

PROJECT MANUAL

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SECTION 2050

DEMOLITION

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Provide all demolition required to perform the work covered under this contract including without limitation:
 - 1. Remove existing construction shown to be removed.
 - 2. Remove and replace existing construction and/or finishes as required to provide access to perform other work included in this contract, including painting.
 - 3. Include removal of mechanical and electrical work that is to be abandoned and is contained in construction to be removed whether or not the mechanical and electrical work is shown. All existing equipment associated with the abandoned magnesium hydroxide, solidum hypochlorite, and sodium hydroxide feed systems are to be demolished, unless specifically noted otherwise. Protect the temporary feed systems installed by the Owner as shown in the drawings. Disconnect and cap off utilities in accordance with applicable codes and safety regulations.
 - 4. Where utilities that are not shown pass through construction that must be removed and those utilities serve other areas notify the Engineer before disrupting service. If rerouting is required to maintain service, the Owner may issue a Change Order to accomplish the required work.
 - 5. Store and protect items intended for reuse.
 - 6. Assume ownership of debris and unwanted materials, remove from the site and dispose of legally.
 - 7. If illegal electrical wiring is encountered such as "BX" or nonmetallic sheathed cable, notify the Engineer.
 - 8. Remove all loose items including rubbish, debris, etc.

1.02 NOISE AND DUST CONTROL

- A. Perform work in accordance with requirements in Division 1. Particular attention is directed without limitation to paragraphs titled: Owner and Contractor's Use of Premises, Cleanup During Construction, Fire Protection During Construction, Maintenance of Exit Routes for Building Users, Temporary Dust Barriers, Noise Control and Care of Existing Facilities.
- B. Provide temporary partitions to control dust and noise and exclude unauthorized persons.
- C. Perform work in a manner to cause least disturbance to building occupants and least damage to work to remain.
- D. Maintain adequate means of safe, clear egress for building occupants.
- E. Employ all available techniques for construction noise abatement. Use remote, well-muffled air compressors and newest noise suppressed pneumatic and electric tools.

1.03 WARNING

- A. The Contractor is advised that work under this Section may be hazardous. The Contractor is to take all necessary precautions to ensure the safety of workers and property. Removal of and/or working in areas containing even minor amounts of hazardous material including without limitation, asbestos, lead-based paint, PCBs or other hazardous materials requires special precautions, knowledge, and procedures. If hazardous material is suspected, notify the Owner.

PART 2 - PRODUCTS - NOT USED

PART 3 - EXECUTION

3.01 REMOVAL OF CONSTRUCTION IN AREAS TO RECEIVE NEW WORK

- A. In areas intended to receive new work and/or finishes, remove all unwanted non-structural partitions, furred walls, chases, suspended or furred ceilings, doors, windows, and finishes.
- B. Remove all unwanted mechanical and electrical work (whether shown or not) that is not wanted and is not needed to serve other areas that is in, on, or concealed behind work being removed. Cap off or terminate all mechanical or electrical work in accordance with the requirements of Divisions 15 and 16.
- C. Protect mechanical and electrical work that serves other areas. Relocate concealed mechanical and electrical work that is required to preserve service to other areas.
- D. Remove structural work designated for removal. Take precautions not to damage structural work intended to remain. Where temporary shoring is needed, submit a design prepared by an appropriately licensed engineer for review before proceeding.
- E. If structural elements are encountered that were not shown, protect them from damage and report their presence to the Owner's representative.

3.02 REMOVAL OF LIMITED PORTIONS OF EXISTING CONSTRUCTION TO PERMIT MODIFICATIONS

- A. Provide careful, selective cutting and removal of existing construction as required to permit relocation or modification of partitions, doors, or openings. Cut and remove the least amount of work possible except when a larger area needs to be removed to permit strengthening existing construction or when required to remove finishes to a natural break line such as a corner or change in material.
- B. Protect existing construction to remain with temporary coverings.
- C. Treat existing mechanical, electrical, or structural work as described in other parts of this Section.
- D. When modifications are complete, replace removed work with new construction and finishes to match adjacent existing work. Standards of material and workmanship shall be in accordance with other portions of this Specification or if not covered then in accordance with current practice for this class of work. Salvaged materials may be used for replacement if in good condition.

3.03 REMOVAL OF EXISTING CONSTRUCTION TO PROVIDE ACCESS TO PERFORM WORK

- A. Provide careful selective cutting and removal of existing construction where required to permit installation of new concealed mechanical or electrical work, or installation of equipment, fixtures, or devices.
- B. Treat existing mechanical, electrical, or structural work as described in other parts of this Section.
- C. Replace and/or patch removed construction and finishes in accordance with other parts of this Section.

3.04 PROTECTION OF WORK TO REMAIN

- A. Protect all work to remain. Repair damage with materials, workmanship, and finishes matching existing work when new.
- B. Most existing floor finishes will not be replaced in this contract. It is essential these floors be protected from any damage due to impact, dirt, abrasion, paints, and solvents.

3.05 CUTTING HOLES IN CONCRETE AND/OR CONCRETE MASONRY UNIT (CMU)

- A. The Contractor is cautioned that electrical conduits and reinforcing that are not shown on Drawings may be concealed in concrete CMU construction. Use electronic detection equipment to locate concealed items before cutting holes. Take all required precautions to avoid damage to existing conduits or reinforcing.
- B. New openings in existing concrete walls or slabs may be saw cut to opening perimeter lines where Drawings do not call for adding reinforcing trim bars to strengthen openings. Do not run saw kerfs past corners of openings. Complete concrete removal at opening corners by chipping and grinding. Take all required precautions to avoid water damage to existing construction or the Owner's property.
- C. Where Drawings call for adding reinforcing trim bars to strengthen openings, limit saw cutting to a depth of 3/4 inch to avoid cutting existing reinforcing steel. Carefully chip out concrete to avoid damaging existing reinforcing steel which is to remain.
- D. Use chipping guns to chip out small holes for pipes or conduits. Proceed carefully to avoid damage to concealed conduits. Core drilling is permitted only at the Contractor's risk and only with the permission from Owner's representative. If core drilling is used, the Contractor shall: 1) use electronic detection equipment to locate conduit before drilling, 2) take precaution to avoid water damage to existing construction or the Owner's property, and 3) replace, at its own expense, any damaged electrical or signal wiring or conduits.

3.06 REMOVE UNWANTED FIXED EQUIPMENT

- A. Remove unwanted mechanical equipment including pumping, piping, tanks, motors, electrical and instrumentation equipment, and appurtenances, fixed and built-in equipment, machinery, machinery bases, and similar items similar items whether shown or not. Cut off protruding bolts or attachment devices flush with existing surfaces.

- B. If items are designated on the Drawings to be salvaged, remove them carefully without causing damage. Contractor shall deliver salvaged items to be turned over to the Owner to the Location determined by the Owner, store the items onsite or load the items in the Owner's truck at the job site. Owner will decide which of these salvage & removal options will be used on a case-by-case basis. Items to be relocated shall be removed and relocated without damage. Contractor shall be responsible for replacement of any equipment damaged as a result of the Contractor's removal process or techniques.
- C. Store and protect items to be reused until time of need on jobsite.

3.07 IF HAZARDOUS MATERIALS ARE ENCOUNTERED

- A. If hazardous materials are discovered, comply with paragraph 1.03 of this Section and all applicable laws.

3.08 REMOVAL AND DISPOSAL OF MATERIAL

- A. Use debris chutes with covered tops emptying into covered containers.
- B. Store debris in suitable covered containers located where directed by the Owner and remove from site when full. Burning on the site is not permitted.
- C. Removed material (other than material to be reused) shall become the property of the Contractor who shall remove it from the site and dispose of it in a legal manner.

3.09 UTILITY LOCATES AND DEMOLITION

- A. There are electrical conduits that may or may not be shown on the Drawings. Locate, demolish, and restore as required for the construction.

END OF SECTION

SECTION 02085

PRECAST CONCRETE UTILITY VAULTS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Precast reinforced concrete box structures for utility service, complete with openings, inserts, ladder rungs (where specifically called for), hardware and sumps.

1.02 REFERENCES

A. ASTM International (ASTM), Standard Specifications:

1. A36 Structural Steel
2. A48 Gray Iron Castings
3. C150 Portland Cement
4. C857 Minimum Structural Design Loading for Underground Precast Concrete Utility Structures
5. C858 Underground Precast Concrete Utility Structures
6. C891 Installation of Underground Precast Concrete Utility Structures

B. American Association of State Highway and Transportation Officials (AASHTO), Standard Specifications for Highway Bridges.

C. Federal Specification: SS-S-210: Sealing Compound, Preformed Plastic, for Expansion Joints and Pipe Joints.

1.03 SUBMITTALS

A. Submit in accordance with Section 01300.

B. Product Data:

1. Descriptive details of the manufacturer's proposed standard products, including:
 - a. Precast sections.
 - b. Minimum concrete 28-day compressive strength.
 - c. Cement certification.
 - d. Hatches
2. Shop drawings, including:
 - a. Design criteria.
 - b. Reinforcing steel location and concrete cover.
 - c. Layout of all inserts, attachments and openings.
 - d. Location and type of joints.

1.04 QUALITY ASSURANCE

A. Provide products of a manufacturer who has been regularly engaged in the design and manufacture of the product.

B. Demonstrate to the satisfaction of the Engineer that the quality is equal to the product made by those manufacturers specifically named herein, if an alternate product manufacturer is proposed.

PART 2 - PRODUCTS

2.01 DESIGN CRITERIA

- A. General: ASTM C857, C858, and also:
 - 1. Structure live load: AASHTO Loading Class HS 20-44, 300 lb/sq. ft.
 - 2. Backfill material: Structural backfill.
 - 3. Buoyancy: Design structure for groundwater up to finish grade.

2.02 PRECAST SECTIONS

- A. General:
 - 1. Cement: ASTM C150, Type II, low alkali.
 - 2. Roof slab openings: Size to support hatch covers.
 - 3. Lifting eyes: Provide for each section.
- B. Manufacturer: Oldcastle Precast; or equal.

2.03 SEALANT GASKETS

- A. Type: Preformed, continuous rope form plastic material, protected by removable two-piece wrapper.
- B. Sealing Compound: Reinforced hydrocarbon resins blended with plasticizing compounds and reinforced with inert mineral filler. No solvents, irritating fumes, or obnoxious odors.
- C. Adhesive and Cohesive Strength: Not dependent on oxidizing, evaporating, or chemical action.
- D. Conform to Federal Specification SS-S-210.
- E. Provide: QUIKSEAL as supplied by Associated Concrete Products, Santa Ana, CA; RAM-NEK as manufactured by K. T. Snyder Company, Inc., Houston, TX; or equal.

2.04 HATCH FRAMES AND COVERS

- A. Minimum clear opening dimensions of each hatch shall be as shown on the. Drawings or as required by the favorably reviewed pump or equipment manufacturer if larger in size. Provide single leaf, Halliday Products "H1W" series, Bilco Type J-AL; or equal.
- B. Door Leaves: ¼ inch (6.35 mm) thick aluminum, diamond pattern, reinforced as required to withstand the specified loads. Each leaf shall be less than 50 pounds in weight.
- C. Frame: ¼ inch (6.35 mm) thick aluminum channel with anchor flange around perimeter for embedment into concrete. Provide channel to collect rainwater and provide 1½ inch (38 mm) drainage coupling for connection to drain lines except for water tight and indoor or non-weather tight hatches are shown on the Drawing.
- D. Doors: Doors shall open to 90 degrees and shall include an automatic hold-open arm with a positive automatic latch that will secure the door in the open position until the release handle is activated. Provide stainless steel hold-open pin through holes in hold-open arms to insure against accidental hatch closure. Attach pin to hatch with a short stainless steel chain to prevent loss. Submit details of latch for review. Door hinges shall be recessed or flush.

- E. Lock: Provide a slam-lock with removable handle. Provide aluminum recessed hasp to door and frame.
- F. Lift-Assist Mechanism: Provide stainless steel compression spring(s) or pneumatic spring(s) enclosed in sealed telescoping tube(s).
- G. Safety Chain: For double leaf doors, provide a stainless steel safety chain between doors at the opposite end from the latch to form a barrier when the doors are locked in the open position.
- H. Safety Grate: Where indicated in the Access Hatch Schedule, provide a secondary fall protection safety grate located beneath the solid hatch cover, which lifts independently from the cover and is equipped with a latch to hold it in the open position. The grate shall be manufactured from aluminum flat bars, load-rated for 300 pounds per square foot, and safety orange in color. The grate shall have a padlock hasp for locking in the closed position. The grate shall comply with OSHA Standard 1910.23 for fall protection.
- I. All non-aluminum metals and hardware: Type 316 stainless steel.
- J. Finish: Mill finish aluminum. All surfaces of aluminum in contact with concrete shall be coated for isolation in accordance with Section 05120.
- K. Warning Sign:
 - 1. Provide a sign or decal permanently attached to the underside of hatch doors reading: "Warning: Permit Confined Space Entry."
 - 2. Provide a 10-inch by 12-inch minimum size sign permanently attached to the underside of the hatch doors reading "Danger: Make Sure Hold-Open Latch is Positively Engaged Before Using. Insert Pin in Holes in Hold-Open Arms to Hold Door Open."
- L. See Section 05500.

2.05 SOURCE QUALITY CONTROL

- A. Precast Sections:
 - 1. Verify concrete compressive strength test results are satisfactory for the sections supplied.
 - 2. State the curing method. Identify the start and end dates for the sections supplied.
- B. Frames and Covers:
 - 1. Verify cast test bar tensile strengths are satisfactory.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. General: ASTM C891 and also:
 - 1. Compact subgrade to 95% relative density for 6-inch minimum depth.
 - 2. Provide minimum 12-inch gravel base under the vault and compact to 95% relative density prior to placement.
 - 3. Apply primer to joint surfaces in accordance with manufacturer's instructions. Make all joints watertight with sealant gaskets.
 - 4. Backfill around the vault with Structural Backfill material. Compact the backfill material to 95% of relative density from the base up to subgrade, over an area defined as being within a distance of 4 feet from the exterior walls of the

vault unless noted otherwise. Place pavement around the vault as required per Section 02700.

5. Accurately locate and place the vault covers to within 1/8-inch vertical elevation in paved areas and to 1/2-inch in other areas. Coordinate the activities of all trades so that this tolerance is achieved.
6. The access hatch shall be cast into the utility vault cover by the vault manufacturer prior to shipment.

3.02 FIELD QUALITY CONTROL

- A. Verify all precast sections are continuously sealed with gaskets.
- B. Verify all covers fit quietly in the frames.

3.03 TEST FOR VAULTS

- A. Furnish and dispose of water used for testing.
- B. Hydraulically test all vaults installed.
- C. After all conduit has been laid and backfilling has been completed, plug the end of the conduit in each vault.
- D. Fill the vault with water and measure leakage over a period of not less than one hour.
- E. Allowable Leakage: Less than one (1) gallon per hour per 10-foot depth of vault.
- F. When leakage from the vault exceeds the above amount, determine the source or sources of the leakage, and repair or replace defective materials and workmanship.
- G. The completed pipe and vault installation shall pass this test before the project can be accepted.

END OF SECTION

SECTION 02300

EARTHWORK

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes: Perform all excavation, shoring, dewatering, backfilling, compaction and grading necessary or required for the construction of the work as covered by these Specifications and indicated on the Drawings. The excavation shall include, without classification, the removal and disposal of all materials of whatever nature encountered, including water and all other obstructions that would interfere with the proper construction and completion of the required work.

1.02 REFERENCES

- A. ASTM International (ASTM).
 - 1. ASTM C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
 - 2. ASTM D448 - Standard Classification for Sizes of Aggregate for Road and Bridge Construction
 - 3. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft³).
 - 4. ASTM D1556 - Standard Test Method for Density of Soil in Place by the Sand-Cone Method.
 - 5. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (6,000 ft-lb/ft³).
 - 6. ASTM D2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
 - 7. ASTM D2487 - Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).
 - 8. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
 - 9. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
 - 10. ASTM D4253 - Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
 - 11. ASTM D4254 - Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
 - 12. ASTM D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
- B. Washington State Department of Transportation (WSDOT), Standard Specifications for Road, Bridge and Municipal Construction (Standard Specifications).

1.03 SUBMITTALS

- A. Submit in accordance with Section 01300.

- B. Submit the following under the Product Review category.
1. Excavation Protection Plan (if applicable): Describe sheeting, shoring, and bracing materials and installation required to protect excavations and adjacent structures and property; include structural calculations for over 20-foot cuts to support plan.
 2. Potholing Report
 3. Product Data: Submit gradation reports for bedding materials and import backfill materials. Submit product data for geotextile fabric indicating fabric and installation procedure.
 4. Samples and Test Results: Furnish, without additional cost to the Owner, such quantities of import materials as may be required by the Engineer for test purposes. Cooperate with the Engineer and furnish necessary facilities for sampling and testing of all materials and workmanship. Submit test results for import materials. Tests shall be performed within 60 days of the submission. All material furnished and all work performed shall be subject to rigid inspection, and no material shall be delivered to the site until it has been favorably reviewed by the Engineer, or used in the construction work until it has been inspected in the field by the Engineer.

1.04 QUALITY ASSURANCE

- A. Source Quality Control: Test import materials proposed for use to demonstrate that the materials conform to the specified requirements. Tests shall be performed by an independent testing laboratory.
1. The Owner's representative will provide the following quality control measures:
 - a. Review materials proposed for use.
 - b. Observe foundations, site grading and borrow operations.
 - c. Observe placement and compaction of fill.
 - d. Test soils during placement of fill (or have these tests performed by an independent testing laboratory) as required herein.
 - e. Review results of independent testing laboratory tests.
 2. The Contractor shall hire an independent laboratory approved by the Engineer to perform the following tasks:
 - a. Test materials proposed for use and submit results to the Engineer.
 - b. Test soils during placement of fill as directed by the Engineer and submit results to the Engineer.
 3. Contractor shall:
 - a. Excavate holes for in-place soil sampling.
 - b. Test soils during placement of fill to verify conformance with material requirements defined herein.
 - c. Be responsible for costs of additional inspection and re-testing resulting from non-compliance.
 - d. Be responsible for coordination with third party testing agency to comply with testing frequency specified herein.
- C. Testing Methods:
1. Testing shall conform to the requirements of the WSDOT Standard Specifications.
 2. Field testing procedures shall be a WSDOT Standard Operating Procedure or a Field Operating Procedure for an AASHTO, ASTM, or WAQTC test procedure. References to manuals containing all of these tests and

procedures can be found in the WSDOT Standard Specifications Section 1-06.2(1).

B. Definitions

1. Relative Compaction: In-place density divided by the maximum dry density laboratory compaction expressed as percentage.
2. Rock Excavation: Excavation of solid ledge rock that, in the opinion of the Engineer, requires for its removal drilling and blasting, wedging, sledging, barring or breaking up with power-operated tools. The term "Rock Excavation" indicates a method of removal and not a geological formation.

1.05 EXPLOSIVES

- A. Do not use explosives unless specifically authorized, in writing, by the Engineer.

1.06 REFERENCE SPECIFICATIONS

- A. Whenever the words "Standard Specifications" are referred to, the reference is to the Washington State Department of Transportation (WSDOT), Standard Specifications for Road, Bridge and Municipal Construction (latest edition).

1.07 ADDITIONAL SAFETY RESPONSIBILITIES

- A. The Contractor shall select, install, and maintain shoring, sheeting, bracing, and sloping as necessary to maintain safe excavations. The Contractor shall be responsible for ensuring such measures: (1) comply fully with 29 CFR Part 1926 OSHA Subpart P Excavations and Trenches requirements, (2) provide necessary support to the sides of excavations, (3) provide safe access to the Engineer's sampling and testing within the excavation, (4) provide safe access for backfill, compaction, and compaction testings, and (5) otherwise maintain excavations in a safe manner that shall not endanger property, life, health, or the project schedule. All earthwork shall be performed in strict accordance with applicable law, including local ordinances, applicable OSHA requirements.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Crushed Rock: Crushed Surfacing Top Course, WSDOT Standard Specifications 9-03.9(3).
- B. Pipe Bedding and Backfill Materials:
1. Gravel Backfill for Pipe Zone Bedding: WSDOT Standard Specifications 9-03.12(3).
 2. Gravel Backfill for Drains: WSDOT Standard Specifications 9-03.12(4).
 3. Bedding Material for Rigid Pipe: WSDOT Standard Specifications 9-03.15.
 4. Bedding Material for Thermoplastic Pipe: WSDOT Standard Specifications 9-03.16.
- C. Native Backfill: Native soil prepared as necessary to be free from clods or rocks larger than 2 inches in greatest dimension. Wet, soft, or frozen material, organic matter, asphalt chunks, or other deleterious substances shall not be used as backfill. It is expected that the trench excavation will provide suitable backfill material.

- D. Imported Backfill: Imported non-expansive soil with liquid limit no greater than 40% and a plasticity index no greater than 15%, free from clods or rocks larger than 2 inches in greatest dimension, and free from organic material.
- E. Water: The water used shall be reasonably free of objectionable quantities of silt, oil, organic matter, alkali, salts, and other impurities. Water quality must be acceptable to the Engineer.
- F. Aggregate Base: Refer to Section 02700.
- G. Detection Tape: Plastic metallic type consisting of a color-coded polyethylene or melinex film, a solid core aluminum foil detection layer and other layers as required. The tape shall be resistant to acids, alkalines and other components likely to be encountered in soils. It shall be designed for both conductive and inductive locating procedures. Terra Tape D" by Griffolyn Company; Detectatape by Allen Systems; or equal. Tape color and lettering shall be as follows:
 - 1. Water pipelines: Blue, imprinted with "CAUTION WATER LINE BURIED BELOW."
 - 2. Electrical conduits: Red, imprinted with "CAUTION ELECTRICAL LINE BURIED BELOW."
 - 3. Chemical pipelines: Yellow, imprinted with "CAUTION CHEMICAL PIPE BURIED BELOW."
 - 4. Drain pipelines: Green, imprinted with "CAUTION SEWER LINE BURIED BELOW."

PART 3 - EXECUTION

3.01 CONTROL OF WATER

- A. All excavations shall be kept free from water and all construction shall be in the dry.
 - 1. It should be presumed that the presence of groundwater will require dewatering operations. Furnish, install, maintain, and operate all necessary pumping and other equipment for dewatering all excavations. At all times have on the project sufficient pumping equipment for immediate use, including standby pumps for use in case other pumps become inoperable.
 - 2. Provide a sufficient number of pumps so as to hold the groundwater level at an elevation of not less than 1 foot below the lowest elevation of the pipe, duct structure or other material or feature to be placed.
 - 3. Dispose of water as required by State and local regulations, and in such a manner as to cause no injury or nuisance to public or private property, or be a menace to the public health. It is the Contractor's responsibility to obtain all necessary Storm Water Discharge Permits.
 - 4. The dewatering operation shall be continuous, so that the excavated areas shall be kept free from water during construction, while concrete is setting and achieves full strength, and until backfill has been placed to a sufficient height to anchor the work against possible flotation.
 - 5. Continue dewatering during backfilling operations such that the groundwater is at least 1 foot below the level of the compaction effort at all times. No compaction of saturated materials will be allowed.
 - 6. Dewatering devices must be adequately filtered to prevent the removal of fines from the soil.

7. The Contractor shall be responsible for any damage to the foundations or any other parts of existing structures or of the new work caused by failure of any part of the Contractor's protective works. After temporary protective works are no longer needed for dewatering purposes, they shall be removed by the Contractor.
 8. If pumping is required on a 24-hour basis, requiring engine drives, then engines shall be equipped in a manner to keep noise to a minimum.
 9. Prevent disposal of sediments from the soils to adjacent lands or waterways by employing whatever methods are necessary, including settling basins.
- B. The Contractor shall be responsible for furnishing temporary drainage facilities to convey and dispose of surface water falling on or passing over the site.

3.02 EXISTING UTILITIES

- A. General: The known existing buried utilities and pipelines are shown on the Drawings in their approximate location. The Contractor shall exercise care in avoiding damage to all utilities as he will be held responsible for their repair if damaged. There is no guarantee that all utilities or obstructions are shown, or that locations indicated are accurate. Utilities are piping, conduits, wire, cable, ducts, manholes, pull boxes and the like, located at the project site.
- B. Check on Locations (Potholing):
1. Contact all affected utility owners and request them to locate their respective utilities prior to the start of "potholing" procedures. The utility owner shall be given 7 days written notice prior to commencing potholing. If a utility owner is not equipped to locate its utility, the Contractor shall locate it.
 2. Clearly paint the location of all affected utility underground pipes, conduits and other utilities on the pavement or identify the location with suitable markers if not on pavement. In addition to the location of metallic pipes and conduits, non-metallic pipe, ducts and conduits shall also be similarly located using surface indicators and detection tape if present and shall then be similarly marked.
 3. After the utility survey is completed, commence "potholing" to determine the actual location and elevation of all utilities where crossings, interferences, or connections to new pipelines or other facilities are shown on the Drawings, marked by the utility companies, or indicated by surface signs. Prior to the preparation of piping shop drawings, or the excavating for any new pipelines or structures, the Contractor shall locate and uncover these existing utilities including services and laterals to a point 1 foot below the utility. Submit a report identifying each underground utility and its depth and location. Any variation in the actual elevations and the indicated elevations shall be brought to the Engineer's attention.
 4. Excavations around underground electrical ducts and conduits shall be performed using extreme caution to prevent injury to workmen or damage to electrical ducts or conduits. Similar precautions shall be exercised around gas lines, telephone and television cables.
 5. Excavations shall have a surface dimension of no more than 18-inch by 18-inch. Air spades and vacuum excavators shall be used to limit the size of the excavation and damage to adjacent facilities. Backfill after completing potholing. In existing streets pave with 1 inch of cold mix asphalt concrete.

- C. Interferences:
1. If interferences occur at locations other than shown on the Drawings, the Contractor shall notify the Engineer, and a method for correcting said interferences shall be supplied by the Engineer. Payment for interferences that are not shown on the plans, nor which may be inferred from surface indications, shall be in accordance with the provisions of the General Conditions, Section 00700. If the Contractor does not expose all required utilities prior to shop drawing preparation, he shall not be entitled to additional compensation for work necessary to avoid interferences, nor for repair to damaged utilities.
 2. Any necessary relocations of utilities, whether shown on the Drawings or not, shall be coordinated with the affected utility. The Contractor shall perform the relocation only if instructed to do so in writing from the utility and the Engineer.
- D. Shutdowns: Planned utility service shutdowns shall be accomplished during period of minimum use. In some cases, this may require night or weekend work. Such work shall be at no additional cost to the Owner. Program work so that service will be restored in the minimum possible time, and shall cooperate with the utility companies in reducing shutdowns of utility systems to a minimum.
1. Disconnections: No utility shall be disconnected without prior written approval from the utility owner. When it is necessary to disconnect a utility, the Contractor shall give the utility owner not less than 72 hours' notice when requesting written approval. The Contractor shall program his work so that service will be restored in the minimum possible time.
- E. Overhead Facilities: There may be existing overhead electric and telephone transmission lines at the site. These overhead utilities are not shown on the Drawings. Extreme caution shall be used when working in the vicinity of overhead utilities so as to prevent injury to workmen or damage to the utilities. The Contractor shall be required to comply with the applicable provisions of the WAC 296-24-960 OR-OSHA when working anywhere on this project.
- F. Existing gas, water, sewer, and telephone house laterals are not specifically shown on the Drawings but do exist along the pipeline routes. Protect all service laterals from damage due to construction operations. If any laterals are damaged, notify the Engineer and the affected utility immediately. The cost of repair shall be borne by the Contractor.

3.03 GENERAL CONSTRUCTION REQUIREMENTS

- A. Site Access: Access to the site will be over public and private roads. Exercise care in the use of such roads and repair at own expense any damage thereto caused by Contractor's operations. Such repair shall be to the satisfaction of the Owner or agency having jurisdiction over the road. Take whatever means are necessary to prevent tracking of mud onto existing roads and shall keep roads free of debris.
- B. Barriers: Barriers shall be placed at each end of all excavations and at such places along excavations as may be necessary to warn all pedestrian and vehicular traffic of such excavations.
- C. Access: Free access must be maintained to all fire hydrants, water valves and meters, and private driveways.
- D. Demolition of Pavement: Where trenching or excavation occurs in paved areas, the pavement shall be scored and broken ahead of the trenching or excavation

operation. The extent of paving removed shall be limited to the minimum necessary for the excavation. All existing asphalt or concrete surfacing shall be saw cut vertically in a straight line, and removed from the jobsite prior to starting the trench excavation. This material shall not be used in any fill or backfill.

- E. Dust Control: Take proper and efficient steps to control dust.
- F. Permits: Refer to General Conditions.
- G. Storage of Materials: Excavated materials unsuitable for backfill shall not be stored on existing streets and shall be disposed of immediately. Neatly place excavated materials far enough from the excavation to prevent stability problems. Keep the materials shaped so as to cause the least possible interference with plant operations and drainage.
- H. Temporary Pavement: Place temporary pavement on trenches in existing streets within 24 hours after the trench has been backfilled. Maintain temporary pavement until permanent pavement is to be placed.
- I. Existing Facilities: Maintain access to existing facilities to permit continued operation. Maintain access for firefighting equipment and to fire hydrants.

3.04 TRENCH EXCAVATION

- A. Excavation for pipe and other utilities such as duct banks shall be in open cut. The trench shall be as wide as necessary for sheeting and bracing and the proper performance of the work up to the maximum width permitted by the typical cross-sections shown on the Drawings. The sides of the trenches shall be vertical in paved areas. The bottom of the trench shall be constructed to the grades and shapes indicated on the Drawings. Should the Contractor desire to use other equivalent methods, he shall submit his method of construction to the Engineer for favorable review prior to its use.
- B. Remove lumped subsoil and rock up to ½ cu yd., measured by volume.
- C. The trench shall not be backfilled until the Engineer reviews the pipe and bedding installation.
- D. Take care not to over excavate. Accurately grade the bottom of the trenches to provide uniform bearing and support for each section of the pipe or conduit at every point along its entire length, except for the portions of the pipe sections where it is necessary to excavate for bell holes and for the proper sealing of pipe joints, and as hereinafter specified. Dig bell holes and depressions for joints after the trench bottom has been graded. In order that the pipe rest on the bedding for as nearly its full length as practicable, bell holes and depressions shall be only of such length, depth and width as required for properly making the joint. Remove stones as necessary to avoid point bearing.
- E. Backfill and compact over excavations in accordance with the requirements of Section 3.07 with bedding material. There shall be no additional payment to the Contractor for over excavations not directed by the Engineer. Remove unsatisfactory material encountered below the grades shown as directed by the Engineer and replace with bedding material. Payment for removal and replacement of such unsatisfactory material directed by the Engineer shall be made in accordance with the provisions of the General Conditions.
- F. Grade trenches so that they are uniformly sloped between the pipe elevations shown on the Drawings. If no elevations are shown on the Drawings, provide 3 feet

of minimum cover. Comply with the minimum and maximum trench widths shown on the Drawings. Notify the Engineer if the trench width exceeds the maximum allowable width for any reason.

- G. For all piping or conduits to be placed in any excavated and backfilled area, such as at manholes or for building connections, the structural backfill shall be first compacted to a level at least 3 feet from the top of the piping or conduit elevation and then retrenched to pipe grade.
- H. Provide ladders for access to the trench by construction and inspection personnel.

3.05 FOUNDATIONS ON UNSTABLE SOILS

- A. If the bottom of the excavation is soft or unstable, and in the opinion of the Engineer, cannot satisfactorily support the pipe or structure, the soft or unstable material shall be removed and replaced a minimum of 12 inches below grade with Stabilization Rock or as otherwise specified by the Engineer. Payment for removal and replacement of such unsatisfactory material directed by the Engineer shall be made in accordance with the provisions of the General Conditions.

3.06 SUPPORT OF EXCAVATIONS

- A. Adequately support excavation for trenches and structures to meet all applicable requirements in the current rules, orders and regulations and WAC 296-155. Excavation shall be adequately shored, braced, and sheeted so that the earth will not slide or settle and so that all existing structures and all new pipe and structures will be fully protected from damage. Keep vehicles, equipment, and materials far enough from the excavation to prevent instability.
- B. Take all necessary measures to protect excavations and adjacent improvements from running, caving, boiling, settling, or sliding soil resulting from the high groundwater table and the nature of the soil excavated.
- C. The support for excavation shall remain in place until the pipeline or structure has been completed. During the backfilling of the pipeline or structure, the shoring, sheeting, and bracing shall be carefully removed so that there shall be no voids created and no caving, lateral movement or flowing of the subsoils.

3.07 BEDDING AND BACKFILL

- A. Place bedding and backfill materials true to the lines, grades, and cross-sections indicated on the Drawings and compacted to the degree specified on the Drawings. Place bedding and backfill materials in horizontal lifts not to exceed 6 inches in thickness measured before compaction. The difference in level on either side of a pipe shall not to exceed 4 inches.
- B. Bedding shall be compacted by vibrating, tamping, or a combination thereof, to 70% relative density for well-graded sand or squeegee material as determined by ASTM D 4253 and D 4254.
- C. Backfill material shall not be placed over the pipe or conduit until after the joints have been completed and inspected by the Engineer.
- D. It shall be incumbent upon the Contractor to protect the pipe or conduit from damage during the construction period. It shall be his responsibility to repair broken or damaged pipe at no extra cost to the Owner. Carefully place backfill around and over the pipe and do not allow it to fall directly upon the pipe. Tamping of backfill

over the pipe shall be done with tampers, vibratory rollers and other machines that will not injure or disturb the pipe.

