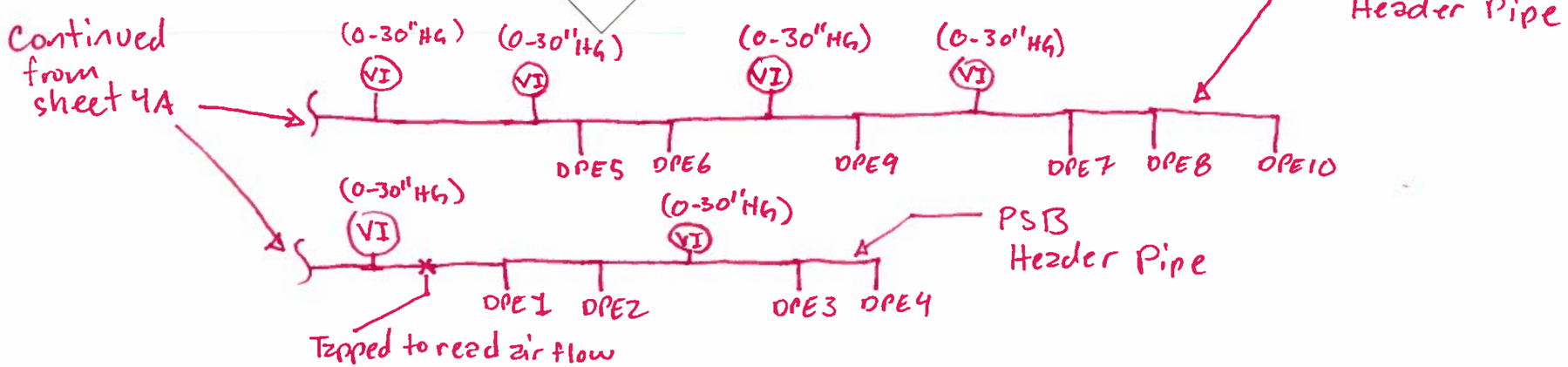
ASBUILT

WELL STUB



WELL VAULT





REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

Seneca Companies
The Complete Solution

JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

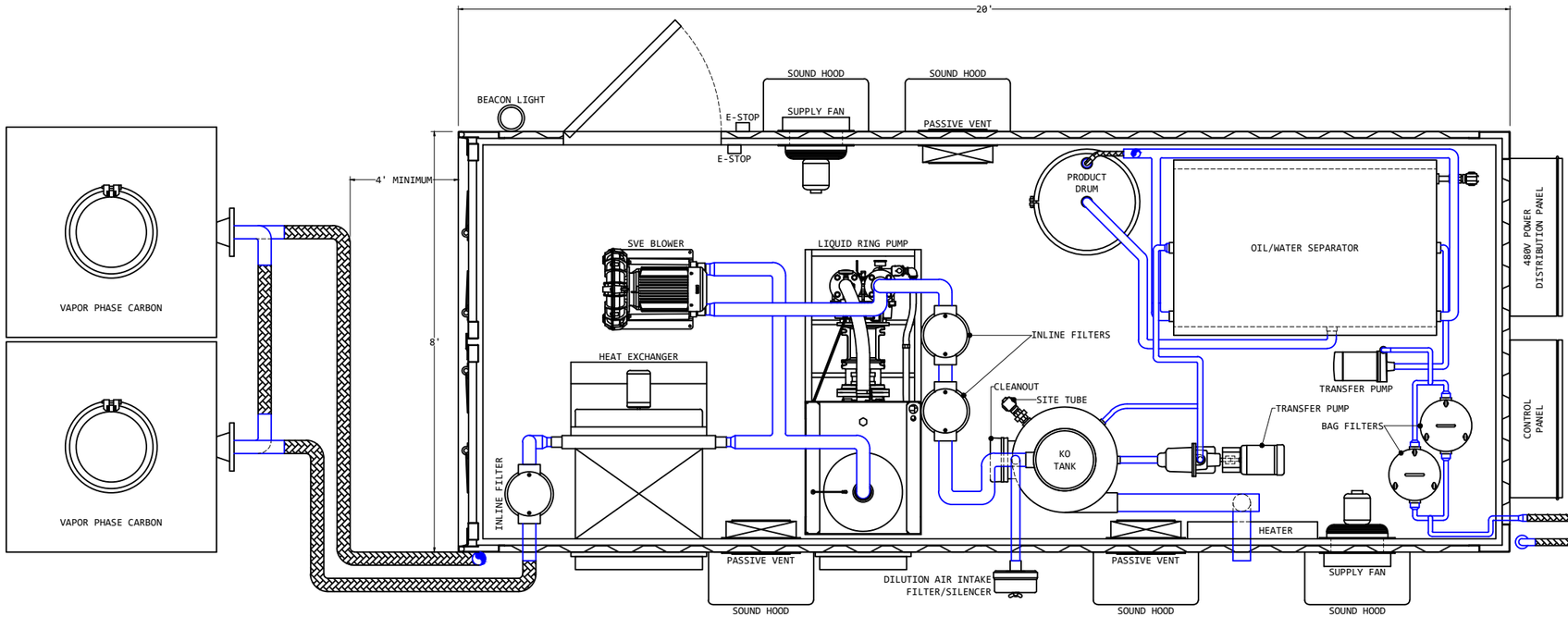
SHEET TITLE:
PROCESS AND INSTRUMENTATION DIAGRAM

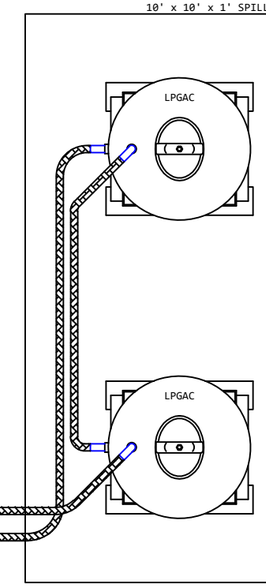
DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: DAN NOLAN
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO: 06 4D

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005501-06

EQUIPMENT LAYOUT

ASBUILT





NOTES:

1. PIPE SUPPORTS TO BE INSTALLED AS REQUIRED.
2. REFER TO PROCESS AND INSTRUMENTATION DIAGRAM FOR PIPING DETAIL (VALVES, SAMPLE PORTS, ETC.) AND SEQUENCE OF OPERATION.

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

Seneca Companies
The Complete Solution

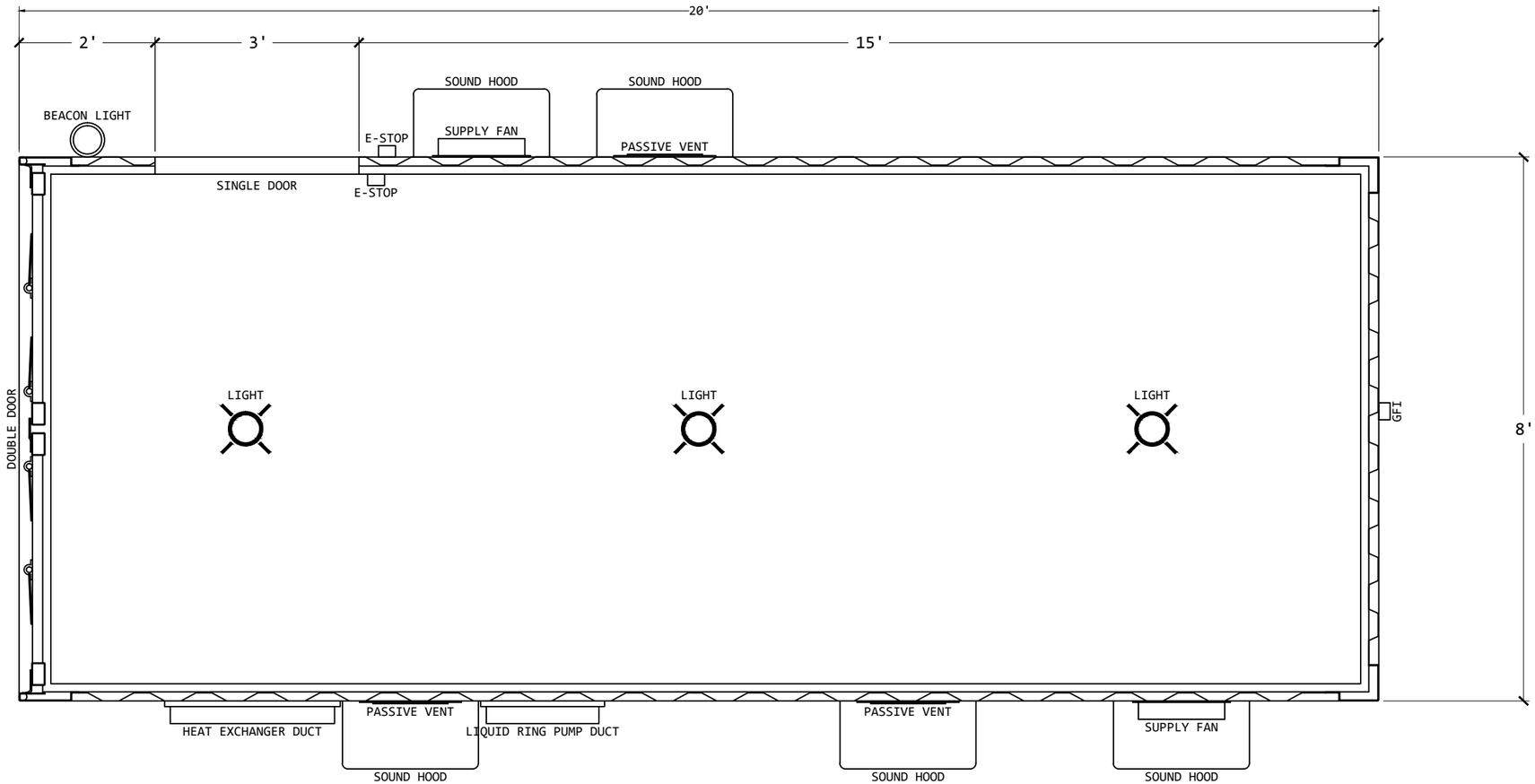
JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
EQUIPMENT LAYOUT

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: DAN NOLAN
SCALE: 3/8"=1'
PROJECT NO: 1715005
SHEET NO. 07

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005S07-09

MAIN FLOOR PLAN



ASBUILT

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

Seneca Companies
The Complete Solution

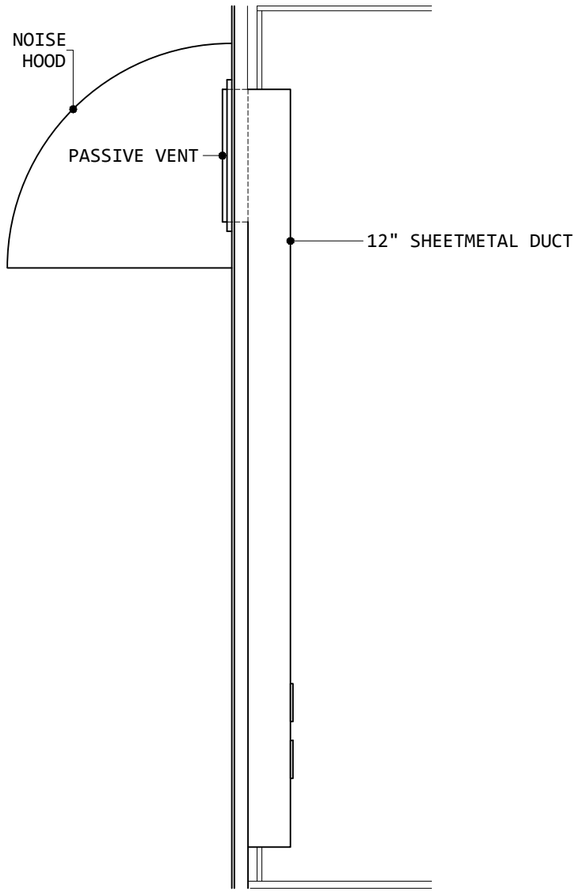
JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
MAIN FLOOR PLAN

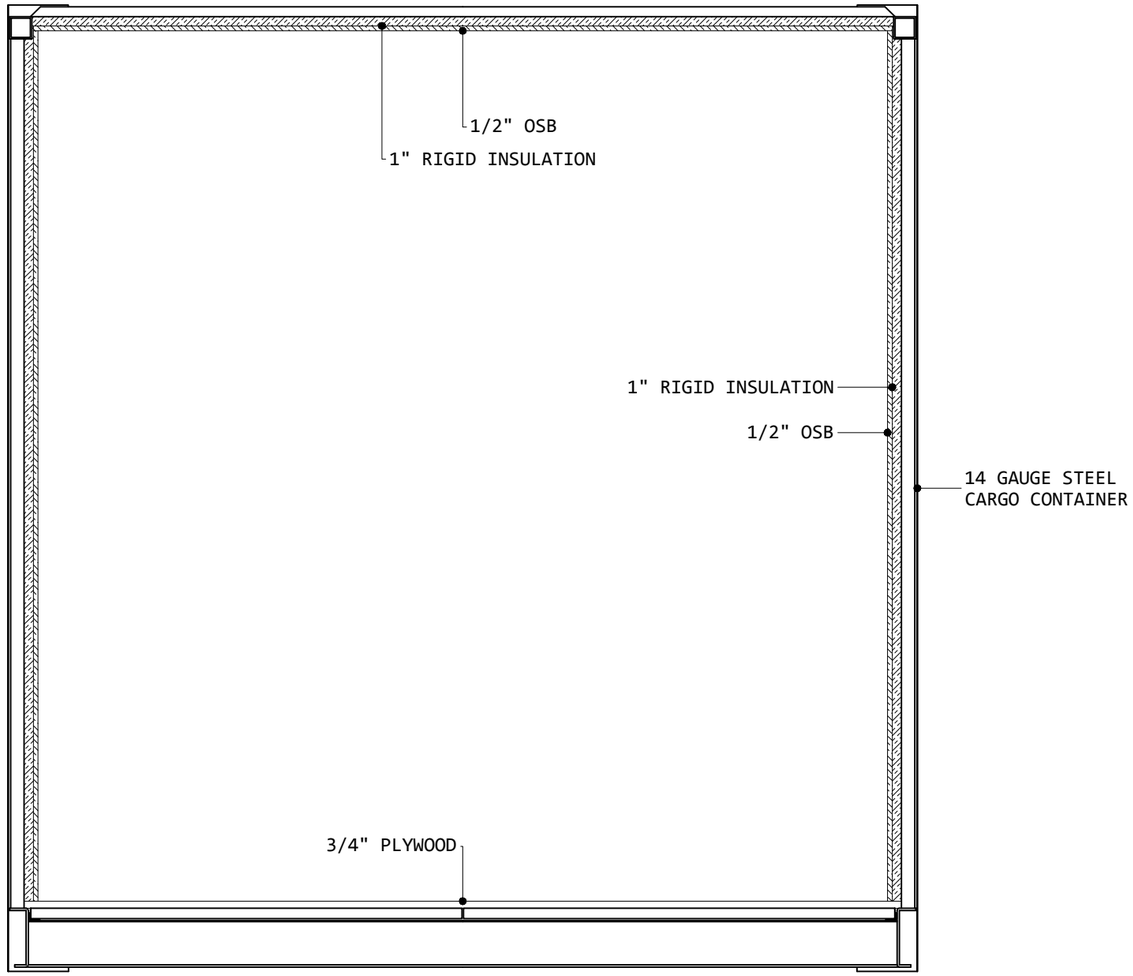
DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: DAN NOLAN
SCALE: 1/2"=1'
PROJECT NO: 1715005
SHEET NO. 08

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005S07-09

VENT DETAIL



WALL SECTION



GENERAL NOTES:

1. PIPE SUPPORTS TO BE INSTALLED AS REQUIRED.
2. REFER TO PROCESS AND INSTRUMENTATION DIAGRAM
3. FOR PIPING DETAIL (VALVES, SAMPLE PORTS, ETC.) AND SEQUENCE OF OPERATION.
4. SITE POWER - 480V, 3 PHASE, 3 WIRE.
5. SITE UTILITY CONNECTION BY OTHERS.

ASBUILT

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

Seneca Companies
The Complete Solution

JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
WALL SECTION

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: DAN NOLAN
SCALE: 3/4"=1'
PROJECT NO: 1715005
SHEET NO. 09

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005S07-09

ASBUILT

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

POWER SUPPLY
480 VAC, 3 PHASE, 3 WIRE, W/GRD, 100A
SUPPLIED BY OTHERS

L1 L2 L3
METER SOCKET
BY OTHERS
MAIN DISCONNECT
RATED: 480VAC, 3 PHASE
3 WIRE, 100 AMP
FUSED @ 100A
6GA
GRD
3GA 3GA 3GA
MAIN CONTROL PANEL
POWER DISTRIBUTION
MD1

NOTES:
1. CABLE SIZED PER LOCAL CODE AND UTILITY REQUIREMENTS.
2. SIZES SHOWN ARE MINIMUM REQUIRED RATINGS.
3. BOND NEUTRAL AND GROUNDS PER NEC CODE FOR UTILITY POWER DISTRIBUTION.
4. PHASE "B" (L2), MUST BE HIGH LEG ON DELTA SYSTEM. (MARKED WITH ORANGE TAPE)
5. ALL MAINTENANCE SHALL BE PERFORMED WITH DEVICES DISCONNECTED FROM THE POWER SUPPLY.
6. ALL SPLICES SHALL BE MECHANICALLY SECURE AND PROVIDE A GOOD ELECTRICAL CONTACT.
7. MINIMUM SUPPLY CONDUCTOR AMPACITY - 100 AMPS
   MAXIMUM SUPPLY OVER CURRENT PROTECTIVE DEVICE - 100 AMPS
   TYPE OF OVER CURRENT PROTECTIVE DEVICE - "R" CLASS FUSES
8. FLEX CONDUIT SHALL BE SECURED AT A MINIMUM EVERY 4 FEET.

CONTROL PANEL
480 VAC, 3 PHASE
480VAC
CP-2

CB18
100A
BRN 3GA
ORG 3GA
YEL 3GA

L1
L2
L3
480
L1
L2
240/120
N

BRN 12GA
YEL 12GA
F1
600VAC
20A
H1 H2 H3 H4 H5 H6 H7 H8
CONTROL TRANSFORMER
5.0 KVA
480-120/240V
X1 X2 X3 X4
F2
20A
WHT 12ga
WHT 12GA
RED 12GA
BLK 12GA
CB1
10A
BLK 14GA
WHT
L G N
L G N
1
2
BLK 14GA
WHT
CONTINUED ON TOP LEFT
OF SHEET E02

BLK
RED
WHT
CB2
20A
BLK 12GA
WHT
GFI
RECEPTACLE
120 VAC, 20 AMP

CB3
15A
BLK 12GA
INTERIOR
EX-ROOM
LIGHT SWITCH
150W
150W
150W
120 VAC, 2.5 AMPS
1 PHASE

WHT 12GA
F3
15A
BRN 12GA
ORG 12GA
YEL 12GA
HC
L1 L2 L3
T1 T2 T3
ORG 12GA
BRN 12GA
YEL 12GA
THERMOSTAT
HEATER
3.6 KW, 480 VAC
3 PHASE, 4.9 FLA

CB5
6-10A
MC-1
ORG
BRN
YEL 14GA
1 2 3
SYMCOM
POWER MONITOR
POWER MONITOR
460 VAC, 3 PHASE
6.0 WATTS

CB6
15A
RED 12GA
BLK
MOTOR M1
SUPPLY FAN #1
0.25 HP, 230 VAC, 1 PHASE
2.6 FLA

CB7
15A
RED 12GA
BLK
MOTOR M2
SUPPLY FAN #2
0.25 HP, 230 VAC, 1 PHASE
2.6 FLA

CB8
12A
LUCC05FU
CONTROL UNIT
ORG
BRN
YEL 12GA
MOTOR M3
KO PUMP
1.5 HP, 460 VAC, 3 PHASE
2.3 FLA

CB9
12A
LUB32
LUCC05FU
CONTROL UNIT
ORG
BRN
YEL 12GA
MOTOR M4
DISCHARGE PUMP
1.5 HP, 460 VAC, 3 PHASE
2.3 FLA

CB10
12A
LUB32
LUCC05FU
CONTROL UNIT
ORG
BRN
YEL 12GA
MOTOR M5
HEAT EXCHANGER
0.75 HP, 460 VAC, 3 PHASE
1.4 FLA

CB11
1.0A
LUB12
LUCA18FU
CONTROL UNIT
ORG
BRN
YEL 12GA
MOTOR M6
SVE BLOWER
7.5 HP, 460 VAC, 3 PHASE
9.3 FLA

CB12
60A
LUB32
MC7
L1 L2 L3
T1 T2 T3
OL7
L1 L2 L3
T1 T2 T3
ORG
BRN
YEL 10GA
MOTOR M7
LIQUID RING PUMP
20 HP, 480 VAC, 3 PHASE
24.0 FLA

HAZARDOUS AREA CLASS 1, DIV. 2, GROUP D
NON-HAZARDOUS AREA

Seneca Companies
The Complete Solution

JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
THREE LINE AC WIRING DIAGRAM
POWER DISTRIBUTION SYSTEM

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: RICH RICHARDS
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO. E01

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005E01-10

NOTES:
1. FOR CONNECTING TO ONLY RESISTIVE NON-ENERGY STORING DEVICES.
2. INSTALL IN ACCORDANCE WITH ART. 504 OF THE NATIONAL ELECTRIC CODE.
3. MAXIMUM CABLE LENGTH IS 900 FEET.
4. WARNING - SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY.
5. PROVIDES INTRINSICALLY SAFE CIRCUIT EXTENSIONS FOR USE IN CLASS 1, DIV. 2, GROUPS C & D, HAZARDOUS LOCATIONS WHEN CONNECTED PER INSTALLATION.
6. SMALLEST WIRE SIZE FOR BRANCH CIRCUITS IS 14 AWG.
7. MOTOR OVERLOAD RELAY MUST BE MANUALLY RESET.
8. LOCATED IN 480VAC PANEL (CP-2).

LEGEND:

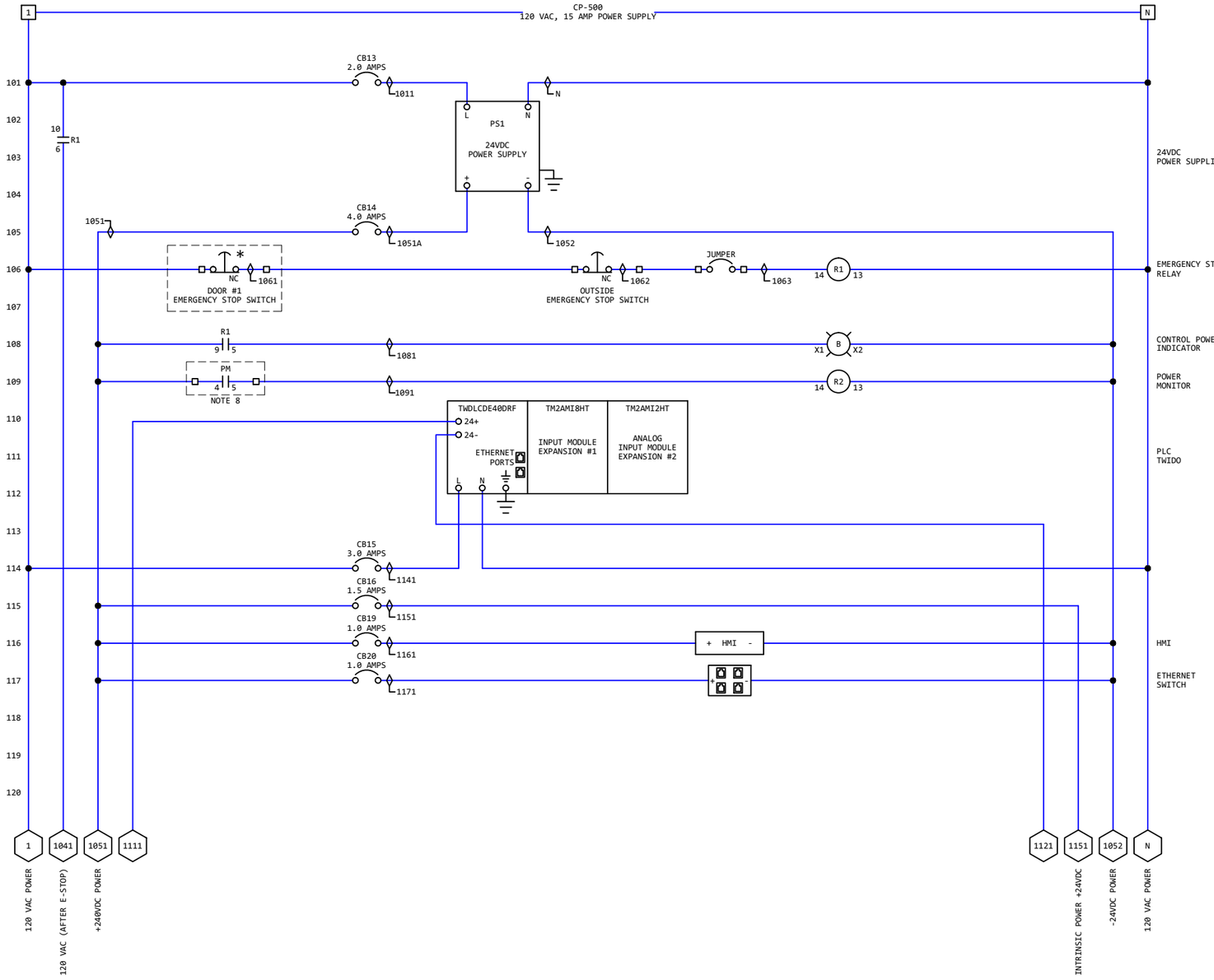
- – – – – DASHED LINES DENOTE WIRING TO FIELD DEVICES
- —E— DENOTES ETHERNET CABLE
- * DENOTES HAZARDOUS LOCATION
- ● DENOTES EQUIPMENT LOCATED IN FIELD LOCATION

LINE NUMBER DESCRIPTION

WIRING DIAGRAM SHEET NUMBER (1 OR 2 DIGITS) — LINE NUMBER (ALWAYS 2 DIGITS)

WIRE NUMBER DESCRIPTION

WIRING DIAGRAM SHEET NUMBER (1 OR 2 DIGITS) — WIRE NUMBER (1 OR 2 DIGITS) — LINE NUMBER (ALWAYS 2 DIGITS)



REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

ASBUILT

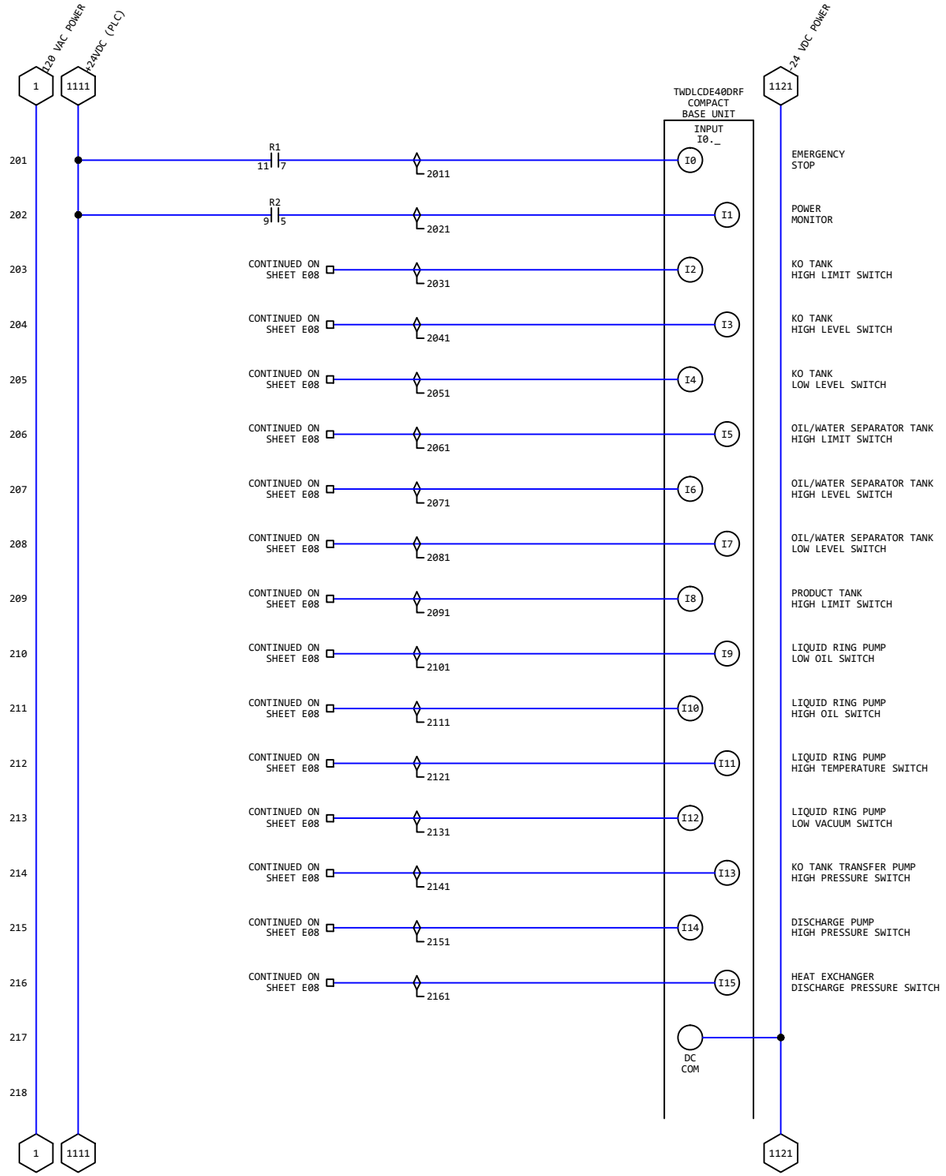
Seneca Companies
The Complete Solution

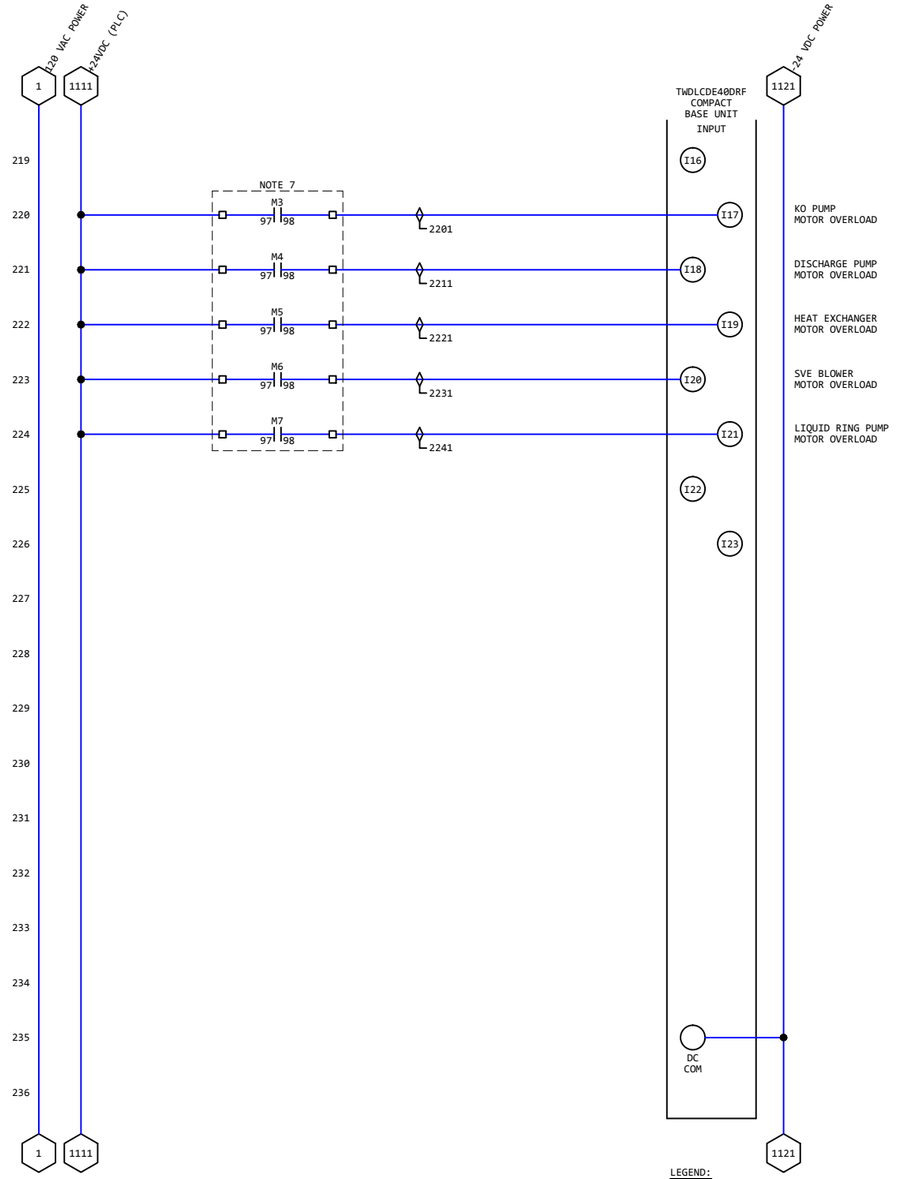
JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
MAIN CONTROL PANEL - POWER WIRING

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: RICH RICHARDS
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO. E02

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005E01-10





NOTES:
1. CABLE SIZED PER LOCAL CODE AND UTILITY REQUIREMENTS.
2. SIZES SHOWN ARE MINIMUM REQUIRED RATINGS.
3. ALL MAINTENANCE SHALL BE PERFORMED WITH DEVICES DISCONNECTED FROM THE POWER SUPPLY.
4. ALL SPLICES SHALL BE MECHANICALLY SECURE AND PROVIDE A GOOD ELECTRICAL CONTACT.
5. MINIMUM SUPPLY CONDUCTOR AMPACITY - 100 AMPS
   MAXIMUM SUPPLY OVER CURRENT PROTECTIVE DEVICE - 100 AMPS
6. FLEX CONDUIT SHALL BE SECURED AT A MINIMUM EVERY 4 FEET.
7. LOCATED IN 480V PANEL - CP-2.
8. LOCATED IN CONTROL PANEL - CP-1.
9. FOR CONNECTING TO ONLY RESISTIVE NON-ENERGY STORING DEVICES.
10. INSTALL IN ACCORDANCE WITH ART. 504 OF THE NATIONAL ELECTRIC CODE.
11. MAXIMUM CABLE LENGTH IS 900 FEET.
12. WARNING - SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY.
13. PROVIDES INTRINSICALLY SAFE CIRCUIT EXTENSIONS FOR USE IN CLASS 1, DIV. 2, GROUPS C & D, HAZARDOUS LOCATIONS WHEN CONNECTED PER INSTALLATION.
14. SMALLEST WIRE SIZE FOR BRANCH CIRCUITS IS 14 AWG.
15. MOTOR OVERLOAD RELAY MUST BE MANUALLY RESET.

LEGEND:
- – – – DASHED LINES DENOTE WIRING TO FIELD DEVICES
- —E— DENOTES ETHERNET CABLE
- —F/O— DENOTES FIBER OPTIC CABLE
- * DENOTES HAZARDOUS LOCATION (AREA 2)
- ● DENOTES EQUIPMENT LOCATED IN FIELD LOCATION

LINE NUMBER DESCRIPTION

WIRING DIAGRAM SHEET NUMBER (1 OR 2 DIGITS) — LINE NUMBER (ALWAYS 2 DIGITS)

WIRE NUMBER DESCRIPTION

WIRING DIAGRAM SHEET NUMBER (1 OR 2 DIGITS) — WIRE NUMBER (1 OR 2 DIGITS); LINE NUMBER (ALWAYS 2 DIGITS)

ASBUILT

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

Seneca Companies
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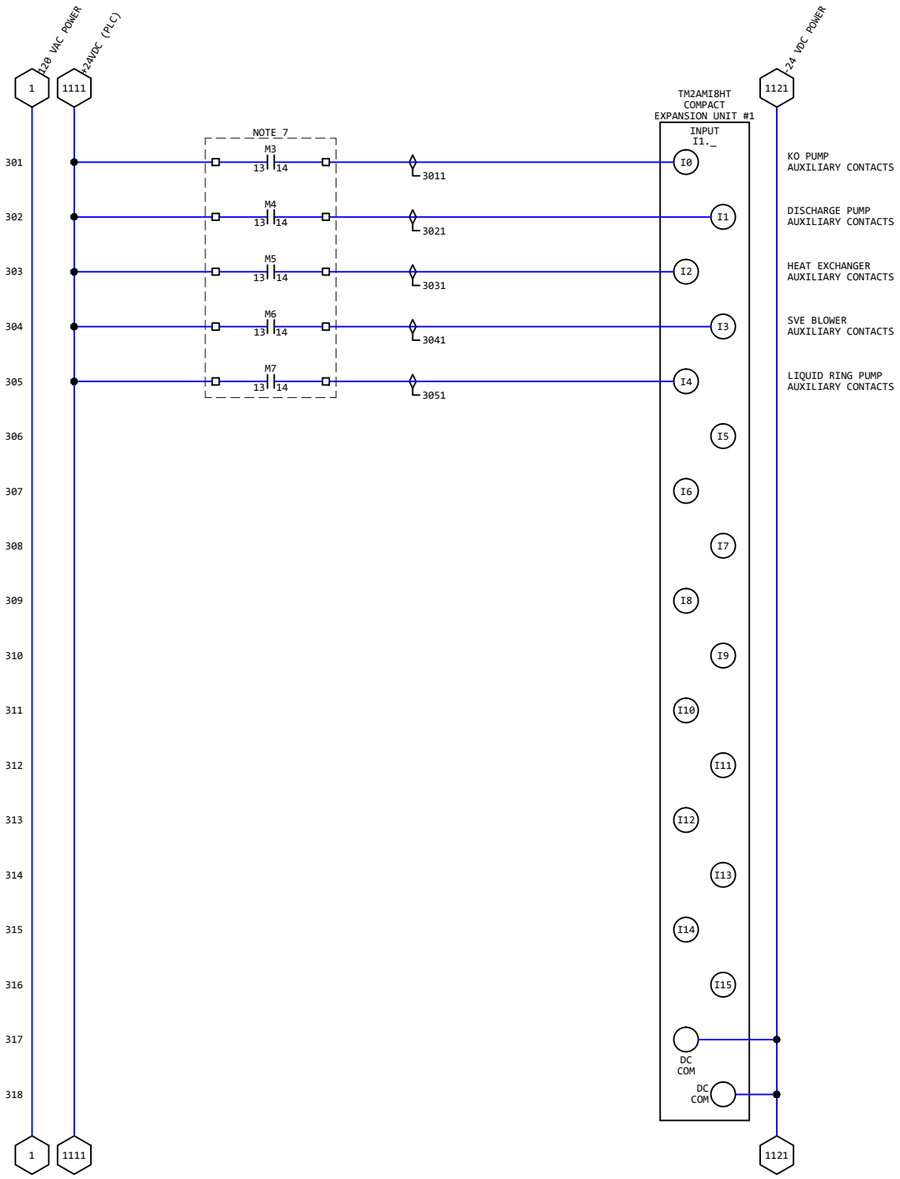
JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
MAIN CONTROL PANEL - PLC DISCRETE INPUTS - BASE UNIT

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: RICH RICHARDS
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO. E03

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005E01-10



NOTES:
1. CABLE SIZED PER LOCAL CODE AND UTILITY REQUIREMENTS.
2. SIZES SHOWN ARE MINIMUM REQUIRED RATINGS.
3. ALL MAINTENANCE SHALL BE PERFORMED WITH DEVICES DISCONNECTED FROM THE POWER SUPPLY.
4. ALL SPLICES SHALL BE MECHANICALLY SECURE AND PROVIDE A GOOD ELECTRICAL CONTACT.
5. MINIMUM SUPPLY CONDUCTOR AMPACITY - 100 AMPS
   MAXIMUM SUPPLY OVER CURRENT PROTECTIVE DEVICE - 100 AMPS
6. FLEX CONDUIT SHALL BE SECURED AT A MINIMUM EVERY 4 FEET.
7. LOCATED IN 480V PANEL - CP-2.
8. LOCATED IN CONTROL PANEL - CP-1.
9. FOR CONNECTING TO ONLY RESISTIVE NON-ENERGY STORING DEVICES.
10. INSTALL IN ACCORDANCE WITH ART. 504 OF THE NATIONAL ELECTRIC CODE.
11. MAXIMUM CABLE LENGTH IS 900 FEET.
12. WARNING - SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY.
13. PROVIDES INTRINSICALLY SAFE CIRCUIT EXTENSIONS FOR USE IN CLASS 1, DIV. 2, GROUPS C & D, HAZARDOUS LOCATIONS WHEN CONNECTED PER INSTALLATION.
14. SMALLEST WIRE SIZE FOR BRANCH CIRCUITS IS 14 AWG.
15. MOTOR OVERLOAD RELAY MUST BE MANUALLY RESET.

LEGEND:
- DASHED LINES DENOTE WIRING TO FIELD DEVICES
- E — DENOTES ETHERNET CABLE
- F/O — DENOTES FIBER OPTIC CABLE
- * DENOTES HAZARDOUS LOCATION (AREA 2)
- ● DENOTES EQUIPMENT LOCATED IN FIELD LOCATION

LINE NUMBER DESCRIPTION
WIRING DIAGRAM SHEET NUMBER (1 OR 2 DIGITS) — LINE NUMBER (ALWAYS 2 DIGITS)

WIRE NUMBER DESCRIPTION
WIRING DIAGRAM SHEET NUMBER (1 OR 2 DIGITS) — WIRE NUMBER (1 OR 2 DIGITS) — LINE NUMBER (ALWAYS 2 DIGITS)

ASBUILT

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

Seneca Companies
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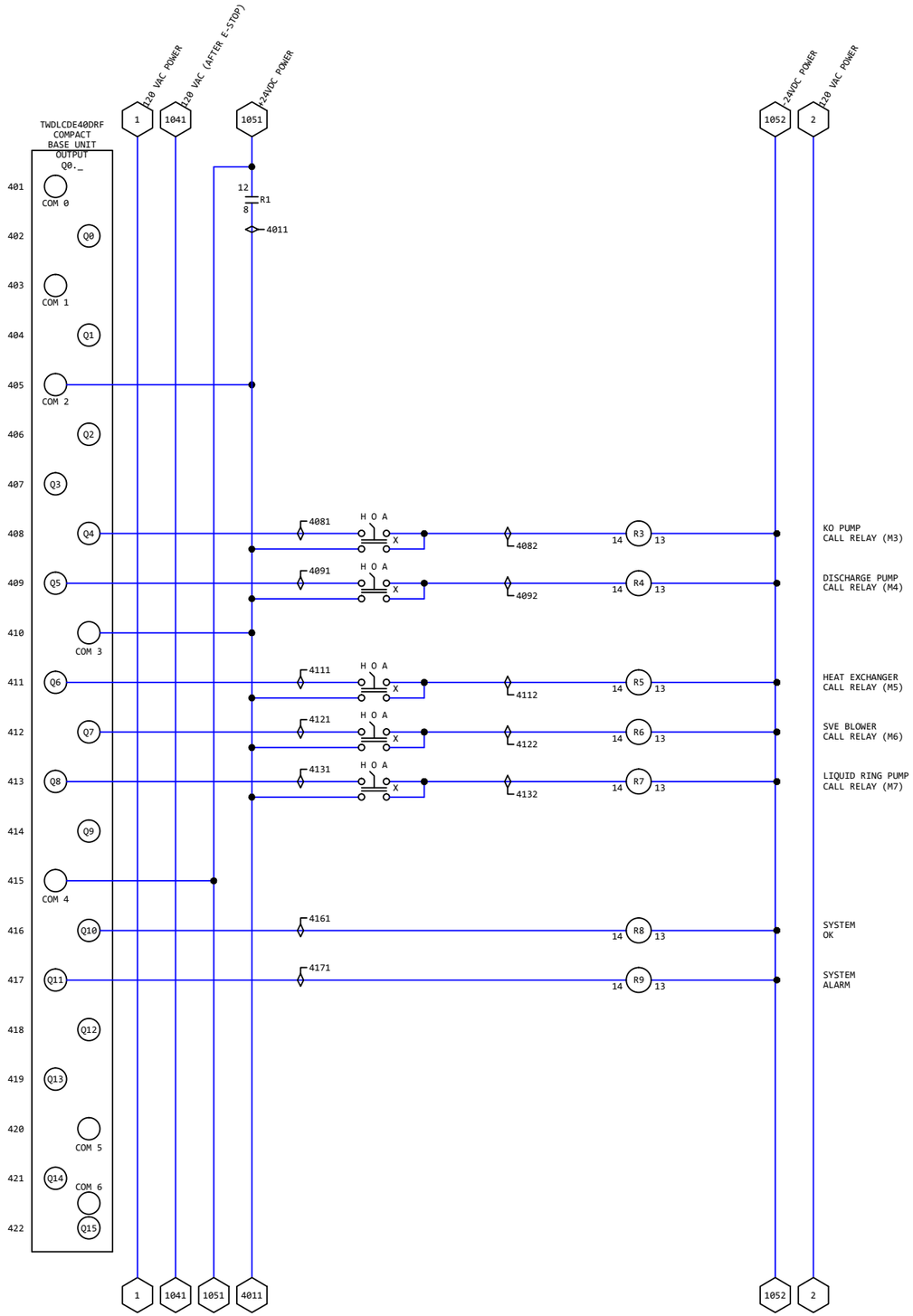
JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
MAIN CONTROL PANEL - PLC I/O LOGIC - EXPANSION UNIT #1

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: RICH RICHARDS
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO. E04

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005E01-10



NOTES:
1. CABLE SIZED PER LOCAL CODE AND UTILITY REQUIREMENTS.
2. SIZES SHOWN ARE MINIMUM REQUIRED RATINGS.
3. ALL MAINTENANCE SHALL BE PERFORMED WITH DEVICES DISCONNECTED FROM THE POWER SUPPLY.
4. ALL SPLICES SHALL BE MECHANICALLY SECURE AND PROVIDE A GOOD ELECTRICAL CONTACT.
5. MINIMUM SUPPLY CONDUCTOR AMPACITY - 100 AMPS
   MAXIMUM SUPPLY OVER CURRENT PROTECTIVE DEVICE - 100 AMPS
6. FLEX CONDUIT SHALL BE SECURED AT A MINIMUM EVERY 4 FEET.
7. LOCATED IN 480V PANEL - MC-1.
8. LOCATED IN CONTROL PANEL - CP-1.
9. FOR CONNECTING TO ONLY RESISTIVE NON-ENERGY STORING DEVICES.
10. INSTALL IN ACCORDANCE WITH ART. 504 OF THE NATIONAL ELECTRIC CODE.
11. MAXIMUM CABLE LENGTH IS 900 FEET.
12. WARNING - SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY.
13. PROVIDES INTRINSICALLY SAFE CIRCUIT EXTENSIONS FOR USE IN CLASS 1, DIV. 2, GROUPS C & D, HAZARDOUS LOCATIONS WHEN CONNECTED PER INSTALLATION.
14. SMALLEST WIRE SIZE FOR BRANCH CIRCUITS IS 14 AWG.
15. MOTOR OVERLOAD RELAY MUST BE MANUALLY RESET.

LEGEND:
- – – – DASHED LINES DENOTE WIRING TO FIELD DEVICES
- —E— DENOTES ETHERNET CABLE
- —F/O— DENOTES FIBER OPTIC CABLE
- * DENOTES HAZARDOUS LOCATION (AREA 2)
- ● DENOTES EQUIPMENT LOCATED IN FIELD LOCATION

LINE NUMBER DESCRIPTION

WIRING DIAGRAM SHEET NUMBER (1 OR 2 DIGITS) — LINE NUMBER (ALWAYS 2 DIGITS)

WIRE NUMBER DESCRIPTION

WIRING DIAGRAM SHEET NUMBER (1 OR 2 DIGITS) — WIRE NUMBER (1 OR 2 DIGITS); LINE NUMBER (ALWAYS 2 DIGITS)

ASBUILT

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

Seneca Companies
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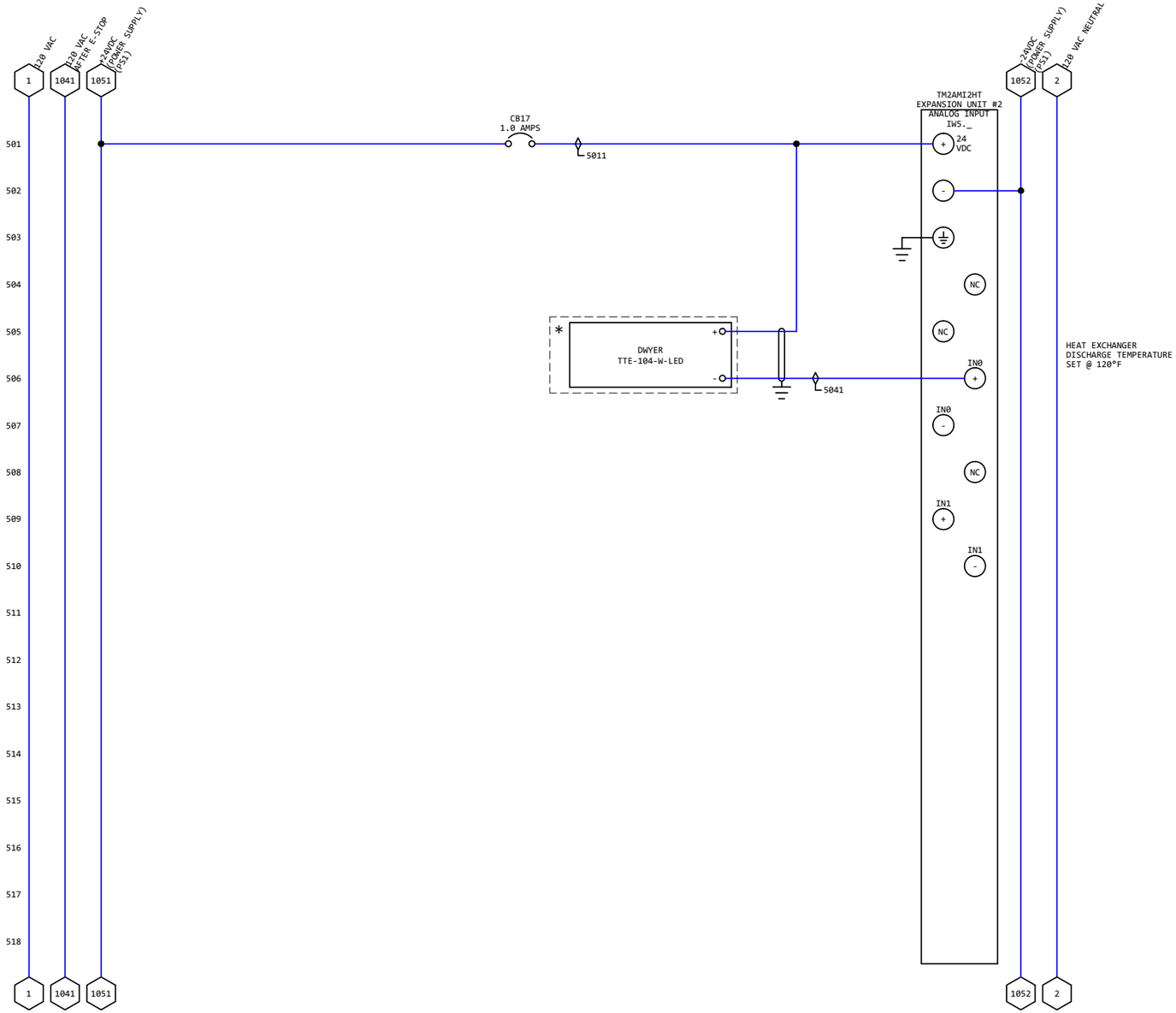
JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
MAIN CONTROL PANEL - PLC DISCRETE OUTPUTS - BASE UNIT

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: RICH RICHARDS
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO. E05

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005E01-10



NOTES:
1. CABLE SIZED PER LOCAL CODE AND UTILITY REQUIREMENTS.
2. SIZES SHOWN ARE MINIMUM REQUIRED RATINGS.
3. ALL MAINTENANCE SHALL BE PERFORMED WITH DEVICES DISCONNECTED FROM THE POWER SUPPLY.
4. ALL SPLICES SHALL BE MECHANICALLY SECURE AND PROVIDE A GOOD ELECTRICAL CONTACT.
5. MINIMUM SUPPLY CONDUCTOR AMPACITY - 100 AMPS
   MAXIMUM SUPPLY OVER CURRENT PROTECTIVE DEVICE - 100 AMPS
6. FLEX CONDUIT SHALL BE SECURED AT A MINIMUM EVERY 4 FEET.
7. LOCATED IN 480V PANEL - MC-1.
8. LOCATED IN CONTROL PANEL - CP-1.
9. FOR CONNECTING TO ONLY RESISTIVE NON-ENERGY STORING DEVICES.
10. INSTALL IN ACCORDANCE WITH ART. 504 OF THE NATIONAL ELECTRIC CODE.
11. MAXIMUM CABLE LENGTH IS 900 FEET.
12. WARNING - SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY.
13. PROVIDES INTRINSICALLY SAFE CIRCUIT EXTENSIONS FOR USE IN CLASS 1, DIV. 2, GROUPS C & D, HAZARDOUS LOCATIONS WHEN CONNECTED PER INSTALLATION.
14. SMALLEST WIRE SIZE FOR BRANCH CIRCUITS IS 14 AWG.
15. MOTOR OVERLOAD RELAY MUST BE MANUALLY RESET.

LEGEND:
- – – – DASHED LINES DENOTE WIRING TO FIELD DEVICES
- —E— DENOTES ETHERNET CABLE
- —F/O— DENOTES FIBER OPTIC CABLE
- * DENOTES HAZARDOUS LOCATION (AREA 2)
- ● DENOTES EQUIPMENT LOCATED IN FIELD LOCATION

LINE NUMBER DESCRIPTION
- WIRING DIAGRAM SHEET NUMBER (1 OR 2 DIGITS)
- LINE NUMBER (ALWAYS 2 DIGITS)

WIRE NUMBER DESCRIPTION
- WIRING DIAGRAM SHEET NUMBER (1 OR 2 DIGITS)
- WIRE NUMBER (1 OR 2 DIGITS)
- LINE NUMBER (ALWAYS 2 DIGITS)

ASBUILT

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

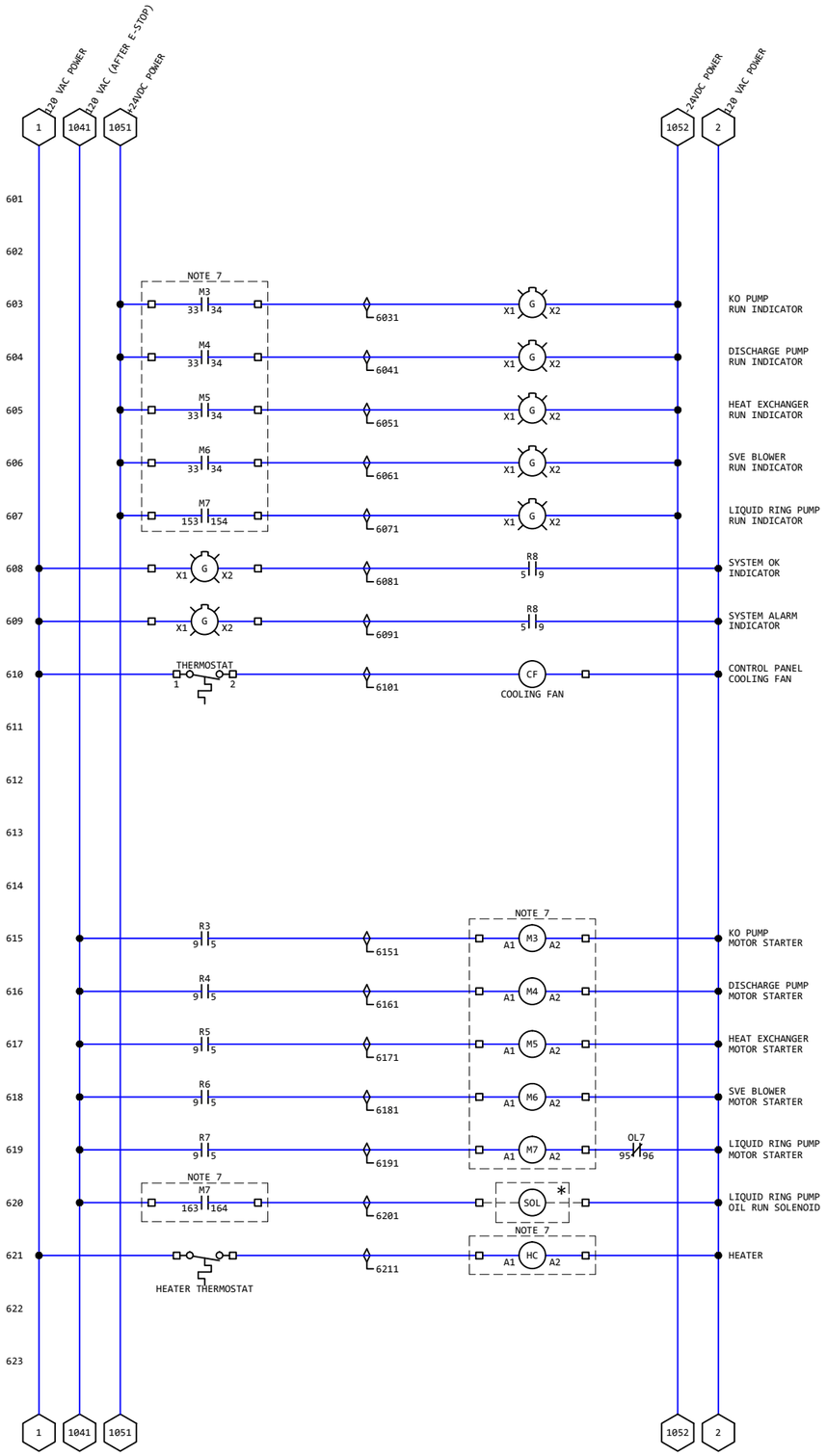
Seneca Companies
The Complete Solution

JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
MAIN CONTROL PANEL
PLC I/O LOGIC OUTPUTS - EXPANSION UNIT #2

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: RICH RICHARDS
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO. E06

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005E01-10



NOTES:
1. CABLE SIZED PER LOCAL CODE AND UTILITY REQUIREMENTS.
2. SIZES SHOWN ARE MINIMUM REQUIRED RATINGS.
3. ALL MAINTENANCE SHALL BE PERFORMED WITH DEVICES DISCONNECTED FROM THE POWER SUPPLY.
4. ALL SPLICES SHALL BE MECHANICALLY SECURE AND PROVIDE A GOOD ELECTRICAL CONTACT.
5. MINIMUM SUPPLY CONDUCTOR AMPACITY - 100 AMPS
   MAXIMUM SUPPLY OVER CURRENT PROTECTIVE DEVICE - 100 AMPS
6. FLEX CONDUIT SHALL BE SECURED AT A MINIMUM EVERY 4 FEET.
7. LOCATED IN 480V PANEL - CP-2.
8. LOCATED IN CONTROL PANEL - CP-1.
9. FOR CONNECTING TO ONLY RESISTIVE NON-ENERGY STORING DEVICES.
10. INSTALL IN ACCORDANCE WITH ART. 504 OF THE NATIONAL ELECTRIC CODE.
11. MAXIMUM CABLE LENGTH IS 900 FEET.
12. WARNING - SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY.
13. PROVIDES INTRINSICALLY SAFE CIRCUIT EXTENSIONS FOR USE IN CLASS 1, DIV. 2, GROUPS C & D, HAZARDOUS LOCATIONS WHEN CONNECTED PER INSTALLATION.
14. SMALLEST WIRE SIZE FOR BRANCH CIRCUITS IS 14 AWG.
15. MOTOR OVERLOAD RELAY MUST BE MANUALLY RESET.

LEGEND:
- DASHED LINES DENOTE WIRING TO FIELD DEVICES
- E — DENOTES ETHERNET CABLE
- F/O — DENOTES FIBER OPTIC CABLE
- * DENOTES HAZARDOUS LOCATION (AREA 2)
- ● DENOTES EQUIPMENT LOCATED IN FIELD LOCATION

LINE NUMBER DESCRIPTION
WIRING DIAGRAM SHEET NUMBER (1 OR 2 DIGITS) — LINE NUMBER (ALWAYS 2 DIGITS)

WIRE NUMBER DESCRIPTION
WIRING DIAGRAM SHEET NUMBER (1 OR 2 DIGITS) — WIRE NUMBER (1 OR 2 DIGITS) — LINE NUMBER (ALWAYS 2 DIGITS)

ASBUILT

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

Seneca Companies
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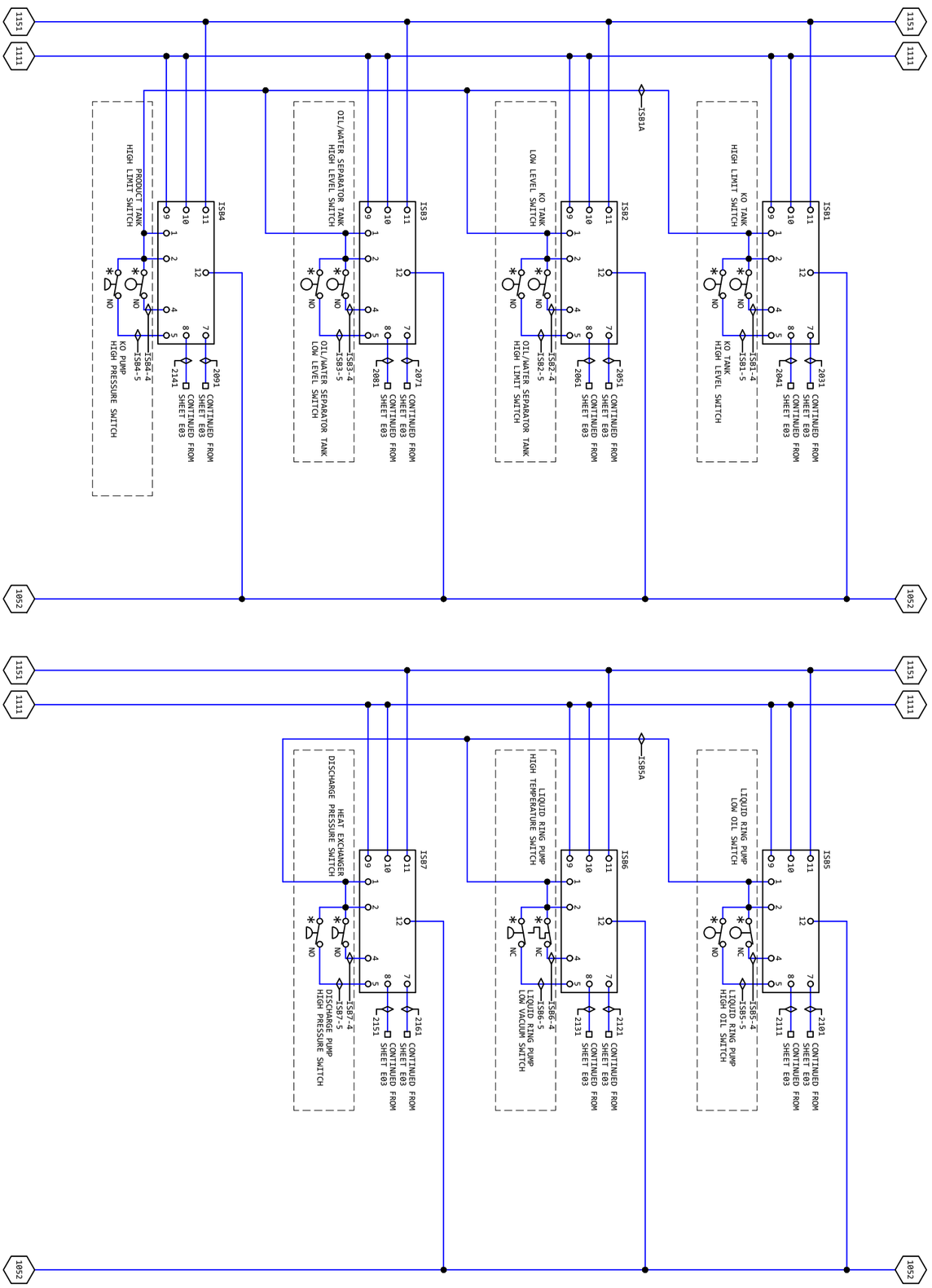
JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
MAIN CONTROL PANEL - MOTOR CONTROLS

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: RICH RICHARDS
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO. E07

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005E01-10

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005E01-10



ASBUILT

DATE:	04/17/2015
DRAWN BY:	DARRICK MORRALL
CHECKED BY:	RICH RICHARDS
SCALE:	NO SCALE
PROJECT NO:	1715005
SHEET NO:	E08

JOB DESCRIPTION:

KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:

MAIN CONTROL PANEL - INTRISIC BARRIERS

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REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

SWING PANEL

BACK PANEL

ASBUILT

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

Seneca Companies
The Complete Solution

JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
MAIN CONTROL PANEL - SWING/BACK PANEL LAYOUT

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: RICH RICHARDS
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO. E09