- E. Do not allow construction traffic nor highway traffic over the pipe trench until the trench backfill has been brought back even with existing adjacent grade.
- F. Import Backfill: The removal and replacement limits and quantity of import backfill material shall be coordinated and accepted by the Engineer and governing authority prior to proceeding with the installation.

3.08 STRUCTURAL BACKFILL

- A. Crushed Rock Subgrade: Place a layer of rock, compacted in accordance with the requirements listed above, under structures to the lines, grades and minimum thicknesses shown on the Drawings. Unless shown specifically otherwise in the Drawings, do not use rock as backfill above the elevation of the highest base slab of the structure.
- B. Backfill Adjacent to Structures:
 - 1. Backfill shall be structural backfill compacted in accordance with the requirements listed above less otherwise specified or shown on the Drawings.
 - 2. Do not place backfill against structures until the concrete has been patched and cured.
 - 3. Do not place backfill against structures until at least 28 days after the concrete was placed, or until the concrete has achieved a strength of at least 2,500 psi, whichever is earlier. Concrete strength shall be demonstrated by field cured cylinders tested at the Contractor's cost, prepared and tested in accordance with ASTM C31 and ASTM C39.
 - 4. Do not place backfill against hydraulic structures until the structure has passed the specified leakage tests.
 - 5. Place backfill in uniform, level layers, not exceeding 8 inches thick measured before compaction. Bring backfill up uniformly on all sides of the structure, and on both sides of buried walls.

3.09 ROCK SUBGRADE UNDER STRUCTURES

- A. 3/4-inch Crushed Rock Bedding shall be used for all pipelines at depths greater than 15 feet and under all structures unless otherwise indicated on the Drawings.
- B. Crushed Rock shall be placed as a 6-inch layer, compacted to 95% relative compaction.

3.10 COMPACTION

- A. Add water to the backfill material or dry the material as necessary to obtain moisture content within 2% of optimum. Employ such means as may be necessary to secure a uniform moisture content throughout the material of each layer being compacted.
- B. After the material has been moisture conditioned, compact it with compaction equipment appropriate for the use to achieve specified compaction.
- C. If the backfill material becomes saturated from rains or any other source because it was not compacted to the specified density or was not backfilled and compacted to surface grade, through negligence or otherwise, remove the faulty material and

replace it with suitable material compacted to the specified density. No additional payment will be made for doing such work or removal and replacement.

- D. Compaction of embankment and backfill materials by flooding, ponding, or jetting is not permitted.
- E. When densities of compacted materials do not meet the requirements, remove and/or recompact the material until the requirements are met.
- F. Material Requirements
 - 1. Pipe Bedding Material: Compact to a minimum 95 percent of maximum density, in accordance with AASHTO T-99 unless otherwise specified or shown on the Drawings.
 - 2. Pipe Zone Material: Compact by hand methods under the haunches of the pipe and in areas not accessible to mechanical tampers unless otherwise specified or shown on the Drawings.
 - 3. Imported Backfill: Compact to a minimum 95 percent of maximum density, in accordance with AASHTO T-99 unless otherwise specified or shown on the Drawings.
 - 4. Native Backfill: Compact to a minimum 85 percent of maximum density, in accordance with AASHTO T-99 unless otherwise specified or shown on the Drawings.
 - 5. Foundation Stabilization: Compact to a minimum 95 percent of maximum density, in accordance with AASHTO T-99 unless otherwise specified or shown on the Drawings.
 - 6. Structural Fill: Compact in accordance with the Geotechnical Report/Engineer unless otherwise specified or shown on the Drawings.
- G. Testing Frequency:
 - 1. Trench Backfill: Test every 200 feet of trench.
 - 2. Earthwork: Test every 500 square feet for each 2 feet of fill.
 - 3. Structural Backfill:
 - a. Sub-base: Test every 200 square feet.
 - b. Base:
 - 1) Test every 200 square feet of building footprint, with no less than 2 tests per structure.
 - 2) Test every 200 cubic yards of material placed within 10 feet around the building.

3.11 FINISH GRADING

- A. Except where shown otherwise in the Drawings, restore the finish grade to the original contours and to the original drainage patterns. Grade surfaces to drain away from structures. The finished surfaces shall be smooth and compacted.

3.12 DISPOSAL OF EXCAVATED MATERIAL

- A. Dispose of unsuitable material or excavated material in excess of that needed for backfill or fill offsite in accordance with the requirements of Section 01140.

END OF SECTION

SECTION 02700

PAVING AND SURFACING

1.01 SUMMARY

- A. Furnishing all labor, material, equipment, tools, and services required for the placing and compacting of asphalt concrete pavement for roadways, parking lots, and walkways to the lines, grades, and dimensions shown on the Drawings and as specified herein.
 - 1. Also included shall be the repair and resurfacing of existing roadway and area paving damaged or removed during construction.

1.02 REFERENCE SPECIFICATIONS

- A. Whenever the words "Standard Specifications" are referred to, the reference is to the Washington State Department of Transportation (WSDOT), Standard Specifications for Road, Bridge and Municipal Construction, latest edition (Standard Specifications).
- B. ASTM International (ASTM):
 - 1. D422 Test Method for Particle-Size Analysis for Soils
 - 2. D1556 Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
 - 3. D2027 Specification for Cutback Asphalt (Medium Curing Type)
 - 4. D2922 Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
- C. Washington Department of Transportation (WSDOT):
 - 1. WSDOT Field Operating Procedure for AASHTO T 310 - Standard Specification for In-Place Density and Moisture Content of Soil and Soil-Aggregate by Nuclear Methods
 - 2. WSDOT Standard Operating Procedure for T 615 - Backfill Compaction
 - 3. WSDOT Field Operating Procedure for AASHTO T 209 - Standard Method of Test for Theoretical Maximum Specific Gravity and Density of Hot-Mix Asphalt Paving Mixtures
 - 4. WSDOT Standard Operating Procedure for T-732 - Superpave Volumetric Design for Hot Mix Asphalt (HMA)
 - 5. Field Operating Procedure for WAQTC TM 8 - Quality Assurance Testing

1.03 SUBMITTALS

- A. Submit the following under the Product Information category.
 - 1. Samples: Furnish, without additional cost to the Owner, such quantities of construction materials as may be required by the Engineer for test purposes. The Contractor shall cooperate with the Engineer and furnish necessary facilities for sampling and testing of all materials and workmanship. All materials furnished and all work performed shall be subject to rigid inspection, and no materials shall be used in the construction work until it has been inspected by the Engineer.
 - 2. Submit a signed verification from each source of supply for each construction material employed on this project indicating that the materials meet the Specification requirements.
 - 3. Mix design for asphalt concrete.

1.04 QUALITY ASSURANCE

- A. Comply with "Standard Specifications".
- B. All pavement stripe painting shall be performed by competent and experienced Equipment operators and painters using proper equipment, tools, stencils, templates, and shields in a workmanlike manner.

1.05 REGULATORY REQUIREMENTS

- A. All work, material, procedures, and practices under this Section shall conform to requirements of the Standard Specifications".

PART 2 - PRODUCTS

2.01 ASPHALT CONCRETE

- A. Description: This Work shall consist of providing and placing 1 (one) or more layers of plant-mixed hot mix asphalt (HMA) in accordance with Section 5-04 of the Standard Specifications on a prepared foundation or base and to the lines, grades, thicknesses, and typical cross-sections shown on the Drawings. HMA shall be composed of asphalt binder, aggregates, and mineral materials as may be required, mixed in the proportions specified to provide a homogeneous, stable, and workable mixture.
- B. Materials: Materials shall meet the requirements of the following sections of the Standard Specifications:

Asphalt Binder	9-02.1(4)
Cationic Emulsified Asphalt	9-02.1(6)
Anti-Stripping Additive	9-02.4
Warm Mix Asphalt Additive	9-02.5
Aggregates	9-03.8
Recycled Material	9-03.21
- C. Paving asphalt binder shall be Performance Grade 64-22 conforming to the requirements of Section 9-02 of the Standard Specifications.
- D. Mix Design:
 - 1. HMA mix design shall comply with the requirements of WSDOT Standard Specification 5-04 with the 20-year design ESAL (in millions) being 0.3 to <3.
 - 2. The results of at least two tests shall be submitted for mix designs. The tests shall be representative of the mix design to be used in the Work and shall be performed within the current production year. Materials used in the tests shall be the same manufacturer as will be used in the final Work. Tests for aggregate material shall be from the same pit as those that will be used in the final HMA.

2.02 TACK COAT

- A. Material for tack coat shall be CSS-1 OR CSS-1h grade emulsified asphalt conforming to Section 9-02 of the Standard Specifications.

2.03 FOG SEAL

- A. Fog seal shall be CSS-1 asphaltic emulsion fog seal conforming to the requirements of the Standard Specifications.

2.04 PRIME COAT (PENETRATION TREATMENT)

- A. Material for tack coat shall be CSS-1 or CSS-1h grade emulsified asphalt conforming to Section 9-02 of the Standard Specifications.

2.05 HEADERS

- A. At straight sections, wood headers shall be constructed of 2-inch by 6-inch construction heart redwood, held in place by 2-inch by 4-inch stakes, of the same materials, 2 feet long and set at 8-foot centers.
- B. At curved sections, wood headers shall be constructed of three ½-inch by 4-inch construction heart redwood bender boards. Boards shall be lapped at one-third of the length of individual boards, with no two boards lapped at the same place. Hold boards in place with stakes same as above.

2.06 AGGREGATE BASE

- A. Aggregate base shall conform to the applicable requirements of the Standard Specifications Section 9-3.

2.07 CONCRETE PAVEMENT

- A. Comply with the requirements of WSDOT Standard Specification 5-01.
- B. Cement: Type II Portland cement of the Standard Specifications Section 9-01.

PART 3 - EXECUTION

3.01 GENERAL

- A. This Specification shall cover newly paved areas as well as existing pavement restoration.
- B. Where trenching or other construction activity has resulted in damage to a localized area of pavement, the damaged pavement shall be cut back 6 inches and shall be removed and replaced.
- C. Where the damaged area extends over more than 50% of the road width or paved area, as determined by the Engineer, the full pavement width or area shall be cut away, removed and repaired.
- D. Structures such as valve boxes, manhole frames and covers, and electrical vaults shall be adjusted to grade as necessary within paved areas.
- E. Existing asphalt pavement islands of 50 square feet or less and strips 18 inches or less in width shall be removed and replaced.
- F. Adjust existing manholes, meter boxes, cleanouts, etc. to match the new grade.

3.02 PAVEMENT CUTTING

- A. After backfilling and prior to paving, proper tools and equipment shall be used in marking and breaking so that the pavement shall be cut accurately and on neat lines parallel to the trench. The asphalt pavement shall be saw cut (using a concrete saw) to a minimum depth equal to or greater than one-half the thickness thereof. The pavement shall be cut back 6 inches on each side of the trench or excavation wall. Any pavement damaged outside these lines shall be re-cut and

restored at the expense of the Contractor. Should voids develop under existing pavements during construction, those affected pavements shall be neatly saw cut in straight lines and replaced after the voids have been filled.

- B. Construct joints between successive runs vertical and at right angles to the line of the improvement. Exercise care in construction of all joints to ensure that the surface of the pavement is true to grade and cross-section. Lapped joints will not be permitted.

3.03 PLACEMENT OF AGGREGATE BASE

- A. Subgrade Preparation: The subgrade shall be watered or dried as required to bring the soil, as close as practicable, to the optimum moisture content for proper compacting and then compacted, as specified, to a relative compaction of not less than 95% in the upper 6 inches. When compaction of the subgrade areas on fill and embankments has been properly obtained, only such additional rolling will be required as necessary to obtain a thoroughly compacted subgrade immediately prior to placing the aggregate base thereon.
- B. Aggregate Base Tolerance: The aggregate base shall not be placed before the subgrade is approved by the Engineer. The finished aggregate base shall not vary more than 0.05-foot above, nor 0.10-foot below, the planned grade.
- C. Aggregate Base Placing: The aggregate base material shall be spread on the prepared subgrade by means of approved spreading devices subject to approval by the Engineer; the aggregate base material may be dumped in piles upon the subgrade and spread by bulldozing ahead from the dumped material. Each layer shall not exceed 0.50 feet. Segregation of large or fine particles of aggregate shall be avoided, and the material as spread shall be free from pockets of large and fine material.
- D. Compaction: The relative compaction of each layer of compacted aggregate base material shall not be less than 95% as determined by using Test Methods WSDOT FOP for AASHTO T 310 and WSDOT SOP for T 615. Compaction shall be in accordance with Section 2-03.3(14) D of the Standard Specifications.

3.04 PRIME COAT APPLICATION

- A. Prime Coat: In advance of spreading paving materials, a prime coat of liquid asphalt shall be applied to all base course surface areas to be covered with asphaltic concrete.
 - 1. Preparation of Base Course: Immediately before applying the prime coat, the area to be surfaced shall be cleaned of all loose material by means of hand brooms.
 - 2. Application: Liquid asphalt shall be applied by pressure distributors at a temperature between 125 and 200°F. The Engineer reserves the right to require an adjustment of the temperature of the liquid asphalt at the time of placement. The rate of application shall be between 2/10 and 3/10 gallon per square yard. Excess liquid asphalt, which has failed to penetrate the base, shall be covered with fine sand. All loose sand shall be removed from the treated areas before placing any surfacing material thereon. Liquid asphalt shall not be applied when the atmospheric temperature is below 50°F. The prime coat shall be applied at least 24 hours in advance of paving. Immediately in advance of paving asphalt concrete surfacing, additional

prime coats shall be applied, as directed by the Engineer, to areas where the prime coat has been damaged.

3.05 TACK COAT APPLICATION

- A. Tack Coat: In advance of spreading bituminous material upon an existing bituminous or portland cement concrete surface, a tack coat shall be applied to all areas to be surfaced and to all vertical surfaces of existing pavement, curb, gutters and construction joints in the surfacing against which additional material is to be placed. When two or more lifts of asphaltic concrete are required, a tack coat shall be applied between each lift.
 - 1. Preparation: Immediately before applying a tack coat, the area to be surfaced shall be cleaned of all loose material.
 - 2. Application: The tack coat shall be applied by means of pressure distributors by pressure hand-spray equipment. The rate of application shall be 1/20 gallon per square yard. Emulsified asphalt shall not be applied when the atmospheric temperature is below 40°F. The rate of application of the dilution shall be such that the rate of application of undiluted emulsion shall be within the tolerances specified.

3.06 PLACEMENT OF ASPHALT CONCRETE

- A. Delivery and Spreading: Bituminous mixtures shall be delivered to the roadbed at temperatures specified in the Standard Specifications. Spreading of the mixture shall be in accordance with 5.04.3(9) of the Standard Specifications. All loads shall be covered with tarpaulin or other material during transportation. The top layer of asphalt concrete shall not exceed 0.20 foot in compacted thickness. The next lower layer shall not exceed 0.25 foot in compacted thickness, and any lower layers shall not exceed 0.50 foot in compacted thickness.
- B. Compaction: Initial or breakdown rolling and the final rolling of the uppermost layer of the asphalt concrete shall be compacted in accordance with 5-04.3(10)A of the Standard Specifications. Compaction by vehicular traffic shall not be permitted. The Engineer reserves the right to require an adjustment of the temperature of the asphalt concrete at the time of placement.
- C. Pavement Thickness: Pavement shall match the existing adjoining pavement in thickness, or as indicated on the Drawings, or as specified, whichever is greater.
- D. Joining Pavement: The joints between old and new pavements or between successive days' work shall be carefully made in such manner as to ensure a continuous bond between old and new sections of the course. Edges of existing pavement shall be exposed and cleaned and edges cut to straight, vertical surfaces. All joints shall be painted with a uniform coat of tack coat before the fresh mixture is applied.
- E. Protection of Pavement: After final rolling, no vehicular traffic of any kind shall be permitted on the pavement until it has cooled and hardened and in no case less than 6 hours.

3.07 APPLICATION OF FOG SEAL

- A. A fog seal shall be applied to the upper surfaces of all installed asphalt concrete. It shall be applied in accordance with the applicable requirements of Section 5-02.3(2)C.

3.08 PAVEMENT RESTORATION

- A. Final pavement restoration shall be made as soon as practicable after backfilling. In that period of time between backfilling and final pavement restoration, the trench shall be maintained level with the adjacent pavement and shall be covered with a 1-inch minimum layer of cutback. Prior to placing the final pavement, the temporary pavement shall be removed, the aggregate base excavated to the lines indicated on the Drawings, and the existing pavement edges saw cut as herein specified. The final asphalt pavement shall not be placed before the primed aggregate base surface is approved by the Engineer.

3.09 PENETRATION TREATMENT APPLICATION

- A. Preparation of Base Aggregate Surface: Immediately before applying the first coat of the penetration treatment, the area to be treated shall be cleaned of all loose material.
- B. Application:
 - 1. The penetration treatment shall be applied in three applications. The first application shall be applied at the rate of 0.5 gallon per square yard, and the second and third applications shall be applied at the rate of 0.25 gallon per square yard. The second and third application shall be placed 2 to 3 weeks apart as approved by the Engineer and after the previous applications have thoroughly penetrated the base.
 - 2. Liquid asphalt shall be applied by pressure distributors at a temperature between 140 and 255°F. The Engineer reserves the right to require an adjustment of the temperature of the liquid asphalt at the time of placement. Excess liquid asphalt, which has failed to penetrate the base in the third application, shall be covered with fine sand. Liquid asphalt shall not be applied when the atmospheric temperature is below 50°F.

3.10 HEADERS

- A. Install wood headers along pavement edges bordered by soil. Install new headers where existing wood headers are damaged during construction, or removed for construction. Install headers with uniform slope between spot elevation indicated on the Drawings or to conform to existing grades.

END OF SECTION

SECTION 03000
CONCRETE GENERAL REQUIREMENTS

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes: General requirements and quality assurance provisions for all cast-in-place concrete.

1.02 REFERENCES

- A. The ASTM Standards referenced herein are listed by Active Standard. The latest version of the standard applies.
- B. Definitions
1. Abbreviations for organizations issuing documents referred to in the specifications are listed below:

AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
ASTM	ASTM International
AWS	American Welding Society
CRSI	Concrete Reinforcing Steel Institute
ICC	International Code Council
PTI	Post-Tensioning Institute
 2. Architectural concrete. Concrete that is exposed as an interior or exterior surface in the completed structure and is designated as architectural concrete in the Contract Documents; contributes to visual character of the completed structure and therefore requires special care in the selection of the concrete materials, forming, placing, and finishing to obtain the desired architectural appearance.
 3. Backshores. Shores placed snugly under a concrete slab or structural member after the original framework and shores have been removed from a small area at a time, without allowing the slab or member to deflect, or support its own weight or existing construction loads from above.
 4. Exposed to public view. Situated so that it can be seen from a public location after completion of the building.
 5. High early strength concrete. Concrete which, through the use of high early strength cement or admixtures, is capable of attaining specified strength at an earlier age than normal concrete.
 6. Lightweight concrete. Concrete of substantially lower unit weight than concrete made using gravel or crushed stone aggregates.
 7. Mass concrete. Any volume of concrete with dimensions large enough to require that measures be taken to cope with generation of heat from hydration of the cement and attendant volume change to minimize cracking.
 8. Mass concrete, plain. Mass concrete containing no reinforcement or less reinforcement than necessary to be considered reinforced mass concrete.
 9. Mass concrete, reinforced. Mass concrete containing adequate reinforcement, prestressed or non-prestressed, designed to act together with

the concrete in resisting all forces, including those induced by temperature and shrinkage.

10. Normal weight concrete. Concrete having a unit weight of approximately 150 pounds per cubic foot made with gravel or crushed stone aggregates.
11. Reference standards. Standards of a technical society, organization, or association, including the codes of local or state authorities, which are referenced in the Contract Documents.
12. Reshores. Shores placed snugly under a stripped concrete slab or other structural member after the original forms and shores have been removed from a large area, thus requiring the new slab or structural member to deflect and support its own weight and existing construction loads applied before the installation of the reshores.
13. Sheathing, wood formwork. The materials forming the contact face of forms; also called lagging or sheeting.
14. Shore. A temporary support designed to support formwork, fresh concrete, and construction loads from above for recently built structures that have not developed full design strength.
15. Shrinkage-compensating concrete. A concrete made using an expansive cement that increases in volume after setting, designed to induce compressive stresses in elastically restrained concrete to approximately offset the tensile stresses resulting from drying shrinkage.
16. Strength test. The average of the compressive strengths of two or more 6-inch diameter by 12-inch cylinders, or 3 or more 4-inch diameter by 8-inch cylinders, made from the same sample of concrete and tested at 28 days or at test age designated for determination of f'_c .
17. Structural lightweight concrete. Structural concrete made with lightweight aggregate; the unit weight usually is in the range of 90 to 115 lb./ft³.
18. Submitted. Submitted to the Engineer for review and acceptance.
19. Work. The entire construction or separately identifiable parts thereof which are required to be furnished under the Contract Documents. Work is the result of performing services, furnishing labor, and furnishing and incorporating materials and equipment into the construction, all as required by the Contract Documents.

1.03 QUALITY ASSURANCE

- A. Referenced Standards and Publications: This section incorporates by reference the revision of the following documents in effect 30 days prior to bid. It is part of all sections in Division 03 CONCRETE of the Specifications as referenced or modified. In case of conflict between the requirements of this section and that of the listed documents, the requirements of this section shall prevail:

1. ACI Standards
 - a. ACI 117 Specifications for Tolerances for Concrete Construction and Materials
 - b. ACI 423.6 Specification for Unbonded Single-Strand Tendons
2. ASTM Standards
 - a. A82 Standard Specification for Steel Wire, Plain, for Concrete Reinforcement
 - b. A184 Standard Specification for Welded Deformed Steel Bar Mats for Concrete Reinforcement

c.	A185	Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement
d.	A416	Standard Specification for Steel Strand, Uncoated Seven-Wire, for Prestressed Concrete
e.	A421	Standard Specification for Uncoated Stress-Relieved Steel Wire for Prestressed Concrete
f.	A496	Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement
g.	A497	Standard Specification for Steel Welded Wire Fabric, Deformed, for Concrete Reinforcement
h.	A615	Standard Specification for Deformed and Carbon Steel Bars for Concrete Reinforcement
i.	A706	Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
j.	A722	Standard Specification for Uncoated High-Strength Steel Bar for Prestressing Concrete
k.	A767	Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement
l.	A775	Standard Specification for Epoxy-Coated Steel Reinforcing Bars
m.	A779	Standard Specification for Steel Strand, Seven-Wire, Uncoated, Compacted, Stress-Relieved for Prestressed Concrete
n.	A780	Standard Practice for Repair of Damaged Hot-Dip Galvanized Coatings
o.	A882	Standard Specification for Filled Epoxy-Coated Seven-Wire Prestressing Steel Strand
p.	A884	Standard Specification for Epoxy-Coated Steel Wire and Welded Wire Reinforcement
q.	A934	Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars
r.	A955	Standard Specification for Deformed and Plain Stainless Steel Bars for Concrete Reinforcement
s.	A970	Standard Specification for Welded or Forged Headed Bars for Concrete Reinforcement
t.	A996	Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement
u.	C31	Standard Practice for Making and Curing Concrete Test Specimens in the Field
v.	C33	Standard Specification for Concrete Aggregates
w.	C39	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
x.	C42	Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
y.	C94	Standard Specification for Ready-Mixed Concrete
z.	C138	Standard Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete
aa.	C143	Standard Test Method for Slump of Hydraulic Cement Concrete
bb.	C150	Standard Specification for Portland Cement

cc.	C171	Standard Specification for Sheet Materials for Curing Concrete
dd.	C172	Standard Practice for Sampling Freshly Mixed Concrete
ee.	C173	Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
ff.	C192	Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
gg.	C231	Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
hh.	C260	Standard Specification for Air-Entraining Admixtures for Concrete
ii.	C309	Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
jj.	C330	Standard Specification for Lightweight Aggregates for Structural Concrete
kk.	C387	Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete
ll.	C404	Standard Specification for Aggregates for Masonry Grout
mm.	C494	Standard Specification for Chemical Admixtures for Concrete
nn.	C495	Standard Test Method for Compressive Strength of Lightweight Insulating Concrete
oo.	C567	Standard Test Method for Determining Density of Structural Lightweight Concrete
pp.	C595	Standard Specification for Blended Hydraulic Cements
qq.	C597	Standard Test Method for Pulse Velocity Through Concrete
rr.	C618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ss.	C684	Standard Test Method for Making, Accelerated Curing, and Testing of Concrete Compression Test Specimens
tt.	C685	Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing
uu.	C796	Standard Test Method for Foaming Agents for Use in Producing Cellular Concrete Using Preformed Foam
vv.	C803	Standard Test Method for Penetration Resistance of Hardened Concrete
ww.	C805	Standard Test Method for Rebound Number of Hardened Concrete
xx.	C845	Standard Specification for Expansive Hydraulic Cement
yy.	C873	Standard Test Method for Compressive Strength of Concrete Cylinders Cast in Place in Cylindrical Molds
zz.	C878	Standard Test Method for Restrained Expansion of Shrinkage-Compensating Concrete
aaa.	C881	Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
bbb.	C900	Standard Test Method for Pullout Strength of Hardened Concrete

ccc.	C928	Standard Specification for Packaged, Dry, Rapid Hardening Cementitious Materials for Concrete Repairs
ddd.	C939	Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method)
eee.	C989	Standard Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars
fff.	C1012	Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution
ggg.	C1017	Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
hhh.	C1059	Standard Specification for Latex Agents for Bonding Fresh to Hardened Concrete
iii.	C1064	Standard Test Methods for Temperature of Freshly Mixed Portland Cement Concrete
jjj.	C1074	Standard Practice for Estimated Concrete Strength by the Maturity Method
kkk.	C1077	Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
lll.	C1107	Standard Specification for Packaged, Dry, Hydraulic Cement Grout (Nonshrink)
mmm.	C1157	Standard Performance Specification for Hydraulic Cement
nnn.	C1218	Standard Test Method for Water-Soluble Chloride in Mortar and Concrete
ooo.	C1240	Standard Specification for Silica Fume Used in Cementitious Mixtures
ppp.	C1315	Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete
qqq.	C1602	Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
rrr.	D98	Standard Specification for Calcium Chloride
sss.	D994	Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type)
ttt.	D1621	Standard Test Methods for Comprehensive Properties of Rigid Cellular Plastics
uuu.	D1751	Standard Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Non-Extruding and Resilient Bituminous Types)
vvv.	D1752	Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
www.	D3575	Standard Test Methods for Flexible Cellular Materials Made from Olefin Polymers
xxx.	E329	Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction
yyy.	E1155	Standard Test Method for Determining FF Floor Flatness and FL Floor Levelness Numbers

3. Other Referenced Standards
 - a. AWS D-1.4 Structural Welding Code-Reinforcing Steel
 - b. CRD C513 Corps of Engineers - Specification for Rubber Waterstops
 - c. CRD C572 Corps of Engineers - Specification for Polyvinyl-Chloride Waterstops
 - d. ADOT&PF Standard Specifications for Highway Construction, 2004
 4. Cited Publications
 - a. ACI 318 Building Code Requirements for Reinforced Concrete
 - b. ACI CP1 ACI Certification Concrete Field Testing Technician – Grade I
 - c. ACI CP10 ACI Certification Flatwork Technician and Flatwork Finisher
 - d. ACI SP Field Reference Manual
 - e. CRSI MSP Manual of Standard Practice
- B. General: Concrete materials and operations will be tested and inspected by the testing agency and Owner as Work progresses. Failure to detect defective work or material shall not prevent rejection later when a defect is discovered nor shall it obligate Engineer or Owner for final acceptance.
- C. Testing Responsibilities of Contractor
1. Duties and Responsibilities. Unless otherwise specified in the Contract Documents, the Contractor shall assume the following duties and responsibilities as listed below. As specified in Section 01040, the Contractor shall arrange and pay for tests, inspections and approvals other than Special Inspections that are required by laws, ordinances, rules, regulations, orders of public authorities having jurisdiction or by the Contract Documents. Special Inspections will be performed by the testing agency hired by the Owner.
 - a. Qualify proposed materials and establish mixture proportions.
 - b. Qualify proposed batching equipment and operators per Section 03310, Concrete Mixtures.
 - c. Furnish any necessary labor to assist the testing agency in obtaining and handling samples at the project site or at the source of materials.
 - d. Notify testing agency at least 24 hours in advance of operations to allow for completion of quality tests and for assignment of personnel.
 - e. Provide and maintain adequate facilities for safe storage and proper curing of concrete test specimens on the job site for initial curing as required by ASTM C31 for the sole use of the testing agency.
 - f. Submit data and test documentation on materials and mixture proportions.
 - g. Submit quality control program of the concrete supplier and provide copies of all test reports.

- h. When it is necessary to base concrete acceptance on accelerated strength testing, submit a request to use accelerated testing along with correlation data for the standard 28-day compressive strength based on at least 15 sets of test data in accordance with 1.3.F with concrete made with the same materials providing a range of at least f'_{cr} plus or minus 1,000 psi.
- D. Coordination with Testing Agency: Unless otherwise specified in the Contract Documents, testing agency will provide the following services:
 - 1. Qualification of proposed materials and establishment of design mixtures.
 - 2. Inspect, sample, and test materials and production of concrete required by the Contract Documents. See Drawing S-002 for a listing of required special inspections. When it appears that material furnished or work performed by Contractor fails to conform to Contract Documents, the testing agency will immediately report such deficiency to the Owner, Contractor, and concrete supplier
 - 3. Report all test and inspection results to Owner, Contractor, and concrete supplier within 7 days after tests and inspections are performed.
 - 4. Testing agency shall perform the following testing services when necessary, at the Contractor's expense:
 - a. Additional testing and inspection required because of changes in materials or mixture proportions requested by the Contractor.
 - b. Additional testing of materials or concrete occasioned by failure to meet specification requirements.
- E. Tests on Hardened Concrete In Place
 - 1. General. Tests on hardened concrete will be performed by the testing agency when such tests are needed. Testing and core filling shall be at the Contractor's expense when tests are performed to verify the strength of the structure when required by this specification. Owner will pay costs if tests are at his request and not required by this specification.
 - 2. Non-Destructive Tests. Use of the rebound hammer in accordance with ASTM C805, pulse velocity methods in accordance with ASTM C597, or other non-destructive devices may be permitted by the Owner in evaluating the uniformity and relative concrete strength in place, or for selecting areas to be cored.
 - 3. Core Tests.
 - a. Where required by the Owner and Engineer, cores shall be obtained and tested in accordance with ASTM C42. Wipe cores surface-dry immediately after coring and allow to dry in air for a period not exceeding 1 hour after drilling. Seal cores in plastic bags or nonabsorbent containers until testing. End preparation of cores shall be completed within 48 hours after drilling. Test cores not earlier than 48 hours after drilling or last wetting and not later than 7 days after the cores were drilled from the structure.
 - b. At least three representative cores shall be taken from each area of in-place concrete that is considered potentially deficient. The location of cores as determined by the Owner and Engineer shall impair the strength of the structure as little as possible. If, before testing, cores show evidence of having been damaged subsequent to or during removal from the structure, replacement cores shall be taken.

- c. Fill core holes with low slump concrete or mortar of a strength equal to or greater than the original concrete.
- F. Acceptance of Concrete Strength
 - 1. Standard Molded and Cured Strength Specimens. The strength level of concrete will be considered satisfactory when the averages of all sets of three consecutive compressive strength test results, molded and cured in accordance with ASTM C31/C31M, equal or exceed the specified compressive strength f_c' and no individual strength test result falls below the specified compressive strength f_c' by more than 500 psi when f_c' is 5,000 psi or less, or by more than $0.10 f_c'$ when f_c' is more than 5,000 psi. These criteria apply also when accelerated strength testing is specified unless another basis for acceptance is specified in the Contract Documents.
 - 2. Nondestructive Tests. Nondestructive tests shall not be used as the sole basis for accepting or rejecting concrete but may be used when permitted to evaluate concrete where standard molded and cured cylinders have yielded results not meeting the criteria established 1.3.F.1.
 - 3. Core Tests. Strength level of concrete in the area represented by core tests will be considered adequate when the average compressive strength of the cores are equal to at least 85 percent of specified compressive strength f_c' , and if no single core is less than 75 percent of the specified compressive strength f_c' .
- G. Field Acceptance of Concrete
 - 1. Air Content. Concrete not within the limits of air entrainment indicated in Section 03310 and tested in accordance with required testing shall not be used in the Work.
 - 2. Slump. Concrete not within the slump limits of Section 03310, at the point of placement shall not be used in the Work.
 - 3. Temperature. Concrete not within temperature limits of Section 03310, shall not be used in the Work.

1.04 ACCEPTANCE OF STRUCTURE

- A. General: Completed concrete work shall conform to applicable requirements of this Specification and the Contract Documents.
 - 1. Concrete work that fails to meet one or more requirements of the Contract Documents but subsequently is repaired to bring the concrete into compliance may be accepted.
 - 2. Concrete work that fails to meet one or more requirements of the Contract Documents and cannot be brought into compliance will be rejected.
 - 3. Repair rejected concrete work by removing and replacing or by reinforcing with additional construction required by the Engineer and Owner. To bring rejected work into compliance, use repair methods that will maintain specified strength and meet all applicable requirements for function, durability, dimensional tolerances, and appearance as determined by the Engineer and Owner.
 - 4. Submit for acceptance the proposed repair methods, materials, and modifications needed to assure that concrete work will meet requirements of Contract Documents.

5. Contractor shall pay all costs to bring concrete work into compliance with requirements of the specification.
 6. Concrete members cast in the wrong location may be rejected.
- B. Dimensional Tolerances
1. Formed surfaces resulting in concrete outlines smaller than permitted by the tolerances of ACI 117, may be considered deficient in strength and subject to the provisions of 1.4.D, Strength of Structure.
 2. Formed surfaces resulting in concrete outlines larger than permitted by ACI 117 may be rejected. Excess materials will be subject to removal when required by the Engineer.
 3. Inaccurately formed concrete surfaces that exceed ACI 117 tolerances may be rejected.
 4. Finished slabs exceeding the tolerances in Section 03300, Cast-in-Place Concrete, may be corrected provided they are brought into compliance with 1.4.C, 1.4.D, and 1.4.E below.
 5. Concrete with tolerances and defects exceeding the limitations of Section 03100, Concrete Formwork, will be rejected.
- C. Appearance
1. Concrete not meeting the requirements of Section 03300 Cast-in-Place Concrete, Paragraph 3.3 or 3.4 (finishing of formed and unformed surfaces) shall be brought into compliance in accordance with Section 03300, Paragraph 3.8.
- D. Strength of Structure
1. Criteria for Determining Potential Strength Deficiency. Strength will be considered deficient and concrete will be rejected when the Work fails to comply with requirements which control the strength of the structure, including but not limited to the following conditions:
 - a. Concrete strength failing to comply with requirements of 1.3.F, Acceptance of Concrete Strength.
 - b. Reinforcing steel size, quantity, strength, position, or arrangement at variance with the requirements of Section 03200, Concrete Reinforcement, or other Contract Document Requirements.
 - c. Concrete elements which differ from the required dimensions or location.
 - d. Curing not in accordance with Contract Documents.
 - e. Inadequate protection of concrete from extreme temperature and other environmental conditions during early stages of hardening and strength development.
 - f. Mechanical injury, construction fires, accidents, or premature removal of formwork resulting in deficient strength.
 2. Action Required When Strength is Potentially Deficient. When strength of the structure is considered potentially deficient, the following actions may be required by Engineer:
 - a. Structural analysis, additional testing, or both.
 - b. Core tests.
 - c. If testing is inconclusive or impractical or if structural analysis does not confirm the safety of the structure, load tests may be required, and their results evaluated in accordance with ACI 318.

- d. Concrete work rejected by structural analysis or by results of a load test shall be reinforced with additional construction when required by Engineer or replaced.
- e. The Contractor shall document all repair work proposed to bring strength-deficient concrete work into compliance with Contract Documents and submit the documentation to Engineer for acceptance.

E. Durability

1. Criteria for Determining Potential Durability Deficiency. Durability of concrete will be considered deficient and the concrete work will be rejected when it fails to comply with the requirements which control durability of the structure, including but not limited to the following conditions:
 - a. Strength failing to comply with 1.3.F., Acceptance of Concrete Strength.
 - b. Materials for concrete not conforming to the requirements in Section 03310.
 - c. Concrete not conforming to the air entrainment requirements in Contract Documents or the total air content limits of Section 03310.
 - d. Curing not in accordance with Contract Documents.
 - e. Inadequate protection of concrete from detrimental temperature and other detrimental environmental conditions during early stages of hardening and strength development.
2. Action Required When Durability is Potentially Deficient. When durability of the structure is considered to be potentially deficient, the following actions may be required by the Engineer:
 - a. Obtain and test samples of the ingredient materials used in the concrete.
 - b. Obtain samples of concrete from the structure by coring, sawing, or other acceptable means.
 - c. Laboratory evaluation of concrete and concrete materials to assess the ability of concrete to resist weathering action, chemical attack, abrasion, or other deterioration, and to protect reinforcement and embedments from corrosion.
 - d. Repair or replace concrete rejected for durability deficiency as directed by Owner and Engineer.
 - e. Document repair work to bring concrete work into compliance with Contract Documents and submit the documentation to Owner and Engineer for acceptance.

1.05 PROTECTION OF IN-PLACE CONCRETE

- A. Loading and Support Of Concrete: Do not allow construction loads to exceed the superimposed load which the structural member, with necessary supplemental support, is capable of carrying safely and without damage or unacceptable deflection. When necessary, the Contractor shall retain a structural engineer to evaluate structural member capacity relative to construction loading.
- B. Protection from Mechanical Injury: During the curing period, protect concrete from damaging mechanical disturbances, including load-induced stresses, shock, and harmful vibration. Protect concrete surfaces from damage by construction traffic, equipment, materials, rain or running water, and other adverse weather conditions.

1.06 PRECONCRETING CONFERENCE

- A. A pre-concreting conference shall be held a minimum of 10 working days before placing concrete to discuss construction procedures, personnel, and equipment to be used. Those attending shall include:
1. Contractor: Project Manager, Superintendent, and all foremen responsible for placement of reinforcement and concrete and construction of forms, and finishing and curing of concrete, including subcontractors, as applicable.
 2. Ready-mix supplier representative. (Optional if less than 25 cubic yards of concrete will be placed for the entire project.)
 3. Owner: Project Manager/Owner's Representative.
 4. Engineer.
 5. Testing agency representative and field special inspection personnel.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

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SECTION 03100
CONCRETE FORMWORK

PART 1 - GENERAL

1.01 SUMMARY

- A. This section covers design, construction, and treatment of formwork to confine and shape concrete to the required dimensions.

1.02 REFERENCES

- A. ACI Standards
1. ACI 117 Specifications for Tolerances for Concrete Construction and Materials
- B. ASTM Standards
1. C31/C31M Standard Practice for Making and Curing Concrete Test Specimens in the Field
 2. C39/C39M Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
 3. C803 Standard Test Method for Penetration Resistance of Hardened Concrete
 4. C873 Standard Test Method for Compressive Strength of Concrete Cylinders Cast in Place in Cylindrical Molds
 5. C900 Standard Test Method for Pullout Strength of Hardened Concrete
 6. C1074 Standard Practice for Estimated Concrete Strength by the Maturity Method

1.03 SUBMITTALS

- A. Submit under provisions of Section 01300 as follows:
1. Submit the following project data unless otherwise specified:
 - a. Formwork Release Agent. Submit data on formwork release agent proposed for use with each form surface to be used for acceptance.
 - b. Shop Drawings. Submit shop drawings for formwork and formwork supports.
 - c. Manufacturer's data for form ties.
 - d. Manufacturer's data for expansion joint materials.
 2. Submit the following data when required:
 - a. Reshoring. When reshoring or backshoring is required or permitted, submit procedures and plans of operations, before use.
 - b. Form Liners. Submit samples and catalog data for form liner material when specified.
 3. Submit the following data when alternatives are proposed:
 - a. Formwork Facing Materials. When formwork facing materials other than those specified are proposed for use, submit data for acceptance.
 - b. Joints. If construction or control joints other than those indicated on Contract Drawings are desired, submit request for acceptance.

- c. Testing for Formwork Removal. When methods other than test of cylinders are proposed for determining time for formwork removal, submit data as specified in 3.4.B.

1.04 MATERIALS HANDLING

- A. All materials and equipment shall be shipped, stored, handled, and installed in such a manner as not to degrade quality, serviceability or appearance.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Form Facing Materials
 - 1. Materials for form faces in contact with concrete shall meet the requirements of Section 03300, Cast-In-Place Concrete, Paragraph 3.3.E, Unspecified Finishes, and the following requirements, unless otherwise specified in the Contract Documents.
 - a. For Rough Form Finish. No form facing material is specified.
 - b. For Smooth Form Finish. Use plywood, tempered concrete-form-grade hardboard, metal, plastic, paper or other acceptable materials capable of producing the desired finish for form-facing materials. Form facing materials shall produce a smooth, uniform texture on the concrete. Do not use form-facing materials with raised grain, torn surfaces, worn edges, patches, dents or other defects that will impair the texture of concrete surfaces. Furnish panels in largest practicable sizes to minimize number of joints.
- B. Form Ties
 - 1. General
 - a. Provide factory-fabricated, adjustable-length, removable or snap-off metal form ties designed to prevent form deflection and to prevent spalling concrete surfaces upon removal.
 - b. Provide ties so that portion remaining within concrete after removal of exterior parts is at least 1 inch from the outer concrete surface. Provide form ties which will not leave a hole larger than 1-inch diameter in the concrete surface.
 - c. Provide tie cones at each end.
 - d. Ties shall positively secure the wall to the required dimension and hold the wall to that dimension prior to and during concrete placement.
 - e. The use of tie wires as form ties will not be permitted.
 - 2. Snap Ties
 - a. Snap ties, if used, shall not be broken until the concrete has reached the design concrete strength. Snap ties, designed so that the ends must be broken off before the forms can be removed, shall not be used.
 - b. Ties for liquid containment structures and walls below grade shall have a neoprene waterstop, factory applied at the center of the tie.
 - 3. Taper Ties. Taper ties with plastic or rubber plugs of an approved and proven design may be used. The plugs shall be driven into the hole with a steel rod, placed in a cylindrical recess made therefore in the wall. At no time shall plugs be driven on the flat area outside the cylindrical recess. Plugs shall be A-58 Sure Plug as manufactured by Dayton Superior, or accepted equal.

- C. Formwork Release Agent
 - 1. Use commercially manufactured form release agent that prevents formwork absorption of moisture, prevents bond with concrete, does not stain the concrete surfaces, and does not leave residual matter on surface of concrete or adversely affect proper bonding or subsequent application of other material applied to concrete surface.
 - 2. For concrete surfaces of tanks or channels used for conveyance, treatment, or storage of water for eventual potable use, form release agents shall be listed in National Sanitation Foundation Standard 61, "Drinking Water System Components – Health Effects."

2.02 PERFORMANCE AND DESIGN REQUIREMENTS

- A. Design and engineering of formwork and formwork supports shall be the responsibility of the Contractor. Designs of formwork and preparation of formwork drawings shall be under the supervision of a professional engineer licensed in the state of Washington and shall conform to ACI 347.
- B. Design formwork for construction loads, lateral pressure, and requirements of the applicable building code, and for construction sequence shown on the Contract Drawings, if applicable. Design formwork to withstand the pressure resulting from placement and vibration of concrete and to maintain specified tolerances. The design assumptions for form pressure and rate of fill limitations for wall forms shall be stated on the formwork drawings. Wall forms shall be designed so wall sections can be poured full height between joints shown on the Contract Drawings without horizontal cold joints.
- C. Do not use earth cuts as forms for vertical or sloping surfaces unless required or permitted by Contract Documents.
- D. Maximum deflection of facing materials reflected on concrete surfaces exposed to view shall be 1/240 of the span between structural members of the formwork, except for architectural concrete.
- E. Locate and detail formed joints to the following requirements:
 - 1. Locate and form construction joints that least impair strength of the structure and meet the requirements of Section 03300. In general, locate construction joints in the middle third of the spans of slabs, beams, and girders. When a beam intersects a girder within this region, offset the joint in the girder a distance equal to or greater than twice the width of the beam. Locate joints in walls and columns at the underside of floors, slabs, beams, or girders and at the top of footings or floor slabs. Make joints perpendicular to the main reinforcement. Any construction joints not shown on the Contract Drawings shall require the approval of the Engineer.
 - 2. Provide keyways where indicated on Contract Drawings. Where longitudinal keyways are indicated on the Contract Drawings, make them a minimum of 1½-inch deep in joints in walls and between walls and slabs or footings.
 - 3. Provide construction and contraction (control) joints where indicated on the Contract Documents. The location of control joints other than those indicated on the Contract Documents shall be submitted for acceptance.
- F. For a smooth form finish, set the facing materials in an orderly and symmetrical arrangement, and keep the number of seams to a practical minimum. Support

facing material with studs or other backing capable of maintaining deflections within the tolerances specified in 2.2.D.

2.03 FABRICATION AND MANUFACTURE

- A. Formwork shall be tight to prevent loss of mortar from concrete. Provide watertight formwork when architectural concrete is specified.
- B. Place ¾-inch-minimum chamfer strips in the corners of formwork to produce beveled edges on permanently exposed surfaces unless otherwise specified. Do not bevel reentrant corners or edges of formed joints of concrete unless otherwise specified in the Contract Documents.
- C. Provide temporary openings at the base of the column and wall formwork and at other points where necessary to facilitate cleaning and inspection. Inspect formwork and remove deleterious material immediately before concrete is placed.
- D. Fabricate embedded form ties so ends or end fasteners can be removed with minimum spalling at the faces of concrete.
- E. After the ends or end fasteners of form ties have been removed, terminate the embedded portion of ties not less than 2 diameters, or twice the minimum cross-section dimension of the tie, from the formed concrete surface. In no case shall this distance be less than ¾ inch. Repair tie holes in accordance with Section 03300.
- F. Locate waterstops in joints where indicated on Contract Drawings. Use pieces of premolded waterstop in accordance with Section 03153 with a maximum practicable length to create the minimum number of end joints. Make joints in waterstops are in accordance with the manufacturer's recommendations. Ensure that joints develop effective watertightness equal to the continuous waterstop material, permanently develop not less than 50% of the strength of the parent section and permanently retain flexibility.

PART 3 - EXECUTION

3.01 CONSTRUCTION AND ERECTION OF FORMWORK

- A. At construction joints, lap contact surface of the form sheathing for flush surfaces exposed to view over the hardened concrete in the previous placement by not more than 1 inch. Ensure formwork is held firmly against hardened concrete to prevent offsets or loss of mortar at construction joints and to maintain a true surface.
- B. Unless otherwise specified in Contract Documents, construct formwork so concrete surfaces will conform to tolerance limits of ACI 117. The class of surface as given in ACI 117 shall be as follows:

Walls, columns, and elevated slabs:	Class A
Footings:	Class C
- C. Provide positive means of adjustment (such as wedges or jacks) of shores and struts. Do not make adjustments in the formwork after concrete has taken its initial set. Brace formwork securely against lateral deflection and lateral instability.
- D. To maintain specified tolerances, camber formwork to compensate for anticipated deflections in formwork prior to hardening of concrete. Set formwork and

intermediate screed strips for slabs accurately to produce designated elevations and contours of the finished surface prior to removal of formwork. Ensure that edge forms and screed strips are sufficiently strong to support vibrating screeds or roller pipe screeds when the finish specified requires the use of such equipment.

- E. When formwork is cambered, set screeds to a like camber to maintain required concrete thickness.
- F. Fasten form wedges in place after final adjustment of forms and prior to concrete placement.
- G. Anchor formwork to shores, supporting surfaces, or members to prevent upward or lateral movement of the formwork system during concrete placement.
- H. The Contractor shall form for and leave all openings in the concrete work where required for the installation of his own work and/or for the work of others. He shall carefully examine all drawings for the need of such openings, and in failing to provide openings as shown on the drawings, he shall cut them at his own expense. Except as otherwise noted or specified, all such openings shall be filled with concrete, after the work to be installed therein has been completed. Construct formwork for wall openings to facilitate removal and to counteract swelling of wood formwork.
- I. Provide runways for moving equipment and support runways directly on the formwork or structural member without resting on the reinforcing steel.
- J. Place sleeves, inserts, anchors, and embedded items required for adjoining work or for support of adjoining work prior to concrete placement.
- K. Position and support expansion joint material, waterstops, and other embedded items to prevent displacement. Fill voids in sleeves, inserts, and anchor slots temporarily with readily removable material to prevent entry of concrete into voids.
- L. Clean surfaces of formwork and embedded materials of mortar, grout, and foreign material before concrete is placed.
- M. Cover surfaces of formwork with an acceptable material that will prevent bond with the concrete. A field-applied formwork release agent or a factory-applied liner may be used. If a formwork release agent is used, apply to the surfaces of the formwork in accordance with the manufacturer's recommendations before placing reinforcing steel. Do not allow formwork release agent to puddle in the forms. Do not allow formwork release agent to contact reinforcing steel or hardened concrete against which fresh concrete is to be placed.
- N. Cleanouts and Access Panels
 - 1. Temporary openings shall be provided at the bottom of the wall forms to facilitate cleaning and inspection prior to placing concrete.
 - 2. Shavings, chips, and all refuse shall be removed, and the forms shall be broom-cleaned before any concrete is placed. Cleanout openings will not be permitted in exposed concrete without the Engineer's approval.

3.02 REMOVAL OF FORMWORK

- A. When finishing is required, remove formwork as soon as removal operations will not damage concrete, subject to Paragraph 3.4, Strength of Concrete Required for Removal of Formwork.
- B. Remove top forms on sloping surfaces of concrete as soon as removal will not allow concrete to sag. Perform needed repairs or treatment required at once and follow immediately with specified curing.
- C. Loosen wood formwork for wall openings when this can be accomplished without causing damage to concrete.
- D. Do not damage concrete during removal of formwork for columns, walls, sides of beams, and other parts not supporting the weight of the concrete. Perform needed repair and treatment required on vertical surfaces at once and follow immediately with specified curing.
- E. Unless otherwise specified, leave formwork and shoring in place to support the weight of concrete in beams, slabs, and in-place structural members until concrete has reached f'_c , in accordance with Paragraph 3.4. If a lower compressive strength is proposed for removal of formwork and shoring, submit detailed plans for review and acceptance. When shores and other vertical supports are arranged to allow the form-facing material to be removed without loosening or disturbing the shores and supports, the facing material may be removed at an earlier age unless otherwise specified.
- F. Form Removal Safety
 - 1. Forms shall be removed in a manner to ensure complete safety of the structure. In no case shall supporting forms or shoring of slabs or other suspended members be removed until members have acquired sufficient strength to support safely their weight and the load thereon.
 - 2. Care shall be taken by the Contractor to assure that newly unsupported portions of the structure are not subjected to heavy construction or material loading. Additional shores or bracing shall be provided, as required to adequately support the members during the construction period.
 - 3. All responsibility involved in the removal of forms, shores, and bracing shall rest with the Contractor, and he shall be solely responsible for accidents to persons and property of any nature.
- G. All parts of removed forms, reserved for reuse shall be inspected, cleaned and repair. Any part or panel which has been dented, deformed, or otherwise rendered unfit for reuse shall be discarded.
- H. Tie-rod clamps to be entirely removed from the wall shall be loosened 24 hours after concrete is placed, and form ties may be removed at that time.

3.03 RESHORING AND BACKSHORING

- A. When reshoring and backshoring is permitted or required, submit for acceptance a plan of reshoring and backshoring procedures and operations prior to their use.
- B. While reshoring or backshoring are underway, do not permit any construction load on new construction.
- C. During reshoring and backshoring, do not allow concrete in beam, slab, column, or any structural member to be loaded with combined dead and construction loads in

excess of the loads permitted by Engineer for the concrete compressive strength at the time of reshoring or backshoring.

- D. Place reshores and backshores in sequence with stripping operations.
- E. Tighten reshores and backshores to carry the required loads without overstressing the concrete members. Leave them in place until tests required by Paragraph 3.4, Strength of Concrete Required for Removal of Formwork, indicate that the concrete compressive strength has attained the minimum value specified in Paragraph 3.2.E.
- F. For floors supporting shores under newly placed concrete, either leave in place the original supporting shores or install reshores and backshores. The shoring system and the supporting slabs shall resist the anticipated loads. Locate reshores and backshores directly under a shore position or as indicated on formwork shop drawings.
- G. In multi-story buildings, extend reshoring over a sufficient number of stories to distribute the weight of newly placed concrete, forms, and construction live loads.

3.04 STRENGTH OF CONCRETE REQUIRED FOR REMOVAL OF FORMWORK

- A. When removal of formwork or reshoring is based on concrete reaching a specified compressive strength, concrete will be presumed to have reached this strength when test cylinders, field cured along with the concrete they represent, have reached the compressive strength specified for removal of formwork or reshoring. Mold cylinders in accordance with ASTM C31/C31M and cure them under the same conditions for moisture and temperature as used for the concrete they represent. Test cylinders in accordance with ASTM C39/C39M.
- B. Alternatively, when specified or permitted, use of the following methods for evaluating concrete strength for formwork removal is permitted. Prior to using methods in Paragraphs 3.4.B.1 through 3.4.B.4, submit sufficient data using job materials to demonstrate correlation of measurements on the structure with the compressive strength of laboratory-cured molded cylinders or drilled cores. Correlation data for each alternative method for determining strength shall be submitted for acceptance.
 - 1. Tests of cast-in-place cylinders in accordance with ASTM C873. This is limited to slabs with concrete depth from 5 to 12 inches.
 - 2. Penetration resistance in accordance with ASTM C803.
 - 3. Pullout strength in accordance with ASTM C900.
 - 4. Maturity method in accordance with ASTM C1074.
- C. Minimum Stripping Time: Form removal for elevated slabs and beam or girder soffits shall be based on paragraph A or B, above, with required concrete compressive strength equal to the specified 28-day compressive strength, but in no case less than 7 days. Form removal for columns, walls, and side forms of beams, girders, or footings shall be not less than 12 hours.

3.05 FIELD QUALITY CONTROL

- A. Establish and maintain survey controls and benchmarks in an undisturbed condition until final completion and acceptance of the project.
- B. Variations from plumb and designated building lines shall not exceed the tolerances specified in ACI 117.

3.06 INSTALLATION OF EMBEDDED ITEMS

A. General

1. The Contractor shall notify all trades when construction is ready for the setting of anchor bolts, inserts, sleeves, and other built-in equipment, in order that such material shall be set at the proper time. Before placing concrete, care shall be taken to determine that all items to be embedded in concrete are accurately located, firmly secured in place, and protected from damage or displacement until securely held by the concrete.
2. All items shall be thoroughly cleaned, free from rust, scale, dirt, grease, or other coating. Any wood used for removable keys shall be thoroughly dampened before concrete is placed against the wood. The Contractor shall be responsible for any displacement of the items caused by his workers.

B. Electrical conduit may be embedded in concrete, provided the following conditions are met. Conduit runs which cannot satisfy these conditions shall be done at the Contractor's expense.

1. Outside diameter of conduit shall not exceed $\frac{1}{3}$ of the concrete thickness.
2. Individual conduits shall not be placed closer than 3 diameters on center.
3. Conduit shall not be embedded in structural concrete slabs less than 6 inches thick.
4. Only two conduits may cross at any point. The sum of the outside diameter of the crossing conduits shall not exceed $\frac{1}{3}$ of the concrete thickness.
5. A $1\frac{1}{2}$ -inch-minimum concrete cover shall be provided for conduits in structural concrete slabs.
6. Conduit shall not be located between bottom of reinforcing steel and bottom of concrete slab.
7. Conduit is generally not permitted in beams or girders.
8. Aluminum conduit shall not be embedded in concrete.
9. Reinforcing steel and/or post-tensioning ducts shall not be repositioned to clear conduit. Adjust conduit positions to clear reinforcement.

END OF SECTION

SECTION 03150
CONCRETE ACCESSORIES GENERAL

PART 1 - GENERAL

1.01 SUMMARY

- A. The work and materials specified in this section include anchor bolts and miscellaneous embedded items, except waterstops that are specified in Section 03153.

1.02 REFERENCES

- A. ASTM Standards
 - 1. A563 Standard Specification for Carbon and Alloy Steel Nuts
 - 2. C881 Specification for Epoxy-Resin-Base Bonding Systems for Concrete
 - 3. C920 Standard Specification for Elastomeric Joint Sealants
 - 4. D1752 Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
 - 5. F436 Standard Specification for Hardened Steel Washers Inch and Metric Dimensions
 - 6. F1554 Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength

1.03 SUBMITTALS

- A. Submit under provisions of Section 01300, Submittals, as follows:
 - 1. Catalog data for all items covered by this section to be incorporated in the Work.

PART 2 - MATERIALS

2.01 ANCHOR BOLTS

- A. Anchor bolts shall be either post installed anchors or cast-in-place as shown on the Plans. Materials for anchor bolts and hardware shall be as specified in Section 05500.
 - 1. Post installed anchors shall be epoxy adhesive type, unless expansion type anchors are indicated as being allowed on the Drawings. Anchors shall be manufactured by Hilti, Powers, Rawl, Covert or approved equal.
 - 2. Hole diameter shall be accordance with manufacturer's instructions.
 - 3. Epoxy for adhesive anchors or dowel embedments shall be a non-sag, two-component epoxy resin conforming to ASTM C881, Type I, IV, or V; Grade 3; Class A, B, C, D, E, or F as required for the temperature of the concrete surface at the time of installation. Rapid setting epoxies shall not be used.
 - 4. Anchors shall be qualified by an IBC or other nationally recognized report as suitable for the application and as required by Contractor's design calculations as provided in other specification sections. When used for seismic loading, provide anchors that are rated for seismic loading as defined in ICC-ERS evaluation reports.

5. Adjustable anchors for equipment shall be floating nut-type which will allow at least ½ inch movement of the fastening stud. Adjustable anchors shall be DECO Manufacturing Co., Decatur Illinois, Standard Anchor or approved equal.
6. All expansion anchors shall be male-type projecting anchors, unless female-type anchors are specifically called out otherwise. Provide not less than minimum embedment depths where shown on the Drawings, but in no case less than ICC minimums for the size called out. Connected work shall not bear on threads.

2.02 PREFORMED JOINT FILLER

- A. Pre-formed joint filler material shall be pre-formed non-extruding type joint filler constructed of cellular neoprene sponge rubber or polyurethane of firm texture. Bituminous fiber type will not be permitted. All non-extruding and resilient-type preformed expansion joint fillers shall conform to the requirements and tests set forth in ASTM D1752 for Type I, except as otherwise specified herein.

2.03 BACKER ROD

- A. Backer rod shall be an extruded closed-cell, polyethylene foam rod. The material shall be compatible with the joint sealant material used and shall have a tensile strength of not less than 40 psi and a compression deflection of approximately 25 percent at 8 psi. The rod shall be 1/8-inch larger in diameter than the joint width except that a one-inch diameter rod shall be used for a ¾-inch wide joint.

2.04 JOINT SEALANT

- A. Joints where indicated on the Drawings, shall be sealed with a mastic joint sealer material of uniform, stiff consistency that does not contain solvents.
- B. The mastic shall tenaciously adhere to primed concrete surfaces, shall remain permanently mastic and shall not contaminate potable water.
- C. The material shall be of a type that will effectively and permanently seal joints subject to movements in concrete.
- D. The mastic joint sealer shall be an acceptable two-part, self-leveling (or gun grade), non-staining, polyurethane elastomeric sealant which cures at ambient temperature. Acceptable sealants shall conform to ASTM C920 or Federal Specification TT-S-00227E.
- E. For sloping joints, vertical joints and overhead horizontal joints, only "non-sag" compounds shall be used; all such compounds shall conform to the requirements of ANSI/ASTM C920 Class 12-1/2, or Federal Specification TT-S-0027 E(3), Type II.
- F. For plane horizontal joints, the self-leveling compounds which meet the requirements of ANSI/ASTM C920 Class 25, or Federal Specification TT-S-0027 E(3), Type I shall be used. For joints subject to either pedestrian or vehicular traffic, a compound providing non-tracking characteristics, and having a Shore "A" hardness range of 25 to 35, shall be used.
- G. Primer materials, if recommended by the sealant manufacturer, shall conform to the printed recommendations of the sealant manufacturer.

- H. Acceptable polyurethane materials are:
 - 1. Sikaflex/2C Polyurethane Elastomeric Sealant, as manufactured by SIKACHEMICAL CORP., Santa Fe Springs, CA (310-941-0231).
 - 2. Or approved equal.

2.05 BOND BREAKER

- A. Bond breaker shall be:
 - 1. Super Bond Breaker Water Base as manufactured by Burke Company, San Mateo, California.
 - 2. Select Emulsion Cure 309, as distributed by Select Products Co., Upland, CA (clear or white pigmented).
 - 3. Approved equal.
- B. Fugitive dye may be used in bondbreakers if recommended by manufacturer.

PART 3 - EXECUTION

3.01 ANCHOR BOLTS

- A. Notification: Owner's representative shall be notified prior to placement of drilled anchors to check and verify anchor size and type, hole depth, preparation, and placement.
- B. Installation Tolerances: Anchor bolts shall be installed with the bolt perpendicular to the concrete surface, +/- 3 degrees. Bolts shall be installed not more than 1/16 inch from their design position measured perpendicular from the centerline of the bolt. Bolt projection from the concrete surface shall be not more than +/- 1/8 inch from their design position, measured in the direction of the bolt axis, for expansion type anchors, nor more than +/- 1/4 inch from their design position for expansion anchors or cast-in-place anchor bolts.
- C. Drilled Holes: Do not drill or install anchors until concrete has reached specified minimum 28-day compressive strength. Drilled holes for expansion or epoxy anchors shall be drilled using rotary driven twist drills of the size and type recommended by the anchor manufacturer. All holes shall be thoroughly cleaned before installation of anchors. Holes for epoxy anchors shall be dry, in accordance with installation instructions requirements of the ICC-Evaluation Service or other testing agency upon whose tests the bolt capacity is based.
- D. Location and Length: Minimum bolt embedment shall be 8-bolt diameters unless otherwise noted on the Contract Drawings. Do not install anchors closer than 6-bolt diameters to free edge of concrete, or closer than 12-bolt diameters to another anchor unless detailed on the Contract Drawings. Locate to clear reinforcing bars in concrete.
- E. Preload: All anchor bolts and anchors for connections to the building structure or large equipment with multiple-bolt base plates shall be preloaded. Cast-in-place anchors shall have bond breaker applied to the shank prior to installation to prevent load transfer to the concrete except at the bolt head or washer. Unless otherwise indicated on the Contract Drawings, drilled anchors shall be preloaded to not less than 50%, nor more than 100% or rated allowable capacity after installation. Cast-in-place anchors shall be preloaded to not less than 10,000 psi, nor more than 20,000 psi tensile stress based on the root area of the thread.

- F. Nuts used to attach equipment or fixtures shall be tightened to not less than the manufacturer's recommended installation torque, or in the absence of specific recommendations, to the following torque values (foot-lbs).

Stud Diameter (inches)	Expansion Type Anchors (ft-lbs)	Resin or Cast-in-Place Anchors (ft-lbs)
1 ¼	--	550
1	--	300
7/8	--	200
¾	175	135
5/8	90	80
1/2	50	35
3/8	25	15
1/4	7	5

3.02 JOINT SEALERS

- A. Joint areas to be sealed shall be sandblasted or roughened and blown clean of dust and sand with compressed air before the material may be applied.
- B. Joints shall be primed (if required) and the sealant shall be applied in accordance with the manufacturer's recommendations.

END OF SECTION

SECTION 03153

WATERSTOPS

PART 1 - GENERAL

1.01 SUMMARY

- A. The work and materials specified in this section include requirements for waterstops.

1.02 REFERENCES

- A. ASTM Standards
 1. D6 Standard Test Method for Loss on Heating of Oil and Asphaltic Compounds
 2. D71 Standard Test Method for Relative Density of Solid Pitch and Asphalt (Displacement Method)
 3. D93 Standard Test Methods for Flash Point by Pensky-Martens Closed Cup Tester
 4. D217 Standard Test Methods for Cone Penetration of Lubricating Grease
 5. D297 Standard Test Methods for Rubber Products - Chemical Analysis
 6. D412 Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
 7. D570 Standard Test Method for Water Absorption of Plastics
 8. D624 Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
 9. D746 Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact
 10. D747 Standard Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam
 11. D792 Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
 12. D2240 Standard Test Method for Rubber Property - Durometer Hardness

1.03 SUBMITTALS

- A. Submit under provisions of Section 01300, Submittals, as follows:
 1. Catalog data for all items covered by this section to be incorporated in the Work.
 2. Samples: When requested, submit to the Engineer for review samples of all the materials and waterstop sections proposed for use on the work. All waterstop sections must conform to the shapes and sizes specified. The samples shall be clearly marked to show the manufacturer's name and product identification. The samples shall be submitted along with the manufacturer's and all laboratory test data required to show compliance with cited reference standards and requirements specified herein.
 3. Certificates: Certification from a recognized independent testing laboratory attesting that the material submitted will meet or exceed each and all of the physical and chemical characteristics specified herein and, in the references, cited herein.

1.04 QUALITY ASSURANCE

- A. Waterstop Inspection: All waterstop placements shall be reviewed and accepted by the testing agency retained by the Owner before concrete may be placed on either side of a waterstopped joint.
- B. All field joints in waterstops shall be reviewed for misalignment, bubbles, inadequate bond, porosity, cracks, offsets, and other defects which would reduce the potential resistance of the material to water pressure at any point. All defective joints shall be replaced with material which will pass said review, and all faulty material shall be removed from the site and disposed of by the Contractor.
- C. The following defects shall be grounds for rejection:
 - 1. Offsets at joints greater than $\frac{1}{32}$ inch (0.8 mm), or 15% of material thickness at any point, whichever is less.
 - 2. Exterior crack at welded joint in outer surface, due to incomplete bond, which is deeper than $\frac{1}{32}$ inch (0.8 mm), or 15% of material thickness at any point, whichever is less.
 - 3. Any combination of offset or exterior crack which will result in a new reduction in the cross-section of the waterstop excess of $\frac{1}{32}$ inch (0.8 mm), or 15% of material thickness at any point, whichever is less.
 - 4. Misalignment of joint which results in a longitudinal misalignment of the waterstop in excess of $\frac{1}{2}$ inch in 10 feet (12 mm in 3 m).
 - 5. Porosity in the welded joint as evidenced by visual observation.
 - 6. Bubbles or inadequate bonding which can be detected with a pen-knife test. (If while prodding the entire joint on each side with the point of a pen knife, the knife breaks through the outer portion of the weld into a bubble, the joint shall be considered defective.)
 - 7. Nail holes in the middle 2/3 of the waterstop material.
 - 8. Dirt, oil, grease, paint, concrete laitance, or other foreign material on the waterstop.