FILE LOCATION: L:\SENECA REMEDIATION\KINDER MORGAN\1715005 - KINDER MORGAN\1715005E01-10

QTY	DESCRIPTION	MANUFACTURER	PART NUMBER
	Panel Hardware		
1	Enclosure - PLC Panel	Hoffman	CSD363612
1	Sub Panel	Hoffman	CP3636
1	Swing Panel	Hoffman	A36P36
1	Hinge Kit	Hoffman	ANADFK
1	Drawing Pocket	Hoffman	ADP2
1	Door Handle	Hoffman	CWHK
1	Cooling Fan Thermostat	Hoffman	ATEMNO
1	Cooling Fan 4"	Hoffman	A4AXFN
1	Cooling Fan 4" Finger Guard	Hoffman	AGARD4
2	Fan Shrouds 4"	Hoffman	T4S3R
3	Vents 4"	Hoffman	AFLT44
1	Mini Circuit Breaker 1.0A 1P Exhaust Fan	Square-D	60101
	480 Volt Panel Hardware		
1	Enclosure 480V	Hoffman	CSD36288
1	Sub Panel	Hoffman	CP3624
1	Door Handle	Hoffman	CWHK
	480V Panel Disconnect		
1	Main Breaker 600V 100A	Square-D	HDL36100C
	Panel Switches		
5	Hand-Off-Auto Switch Maintain - Illuminated	Telemecanique	ZB4BK1333
5	Contact Block	Telemecanique	ZB4BZ103
	Panel Lights-Meters		
5	Pilot Light Assembly-Lens White 24vdc	Telemecanique	XB4BVB1
1	Pilot Light Assembly-Lens Blue 24vdc	Telemecanique	XB4BVB6
	Panel Labels		
5	Legend Plate Hand/Off/Auto	Telemecanique	ZBY2387
	Motor Starters-Overloads-Breakers		
	Liquid Ring Pump		
1	Contactor 20HP 480V 3Ph 27FLA	Square-D	LC1D40AG7
1	Overload Module 23-32A	Square-D	LRD332
1	Auxiliary Contacts	Square-D	LAD8N20
1	Surge Suppressor	Square-D	LAD4RC3U
1	Circuit Breaker 480V 3P 60A	Square-D	GV7RE80
	SVE Blower		
1	Contactor 7.5HP 480V 3Ph 11.0FLA	Square-D	LUB32
1	Overload Module 4.5-18A	Square-D	LUCA18FU
1	Auxiliary Contacts	Square-D	LUFN20
1	Auxillary Contacts - Overload	Telemecanique	LUA1C20
1	Incoming Line Barrier	Telemecanique	LU9SPO
	Heat Exchanger		
1	Contactor 0.5HP 480V 3Ph 1.1FLA	Square-D	LUB32
1	Overload Module 1.25-5A	Square-D	LUCA05FU
1	Auxiliary Contacts	Square-D	LUFN20
1	Auxillary Contacts - Overload	Telemecanique	LUA1C20
1	Incoming Line Barrier	Telemecanique	LU9SPO
	KO Tank Transfer Pump		
1	Contactor 1.0HP 480V 3Ph 2.1FLA	Square-D	LUB32
1	Overload Module 1.25-5A	Square-D	LUCA05FU
1	Auxiliary Contacts	Square-D	LUFN20
1	Auxillary Contacts - Overload	Telemecanique	LUA1C20
1	Incoming Line Barrier	Telemecanique	LU9SPO
	Discharge Pump		
1	Contactor 1.5HP 480V 3Ph 3.0FLA	Square-D	LUB32
1	Overload Module 1.25-5A	Square-D	LUCA05FU
1	Auxiliary Contacts	Square-D	LUFN20
1	Auxillary Contacts - Overload	Telemecanique	LUA1C20
1	Incoming Line Barrier	Telemecanique	LU9SPO
	Heater		
1	Contactor	Square-D	LC1D12G7
1	Fuses Holder, Heater 600V 2P 30A	Ferraz/Shawmut	US3J3I
2	Fuses, Heater 600V 15A	Ferraz/Shawmut	AJT15
	Exhaust Fan		
2	Mini Circuit Breaker Lights 240VAC 15A 2P	Square-D	60146
	PLC		
1	PLC - TWIDO 40 I/O 120-230VAC Pwr	Telemecanique	TWDLCAE40DRF
1	Digital Input Module 8Pt.	Telemecanique	TM2DDI8DT
0	Digital Output Module 8Pt.	Telemecanique	TM2DRA8RT
1	Analog Input Module 2Ch 4-20mA	Telemecanique	TM2AMI2HT
1	Battery	Telemecanique	TSXPLP01
1	Mini Circuit Breaker 1.5A 1P PLC	Square-D	60102

	HMI		
1	HMI 5.7" Color w/Ethernet, Compact Flash	Square-D	HMISTU855
1	Flash Drive 8GB	Kingston	DTMCK/8GB
1	Mini Circuit Breaker 1.0A 1P HMI	Square-D	60101
	Ethernet Switch		
1	Ethernet Switch 4 Port	N-Tron	104TX
1	Circuit Breaker 1P 1A Ethernet Switch	Square-D	60101
	Ethernet Cables		
1	1' Ethernet Cable	3E	QTN530100001
1	2' Ethernet Cable	3E	QTN530100002
1	6' Ethernet Cable	3E	QTN27250
1	Panel Mount Ethernet Port 22mm	WAG	51205068
	Intrinsic/Isolation Barriers		
7	Discrete Barriers	Turk	IM1-22EX-R/24VDC
	Panel Protection		
1	Surge Arrestor	Ferraz/Shawmut	ST1201PG
1	Circuit Breaker Phase Monitor 1P 4A	Square-D	MGN61326
1	Phase Monitor	SymCom	460
	Misc. Panel Items		
1	Power Supply 24VDC 4.2A	Puls	ML100100
1	Mini Circuit Breaker Primary 120vac 3A	Square-D	60104
1	Mini Circuit Breaker Secondary 4.0A 1P	Square-D	60105
1	Mini Circuit Breaker Analog Devices 24vdc 1A	Telemecanique	60101
1	Auxillary Relay 120vac	Telemecanique	RXM4AB2F7
7	Auxillary Relay 24vdc	Telemecanique	RXM4AB2BD
8	Relay Socket	Telemecanique	RXZE2S114M
1	120Vac Relay Varistor	Telemecanique	RXM021FP
7	24Vdc Relay Varistor	Telemecanique	RXM021BN
1	Flashing Beacon - Red	Federal Signal	SLM100R
1	Flashing Beacon - Green	Federal Signal	SLM100G
1	Wall Mount Base Dual	Federal Signal	SLMBT120-240/GY
2	Grounding Bus Bar	Square-D	PK15GTAL
6	Din Rail	IDEC	BNDN1000
36	Din Rail Retainers	IDEC	BNL5
1	Din Rail Retainers	Allen-Bradley	1492-EAJ35
4	Terminal Blocks 2 Conductor	Allen-Bradley	1492-JD3
1	End Barrier	Allen-Bradley	1492-EBJD3
67	Terminal Blocks	Square-D	9080GR6
31	Terminal Blocks	Square-D	9080GM6
7	End Barrier	Square-D	9080GM6B
2	Terminal Block Green	WAGO	2002-1307
2	End Barrier	WAGO	2002-1391
1	Terminal Block 3 Conductor	WAGO	2002-3218
1	End Barrier	WAGO	2002-3291
3	Power Distribution 480vac	Ferraz/Shawmut	FSPDB3A
3	Power Distribution 240/120vac	Ferraz/Shawmut	FSPDB2A
8	Distribution Block Pins	Ferraz/Shawmut	FSPIN1
1	Mini Circuit Breaker Control Pwr 120VAC 10A	Square-D	60110
1	Mini Circuit Breaker Lights 120VAC 15A	Square-D	60112
1	Mini Circuit Breaker GFI 120VAC 20A	Square-D	60113
2	Fuses Holder, Control Transformer 600V 2P 30A	Ferraz/Shawmut	US3J2I
4	Fuses, Control Transformer 600V 20A	Ferraz/Shawmut	AJT20
	Other Items		
3	Thermostat	Columbus Electric	EP-ETD-8D
1	Emergency Stop Switch - Exp	Appleton	EFKBUM1
1	Emergency Stop Switch Box - Exp	Appleton	EFDC175NLQ
3	Light	Appleton	VXHA1075G
1	Light Switch Box - Exp	Killark	SWB-2
1	Light Switch Cover - Exp	Killark	XNS-2C
1	Light Switch	P&S	PS20AC1-W
1	GFI Receptacle	P&S	2095-TRWRW
1	GFI Cover	Intermatic	CKMUV
1	WP Box 1G 3 Hole 1/2" Hubs	Raco	5385-0
1	Distribution Transformer 5.0KVA 480-120/240V 1Ph	Hammond	C1F005LES
1	Surge Arrestor 480/277V 3Ph 40kA Per Phase	Square-D	SDSA3650D

ASBUILT

REV NO	DATE
01	06/05/2015
02	06/11/2015
03	07/07/2015

Seneca Companies
The Complete Solution

JOB DESCRIPTION:
KINDER MORGAN
1009 EAST SMITH ROAD
BELLINGHAM, WA 98226

SHEET TITLE:
MAIN CONTROL PANEL - BILL OF MATERIAL

DATE: 04/17/2015
DRAWN BY: DARRICK WORRALL
CHECKED BY: RICH RICHARDS
SCALE: NO SCALE
PROJECT NO: 1715005
SHEET NO. E10

APPENDIX D

System Photographs

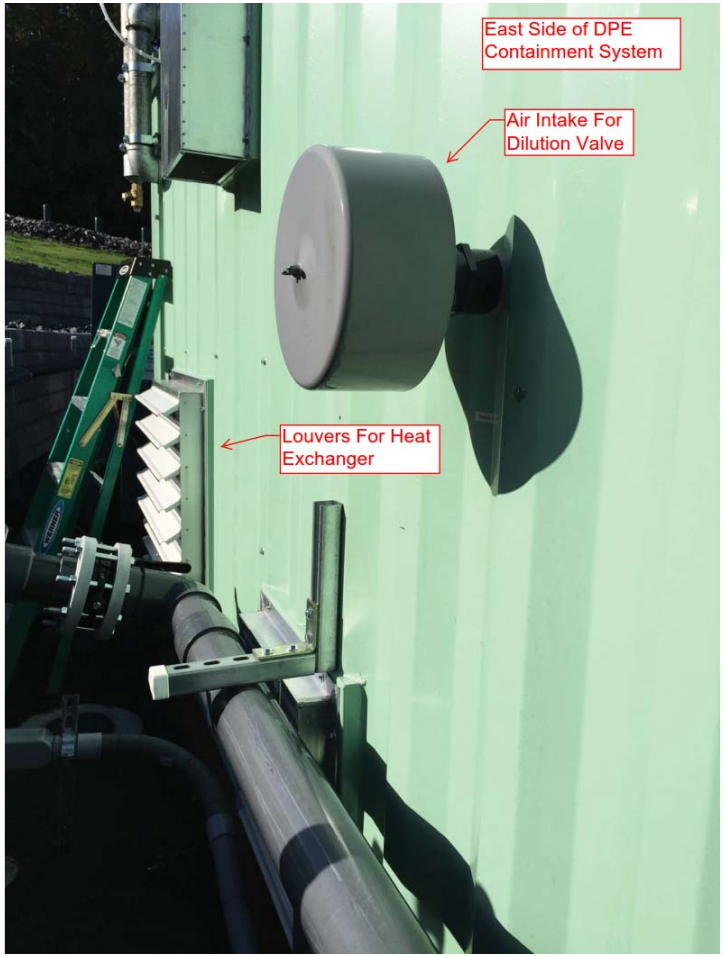
Photo Log

Treatment System	Photo Description	Page
General DPE System (Outside)	Containerized DPE system	2
	Dilution valve air intake and louvers for heat exchanger	2
	Control panel	3
	Inside of control panel	3
	HMI Ladder Logic Screen	4
	Emergency Stop (Outside)	4
	Sound hood for supply fans	5
	Header pipe and instrumentation for PMS	5
	Header pipe for PMS and sampling port	6
	Header pipe and instrumentation for PSB	6
	Header pipe for PSB and sampling port	7
	Passive vent well (Covered)	7
	Passive vent well	8
	DPE well vault	8
Groundwater Phase Treatment	Knockout tank and sight tube	10
	Knockout tank pump flow meter	10
	Knockout tank pump assembly	11
	Liquid ring pump assembly	11
	Liquid ring pump oil level sight glass	12
	Liquid ring pump motor and grease locations	12
	Inline filter replacement cartridge for liquid ring pump	13
	Oil Water Separator	13
	Oil Water Separator product tank	14
	Liquid-phase particulate bag filters	14
	Liquid-phase carbon tanks	15
	Totalizer and sampling port	15
Vapor Phase Treatment	SVE Blower	17
	Particulate filters 1 and 2	17
	Particulate filter replacement cartridge	18
	Pre carbon treatment particulate filter	18
	Vapor-phase carbon tank and sampling port	19
	Exhaust stack	19
General DPE System (Inside Container)	Dilution air flow gauge	21
	Heat Exchanger	21
	Emergency stop (Inside) and temperature controls	22
	Supply Fan	22

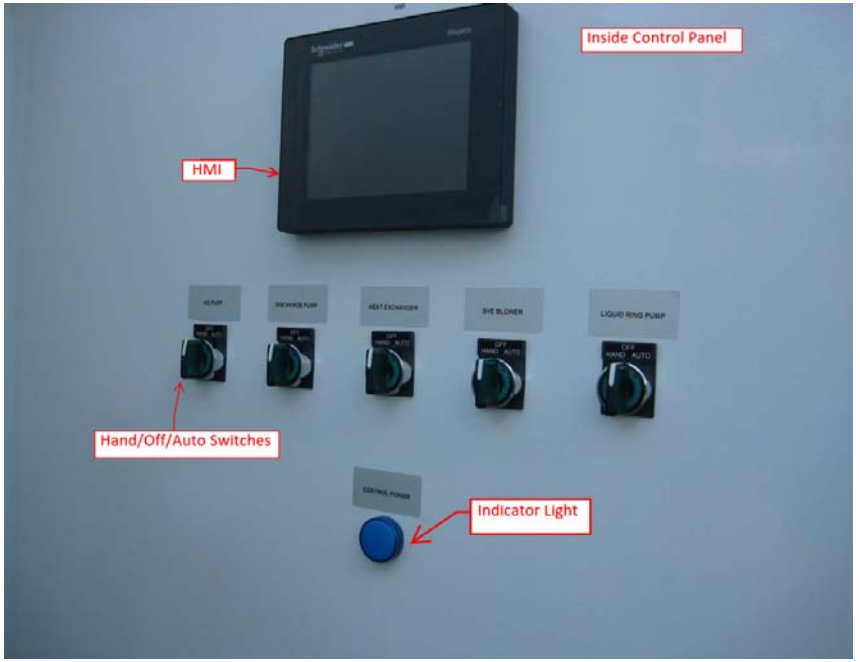
DPE - Dual-Phase Extraction
HMI - Human Machine Interface
PSB - Pump Station Building
PMS - Piping Manifold Shelter
SVE - Soil Vapor Extraction
OWS - Oil Water Separator

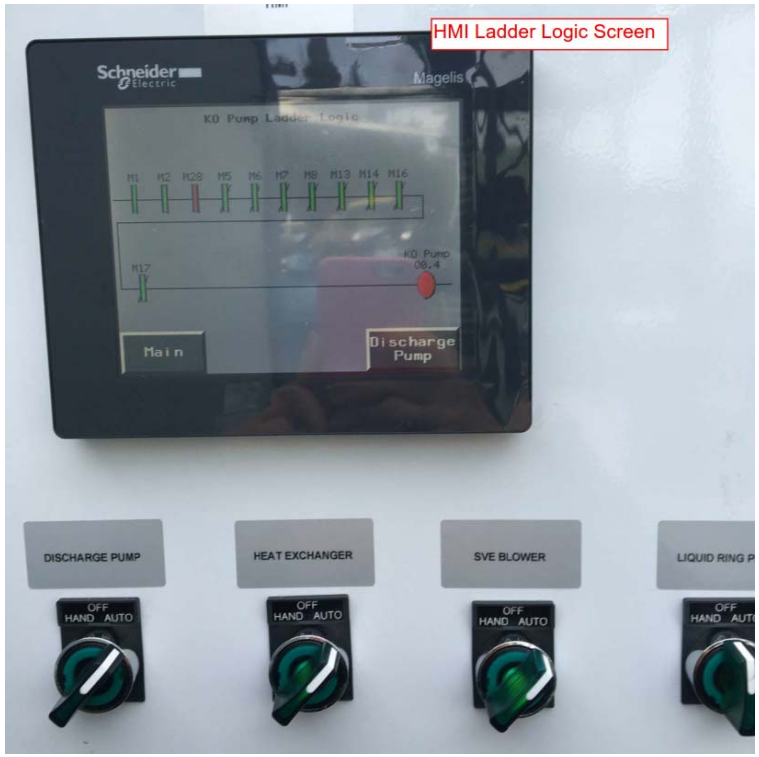
General DPE System (Outside)


Containerized DPE System


East Side of DPE
Containment System
Air Intake For
Dilution Valve
Louvers For Heat
Exchanger

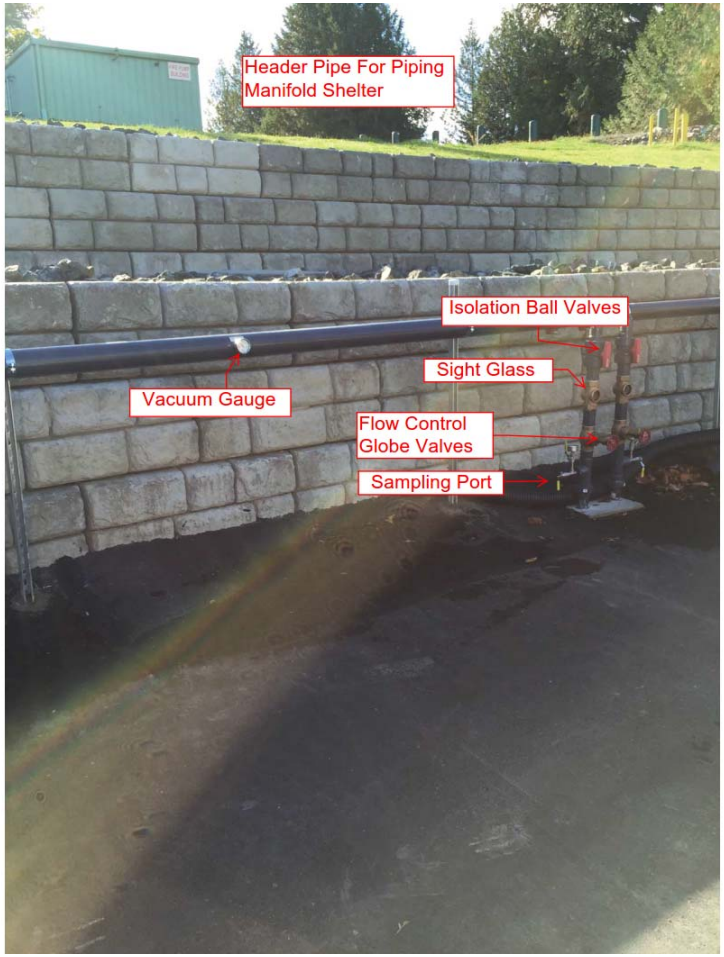

Control Panel (North Side of Container)
WARNING
SINGLE PHASE
120 VOLTS
240 VOLTS

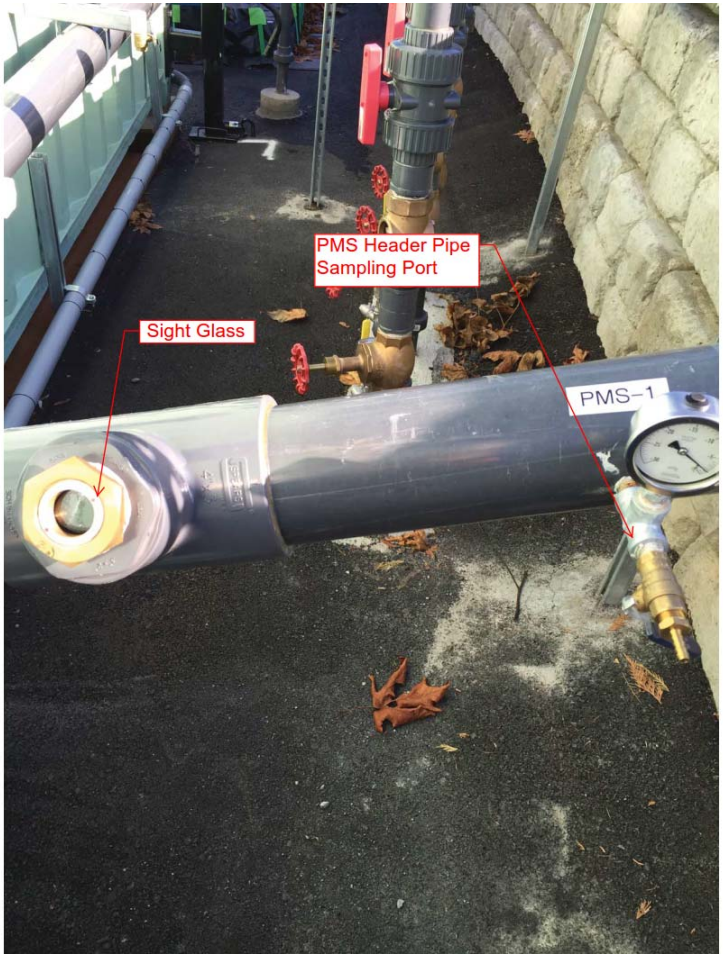

Inside Control Panel
HMI
Hand/Off/Auto Switches
Indicator Light

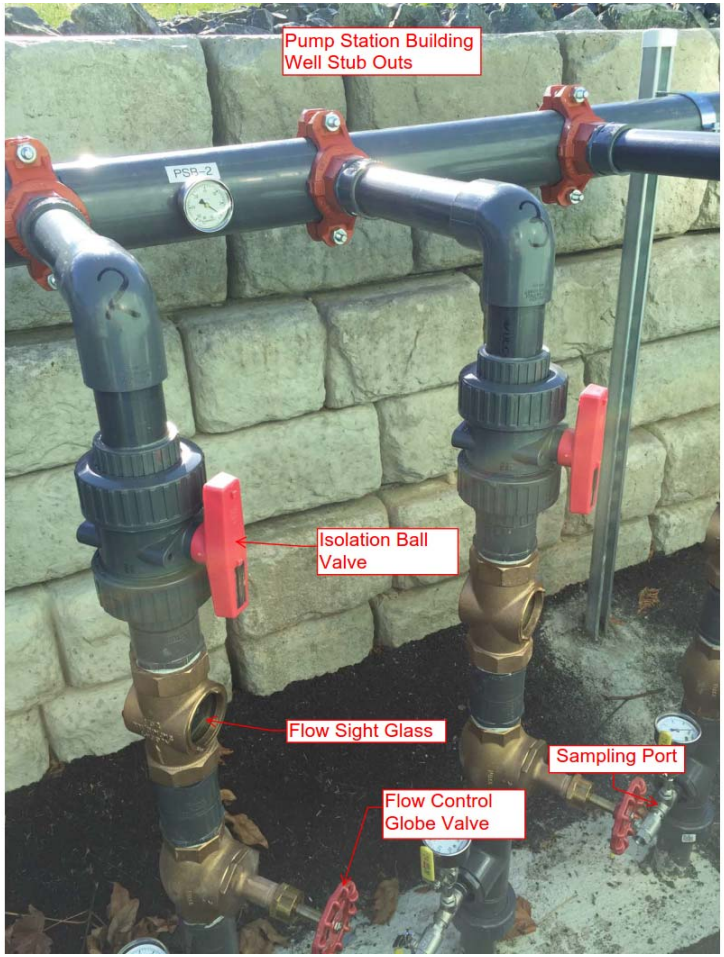

HMI Ladder Logic Screen
Schneider Electric
Magelis
KO Pump Ladder Logic
M1 M2 M28 M5 M6 M7 M8 M13 M14 M16
M17
KO Pump
Main
Discharge Pump
DISCHARGE PUMP
HEAT EXCHANGER
SVE BLOWER
OFF HAND AUTO


Outdoor Emergency Stop Located On South West Corner of DPE System Container
EMERGENCY STOP


Sound Hood For Supply Fans
Supply Fan Filter

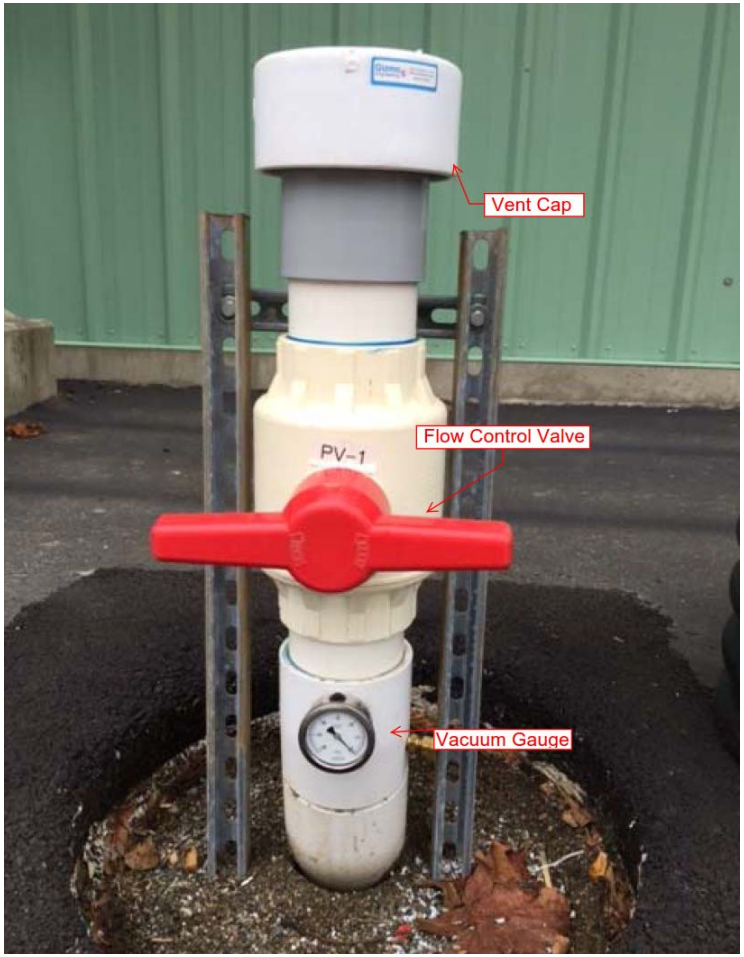

Header Pipe For Piping Manifold Shelter
Isolation Ball Valves
Sight Glass
Vacuum Gauge
Flow Control Globe Valves
Sampling Port

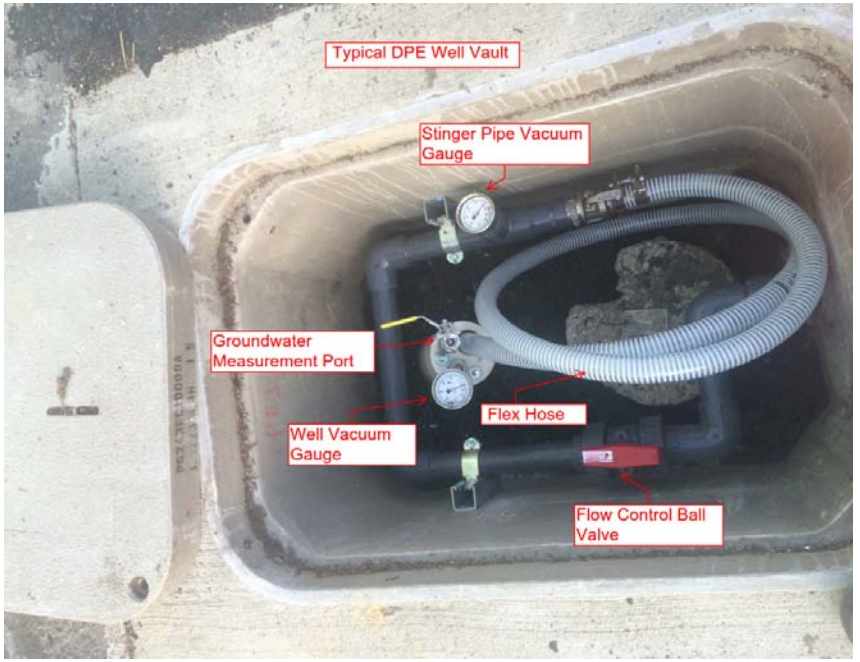

PMS Header Pipe
Sampling Port
Sight Glass
PMS-1


Pump Station Building
Well Stub Outs
PSR-2
Isolation Ball
Valve
Flow Sight Glass
Sampling Port
Flow Control
Globe Valve


PSB Header Pipe
PMS Header Pipe
PSB HEADER
Sampling Port


Passive Vent Well

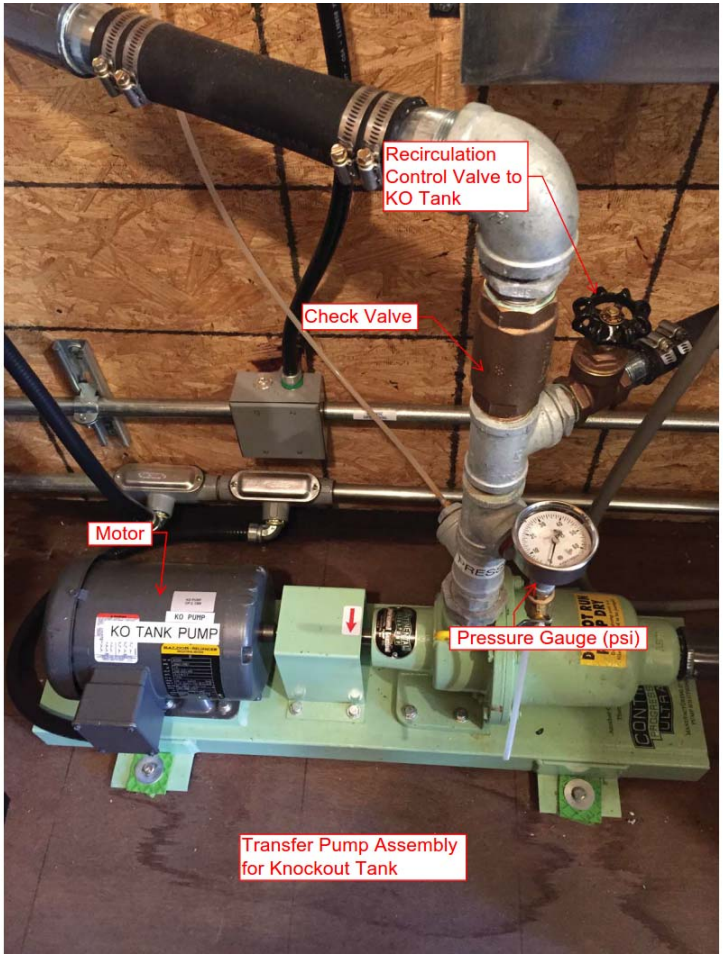

Vent Cap
Flow Control Valve
PV-1
Vacuum Gauge

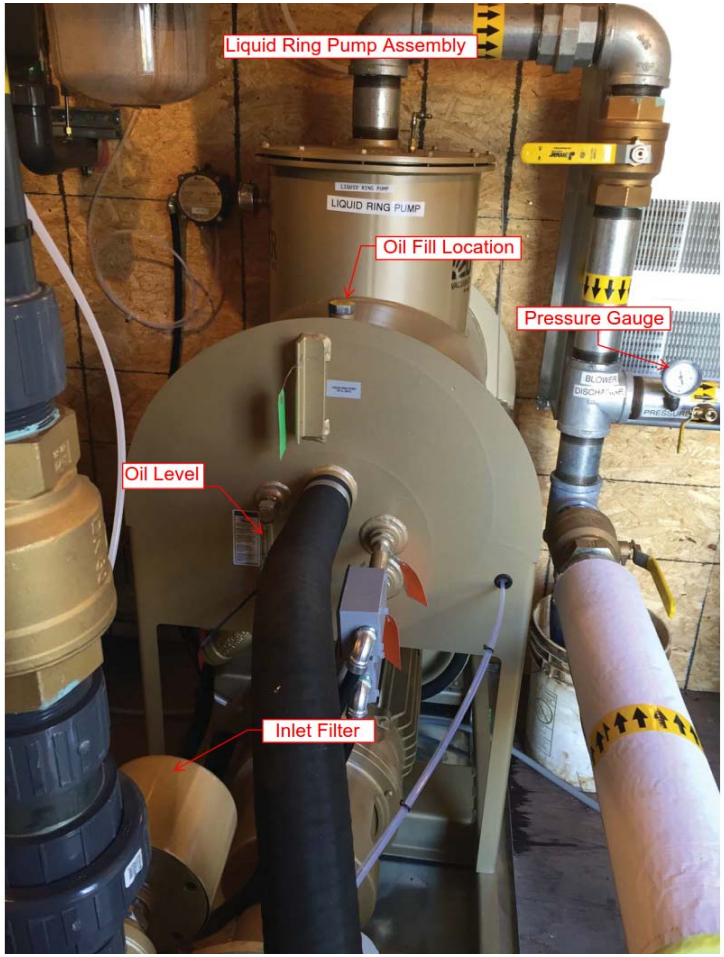

Typical DPE Well Vault
Stinger Pipe Vacuum Gauge
Groundwater Measurement Port
Flex Hose
Well Vacuum Gauge
Flow Control Ball Valve

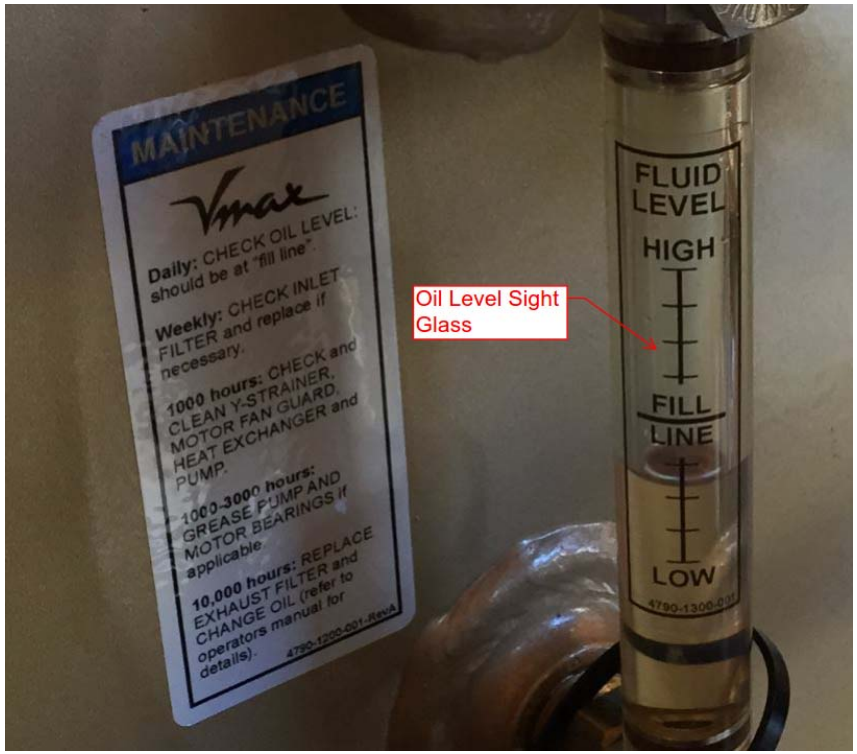
Groundwater Phase Treatment

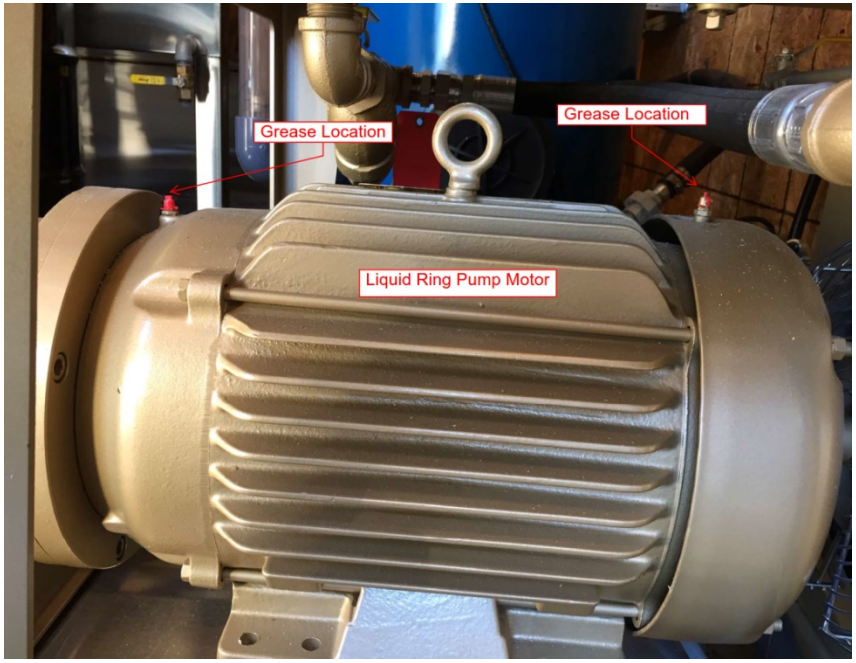

Knockout Tank
Sight Tube for
Knockout Tank


Flow Meter (gpm) for
Knockout Tank Pump
Union Connections


Recirculation Control Valve to KO Tank
Check Valve
Motor
KO TANK PUMP
Pressure Gauge (psi)
Transfer Pump Assembly for Knockout Tank


Liquid Ring Pump Assembly
LIQUID RING PUMP
Oil Fill Location
Pressure Gauge
Oil Level
Inlet Filter


MAINTENANCE
Vmax
Daily: CHECK OIL LEVEL: should be at "fill line".
Weekly: CHECK INLET FILTER and replace if necessary.
1000 hours: CHECK and CLEAN Y-STRAINER, MOTOR FAN GUARD, HEAT EXCHANGER and PUMP.
1000-3000 hours: GREASE PUMP AND MOTOR BEARINGS if applicable.
10,000 hours: REPLACE EXHAUST FILTER and CHANGE OIL (refer to operators manual for details).
4799-1200-001-RevA
Oil Level Sight Glass
FLUID LEVEL
HIGH
FILL LINE
LOW
4799-1300-001

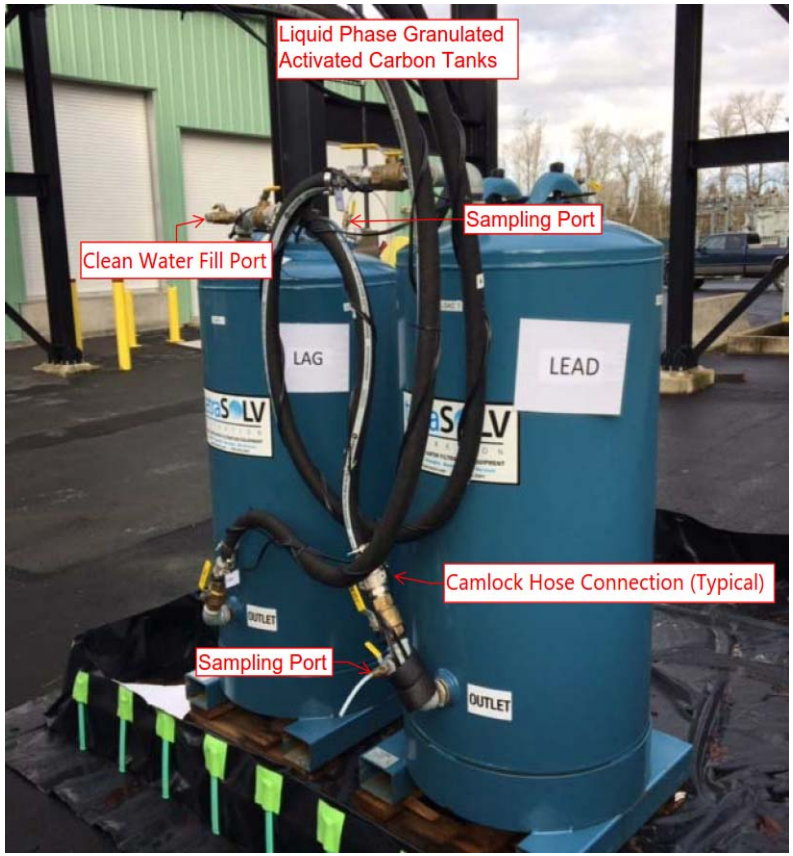

Grease Location
Grease Location
Liquid Ring Pump Motor

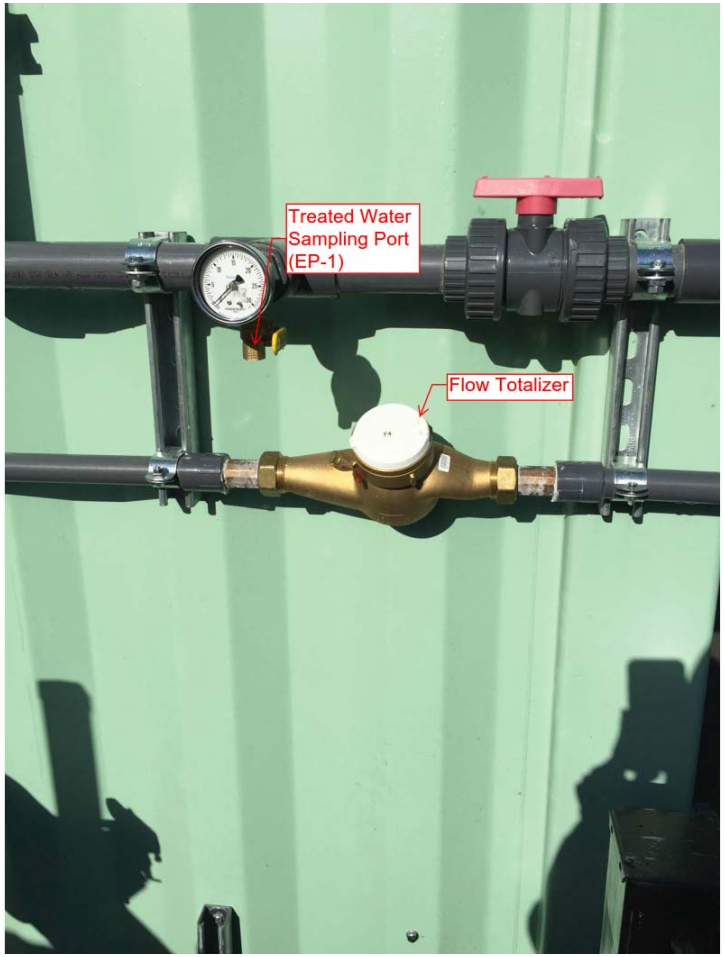

Liquid Ring Pump Assembly
Opened Filter For Liquid Ring Pump Assembly
LRP Head


Oil Water Separator
Adjustable Overflow Weir (Not Visible)
Stop Weir
Adjustable Product Skimmer Pipe
Coalescing Plates

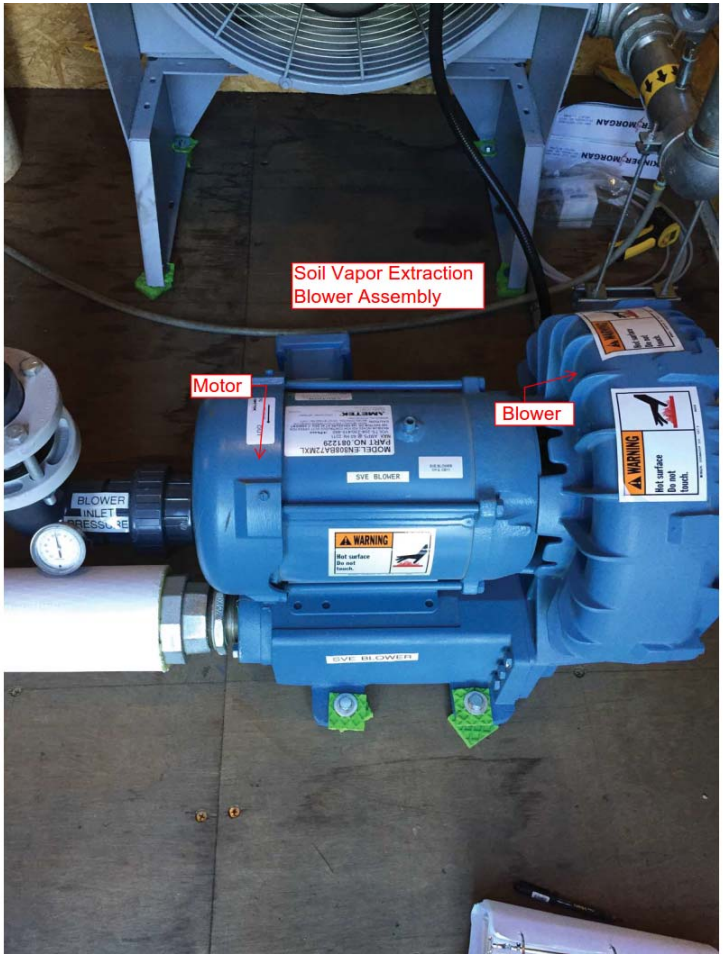

OWS Product Tank
OWS SEPERATOR PRODUCT TANK
Product Tank Drain


Bag Filters
(Groundwater Phase
Treatment System)
BAG FILTER
BAG FILTER
BAG FILTER
OWS Discharge
Transfer Pump


Liquid Phase Granulated Activated Carbon Tanks
Clean Water Fill Port
Sampling Port
LAG
LEAD
Camlock Hose Connection (Typical)
Sampling Port
OUTLET
OUTLET

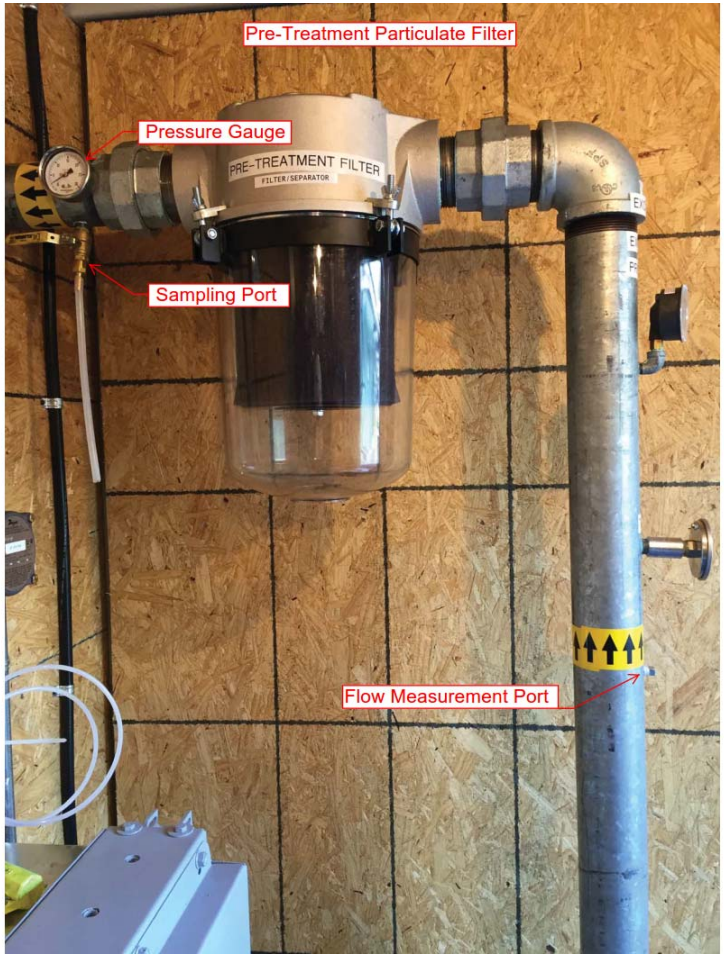

Treated Water Sampling Port (EP-1)
Flow Totalizer

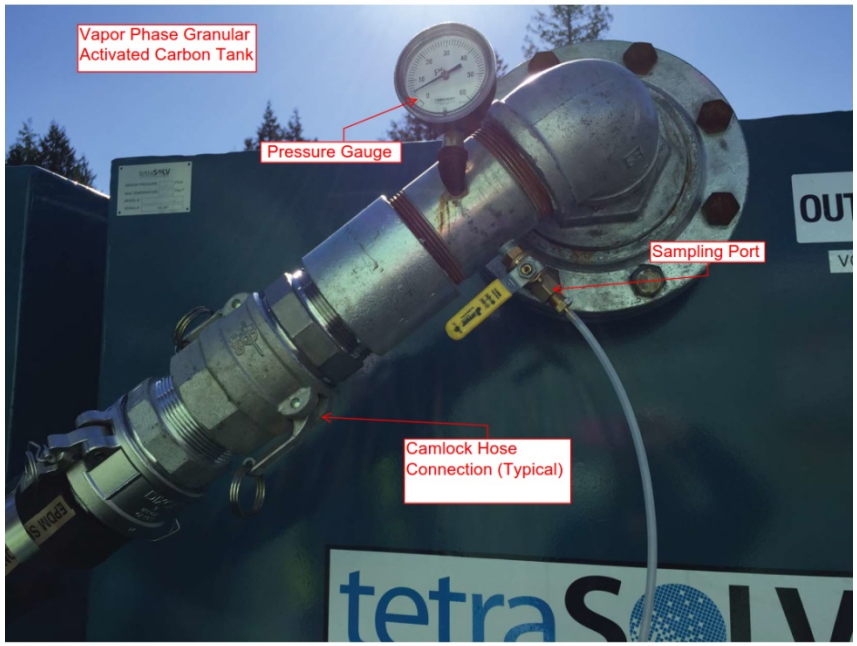
Vapor Phase Treatment

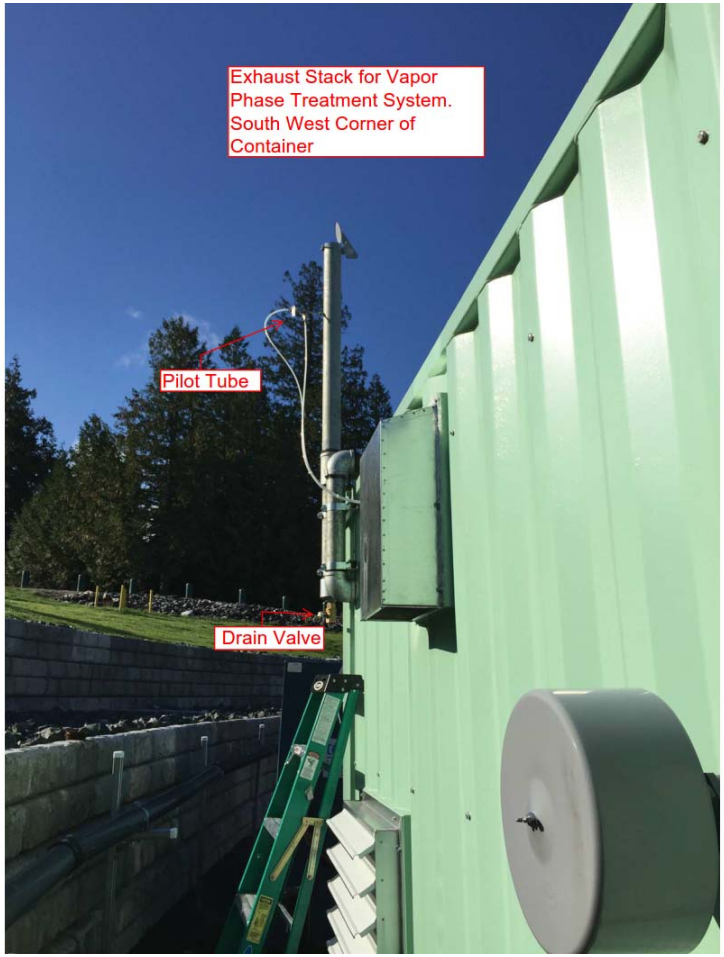

Soil Vapor Extraction
Blower Assembly
Motor
Blower
BLOWER
INLET
SVE BLOWER
WARNING
Hot surface
Do not
touch.


Particulate Filters
PARTICULATE FILTER 2
INLINE FILTER
PARTICULATE FILTER 1
INLINE FILTER


Inline Particulate Filter
Replacement Cartridge


Pre-Treatment Particulate Filter
Pressure Gauge
PRE-TREATMENT FILTER
FILTER/SEPARATOR
Sampling Port
Flow Measurement Port

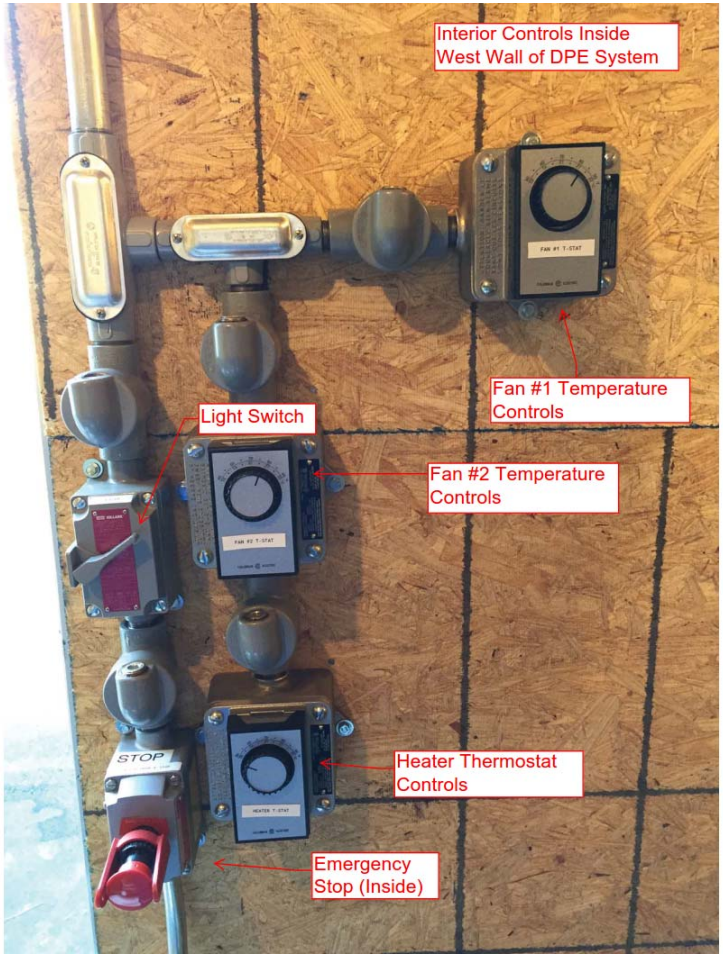

Vapor Phase Granular Activated Carbon Tank
Pressure Gauge
Sampling Port
Camlock Hose Connection (Typical)
tetraSOLV

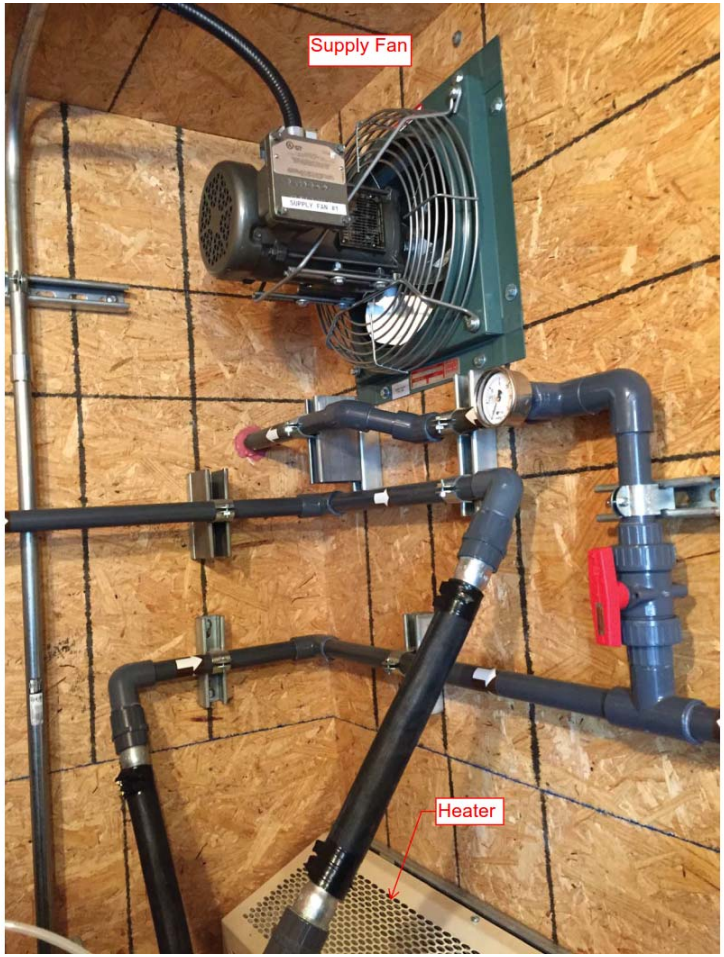

Exhaust Stack for Vapor Phase Treatment System. South West Corner of Container
Pilot Tube
Drain Valve

General DPE System (Inside Container)


Dilution Air Flow
Gauge (in H2O)


Heat Exchanger Assembly


Interior Controls Inside
West Wall of DPE System
Fan #1 Temperature
Controls
Light Switch
Fan #2 Temperature
Controls
Heater Thermostat
Controls
Emergency
Stop (Inside)


Supply Fan
Heater

APPENDIX E

Site Inspection Checklist and Field Forms

TREATMENT TRAIN MONITORING
LAUREL STATION DPE SYSTEM

Field Technicians		**Client**	Kinder Morgan
Project Number		**Installation**	Laurel Station
Company Name		**Location**	Bellingham, Washington

List Reference Where Information came from (e.g. Log Book name)

GENERAL SYSTEM STATUS (UPON ARRIVAL)

Date	*Actual*	*HMI*	**HOUR METERS**	**(Hours)**	**ALARMS**	**YES or NO**	**DATE / TIME**
Time	*Actual*	*HMI*	LRP (DPE) Pump		Alarm 1		
System Status (on/off)			SVE Blower		Alarm 2		
System Mode (DPE/SVE)			Heat Exchanger		Alarm 3		
Ambient Temp (F)			Heat Exchanger Exit Temp (F)	*From HMI Display*	Alarm 4		
Technician Initials			KO & OWS Pumps	NA	Alarm 5		

VAPOR PHASE TREATMENT

KO Inlet Vacuum (in Hg)	V1	**GAUGES**	**Vacuum/Pressure (in H_2O)**	**Visual**	**Differential Pressure (Calculated)**	
Dilution Valve (DV) Position (% open)		Filter #1 (IN)	V2 *Vacuum*			
DV PITOT TUBE (in H_2O)	F1	Mid Point	V3 *Vacuum*			
Liquid Ring Pump Temp (F)	T1	Filter #2 (OUT)	V4 *Vacuum*			
Heat Exchanger Inlet Temp (F)	T2	Blower (IN)	V5 *Vacuum*			
Heat Exchanger Exit Temp (F)	T3	Liquid Ring Pump (IN)	V6 *Vacuum*			
Liquid Ring Discharge Filter Pressure (PSI)	P1	Heat Exchanger (IN)	P2 ***Pressure***			
Oil Level & Color		Heat Exchanger (OUT) and Filter #3 (IN)	P3 ***Pressure***			

Treatment Position	**Vapor GAC**	**Pressure (in H_2O)**	**PID (ppm)**	**FID (ppm)**	**Air Flow (ft/min)**	**PITOT TUBE (in H_2O)**
LEAD VGAC (IN) and Filter #3 (OUT)	VGAC #	P4 *psi*				
Mid Point		P5				
LAG VGAC (OUT)	VGAC #	P6				
STACK		No Gauge Present				F2

WATER PHASE TREATMENT

KO Tank Sight Glass Level		**BAG FILTERS**	# (1 or 2) bags used	**Treatment Position**	**Liquid GAC**	**Pressure (psi)**
KO Pump Pressure (psi)	P8	Influent (psi)	P10	LEAD LGAC (IN)	LGAC # 1	P12
KO Flow (gpm)	F3	Effluent (psi)	P11	Mid Point		P13
OWS Sight Glass Level		Differential (psid)		LAG LGAC (OUT)	LGAC # 2	P14
OWS Pump (psi)	P9	Bag(s) Changed (YES or NO)		**H_20 Effluent**	TOTALIZER (GAL)	
OWS Visual (oil/sheen)		Secondary Containment Level at Drain (feet)		**PRODUCT DRUM**	DTW _____ (feet)	DTP _____(feet)

GENERAL SYSTEM STATUS (WHEN LEAVING SITE)

Time Leaving Site		**DOWNTIME**	**YES or NO**	**MAINTENANCE**	**YES or NO**	**HR METER RESET**
System Status (on/off)		Time Turned OFF				YES or NO
System Mode (DPE/SVE)		Time Turned ON				Time:

Recorded By	Date
Checked By	Date

"blank" or "NC" = Not Checked
"NA" = Not Applicable
btoc - below top of casing
cfm - cubic feet per minute
H2O - Water
Hg - Mercury
HMI - Human Machine Interface
KO - knock out tank

CSB - Cary S Brown
DC - Demetrio Cabanillas
SN - Shelby Nerison
JO - Justin Odens

Recommendations for next Visit:

2-inch pipe emissions at 25°C (lbs/day) = CFID (ppm) x Flow (ft/min) x 6.94 x 10-6

WELL FIELD INFLUENT MONITORING
LAUREL STATION DPE SYSTEM

Field Technicians		**Client**	Kinder Morgan
Project Number		**Installation**	Laurel Station
Company Name		**Location**	Bellingham, Washington

List Reference Where Information came from (e.g. Log Book name)

Date Measured	Time Measured	DPE Well ID	Measurement Location	Vacuum (in Hg)	Visual Observations Water? (YES or NO)	Valve Position (% Open)	PID (ppm)	FID (ppm)	Air Flow Meter (ft/min)	Flow Indicator Position (__ / 8)	Depth To Water (FT BTOC)	Remarks
PIPING MANIFOLD SHELTER (PMS) MONITORING POINTS												
		PMS	**Header**									
		PMS-1	Manifold									
		PMS-2	Manifold									
		PMS-3	Manifold									
		PMS-4	Manifold									
		DPE-5	Lateral									
		Stinger Depth	Stinger									
		ft BTOC	Well									
		DPE-6	Lateral									
		Stinger Depth	Stinger									
		ft BTOC	Well									
		DPE-7	Lateral									
		Stinger Depth	Stinger									
		ft BTOC	Well									
		DPE-8	Lateral									
		Stinger Depth	Stinger									
		ft BTOC	Well									
		DPE-9	Lateral									
		Stinger Depth	Stinger									
		ft BTOC	Well									
		DPE-10	Lateral									
		Stinger Depth	Stinger									
		ft BTOC	Well									

Recorded By	Date
Checked By	Date

WELL FIELD INFLUENT MONITORING
LAUREL STATION DPE SYSTEM

Field Technicians		**Client**	Kinder Morgan
Project Number		**Installation**	Laurel Station
Company Name		**Location**	Bellingham, Washington

List Reference Where Information came from (e.g. Log Book name)

Date Measured	Time Measured	DPE Well ID	Measurement Location	Vacuum (in Hg)	Visual Observations Water? (YES or NO)	Valve Position (% Open)	PID (ppm)	FID (ppm)	Air Flow Meter (ft/min)	Flow Indicator Position (__ / 8)	Depth To Water (FT BTOC)	Remarks
PUMP STATION BUILDING (PSB) MONITORING POINTS												
		PSB	**Header**									
		PSB-1	Manifold									
		PSB-2	Manifold									
		DPE-1	Lateral									
		Stinger Depth	Stinger									
		ft BTOC	Well									
		DPE-2	Lateral									
		Stinger Depth	Stinger									
		ft BTOC	Well									
		DPE-3	Lateral									
		Stinger Depth	Stinger									
		ft BTOC	Well									
		DPE-4	Lateral									
		Stinger Depth	Stinger									
		ft BTOC	Well									
		PV-1	Well									

Recorded By	Date
Checked By	Date

"blank" or "NC" = Not Checked
"NA" = Not Applicable
btoc - below top of casing
cfm - cubic feet per minute
ppmv - parts per million by volume
Hg - Mercury
H2O - Water

COMPLIANCE EFFLUENT MONITORING
LAUREL STATION DPE SYSTEM

Field Technician(s)		**Client**	Kinder Morgan
Project Number		**Installation**	Laurel Station
Company Name		**Location**	Bellingham, Washington

List Reference Where Information came from (e.g. Log Book name)

Date Measured	Time Measured	DPE System Measurement Location	Pressure Gauge (in H2O)	PID (ppm)	FID (ppm)	Pitot Tube Gauge (in H2O)	Air Flow Meter (ft/min)	Remarks

Recorded By	Date
Checked By	Date

"blank" or "NC" = Not Checked
ppmv - parts per million by vollume
Hg - Mercury
H2O - Water

Date:

GROUNDWATER MONITORING
LAUREL STATION DPE SYSTEM

Field Technicians:	Client: Kinder Morgan
Project Number:	Installation: Laurel Station
Company Name:	Location: Bellingham, Washington

Well ID	(a) Length to Water[a] (ft)	(b) Depth to Water bgs (ft)	(c) Length of Well (ft)	(d) Feet of Water[b] (ft)	(e) Product Thickness (in)	(f) Well Diameter (in)	(g) Length of Stinger in Well[c] (ft)	Well Condition/Comments
DPE-1								
DPE-2								
DPE-3								
DPE-4	NA							
DPE-5	NA							
DPE-6								
DPE-7								
DPE-8								
DPE-9	NA							
DPE-10								
MW-3	NA							
MW-4	NA							
MW-6	NA							
MW-8	NA							
MW-11	NA							
MW-12	NA							
MW-13	NA							
MW-14	NA							
MW-15	NA							
MW-16	NA							
SW-1	NA							
SW-2	NA							
SW-3	NA							

a = Only applicable for wells installed at an angle

b = For feet of water in angle wells subtract column (c) from column (a). For non angle wells subract column (c) from column (b).

c= If water is present in the well adjust length of stinger in the well so it is in the water column. For angle wells use column (a) for non angle wells use column (b).