1.05 STORAGE AND HANDLING

- A. All waterstops shall be stored out of direct sunlight so as to permit free circulation of air around the waterstop material. In the event any waterstop is installed in the concrete on one side of a joint and will remain unembedded in concrete on the opposite side of the joint for more than 2 days, suitable precautions shall be taken to shade and protect the exposed waterstop from the direct rays of the sun during the entire exposure and until the waterstop is embedded in the concrete on both sides of the joint.
- B. Hydrophilic waterstop material shall be kept in dry storage prior to use and shall be kept dry after installation until concrete is placed. Waterstop which has started to swell from moisture contact shall not be installed in the work.

PART 2 - PRODUCTS

2.01 WATERSTOPS

- A. Waterstops shall be of the following types as permitted by the specifications and shown on the Contract Drawings. Unless noted otherwise, use chemical-resistant thermoplastic waterstop for chemical containment areas.

1. PVC waterstop. Except where other waterstop types are shown on the Plans, all waterstops shall be extruded virgin polyvinyl chloride, meeting the following minimum requirements:

a. Tensile strength	2,000 psi	ASTM D412
b. Ultimate elongation	375%	ASTM D412
c. Shore hardness	75±5	ASTM D2240
d. Specific gravity	1.3	ASTM D792
e. Stiffness in flexure	600 psi	ASTM D747
f. Cold brittleness	-35o F	ASTM D746
g. Water absorption: 48 hours	0.32% max.	ASTM D570
h. Tear resistance	290 lb. in.	ASTM D624

PVC waterstops shall be of the size and profile shown on the Plans.

"Split rib" or "split flange" waterstops shall not be used.

2. Chemical-resistant thermoplastic waterstop. Chemical-resistant waterstop shall be thermoplastic elastomeric rubber (TPER) as manufactured by WESTEC, St. Louis, MO, or approved alternate with the following properties:

a. Tensile strength	1,800 psi	ASTM D412
b. Ultimate elongation	450%	ASTM D412
c. 100% modules	1,000 psi	ASTM D412
d. Shore & hardness	85±5	ASTM D2240

- B. Retrofit Waterstop: Retrofit waterstop shall be either PVC or chemical-resistant thermoplastic type unless stipulated otherwise on the Drawings. Use chemical-resistant thermoplastic for chemical containment areas. Waterstop shall be a 'T' profile, with the stem projecting into the new concrete side of the joint. The stem shall be ribbed and project at least 2 inches into the new concrete. Provide a centerbulb at the base of the 'T'. The waterstop shall be provided with 316 stainless steel batten bars and concrete screws for securing to existing concrete. The waterstop shall be grooved to match the battens.

- C. Hydrophilic Waterstop: Hydrophilic waterstops shall all be one type, either bentonite or modified chloroprene rubber unless noted otherwise on the plans.

1. Bentonite Waterstop

- a. Waterstops shall be 1" x ¾" minimum, strip type, sodium bentonite base material.
- b. The material shall meet or exceed the requirements in Table 2.1.C.1 as follows:

Table 2.1.C.1: Bentonite Waterstop Criteria		
Item	Standard	Criteria
Butyl Rubber – Hydrocarbon (% by weight)	ASTM D297	25%
Bentonite	SS-S-210A	75%
Volatile Matter	ASTM D6	Below 1%
Specific Gravity at 77°F	ASTM D71	1.57
Penetration	ASTM D217	
	150 GTL	58
	300 GTL	85
Flash Point	ASTM D93	365

- c. Waterstop shall be Greenstreak "Swellstop" or approved equal.

2. Modified Chloroprene Rubber Waterstop
 - a. Waterstop shall be nominal 1"x1" outside dimension, hollow core profile.
 - b. The material shall meet or exceed:

Table 2.1.C.2: Modified Chloroprene Rubber Waterstop Criteria		
Property	Unit	Chloroprene Rubber
Specific gravity		1.41
Hardness	(JIS-A)	51
Tensile strength	kgf/cm ² (psi)	125 (1774)
Elongation	%	435

- c. Waterstop shall be Greenstreak "Hydrotite" or approved equal.

PART 3 - EXECUTION

3.01 INSTALLATION OF WATERSTOPS

- A. All waterstops shall be fully continuous for the extent of the joint. Splices necessary to provide such continuity shall be accomplished in conformance to printed instructions of manufacturer of the waterstop.
- B. Contractor shall pay particular attention to removing all obstructions such as concrete, nails, etc., from joints when movements of floor, wall and roof sections can be expected under prestressing, temperature and other conditions.
- C. The Contractor shall take suitable precautions and means to support and protect the waterstops during the progress of the work and shall repair or replace at his own expense any waterstop damage during the progress of the work.
- D. All waterstops shall be stored so as to permit free circulation of air around the waterstop material. In the event any waterstop is installed in the concrete on one side of a joint and will remain unembedded in concrete on the opposite side of the joint form more than 2 days, suitable precautions shall be taken to shade and protect the exposed waterstop from the direct rays of the sun during the entire exposure and until the waterstop is embedded in the concrete on both sides of the joint.
- E. The waterstop shall be correctly positioned in the forms prior to concrete placement so that the center of the waterstop is centered on the joint unless otherwise detailed per the Drawings.
- F. In cases where preformed expansion joint material is used in conjunction with the waterstop, allowance shall be made for equal waterstop embedment on each side in the concrete.
- G. Waterstop shall be held in place in the forms by use of a split form or other approved method that will positively hold the waterstop in the correct position and to the correct alignment.
- H. Horizontal waterstops shall be bent up during placing of concrete until the concrete has been brought to the level of the waterstop; additional concrete shall then be placed over the waterstop, after which the concrete shall be thoroughly vibrated.

- I. All horizontal and vertical waterstops which are not accessible during pouring shall be tied off in two directions every 12 inches in such a manner that bending over one way or another is prevented.
- J. A hog-ring or nail may be driven through both ends of the waterstop to facilitate placing and tying of waterstops to reinforcing steel forms or form-ties.

3.02 SPLICES IN ELASTOMERIC WATERSTOPS

- A. Splices in the continuity or at intersections around the waterstops shall be performed by heat-sealing the adjacent waterstop sections in accordance with the manufacturer's printed recommendations. It is essential that:
 - 1. The material not be damaged by heat sealing.
 - 2. The splices have a tensile strength of not less than 75 percent of the unspliced materials tensile strength.
 - 3. The continuity of the waterstop ribs and centerbulbs shall be maintained. Maintain continuity at bends in the plane of the waterstop by using miter cuts so ribs and centerbulbs remain aligned.
- B. Butt joints of the ends of two identical waterstop sections may be made while the material is in place in the forms.
- C. All joints in waterstop involving more than two ends jointed together, and all joints which involve an angle cut, alignment change, or the joining of two dissimilar waterstop sections shall be fabricated by the Contractor prior to placement in the forms, allowing not less than 18-inch-long (450 mm) strips of waterstop material beyond the joint. Upon being inspected and approved, such prefabricated waterstop joint assemblies shall be installed in the forms and the ends of the 18-inch (450 mm) strips shall be butt-welded to the straight-run portions of waterstop in place in the forms.
- D. All waterstops shall be properly spliced, and joints shall be checked for strength and pinholes after splicing.

3.03 HANDLING OF HYDROPHILIC WATERSTOP

- A. Confine waterstop within the concrete joint, with a minimum 2-inch concrete cover to the exterior joint surface, unless otherwise indicated.
- B. Exposed waterstop must be kept dry before concrete pour. If swelling occurs prior to confinement, replace with new material.
- C. Nail waterstop to hardened concrete to hold securely in place during concrete placement of second pour.

3.04 SPLICES FOR HYDROPHILIC WATERSTOP

- A. Bentonite Type: Butt ends of waterstop together. Do not overlap.
- B. Modified Chloroprene Rubber: Butt ends of waterstop together and glue with Manufacturer's recommended adhesive.

3.05 CONCRETE PLACEMENT AROUND WATERSTOPS

- A. Special care shall be used in placing concrete around waterstops by careful working, routing, and vibrating to ensure all air and rock pockets are eliminated.

3.06 INSTALLATION OF RETROFIT WATERSTOP

- A. Existing concrete shall be cleaned and roughened by bush hammer in areas to receive retrofit waterstop. The waterstop shall be bonded to the prepared concrete with epoxy adhesive and mechanically anchored with stainless steel battens and concrete screws or anchors in accordance with Manufacturer's installation instructions.

END OF SECTION

SECTION 03200
CONCRETE REINFORCEMENT

PART 1 - GENERAL

1.01 SUMMARY

- A. This section covers materials, fabrication, placement, and tolerances of reinforcement and reinforcement accessories.

1.02 REFERENCES

- A. ACI Standards
1. ACI 117 Specifications for Tolerances for Concrete Construction and Materials
 2. ACI 318 Building Code Requirements for Reinforced Concrete
- B. ASTM Standards
1. A82 Standard Specification for Steel Wire, Plain, for Concrete Reinforcement
 2. A184 Standard Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement
 3. A185 Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement
 4. A496 Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement
 5. A497 Standard Specification for Steel Welded Wire Fabric, Deformed, for Concrete Reinforcement
 6. A615 Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
 7. A706 Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
 8. A775 Standard Specification for Epoxy-Coated Reinforcing Steel Bars
- C. AWS Standards
1. ANSI/AWS D1.4 Structural Welding Code-Reinforcing Steel
- D. Other Referenced Standards
1. CRSI Manual of Standard Practice, Chapter 3

1.03 SUBMITTALS

- A. Submit under provisions of Section 01300, Submittals, as follows:
1. Submit the following project data unless otherwise specified:
 - a. Reinforcement. Submit manufacturer's certified test report.
 - b. Placing Drawings. Submit placing drawings showing fabrication dimensions and locations for placement of reinforcement and reinforcement supports.
 - c. Splices. Submit a list and request to use splices not indicated in Contract Documents.
 - d. Mechanical Splices. Submit request for the use of mechanical splices not shown on the Project Drawings.

- e. Column Dowels. Submit requests to place column dowels without the use of templates.
 - f. Field Bending. Submit requests and procedures to field bend or straighten reinforcement partially embedded in concrete.
- 2. Submit the following data when required:
 - a. Welding. Submit description of reinforcement weld locations and welding procedures, when welding is permitted in accordance with Paragraph 2.2.B.
- 3. Submit the following data when alternatives are proposed:
 - a. Reinforcement Relocation. Submit request to relocate any reinforcement that exceeds placement tolerances.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Prevent bending, coating with earth, oil, or other material, or otherwise damaging the reinforcement.

1.05 SUPPLEMENTAL REINFORCEMENT NOT SHOWN ON THE PLANS

- A. The Contractor shall provide and install any additional bars required to support primary reinforcement so that primary reinforcement is located as required by the documents.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Reinforcing Bars: Bars used as reinforcement shall be deformed except spirals and welded wire reinforcement, which may be plain unless otherwise designated on the Contract Drawings. Reinforcement shall be grade 60 unless otherwise indicated on the Contract Drawings and shall conform to one of the following:
 - 1. ASTM A615.
 - 2. ASTM A706.
- B. Epoxy Coated Reinforcement: Epoxy-coated reinforcement shall conform to ASTM A775. Repair damaged areas with patching material conforming to ASTM A775 and in accordance with the material manufacturer's recommendations.
 - 1. Repair all coating damage due to shipping, handling, and placing.
 - 2. The maximum amount of repaired damaged areas shall not exceed 2 percent of the surface area in each linear foot of each bar.
 - 3. Fading of the coating color will not be cause for rejection of epoxy-coated reinforcing bars.
- C. Bar Mats: Bar mats shall conform to ASTM A184.
- D. Wire: Use plain or deformed wire as indicated on the Contract Drawings. Plain wire may be used for spirals.
 - 1. Plain wire shall conform to ASTM A82.
 - 2. Deformed wire size D4 and larger shall conform to ASTM A496.
 - 3. For wire with a specified yield strength f_y exceeding 60,000 psi, f_y shall correspond to a strain of 0.35 percent.
- E. Welded Wire Reinforcement: Use welded wire reinforcement specified in Contract Documents and conforming to one of the following specifications:

1. Plain Welded Wire Reinforcement. ASTM A185, with welded intersections spaced not farther apart than 12 inches in the direction of principal reinforcement.
 2. Deformed Welded Wire Reinforcement. ASTM A497, with welded intersections spaced not farther than 16 inches in the direction of principal reinforcement.
 3. For welded wire reinforcement with a specified yield strength f_y exceeding 60,000 psi, f_y shall correspond to a strain of 0.35 percent.
- F. Wire Reinforcement Supports: Unless otherwise specified or permitted, use wire reinforcement supports complying with Class 1, maximum protection, or Class 2, moderate protection as indicated in the CRSI Manual of Standard Practice, Chapter 3.
- G. Precast Concrete Reinforcement Supports: Precast concrete supports for supporting reinforcement shall not be less than 4 square inches having a compressive strength equal to or greater than the specified compressive strength of the concrete being placed.
- H. All-Plastic Bar Supports: All-plastic bar supports may be used for horizontal and vertical reinforcing steel. They may have a snap-on action or other method of attachment. All-plastic supports shall be non-porous and chemically inert in concrete. All-plastic bar supports shall have rounded seatings so as not to punch holes in the formwork and shall not deform under load when subjected to normal temperatures encountered in use, nor shall they shatter or severely crack under impact loadings when used in cold weather. All-plastic bar supports shall have at least 25% of their gross plane area perforated and shall not be placed closer than 12 inches apart along a bar.
- I. Tie Wire: No. 16 American Wire Gauge or heavier, black annealed per ASTM A82.

2.02 FABRICATION

- A. Reinforcement: Bend all reinforcement cold unless heating is specifically authorized in the Contract Documents or by the Engineer. Fabricate reinforcement in accordance with fabricating tolerances of ACI 117.
- B. Welding: When welding of reinforcement is permitted by the Engineer, make all welds in conformance with ANSI/AWS D1.4. Do not weld crossing bars (tack welding) for assembly of reinforcement, supports, or embedded items.

PART 3 - EXECUTION

3.01 PREPARATION

- A. When concrete is placed, reinforcement shall be free of materials deleterious to bond. Reinforcement with rust, mill scale, or a combination of both will be considered satisfactory, provided the minimum nominal dimensions, nominal weight and the minimum average height of deformations of a hand-wire-brushed test specimen are not less than the applicable ASTM specification requirements.

3.02 PLACEMENT

- A. Tolerances: Place, support, and fasten reinforcement as shown on the Contract Drawings. Do not exceed the placing tolerances specified in ACI 117 before concrete is placed. Placing tolerances shall not reduce cover requirements except as specified in ACI 117.
- B. Reinforcement Relocation: When necessary to move reinforcement beyond the specified placing tolerances to avoid interference with other reinforcement, conduits, or embedded items, submit the resulting arrangement of reinforcement for acceptance.
- C. Concrete Cover: Minimum concrete cover for reinforcement, unless otherwise indicated in the Contract Drawings, shall be as indicated below. For bundled bars, minimum concrete cover shall be equal to the equivalent diameter of the bundle but need not be greater than 2 inches, except the minimum cover shall not be less than specified below. The equivalent diameter of the bundle shall be based on a single bar of a diameter derived from the equivalent total area. Tolerances on minimum concrete cover shall meet the requirements of ACI 117.

	Minimum Cover (inches)
Slabs & Joists	
Top & bottom bars for dry conditions	
#11 bars and smaller	$\frac{3}{4}$
#14 and #18 bars	$1\frac{1}{2}$
Formed concrete surfaces exposed to earth, water, or weather, and over or in contact with sewage and for bottoms bearing on work mat, or slabs supporting earth cover.	
#5 bars and smaller, W31 or D31 wire and smaller	$1\frac{1}{2}$
#6 through #18 bars, W45 or D45 wire	2
Beams & Columns, formed	
For dry conditions	
Stirrups, spirals, and ties	$1\frac{1}{2}$
Principal reinforcement	2
Exposed to earth, water, sewage, or weather	
Stirrups, spirals and ties	2
Principal reinforcement	$2\frac{1}{2}$
Walls	
For dry conditions	
#11 bars and smaller	$\frac{3}{4}$
#14 and #18 bars	$1\frac{1}{2}$
Formed concrete surfaces exposed to earth, water, sewage, weather, or in contact with ground	2
Footings and Base Slabs	
At formed surfaces and bottoms bearing on concrete work mat	2
At unformed surfaces and bottoms in contact with earth	3
Top of footings	same as slabs
Over top of piles	2

- D. Reinforcement Supports
1. Size and spacing of reinforcement supports shall conform to the CRSI Manual of Standard Practice. Reinforcement shown on the Contract Drawings shall not be relocated to serve as bolsters for other bars. The Contractor shall provide additional bars if necessary, to support the reinforcement shown on the Contract Drawings.
 2. Horizontal bars in slabs and beams shall be supported at intervals not greater than 48 inches.
 3. Wall and column reinforcement shall be laterally supported by side form spacers or other means at intervals not greater than 48 inches horizontally or vertically in the case of walls, and not greater than 48 inches vertically and at not less than 90-degree intervals in the case of columns.
 4. Unless otherwise reviewed by the Engineer, use the following reinforcement supports:
 - a. Place reinforcement supported from the ground or mud on precast concrete reinforcement supports.
 - b. Place reinforcement supported from formwork on reinforcement supports made of concrete, metal, or plastic.
- E. Welded Wire Reinforcement: For slabs on grade, extend welded wire reinforcement to within 2 inches of the concrete edge. Lap edges and ends of welded wire reinforcement sheets a minimum of one-mesh spacing or 8 inches, whichever is greater. Welded wire reinforcement may extend through contraction joints only where permitted. Support welded wire reinforcement during placing of concrete to assure required positioning in the slab. Do not place welded wire reinforcement on grade and subsequently raise into position in concrete.
- F. Column Dowels: Furnish and use templates for placement of column dowels unless otherwise permitted.
- G. Make splices as indicated on the Contract Drawings unless otherwise reviewed by the Engineer. Mechanical splices for reinforcement not shown on the Contract Drawings may be used only when accepted by the Engineer.
- H. Field Bending or Straightening: In accordance with ACI 318, Chapter 7, unless noted on the Drawings, no bending or straightening of reinforcement will be permitted after partial embedment in concrete. Heating of reinforcement will be permitted only if the entire operation is submitted and approved by the Engineer.
- I. Field Cutting of Reinforcement: Reinforcement shall not be cut in the field except when specifically permitted.

END OF SECTION

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SECTION 03300
CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.01 SUMMARY

- A. This section covers the production of cast-in-place structural concrete. Included are methods and procedures for obtaining quality concrete through proper handling, placing, finishing, curing, and repair of surface defects.

1.02 REFERENCES

- A. ACI Standards
1. ACI 117 Specifications for Tolerances for Concrete Construction and Materials
- B. ASTM Standards
1. C39/C39M Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
 2. C171 Standard Specification for Sheet Materials for Curing Concrete
 3. C309 Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
 4. C881/C881M Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
 5. C928 Standard Specification for Packaged, Dry, Rapid Hardening Cementitious Materials for Concrete Repairs
 6. C1059 Standard Specification for Latex Agents for Bonding Fresh to Hardened Concrete
 7. C1107 Standard Specification for Packaged, Dry, Hydraulic Cement Grout
 8. C1315 Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete

1.03 SUBMITTALS

- A. Submit under provisions of Section 01300, Submittals, as follows:
1. Submit the following data unless otherwise specified:
 - a. Field Control Test Reports. Maintain and submit accurate records of all test and inspection reports.
 - b. Conveying Equipment. Submit description of conveying equipment.
 - c. Temperature Measurement. Submit proposed method of measuring concrete surface temperature changes.
 - d. Repair Methods. When stains, rust, efflorescence, and surface deposits must be removed as described in Paragraph 3.8.G, submit the proposed method of removal.

- e. Placement Notification. Submit notification at least 48 hours in advance of concrete placement.
 - f. Preplacement Requirements. Submit requests for acceptance of reinforcement and form placement at least 48 hours in advance of concrete placement.
 - g. Wet Weather Placement. When placement is scheduled during wet weather, submit request for acceptance of protection.
2. Submit the following data when required:
- a. Matching Sample Finish. When special finishes are required by Contract Documents, submit sample finish described in 3.3.B.
 - b. Exposed Aggregate Surface. When an exposed aggregate surface is specified and a chemical retarder is proposed to be used, submit specification and data on the retarder and proposed method of use of retarder.
3. Submit the following data when alternatives are proposed:
- a. Joints. Submit information for acceptance of proposed location and treatment of construction joints and control joints proposed but not indicated on the Contract Drawings. The determination of acceptability of proposed joints shall be made solely by the Engineer.
 - b. Two-Course Slabs. When a bonding agent other than cement grout is proposed, submit specification and data of bonding agent.
 - c. Saw Cut Joints. When sawcut joints other than those indicated on the Contract Drawings are proposed, submit request of the proposed method.
 - d. Moisture-Preserving Method. When a moisture-preserving method other than specified in Paragraph 3.6.C is proposed, submit request of the proposed method.
 - e. Coated Ties. When coated form ties described in Paragraph 3.8.B are proposed to preclude the requirement to patch tie holes, submit proposed coated tie description.
 - f. Repair Material. When repair material described in Paragraph 2.1.C, Proprietary Patching Materials, is proposed, submit the repair material specification, data on the proposed patching material, and proposed preparation and application procedure.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Delivery: Place concrete within the time limits required in Section 03310, Concrete Mixtures.
- B. Storage and Handling: Store and handle products to retain original quality. Do not use products stored beyond the manufacturer's recommended shelf life.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Curing Compounds: Where the use of curing compounds is approved by the Engineer, use curing compounds that conform to ASTM C309 or ASTM C1315. Curing compound shall be translucent with fugitive dye. Combination curing compound/sealer products shall not be used unless sealer is part of the specified finish. Where concrete is to be coated with moisture- or waterproofing compound or sealer, curing compounds shall not be used unless certified by the manufacturer as not adversely affecting the bond or performance of subsequently applied coatings, or shall be removed after completion of the cure using light water blast in accordance with manufacturer's recommendations.
- B. Sheet Materials for Curing Concrete: Use sheeting materials that conform to ASTM C171.
- C. Proprietary Patching Materials: Use acceptable proprietary patching materials complying with 3.8.F, Repair Materials Other Than Site-Mixed Portland Cement Mortar.
- D. Bonding Grout: Use bonding grout in accordance with Paragraph 3.8.D, Preparation of Bonding Grout.
- E. Site-Mixed Portland Cement Repair Mortar: Use repair mortar in accordance with Paragraph 3.8.E, Site-Mixed Portland Cement Repair Mortar.
- F. Floor Hardener: Floor hardener shall be a graded, iron aggregate base compound for dry-shake application and trowel embedment into fresh concrete. The compound shall be packaged in 90-lb, poly-lined bags and shall contain a dispersing agent, Portland cement and a stable lime-proof pigmentation to color the application gray. Wet cure or use curing compound recommended by the hardener manufacturer.
- G. Floor Sealer: Cresteseal CS2000, Rain Guard Floor-Lok, or accepted equal.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Do not place concrete until data on materials and mixture proportions are accepted.
- B. Remove hardened concrete and foreign material from the inner surfaces of conveying equipment.
- C. Before placing concrete in forms, complete the following:
 - 1. Comply with formwork requirements specified in Section 03100, Concrete Formwork.
 - 2. Remove snow, ice, frost, water, and other foreign material from surfaces, including reinforcement and embedded items, against which concrete will be placed.
 - 3. Comply with reinforcing steel placement requirements in Section 03200, Concrete Reinforcement.

4. Position and secure in place waterstop, anchors, and other embedded items.
 5. Obtain acceptance of finished preparation.
- D. Before placing a concrete slab on grade, clean foreign material from the subgrade and complete the following:
1. Subgrade shall be well drained and of uniform load-bearing nature.
 2. In-place density of subgrade soils shall be uniform throughout the area and at least the minimum required by Contract Documents.
 3. Subgrade shall be free from frost or ice.
 4. Subgrade shall be moist with no free water and no muddy or soft spots.
 5. If a slipsheet is indicated on the Contract Drawings, slabs and foundations on grade shall be underlain with two layers of 8 mil polyethylene sheeting, perforated to allow bleedwater to escape.
- E. When high evaporative conditions necessitate protection of concrete immediately after placing or finishing, make provisions in advance of concrete placement for windbreaks, shading, fogging, sprinkling, ponding, or wet covering.
- F. During ambient temperature conditions described in Section 03310, Paragraph 2.2.G, Concrete Temperature, make provisions in advance of concrete placement to maintain the temperature of the concrete as specified in Paragraph 3.2.A below. Use heating, covering, or other means adequate to maintain required temperature without overheating or drying of concrete due to concentration of heat. Do not use combustion heaters unless precautions are taken to prevent exposure of the concrete to exhaust gases containing carbon dioxide.

3.02 PLACEMENT OF CONCRETE

- A. Weather and Exposure Considerations
1. Wet Weather. Do not begin to place concrete while rain, sleet, or snow is falling unless adequate protection is provided, and approval of protection is obtained from the Engineer. Do not allow rainwater to increase mixing water or to damage the surface of the concrete.
 2. Cold Weather. Concrete temperatures and ambient temperatures shall meet minimum temperature requirements of Section 03310, Paragraph 2.2.G, Concrete Temperature.
 3. Hot Weather. When ambient temperatures exceed 90° F, the temperature of concrete as placed shall not exceed 80° F. Loss of slump, flash set, or cold joints due to temperature of concrete as placed will be rejected. When temperature of steel reinforcement, embedments, or forms is greater than 120° F, fog steel reinforcement, embedments, and forms with water immediately prior to placing concrete. Remove standing water prior to placing concrete.
 4. Concrete Placed In Water. No concrete shall be placed underwater or in standing water.
- B. Conveying: Convey concrete from mixer to the place of final deposit rapidly by methods which prevent segregation or loss of ingredients and will assure the required quality of concrete. Do not use aluminum pipes or chutes.

C. Conveying Equipment:

1. Use acceptable conveying equipment of a size and design that will prevent cold joints from occurring. Clean conveying equipment before each placement.
 - a. Use belt conveyors that are horizontal or at a slope that will not cause excessive segregation or loss of ingredients. Project concrete to minimize drying and the effects of temperature rise. Use an acceptable discharge baffle or hopper at the discharge end to prevent segregation. Do not allow mortar to adhere to the return length of the belt.
 - b. Use metal or metal-lined chutes having rounded bottoms and sloped between 1 vertical to 2 horizontal and 1 vertical to 3 horizontal. Chutes more than 20 feet long and chutes not meeting slope requirements may be used provided the discharge is into a hopper before distributing into the forms.
 - c. Use pumping conveying equipment that permits placement rates that avoid cold joints and prevents segregation in discharge of pumped concrete.

D. Depositing:

1. All concrete shall be delivered, discharged, and placed within the time limits specified in Section 03310, Concrete Mixtures, 3.2.A.2.
2. Deposit concrete continuously in one layer or in layers to have fresh concrete deposited on in-place concrete that is still plastic. Do not deposit fresh concrete on concrete that has hardened sufficiently to cause formation of seams or planes of weakness within the section, unless construction joint requirements of Paragraph 3.2.F are met.
3. Once concreting is started, it shall be carried on as a continuous operation until the placing of the panel or section is complete. Suspension of operations for more than 1½ hours will not be permitted during a continuous placement, and this limit may be shortened on order by the Engineer.
4. Concrete shall be placed generally in horizontal layers not more than 24 inches thick, except as otherwise specified. Each layer of concrete is to be laid and worked before the succeeding layer can be superimposed in the process of monolithic construction. When a monolithic layer cannot be completed in one operation, it shall be terminated with a vertical bulkhead. Feathering out to less than 6 inches will not be permitted.
5. Concrete shall be placed so as to prevent segregation of the materials and the displacement of the reinforcement. Where placing operations would involve the dropping of concrete through completed forms from heights of 4 or more feet, concrete so placed shall be pumped or discharged into hoppers feeding into flexible drop chutes to within 2 feet of the concrete's final deposition point. Encrustation of installed reinforcement by concrete spilled on it will be tolerated only for a length of time shorter than the encrusting concrete needs for drying out.
6. Do not use concrete that has surface dried, partially hardened, or contains foreign material.
7. When temporary spreaders are used in the forms, remove the spreaders as their service becomes unnecessary. Spreaders made of metal or concrete may be left in place if prior acceptance is obtained.
8. Do not place concrete over columns and walls until concrete in columns and walls is no longer plastic and has been in place at least 1 hour.

9. Do not subject concrete to any procedure that will cause segregation. Deposit concrete as near as practicable to the final position to avoid segregation.
 10. Place concrete for beams, girders, brackets, column capitals, haunches, and drop panels at the same time as concrete for slabs.
 11. When placing concrete for columns, do not exceed the top-of-pour elevation indicated on the Contract Drawings for the joint between the column and the slab or drop panel it supports.
- E. Consolidating:
1. Consolidate concrete by vibration. Concrete shall be thoroughly worked around reinforcement and embedded items and into corners of forms, eliminating all air or stone pockets which may cause honeycombing, pitting, or planes of weakness. Use internal vibrators of the largest size and power that can properly be used in the work. Workers shall be experienced in use of the vibrators. Do not use vibrators to move concrete within the forms.
 2. The Contractor shall supply enough vibrators to consolidate the concrete (except that placed underwater) according to the requirements of this section. Each vibrator must:
 - a. Be designed to operate while submerged in the concrete
 - b. Vibrate at a rate of at least 7,000 pulses per minute
 - c. Receive the Engineer's approval on its type and method of use.
 3. Immediately after concrete is placed, vibration shall be applied in the fresh batch at the point of deposit. In doing so, the Contractor shall:
 - a. Space the vibrators evenly, no farther apart than twice the radius of the visible effects of the vibration
 - b. Ensure that vibration intensity is great enough to visibly affect a weight of 1-inch slump concrete across a radius of at least 18 inches
 - c. Insert the vibrators slowly to a depth that will effectively vibrate the full depth of each layer, penetrating into the previous layer on multilayer pours
 - d. Protect partially hardened concrete (i.e., non-plastic, which prevents the vibrator penetration when only its own weight is applied) by preventing the vibrator from penetrating it or making direct contact with steel that extends into it
 - e. Not allow vibration to continue in one place long enough to form pools of grout
 - f. Continue vibration long enough to consolidate the concrete thoroughly, but not so long as to segregate it
 - g. Withdraw the vibrators slowly when the process is complete
 - h. Not use vibrators to move concrete from one point to another in the forms
 - i. Use internal vibrators of the largest size and power than can properly be used in the Work
 - j. Use immersion-type vibrators with nonmetallic heads when consolidating concrete around epoxy-coated reinforcement. Workers shall be experienced in use of the vibrators.

4. When vibrating and finishing top surfaces that will be exposed to weather or wear, the Contractor shall not draw water or laitance to the surface. In high lifts, the top layer shall be shallow and made up of a concrete mix as stiff as can be effectively vibrated and finished.
 5. To produce a smooth, dense finish on outside surfaces, the Contractor shall hand tamp the concrete.
- F. Construction Joints and Other Bonded Joints:
1. Locate construction joints as indicated per the Drawings or as accepted in accordance with 1.3.A.3.a. The use of construction joints not shown on the Drawings is prohibited unless approved by the Engineer. Formed construction joints shall be thoroughly cleaned, laitance removed, and dampened prior to placement of fresh concrete. When bond is required or permitted, it shall be achieved by one of the following:
 - a. Use an acceptable adhesive applied in accordance with the manufacturer's recommendations.
 - b. Use an acceptable surface retarder in accordance with the manufacturer's recommendations.
 - c. Roughen the surface in an acceptable manner that exposes the aggregate uniformly and does not leave laitance, loosened particles of aggregate, or damaged concrete at the surface. The joint shall be roughened with a chipping hammer to expose the aggregate of the previous pour. The exposed aggregate shall protrude a minimum of $\frac{1}{4}$ inch.
 - d. Use portland cement grout of the same proportions as the mortar in the concrete in an acceptable manner.
- G. Contraction/Control Joints:
1. The location of contraction or control joints shall be as shown on the plans or as approved by the Engineer. Contraction joints shall be saw cut, preformed, or tooled $\frac{1}{4}$ inch wide by $\frac{1}{4}$ of the slab depth, but not less than $1\frac{1}{2}$ inches deep, unless otherwise detailed on the Contract Drawings. Contraction joints shall be finished with backing rod and sealant.
- H. Pipe Penetrations:
1. Where pipes pass through the structure, they shall be cast in place, unless permission is given by the Engineer to do otherwise or formed blockouts are shown on the Drawings. Whenever these requirements interfere with the placement of reinforcing steel as indicated by the Contract Drawings, the bars shall be spread and rearranged as directed by the Engineer.

3.03 FINISHING FORMED SURFACES

- A. General: After removal of forms, in accordance with Table 3.3.A, give each formed surface one or more of the finishes described in Paragraphs 3.3.B, Matching Sample Finish; 3.3.C, As-Cast Finishes; or 3.3.D, Rubbed Finishes. When Contract Documents do not specify a finish, finish surfaces as required by Paragraph 3.3.E, Unspecified Finishes.