"blank" or "NC" = Not Checked

"NA" = Not Applicable

bgs = below ground surface

ft = feet

in = inches

Comments:

STINGER PLACEMENT CHART
LAUREL STATION DPE SYSTEM
Dual-Phase Extraction Wells

DPE-1				DPE-2				DPE-3				DPE-4				DPE-5			
TL = 27.98 @ 30 degrees				TL=24.15 @ 35 degrees				TL=22.24 @ 30 degrees				TD = 15.45				TD = 23.95			
Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe	
	FT		1		FT		1		FT		1		FT		1		FT		1
LTW	Total		2	LTW	Total		2	LTW	Total		2	DTW	Total	NA	NA	DTW	Total		2
FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3
Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe	
	FT		1		FT		1		FT		1		FT		1		FT		1
LTW	Total		2	LTW	Total		2	LTW	Total		2	DTW	Total	NA	NA	DTW	Total		2
FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3
Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe	
	FT		1		FT		1		FT		1		FT		1		FT		1
LTW	Total		2	LTW	Total		2	LTW	Total		2	DTW	Total	NA	NA	DTW	Total		2
FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3
Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe	
	FT		1		FT		1		FT		1		FT		1		FT		1
LTW	Total		2	LTW	Total		2	LTW	Total		2	DTW	Total	NA	NA	DTW	Total		2
FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3
Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe	
	FT		1		FT		1		FT		1		FT		1		FT		1
LTW	Total		2	LTW	Total		2	LTW	Total		2	DTW	Total	NA	NA	DTW	Total		2
FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3
Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe	
	FT		1		FT		1		FT		1		FT		1		FT		1
LTW	Total		2	LTW	Total		2	LTW	Total		2	DTW	Total	NA	NA	DTW	Total		2
FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3
Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe	
	FT		1		FT		1		FT		1		FT		1		FT		1
LTW	Total		2	LTW	Total		2	LTW	Total		2	DTW	Total	NA	NA	DTW	Total		2
FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3
Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe	
	FT		1		FT		1		FT		1		FT		1		FT		1
LTW	Total		2	LTW	Total		2	LTW	Total		2	DTW	Total	NA	NA	DTW	Total		2
FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3
Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe	
	FT		1		FT		1		FT		1		FT		1		FT		1
LTW	Total		2	LTW	Total		2	LTW	Total		2	DTW	Total	NA	NA	DTW	Total		2
FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3

DPE-6				DPE-7				DPE-8				DPE-9				DPE-10			
TL=34.9 @ 45 degrees				TL=34.3 @ 45 degrees				TL=34.0 @ 35 degrees				TD = 34.1				TL=26.1 @ 45 degrees			
Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe	
	FT		1		FT		1		FT		1		FT		1		FT		1
LTW	Total		2	LTW	Total		2	LTW	Total		2	DTW	Total		2	LTW	Total		2
FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3
Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe	
	FT		1		FT		1		FT		1		FT		1		FT		1
LTW	Total		2	LTW	Total		2	LTW	Total		2	DTW	Total		2	LTW	Total		2
FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3
Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe	
	FT		1		FT		1		FT		1		FT		1		FT		1
LTW	Total		2	LTW	Total		2	LTW	Total		2	DTW	Total		2	LTW	Total		2
FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3
Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe	
	FT		1		FT		1		FT		1		FT		1		FT		1
LTW	Total		2	LTW	Total		2	LTW	Total		2	DTW	Total		2	LTW	Total		2
FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3
Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe	
	FT		1		FT		1		FT		1		FT		1		FT		1
LTW	Total		2	LTW	Total		2	LTW	Total		2	DTW	Total		2	LTW	Total		2
FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3
Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe	
	FT		1		FT		1		FT		1		FT		1		FT		1
LTW	Total		2	LTW	Total		2	LTW	Total		2	DTW	Total		2	LTW	Total		2
FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3
Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe	
	FT		1		FT		1		FT		1		FT		1		FT		1
LTW	Total		2	LTW	Total		2	LTW	Total		2	DTW	Total		2	LTW	Total		2
FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3
Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe	
	FT		1		FT		1		FT		1		FT		1		FT		1
LTW	Total		2	LTW	Total		2	LTW	Total		2	DTW	Total		2	LTW	Total		2
FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3
Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe		Date	Hose	Pipe	
	FT		1		FT		1		FT		1		FT		1		FT		1
LTW	Total		2	LTW	Total		2	LTW	Total		2	DTW	Total		2	LTW	Total		2
FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3	FT	FT		3

Notes:

Check boxes 1, 2 or 3 if the respective section of the stinger pipe are installed

Section 1 - 3.1 feet long	1+2+3 = 18.2 feet
Section 2 - 5.1 feet long	2+3 = 15.1 feet
Section 3 - 10.0 feet long	1+3 = 13.1 feet

TOC	Top Of Casing
TOTAL	Represents the Stinger Length from the top of well casing to the inlet of the stinger pipe in feet
Date	The date the stinger pipe was adjusted or confirmed
Initial	The initials of the person who adjusted or confirmed the length of the stinger pipe in the well
DTW	Depth to Water (recorded in feet)
TD	TOTAL DEPTH of stinter measured from top of casing TOC (recorded in feet)
LTW	Length to Water (recorded in feet)
TL	TOTAL LENGTH of stinger measured from TOC

APPENDIX F

DPE Well Vault Forms

APPENDIX G

Equipment Information to Supplement Seneca O&M Manual

APPENDIX H

Ladder Logic Controls

APPENDIX F

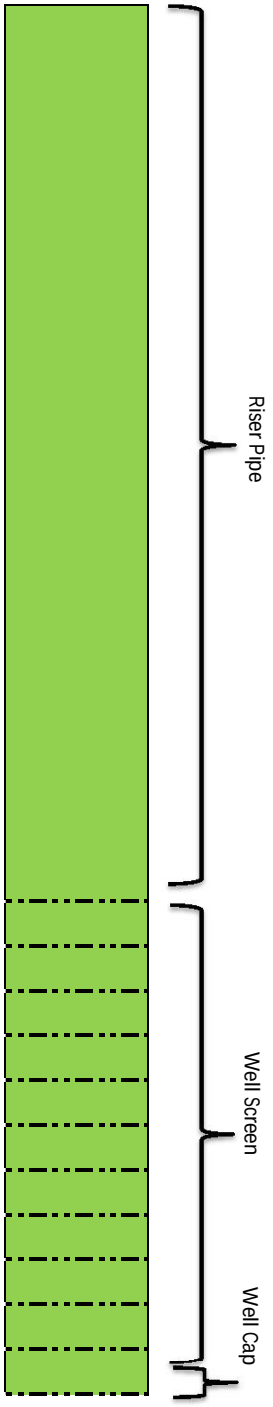
DPE Well Vault Forms

Dual Phase Extraction Well #1 (DPE 1)

Date Started:	12/9/2014
Date Completed:	12/10/2014
Drilling Method:	Sonic Drill Rig
Drill Casing Used:	8 inch
Angle of Well:	30 degree

WELL DETAILS	Riser Pipe	4" Sch. 40 PVC riser (19.5 FT)
	Screen	4" Sch. 40 0.030" PVC screen (10 FT)
	Well Cap	4" Sch. 40 PVC cap (0.5 FT)
	Total Well Length	30.0 FT
	Total Well Depth	25.98 FT

Length of Well FT	Actual Depth FT (bgs)
0.00	0.00
1.00	0.87
2.00	1.73
3.00	2.60
4.00	3.46
5.00	4.33
6.00	5.20
7.00	6.06
8.00	6.93
9.00	7.79
10.00	8.66
11.00	9.53
12.00	10.39
13.00	11.26
14.00	12.12
15.00	12.99
16.00	13.86
17.00	14.72
18.00	15.59
19.00	16.45
20.00	17.32
21.00	18.19
22.00	19.05
23.00	19.92
24.00	20.78
25.00	21.65
26.00	22.52
27.00	23.38
28.00	24.25
29.00	25.11
30.00	25.98



Conversion Factor For 30° Well Length to Depth: 0.87

Measurements used to determine depths between each foot length interval

Length (FT)	Depth (FT)
0.10	0.09
0.20	0.17
0.30	0.26
0.40	0.35
0.50	0.43
0.60	0.52
0.70	0.61
0.80	0.69
0.90	0.78
1.00	0.87

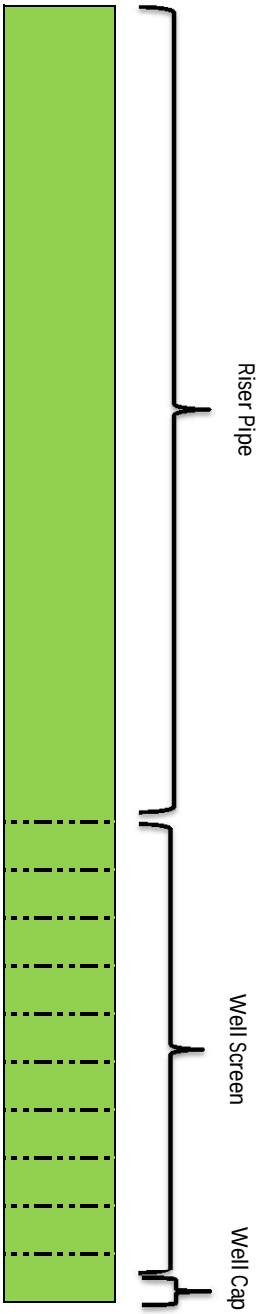
WELL SCREEN	Length (FT)	Depth (FT)
TOP	19.50	16.89
BOTTOM	29.50	25.55

Dual Phase Extraction Well #2 (DPE-2)

Date Started:	12/11/2014
Date Completed:	12/11/2014
Drilling Method:	Sonic Drill Rig
Drill Casing Used:	8 inch
Angle of Well:	35 degrees

WELL DETAILS	Riser Pipe	4" Sch. 40 PVC riser (15.5 FT)
	Screen	4" Sch. 40 0.030" PVC screen (10.0 FT)
	Well Cap	4" Sch. 40 PVC cap (0.5 FT)
	Total Well Length	26.0 FT
	Total Well Depth	21.3 FT

Length of Well (FT)	Actual Depth (FT BGS)
0.00	0.00
1.00	0.82
2.00	1.64
3.00	2.46
4.00	3.28
5.00	4.10
6.00	4.91
7.00	5.73
8.00	6.55
9.00	7.37
10.00	8.19
11.00	9.01
12.00	9.83
13.00	10.65
14.00	11.47
15.00	12.29
16.00	13.11
17.00	13.93
18.00	14.74
19.00	15.56
20.00	16.38
21.00	17.20
22.00	18.02
23.00	18.84
24.00	19.66
25.00	20.48
26.00	21.30



Conversion Factor For 35° Well Length to Depth: 0.82

Measurements used to determine depths between each foot length interval

Length (FT)	Depth (FT)
0.10	0.08
0.20	0.16
0.30	0.25
0.40	0.33
0.50	0.41
0.60	0.49
0.70	0.57
0.80	0.66
0.90	0.74
1.00	0.82

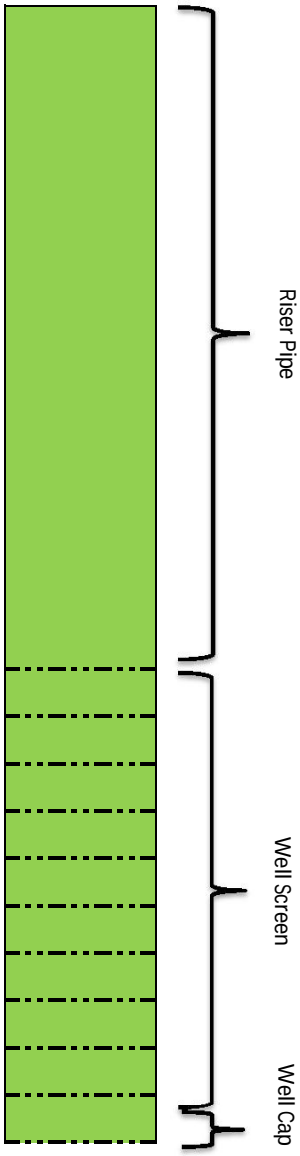
WELL SCREEN	Length (FT)	Depth (FT)
TOP	15.50	12.70
BOTTOM	25.50	20.89

Dual Phase Extraction Well #3 (DPE 3)

Date Started:	12/9/2014
Date Completed:	12/9/2014
Drilling Method:	Sonic Drill Rig
Drill Casing Used:	8 inch
Angle of Well:	30 degree

WELL DETAILS	Riser Pipe	4" Sch. 40 PVC riser (12.5 FT)
	Screen	4" Sch. 40 0.030" PVC screen (10 FT)
	Well Cap	4" Sch. 40 PVC cap (0.5 FT)
	Total Well Length	23.0 FT
	Total Well Depth	19.92 FT

Length of Well FT	Actual Depth FT (bgs)
0.00	0.00
1.00	0.87
2.00	1.73
3.00	2.60
4.00	3.46
5.00	4.33
6.00	5.20
7.00	6.06
8.00	6.93
9.00	7.79
10.00	8.66
11.00	9.53
12.00	10.39
13.00	11.26
14.00	12.12
15.00	12.99
16.00	13.86
17.00	14.72
18.00	15.59
19.00	16.45
20.00	17.32
21.00	18.19
22.00	19.05
23.00	19.92



Conversion Factor For 30° Well Length to Depth: 0.87

Measurements used to determine depths between each foot length interval

Length (FT)	Depth (FT)
0.10	0.09
0.20	0.17
0.30	0.26
0.40	0.35
0.50	0.43
0.60	0.52
0.70	0.61
0.80	0.69
0.90	0.78
1.00	0.87

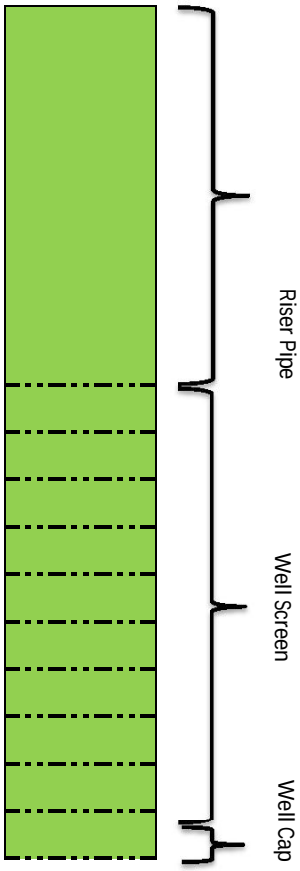
WELL SCREEN	Length (FT)	Depth (FT)
TOP	12.50	10.83
BOTTOM	22.50	19.49

Dual Phase Extraction Well #4 (DPE 4)

Date Started:	1/19/2015
Date Completed:	1/19/2015
Drilling Method:	Sonic Drill Rig
Drill Casing Used:	8 inch
Angle of Well:	NA

WELL DETAILS	Riser Pipe	4" Sch. 40 PVC riser (6.5 FT)
	Screen	4" Sch. 40 0.030" PVC screen (10 FT)
	Well Cap	4" Sch. 40 PVC cap (0.5 FT)
	Total Well Length	17.0 FT
	Total Well Depth	17.0 FT

Depth of Well FT (bgs)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
15.00
16.00
17.00



WELL SCREEN	Depth (FT)
TOP	6.50
BOTTOM	16.50

Dual Phase Extraction Well #5 (DPE 5)

Date Started:	1/17/2015
Date Completed:	1/17/2015
Drilling Method:	Sonic Drill Rig
Drill Casing Used:	8 inch
Angle of Well:	NA

WELL DETAILS	Riser Pipe	4" Sch. 40 PVC riser (14.5 FT)
	Screen	4" Sch. 40 0.030" PVC screen (10 FT)
	Well Cap	4" Sch. 40 PVC cap (0.5 FT)
	Total Well Length	25.0 FT
	Total Well Depth	25.0 FT

Depth of Well FT (bgs)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
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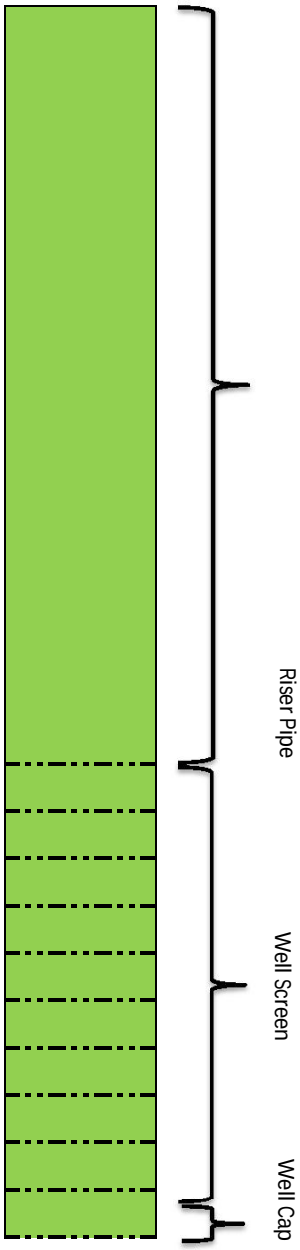
23.00
24.00
25.00



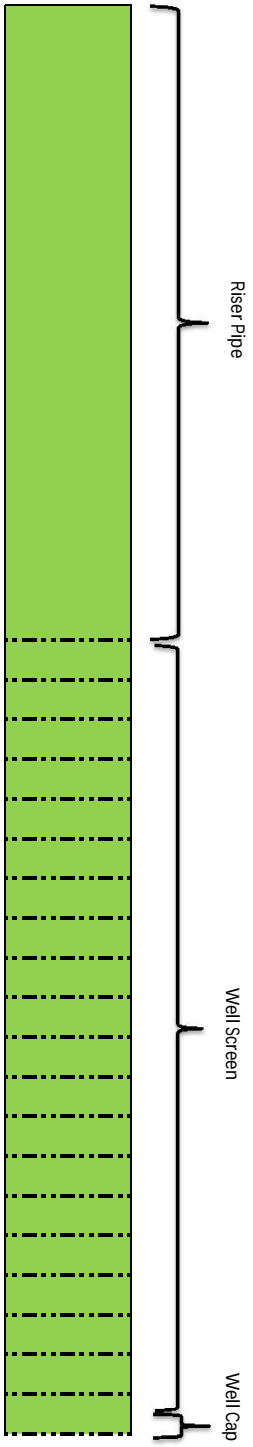
WELL SCREEN	Depth (FT)
TOP	14.50
BOTTOM	24.50

Dual Phase Extraction Well #6 (DPE 6)

Date Started:	1/14/2015
Date Completed:	1/15/2015
Drilling Method:	Sonic Drill Rig
Drill Casing Used:	8 inch
Angle of Well:	45 degree

WELL DETAILS	Riser Pipe	4" Sch. 40 PVC riser (14.5 FT)
	Screen	4" Sch. 40 0.030" PVC screen (20 FT)
	Well Cap	4" Sch. 40 PVC cap (0.5 FT)
	Total Well Length	35.0 FT
	Total Well Depth	24.8 FT

Length of Well FT	Actual Depth FT (bgs)
0.00	0.00
1.00	0.71
2.00	1.41
3.00	2.12
4.00	2.83
5.00	3.54
6.00	4.24
7.00	4.95
8.00	5.66
9.00	6.36
10.00	7.07
11.00	7.78
12.00	8.49
13.00	9.19
14.00	9.90
15.00	10.61
16.00	11.31
17.00	12.02
18.00	12.73
19.00	13.44
20.00	14.14
21.00	14.85
22.00	15.56
23.00	16.26
24.00	16.97
25.00	17.68
26.00	18.38
27.00	19.09
28.00	19.80
29.00	20.51
30.00	21.21
31.00	21.92
32.00	22.63
33.00	23.33
34.00	24.04
35.00	24.75



Conversion Factor For 45° Well Length to Depth: 0.70

Measurements used to determine depths between each foot length interval

Length (FT)	Depth (FT)
0.10	0.07
0.20	0.14
0.30	0.21
0.40	0.28
0.50	0.35
0.60	0.42
0.70	0.49
0.80	0.57
0.90	0.64
1.00	0.71

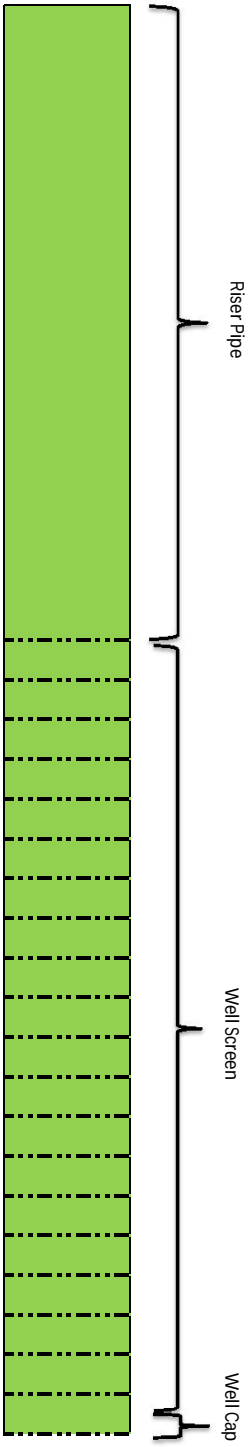
WELL SCREEN	Length (FT)	Depth (FT)
TOP	14.50	10.25
BOTTOM	34.50	24.40

Dual Phase Extraction Well #7 (DPE 7)

Date Started:	1/13/2015
Date Completed:	1/14/2015
Drilling Method:	Sonic Drill Rig
Drill Casing Used:	8 inch
Angle of Well:	45 degree

WELL DETAILS	Riser Pipe	4" Sch. 40 PVC riser (14.5 FT)
	Screen	4" Sch. 40 0.030" PVC screen (20 FT)
	Well Cap	4" Sch. 40 PVC cap (0.5 FT)
	Total Well Length	35.0 FT
	Total Well Depth	24.8 FT

Length of Well FT	Actual Depth FT (bgs)
0.00	0.00
1.00	0.71
2.00	1.41
3.00	2.12
4.00	2.83
5.00	3.54
6.00	4.24
7.00	4.95
8.00	5.66
9.00	6.36
10.00	7.07
11.00	7.78
12.00	8.49
13.00	9.19
14.00	9.90
15.00	10.61
16.00	11.31
17.00	12.02
18.00	12.73
19.00	13.44
20.00	14.14
21.00	14.85
22.00	15.56
23.00	16.26
24.00	16.97
25.00	17.68
26.00	18.38
27.00	19.09
28.00	19.80
29.00	20.51
30.00	21.21
31.00	21.92
32.00	22.63
33.00	23.33
34.00	24.04
35.00	24.75



Conversion Factor For 45° Well Length to Depth: 0.70

Measurements used to determine depths between each foot length interval

Length (FT)	Depth (FT)
0.10	0.07
0.20	0.14
0.30	0.21
0.40	0.28
0.50	0.35
0.60	0.42
0.70	0.49
0.80	0.57
0.90	0.64
1.00	0.71

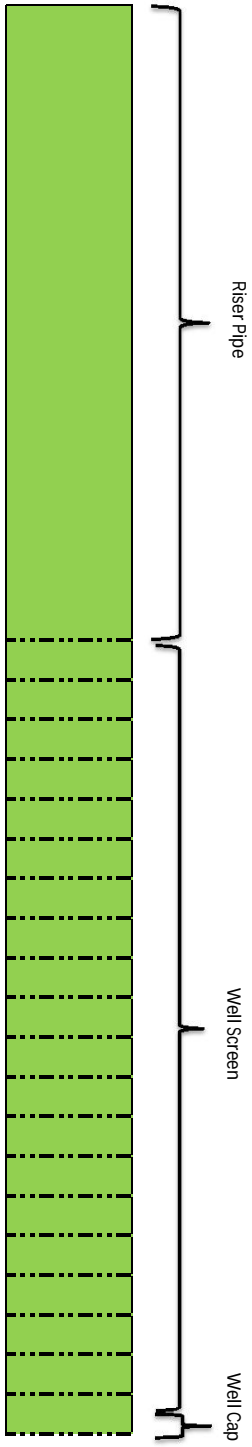
WELL SCREEN	Length (FT)	Depth (FT)
TOP	14.50	10.25
BOTTOM	34.50	24.40

Dual Phase Extraction Well #8 (DPE 8)

Date Started:	12/11/2014
Date Completed:	12/11/2014
Drilling Method:	Sonic Drill Rig
Drill Casing Used:	8 inch
Angle of Well:	35 degrees

WELL DETAILS	Riser Pipe	4" Sch. 40 PVC riser (14.5 FT)
	Screen	4" Sch. 40 0.030" PVC screen (20 FT)
	Well Cap	4" Sch. 40 PVC cap (0.5 FT)
	Total Well Length	35.0 FT
	Total Well Depth	24.8 FT

Length of Well FT	Actual Depth FT (bgs)
0.00	0.00
1.00	0.82
2.00	1.64
3.00	2.46
4.00	3.28
5.00	4.10
6.00	4.91
7.00	5.73
8.00	6.55
9.00	7.37
10.00	8.19
11.00	9.01
12.00	9.83
13.00	10.65
14.00	11.47
15.00	12.29
16.00	13.11
17.00	13.93
18.00	14.74
19.00	15.56
20.00	16.38
21.00	17.20
22.00	18.02
23.00	18.84
24.00	19.66
25.00	20.48
26.00	21.30
27.00	22.12
28.00	22.94
29.00	23.76
30.00	24.57
31.00	25.39
32.00	26.21
33.00	27.03
34.00	27.85
35.00	28.67



Conversion Factor For 35° Well Length to Depth: 0.82

Measurements used to determine depths between each foot length interval

Length (FT)	Depth (FT)
0.10	0.00
0.20	0.08
0.30	0.16
0.40	0.25
0.50	0.33
0.60	0.41
0.70	0.49
0.80	0.57
0.90	0.66
1.00	0.74

WELL SCREEN	Length (FT)	Depth (FT)
TOP	14.50	11.88
BOTTOM	34.50	28.26

Dual Phase Extraction Well #9 (DPE 9)

Date Started:	1/16/2015
Date Completed:	1/16/2015
Drilling Method:	Sonic Drill Rig
Drill Casing Used:	8 inch
Angle of Well:	NA

WELL DETAILS	Riser Pipe	4" Sch. 40 PVC riser (24.5 FT)
	Screen	4" Sch. 40 0.030" PVC screen (10 FT)
	Well Cap	4" Sch. 40 PVC cap (0.5 FT)
	Total Well Length	35.0 FT
	Total Well Depth	35.0 FT

Depth of Well FT (bgs)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
15.00
16.00
17.00
18.00
19.00
20.00
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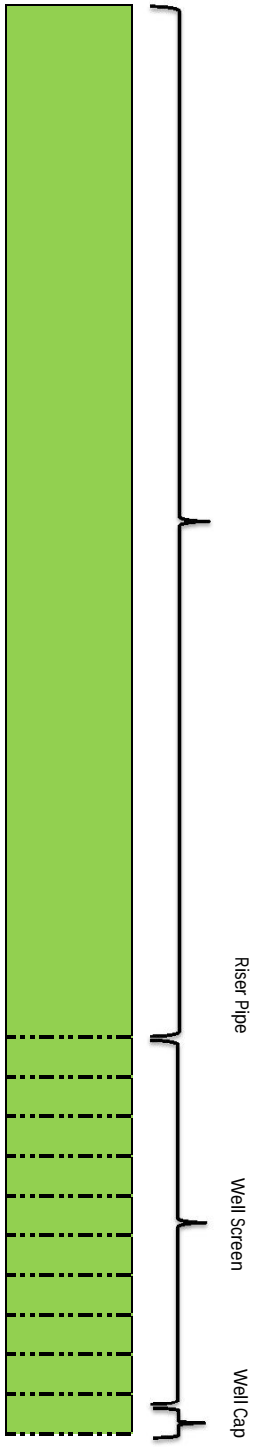


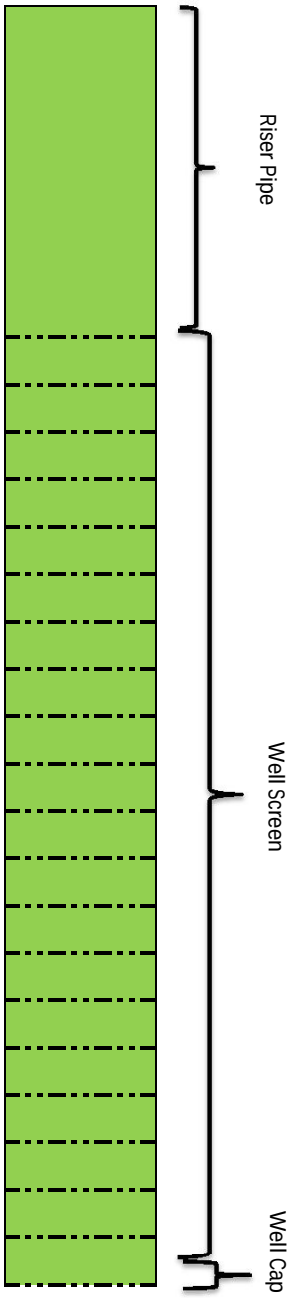
WELL SCREEN	Depth (FT)
TOP	24.50
BOTTOM	34.50

Dual Phase Extraction Well #10 (DPE 10)

Date Started:	1/15/2015
Date Completed:	1/15/2015
Drilling Method:	Sonic Drill Rig
Drill Casing Used:	8 inch
Angle of Well:	45 degree

WELL DETAILS	Riser Pipe	4" Sch. 40 PVC riser (5.5 FT)
	Screen	4" Sch. 40 0.030" PVC screen (20 FT)
	Well Cap	4" Sch. 40 PVC cap (0.5 FT)
	Total Well Length	26.0 FT
	Total Well Depth	18.4 FT

Length of Well FT	Actual Depth FT (bgs)
0.00	0.00
1.00	0.71
2.00	1.41
3.00	2.12
4.00	2.83
5.00	3.54
6.00	4.24
7.00	4.95
8.00	5.66
9.00	6.36
10.00	7.07
11.00	7.78
12.00	8.49
13.00	9.19
14.00	9.90
15.00	10.61
16.00	11.31
17.00	12.02
18.00	12.73
19.00	13.44
20.00	14.14
21.00	14.85
22.00	15.56
23.00	16.26
24.00	16.97
25.00	17.68
26.00	18.38



Conversion Factor For 45° Well Length to Depth: 0.70

Measurements used to determine depths between each foot length interval

Length (FT)	Depth (FT)
0.10	0.07
0.20	0.14
0.30	0.21
0.40	0.28
0.50	0.35
0.60	0.42
0.70	0.49
0.80	0.57
0.90	0.64
1.00	0.71

WELL SCREEN	Length (FT)	Depth (FT)
TOP	5.50	3.89
BOTTOM	25.50	18.03

APPENDIX G

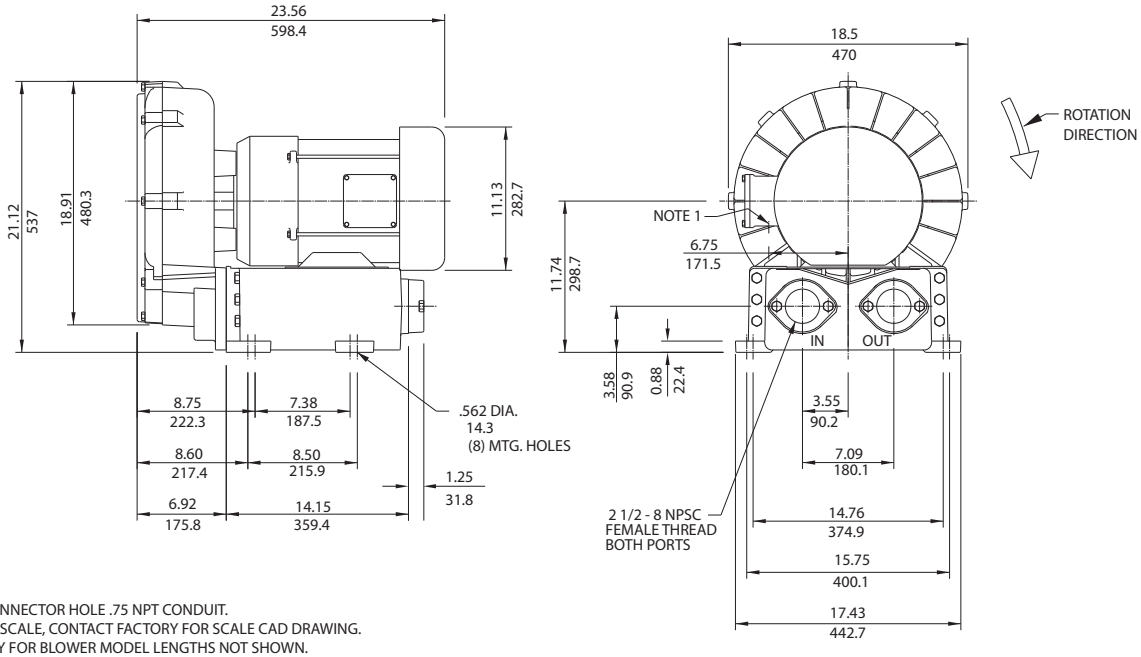
Equipment Information to Supplement Seneca O&M Manual

Environmental / Chemical Processing Blowers

ROTRON®

EN 808 & CP 808 Three-Phase

Sealed Regenerative Blower w/Explosion-proof Motor



IN
MM

NOTES
1. TERMINAL BOX CONNECTOR HOLE .75 NPT CONDUIT.
2. DRAWING NOT TO SCALE, CONTACT FACTORY FOR SCALE CAD DRAWING.
3. CONTACT FACTORY FOR BLOWER MODEL LENGTHS NOT SHOWN.