Table 3.3.A: Finish Schedule	
Location	Finish Type
Backfilled surfaces	Rough form finish
Exposed foundation surfaces where form liner does not exist and exposed face of top slabs	Smooth form finish
All other surfaces	Grout-cleaned finish

- B. Matching Sample Finish: When the finish is required by the Contract Documents to match a sample panel furnished to the Contractor, reproduce the sample finish on an area at least 100 square feet in a location designated by the Engineer and obtain acceptance before proceeding with that finish in the specified location.
- C. As-Cast Finishes
1. Rough Form Finish. Patch tie holes and defects. Chip or rub off fins exceeding $\frac{1}{4}$ inch in height. Leave surfaces with the texture imparted by the forms.
 2. Smooth Form Finish. Patch tie holes and defects. Remove all fins completely.
 3. Architectural Finishes. Produce architectural finishes including special textured finishes, exposed aggregate finish, and aggregate transfer finish in accordance with specifications for Architectural Concrete, if included in the Contract Documents.
- D. Rubbed Finishes: Remove forms as early as permitted by Section 03100, Concrete Formwork, Paragraph 3.2, Removal of Formwork. Produce one of the following finishes on concrete specified to have a smooth form finish:
1. Smooth Rubbed Finish. Remove forms as early as permitted by Section 03100, Concrete Formwork, and perform necessary patching. Produce finish on newly hardened concrete no later than the day following form removal. Wet the surface and rub it with carborundum brick or other abrasive until uniform color and texture are produced. Use no cement grout other than cement paste drawn from the concrete itself by the rubbing process.
 2. Grout-Cleaned Finish. Begin cleaning operations after all contiguous surfaces to be cleaned are completed and accessible. Do not clean surfaces as Work progresses. Wet the surface and apply grout consisting of 1-part portland cement and $1\frac{1}{2}$ parts fine sand with enough water to produce the consistency of thick paint. Add white cement as needed to match color of surrounding concrete. Scrub grout into all voids and remove all excess grout. When grout whitens, rub the surface and keep the surface damp for 36 hours afterwards.

3. Cork-Floated Finish. Perform necessary repairs. Remove ties, burrs, and fins. Wet the surface and apply stiff grout of one-part portland cement and one-part fine sand, filling all voids. Add white cement as needed to match color of surrounding concrete. Use enough water to produce a stiff consistency. Compress grout into voids by grinding the surface with a slow-speed grinder. Produce the final finish with cork float, using a swirling motion.
- E. Unspecified Finishes: When a specific finish is not specified in the Contract Documents for a concrete surface, apply the following finishes:
1. Rough form finish on all concrete surfaces not exposed to public view.
 2. Smooth form finish on all concrete surfaces exposed to public view.

3.04 FINISHING UNFORMED SURFACES

- A. Placement
1. Place concrete at a rate that allows spreading, straight edging, and darbying or bull-floating before bleed water appears.
 2. Strike smooth the top of walls, buttresses, horizontal offsets, and other similar unformed surfaces, and float them to a texture consistent with finish of adjacent formed surface.
 3. Finish slab surfaces in accordance with one of the finishes in 3.4.B, Finishes, as specified in Table 3.4.A.

Table 3.4.A: Finish Schedule	
Location	Finish Type
Interior slabs	Troweled finish (with floor sealer)
Tops of footings or other backfilled surfaces	Floated finish
Exterior slabs, walks, and steps	Broom finish

- B. Finishes
1. Scratched Finish. Place, consolidate, strike off and level concrete, eliminating high spots and low spots. Roughen the surface with stiff brushes or rakes before the final set.
 2. Floated Finish. Place, consolidate, strike off and level concrete, eliminating high spots and low spots. Do not work concrete further until it is ready for floating. Begin floating with a hand float, a bladed power float equipped with float shoes, or a powered disk float when the bleed water sheen has disappeared, and the surface has stiffened sufficiently to permit the operation. During or after the first floating, check flatness of surface with a 10-foot straightedge applied in two or more directions. Produce a conventional, straightedge finish in accordance with ACI 117, then refloat the slab immediately to a uniform texture.
 3. Troweled Finish. Float concrete surface, then power trowel the surface. Hand trowel the surface smooth and free of trowel marks. Continue hand troweling until a ringing sound is produced as the floor is troweled. Tolerance for concrete floors shall be conventional straightedge in accordance with ACI 117, unless otherwise specified. Concrete surfaces intended to support floor covering shall not have defects that will reflect through floor covering.

4. Broom or Belt Finish. Immediately after concrete has received a steel-troweled finish, give the concrete surface a coarse transverse scored texture by drawing a broom or burlap belt across the surface.
5. Dry-Shake Finish.
 - a. Blend metallic or mineral aggregate floor hardener with portland cement in the proportions recommended by the aggregate manufacturer, or use bagged premixed material as recommended by the manufacturer. Float finish the concrete surface. Apply approximately two-thirds of the blended material required for coverage to the surface by a method that ensures even coverage without segregation. Float finish the surface after application of the first dry-shake. Apply the remaining dry-shake material at right angles to the first application and in locations necessary to provide the specified minimum thickness. Begin final floating and finishing immediately after application of the dry-shake.
 - b. After selected material is embedded by the two floating, complete operation with a broomed, floated, or troweled finish, as designated in the Contract Documents.
6. Heavy Duty Topping for Two-Course Slabs.
 - a. For heavy duty topping mix, use materials and methods specified in Contract Documents. Place and consolidate concrete for the base slab and creed concrete to the specified depth below the top of the finish surface.
 - b. Topping placed the same day as the base slab may be placed as soon as bleed water in the base slab has disappeared and the surface will support a person without appreciable indentation.
 - c. When topping placement is deferred, brush the surface with a coarse wire broom to remove laitance and scratch the surface when concrete is plastic. Wet cure the base slab at least three days. Before placing the topping, clean the base slab surface thoroughly of contaminants and loose mortar or aggregate. Dampen the surface, leaving it free of standing water.
 - d. Immediately before placing topping, scrub into the slab surface a coat of bonding grout consisting of equal parts of cement and fine sand with enough water to make a creamy mixture. Do not allow grout to set or dry before topping is placed. Bonding agents other than cement grout may be used with prior acceptance.
 - e. Spread, compact, and float the topping mixture. Check for trueness of surface and float, trowel, or broom finish as specified.
7. Topping for Two-Course Slab Not Intended for Heavy Duty Service. Preparation of base slab, selection of topping material, mixing, placing, consolidating, and finishing operations shall be as specified in Paragraph 3.4.B.6, Heavy Duty Topping for Two-Course Slabs, except that the aggregate need not be selected for special wear resistance.
8. Non-Slip Finish. Where a non-slip finish is required, give the surface a broom finish or belt finish or a dry-shake application of crushed aluminum oxide or other abrasive particles, as specified in the Contract Documents. Rate of application shall be not less than 25 pounds per 100 cubic feet.
9. Exposed Aggregate Finish.
 - a. Immediately after surface of the concrete has been leveled to the specified straightedge method tolerance and the bleed water sheen has disappeared, spread aggregate of the color and size specified in

- Contract Documents uniformly over the surface to provide complete coverage to a depth of one stone.
- b. Tamp the aggregate lightly to embed aggregate in the surface. Float the surface until the embedded stone is fully coated with mortar and the surface has been brought to a true plane within the specified straightedge tolerance. After the matrix has hardened sufficiently to prevent dislodgement of the aggregate, apply water carefully and brush the surface with a fine bristle brush to expose the aggregate without dislodging it.
 - c. An acceptable chemical retarder sprayed on freshly floated concrete surface may be used to extend the working time for the exposure of aggregate.
10. **Non-Specified Finish.** When the type of finish is not specified in Contract Documents, use one of the following appropriate finishes and accompanying tolerances.
- a. *Scratched Finish.* For surfaces intended to receive bonded cementitious mixtures.
 - b. *Floated Finish.* For walks, drives, steps, ramps, and for surfaces intended to receive waterproofing, roofing, insulation, or sand-bed terrazzo.
 - c. *Troweled Finish.* For floors intended as walking surfaces, floors in manufacturing, storage and warehousing areas, or for reception of floor coverings.
- C. **Finishing Tolerances for Slabs**
1. Finish floor slabs to meet the requirements of ACI 117 as specified in Paragraph 3.4.B. Measure floor finish tolerances within 72 hours after slab finishing.
 2. Unless otherwise specified in the Contract Documents, measure floor tolerances in accordance with the "10 ft. straightedge method" in ACI 117.

3.05 SAWED CONTRACTION JOINTS

- A. Where saw cut joints are required or permitted, start cutting as soon as concrete has hardened sufficiently to prevent dislodgement of aggregates. Saw a continuous slot to a depth of one-fourth the thickness of the slab but not less than 1 inch. Complete sawing within 12 hours after placement.

3.06 CURING AND PROTECTION

- A. **General:** Immediately after placement, protect concrete from premature drying, excessively hot or cold temperatures, and mechanical injury. Protect concrete from physical damage or reduced strength due to weather extremes.
1. In cold weather comply with ACI 306R except as modified herein:
 - a. Do not place concrete on frozen ground or in contact with forms or reinforcing bars coated with frost, ice, or snow.
 - b. Minimum concrete temperature at the time of mixing:

Outdoor Temperature at Placement (In Shade)	Concrete Temperature at Mixing
Below 30° F	70° F
Between 30-45° F	60° F
Above 45° F	50° F

- c. Do not place heated concrete that is warmer than 80° F.
 - d. If freezing temperatures are expected during curing, maintain the concrete temperature at or above 50° F for 7 days or 70° F for 3 days.
 - e. Do not allow concrete to cool suddenly.
 - 2. In hot weather comply with ACI 305R except as modified herein:
 - a. At air temperature of 90° F and above, keep concrete as cool as possible during placement and curing.
 - b. Do not allow concrete temperature to exceed 90° F at placement.
 - c. Prevent plastic shrinkage cracking due to rapid evaporation of moisture.
 - d. Do not place concrete when the actual or anticipated evaporation rate equals or exceeds 0.2 LBS/SF/HR as determined from ACI 305R, Figure 2.1.5.
 - 3. Cure concrete in accordance with Paragraph 3.6.C. for 7 days after placement. Alternatively, moisture retention measures may be terminated when:
 - a. Tests are made on at least two additional cylinders kept adjacent to the structure and cured by the same methods as the structure, and tests indicate 70 percent of the specified compressive strength f_c' , as determined in accordance with ASTM C39/C39M.
 - b. Temperature of the concrete is maintained at 50° F or higher for the time required to achieve 85 percent of f_c' in laboratory-cured cylinders representative of the concrete in place.
 - c. Strength of concrete reaches f_c' as determined by accepted non-destructive methods meeting the requirements of Section 03100, Concrete Formwork, Paragraph 3.4.B.
- B. Formed Concrete Surfaces: Keep absorbent wood forms wet until they are removed. After form removal, cure concrete by one of the methods in 3.6.C, Preservation of Moisture.
- C. Preservation of Moisture: After placing and finishing, use one of the following methods below to preserve moisture in concrete:
- 1. Wet Cure Method.
 - a. Provide continuous moisture by ponding or watering a covering of heavy quilted blankets, by watering and covering with a white reflective-type sheeting, or by wetting the outside surfaces of wood forms. Runoff water shall be collected and disposed of in accordance with all applicable regulations. In no case shall runoff water be allowed to enter any lakes, streams, or other surface waters.
 - b. When curing slabs with wet heavy quilted blankets or burlap, a fog or mist spray of water shall be sprayed on the entire surface before the bleed water has evaporated. As soon as the concrete has achieved initial set, the surface shall be covered with presoaked heavy quilted blankets or burlap. The fog or mist spray shall be applied continuously until the presoaked heavy quilted blankets or burlap are placed. If the fog or mist spray cannot be applied continuously, two coats of curing compound shall be applied after the initial fog or mist spray application and before the presoaked heavy quilted blankets or burlap are placed.
 - c. Ponding may be used for slabs on grade.
 - 2. Curing Compound Method.
 - a. Application of a curing compound conforming to ASTM C309. Apply the compound in accordance with manufacturer's recommendation after

water sheen has disappeared from the concrete surface and after finishing operations. The rate of application shall not exceed 150 square feet per gallon. Apply in two applications at right angles to each other, not to exceed 150 square feet per gallon for each coat. Do not use curing compound on any surface where concrete or other material will be bonded unless the curing compound will not prevent bond or unless measures are to be taken to completely remove the curing compound from areas to receive bonded applications.

- b. No later than the morning after applying the curing compound, the Contractor shall cover the top surfaces with white, reflective sheeting, leaving it in place for at least 10 days. Throughout this period, the sheeting shall be kept in place by taping or weighting the edges.

3.07 FLOOR SEALER PREPARATION AND APPLICATION

A. General

1. The Contractor shall provide and utilize all equipment and materials required for proper preparation of the concrete sealer. Sealer shall be applied at the rate and means as specified by the manufacturer. Provide protection of the health and safety of all workers during the application.
2. Adjacent surfaces shall be protected with suitable masking and drop cloths as required.
3. Coating materials shall be applied to surfaces under environmental conditions and within the limitations recommended by the sealer manufacturer. Sealer shall not be applied in areas where dust is being generated.

- #### B. Corrections and Cleanup:
- Upon completion and prior to final acceptance, all equipment and unused materials shall be removed from the site and any spillage other misplaced sealer material shall be removed in a manner which will not damage surfaces. Repair, and cleaning shall be performed to the satisfaction of the Engineer.

3.08 REPAIR OF SURFACE DEFECTS

- #### A. General:
- Repair tie holes and surface defects immediately after form removal. Where the concrete surface will be textured by sandblasting or bush-hammering, repair surface defects before texturing.

B. Repair of Tie Holes

1. Plug tie holes except where stainless steel ties, non-corroding ties, or acceptably coated ties are used, and omission of plugging is approved by the Engineer.
2. When portland cement patching mortar conforming to Paragraph 3.8.E, Site-Mixed Portland Cement Repair Mortar, is used for plugging, clean and dampen tie holes before applying the mortar.
3. When other materials are used, apply them in accordance with Manufacturer's recommendations.
4. Finish tie holes flush with surrounding wall surface.

C. Repair of Surface Defects Other Than Tie Holes

1. Outline honeycombed or otherwise defective concrete with a ½- to ¾-inch-deep saw cut and remove such concrete down to sound concrete. When chipping is necessary, leave chipped edges perpendicular to the surface or

- slightly undercut. Do not feather edges. Dampen the area to be patched, plus another 6 inches around the patch area perimeter. Prepare bonding grout according to Paragraph 3.8.D, Preparation of Bonding Grout. Thoroughly brush grout into the surface.
2. When the bond coat begins to lose water sheen, apply patching mortar prepared in accordance with Paragraph 3.8.E, Site-Mixed Portland Cement Patching Mortar, and thoroughly consolidate mortar into place. Strike mortar leaving the patch slightly higher than the surrounding surface to permit initial shrinkage. Leave the patch undisturbed for 1 hour before finishing. Keep the patch damp for 7 days.
- D. Preparation of Bonding Grout: For bonding grout, mix approximately one part of cement and one part of fine sand with water to a consistency of thick cream.
- E. Site-Mixed Portland Cement Repair Mortar
1. Mix repair mortar using the same materials as concrete to be patched with no coarse aggregate. Use not more than one-part cement to two and one-half parts sand by loose damp volume.
 2. For repairs in exposed concrete, make a trial batch and check color compatibility of repair material with surrounding concrete. When the repair is too dark, substitute white portland cement for a part of the gray cement to produce a color closely matching surrounding concrete.
 3. Use a repair mortar at a stiff consistency with no more mixing water than is necessary for handling and placing. Mix the repair mortar and manipulate the mortar frequently with a trowel without adding water. Use mortar at a stiff consistency.
 4. Repair mortar may be used for holes at least 1 inch deep where the depth is equal to or greater than the smallest surface dimension of the defect, and for narrow slots cut for the repair of cracks. Do not use where lateral restraint cannot be obtained. Place and dry-pack mortar in layers having a compacted thickness of approximately 1 inch.
 5. Solidly compact each layer over its entire surface by use of a hardwood stick and hammer. Do not use metal tools for compacting. compact surface just flush with adjacent area. Do not use steel finishing tools or water to facilitate finishing.
- F. Repair Materials Other Than Site-Mixed Portland Cement Mortar: Materials other than site-mixed Portland cement may be used for repair when prepared by the Engineer. Materials include, but are not limited to:
1. Shotcrete.
 2. Commercial Patching Products. Including:
 - a. Portland cement mortar modified with a latex bonding agent, conforming to ASTM C1059 Type II.
 - b. Epoxy mortars and epoxy compounds that are moisture-insensitive during application and after curing, which embody an epoxy binder that conforms to ASTM C881/C881M, Type III. The type, grade, and class shall be appropriate for the application as specified in ASTM C881/C881M.
 - c. Shrinkage-compensating or non-shrink portland cement grout, conforming to ASTM C1107.
 - d. Packaged dry concrete repair materials, conforming to ASTM C928.

- G. Removal of Stains, Rust, Efflorescence, and Surface Deposits: Remove stains, rust efflorescence and surface deposits considered objectionable by Engineer by acceptable methods.
- H. Concrete Replacement
 - 1. Use concrete replacement for:
 - a. Holes extending entirely through concrete sections.
 - b. For holes larger than 1 square foot and deeper than 4 inches in which no reinforcement is encountered.
 - c. For holes larger than $\frac{1}{2}$ of 1 square foot where reinforcement is exposed.
 - 2. Concrete used for replacement shall be the same strength and mixture as used in the structure.

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SECTION 03310
CONCRETE MIXTURES

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes: Requirements for materials, proportioning, production and delivery of concrete.

1.02 REFERENCES

- A. ACI Standards
1. ACI 117 Specifications for Tolerances for Concrete Construction and Materials
 2. ACI 301 Specifications for Structural Concrete
- B. ASTM Standards
1. C31 Standard Practice for Making and Curing Concrete Test Specimens in the Field
 2. C33 Standard Specification for Concrete Aggregates
 3. C39 Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
 4. C94 Standard Specification for Ready-Mixed Concrete
 5. C138 Standard Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete
 6. C143 Standard Test Method for Slump of Hydraulic Cement Concrete
 7. C150 Standard Specification for Portland Cement
 8. C173 Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
 9. C231 Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
 10. C260 Standard Specification for Air-Entraining Admixtures for Concrete
 11. C387 Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete
 12. C494 Standard Specification for Chemical Admixtures for Concrete
 13. C595 Standard Specification for Blended Hydraulic Cements
 14. C618 Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
 15. C685 Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing
 16. C845 Standard Specification for Expansive Hydraulic Cement
 17. C989 Standard Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars
 18. C1017 Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
 19. C1240 Standard Specification for Silica Fume Used in Cementitious Mixtures
 20. C1602 Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete

1.03 SUBMITTALS

- A. Submit under provisions of Section 01300, Submittals, as follows:
1. Mixture proportions. At least 45 days prior to commencing concrete placing operations, submit concrete mixture proportions, characteristics and the results of field data or trial mix results to validate strength and workability for each concrete mix required.
 2. Mixture proportion data. Submit field test data or trial mix results used to establish the required average strength. Mix design shall be certified and stamped by a licensed engineer.
 3. Concrete materials. Submit the following information for concrete materials, along with evidence demonstrating compliance with Paragraph 2.1, Materials:
 - a. *For Cementitious Materials.* Types, classes, producers' names, plant locations, and evidence not more than 90 days old demonstrating compliance with Paragraph 2.1, Materials.
 - b. *For Aggregates.* Types, pit or quarry locations, producers' names, gradations, specific gravities and evidence not more than 90 days old demonstrating compliance with Paragraph 2.1, Materials.
 - c. *For Admixtures.* Types, brand names, producers, manufacturer's technical data sheets, and certification data.
 - d. *For Water.* Source of supply.
 4. Field test data basis. When field test data is used as a basis for selecting proportions for a concrete mixture, submit data on materials and mixture proportions, with supporting test results confirming conformance with specified requirements.
 5. Mixture proportion adjustments. Submit any adjustments to mixture proportions or changes in materials, along with supporting documentation, made during the course of the Work.
 6. Concrete for floors. Submit evaluations and test results verifying adequacy of concrete to be placed in floors when cementing content is less than the minimum specified in Table 2.2.A.
 7. Calcium chloride. Calcium chloride shall not be added to the concrete.
 8. Volumetric batching. When it is desired to produce concrete by the volumetric batch method, submit request along with description of proposed method.
 9. Time of discharge. When it is desired to exceed time for discharge of concrete required by ASTM C94, submit a request along with a description of the precautions to be taken.
 10. Submittal Processing. Initial submittal of above data shall be not less than 40 calendar days before the planned production date.

1.04 QUALITY CONTROL

- A. The Contractor shall maintain records verifying materials used are of the specified and accepted types and sizes and are in conformance with the requirements of Paragraph 2.1, Materials.
- B. The Contractor shall ensure that production and delivery of concrete conform to the requirements of Paragraph 3.1, Measuring, Batching and Mixing and Paragraph 3.2, Delivery.

- C. The Contractor shall ensure that the concrete produced has the specified characteristics in the freshly mixed state and that they are maintained during transport and delivery.
- D. Concrete mixing and placement are subject to continuous Special Inspection. The Contractor shall oversee and schedule placement and testing activities with the testing agency. Provide ample notice prior to concrete placement (48 hours minimum).
- E. Production Facility Certification Requirements:
 - 1. The Concrete Batch Plant and Delivery Vehicles shall be certified in accordance with the National Reinforced Concrete Manufacturer's Association (NRCMA) Certification of Ready Mix Concrete Production Facilities.
 - 2. The Concrete Batch Plant Operator shall be certified by the National Reinforced Concrete Manufacturer's Association as a Ready Mix Concrete Plant Manager.

1.05 MATERIALS STORAGE AND HANDLING

- A. Cementitious Material: Store cementitious materials in dry, weathertight buildings, bins, or silos which will exclude contaminants.
- B. Aggregates: Store and handle aggregate in a manner that will avoid segregation and prevent contamination with other materials or other sizes of aggregates. Store aggregates to drain freely. Do not use aggregates that contain frozen lumps.
- C. Water: Protect mixing water from contamination during storage and delivery.
- D. Admixtures: Protect stored admixtures against contamination, evaporation, or damage. Provide agitating equipment for admixtures used in the form of suspensions or non-stable solutions to ensure thorough distribution of ingredients. Protect liquid admixtures from freezing and from temperature changes which would adversely affect their characteristics.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Cementitious Material
 - 1. Cementitious material shall consist of portland cement conforming to ASTM C150, with or without the addition of cementitious or pozzolanic mineral admixtures conforming to ASTM C618 or ASTM C989, or blended hydraulic cement conforming to ASTM C595. Cementitious material shall conform to ASTM C150, without the addition of cementitious or pozzolanic mineral admixtures. The tricalcium aluminum (Ca3Al) content of the portland cement shall be less than 8 percent in all concrete. In addition, cement shall meet the heat of hydration limits of Table 4 in ASTM C150. Cement for shrinkage compensating concrete shall conform to ASTM C845.
 - 2. Cementitious material used in concrete shall be the same brand and type, and from the same plant of manufacture as the cementitious material used in the concrete represented by the submitted field test data or used in the trial mixtures.

3. When specified or permitted in combination with portland cement, the following cementitious materials may also be used:
 - a. Fly ash conforming to ASTM C618, Class F, maximum 2% loss on ignition. When fly ash is used, the minimum amount shall be 15% by weight of the total cementitious materials unless otherwise specified.
 - b. Ground-granulated blast-furnace slag conforming to ASTM C989.
 - c. Silica fume conforming to ASTM C1240.
- B. Aggregates
 1. Aggregates shall conform to ASTM C33 unless otherwise specified. When a single size or a combination of two or more sizes of coarse aggregates are used, the final gradation shall conform to the grading requirements of ASTM C33 unless otherwise specified or permitted. All aggregates used for concrete shall be washed using fresh water and free of chlorides.
 2. Aggregates used in concrete shall be obtained from the same sources and have the same size ranges as the aggregates used in the concrete represented by submitted historical data or used in trial mixtures.
- C. Water: Mixing water for concrete shall meet the requirements of ASTM C1602. Maximum water soluble chlorine ion 0.30 ppm. Under no circumstances shall seawater be used for the making of concrete or the washing of aggregate.
- D. Admixtures: Admixtures shall meet the requirements of the following:
 1. Provide admixtures produced and serviced by an established, reputable manufacturer, used in compliance with Manufacturer's recommendations. All the admixtures used shall be from the same manufacturer and compatible with each other.
 - a. *Air-entraining admixture*: Conform to ASTM C260. Admixture shall contain no chlorides and shall be capable of maintaining the air percentage as batched, within $\pm 2\%$ at point of placement, for 2 hours.
 - b. *Water-reducing set, set-controlling admixture*: Conform to ASTM C494, Type A or D. Admixture shall contain no chlorides and shall be compatible with the air-entraining admixtures. The amount of admixture added to the concrete shall be in accordance with the Manufacturer's recommendations to obtain at least 12% water reduction. No retarder shall be used without Engineer's approval. Submit written proposed details of use.
 - c. *Non-chloride, non-corrosive accelerators*: Conform to ASTM C494, Type E, Admixture, shall be non-chloride and shall not promote corrosion of reinforcing steel in concrete.
 - d. *High-range water reducer*: Conform to ASTM C494, Type F or G. The admixture shall be free of chlorides and alkalines. Water reducers shall be batch plant added.
 - e. *Chemical admixtures for producing flowing concrete*: Conform to ASTM C1017.
 - f. *Fiber reinforcement*: Fiber reinforcement shall be nominal 1/2-inch fibrillated polypropylene, Fibermesh, W.R. Grace, or other approved polypropylene product designed specifically for control of shrinkage and drying cracking in portland cement concrete.
 - g. *Retarding admixture*: Confirm to ASTM A494, Type B. Admixtures used in concrete shall be the same as those used in the concrete represented by submitted field test data or used in trial mixtures.

- E. Change of Materials: When brand type, size, or source of cementitious materials, aggregates, water, ice, or admixtures are proposed to be changed, new field data or data from new trial mixtures or evidence which indicates that the change will not adversely affect the relevant properties of the concrete shall be submitted for acceptance before changes are made.

2.02 PERFORMANCE AND DESIGN REQUIREMENTS

A. Cementitious Material Content

1. The cementitious material content shall be adequate for concrete to satisfy the specified requirements for strength, water-cement ratio, and finishing ability. Not more than 20% fly ash may be substituted for portland cement at the Contractor's option. However, mix designs with fly ash shall not be used for floor slabs.
2. For concrete used in floors, cement content shall not be less than indicated in Table 2.2.A unless approved by the Engineer. Acceptance of a lower cement content will be contingent upon verification that concrete mixtures with a lower cement content will meet the specified strength requirements and will produce concrete with equal finish quality, appearance, durability, and surface hardness.
3. When a history of finishing quality is not available, evaluate the proposed mixture by placing concrete in a slab at the job using job materials, equipment, and personnel. The slab shall be at least 8 feet square and have an acceptable thickness. Slump shall not exceed the specified slump. Submit the evaluation results for acceptance.

Table 2.2.A: Minimum Cement Content Requirements for Floors	
Nominal Maximum Size of Aggregate (in.)	Minimum Cement Content (lb/yd)
1½	470*
1	520
¾	540
3/8	610

**Minimum cement content shall be 501 lb/yd³ if concrete will be exposed to freezing and thawing in the presence of de-icing chemicals.*

B. Slump

1. Concrete shall have, at the point of placement, slump in accordance with Table 2.2.B. Determine the slump by ASTM C143. Slump tolerances shall meet the requirements of ACI 117.
2. When use of a Type I or II plasticizing admixture conforming to ASTM C1017 or when a Type F or G high-range water-reducing admixture conforming to ASTM C494 is permitted to increase the slump of concrete, concrete shall have a slump of 2 to 4 in. before the admixture is added and a maximum slump of 8 in. at the point of delivery after the admixture is added unless otherwise specified. Contractor to test slump at plant and provide information to testing agency.

Table 2.2.B: Slump Schedule		
	Maximum	Minimum
Slabs	4"	2"
Footings	3"	1"
Walls	5"	2"

- C. **Size of Coarse Aggregate:** Except when otherwise specified or permitted, nominal maximum size of coarse aggregate shall not exceed 3/4 of the minimum clear spacing between reinforcing bars; 1/5 of the narrowest dimension between sides of forms; or 1/3 of the thickness of slabs or toppings.
- D. **Air Content**
1. Unless otherwise specified, concrete shall be air-entrained. Unless otherwise specified, air content at the point of delivery shall conform to the requirements of Table 2.2.D for moderate exposure.
 2. Air content shall be measured in accordance with ASTM C138, C173, or C231. ASTM C231 shall be the preferred method.
 3. Maximum air entrainment shall not exceed 3 percent for interior floor slabs to receive floor hardener and sealing compound.

Table 2.2.D: Total Air Content* of Concrete for Various Sizes of Coarse Aggregate			
Nominal Max. Size of Aggregate (in.)	Total Air Content (Percent)**		
	Severe Exposure	Moderate Exposure	Mild Exposure
Less than 3/8	9	7	5
3/8	7.5	6	4.5
1/2	7	5.5	4
3/4	6	5	3.5
1	6	4.5	3
1 1/2	5.5	4.5	2.5
2	5	4	2
3	4.5	3.5	1.5
6	4	3	1.5
* Measured in accordance with ASTM C138, C137 or C231.			
** Air content tolerance is +1% to -1 1/2%.			

- E. **Admixtures:** When admixtures are specified in the Contract Documents for particular parts of the Work, use the types specified.
1. Water-reducing admixtures may be used at the option of the Contractor.
 2. Accelerators shall not be used without the approval of the Engineer.
 3. Provide fiber reinforcement at an application rate of 1.5 lb./fiber per cubic yard of concrete where fiber reinforcement is specified.
- F. **Concrete Class and Location:** The proportions of cement, aggregate, and water for concrete shall be determined by the Contractor and subject to the requirements of this section and the Structural General Notes.

G. Concrete Temperature

1. When the average of the highest and lowest temperature during the period from midnight to midnight is expected to drop below 40°F for more than 3 successive days, concrete shall be delivered to meet the following minimum temperature immediately after placement:
 - a. 55°F for sections less than 12" in the least dimension
 - b. 50°F for sections 12" to 16" in the least dimension
 - c. 45°F for sections 36" to 72" in the least dimension
 - d. 40°F for sections greater than 72" in the least dimension
2. The temperature of concrete as placed shall not exceed these values by more than 20°F.
3. These minimum requirements may be terminated when temperatures above 50°F occur during more than half of any 24-hour duration.
4. Unless otherwise specified or permitted, the temperature of concrete as delivered shall not exceed 90°F, except during hot weather (as defined in Paragraph 3.2.A of Section 03300) the temperature of concrete as delivered shall not exceed 80° F.

H. Strength and Water-Cementitious Material Ratio: When compressive strength and, when required, the water-cementitious material ratio of the concrete is specified the following ratios must be considered in mixture calculations:

1. The maximum weight of fly ash, pozzolan or ground granulated blast-furnace slag that is included in the calculation of water-cementitious material ratio shall not exceed the following percentages of the total weight of cementitious materials given in Table 2.2.H.
2. Unless otherwise specified, strength requirements shall be based on the 28-day compressive strength determined on 4"x8" cylindrical specimens made and test in accordance with ASTM C31 and C39.

Table 2.2.H: Maximum Cementitious Material Requirements	
Cementitious Material	Maximum Percent of Total Cementitious Material by Weight *
Fly ash or other pozzolans conforming to ASTM C618	25
Slag conforming to ASTM 989	50
Silica fume conforming to ASTM C1240	10
Total of fly ash or other pozzolans, slag, and silica fume	50 **
Total of fly ash or other pozzolans and silica fume	35 **
Notes: * Total cementitious material also includes ASTM C150, C595 and C845 cement. The maximum percentages above shall include: a) Fly ash or other pozzolans present in Type IP or I(PM) blended cement, ASTM C595 b) Slag used in manufacture of an IS or I(SM) blended cement, ASTM C595 c) Silica fume, ASTM C1240, present in blended cement. ** Fly ash or other pozzolans and silica fume shall constitute no more than 25% and 10%, respectively, of the total weight of cementitious material.	

2.03 PROPORTIONING

- A. Proportion concrete to conform with Paragraph 2.2, Performance and Design Requirements, to provide workability and consistency so concrete can be worked

readily into forms and around reinforcement without segregation or bleeding, and to provide an average compressive strength adequate to meet acceptance requirements.

- B. Select and determine proportions in accordance with ACI 301, Paragraph 4.2.3. Proportion ingredients to produce proper workability, durability, strength, and other required design properties. Mix designs to be used will be determined by either by field test data or trial mix results as specified in ACI 301. Once determined and approved, make no changes to mix without written approval of the Engineer.
- C. Field Verification of Adequacy of Selected Proportions: Using materials accepted for use in the Work, verify in the field the adequacy of the selected proportions to produce concrete with the required total air content and consistency, and with workability compatible with the intended placing method. Make suitable corrections as necessary and submit for acceptance the adjusted proportions.

PART 3 - EXECUTION

3.01 MEASURING, BATCHING, AND MIXING

- A. Production facilities shall produce concrete of the specified quality and conforming to the requirements of this Specification.
 - 1. Ready-mixed and site-produced concrete. Unless otherwise specified, measure, batch and mix concrete materials and concrete in conformance with ASTM C94.
 - 2. Concrete produced by volumetric batching and continuous mixing. When concrete made by volumetric batching and continuous mixing is permitted, it shall conform to the requirements of ASTM C685.
 - 3. Prepackaged dry materials used in concrete. If packaged dry combined materials are used, they shall conform to the requirements of ASTM C387.

3.02 DELIVERY

- A. Deliver concrete which will possess the specified characteristics in the freshly mixed state at the point of placing. Transport and deliver concrete in equipment conforming to the requirements of ASTM C94.
 - 1. Slump adjustment.
 - a. When concrete arrives at the point of delivery with a slump below that which will result in the specified slump at the point of placement and is unsuitable for placing at that slump, the slump may be adjusted to the required value by adding water up to the amount allowed in the accepted mixture proportions when permitted by the Engineer. Addition of water shall be in accordance with ASTM C94. Do not exceed the specified water-cementitious material ratio or slump. Do not add water to concrete containing a plasticizing or a high-range, water-reducing admixture. Do not add water to concrete delivered in equipment not acceptable for mixing.
 - b. Measure slump and air content of air-entrained concrete, after slump adjustment, to verify compliance with specified requirements.
 - 2. Time of discharge.
 - a. Time for completion of discharge shall be within 90 minutes of the first addition of cement to the truck. This length of time may be extended,

- on a case-by-case basis, an additional 30 minutes at the discretion of the Engineer or the Owner's Resident Project Representative provided the mix remains fluid and placeable and shows no signs of stiffening or set.
- b. If delivery logistics make it impractical to discharge concrete within the above time limits, the Contractor may use an approved retarder admixture, delay the introduction of mixing water until the truck is closer to the job site, or propose other means, subject to approval by the Engineer, to assure that concrete is in acceptable condition at the time of discharge.
3. Batch ticket information.
- a. The manufacturer of the concrete shall furnish to the Contractor and to the Owner's Representative with each batch of concrete before unloading at the site, a delivery ticket on which is printed, stamped, or written, information concerning said concrete as follows:
 - 1) Name of ready-mix batch plant
 - 2) Serial number of ticket
 - 3) Date
 - 4) Truck number
 - 5) Name of purchaser
 - 6) Specific designation of job (name and location)
 - 7) Specific class or designation of the concrete in conformance with that employed in job specifications
 - 8) Amount of concrete in cubic yards (or cubic meters)
 - 9) Time loaded or of first mixing of cement and aggregates
 - 10) Water added by receiver of concrete and his initials
 - 11) Reading of revolution counter at the first addition of water
 - 12) Type and brand, and amount of cement
 - 13) Type and brand, and amount of admixtures
 - 14) Information necessary to calculate the total mixing water added by the producer. Total mixing water includes free water on the aggregates, water, and ice batched at the plant, and water added by the truck operator from the mixer tank
 - 15) Maximum size of aggregate
 - 16) Weights of fine and coarse aggregate
 - 17) Ingredients certified as being previously approved
 - 18) Signature or initials of ready-mix representative
 - b. The Contractor shall keep a record of where in the work each batch was placed.

END OF SECTION

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SECTION 03600

GROUT

PART 1 - GENERAL

1.01 SUMMARY

- A. This section covers the supply of materials, mixing of materials, and the installation of various grades of grouts utilized in the project, for general purposes.

1.02 REFERENCES

- A. ASTM Standards
 - 1. C109 Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)
 - 2. C404 Standard Specification for Aggregates for Masonry Grout
 - 3. C881 Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
 - 4. C939 Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method)
 - 5. C1107 Standard Specification for Packaged, Dry, Hydraulic Cement Grout (Nonshrink)
- B. Standards and Codes: See Section 03000, Concrete General Requirements, for standards referenced in this section.

1.03 SUBMITTALS

- A. Submit under provisions of Section 01300, Submittals, as follows:
 - 1. Manufacturer's data on all products.

PART 2 - PRODUCTS

2.01 EPOXY-RESIN-BASE BONDING SYSTEM

- A. For all grouted pipe penetrations, where called for on the Drawings and in all cases where less than a 13-inch thickness of grout or mortar overlays existing concrete or green concrete, a bonding system complying with ASTM C881 shall be used, such as Sonobond by Sonneborn or accepted equal.

2.02 PRECISION GROUT

- A. Filling of anchor bolt pockets; handrail pockets; and under equipment, pipe support and column base plates shall be classified as precision grouting. Grout used for precision grouting shall be a pre-packaged, non-shrink grout using a mixture of metallic and natural aggregates, and shall conform to the most current version of ASTM 1107 Grade B or C when tested at a fluid consistency of 25 to 30 seconds per ASTM C939 at temperature extremes of 45 and 90°F and an extended working time of 30 minutes. Master Builders Embeco 636 or 885 are acceptable brand and grout types conforming to this specification.

- B. All material used, including water, mixer and pre-packaged grout must be initially within the 45 and 90° F limits when testing is initiated. Manufacturer shall provide independent certification of ASTM C1107, compliance without modification of standard methods, and certify that the grout's post-hardening, non-shrink property is not based on gas expansion.
- C. Grout shall have strengths of 3000 psi at 3 days, 5000 psi at 7 days, and 7000 psi at 28 days when cured at 72°F, as well as meet the 3-, 7-, and 28-day strengths when tested and cured at the 45 and 90° F limits, and shall not bleed when placed at a fluid consistency.

2.03 PORTLAND CEMENT GROUT

- A. Portland Cement Grout shall be used to provide flow concentration in channels, at fillets, at the bottom of high walls, and in other locations where a general purpose grout is required. Portland cement grout shall be mixed with sand on a ratio of one-part cement to two parts sand with an expansive agent included to limit drying shrinkage. Sufficient water shall be added for placement while maintaining a minimum 4,500 psi 28-day compressive strength.

2.04 TOPPING COURSE GROUT

- A. This grout shall be used for leveling the bottom of structures. This mix shall contain 6½ sacks of cement per cubic yard of concrete, use sand and 3/8-inch course aggregate, size No. 89 in ASTM C404, and use water-reducing and expansive additives. The minimum compressive strength shall be 4,500 psi in 28 days. Topping grout over floor slabs shall be reinforced with WWR 6x6 W1.4xW1.4.

2.05 RAPID CURE GROUT

- A. Rapid cure grout shall be mixed with aggregate as recommended by the manufacturer. The grout shall be Master Builders Set 45 or accepted equal. The minimum compressive strength shall be 4,500 psi in 28 days. Rapid cure grout shall only be used where noted on the Drawings or as approved by the Engineer.

2.06 SELF-LEVELING UNDERLAYMENT

- A. Self-leveling cement underlayment shall be Ardex K-15. The compressive strength shall be 4,500 psi per ASTM C109 and shall be capable of feather-edge thickness application. Self-leveling cement underlayment shall be used to level floors where noted on the Drawings.

PART 3 - EXECUTION

3.01 MIXING

- A. All parts of the respective grouts shall be proportioned by volume measurement. Mixing shall be accomplished using a mechanical mixer suitable to the required quantities. Each batch shall be mixed for not less than 5 minutes. The respective grouts and mortars shall be mixed with sufficient water to maintain the fluidity required while attaining the minimum compressive strength indicated.

3.02 RETEMPERING AND TIME LIMIT

- A. Do not retemper or use mortar which has become harsh and nonplastic. When mortar has been maintained plastic and grout fluid, they may be used up to, but not more than, one hour after original mixing.

3.03 TEMPERATURE

- A. Grouting operations shall not commence when the ambient temperature has dropped below 45°F or when the surface to which it is being applied is less than 40°F.

3.04 PROTECTION

- A. All grouting operations shall be protected against moisture intrusion and a sealer, linseed oil or Thoroclear 777, shall be applied at the completion of the work.

3.05 SURFACE PREPARATION

- A. The existing concrete surface that the respective grout or mortar shall be placed against shall be cleaned as follows:
 - 1. If the existing surface has been exposed to sludge, chlorine, or other solutions, or was previously painted or treated, the surface shall be sandblasted and steam-cleaned, then treated with a diluted solution of muriatic acid neutralized with an alkaline solution and flushed with clean water.
 - 2. If the existing surface was not exposed to solution other than water, then the surface shall be washed with a diluted (2 parts water to 1-part acid) solution of muriatic acid, neutralized with an alkaline solution, and flushed with clean water.

3.06 PRECISION GROUTING

- A. This section describes additional special provisions for the grouting of anchor bolts; handrail pockets; and column, pipe support, and equipment baseplates, defined herein as precision grouting.
- B. All grout used for precision grouting shall be placed in a fluid consistency, with an efflux time of 25 to 30 seconds through a standard flow cone as defined by ASTM C939. The Contractor shall have a standard flow cone on-site to verify grout consistency prior to placement.
- C. Contractor shall not mix more grout than can be placed in approximately 10 minutes. Contractor shall not attempt to retemper grout by adding water or remixing after it stiffens.
- D. All grout used for filling under column and machinery base plates shall be placed from one side using a form around the grouted area. A beveled form edge shall be provided on one side to help direct the grout flow under the base plate. Do not vibrate grout. Immediately after placement, trim the surfaces with a trowel and cover the exposed grout with clean, wet rags and maintain this moisture for 4 to 6 hours.

- E. Forms and excess grout shall be removed after the grout has achieved initial set. The grout should offer stiff resistance to penetration with a pointed mason's trowel prior to removing the grout forms. Exposed shoulders shall be finished and wet cured immediately after form removal, and until grout has reached final set, but not less than 48 hours, followed by two coats of curing compound.

END OF SECTION

SECTION 05120
STRUCTURAL STEEL FRAMING

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Structural steel framing members, support member struts and related items.
 - 2. Base plates, shear stud connectors.
- B. Substitutions: Substitutions will be considered only under the terms and conditions of Section 01300, Submittals.

1.02 REFERENCES

- A. AISC - Code of Standard Practice - Manual of Steel Construction – Allowable Stress Design (ASD) and Load & Resistance Factored Design (LRFD).
- B. ASTM Standards
 - 1. A36/A36M Channels, Angles & Plates
 - 2. A992 $F_y = 50$ ksi – Wide Flange Shapes
 - 3. A500 $F_y = 46$ ksi – HSS Shapes
 - 4. A307 Carbon Steel Externally Threaded Standard Fasteners
 - 5. A325 High Strength Bolts for Structural Steel Joints
 - 6. A563 Carbon and Alloy Steel Nuts.
- C. AWS D1.1 - Structural Welding Code.

1.03 SUBMITTALS

- A. Submit information in accordance with requirements of Section 01300.
- B. Shop Drawings: Submit shop drawings prior to commencing any fabrication of structural steel. Show framing layout, dimensions, connections with adjoining materials and construction, finishes, welds, bolts and fasteners, and anchoring; show field welds, cuts, holes and fasteners; verify all dimensions; indicate size, type, grade, and camber of all members.
 - 1. Indicate welds by standard AWS A2.4 symbols. Show size, length, and type of each weld.
 - 2. Provide setting drawings, templates, and directions for installation of anchor bolts and other anchorages to be installed as work of other sections.
 - 3. Include with each detail shown on the shop drawings, a reference to the Architect's and Engineer's drawings and details, where applicable.
 - 4. Include with each beam or column a shop drawing location.
- C. Certification
 - 1. Stud Base Qualifications. Shear stud manufacturer shall submit written certification that the stud base has passed the 90-degree bend tests as described in AWS D1.1, Section 7.A. Stud base shall be considered as qualified if, in all required test specimens, fracture occurs in the plate material or shank of the stud and not in the weld.

- D. Certificates of Conformance: Submit certificates of conformance or product data for welding electrodes and rods, high-strength bolts and nuts, galvanizing repair compound, shear connection studs, and deformed bar anchors.
- E. Testing Agency Reports: Submit the following reports from the Contractor's testing agency to the Architect and Structural Engineer.
 - 1. Welder Certifications.
 - 2. Welding Inspections.
 - 3. High-Strength Bolted Connection Inspection.
- F. Fabricators shall submit certificate of compliance that the work was performed in accordance with the approved construction documents to the local building official and Architect.

1.04 QUALITY ASSURANCE

- A. Codes and Standards: Comply with provisions of following, except as otherwise indicated:
 - 1. American Institute of Steel Construction (AISC) "Code of Standard Practice for Steel Buildings and Bridges."
 - a. Paragraph 4.2.1 of the above code is hereby modified by deletion of the following sentence: "This approval constitutes the owner's acceptance of all responsibility for the design adequacy of any detail configuration of connections developed by the fabricator as a part of his preparation of these shop drawings."
 - 2. AISC "Specifications for the Design Fabrication and Erection of Structural Steel for Buildings."
 - 3. "Specifications for Structural Joints using ASTM A325 or A490 Bolts" approved by the Research Council on Structural Connections.
 - 4. American Welding Society (AWS) D1.1 "Structural Welding Code - Steel."
 - 5. ASTM A6 "General Requirements for Delivery of Rolled Steel Plates, Shapes, Sheet Piling and Bars for Structural Use."
 - 6. Washington Association of Building Officials (WABO).
- B. Qualifications for Welding Work: Qualify welding procedures and welding operators in accordance with AWS "Qualification" requirements.
 - 1. Provide certification that welders to be employed in work have satisfactorily passed AWS qualification test and are WABO certified.
 - 2. If recertification of welders is required, retesting will be Contractor's responsibility and expense.
 - 3. Fabricator's shop shall be registered and approved by the building official for all shop welding procedures to be used.
- C. Allowable Tolerances: Unless otherwise noted on drawings or specified, provide structural steel work in accordance with the following minimum tolerances:
 - 1. Fabrication Tolerances. In accordance with requirements of AISC "Code of Standard Practice," except as required to maintain the erection tolerances specified herein.
 - 2. Erection Tolerances. Level and plumb individual members within AISC specified tolerances.
- D. Tests and Inspection: Work is subject to special testing and inspection. The fabricator shall provide the Owner's Inspector access to places where material is being fabricated.

- E. Mill Test Reports: Submit mill test reports on all steel which can be identified to the Inspector verifying compliance with specified requirements as required by regulations and standard specifications.
- F. Fabricator: Company specializing in performing the work of this section with minimum 5 years' experience.
- G. Erector: Company specializing in performing the work of this section with minimum 5 years' experience.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to site at such intervals to ensure uninterrupted progress of work.
- B. Deliver anchor bolts and anchorage devices, which are to be embedded in cast-in-place concrete or masonry, in ample time to not to delay work.
- C. Store materials to permit easy access for inspection and identification. Keep steel members off ground by using pallets, platforms, or other supports. Protect steel members and packaged materials from corrosion and deterioration. If bolts and nuts become dry or rusty, clean and relubricate before use.
 - 1. Do not store materials on structure in a manner that might cause distortion or damage to members or supporting structures. Repair or replace damaged materials or structures as directed.
- D. Project/Site Holding and Protection: In assembling and during welding, the component parts shall be held with sufficient clamps or other adequate means to keep parts straight and in close contact. In welding, precautions shall be taken to minimize "lock-up" stress and distortion due to heat. In wind, welding shall be done only after adequate wind protection is furnished and set up.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Structural Steel Members: ASTM A36 and ASTM A992 Grade 50 as noted on the structural drawings.
- B. Hollow Structural Section: ASTM A500, Grade B.
- C. Pipe: ASTM A53, Grade B.
- D. Headed Shear Stud Connectors: ASTM A108; Grade C1015, C1017 or C1020. Use Nelson shear Connectors or an approved equal.
- E. High-Strength Bolts, Nuts, and Washers: ASTM A325 bolts.
- F. Anchor Bolts: See Section 05500.
- G. Welding Electrodes:
 - 1. Electrodes used for making complete penetration welds shall be of classification that will provide weld metal with a tensile strength not less than that of the base metal being welded.
 - 2. Electrodes for making fillet, plug, slot, or partial penetration groove welds shall conform to AWS A5.1 or A5.5, E70XX Series.
 - 3. Use only low hydrogen electrodes for all welding of complete and partial penetration groove welds of ASTM A572 base metal made in the field and for

manual shielded metal arc welding of ASTM A36 steel which is more than one inch thick.

- H. Galvanizing: Hot dipped, 1.5 ounces per square foot. Unless otherwise noted, galvanize all steel members except W36 ridge beam and structural steel used to support bridge crane. Portions of structural steel members that have been field welded or where galvanized material has been damaged during transportation or erection shall be coated with zinc-rich paint such as "Galvacon," or as approved.
- I. Drilled In Concrete Expansion Anchors: See Section 05500.
- J. Deformed Bar Anchors: All deformed steel bar anchors welded to steel for concrete connections shall be "Nelson Deformed Bar Anchors" or approved. All deformed bar anchors shall be automatically end welded in shop or field as recommended by manufacturer of anchors. Deformed bar anchors shall conform to ASTM A496, with a minimum ultimate tensile strength of 80,000 psi.
- K. Grout: Non-shrink type per Section 03600, Grout.
- L. Shop and Touch-Up Primer: SSPC 15, Type 1, red oxide.

2.02 FABRICATION

- A. Shop Fabrication and Assembly: Fabricate and assemble structural assemblies in shop to greatest extent possible. Fabricate items of structural steel in accordance with AISC Specifications and as indicated on final approved shop drawings. Provide camber in structural members where indicated.
 - 1. Properly mark and match-mark materials for field assembly. Fabricate for delivery sequence that will expedite erection and minimize field handling of materials.
 - 2. Where finishing is required, complete assembly, including welding of units, before start of finishing operations. Provide finish surfaces of members exposed in final structure free of markings, burrs, and other defects.
- B. Connections: Weld shop connections, as indicated.
- C. Bolt field connections, except where welded connections or other connections are indicated.
 - 1. Provide high-strength threaded fasteners for all bolted connections, except where unfinished bolts are indicated.
 - 2. At Contractor's discretion, provide unfinished threaded fasteners for temporary bracing to facilitate erection.
- D. High-Strength Bolted Construction: Install high-strength threaded fasteners in accordance with AISC "Specifications for Structural Joints using ASTM A 325 or A 490 Bolts."
- E. Welded Construction: Comply with AWS Code for procedures, appearance and quality of welds, and methods used in correction welding work.
 - 1. Unless specifically permitted in writing by the Engineer, welding processes other than shielded metal arc, submerged arc, gas metal arc, and flux cored arc shall not be used on this project. Electroslag and electrogas welding processes may be used, provided they are qualified by applicable tests.
 - 2. For high-strength, low-alloy steels, follow welding procedures as recommended by steel producer for exposed and concealed connections.

- 3. Welds not specified shall be continuous fillet welds, using not less than the minimum fillet as specified by AWS.
- F. Shear Connectors: Prepare steel surfaces as recommended by manufacturer of shear connectors. Weld shear connectors in field, spaced as shown, to beams and girders in composite construction. Use automatic end welding of headed stud shear connectors in accordance with manufacturer's printed instructions. Provide appropriate-sized furrule for each stud.
- G. Holes in Steel Members: Punch or drill as necessary to receive bolt and similar items. Do not cut holes with a torch. Drill holes in bearing plates. Provide holes required for securing other work to structural steel framing and for passage of other work through steel framing and other specialty items as indicated to receive other work. Bolt holes in steel shall be drilled 1/16" larger in diameter than bolt size used, unless noted otherwise. Bolt holes in steel base plates for anchor bolts shall be drilled 3/16" larger in diameter than anchor bolt size used.

2.03 SHOP FINISH

- A. Surface Preparation: After fabrication, but before erection, clean all surfaces by mechanical or chemical methods, to remove rust, scale, oil, corrosion, or other substances detrimental to bonding of subsequently applied protective coatings. Comply with SSPC-SP2, and SP3.
- B. Galvanizing: Unless otherwise noted, galvanize all steel members, except W36 ridge beam and structural steel used to support bridge crane, in accordance with ASTM A123. Sheet with G90 coating in accordance with ASTM A525.
- C. Painting: For W36 ridge beam and structural steel used to support bridge crane, immediately after surface preparation, apply structural steel primer paint in accordance with manufacturer's instructions and at a rate to provide dry film thickness of not less than 1.5 mils. Use painting methods that result in full coverage of joints, corners, edges, and exposed surfaces.
- D. Touch-up damaged areas in galvanizing or primer coatings with same materials, before installation. Apply zinc coatings and paint primers uniformly and smoothly; leave ready for finish painting.
- E. Where surfaces are to be welded or where high strength bolts are used, either mask areas before painting or galvanizing member prior to bolting or welding operation. For galvanized members, the galvanic material may be brushed off in lieu of masking prior to bolting and welding operations.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Verify existing conditions prior to beginning work.

3.02 ERECTION

- A. Allow for erection loads, and for sufficient temporary bracing to maintain structure safe, plumb, and in true alignment until completion of erection and installation of permanent bracing.

- B. Anchor Bolts
 - 1. Furnish anchor bolts and other connectors required for securing structural steel to foundations and other in-place work.
 - 2. Furnish steel templates and other devices as necessary for presenting bolts and other anchors to accurate locations.
- C. Setting Bases and Bearing Plates: Clean concrete and masonry bearing surfaces of bond-reducing materials and roughen to improve bond to surfaces. Clean bottom surface of base and bearing plates.
 - 1. Set loose and attached base plates and bearing plates for structural members on wedges or other adjusting devices.
 - 2. Tighten anchor bolts after supported members have been positioned and plumbed. Do not remove wedges or shims, but if protruding, cut off flush with edge of base or bearing plate prior to packing with grout.
 - 3. Pack grout solidly between bearing surfaces and bases or plates to ensure that no voids remain. Finish exposed surfaces, protect installed materials, and allow to cure.
- D. Field Assembly: Set structural frames accurately to lines and elevations indicated. Align and adjust various members forming part of complete frame or structure before permanently fastening. Clean bearing surfaces and other surfaces that will be in permanent contact before assembly. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.
- E. Provide protection during the unloading and erection sequence to minimized damage to the finish materials.
- F. Level and plumb individual members of structure within specified AISC tolerances.
- G. Establish required leveling and plumbing measurements on mean operation temperature of structure. Make allowances for difference between temperature at time of erection and mean temperature at which structure will be when completed and in service.
- H. Erection Bolts: On exposed welded construction, remove erection bolts, fill holes with plug welds, and grind smooth at exposed surfaces.
 - 1. Comply with AISC Specifications for bearing, adequacy of temporary connections, alignment, and removal of paint on surfaces adjacent to field welds.
 - 2. Do not enlarge unfair holes in members by burning or by using drift pins. Ream holes that must be enlarged to admit bolts.
- I. Gas Cutting: Do not use gas-cutting torches in field for correcting fabrication errors in primary structural framing. Cutting will be permitted only on secondary members that are not under stress, as acceptable to Architect. Finish gas-cut sections equal to a sheared appearance when permitted.
- J. Finish Touchup: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop finish. Apply paint to exposed areas using same material as used for shop painting or zinc-rich paint such as "Galvacon," for galvanized surfaces. Apply by brush or spray to provide minimum dry thickness to match the original application.

- K. Erection Loading
1. The structural design of the building assumes the elements of the structure to be completely assembled and connected to resist the dead loads, code specified lateral loads, and maximum expected service loads.
 2. No consideration has been given to loads, which will be induced by erection procedures or sequencing. The Contractor shall verify, to the satisfaction of himself and the Owner, the ability of the structure's elements to resist all erection loads without exceeding the allowable stresses of the materials used. Where erection loads would overstress the structure, special temporary bracing and strengthening shall be utilized to prevent such overstress during erection.

3.03 BOLTED CONNECTIONS

- A. Except as otherwise indicated on the drawings or specified, all bolted connections shall be bearing type ASTM A325 high-strength bolts conforming to the requirements of "Specifications for Structural Joints Using ASTM A325 or A490 Bolts".
- B. Install all high-strength bolts in accordance with Section 8, "Installation and Tightening". All bolts are to be fully pretensioned to the requirements of Paragraph 8(d), except that bolts in beam-to-beam connections may be tightened to the snug tight condition of Paragraph 8(c), upon approval of the Owner and structural engineer. In connections requiring fully pretension bolts, per the structural drawings, by direct tension indicating bolts or load indicator washers.
1. Load indicator washers shall be positioned with the protrusions facing the bolt head when the nut is the turning element.
 2. If the load indicator is placed under the bolt head and the bolt head is the turning element, then place a hardened flat washer against the load indicator protrusion.
 3. When it is required to use the load indicator under the nut, fit a hardened flat washer against the load indicator protrusions before the nut is installed. Either the nut or bolt may be turned to tighten the assembly.
- C. To avoid excessive galling of soft nuts or steel surfaces, hardened flat washers shall always be used under the nuts of all A325 bolts 7/8-inch diameter or larger.
- D. None of the above requirements shall relieve the use of hardened flat washers required with short slotted or oversize holes but may be used in conjunction with load indicators.

3.04 FIELD QUALITY CONTROL

- A. Follow the requirements of Division 1.
- B. Design of Members and Connections: Details shown are typical; similar details apply to similar conditions, unless otherwise indicated. Verify dimensions at site whenever possible without causing delay in the work.
1. Promptly notify Engineer whenever design of members and connections for any portion of structure are not clearly indicated.
- C. Inspection
1. An independent testing laboratory selected by the Engineer and paid by the Owner will perform all tests required for shop and field work except that costs of certain testing and inspection as specified herein shall be paid by the

Contractor. All testing shall be in accordance with applicable sections of the IBC, IBC Standards, and as specified herein.

- D. Access to Shop and Field
 - 1. The Contractor shall cooperate in giving advance notice of his operations and shall provide access to the work. Inspection in shop or field shall not relieve the Contractor of his responsibility to furnish satisfactory products. The acceptance of material or finished members by the inspector shall not prevent subsequent rejection if found defective either because of inferior materials or inferior workmanship. Inferior material or workmanship will be subject to rejection unless correction acceptable to the Architect can be made prior to final acceptance of the structure and at no extra cost to the Owner.
 - 2. Testing agency shall inspect structural steel at plant before shipment. Correct deficiencies in structural steel work which inspections and laboratory test reports have indicated to be in non-compliance with requirements. Perform additional tests, at Contractor's expense, as may be necessary to reconfirm any non-compliance of original work and as may be necessary to show compliance of corrected work.
- E. Welding Inspection: All shop and field welding shall be subject to inspection by a qualified welding inspector engaged by the Owner. To determine the quality of welds, the welding inspector shall utilize X- or gamma-ray tests, ultrasonic testing, magnetic particle inspection, and any other aid to visual inspection, which he may deem necessary to assure himself of the adequacy of the welding.
- F. Welds to be Inspected: The following welds shall be inspected by the methods given below without costs to the Contractor.
 - 1. 25 percent of all complete and partial penetration welds shall be checked by radiographic or ultrasonic testing.
 - 2. All fillet and other remaining welds shall be visually inspected.
 - 3. Where radiographic testing is performed, it shall consist of one spot test per weld. Where a spot radiographic test shows defects that required repair, the remainder of that weld shall be radiographed at the expense of the Contractor. Each 6-inch increment of weld or fraction thereof shall be considered one weld.
 - 4. Where ultrasonic testing is performed, the entire weld shall be tested.
- G. Standards of Acceptance: Welds tested by radiographic and ultrasonic methods shall be accepted or rejected in accordance with ASNI/AWS D1.1.
- H. Defective Welds: All welds found defective and repaired shall be reinspected by the same methods originally used and this reinspection shall be paid for by the Contractor.
- I. Bolted Connection Inspection:
 - 1. The sizes and grades of bolts shall be inspected to verify conformance with plans and specifications without costs to the Contractor, unless reinspection is required because of products or installation that does not meet specification requirements.
 - 2. High-strength bolted connections shall be inspected in accordance with the specification for "Structural Joints Using ASTM A325 or A490 Bolts."
 - 3. Test a minimum of 10% of bolts in all fully tensioned connections (2 bolts minimum) with a calibrated wrench. Verify that minimum required bolt

tension is furnished. Should any bolt in a given connection test below minimum tension required, test all bolts in that connection.

4. If snug tight bolts are approved for beam-to-beam connections, visually inspect all connections to ensure that plates are brought into contact. Randomly observe bolt-tightening operations to verify that AISC minimum snug tight requirements are complied with.
- J. Shear Connector Studs: Inspect and test stud welding in accordance with AWS D1.1 Section 7.

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SECTION 05400
COLD-FORMED METAL FRAMING

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

- A. Section Includes:
 - 1. Load-bearing wall framing.
 - 2. Ceiling joist framing.

1.02 SUBMITTALS

- A. Action Submittals
 - 1. Product Data: For each type of cold-formed steel framing product and accessory.
- B. Informational Submittals
 - 1. Qualification Data: For testing agency.
 - 2. Welding certificates.
 - 3. Product Test Reports: For each listed product, for tests performed by a qualified testing agency.
 - a. Expansion anchors.
 - b. Power-actuated anchors.

1.03 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Protect cold-formed steel framing from corrosion, moisture staining, deformation, and other damage during delivery, storage, and handling.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Craco Manufacturing, Inc.
- B. Nuconsteel, A Nucor Company.
- C. United Metal Products, Inc.
- D. Or approved equal.

2.02 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Provide cold-formed steel framing capable of withstanding design loads within limits and under conditions indicated.
 - 1. Design Loads: As indicated on plans.

2. Deflection Limits: Design framing systems to withstand design loads without deflections greater than the following:
 - a. Interior Load-Bearing Wall Framing: Horizontal deflection of 1/360 of the wall height under a horizontal load of 5 lbf/sq. ft. (239 Pa).
 - b. Ceiling Joist Framing: Vertical deflection of 1/360 of the span for live loads and 1/240 for total loads of the span.
 3. Design framing systems to provide for movement of framing members located inside the insulated building envelope without damage or overstressing, sheathing failure, connection failure, undue strain on fasteners and anchors, or other detrimental effects when subject to a maximum ambient temperature change of 120 deg F.
 4. Design exterior non-load-bearing wall framing to accommodate horizontal deflection without regard for contribution of sheathing materials.
- B. Cold-Formed Steel Framing Design Standards:
1. Floor and Roof Systems: AISI S210.
 2. Wall Studs: AISI S211.
 3. Headers: AISI S212.
 4. Lateral Design: AISI S213.
- C. Fire-Resistance Ratings: Comply with ASTM E 119; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
1. Indicate design designations from UL's "Fire Resistance Directory" or from the listings of another qualified testing agency.

2.03 LOAD-BEARING WALL FRAMING

- A. Steel Studs: Manufacturer's standard C-shaped steel studs, of web depths indicated, punched, with stiffened flanges, and as follows:
1. Minimum Base-Metal Thickness: 0.0428 inch
 2. Minimum Flange Width: 2 inches
- B. Steel Box or Back-to-Back Headers: Manufacturer's standard C-shapes used to form header beams, of web depths indicated, unpunched, with stiffened flanges, and as follows:
1. Minimum Base-Metal Thickness: 0.0428 inch
 2. Minimum Flange Width: 1-5/8 inches
- C. Steel Single- or Double-L Headers: Manufacturer's standard L-shapes used to form header beams, of web depths indicated, and as follows:
1. Minimum Base-Metal Thickness: 0.0428 inch
 2. Minimum Top Flange Width: 1-5/8 inches

2.04 CEILING JOIST FRAMING

- A. Steel Ceiling Joists: Manufacturer's standard C-shaped steel sections, of web depths indicated, unpunched with stiffened flanges, and as follows:
1. Minimum Base-Metal Thickness: 0.0428 inch.
 2. Flange Width: 2 inches minimum.

2.05 FRAMING ACCESSORIES

- A. Fabricate steel-framing accessories from steel sheet, ASTM A 1003/A 1003M, Structural Grade, Type H, metallic coated, of same grade and coating weight used for framing members.

- B. Provide accessories of manufacturer's standard thickness and configuration, unless otherwise indicated, as follows:
 - 1. Supplementary framing.
 - 2. Bracing, bridging, and solid blocking.
 - 3. Web stiffeners.
 - 4. Anchor clips.
 - 5. End clips.
 - 6. Foundation clips.
 - 7. Gusset plates.
 - 8. Stud kickers and knee braces.
 - 9. Joist hangers and end closures.
 - 10. Hole reinforcing plates.
 - 11. Backer plates.

2.06 ANCHORS, CLIPS, AND FASTENERS

- A. Steel Shapes and Clips: ASTM A 36/A 36M, zinc coated by hot-dip process according to ASTM A 123/A 123M.
- B. Anchor Bolts: ASTM F1554, Grade 36, threaded carbon-steel hex-headed bolts and carbon-steel nuts; and flat, hardened-steel washers; zinc coated by mechanically deposition according to ASTM B 695, Class 50
- C. Expansion Anchors: Fabricated from corrosion-resistant materials, with allowable load or strength design capacities calculated according to ICC-ES AC193 and ACI 318 greater than or equal to the design load, as determined by testing per ASTM E 488 conducted by a qualified testing agency.
- D. Power-Actuated Anchors: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with allowable load capacities calculated according to ICC-ES AC70, greater than or equal to the design load, as determined by testing per ASTM E 1190 conducted by a qualified testing agency.
- E. Mechanical Fasteners: ASTM C 1513, corrosion-resistant-coated, self-drilling, self-tapping, steel drill screws.
 - 1. Head Type: Low-profile head beneath sheathing, manufacturer's standard elsewhere.
- F. Welding Electrodes: Comply with AWS standards.

2.07 MISCELLANEOUS MATERIALS

- A. Galvanizing Repair Paint: SSPC-Paint 20 or MIL-P-21035B
- B. Shims: Load bearing, high-density multimonomer plastic, and nonleaching; or of cold-formed steel of same grade and coating as framing members supported by shims.
- C. Sealer Gaskets: Closed-cell neoprene foam, 1/4-inch thick, selected from manufacturer's standard widths to match width of bottom track or rim track members.