		Part/ Model Number		
		EN808BA72MXL	EN808BA86MXL	CP808FY72MXLR
Specification	Units	081229	081230	081234
Motor Enclosure - Shaft Mtl.	-	Explosion-proof-CS	Explosion-proof-CS	Chem XP-SS
Horsepower	-	7.5	7.5	7.5
Phase - Frequency	-	Three-60 hz	Three-60 hz	Three-60 hz
Voltage	AC	230/460	575	230/460
Motor Nameplate Amps	Amps (A)	18.6/9.3	7.4	18.6/9.3
Max. Blower Amps	Amps (A)	22.0/11.0	8.1	22.0/11.0
Inrush Amps	Amps (A)	126/63	56	126/63
Service Factor	-	1.0	1.0	1.0
Starter Size	-	1/1	1	1/1
Thermal Protection	-	Class B - Pilot Duty	Class B - Pilot Duty	Class B - Pilot Duty
XP Motor Class - Group	-	I-D, II-F&G	I-D, II-F&G	I-D, II-F&G
Shipping Weight	Lbs	287	287	287
	Kg	130.2	130.2	130.2

Voltage - ROTRON motors are designed to handle a broad range of world voltages and power supply variations. Our dual voltage 3 phase motors are factory tested and certified to operate on both: **208-230/415-460 VAC-3 ph-60 Hz** and **190-208/380-415 VAC-3 ph-50 Hz**. Our dual voltage 1 phase motors are factory tested and certified to operate on both: **104-115/208-230 VAC-1 ph-60 Hz** and **100-110/200-220 VAC-1 ph-50 Hz**. All voltages above can handle a ±10% voltage fluctuation. Special wound motors can be ordered for voltages outside our certified range.

Operating Temperatures - Maximum operating temperature: Motor winding temperature (winding rise plus ambient) should not exceed 140°C for Class F rated motors or 120°C for Class B rated motors. Blower outlet air temperature should not exceed 140°C (air temperature rise plus inlet temperature). Performance curve maximum pressure and suction points are based on a 40°C inlet and ambient temperature. Consult factory for inlet or ambient temperatures above 40°C.

Maximum Blower Amps - Corresponds to the performance point at which the motor or blower temperature rise with a 40°C inlet and/or ambient temperature reaches the maximum operating temperature.

XP Motor Class - Group - See Explosive Atmosphere Classification Chart in Section I

AMETEK TECHNICAL & INDUSTRIAL PRODUCTS
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Customer Service Fax: +1 215.256.1338
www.ametektip.com

AMETEK®
TECHNICAL & INDUSTRIAL PRODUCTS

Environmental / Chemical Processing Blowers

EN 808 & CP 808 Three-Phase

ROTRON®

Sealed Regenerative Blower w/Explosion-proof Motor

FEATURES

- Manufactured in the USA - ISO 9001 and NAFTA compliant
- Maximum flow: 360 SCFM
- Maximum pressure: 85 IWG
- Maximum vacuum: 90 IWG
- Standard motor: 7.5 HP, explosion-proof
- Cast aluminum blower housing, impeller , cover & manifold; cast iron flanges (threaded); teflon® lip seal
- UL & CSA approved motor with permanently sealed ball bearings for explosive gas atmospheres Class I Group D minimum
- Sealed blower assembly
- Quiet operation within OSHA standards

MOTOR OPTIONS

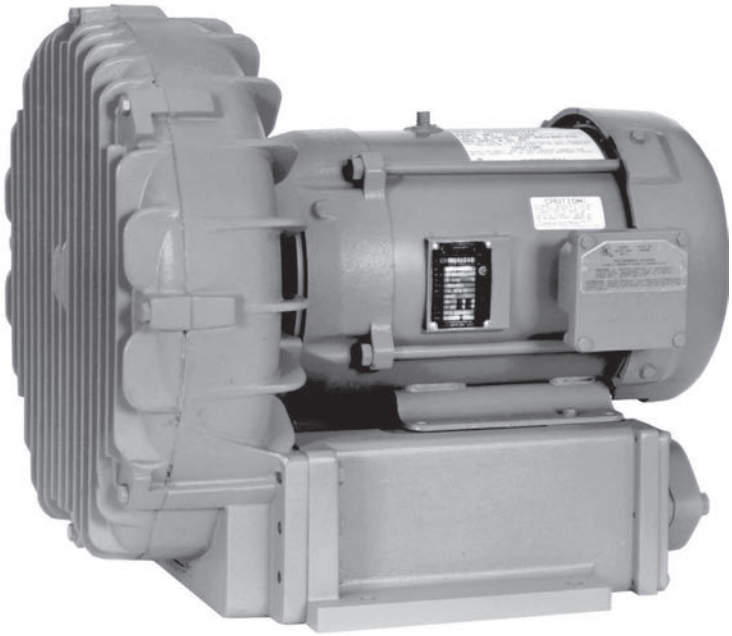
- International voltage & frequency (Hz)
- Chemical duty, high efficiency, inverter duty or industry-specific designs
- Various horsepowers for application-specific needs

BLOWER OPTIONS

- Corrosion resistant surface treatments & sealing options
- Remote drive (motorless) models
- Slip-on or face flanges for application-specific needs

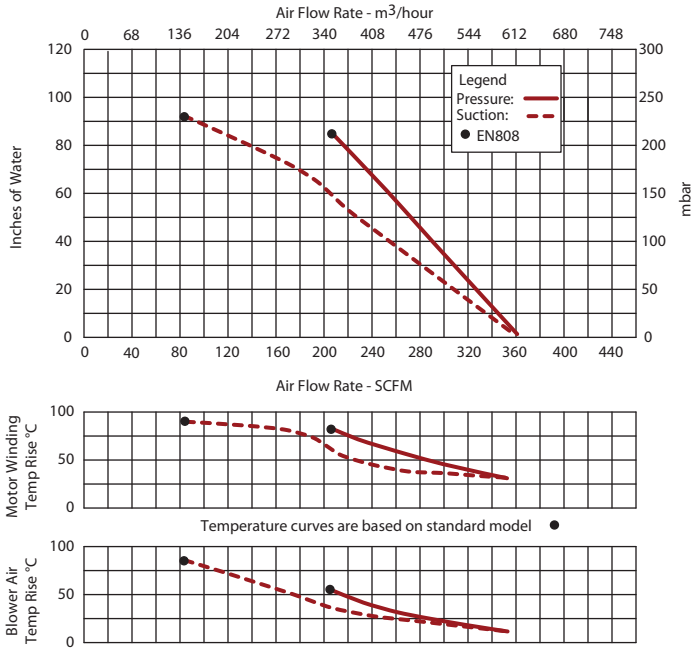
ACCESSORIES

- Flowmeters reading in SCFM
- Filters & moisture separators
- Pressure gauges, vacuum gauges, & relief valves
- Switches - air flow, pressure, vacuum, or temperature
- External mufflers for additional silencing
- Air knives (used on blow-off applications)
- Variable frequency drive package

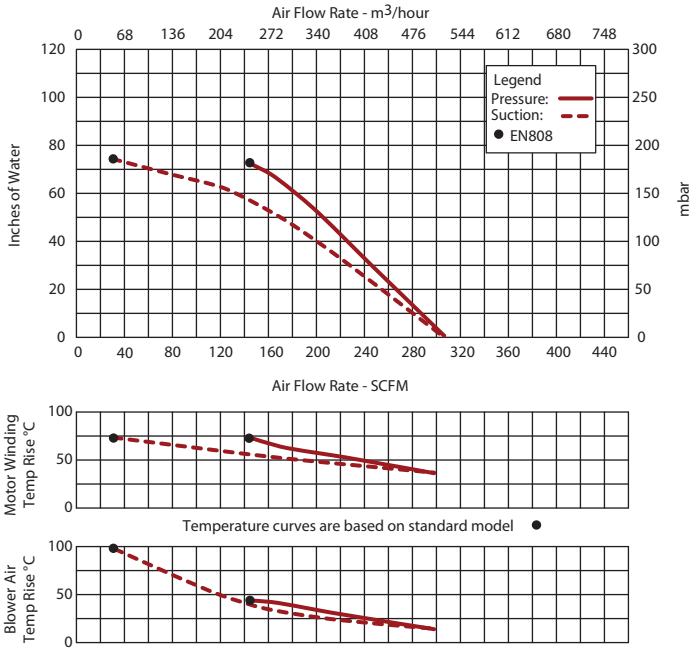


Blower Performance at Standard Conditions

60 Hz



50 Hz



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Customer Service Fax: +1 215.256.1338
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AMETEK® TECHNICAL & INDUSTRIAL PRODUCTS

Contents:

Liquid Filters

AFD Series

- AFD-30
- AFD-55
- AFD-85
- AFD-110

AF Series

- AF-250
- AF-500
- AF-1000
- AF-2000
- AF-3000
- AF-5000
- AF-10000

HPAF Series

- HPAF-500
- HPAF-1000
- HPAF-2000
- HPAF-3000
- HPAF-5000
- HPAF-10000
- HPAF-20000

HPP Series

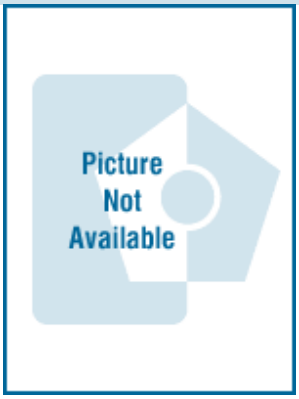
- HPP-50
- HPP-100
- HPP-200
- HPP-300
- HPP-500
- HPP-1000
- HPP-2000

Vapor Filters

Filtration Media

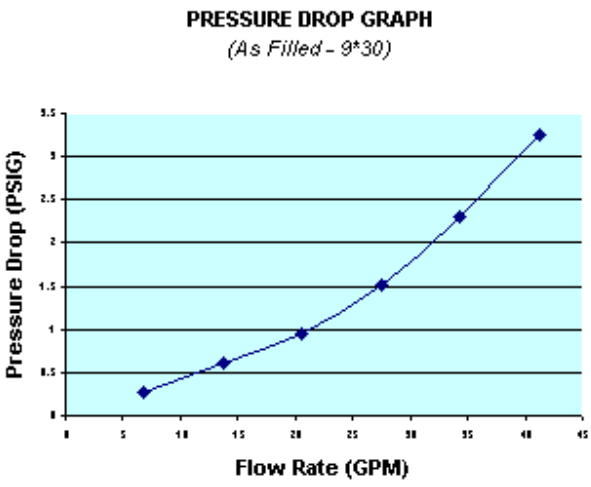
Special Products

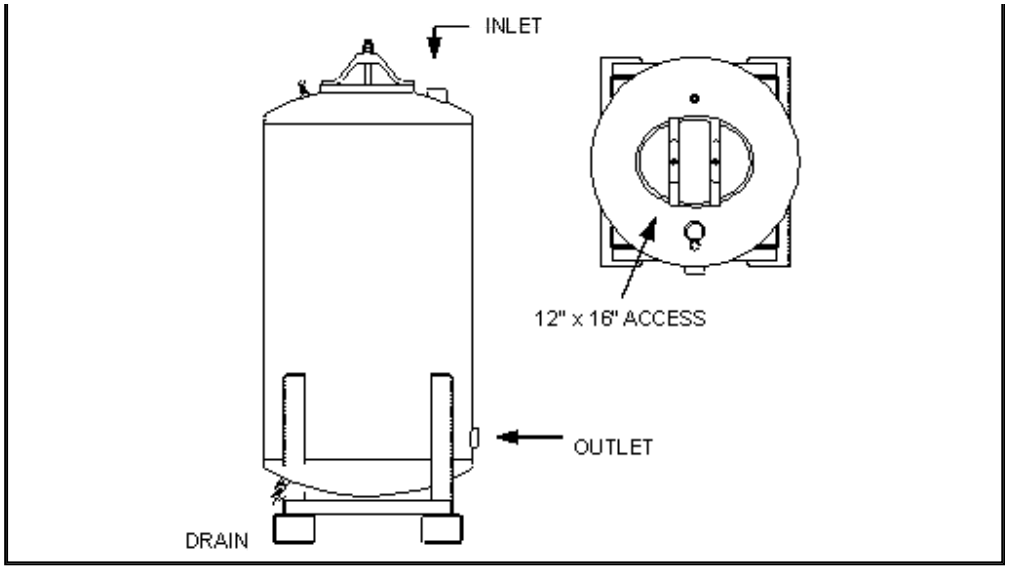
HPAF SERIES FILTERS
MODEL HPAF-500



The HPAF-500 filter is a media filter vessel designed to treat liquid streams. While the typical design application is a activated carbon adsorbtion unit, the filter can easily accommodate many medias. Some applications include:

- Dissolved Organic Removal (Activated Carbon)
- Suspended Solids Removal (Sand Filter)
- Dissolved Minerals (Softener Resin)
- Oil and Grease Removal (Organo-Clays)
- Dissolved and Precipitated Metals Removal
- Special Organics (Resin/Carbon Blend)
- Catalytic Reactor (Chlorine and Peroxide Removal)
- Bio-Remediation Contactor Unit





Carbon Bed Capacity Approximately 125 Gallons

HPAF-500 SPECIFICATIONS			
Overall Height	5'11"	Vessel/Internal Piping Materials	CS (SA-36) / SCH 40 PVC
Diameter	30"	Internal Coating	Polyamide Epoxy Resin
Inlet / Outlet (FNPT)	2"	External Coating	Epoxy Mastic
Drain / Vent (FNPT)	1/2" / 1/4"	Maximum Pressure / Temp	75 PSIG / 140º F
GAC Fill (lbs)	500	Cross Sectional Bed Area	4.9 FT^2
Shipping / Operational Weight (lbs)	850/1,770	Bed Depth/Volume	3.4 FT / 16.7 FT^3

Our Company | News | Catalog | Services | RFQs | Contact

Tetrasolv Filtration, Inc. • 1200 East 26th Street • Anderson, Indiana 46016 • USA
Toll Free: 800-441-4034 Telephone: 765-643-3941 • Fax: 765-643-3949
www.tetrasolv.com • info@tetrasolv.com

Contents:

Liquid Filters

Vapor Filters

VFD Series

- VFD-30
- VFD-55
- VFD-85
- VFD-110

VFV Series

- VFV-250
- VFV-500
- VFV-1000
- VFV-2000
- VFV-3000
- VFV-5000
- VFV-10000

VF Series

- VF-500
- VF-1000
- VF-2000
- VF-3000
- VF-5000
- VF-10000

VR Series

- VR-140
- VR-170
- VR-225
- VR-400
- VR-700
- VR-1600
- VR-2600

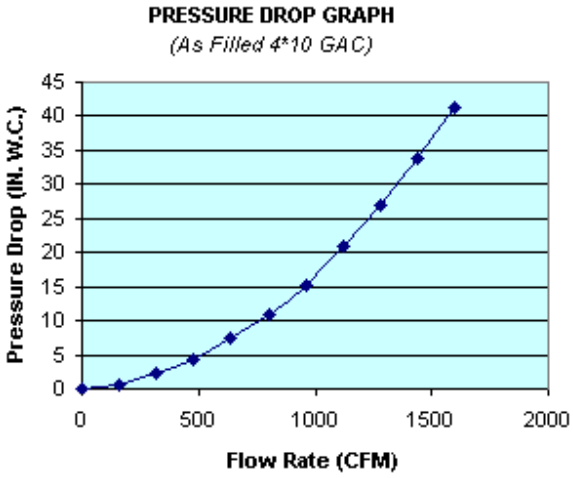
Filtration Media

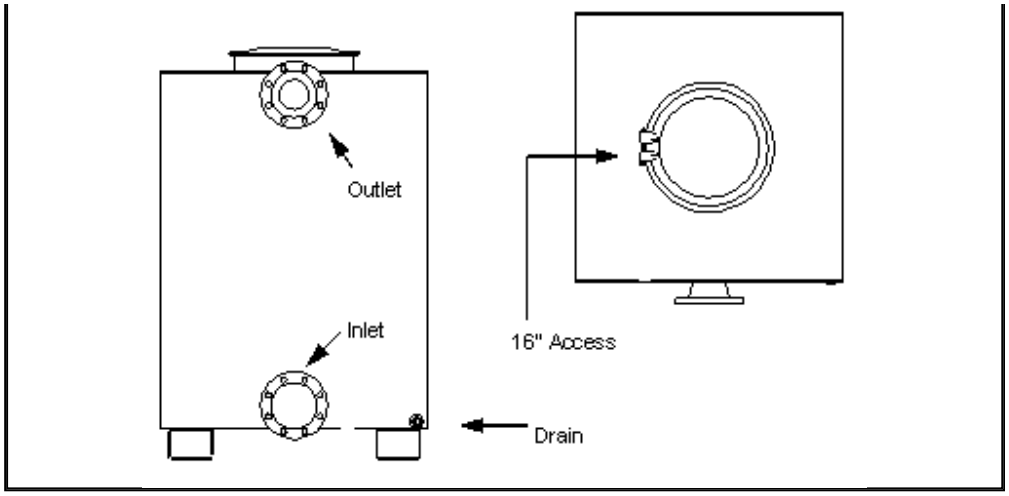
Special Products

VF SERIES FILTERS
MODEL VF-2000

The VF-2000 filter is a media filter vessel designed to treat vapor streams where pressure drop is a strong concern. While the typical design application is a activated carbon adsorbtion unit, the filter can easily accommodate many medias. The sturdy construction makes these filter vessels ideal for long term treatment units. Some applications include:

- Soil Vapor Extraction Treatment
- Air Stripper Off Gas Treatment
- Odor Removal System
- Storage Tank Purge Vapor Treatment
- Pilot Study
- Industrial Process Treatment





Carbon Bed Capacity Approximately 530 Gallons

VF-2000 SPECIFICATIONS			
Overall Height	6’8”	Vessel/Internal Piping Materials	Polypropylene
Footprint	4’ x 4’	Internal Coating	Polyamide (2-Part) Epoxy Resin
Inlet / Outlet (150# FLNG)	6”	External Coating	Epoxy Mastic (Light Grey)
Drain / Vent (FNPT)	1/2”	Maximum Pressure / Temp	3 PSIG / 250º F
GAC Fill (lbs)	2000	Cross Sectional Bed Area	16 FT^2
Shipping / Operational Weight (lbs)	2,650/3,200	Bed Depth/Volume	4.5 FT / 71 FT^3

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APPENDIX H

Ladder Logic Controls

TwidoSuite
Kinder Morgan Bellingham Site

Project Information

Print date	7/8/2015
Author	RR
Department	SES
Index	
Industrial Property	

Comment

Job # 1715005

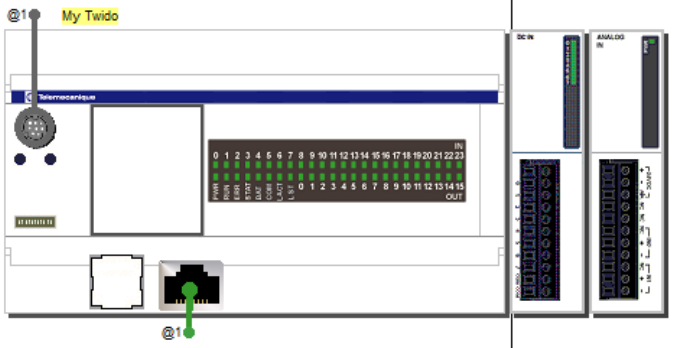
1009 East Smith Road

Bellingham, WAshington 98226

HMI

Contents

First Page	1
History	Not required
Contents	3
Graphical Description	4
Properties	7
Bill of material	8
Hardware	9
Memory objects	10
Memory report	12
Behavior configuration	13
Content	14
Symbols	27
Cross references	30
Animation table	31
Preferences	Not required
About	Not required
Total Page Number	31



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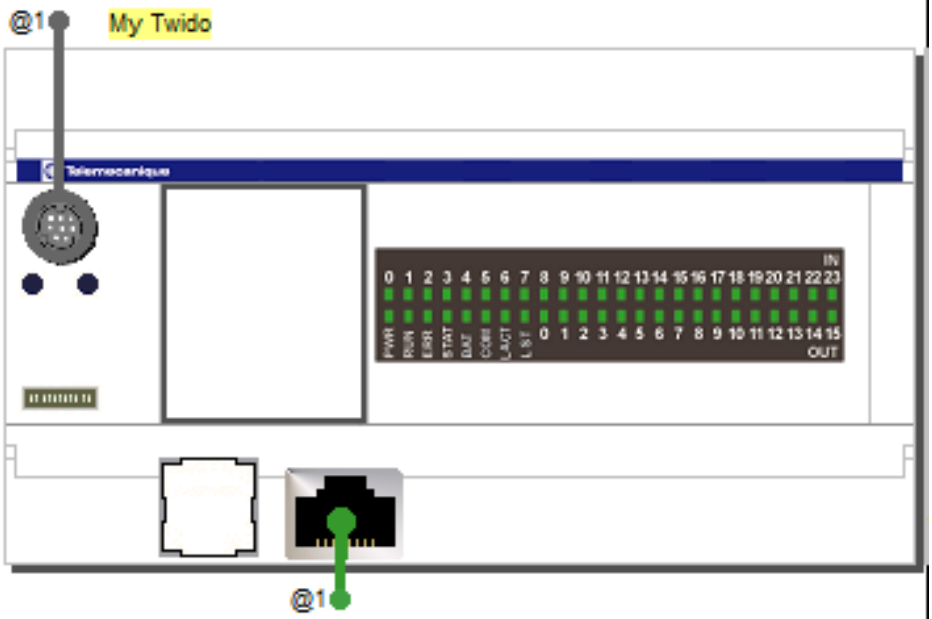
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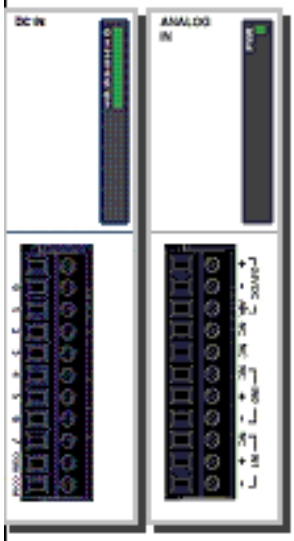
Page 1



Page 2

Properties

Ethernet Port :

IP address configuration

IP address :
Subnet mask :
Gateway address :

Marked IP

Marked IP address :

Idle time

Time (min) : 10

Remote devices

Index	IP	Unit ID	Timeout

Bill of material

Family	Reference number	Quantity
Twido	TWDLCAE40DRF	1
Twido	TM2DDI8DT	1
Twido	TM2AMI2HT	1

Hardware configuration

Base

TWDLCAE40DRF

Expansion bus modules

1 : TM2DDI8DT

2 : TM2AMI2HT

Memory objects configuration

Timer configuration (%TM)

Used	%TM	Symbol	Type	Adjustable	Time Base	Preset
Yes	%TM0	KO_TNK_HLIM_DLY_TMR	TON	Yes	1 min	20
Yes	%TM1	OW_SEP_TNK_HLIM_DLY_TMR	TON	Yes	1 min	20
Yes	%TM2	LRP_LOIL_LEV_DLY_TMR	TON	Yes	1 s	5
Yes	%TM3	LRP_HOIL_LEV_DLY_TMR	TON	Yes	1 s	5
Yes	%TM4	LRP_HTEMP_DLY_TMR	TON	Yes	1 s	5
Yes	%TM5	LRP_LAC_DLY_TMR	TON	Yes	1 s	15
Yes	%TM6	KO_PMP_HPRES_DLY_TMR	TON	Yes	1 s	5
Yes	%TM7	DC_PMP_HPRES_DLY_TMR	TON	Yes	1 s	5
Yes	%TM8	HT_EXCHG_HPRES_DLY_TMR	TON	Yes	1 s	5
Yes	%TM9	HT_EXCHG_DISCHG_HTEMP_LTCH	TON	Yes	1 s	5
Yes	%TM10	ETM_MIN_TMR	TON	Yes	1 min	6
Yes	%TM11	HT_EXCHG_ETM_REST_TIMR	TON	Yes	1 s	10
Yes	%TM12	SVE_BLW_ETM_REST_TMR	TON	Yes	1 s	10
Yes	%TM13	LRP_ETM_REST_TMR	TON	Yes	1 s	10

Counter configuration (%C)

Register configuration (%R)

Drum configuration (%DR)

Scheduler block configuration (%SCH)

Fast counters configuration (%FC)

Very fast counters configuration (%VFC)

Memory words (%MD)

Used	%MD	Symbol	Allocated
Yes	%MD100	HT_EXCHG_ETM	Yes
Yes	%MD102	SVE_BLW_ETM	Yes
Yes	%MD104	LRP_ETM	Yes

Memory words (%MW)

Used	%MW	Symbol	Allocated
Yes	%MW0	HT_EXCHG_DISCHG_TEMP	Yes
Yes	%MW1	HT_EXCHG_DISCHG_HTEMP_ST_PT	Yes
Yes	%MW701	DIALOG_TABLE_RTC1	Yes
Yes	%MW702	DIALOG_TABLE_RTC2	Yes
Yes	%MW703	DIALOG_TABLE_RTC3	Yes
Yes	%MW704	DIALOG_TABLE_RTC4	Yes
Yes	%MW705	DIALOG_TABLE_CALC	Yes

Memory words (%MF)

Memory bits (%M)

Used	%M	Symbol	Allocated
Yes	%M0	E_STOP_REST_BIT	Yes
Yes	%M1	E_STOP_BIT	Yes

Used	%M	Symbol	Allocated
Yes	%M2	PWR_MON_BIT	Yes
Yes	%M3	PWR_MON_LTCH	Yes
Yes	%M4	KO_TNK_HLIM_BIT	Yes
Yes	%M5	KO_TNK_HLIM_LTCH	Yes
Yes	%M6	OW_SEP_TNK_HLIM_BIT	Yes
Yes	%M7	OW_SEP_TNK_HLIM_LTCH	Yes
Yes	%M8	PRD_TNK_HLIM_LTCH	Yes
Yes	%M9	LRP_LOIL_LEV_LTCH	Yes
Yes	%M10	LRP_HOIL_LEV_LTCH	Yes
Yes	%M11	LRP_HTEMP_LTCH	Yes
Yes	%M12	LRP_LVAC_LTCH	Yes
Yes	%M13	KO_PMP_HPRES_LTCH	Yes
Yes	%M14	DC_PMP_HPRES_LTCH	Yes
Yes	%M15	HT_EXCHG_DISCHG_HPRES_LTCH	Yes
Yes	%M16	KO_PMP_MTR_OL_LTCH	Yes
Yes	%M17	DC_PMP_MTR_OL_LTCH	Yes
Yes	%M18	HT_EXCHG_MTR_OL_LTCH	Yes
Yes	%M19	SVE_BLW_MTR_OL_LTCH	Yes
Yes	%M20	LRP_MTR_OL_LTCH	Yes
Yes	%M21	KO_PMP_AUX_BIT	Yes
Yes	%M22	DC_PMP_AUX_BIT	Yes
Yes	%M23	HT_EXCHG_AUX_BIT	Yes
Yes	%M24	SVE_BLW_AUX_BIT	Yes
Yes	%M25	LRP_AUX_BIT	Yes
Yes	%M26	SYSTM_OK_BIT	Yes
Yes	%M27	SYSTM_ALRM_BIT	Yes
Yes	%M28	KO_TNK_LEV_CNTRL_BIT	Yes
Yes	%M29	OW_SEP_TNK_LEV_CNTRL_BIT	Yes
Yes	%M30	HT_EXCHG_ETM_REST_BIT	Yes
Yes	%M31	SVE_BLW_ETM_REST_BIT	Yes
Yes	%M32	LRP_ETM_REST_BIT	Yes
Yes	%M33	SYSTM_REST_BIT	Yes
Yes	%M34	HT_EXCHG_HTEMP_LTCH	Yes
Yes	%M35	KO_PMP_CNTRL_CONTINU	Yes
Yes	%M36	SVE_BLW_CNTRL_CONTINU	Yes
Yes	%M37	LRP_CNTRL_CONTINU	Yes
Yes	%M38	ETM_MIN_TMR_REST_BIT	Yes
Yes	%M39	SYSTM_CNTRL_CONTINU	Yes

PID configuration (PID)

Constant configuration (%KD)

Constant configuration (%KW)

Constant configuration (%KF)

PLS/PWM configuration (%PLS/%PWM)

Configuration of external objects Comm

Configuration of external objects Drive

Configuration of external objects Tesys

Configuration of external objects Advantys OTB

Memory

Memory usage statistic

User data			
Memory bits	:	40 Bits	0.1%
Memory words	:	706 Words	20.5%
Backed up	:	343 Words	
RAM = EEPROM	:	???	
Constants	:	0 Words	0.0%
Configuration	:	502 Words	14.6%
Avail. mem. data	:	2146 Words	62.1%

User program			
Executable code	:	926 Words	6.0%
Prog. data	:	4 Words	0.1%
Online modif.	:	0 Words	0.0%
Avail. code mem.	:	14168 Words	91.8%

Other			
Execution data	:	88 Words	2.6%
:	88 Words	2.6%	

Configure the behavior

Functional levels

Functional levels management

Management :	Automatic
Level :	The highest possible

Scan mode

Scan mode

Mode :	Normal
Duration (ms) :	-

Watchdog

Duration (ms) :	250

Periodic event

Not used :	Yes

Startup

Parameters

Automatic start in Run :	Yes
Run/Stop Input:	None

Autosave

Parameters

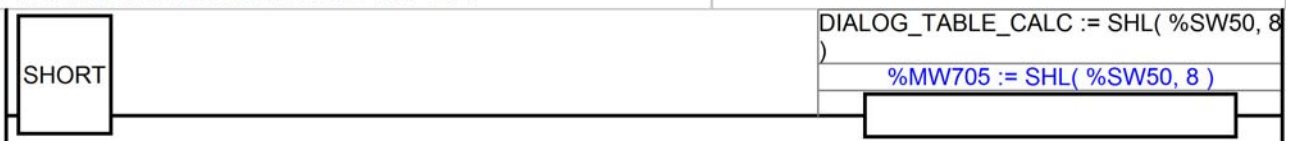
Autosave RAM=>EEPROM :	Yes

Program lists and diagrams

1 LD HMI Real-Time Clock Synchronization

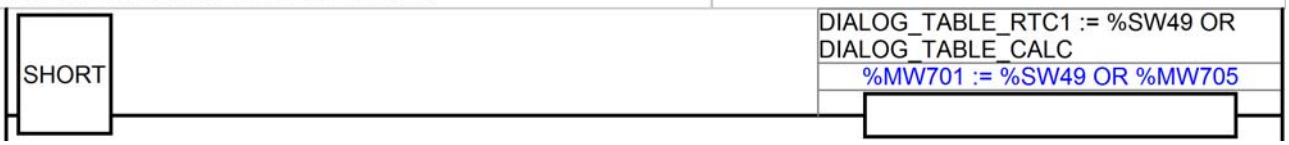
COPT RTC TO MW FOR HMI DIALOG TABLE

Rung 0



SECONDS BYTE OR WITH DAY OF WEEK

Rung 1



HOUR, MINUTE

Rung 2

MONTH, DAY

Rung 3

CENTURY, YEAR

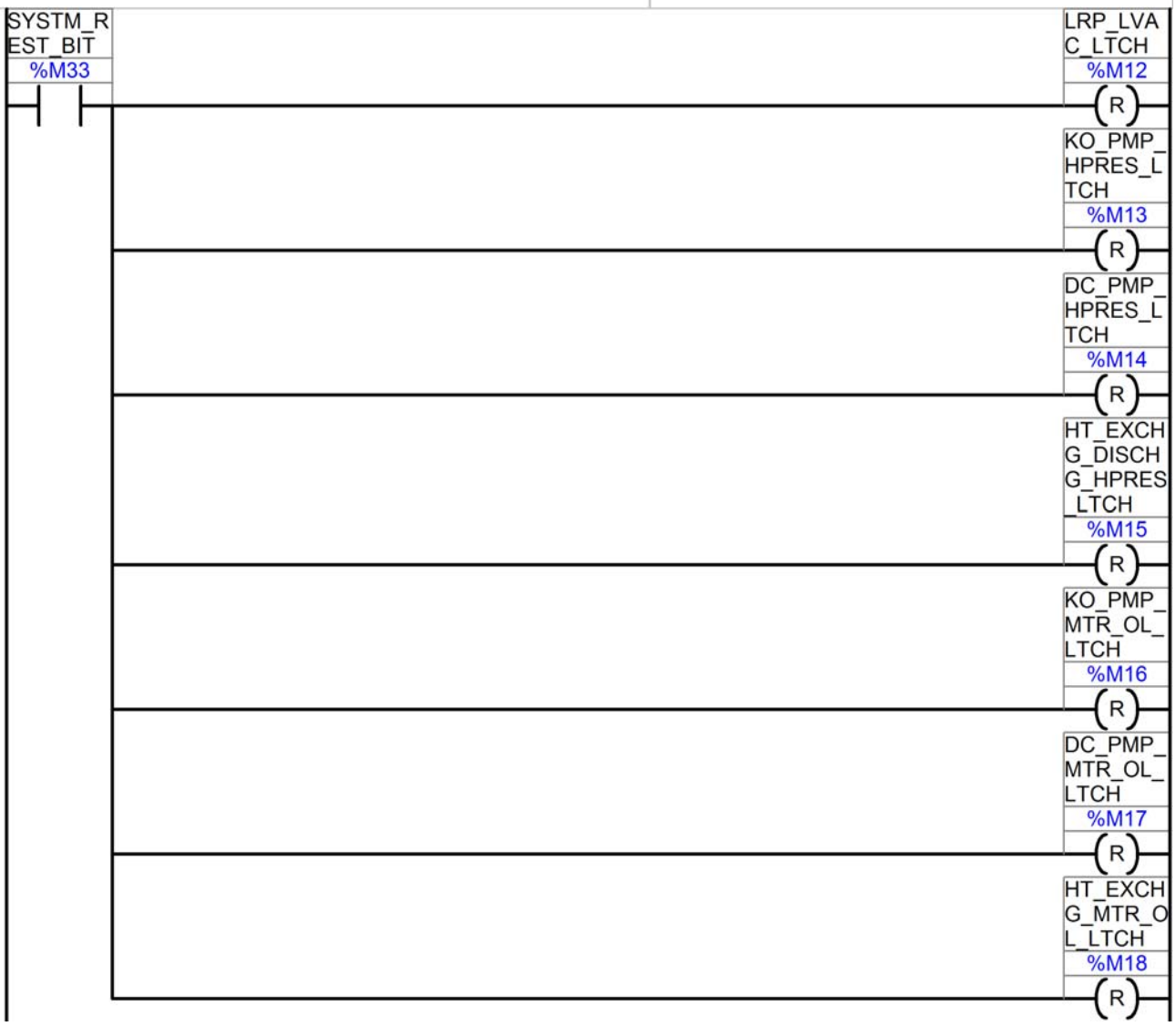
Rung 4

2 LD System Alarm's and Resets

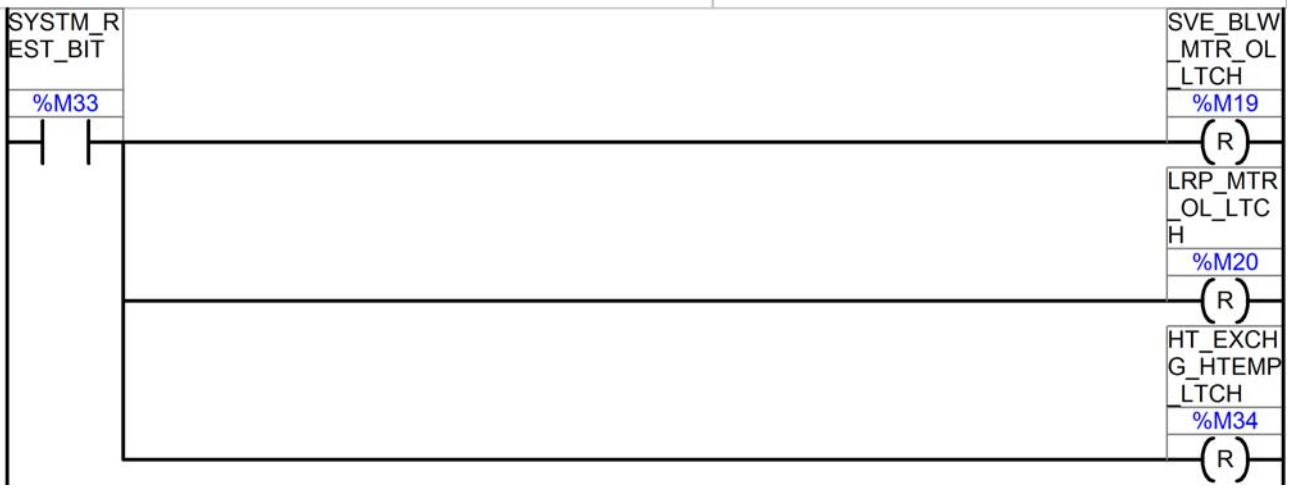
SYSTEM ALARMS

Rung 0

Rung 1


SYSTM_REST_BIT
%M33
LRP_LVAC_LTCH
%M12
R
KO_PMP_HPRES_LTCH
%M13
R
DC_PMP_HPRES_LTCH
%M14
R
HT_EXCHG_DISCHG_HPRES_LTCH
%M15
R
KO_PMP_MTR_OL_LTCH
%M16
R
DC_PMP_MTR_OL_LTCH
%M17
R
HT_EXCHG_MTR_OL_LTCH
%M18
R