2.08 FABRICATION

- A. Fabricate cold-formed steel framing and accessories plumb, square, and true to line, and with connections securely fastened, according to referenced AISI's specifications and standards, manufacturer's written instructions, and requirements in this Section.
 - 1. Fabricate framing assemblies using jigs or templates.
 - 2. Cut framing members by sawing or shearing; do not torch cut.
 - 3. Fasten cold-formed steel framing members by welding, screw fastening, clinch fastening, pneumatic pin fastening, or riveting as standard with fabricator. Wire tying of framing members is not permitted.
 - a. Comply with AWS D1.3/D1.3M requirements and procedures for welding, appearance and quality of welds, and methods used in correcting welding work.
 - b. Locate mechanical fasteners and install according to Shop Drawings, with screw penetrating joined members by no fewer than three exposed screw threads.
 - 4. Fasten other materials to cold-formed steel framing by welding, bolting, pneumatic pin fastening, or screw fastening, according to Shop Drawings.
- B. Reinforce, stiffen, and brace framing assemblies to withstand handling, delivery, and erection stresses. Lift fabricated assemblies to prevent damage or permanent distortion.
- C. Fabrication Tolerances: Fabricate assemblies level, plumb, and true to line to a maximum allowable tolerance variation of 1/8 inch in 10 feet (1:960) and as follows:
 - 1. Spacing: Space individual framing members no more than plus or minus 1/8 inch from plan location. Cumulative error shall not exceed minimum fastening requirements of sheathing or other finishing materials.
 - 2. Squareness: Fabricate each cold-formed steel framing assembly to a maximum out-of-square tolerance of 1/8 inch.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine supporting substrates and abutting structural framing for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Before sprayed fire-resistive materials are applied, attach continuous angles, supplementary framing, or tracks to structural members indicated to receive sprayed fire-resistive materials.
- B. After applying sprayed fire-resistive materials, remove only as much of these materials as needed to complete installation of cold-formed framing without reducing thickness of fire-resistive materials below that are required to obtain fire-resistance rating indicated. Protect remaining fire-resistive materials from damage.

- C. Install load bearing shims or grout between the underside of load-bearing wall bottom track and the top of foundation wall or slab at locations with a gap larger than 1/4 inch to ensure a uniform bearing surface on supporting concrete or masonry construction.
- D. Install sealer gaskets at the underside of wall bottom track or rim track and at the top of foundation wall or slab at stud or joist locations.

3.03 INSTALLATION, GENERAL

- A. Cold-formed steel framing may be shop or field fabricated for installation, or it may be field assembled.
- B. Install cold-formed steel framing according to AISI S200 and to manufacturer's written instructions unless more stringent requirements are indicated.
- C. Install shop- or field-fabricated, cold-formed framing and securely anchor to supporting structure.
 - 1. Screw, bolt, or weld wall panels at horizontal and vertical junctures to produce flush, even, true-to-line joints with maximum variation in plane and true position between fabricated panels not exceeding 1/16 inch.
- D. Install cold-formed steel framing and accessories plumb, square, and true to line, and with connections securely fastened.
 - 1. Cut framing members by sawing or shearing; do not torch cut.
 - 2. Fasten cold-formed steel framing members by welding, screw fastening, clinch fastening, or riveting. Wire tying of framing members is not permitted.
 - a. Comply with AWS D1.3/D1.3M requirements and procedures for welding, appearance and quality of welds, and methods used in correcting welding work.
 - b. Locate mechanical fasteners and install according to Shop Drawings, and complying with requirements for spacing, edge distances, and screw penetration.
- E. Install framing members in one-piece lengths unless splice connections are indicated for track or tension members.
- F. Install temporary bracing and supports to secure framing and support loads comparable in intensity to those for which structure was designed. Maintain braces and supports in place, undisturbed, until entire integrated supporting structure has been completed and permanent connections to framing are secured.
- G. Do not bridge building expansion joints with cold-formed steel framing. Independently frame both sides of joints.
- H. Install insulation, specified in Section 07200 - Insulation, in built-up exterior framing members, such as headers, sills, boxed joists, and multiple studs at openings, that are inaccessible on completion of framing work.
- I. Fasten hole reinforcing plate over web penetrations that exceed size of manufacturer's approved or standard punched openings.
- J. Erection Tolerances: Install cold-formed steel framing level, plumb, and true to line to a maximum allowable tolerance variation of 1/8 inch in 10 feet (1:960) and as follows:

1. Space individual framing members no more than plus or minus 1/8 inch from plan location. Cumulative error shall not exceed minimum fastening requirements of sheathing or other finishing materials.

3.04 LOAD-BEARING WALL INSTALLATION

- A. Install continuous top and bottom tracks sized to match studs. Align tracks accurately and securely anchor at corners and ends, and at spacings as follows:
 1. Anchor Spacing: To match stud spacing
- B. Squarely seat studs against top and bottom tracks with gap not exceeding of 1/8 inch between the end of wall framing member and the web of track. Fasten both flanges of studs to top and bottom tracks. Space studs as follows:
 1. Stud Spacing: 16 inches, max or as indicated
- C. Set studs plumb, except as needed for diagonal bracing or required for nonplumb walls or warped surfaces and similar configurations.
- D. Align studs vertically where floor framing interrupts wall-framing continuity. Where studs cannot be aligned, continuously reinforce track to transfer loads.
- E. Align floor and roof framing over studs according to AISI S200, Section C1. Where framing cannot be aligned, continuously reinforce track to transfer loads.
- F. Anchor studs abutting structural columns or walls, including masonry walls, to supporting structure as indicated.
- G. Install headers over wall openings wider than stud spacing. Locate headers above openings as indicated. Fabricate headers of compound shapes indicated or required to transfer load to supporting studs, complete with clip-angle connectors, web stiffeners, or gusset plates.
 1. Frame wall openings with not less than a double stud at each jamb of frame as indicated on Shop Drawings. Fasten jamb members together to uniformly distribute loads.
 2. Install runner tracks and jack studs above and below wall openings. Anchor tracks to jamb studs with clip angles or by welding, and space jack studs same as full-height wall studs.
- H. Install supplementary framing, blocking, and bracing in stud framing indicated to support fixtures, equipment, services, casework, heavy trim, furnishings, and similar work requiring attachment to framing.
 1. If type of supplementary support is not indicated, comply with stud manufacturer's written recommendations and industry standards in each case, considering weight or load resulting from item supported.
- I. Install horizontal bridging in stud system, spaced vertically as indicated on Shop Drawings. Fasten at each stud intersection.
 1. Bridging: Cold-rolled steel channel, welded or mechanically fastened to webs of punched studs with a minimum of two screws into each flange of the clip angle for framing members up to 6 inches deep.
 2. Bridging: Combination of flat, taut, steel sheet straps of width and thickness indicated and stud-track solid blocking of width and thickness to match studs. Fasten flat straps to stud flanges and secure solid blocking to stud webs or flanges.
 3. Bridging: Proprietary bridging bars installed according to manufacturer's written instructions.

- J. Install steel sheet diagonal bracing straps to both stud flanges, terminate at and fasten to reinforced top and bottom tracks. Fasten clip-angle connectors to multiple studs at ends of bracing and anchor to structure.
- K. Install miscellaneous framing and connections, including supplementary framing, web stiffeners, clip angles, continuous angles, anchors, and fasteners, to provide a complete and stable wall-framing system.

3.05 JOIST INSTALLATION

- A. Install perimeter joist track sized to match joists. Align and securely anchor or fasten track to supporting structure at corners, ends, and spacings indicated on Shop Drawings.
- B. Install joists bearing on supporting frame, level, straight, and plumb; adjust to final position, brace, and reinforce. Fasten joists to both flanges of joist track.
 - 1. Install joists over supporting frame with a minimum end bearing of 1-1/2 inches.
 - 2. Reinforce ends and bearing points of joists with web stiffeners, end clips, joist hangers, steel clip angles, or steel-stud sections as indicated on Shop Drawings.
- C. Space joists not more than 2 inches from abutting walls, and as follows:
 - 1. Joist Spacing: 16 inches or as indicated.
- D. Frame openings with built-up joist headers consisting of joist and joist track, or another combination of connected joists if indicated.
- E. Install joist reinforcement at interior supports with single, short length of joist section located directly over interior support, with lapped joists of equal length to joist reinforcement, or as indicated on Shop Drawings.
 - 1. Install web stiffeners to transfer axial loads of walls above.
- F. Install bridging at intervals indicated on Shop Drawings. Fasten bridging at each joist intersection as follows:
 - 1. Bridging: Joist-track solid blocking of width and thickness indicated, secured to joist webs.
 - 2. Bridging: Combination of flat, taut, steel sheet straps of width and thickness indicated and joist-track solid blocking of width and thickness indicated. Fasten flat straps to bottom flange of joists and secure solid blocking to joist webs.
- G. Secure joists to load-bearing interior walls to prevent lateral movement of bottom flange.
- H. Install miscellaneous joist framing and connections, including web stiffeners, closure pieces, clip angles, continuous angles, hold-down angles, anchors, and fasteners, to provide a complete and stable joist-framing assembly.

3.06 FIELD QUALITY CONTROL

- A. Testing: Owner will engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.
- B. Field and shop welds will be subject to testing and inspecting.

- C. Testing agency will report test results promptly and in writing to Contractor and Architect.
- D. Remove and replace work where test results indicate that it does not comply with specified requirements.
- E. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.07 REPAIRS AND PROTECTION

- A. Galvanizing Repairs: Prepare and repair damaged galvanized coatings on fabricated and installed cold-formed steel framing with galvanized repair paint according to ASTM A 780 and manufacturer's written instructions.
- B. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer that ensure that cold-formed steel framing is without damage or deterioration at time of Substantial Completion.

END OF SECTION

SECTION 05500
METAL FABRICATIONS

PART 1 - GENERAL

1.01 SUMMARY

- A. Section includes anchors, hardware, and miscellaneous iron, steel, aluminum, or other non-ferrous metal work, not specifically described in other sections.

1.02 REFERENCES

- A. Unless noted otherwise, this section incorporates by reference the latest revision of the following documents. In case of conflict between the requirements of this section and that of the listed documents, the requirements of this section shall prevail:
1. American Institute of Steel Construction,
 - a. "Code of Standard Practice for Steel Buildings and Bridges," 2016, excluding:
 - 1) Section 4.4 Approval
 - 2) Section 7 Erection
 - 3) Section 9 Contracts.
 2. Research Council on Structural Connections
 - a. Specification for Structural Joints Using ASTM A325 or A490 Bolts
 3. American National Standards Institute (ANSI):
 - a. A14.3 Ladders - Fixed - Safety Requirements
 4. American Welding Society Standards
 - a. D1.1/D1.1M Structural Welding Code - Steel
 - b. D1.2/D1.2M Structural Welding Code - Aluminum
 - c. D10.4-86R Recommended Practices for Welding Austenitic Chromium Nickel Stainless Steel Piping and Tubing
 5. ASTM Standards
 - a. A6 General Requirements for Rolled Steel, Structural Steel Bars, Plates, Shapes, and Sheet Piling
 - b. A36 Carbon Structural Steel
 - c. A47 Ferritic Malleable Iron Castings
 - d. A48 Gray Iron Castings
 - e. A53 Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
 - f. A90/A90M Standard Test Method for Weight (Mass) of Coating on Iron or Steel Articles with Zinc or Zinc-Alloy Coatings
 - g. A108 Steel Bar, Carbon and Alloy, Cold Finished
 - h. A123/A123M Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
 - i. A143/A143M Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement
 - j. A153/A153M Zinc Coating (Hot-Dip) on Iron and Steel Hardware
 - k. A193/A193M Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications

l.	A194	Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
m.	A197	Cupola Malleable Iron
n.	A269	Seamless and Welded Austenitic Stainless Steel Tubing for General Service
o.	A276	Stainless Steel Bars and Shapes
p.	A307	Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength
q.	A312	Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
r.	A325	Structural Bolts, Steel, Heat Treated, 120/105 KSI Minimum Tensile Strength
s.	A380	Cleaning and Descaling Stainless Steel Parts, Equipment, and Systems
t.	A384/A384M	Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies
u.	A385	Providing High Quality Zinc Coatings (Hot-Dip)
v.	A496	Steel Wire, Deformed, for Concrete Reinforcement
w.	A500	Cold Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
x.	A501	Hot-Formed Welded and Seamless Carbon Steel Structural Tubing
y.	A536	Ductile Iron Castings
z.	A554	Welded Stainless Steel Mechanical Tubing
aa.	A563	Carbon and Alloy Steel Nuts
bb.	A572	High-Strength Low-Alloy Columbium-Vanadium Structural Steel
cc.	A666	Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar
dd.	A668	Steel Forgings, Carbon and Alloy, for General Industrial Use
ee.	A780	Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ff.	A786	Hot-Rolled Carbon, Low-Alloy, High-Strength Low-Alloy, and Alloy Steel Floor Plates
gg.	A967	Chemical Passivation Treatments for Stainless Steel Parts
hh.	A992	Structural Steel Shapes
ii.	A1011	Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy with Improved Formability
jj.	A1064	Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
kk.	A1554	Anchor Bolts, Steel, 36, 55 and 105-KSI Yield Strength
ll.	B209	Aluminum and Aluminum-Alloy Sheet and Plate
mm.	B221	Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
nn.	F467	Nonferrous Nuts for General Use
oo.	F468	Standard Specification for Nonferrous Bolts, Hex Cap Screws, and Studs for General Use
pp.	F593	Stainless Steel Bolts, Hex Cap Screws, and Studs
qq.	F594	Stainless Steel Nuts

rr.	F835	Alloy Steel Socket Button and Flat Countersunk Head Cap Screws
ss.	F879	Stainless Steel Socket Button and Flat Countersunk Head Cap Screws
tt.	F959	Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners
uu.	F1554	Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength
vv.	F1789	Standard Terminology for F16 Mechanical Fasteners
ww.	F1852	"Twist Off" Type Tension Control Structural Bolt/Nut/Washer Assemblies, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength

1.03 SUBMITTALS

- A. In accordance with the provisions of Section 01300, Submittals, submit the following:
 - 1. Complete detail drawings of all miscellaneous metal items specified herein or shown on the Drawings.
 - 2. Certifications of conformance to specifications for nuts and bolts.
 - 3. Certification of conformance with ASTM A380 for handling and cleaning of stainless steel.
 - 4. Individual welder AWS certifications for field welders and AISC/AWS certification for fabricator performing shop welding.
 - 5. Material data and certification for steels and weld electrodes.
 - 6. Product data for manufactured items.
 - 7. Manufacturer's installation instructions.
 - 8. Provide manufacturer's standard allowable load tables for the following:
 - a. Expansion anchor bolts.
 - b. Adhesive anchor bolts.
 - 9. Certification that Contractor designed systems and components (e.g., landings and ladders) meet all design loads specified and shop drawings stamped by a professional structural engineer that indicate design live loads.

1.04 DEFINITIONS

- A. Fasteners: As defined in ASTM F1789.
- B. Galvanizing: Hot-dip galvanizing per ASTM A123/A123M or ASTM A153/A153M with minimum coating of 2.0 OZ of zinc per square foot of metal (average of specimens) unless noted otherwise or dictated by standard.
- C. Hardware: As defined in ASTM A153/A153M.
- D. Installer or Applicator
 - 1. Installer or applicator is the person actually installing or applying the product in the field at the Project site.
 - 2. Installer and applicator are synonymous.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and handle fabrications to avoid damage.
- B. Store above ground on skids or other supports to keep items free of dirt and other foreign debris and to protect against corrosion.

PART 2 - PRODUCTS

2.01 GENERAL MATERIALS

- A. Structural Steel: ASTM A36 (rolled shapes other than wide flange shapes), ASTM A500 Grade B (tubing), ASTM A53, Grade B (pipe), ASTM A6/A6M (general requirements).
 - 1. Filler metal strength for welding shall be not less than 70 ksi, low hydrogen type.
 - 2. Wide flange shapes and structural tee sections fabricated from wide flange shapes shall be ASTM A992.
 - 3. Structural tee sections shall be straightened after cutting if necessary, to meet the tolerances of ASTM A6.
- B. Miscellaneous Carbon Steel Sheet and Strip: ASTM A1011/A1011M, "Structural Quality," Grade 36 or better.
- C. Aluminum: ASTM B209 or B221, type 6061 or 6063.
 - 1. Welding shall be with an inert gas shielded arc or resistance welding process.
 - 2. No welding process that requires a welding flux shall be used.
 - 3. Weld filler shall conform to type recommended by AWS D1.2 for the alloys joined.
- D. Stainless Steel: ASTM A666, Type 304 or 316. Use 304L or 316L for shapes to be welded.
 - 1. Filler metals for welding shall be as specified in ANSI/AWS A5.9 Specification for Corrosion-Resisting Chromium and Chromium-Nickel Steel Bare and Composite Metal Cored and Stranded Welding Electrodes and Welding Rods.
 - 2. Molybdenum content of filler metal shall be not less than 6 percent.
- E. Iron
 - 1. Ductile iron. ASTM A536.
 - 2. Gray cast iron. ASTM A48 (minimum 30,000 psi tensile strength).
 - 3. Malleable iron. ASTM A47, ASTM A197.
- F. Bolts, Washers, and Nuts: Bolts, washer, and nuts shall meet the requirements of the following specifications:
 - 1. Anchor rods. All anchor bolts, nuts and washers shall be Type 316 stainless steel unless called out otherwise on the Drawings or specified. Stainless steel anchor rods shall be ASTM F593 (Group 2 Type 316) or all thread ASTM A193 Grade B8M. Anchor rods shall be headed stud type. "L" or "J" type bolts shall not be used.
 - 2. Expansion bolts. Expansion anchors shall be Hilti "Kwik Bolt TZ" Type 316 stainless steel, or approved equivalent. Alternative anchor must have a current ICC-ES Evaluation Report. Minimum embedment depth shall be 4.5 times diameter of bolt unless noted otherwise on drawings. Wedges shall be double plated spring steel.
 - 3. Bolts and nuts. Bolts shall be stainless steel conforming to ASTM F593 Grade B8M. Nuts shall be stainless steel conforming to ASTM F594. Bolts and nuts to be Alloy Group 2, Condition CW1 if 5/8" or less, otherwise CW2.
 - 4. Washers. Washers shall be the same material and alloy as found in accompanying bolts and nuts, Type 316 stainless steel.

- G. Metal Type: Unless otherwise specified or noted on the Drawings, metal fabrications shall be Type 316/316L stainless steel. All carbon steel fabrications shall be galvanized, unless otherwise specified or noted on the Drawings.

2.02 FABRICATION

A. Fabrication-General

1. Workmanship. Conform to accepted shop practices.
 - a. Form work true to detail, with clean, straight, sharply defined profiles.
 - b. Unless otherwise shown or specified, finish exposed welds flush and smooth.
2. Joints and Connections. Weld all joints, unless other fastening methods are shown, specified, or specifically approved.
 - a. Close fit exposed joints; make joints where least conspicuous.
 - b. Unless otherwise shown or specified, use flat and countersunk headed bolts or screws in exposed connections.
3. Cutting, Drilling. Perform coping, cutting, drilling, and punching required for accurate fitting and assembly work.
 - a. Perform similar operations as required for attachment of work of other trades, provided that directions for such work are supplied prior to project data approval.
 - b. Where galvanized assemblies, punched holes shall be reamed; use flame cutting rather than cold shearing; avoid cold forming to prevent galvanizing vent holes in closed assemblies in accordance with Zinc Institute recommendations.
4. Provisions for Attachment to Structure. Furnish miscellaneous metal items complete with framing, supports, hangers, bracing, anchors, and other devices shown, specified or necessary for reinforcement and proper, secure setting or attachment.
5. Dissimilar Materials Protection. Insulate aluminum surfaces in contact with plaster, concrete, or metals other than galvanized or stainless steel. See General Structural Notes for coating requirements.
6. Workmanship. Fabricate all items neatly and rigidly in accordance with the details.
 - a. Form curved metal neatly to radii indicated.
 - b. Provide member sizes indicated and weld, bolt or rivet securely.
 - c. Furnish bolts, nuts, washers, and other fastening devices required for anchoring and securing work.
7. Welding. Use electric shielded-arc process in accordance with Welding Specifications of American Welding Society.
 - a. Use only welding operators properly trained, highly skilled, and AWS-certified in arc welding.
 - b. Grind smooth all surface welds exposed to view.

B. Special Requirements for Stainless Steel Fabrications

1. Welds and joint areas shall be cleaned before and after welding in accordance with gross inspection requirements of ASTM A380.
2. Observe precautions against contamination with free iron and protection of cleaned surfaces in accordance with ASTM A380.

2.03 HOT-DIP GALVANIZING

- A. Steel items called out on the Drawings or specified herein as galvanized or hot-dip galvanized shall be hot-dip coated in accordance with one or more of the following in Table 2.3.A.

Table 2.3.A: Hot-Dip Galvanizing	
Reference	Title
ASTM A90/A90M	Standard Test Method for Weight (Mass) of Coating on Iron or Steel Articles with Zinc or Zinc-Alloy Coatings
ASTM A123/A123M	Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A143/A143M	Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement
ASTM A153/A153M	Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A384/A384M	Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies
ASTM A385	Providing High Quality Zinc Coatings (Hot-Dip)
MILSPEC DOD-P-1035	Paint, High Zinc Dust Content, Galvanizing Repair

PART 3 - EXECUTION

3.01 PREPARATION

- A. Provide items to be built into other construction in time to allow their installation:
1. If such items are not provided in time for installation, cut in and install.
- B. Prior to installation, inspect and verify condition of substrate.
- C. Correct surface defects or conditions which may interfere with or prevent a satisfactory installation.

3.02 INSTALLATION

- A. General: Install work in strict accordance with the Drawings and manufacturer's installation instructions. Perform cutting, drilling, and fitting required. Accurately set, place and properly, securely attach work in true plans, alignment, plumb and level; properly adequately reinforce and stiffen.
- B. Prime Coat Touchup: After installation of steel items, touch up field bolts, field welds, uncoated connections, and abrasions to shop protective coatings. Clean items of mud, dirt, and other objectionable foreign matter prior to touching up the prime coat and field painting.
- C. Galvanized Items: Items that have been drilled, cut, welded, or otherwise damaged shall be touched up using either of the following products:

1. "Galv-Weld," manufactured by Kenco Division of Southern Coating and Chemical Co., Galv-Weld Products, Sumter, South Carolina. Apply in accordance with manufacturer's instructions and to same thickness as specified hot dip coating.
 2. Hot stick followed by CRC Zinc Re-nu brush-on cold galvanizing compound with epoxy binder. Apply in accordance with manufacturer's instructions.
- D. Aluminum Items: Aluminum items in contact with concrete shall have contact surfaces coated to prevent corrosion. Aluminum items in contact with steel shall be electrically isolated with gaskets and fastener sleeves.
- E. Field Measurements
1. Take field measurements as necessary to verify or supplement dimensions indicated on the Drawings.
 2. Contractor is responsible for the accurate fit of the work.
 3. Check the elevations of all finished footings or foundations and the location and alignment of all anchor bolts before starting erection:
 - a. Use surveyor's level.
 - b. Notify Engineer of any errors or deviations found by such checking.
 4. Erect plumb and level; introduce temporary bracing required to support erection loads.
 5. Use light drifting necessary to draw holes together:
 - a. Drifting to match unfair holes is not allowed.
- F. Welding
1. Conform to AWS D1.1 and requirements of Article 2.4.
 2. When joining two (2) sections of steel of different ASTM designations, welding techniques shall be in accordance with a qualified AWS D1.1 procedure.
 3. Shore existing members when unbolting of common connections is required.
 4. Grind welds smooth where field welding is required.
 5. Clean stored material of all foreign matter accumulated during erection period.
- G. Bolt Field Connections
1. Where practicable, conceal fastenings.
 2. Use new bolts for re-bolting connections.
 3. Unless noted or specified otherwise:
 - a. Connect steel members to steel members with 3/4-inch DIA ASTM A325 high strength bolts.
 - b. Provide washers for all bolted connections.
 - c. Where exposed, bolts shall extend a maximum of 3/4 inches and a minimum of 1/2 inches above the top nut:
 - d. If bolts are cut off to required maximum height, threads must be dressed to allow nuts to be removed without damage to the bolt or the nuts.
 4. Install and tighten ASTM A325 high-strength bolts in accordance with the AISC 325, Allowable Stress Design (ASD).
 5. Provide hardened washers for all ASTM A325 bolts:
 - a. Provide the hardened washer under the element (nut or bolt head) turned in tightening.
 - b. Provide bearing type connection.

6. After bolts are tightened, upset threads of ASTM A307 unfinished bolts or anchor bolts to prevent nuts from backing off.
 7. Do not field splice fabricated items unless said items exceed standard shipping length or change of direction requires splicing.
 8. Provide full penetration welded splices where continuity is required.
- H. Provide each fabricated item complete with attachment devices as indicated or required to install.
- I. Anchor such that work will not be distorted, nor fasteners overstressed from expansion and contraction:
1. Fill space between bearing surface and bottom of base plate with nonshrink grout:
 - a. Fill space until voids are completely filled and base plates are fully bedded on wedges, shims, and grout.
 2. Do not remove wedges or shims:
 - a. Where they protrude, cut off flush with edge of base plate.
 3. Fill sleeves around anchor bolts solid with non-shrink grout.
- J. Tie anchor bolts in position to embedded reinforcing steel using wire:
1. Tack welding prohibited:
 - a. Coat bolt threads and nuts with heavy coat of clean grease.
 2. Anchor bolt location tolerance:
 - a. 1/16-inch.
 - b. Provide steel templates for all column anchor bolts.
- K. Repair damaged galvanized surfaces in accordance with ASTM A780:
1. Prepare damaged surfaces by abrasive blasting or power sanding.
 2. Apply galvanizing repair paint to minimum 6 mils DFT in accordance with manufacturer's instructions.

3.03 CLEANING

- A. After erection, installation, or application, clean all miscellaneous metal fabrication surfaces of all dirt, weld slag and other foreign matter.
- B. Provide surface acceptable to receive field applied paint coatings as specified.

END OF SECTION

SECTION 05724

ALUMINUM COMPONENT RAILING SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Guardrails, stair rails, handrails, toeboards and related work employing a stock manufactured Aluminum Component Railing System.
 - 2. Related custom manufactured items.
 - 3. Work in this Section requires the highest level of workmanship, skill and care and may require specialized manufacturing equipment and techniques.

1.02 REFERENCES

- A. Aluminum Association:
 - 1. AA ASD-2013 Aluminum Standards and Data
 - 2. AA SAA46 Standards for Anodized Architectural Aluminum
- B. ASTM International (ASTM):
 - 1. B241 Standard Specification for Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube
 - 2. B244 Standard Test Method for Measurement of Thickness of Anodic Coatings on Aluminum and Other Non-Conductive Coatings on Nonmagnetic Basis Metals with Eddy-Current Instruments
 - 3. B429 Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube
 - 4. B483 Standard Specification for Aluminum and Aluminum-Alloy Drawn Tubes and Drawn Pipes for General Purpose Applications
 - 5. C595 Specification for Blended Hydraulic Cements
- C. American Welding Society (AWS)
 - 1. B2.1 Specification for Welding Procedure and Performance Qualification
 - 2. WHB Welding Handbook - Materials and Applications
- D. National Association of Architectural Metal Manufacturers (NAAMM)
 - 1. AMP 500 Metal Finishes Manual
 - 2. AMP 521 Pipe Railings Systems Manual
- E. Washington State Building Code Council (WSBCC):
 - 1. 2015 Washington State Building Code (based on 2015 International Building Code).

1.03 SUBMITTALS

- A. Product Data: Submit manufacturer's fully described product literature.
- B. Shop Drawings:
 - 1. Show dimensions, materials, alloys, finishes, joining, attachments, field splices, control joints, inserts, and relationships of work to adjoining construction.

2. Indicate all shop and erection details including cuts, copes, connections, slip joints, holes, threaded fasteners, and welds. Indicate welds using AWS "Welding Symbols."
 3. Show field measured dimensions of this and adjacent work and field measured locations of cans and inserts.
 4. Provide setting drawings, templates, and directions for installation.
 5. Submit calculations or certification that rail system is designed to meet loading criteria noted herein or on the Drawings.
- C. Samples: A full size sample section of railing showing the intersection of an intermediate end post with a top rail and mid rails. Apply the specified finish and Anodic coating.

1.04 QUALITY ASSURANCE

- A. Qualifications:
1. The fabricator and installer must be a State Licensed Specialty Contractor regularly engaged in fabrication and installation of architectural aluminum component railings systems. Fabricator and installer must be approved by Component Railing System manufacturer.
 2. Welding procedures, welders, and welding operations shall be qualified for the type of material and work required in accordance with American Welding Society (AWS) B 2.1.
 3. Provide minimum three (3) project references of nearby installations of similar size and scope.
- B. Comply with the following regulatory requirements:
1. Washington State Building Code (WSBC), adopted edition.
 2. Stair/Handrail, Guardrail and/or Ladder/Stile design requirements of OSHA.
- C. Comply with the following trade association and reference standards:
1. "Pipe Railing Systems Manual," the National Association of Architectural Metal Manufacturers (NAAMM).
 2. "Metal Finishes Manual" NAAMM.
 3. "Welding Handbook - Materials and Applications" American Welding Society.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Provide inserts, sleeves, and anchorage devices in time to be incorporated in other work. Provide setting drawings, templates and directions for installation.
- B. Store materials above ground on platforms, skids, or other supports, and in a manner to avoid damage. Stacking shall be done in a way which will prevent bending. Store all fasteners and welding electrodes in a dry, weathertight place away from uncured concrete and masonry. Store packaged materials in their original containers.

PART 2 - PRODUCTS

2.01 MATERIALS, GENERAL

- A. Provide an Aluminum Component Railing System manufactured and installed under the responsibility of a single specialist firm.
- B. Furnish a system that employs horizontal and angled fittings that are internally welded to vertical members. Screw and/or rivet attachment is NOT acceptable.

- C. Manufacturer/Installer and Product Line: CV Pipe Rail C4300 by CraneVeyor Corporation (CVC); Series 550 Pipe Railing by The Wager Companies; or equal.
- D. Railing components in this Specification Section are Crane Veyor products and are used to describe the quality and function of the item required.
- E. Posts, Rails, Connectors, Toeboards and Related Items for Component Railing System:
 - 1. 1 ½ inch Aluminum Pipe: Schedule 40, 1.90 inch outside diameter, Alloy 6063 in T6 temper handrail grade, or 6063 T1 or T52 handrail grade where required for bending. Use 6063 T832 where a clear anodized finish is required.
 - 2. Aluminum Reinforcing Sleeve: Aluminum drawn tube, 6063-T832, 1.6-inch diameter x 0.125-inch thickness. Outside diameter to be a tight fit inside the aluminum pipe.
 - 3. Aluminum Reinforcing Bar: Solid aluminum bar, 6061 T6, outside diameter to be a tight fit inside the aluminum pipe.
 - 4. Component Railing System Connectors:
 - a. Drawn, forged or fabricated aluminum Alloy 6063 T5, T6, or T832.
 - b. Coped to fit tightly at joint to post, rails or other members and shall have a stub or sleeve of reduced diameter to fit snugly inside the connecting member.
 - c. Provide an internal bulkhead just inside the point where the connectors are copied to fit the post or connecting member.
- F. Attachments:
 - 1. Adhesive Attachment: Provide structural adhesive (two-part epoxy adhesive per manufacturer's system requirements) at splices. Structural Epoxy Adhesive: #C4907, Scotch-Weld 3M Company; Devon; or equal.
 - 2. Weld Attachment: Provide ½ inch-diameter hole in the center of the bulkhead and weld the connector to the member to which it is being attached through the hole.
 - 3. Mechanical attachment (rivets and/or screws) of connector to post is NOT ACCEPTABLE.
 - 4. At intermediate railing posts use a "T" top rail connector and saddle intermediate rail connectors.
 - 5. At end railing post, join the top rail to the post with a pipe bend or radius elbow. Mitters or "T" connectors with end cap are unacceptable.
 - 6. At inside and outside corners:
 - a. Use two posts located close to the corner in each direction such that clear space between posts does not exceed maximum spacing allowed between horizontal rails. Bend top rail at corners or use a welded radius elbow to close clear space between posts.
 - b. Where shown or required, use a custom fabricated single corner post with a side outlet elbow (3-way elbow) as a top of post fitting. Attach top rails to posts with "T" top rail connector; attach intermediate rails to posts with saddle connectors.
 - c. Provide 4 inches high extruded aluminum with "F" shaped flanges along the top and bottom edge. At interior and exterior corners, use special corner connectors and splices.
- G. Set guardrail posts in pockets cast in concrete. Form a void in concrete with 16-gauge stainless steel sleeves, 1-inch larger than post diameter by 6 inches deep with closed bottom and removable slip-on plastic covers, or use a removable

Styrofoam void forming device of the same size. CVC; The Wagner Companies; or equal.

- H. Use a stainless steel base plate for bolt attachment to steel channel stair stringers. Weld a stainless steel tube to a 3/8 inch-thick stainless steel base plate sized to fit inside the aluminum pipe rail post.
- I. Socket for Removable Posts: Stainless steel post socket with closed bottom.
- J. Aluminum Bars and Plates: 6063 T6 alloy, 35,000 psi yield, 21,000 psi allowable.
- K. Toe Boards: Aluminum, 1.5" x 3.5" min. rectangular rail. From single-source supplier, provide all necessary compatible brackets, hardware, splices, etc. for fastening to rail and/or base plates as required. Vertical orientation only, no protruding angled faces allowed to prevent trip hazard.
- L. Adhesive Capsule Anchors, and Wedge Anchor Bolts for attaching items to concrete or masonry:
 - 1. Adhesive capsule anchors: Stainless steel, Molly Parabond capsule anchors, by the Molly Division of the Emhart Fastener Group; HVA adhesive anchors by Hilti Fastening Systems; or equal.
 - 2. Wedge anchor bolts, stainless steel, special machine bolts with built-in expanding wedge. Minimum size: 3/8-inch-diameter by 3-inch embedment in concrete or masonry. Do not load in excess of one-fourth of certified test value. Phillips Red Head Wedge Anchors; Wej-it expansion bolts; or equal. Use where noted and for:
 - a. Loads less than 200 lbs.
 - b. Load in shear only.
- M. Grout: Hydraulic quick-setting cement, nonshrinking, unaffected by water after setting and conforming to ASTM C595.
- N. Bolts, nuts, washers, and screws in contact with aluminum: Stainless Steel, AISI Type 304, with hex head bolts and nuts.
- O. Handrail Wall Brackets for Aluminum Railing: Cast aluminum Alloy 214, or Almag 35, extruded aluminum 6063 alloy or formed aluminum 5052 alloy, drilled for screw attachment to pipe handrail and for 3/8 inch-diameter bolt anchor to wall, 2 1/2 inch or 3 inch offset.
- P. Wall Flanges: Two-part consisting of: 1) an extra-heavy wall attachment flange, 1/4-inch-diameter drilled for four 1/4-inch-diameter countersunk head expansion anchor bolts and 2) a cover flange.