Rung 2

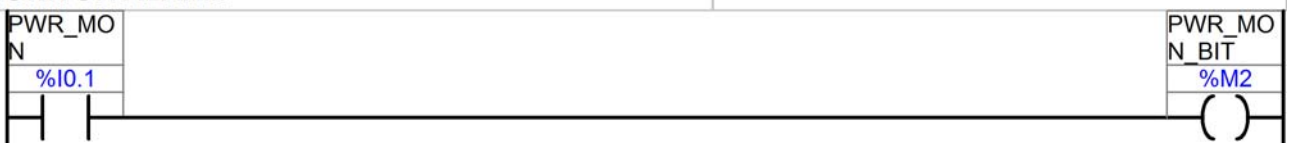

SYSTM_REST_BIT
%M33
SVE_BLW_MTR_OL_LTCH
%M19
R
LRP_MTR_OL_LTCH
%M20
R
HT_EXCHG_HTEMP_LTCH
%M34
R

EMERGENCY STOP RESET

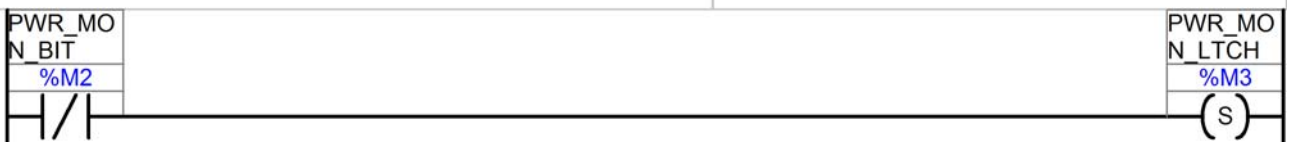
Rung 3

POWER MONITOR ALARM

Rung 4



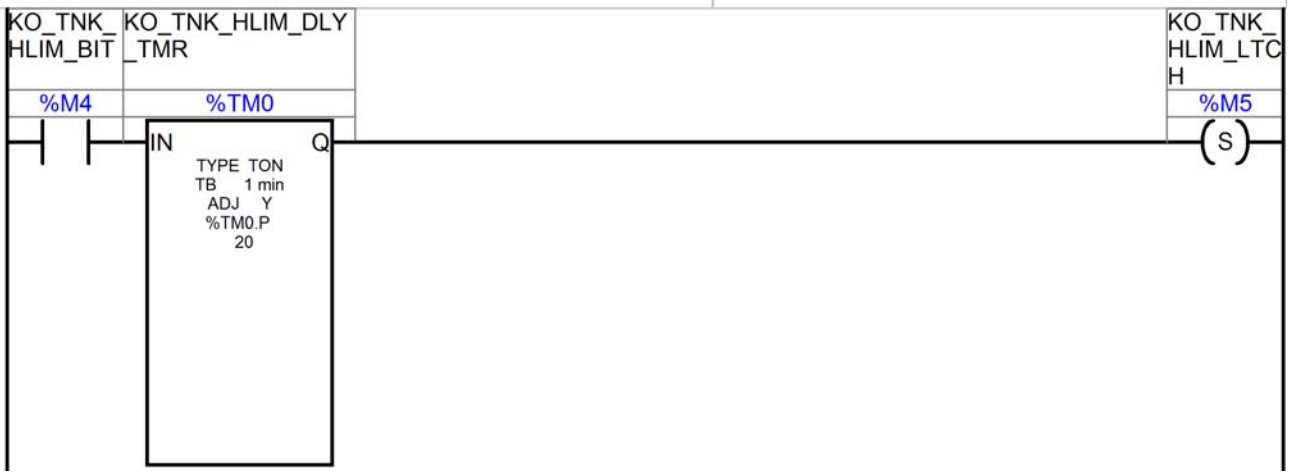
Rung 5



KO TANK HIGH LIMIT ALARM

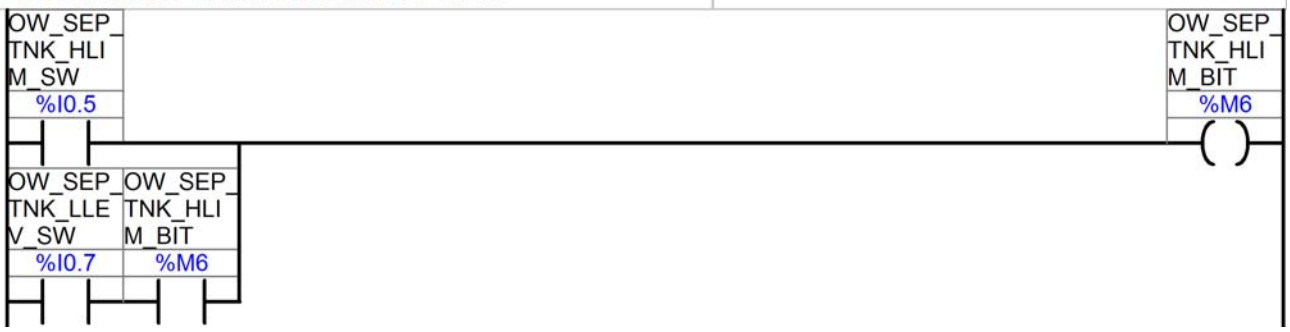
Rung 6

Rung 7

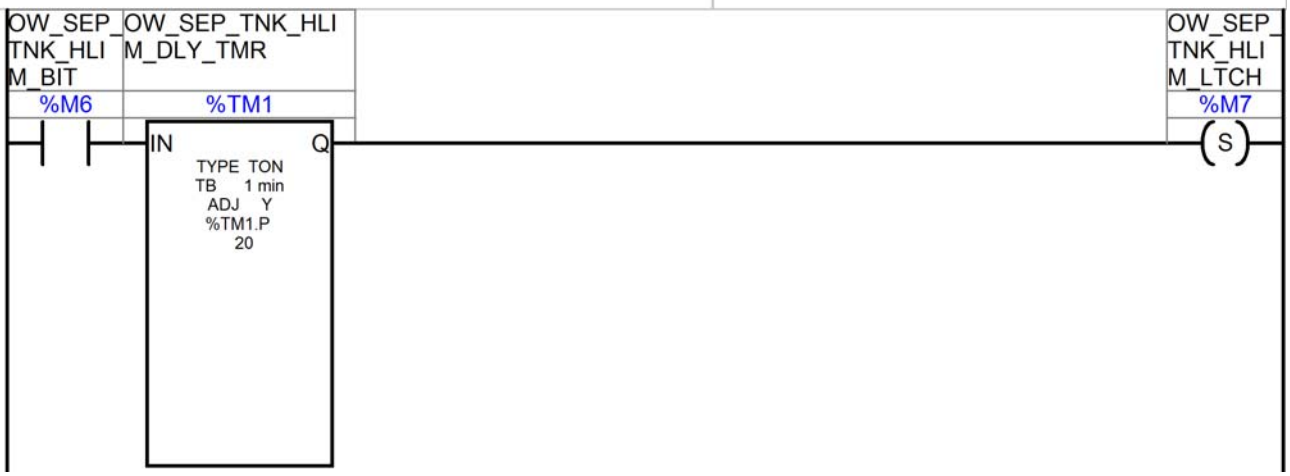


OIL / WATER SEPARATOR HIGH LIMIT ALARM

Rung 8



Rung 9

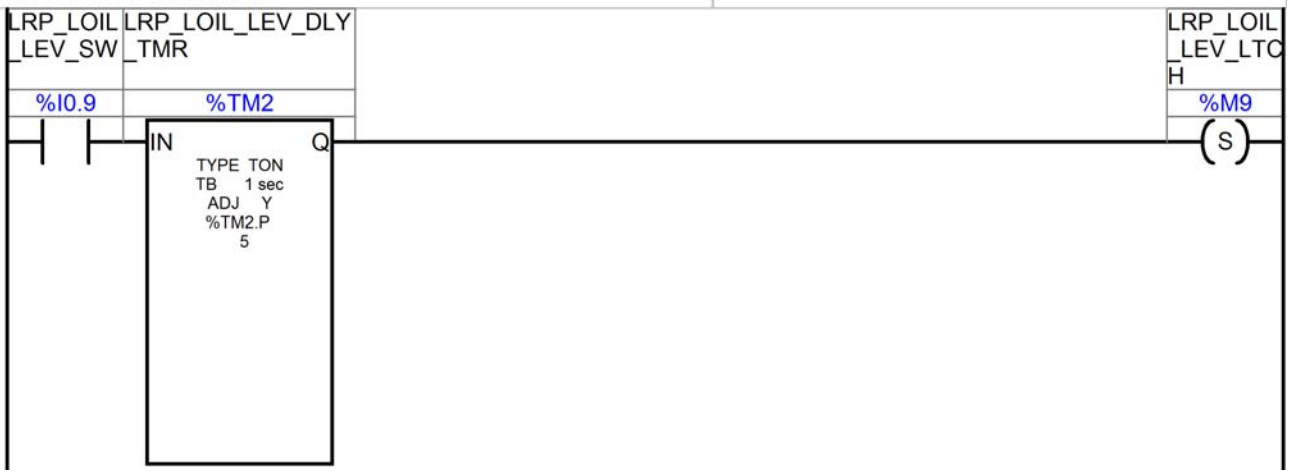


PRODUCT TANK HIGH LIMIT ALARM

Rung 10

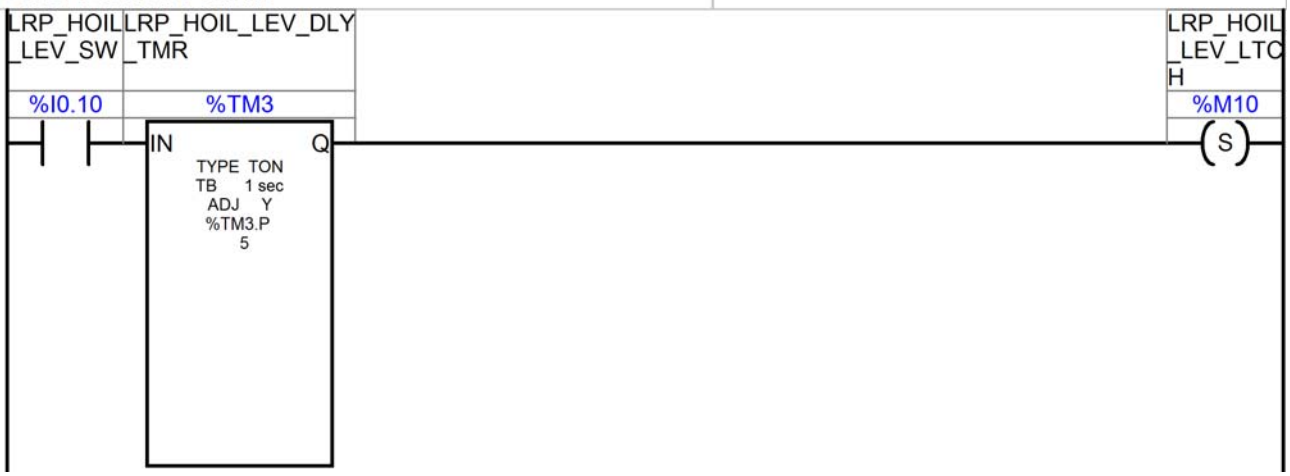
LRP LOW OIL LEVEL ALARM

Rung 11



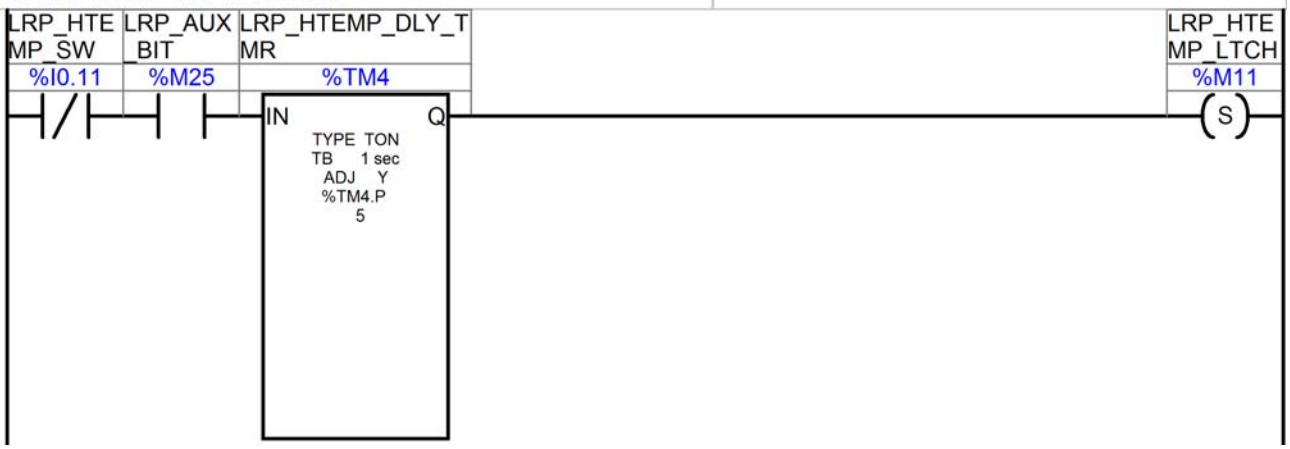
LRP HIGH OIL LEVEL ALARM

Rung 12



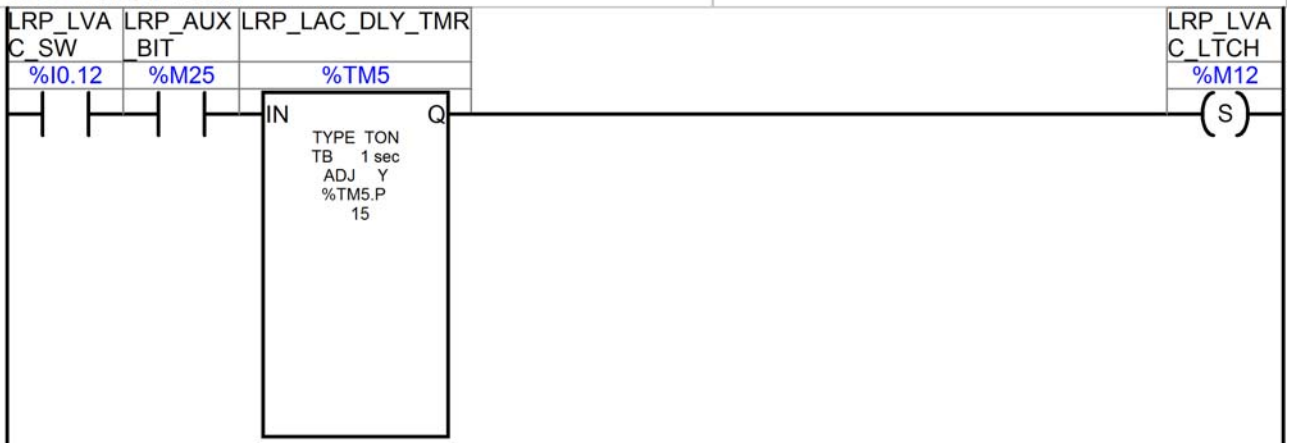
LRP HIGH TEMPERATURE ALARM

Rung 13



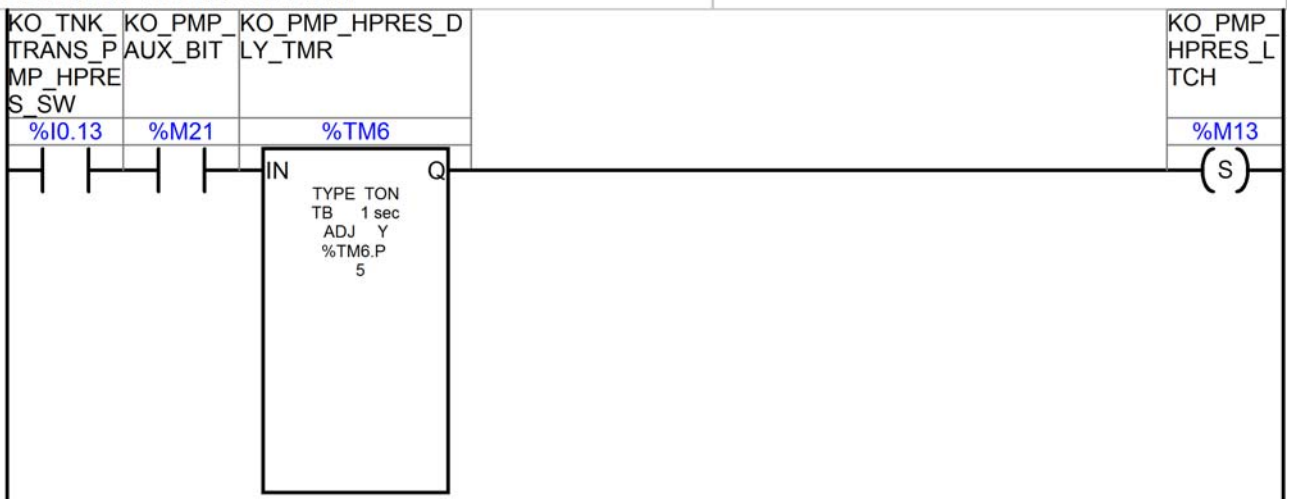
LRP LOW VACUUM ALARM

Rung 14



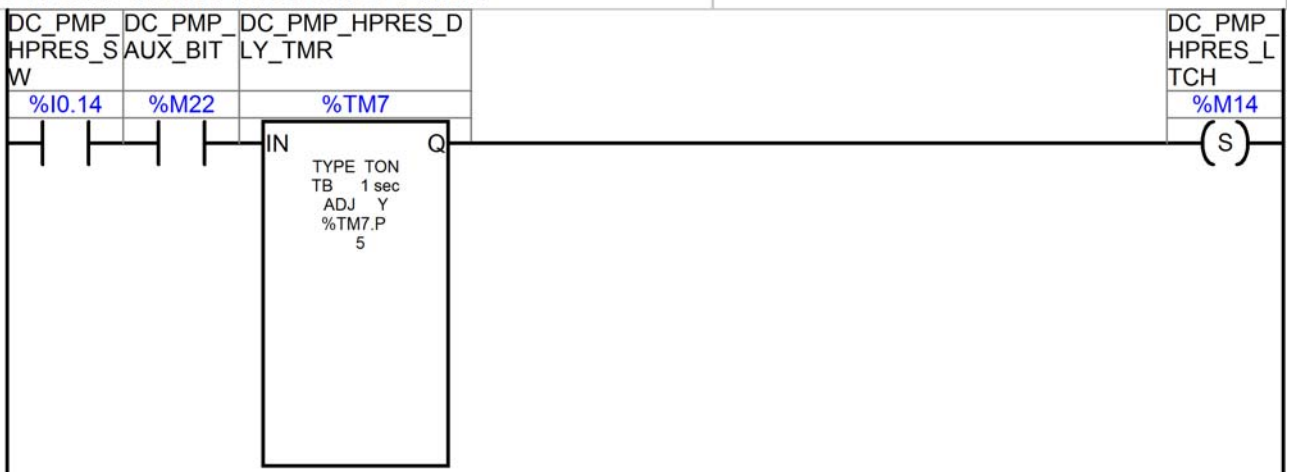
KO PUMP HIGH PRESSURE ALARM

Rung 15



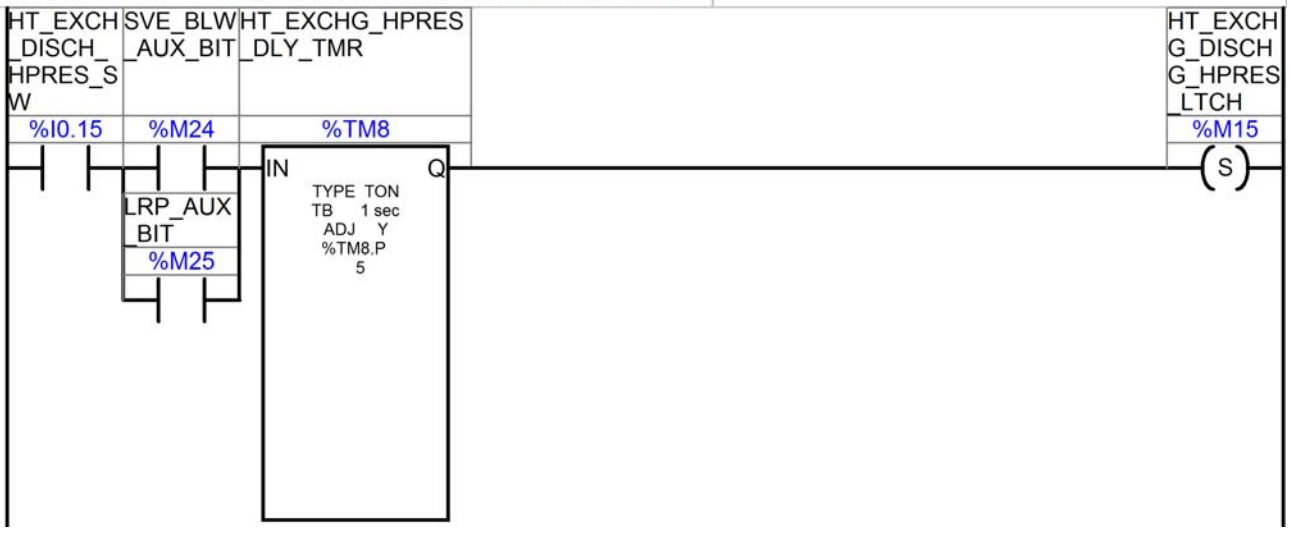
DISCHARGE PUMP HIGH PRESSURE ALARM

Rung 16



HEAT EXCHANGER DISCHARGE HIGH PRESSURE ALARM

Rung 17

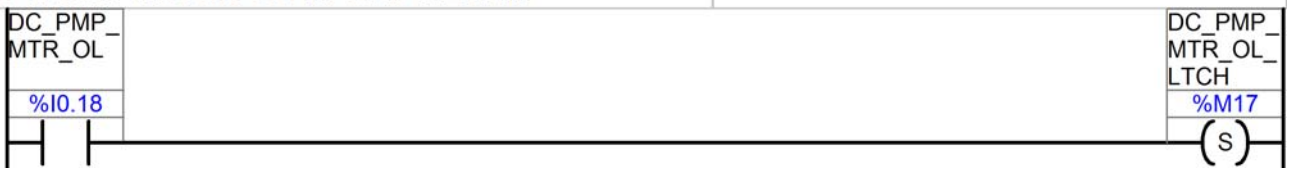


KO PUMP MOTOR OVERLOAD ALARM

Rung 18

DISCHARGE PUMP MOTOR OVERLOAD ALARM

Rung 19



HEAT EXCHANGER MOTOR OVERLOAD ALARM

Rung 20

SVE BLOWER MOTOR OVERLOAD ALARM

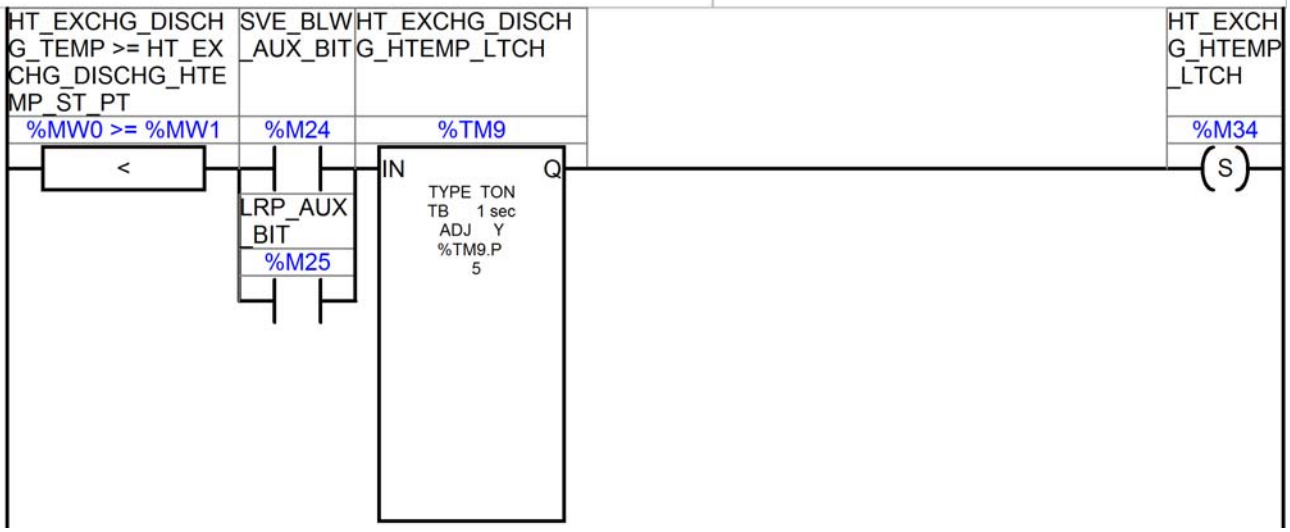
Rung 21

LRP MOTOR OVERLOAD ALARM

Rung 22

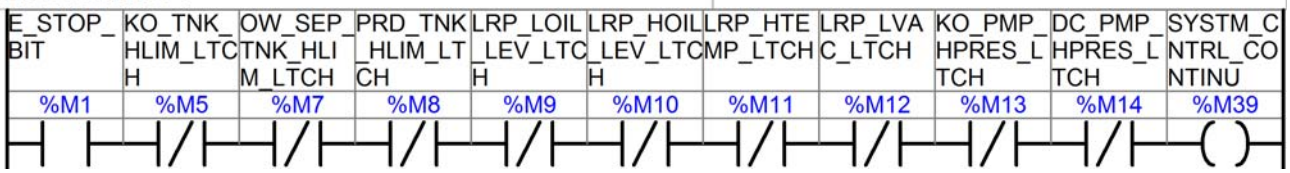
HEAT EXCHANGER DISCHARGE HIGH TEMPERATURE ALARM

Rung 23

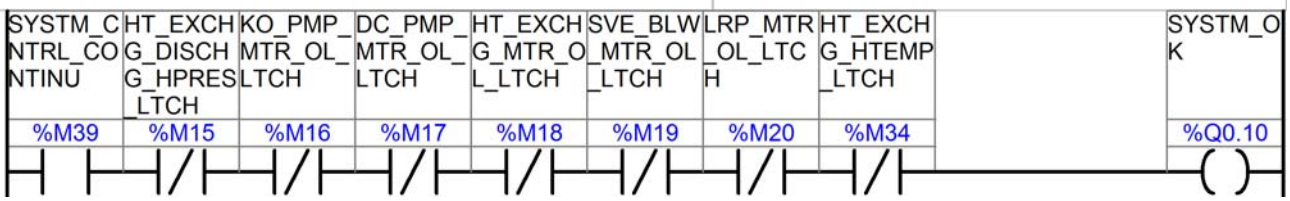


SYSTEM OK CONTROL

Rung 24

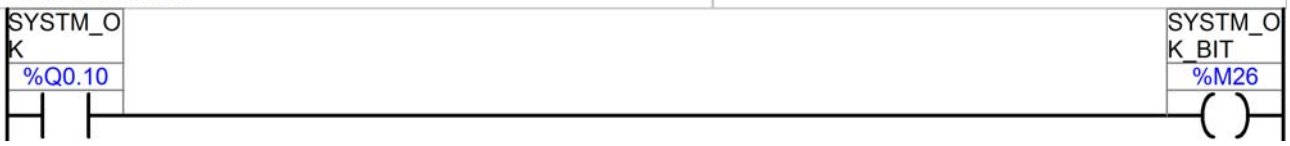


Rung 25



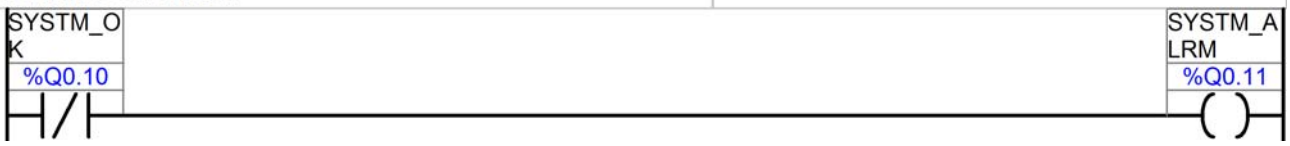
SYSTEM OK AUXILIARY

Rung 26



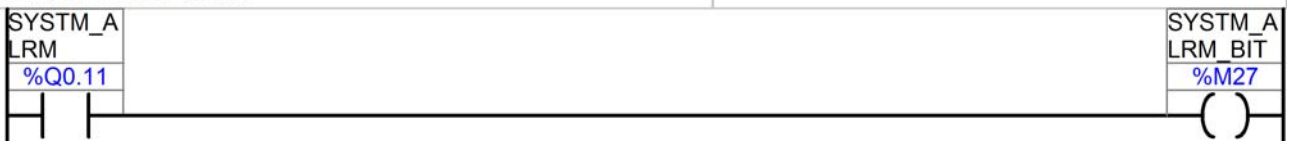
SYSTEM ALARM CONTROL

Rung 27



SYSTEM ALARM AUXILIARY

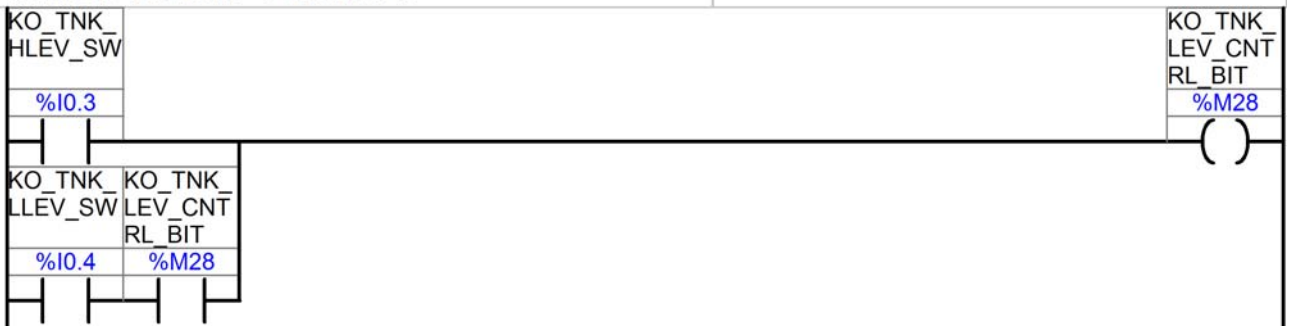
Rung 28



3 LD Motor Controls

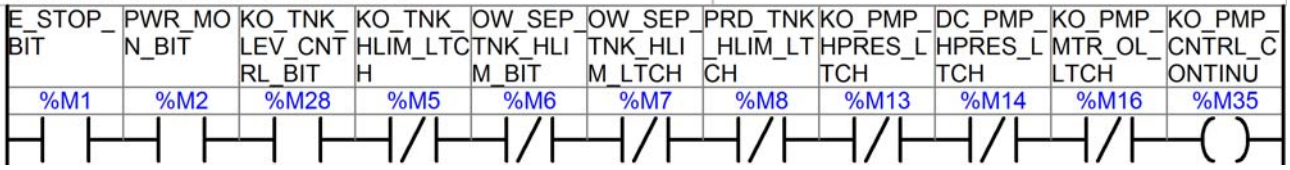
KO TANK TRANSFER PUMP CONTROLS

Rung 0



KO TANK TRANSFER PUMP CONTROL

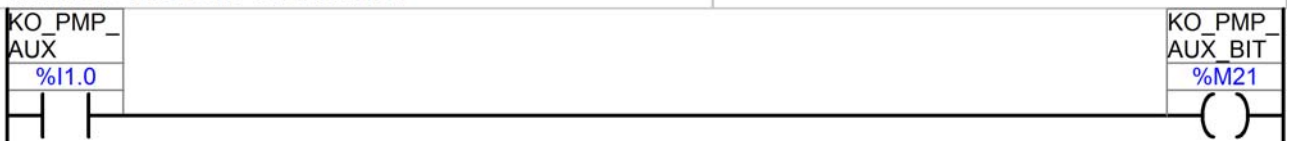
Rung 1



Rung 2

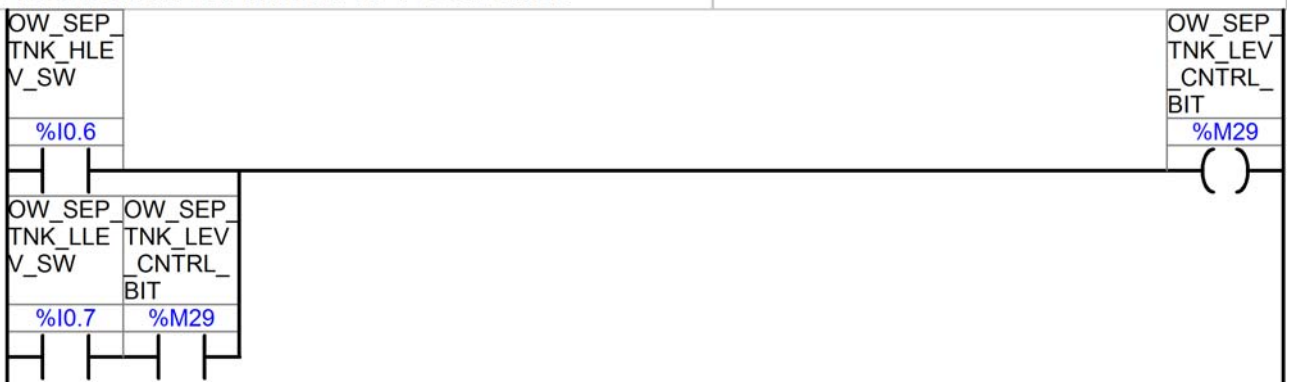
KO TANK TRANSFER PUMP AUXILIARY

Rung 3



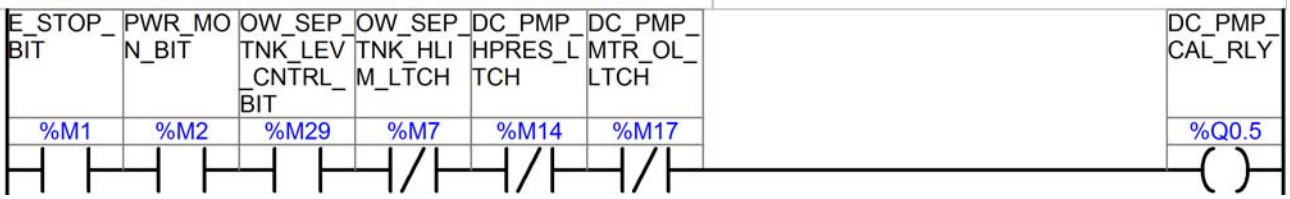
OIL / WATER SEPARATOR TANK LEVEL CONTROL

Rung 4



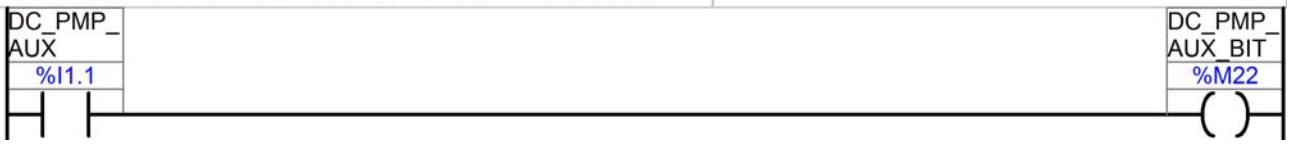
OIL / WATER SEPARATOR DISCHARGE PUMP CONTROL

Rung 5



OIL / WATER SEPARATOR DISCHARGE PUMP AUXILIARY

Rung 6



HEAT EXCHANGER CONTROL

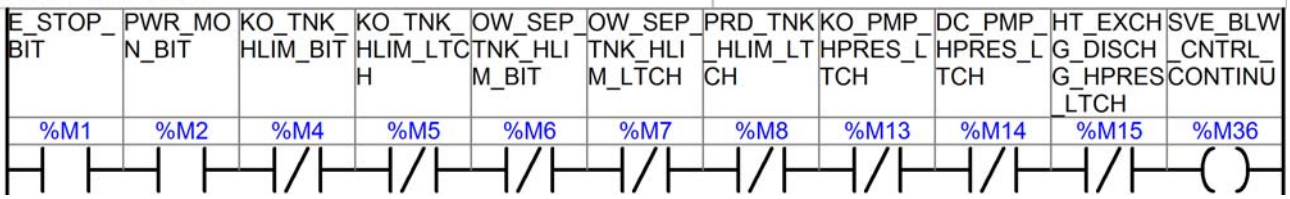
Rung 7

HEAT EXCHANGER AUXILIARY

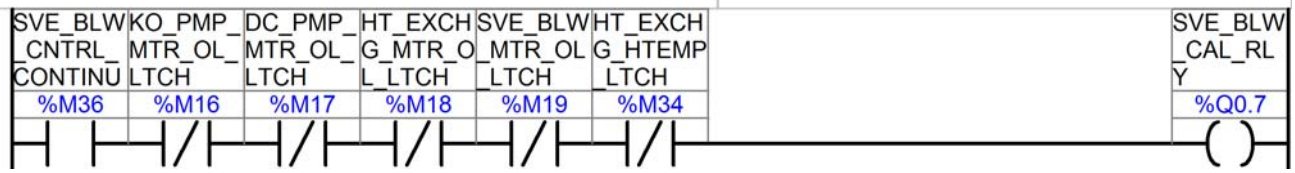
Rung 8

SVE BLOWER CONTROL

Rung 9

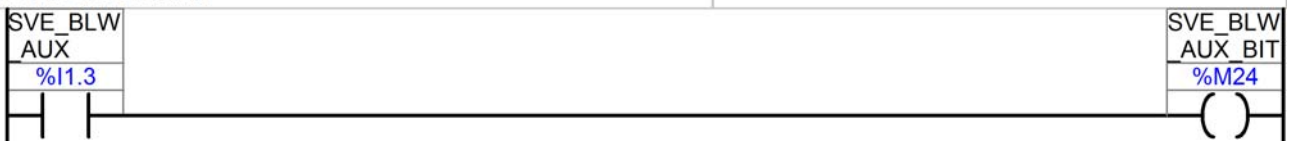


Rung 10



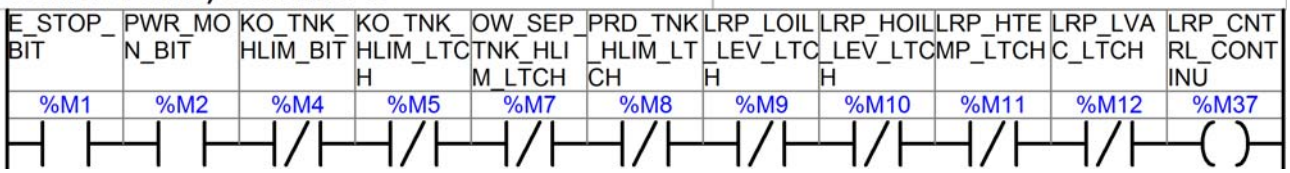
SVE BLOWER AUXILIARY

Rung 11

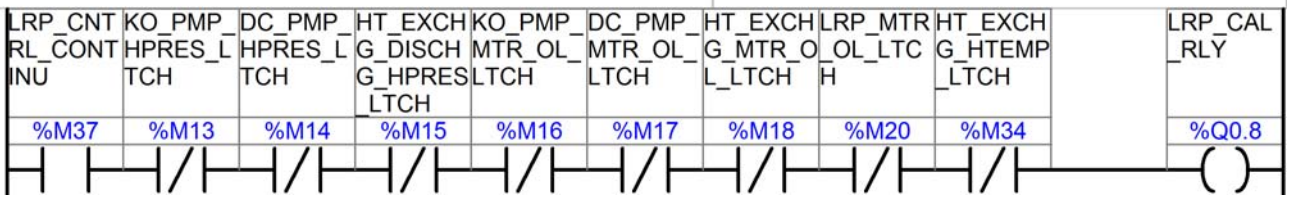


LRP (LIQUID RING PUMP) CONTROLS

Rung 12

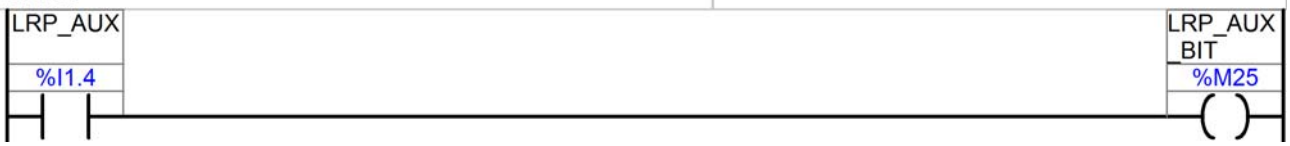


Rung 13



LRP AUXILIARY

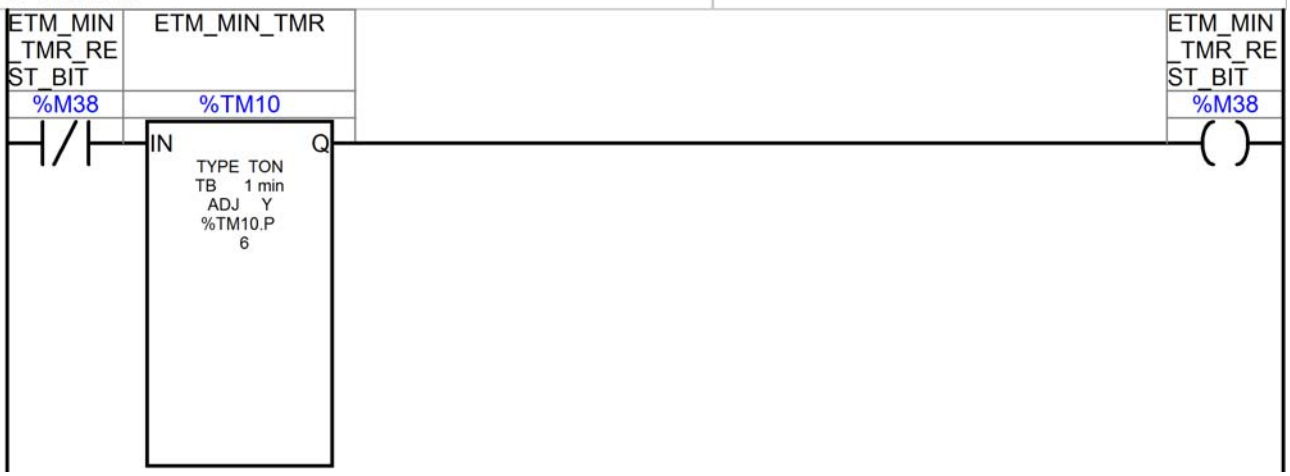
Rung 14



4 LD	Elapse Time Meter (ETM)	

ETM MINUTE TIMER

Rung 0

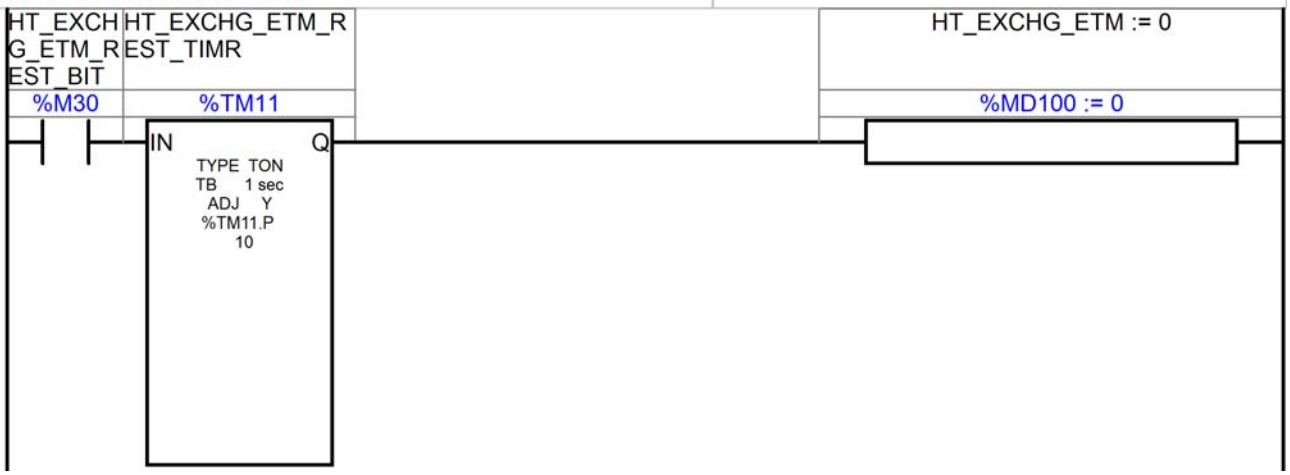


HEAT EXCHANGER ETM

Rung 1

HEAT EXCHANGER ETM RESET

Rung 2

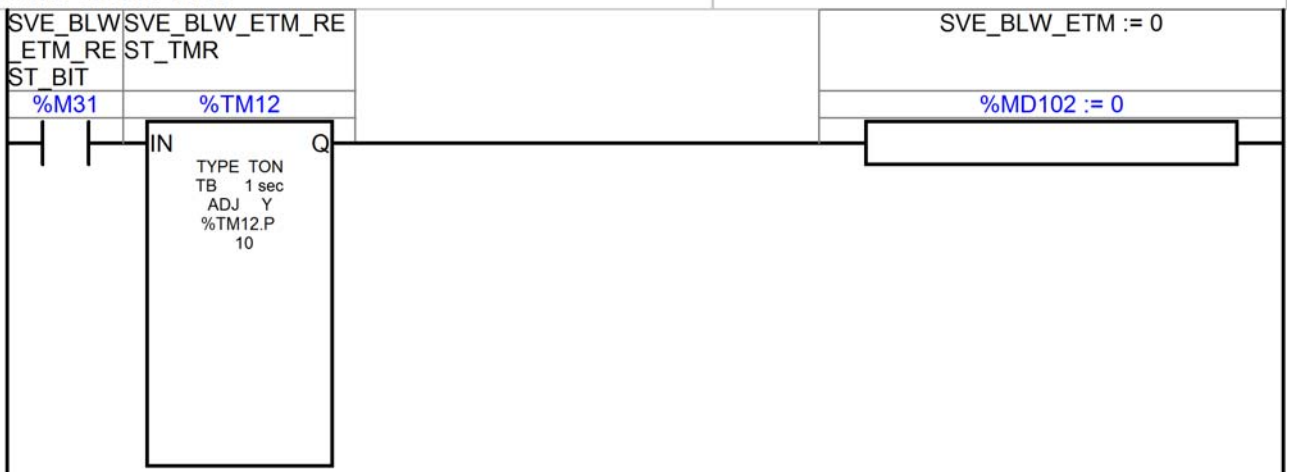


SVE BLOWER ETM

Rung 3

SVE BLOWER ETM RESET

Rung 4

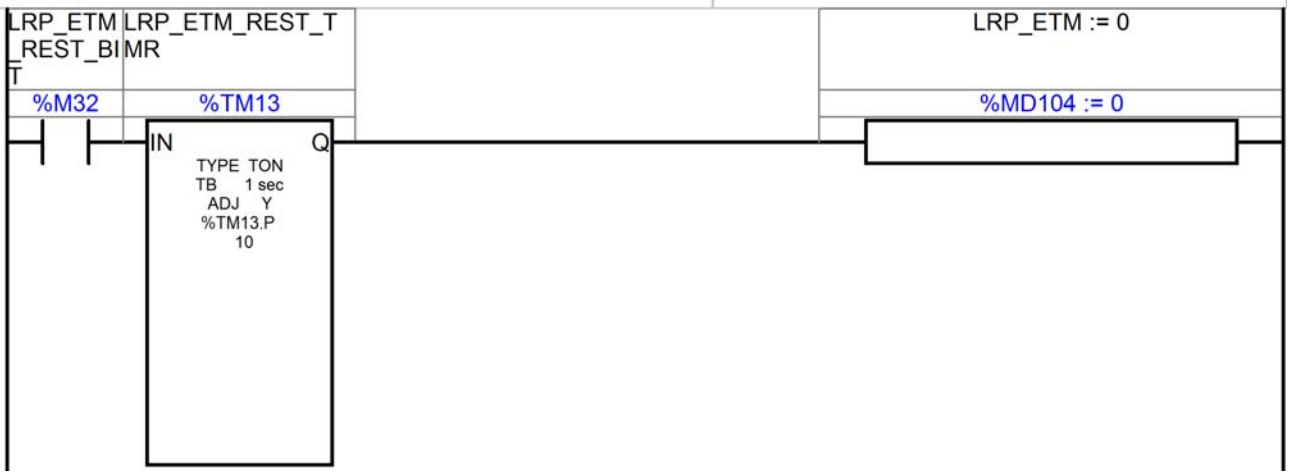


LRP ETM

Rung 5

LRP ETM RESET

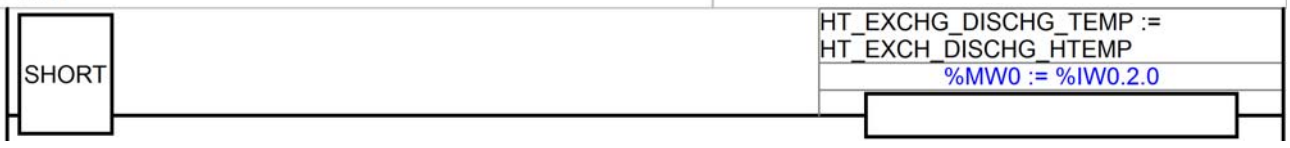
Rung 6



5 LD Analog Devices

HEAT EXCHANGER DISCHARGE TEMPERATURE TRANSMITTER

Rung 0



Symbols

Used	Address	Symbol	Comment
Yes	%I1.1	DC_PMP_AUX	Discharge Pump Auxiliary
Yes	%M22	DC_PMP_AUX_BIT	Discharge Pump Auxiliary Bit
Yes	%Q0.5	DC_PMP_CAL_RLY	Discharge Pump Call Relay
Yes	%TM7	DC_PMP_HPRES_DLY_TMR	DC Pump High Pressure Delay Timer
Yes	%M14	DC_PMP_HPRES_LTCH	DC Pump High Pressure Latch
Yes	%I0.14	DC_PMP_HPRES_SW	Discharge Pump High Pressure Switch
Yes	%I0.18	DC_PMP_MTR_OL	Discharge Pump Motor Overload
Yes	%M17	DC_PMP_MTR_OL_LTCH	Discharge Pump Motor Overload Latch
Yes	%MW705	DIALOG_TABLE_CALC	Dialog Table Calc
Yes	%MW701	DIALOG_TABLE_RTC1	Dialog Table RTC1
Yes	%MW702	DIALOG_TABLE_RTC2	Dialog Table RTC2
Yes	%MW703	DIALOG_TABLE_RTC3	Dialog Table RTC3
Yes	%MW704	DIALOG_TABLE_RTC4	Dialog TAble TRC4
Yes	%TM10	ETM_MIN_TMR	ETM Minute Timer
Yes	%M38	ETM_MIN_TMR_REST_BIT	ETM Minute Timer Reset Bit
Yes	%I0.0	E_STOP	Emergency Stop Switch
Yes	%M1	E_STOP_BIT	Emergency Stop Bit
Yes	%M0	E_STOP_REST_BIT	Emergency Stop Reset Bit
Yes	%M23	HT_EXCHG_AUX_BIT	Heat Exchanger Auxiliary Bit
Yes	%M15	HT_EXCHG_DISCHG_HPRES_LTCH	Heat Exchanger Discharge High Pressure Latch
Yes	%TM9	HT_EXCHG_DISCHG_HTEMP_LTCH	Heat Exchanger Discharge High Temperature Latch
Yes	%MW1	HT_EXCHG_DISCHG_HTEMP_ST_PT	Heat Exchanger Discharge Temperature High Set Point
Yes	%MW0	HT_EXCHG_DISCHG_TEMP	Heat Exchanger Discharge Temperature
Yes	%MD100	HT_EXCHG_ETM	Heat Exchanger ETM
Yes	%M30	HT_EXCHG_ETM_REST_BIT	Heat Exchanger ETM Reset Bit
Yes	%TM11	HT_EXCHG_ETM_REST_TIMR	Heat Exchanger ETM Reset Timer
Yes	%TM8	HT_EXCHG_HPRES_DLY_TMR	Heat Exchanger High Pressure Delay Timer
Yes	%M34	HT_EXCHG_HTEMP_LTCH	Heat Exchanger Discharge High Temperature Latch
Yes	%M18	HT_EXCHG_MTR_OL_LTCH	Heat Exchanger Motor Overload Latch
Yes	%I1.2	HT_EXCH_AUX	Heat Exchanger Auxiliary
Yes	%Q0.6	HT_EXCH_CAL_RLY	Heat Exchanger Call Relay
Yes	%IW2.0	HT_EXCH_DISCHG_HTEMP	Heat Exchanger Discharge High Temperature
Yes	%I0.15	HT_EXCH_DISCH_HPRES_SW	Heat Exchanger Discharge High Pressure Switch
Yes	%I0.19	HT_EXCH_MTR_OL	Heat Exchanger Motor Overload
Yes	%I1.0	KO_PMP_AUX	KO Pump Auxiliary
Yes	%M21	KO_PMP_AUX_BIT	KO Pump Auxiliary Bit
Yes	%Q0.4	KO_PMP_CAL_RLY	KO Pump Call Relay
Yes	%M35	KO_PMP_CNTRL_CONTINU	KO Pump Control Continued
Yes	%TM6	KO_PMP_HPRES_DLY_TMR	KO Pump High Pressure Delay Timer
Yes	%M13	KO_PMP_HPRES_LTCH	KO Pump High Pressure Latch
Yes	%I0.17	KO_PMP_MTR_OL	KO Pump Motor Overload
Yes	%M16	KO_PMP_MTR_OL_LTCH	KO Pump Motor Overload Latch
Yes	%I0.3	KO_TNK_HLEV_SW	KO Tank High Level switch
Yes	%M4	KO_TNK_HLIM_BIT	KO Tank High Limit Bit
Yes	%TM0	KO_TNK_HLIM_DLY_TMR	KO Tank High Limit Delay Timer

Used	Address	Symbol	Comment
Yes	%M5	KO_TNK_HLIM_LTCH	KO Tank High Limit Latch
Yes	%I0.2	KO_TNK_HLIM_SW	KO Tank High Limit Switch
Yes	%M28	KO_TNK_LEV_CNTRL_BIT	KO Tank Level Control Bit
Yes	%I0.4	KO_TNK_LLEV_SW	KO Tank Low Level Switch
Yes	%I0.13	KO_TNK_TRANS_PMP_HPRES_SW	KO Pump High Pressure Switch
Yes	%I1.4	LRP_AUX	LRP Auxiliary
Yes	%M25	LRP_AUX_BIT	LRP Auxiliary Bit
Yes	%Q0.8	LRP_CAL_RLY	LRP Call Relay
Yes	%M37	LRP_CNTRL_CONTINU	LRP Controls Continued
Yes	%MD104	LRP_ETM	LRP ETM
Yes	%M32	LRP_ETM_REST_BIT	LRP ETM Reset Bit
Yes	%TM13	LRP_ETM_REST_TMR	LRP ETM Reset Timer
Yes	%TM3	LRP_HOIL_LEV_DLY_TMR	LRP High Ol Level Delay Timer
Yes	%M10	LRP_HOIL_LEV_LTCH	LRP High Oil Level Latch
Yes	%I0.10	LRP_HOIL_LEV_SW	LRP High Oil Level Switch
Yes	%TM4	LRP_HTEMP_DLY_TMR	LRP High Temperature Delay Timer
Yes	%M11	LRP_HTEMP_LTCH	LRP High Temperature Latch
Yes	%I0.11	LRP_HTEMP_SW	LRP High Temperature Switch
Yes	%TM5	LRP_LAC_DLY_TMR	LRP Low Vacuum Delay imer
Yes	%TM2	LRP_LOIL_LEV_DLY_TMR	LRP Low Oil Level Delay Timer
Yes	%M9	LRP_LOIL_LEV_LTCH	LRP Low Oil Level Latch
Yes	%I0.9	LRP_LOIL_LEV_SW	LRP Low Oil Level Switch
Yes	%M12	LRP_LVAC_LTCH	LRP Low Vacuum Latch
Yes	%I0.12	LRP_LVAC_SW	LRP Low Vacuum Switch
Yes	%I0.21	LRP_MTR_OL	LRP Motor Overload
Yes	%M20	LRP_MTR_OL_LTCH	LRP Motor Overload Latch
Yes	%I0.6	OW_SEP_TNK_HLEV_SW	Oil/Water Separator Tank High Level Switch
Yes	%M6	OW_SEP_TNK_HLIM_BIT	OW Separator Tank High Limit Bit
Yes	%TM1	OW_SEP_TNK_HLIM_DLY_TMR	OW Separator Tank High Limit Delay Timer
Yes	%M7	OW_SEP_TNK_HLIM_LTCH	OW Separator Tank High Limit Latch
Yes	%I0.5	OW_SEP_TNK_HLIM_SW	Oil/Water Separator Tank High Limit Switch
Yes	%M29	OW_SEP_TNK_LEV_CNTRL_BIT	OW Separator Tank Level Control Bit
Yes	%I0.7	OW_SEP_TNK_LLEV_SW	Oil/Water Separator Tank Low Level Switch
Yes	%M8	PRD_TNK_HLIM_LTCH	Product Tank High Limit Latch
Yes	%I0.8	PRD_TNK_HLIM_SW	Product Tank High Limit Switch
Yes	%I0.1	PWR_MON	Power Monitor
Yes	%M2	PWR_MON_BIT	Powr Monitor Bit
Yes	%M3	PWR_MON_LTCH	Power Monitor Latch
No	%MW700	REAL_TM_STRT	Start Real Time Clock
Yes	%I1.3	SVE_BLW_AUX	SVE Blower Auxiliary
Yes	%M24	SVE_BLW_AUX_BIT	SVE Blower Auxiliary Bit
Yes	%Q0.7	SVE_BLW_CAL_RLY	SVE Blower Call Relay
Yes	%M36	SVE_BLW_CNTRL_CONTINU	SVE Blower Control Continued
Yes	%MD102	SVE_BLW_ETM	SVE Blower ETM
Yes	%M31	SVE_BLW_ETM_REST_BIT	SVE Blower ETM Reset Bit
Yes	%TM12	SVE_BLW_ETM_REST_TMR	SVE Blower ETM Reset Timer
Yes	%I0.20	SVE_BLW_MTR_OL	SVE Blower Motor Overload
Yes	%M19	SVE_BLW_MTR_OL_LTCH	SVE Blower Motor Overload Latch
Yes	%Q0.11	SYSTM_ALRM	System Alarm
Yes	%M27	SYSTM_ALRM_BIT	System Alarm Bit
Yes	%M39	SYSTM_CNTRL_CONTINU	System OK Control Continued
Yes	%Q0.10	SYSTM_OK	System OK
Yes	%M26	SYSTM_OK_BIT	System OK Bit

Used	Address	Symbol	Comment
Yes	%M33	SYSTM_REST_BIT	System Reset Bit

Cross references

Address	Symbol	Section	Lines/Networks	Operator
%MW701	DIALOG_TABLE_RTC1	1	1	[:= OR]
%MW702	DIALOG_TABLE_RTC2	1	2	[:=]
%MW703	DIALOG_TABLE_RTC3	1	3	[:=]
%MW704	DIALOG_TABLE_RTC4	1	4	[:=]
%MW705	DIALOG_TABLE_CALC	1	1	[:= OR]
%SW49		1	1	[:= OR]
%SW51		1	2	[:=]
%SW52		1	3	[:=]
%SW53		1	4	[:=]
1		1	1	LD
		1	2	LD
		1	3	LD
		1	4	LD

Animation table

My animation table 1

Used	Address	Symbol	Units
Yes	%TM0.P	KO_TNK_HLIM_DLY_TMR.P	Decimal
Yes	%TM0.V	KO_TNK_HLIM_DLY_TMR.V	Decimal
Yes	%TM0.Q	KO_TNK_HLIM_DLY_TMR.Q	Decimal
Yes	%TM1.P	OW_SEP_TNK_HLIM_DLY_TMR.P	Decimal
Yes	%TM1.V	OW_SEP_TNK_HLIM_DLY_TMR.V	Decimal
Yes	%TM1.Q	OW_SEP_TNK_HLIM_DLY_TMR.Q	Decimal