2.02 ALUMINUM ANODIZING

- A. After fabrication and finishing, give all aluminum railings a medium chemical etch and a clear Architectural Class I anodic coating, at least 0.7 mils thick, clear AA-C11-A41. Comply with the "Standards for Anodized Architectural Aluminum," published by the Aluminum Association and referred to in NAAMM "Metal Finishes Manual." Measure thickness in accordance with ASTM B244.
- B. Where aluminum is in contact with concrete, grout, plaster, or other metals, apply a coating of aluminum pigmented bituminous paint or epoxy paint to the aluminum after anodizing to act as an isolation barrier.

2.03 FABRICATION OF ALUMINUM HANDRAILS, GUARDRAILS, AND STAIR RAILS

- A. Make joints with special connectors designed for concealing shop welding to posts and flush slip on epoxy bonding of horizontal railing members in the field. Accurately cope connectors for a smooth hairline fit. Joints shall be weld joints on the inside of the connector so that welds are not visible from the outside. Bolts, screws, pop-rivets, or other exposed fasteners are not acceptable. Remove all sharp edges with fine abrasive.
- B. Fabricate custom components that cannot be assembled with fittings using aluminum pipe and welding type fittings. Fully weld all joints all around using Alloy 5356 filler wire, grind smooth and finish with progressively finer grits of abrasive ending with 180 grit.
 - 1. Avoid posts at inside or outside corners. Locate a post close enough to the corner in each direction such that clear space between posts does not exceed maximum spacing allowed between horizontal rails. From the corner with tight radius pipe bends or manufactured welding type elbows. Miters not permitted.
 - 2. At wall returns, at intersections of top rails with posts at the end of a run, and at other changes in direction, either custom bend the pipe rail or use manufactured formed or bent pipe ell's having a minimum 2-inch-inside radius. Make custom bends on a roll type hydraulic tubing bender. Provide bends that are free of buckles, puckers or deformed surfaces.
 - 3. At all cross and tee intersections, accurately cope members for a tight fit and internally plug weld as described above.
 - 4. Cap ends of pipes except wall returns with manufactured bulb end caps. Return wall rails to within 1/8 inch of the wall.
 - 5. Posts: Schedule 40 pipe internally reinforced at the bottom with a 20-inch-long tight-fitting solid aluminum bar bonded to the inside of the post with structural epoxy. Space posts no further apart than 6 feet regardless of spacing shown on drawing.
 - 6. Where posts are bolted to the top edge of stair stringers or at similar situations where a flanged connection is required, fabricate the flange from a 1/4 inch-thick stainless steel plate. Round corners to a 1/4 inch radius and ease all exposed edges to a 1/16-inch radius. Weld a stainless steel sleeve to the plate. Size the sleeve to be a snug fit inside of the aluminum pipe post. Slide the post over the stainless steel sleeve and bond with epoxy.
 - 7. Where chains and snap rings are required, provide a continuous aluminum reinforcing sleeve inside of the aluminum post. Provide 1-inch-diameter 304 stainless steel eye bolts, a 304 stainless steel chain with 13 welded 3/16 inch-diameter wire links per foot, and chrome plated brass snap fasteners. Locate the eyes of the eye bolts on the outside of the post away from the walking side of the rail and not facing the opening that the chain closes.
 - 8. Provide expansion joints consisting of a 6-inch-long solid aluminum sleeve sized to slip inside the members and bonded on one side of the joint only to allow for the thermal movement. Allow a minimum of 1/4 inch space for expansion in each 24-foot section. Allow more space if required to accommodate anticipated temperature changes. Locate expansion joints within 6 inches of a post. Ease exposed edges of pipe rail to a 1/16-inch radius.
 - 9. Mix and apply structural epoxy in accordance with the manufacturer's instructions.

10. Provide 3/16 inch-diameter holes in inconspicuous locations to vent interior of members.
- C. Anodizing:
1. Anodize all parts after the exposed welding is complete in accordance with paragraph 2.02 of this Section. Internally welded connectors may be attached to posts after anodizing.

PART 3 - EXECUTION

3.01 INSTALLATION, GENERAL

- A. Shop weld all connectors and fittings to vertical post assemblies. Field cut horizontal railing members and epoxy bond to connectors on post assemblies.
- B. Install work to a straight line or flat plane to within 1/8 inch in 6 feet and to within 1/4 inch total deviation. Install curved surfaces conforming to a true arc of a circle to within 1/16 inch.
- C. Equally space posts in any run and not more than 6 feet on center. Space posts in parallel rows so they are in alignment.
- D. Make proper allowance for expansion and contraction of the metals and of the materials to which they are fastened.
- E. Set posts 6 inches deep in sleeves cast in concrete using waterproof, nonshrinking grout. Attach wall or floor flanges to concrete with stainless steel epoxy capsule anchor bolts or to other construction with stainless steel machine bolts.
- F. Component Adhesive Attachment: Clean and dry areas to be joined thoroughly. Mix epoxy adhesive according manufacturer's directions (mixing only enough to use within 1/2 hour). Apply to inside surface of pipe, then slip splice sleeve into the pipe. Wipe off excess adhesive after components are properly joined. Leave connected areas undisturbed for eight (8) hours (longer in cold weather per manufacturer's recommendations).
- G. Construct work to withstand the forces required by WSBC and OSHA.
- H. Round and grind smooth all exposed corners and edges.
- I. Component Weld Attachment: Weld all the way around the perimeter of the hole in the bulkhead to develop the full strength 1/2 inch-diameter weld with a fully concealed weld
- J. Perform all welding in accordance with AWS manual "Welding Handbook". Employ methods and techniques to achieve the full strength of the members joined and architectural appearance.
- K. Field Assembly: Set members to lines and elevations indicated. Align and adjust members before making any permanent connections.

3.02 GUARDRAILS AND HANDRAILS

- A. Provide work of the highest quality performed by mechanics skilled in executing high quality architectural metal work.
- B. Set shop fabricated guardrail sections into position and align the top rail so that it is true to specified tolerances. Do field joining with structural epoxy adhesive. Mix and apply adhesive in accordance with manufacturer's instructions.

- C. Support guardrails with temporary braces and shoring to maintain true alignment until all final connections and grouting are completed. Build surface of grout up at post, ¼ inch higher than surrounding surfaces to direct water away from post.
- D. Attach toeboards to posts using two self-tapping, stainless steel machine screws minimum at each connection. Use special toeboard connectors at corners and special splice plates at end joints.
- E. Coat surfaces of aluminum in contact with concrete, grout, plaster, or dissimilar metals with specified coating material.

3.03 REPAIRS

- A. Replace all defective work including:
 - 1. Unsightly welds.
 - 2. Discontinuous welds.
 - 3. Uneven connections, surfaces, finishes or coatings.
 - 4. Variations exceeding specified tolerances.
 - 5. Kinks, bends, tool marks, grinding marks.
 - 6. Other defects affecting the quality, strength, utility, and appearance of the work.

3.04 CLEANING

- A. Wash thoroughly using clean water and detergent.
- B. Do not use acid solutions, steel wool, or other abrasives.
- C. Remove stubborn grease stains with mineral spirits.

END OF SECTION

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SECTION 06611

FIBERGLASS REINFORCED PLASTIC (FRP) MOLDED GRATING

PART 1 - GENERAL

1.01 SUMMARY

- A. Furnish, fabricate, and install all fiberglass reinforced plastic (FRP) molded grating and associated supports with all appurtenances, accessories and incidentals necessary to produce a complete, operable and serviceable installation as shown on the Drawings and as specified herein, and in accordance with the requirements of the Contract Documents.

1.02 REFERENCES

- A. The publications listed below (latest revision applicable) form a part of this specification to the extent referenced herein. The publications are referred to within the text by the designation only.
 - 1. ASTM International (ASTM) Standards:
 - a. ASTM D635 – Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position
 - b. ASTM E84 – Surface Burning Characteristics of Building Materials

1.03 SUBMITTALS

- A. In accordance with the requirements set forth in Section 01300, submit the following information:
 - 1. Shop Drawings: Grating layout, material sizes, types, styles, part or catalog numbers, complete details for the fabrication and erection of components including, but not limited to, location, lengths, type and sizes of edger angles, embedded angles, support beams, fasteners, clip angles, and connection details.
 - 2. Product Data:
 - a. Manufacturers' literature including structural design data, structural properties data, grating load/deflection tables, corrosion resistance tables, certificates of compliance, test reports as applicable, concrete anchor systems and their allowable load tables, and design calculations for systems not sized or designed in the Contract Documents.
 - b. Fiberglass specifications.
 - c. Submit color samples for Owner selection.
 - d. Statement from an independent testing laboratory certifying the grating meets the fire retardant and flame speed rating specified.
 - e. When requested, submit sample pieces of each item specified herein for acceptance by the Engineer as to quality and color. Sample pieces shall be manufactured by the method as required for this project.

1.04 QUALITY ASSURANCE

- A. All items to be provided under this section shall be furnished only by manufacturers having a minimum of ten (10) years of experience in the design and manufacture of similar products and systems. Additionally, if requested, a record of at least five

(5) previous, separate, similar successful installations in the last five (5) years shall be provided.

- B. Manufacturer shall offer a 3-year limited warranty on all FRP products against defects in materials and workmanship.
- C. Manufacturer shall be certified to the ISO 9001-2000 standard.
- D. Manufacturer shall provide proof of certification from at least two other quality assurance programs for its facilities or products (UL, DNV, ABS, USCG, AARR).

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Manufactured materials shall be delivered in original, unbroken pallets, packages, containers, or bundles bearing the label of the manufacturer. Adhesives, resins and their catalysts and hardeners shall be crated or boxed separately and noted as such to facilitate their movement to a dry indoor storage facility.
- B. Adhesives, resins, and their catalysts are to be stored in dry indoor storage facilities between 70 and 85 degrees Fahrenheit (21 to 29 degrees Celsius) until they are required.
- C. All materials shall be carefully handled to prevent them from abrasion, cracking, chipping, twisting, other deformations, and other types of damage.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All FRP items shall be by Fibergrate, or equal.
- B. All FRP items furnished under this section shall be composed of fiberglass reinforcement and resin in qualities, quantities, properties, arrangements, and dimensions as necessary to meet the design requirements and dimensions as specified in the Contract Documents.
- C. Fiberglass reinforcement shall be continuous roving in sufficient quantities as needed by the application and/or physical properties required.
- D. Resin shall be with chemical formulations as necessary to provide the corrosion resistance, strength, and other physical properties as required and shall be resistant to 12.5% sodium hypochlorite, 50% sodium hydroxide, and 60% magnesium hydroxide slurry and be resistant to degradation from exposure to UV light.
- E. All finished surfaces of FRP items and fabrications shall be smooth, resin-rich, free of voids and without dry spots, cracks, crazes, or unreinforced areas. All glass fibers shall be well covered with resin to protect against their exposure due to wear or weathering.
- F. All grating products shall have a tested flame spread rating of 25 or less per ASTM E-84 Tunnel Test. Gratings shall also have tested burn time of less than 30 seconds and an extent of burn rate of less than or equal to 10 millimeters per ASTM D635. Certifications shall be dated within the past 2 years and test data performed only on the resin shall not be acceptable.

- G. All hardware, fasteners and mechanical grating clips shall be manufactured of Type 316 stainless steel.

2.02 MOLDED FRP GRATING

- A. Grating shall be of a one-piece molded construction with tops and bottoms of bearing bars and cross bars in the same plane. Grating bar intersections are to be filleted to a minimum radius of 1/16-inch to eliminate local stress concentrations and the possibility of resin cracking at these locations. Grating shall have a 2-inch depth and 2-inch by 2-inch square mesh pattern, except where noted otherwise on the Drawings. The mesh shall have a tolerance of plus or minus 1/16-inch centerline to centerline. Grating depth shall have a tolerance of plus or minus 1/16 inch. Where new grating is placed in existing grating supports, the grating depth must match the existing depth to the support.
- B. Grating shall be reinforced with continuous rovings of equal number of layers in each direction. The top layer of reinforcement in the grating panel shall be no more than 3/16 inch below the top surface of the grating so as to provide maximum stiffness and prevent resin chipping of unreinforced surfaces. Percentage of glass (by weight) shall not exceed 35% to achieve maximum corrosion resistance, and as required to maintain the structural requirements of the Contract Documents.
- C. After molding, no dry glass fibers shall be visible on any surface of bearing bars or cross bars. All bars shall be smooth and uniform with no evidence of fiber orientation irregularities, resin rich, or resin starved areas.
- D. Unless noted otherwise, molded grating shall be open mesh. Where covered molded grating is required, the grating fiberglass cover plate shall be attached to the completed panel of grating by chemical means to ensure integral action of the panel and plate. The fiberglass top plate shall have a thickness of 1/8 inch, unless otherwise noted, with a tolerance of 1/32 inch. The panel and grating shall be uniformly clamped together to ensure that all contact surface remain in contact throughout the curing process.
- E. All grating shall have a gritted non-slip top surface.
- F. The resin system used in the manufacture of the grating shall be Vi-Corr® vinyl ester resin or approved equivalent. Manufacturer may be required to submit corrosion data from tests performed on actual grating products in standard chemical environments. Corrosion resistance data of the base resin from the manufacturer is not a true indicator of grating product corrosion resistance and shall not be accepted.
- G. Color shall be as determined by the Owner from the manufacturer's standard color options.
- H. Panel dimensions shown or specified on the Drawings are nominal sizes and actual panel dimensions shall include the clearance gaps as shown in the Drawing details with a tolerance of plus or minus 1/16 inch. Where panel sizes are not noted, cut panels to dimensions such that the weight of any single panel does not exceed 50 pounds.
- I. Provide FRP grating supports as shown on the Drawings. Embedded angle supports for spans up to 30" shall be EZ Angle® by Fibergrate, or equal.

- J. Grating load/deflection requirements at the required span shall be less than manufacturer's published maximum recommended loads. Maximum recommended loads shall be determined by acoustic emission testing. Unless noted otherwise, grating panels shall be designed for a uniform load of 65 psf or concentrated load of 300 lb. Deflection is not to exceed 0.375" or $L/D = 180$, whichever is less.
- K. Other products of equivalent or greater strength, stiffness, corrosion resistance, and overall quality may be submitted with the proper supporting data provided for review.

2.03 GRATING FABRICATION

- A. Grating supplied shall meet the dimensional requirements and tolerances as shown or specified. The Contractor shall provide and/or verify measurements in the field for work fabricated to fit field conditions as required by grating manufacturer to complete the work. When field dimensions are not required, Contractor shall determine correct size and locations of required holes or cutouts from field dimensions before grating fabrication.
- B. Grating sections over sumps and shallow trenches using embedded angle supports need not be tied down. All other grating sections shall be tied down with appropriate anchors or hold-down clips that allow removal from the top of the grating. Clips shall be Fibergrate "G" style clips, or equal. Hold-down clips shall be provided and spaced at a maximum of 4 feet apart with a minimum of four per piece of grating, or as recommended by the manufacturer.
- C. Manufacturer to provide openings and holes where items are shown passing through the grating on the Drawings. Grating openings which fit around protrusions (pipes, cables, machinery, etc.) shall be field cut or, when shop fabricated, discontinuous at approximately the centerline of opening so each section of grating is readily removable.
- D. All shop fabricated grating cuts shall be sealed with resin to provide maximum corrosion resistance. All field fabricated grating cuts shall be coated similarly with resin by the Contractor in accordance with the manufacturer's instructions.
- E. Provide Type 316 stainless steel hardware, fasteners, and hold-down clips.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Contractor shall install grating in accordance with manufacturer's assembly drawings. Fasten grating panels securely in place with hold-down clips as specified herein. Field cut and drill fiberglass reinforced plastic products with carbide or diamond tipped bits and blades. Seal cut or drilled surfaces in accordance with manufacturer's instructions. Follow manufacturer's instructions when cutting or drilling fiberglass products or using resin products; provide adequate ventilation.

3.02 INSPECTION

- A. Shop inspection is authorized as required by the Owner and shall be at the Owner's expense. The fabricator shall give ample notice to Contractor prior to the beginning of any fabrication work so that inspection may be provided. The grating shall be as free, as commercially possible, from visual defects such as foreign inclusions, delamination, blisters, resin burns, air bubbles and pits. The surface shall have a smooth finish (except for grit top surfaces).

END OF SECTION

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SECTION 06850

FIBERGLASS REINFORCED PLASTIC (FRP) BAFFLE WALL SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes: Design and provide all materials, equipment, and labor for installation of a fiberglass reinforced plastic (FRP) slide guide type baffle wall system including FRP baffle wall panels; wall-mounted FRP structural support angles; floor-mounted FRP structural support columns with baseplates and angle clips; required FRP knee-brace beams and angle clips to support the columns; and post-installed Type 316 stainless steel anchors, fasteners and connection hardware.
- B. Baffle wall system to be designed by a professional engineer registered in Washington State, retained by the manufacturer. Submit detailed shop drawings and calculations for structural design of baffles, support frames, and anchorages.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. ASTM D4385 – Standard Practice for Classifying Visual Defects in Thermosetting Reinforced Plastic Pultruded Products
 - 2. ASTM D638 – Standard Test Method for Tensile Properties of Plastics
 - 3. ASTM D695 – Standard Test Method for Compressive Properties of Rigid Plastics
 - 4. ASTM D790 – Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
 - 5. ASTM D256 – Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics
 - 6. ASTM D570 – Standard Test Method for Water Absorption of Plastics

1.03 SYSTEM DESCRIPTION

- A. Design Requirements:
 - 1. Design Load: Specified percentage of hydrodynamic loading varying from 360 pound per square foot (psf) at the ordinary tank operating water surface to 90 psf at the bottom of the tank. Alternate design loading may be proposed with supporting documentation for review by Engineer during the submittal process.
 - a. Baffles: 25 percent of the given hydrodynamic loading on the baffle wall. Baffle panels to be designed to lower loading criteria than wall framing to protect wall framing from failure.
 - b. Baffle Wall Framing: 50 percent of the given hydrodynamic loading on baffle wall.
 - c. Wind Load: Not applicable.
 - 2. Deflection Limit and Factor of Safety
 - a. Baffle Panels: $L/D = 70$; Max Deflection = Panel Profile Depth; Factor of Safety = 2.0.
 - b. Baffle Support Framing: Factor of Safety = 2.5.

3. Baffle and Support Framing Hydraulic Design
 - a. Baffle wall system shall be designed to avoid accumulation of scum, foam, and other floatables.

1.04 SUBMITTALS

- A. Submit in accordance with Section 01300.
- B. Product Data: Fully describe all products proposed for use. Include data on physical, chemical, and structural engineering properties.
- C. Shop Drawings: Custom prepared project specific shop drawings and calculations for structural design of baffles, support frames and anchorage.
- D. Samples: Submit samples of all shapes and sizes.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Inspect all items delivered to the site for damage. Replace items that have splintered or suffered surface damage.
- B. Store in a clean area without adding other concentrated or distributed loads above the items.
- C. All materials shall be carefully handled to prevent them from abrasion, cracking, chipping, twisting, other deformations, and other types of damage.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Aquaspan 'H' Series Baffle Wall manufactured by Enduro Composites, www.endurocomposites.com, 16602 Central Green Blvd, Houston, TX 77024, Tel: 800-231-7271.
- B. Strongwell Fiberglass Baffle Panels, www.strongwell.com, 400 Commonwealth Ave, Bristol, VA 24201, Tel: 276-645-8000.
- C. Or equal.
- D. The design shown on the Drawings is based on the first named manufacturer (Enduro Composites). Although alternate named products are very similar and should not require significant modification of the design, the Contractor shall be responsible for all costs associated with alterations to accommodate other named manufacturers, or any proposed equal manufacturer if approved, that may be of slightly different size, configuration, etc.

2.02 MATERIALS

- A. FRP Baffle Panels, Columns, Angles and Beams: Manufactured using the pultrusion process and conforming to ASTM D4385; ANSI/NSF Standard 61 certified for potable water application.
- B. FRP Baffle Panel Structural Properties (Minimum):
 1. Stiffness (EI): 1,780,000 lb-in²/ft
 2. Moment Capacity: 39,200 lb-in/ft

- C. FRP Structural Material Strength Properties (Minimum):
 - 1. Tensile Strength: 40,000 psi (ASTM D638)
 - 2. Compressive Strength: 37,000 psi (ASTM D695)
 - 3. Flexural Strength: 58,000 psi (ASTM D790)
 - 4. Flexural Modulus: 1,900,000 psi (ASTM D790)
 - 5. Izod Impact (Notched): 25 (ASTM D256)
 - 6. Water Absorption: 0.6 percent maximum (ASTM D570)
- D. FRP materials shall include UV stabilized polyester resin with surfacing veil covering the exterior surface; gray color; 50 percent glass fiber reinforcing (by weight).
- E. Factory cut edges and drilled holes shall be sealed with ANSI/NSF approved material.
- F. FRP Baffle Panels: Minimum 2.75-inch profile depth with horizontal ribs (including top and bottom of each panel); minimum 0.170-inch (approximately 3/16-inch) nominal thickness; 12 to 24 inches tall, as shown on the Drawings.
- G. Column baseplates shall be Type 316 stainless steel. Base plates or angles shall be factory attached to FRP members to the extent possible. Vertical columns shall be knee-braced.
- H. Hardware:
 - 1. Fasteners, anchors, and other structural hardware: Type 316 stainless steel.
 - 2. All anchors shall be epoxy adhesive type.
 - 3. Minimum fastener diameter: 5/8-inch.

PART 3 - EXECUTION

3.01 FABRICATION

- A. Fabricate all structural components in the shop to the greatest extent possible. Minimize the number of bolted connections required in the field.
- B. Repair and seal all cut and drilled FRP surfaces with compatible catalyzed resin.
- C. Provide a gap in the slide guide where the top panel will reside for the baffle wall section that overlaps with the concrete overhang in each tank. This will facilitate installation of the panels without conflicting with the overhang. After installation of the last panel in those sections, close the gap in the slide guide on each side with bolted angles.

3.02 INSTALLATION

- A. Install items specified as indicated and in accordance with manufacturer's instructions.
- B. Set support frames and miscellaneous structural components accurately in position in tank and anchor accurately in position with Type 316 stainless steel adhesive anchors to accept FRP baffles.
- C. Provide temporary bracing or anchors in form work for items that are to be built into concrete or similar construction.
- D. Set FRP baffle panels accurately in position and install all fastenings to frames in accordance with approved shop drawings.

- E. Repair and seal all damaged FRP surfaces with compatible catalyzed resin as recommended by the manufacturer. Field-cutting and field-drilling of FRP components shall be avoided whenever possible, but if required shall also be sealed with compatible catalyzed resin.

END OF SECTION

SECTION 07200

INSULATION

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Building thermal insulation.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. C167 Test Methods for Thickness and Density of Blanket or Batt Thermal Insulations
 - 2. C518 Test Method of Steady-State Thermal Transmission Properties by Means of Heat Flow Meter ("R" Value)
 - 3. C665 Specification for Mineral-Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing
 - 4. C991 Specification for Flexible Fibrous Glass Insulation for Metal Buildings
 - 5. E84 Surface Burning Characteristics
 - 6. E96 Test Method for Water Vapor Transmission of Materials (Perm Rating)
 - 7. E136 Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C.
- B. Underwriters Laboratories (UL):
 - 1. UL1256 Fire Test of Roof Deck Construction
- C. Washington State Building Code Council (WSBCC):
 - 1. 2015 Washington State Building Code (based on 2015 International Building Code).
 - 2. 2018 Washington State Energy Code – Commercial Provisions

1.03 SUBMITTALS

- A. Product Data: Fully describe every item proposed for use.

1.04 PRODUCT, DELIVERY, STORAGE, AND HANDLING

- A. Deliver insulation materials to the job in original packages with manufacturer's "R" Values and UL flame spread ratings clearly shown. Provide certification of compliance with applicable Federal Specifications.

PART 2 - PRODUCTS

2.01 LOW DENSITY BLANKET/BATT INSULATION

- A. Thermal Batt Insulation: At walls, use glass fiber thermal insulation; R-values as indicated on Drawings. FSK-faced ASTM C665, Type II, Class A. Owens-Corning EcoTouch; Johns-Manville; or equal.

PART 3 - EXECUTION

3.01 INSTALLATION OF LOW DENSITY FIBERGLASS BLANKET/BATT THERMAL INSULATION

- A. Between Wall Studs:
 - 1. Friction fit insulation between studs.
 - 2. Place foil face on the conditioned side, overlap tabs and staple.

END OF SECTION

SECTION 07600

FLASHING AND SHEET METAL

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Galvanized steel sheet metal flashing, counterflashing, copings, expansion joints, and all other sheet metal work not covered in other sections.

1.02 REFERENCES

- A. "Architectural Sheet Metal Standards" by Sheet Metal and Air Conditioning Contractors National Association (SMACNA), latest edition.
- B. ASTM International (American Society for Testing and Materials - ASTM):
 - 1. A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
 - 2. A924 - Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
- C. Washington State Building Code Council (WSBCC):
 - 1. 2015 Washington State Building Code (based on 2015 International Building Code).
 - 2. 2018 Washington State Energy Code – Commercial Provisions

1.03 SUBMITTALS

- A. Product Data: Fully describe all manufactured items to be furnished.
- B. Shop Drawings: Show all custom-fabricated items clearly illustrating the design, dimensions, materials, methods of construction and installation of each piece of work.
- C. Manufacturers' Instructions: For manufactured items.

1.04 QUALITY ASSURANCE

- A. Comply with the adopted edition of the 2018 Washington State Building Code (WSBC), especially Chapters 14, 15, and 25.
- B. Where specific details are not provided comply with applicable details in the SMACNA Architectural Sheet Metal Standards.
- C. Except where otherwise indicated, comply with minimum thickness or gage requirements as specified in SMACNA Architectural Sheet Metal Manual.

1.05 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. For unpainted items, deliver all items to the job site, allowing time for field priming and incorporation into work of other trades.
- B. Store materials under dry conditions and protect from moisture and physical damage.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Sheet Steel: Copper bearing, 26-gauge or heavier where noted; hot dip galvanized complying with ASTM A653 and A924, G90 Commercial Class 1.25 ounce per square foot, mill phosphatized for maximum paint adherence.
 - 1. Pre-finished metals to have factory finish (Kynar 500 or equal), 24 gauge minimum, color as selected from manufacturer's full range of standard, premium and custom colors.
- B. Fasteners:
 - 1. To Concrete Masonry Units: Deformed steel wedge pins driven into lead expansion shields; RAWL, Tapcon, or equal.
 - 2. To Wood Nailers and Sills: Pan head, noncorrosive, sheet metal screws.
 - 3. Component Fasteners: Self-drilling/self-tapping, stainless steel screws, type S-12, Buildex TEKS; Fastenal; or equal.
 - 4. Screw heads shall be furnished with neoprene washers.
- C. Sealant: Polyurethane sealant type as specified in Section 07900. Where specified sealant is incompatible with other adjacent sealants, Contractor shall submit a sealant suitable for intended use and of equivalent life expectancy.
- D. Isolating Material: Alkali-resistant bituminous paint or varnish.
- E. Flashing for Vent Pipes, Conduits, Etc. Through Roof: Provide round base, UV-resistant pipe flashing in diameter sized to penetration. Include aluminum insert to conform to panel configuration and/or roof pitch. Flashing to be black in color.

2.02 FABRICATION

- A. Before fabrication, take field measurements, ascertain existing field conditions and have discrepancies corrected before proceeding with sheet metal work.
- B. Fabricate sheet metal items in the shop to the greatest extent possible. Fabricate using techniques and methods described in the SMACNA Architectural Sheet Metal Standards.
- C. Make sections uniform with true, straight breaks, accurately fitted and rigidly secured. Provide overlapping tabs for soldered joints. Fabricate items in maximum lengths.

- D. Provide accessories necessary to complete installation. Provide ribs, cleats, stiffeners, sleeves, hangers, and other reinforcements required to make sections rigid and substantial, in same metal as basic unit.
- E. Miter corner joints and reinforce with extended tabs or backing plates.
- F. Lap expansion joints at least 4 inches and seal with polyurethane sealant, type "B".

PART 3 - EXECUTION

3.01 INSPECTION

- A. Examine surfaces to receive sheet metal work for defects that will adversely affect the execution and quality of the work.
- B. Do not start work until all unsatisfactory conditions are corrected.
- C. Ensure that all wood nailers have been properly installed.
- D. Ensure that all galvanized sheet metal items are prime coat painted on all concealed and exposed surfaces, under Section 09900, before installation.

3.02 WORKMANSHIP

- A. All work shall be watertight and shall drain properly.
- B. Make proper allowance for expansion and contraction of the metals and of the materials to which they are fastened.
- C. Form work accurately to sizes, shapes, and dimensions indicated or necessary, with angles and lines in true alignment, straight and sharp; miters and joints accurately fitted.
- D. Erect work plumb, level and in proper plane, without bulges, or waves. Fit metal closely and neatly to cores or framework. Cope or flange intersections to fit accurately. Reinforce heavily loaded joints with screws or rivets. Corners shall be reinforced, and seams made waterproof. Exposed work shall be free of dents and other defects. Edges of sheet metal shall be hemmed.
- E. Set items in sealant or plastic cement as shown or noted; or when such application is necessary to provide a watertight job.
- F. Provide isolation between dissimilar metals or other materials with sealant, butyl tape, bituminous paint or asphalt saturated felt. Provide waterproof neoprene washers wherever fasteners penetrate sheet metal. Exposed fasteners will not be permitted for any portion of this work.
- G. Perform sealant work in conformance with the requirements of Section 07900.

3.03 FLASHING

- A. Install all Flashings as required to provide watertight protection.
- B. Lap all seams in direction of water flow.
- C. Carry Flashings around corners at least 4 inches.
- D. Lap joints 4 inches minimum. Apply sealant to the overlapping surfaces of the joints. Beads of sealant which will be concealed in the finished work shall be continuous with no voids of material.

3.04 INSTALLATION

- A. Provide sill and head Flashing at all louvers, doors and windows as shown and as required for a watertight installation. Furnish in the same metal as the louver.
- B. Provide Flashing where shown and where required for a watertight installation.

3.05 CLEANUP

- A. Clean all finished surfaces, removing all excess sealant, etc. Wash down all work with soap and hot water, flush with clean water, and wipe dry.
- B. Repair or replace all damaged or defective areas to ensure watertightness and neat appearance.

END OF SECTION

SECTION 07900

JOINT SEALANTS

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Sealant work required:
 - a. For a watertight project.
 - b. Required by code and not specifically covered in another section.
 - 2. Seal between all door frames, louvers and adjacent surfaces.
 - 3. Minimum standards for all sealant work whether covered in this Section or in other sections.

1.02 REFERENCES

- A. ASTM International (ASTM)
 - 1. C920 Standard Specification for Elastomeric Joint Sealants
- B. Washington State Building Code Council (WSBCC):
 - 1. 2015 Washington State Building Code (based on 2015 International Building Code).
 - 2. 2018 Washington State Energy Code – Commercial Provisions

1.03 SUBMITTALS

- A. Product Data: Fully describe all products proposed for use.
- B. Samples: Physical samples of cured sealants for selection of colors.
- C. Manufacturer's Instructions: Application instructions for all products used.

1.04 QUALITY ASSURANCE

- A. Qualifications: Provide sealant work performed by a licensed Specialty Sealant and Waterproofing Contractor who is exclusively engaged in sealant application work. All work to be performed by qualified journeymen proficient in the craft of sealant application.
- B. Regulatory Requirements: Comply with the Washington State Building Code (WSBC), 2018 edition.

1.05 PROJECT CONDITIONS

- A. Environmental Requirements: Apply sealant only when temperature and humidity conditions are at the levels recommended by the sealant manufacturer.

1.06 SPECIAL GUARANTEE

- A. Provide a written Special Guarantee covering replacement of sealant work that fails within 2 years of the date of project acceptance. Failure includes:
1. Becomes brittle or cracking due to exposure, contraction, or expansion.
 2. Failure to resist abrasion of normal use and traffic.
 3. Tear failure due to movement within 50% of joint width for Class A sealants.
 4. Cohesive or adhesive failure due to movement within 50% of joint width for Fed. Spec. Class A sealants.
 5. Water infiltration for joints intended to exclude water, air infiltration for joints intended to exclude air.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Sealant Type "A": Exterior and interior horizontal traffic deck sealant two-part self-leveling polyurethane with a Shore "A" hardness greater than 30, conforming to ASTM C920 Type I or Type II, Class A, in color selected. Acceptable products are:
1. Tremco "Vulkem" No. 445SSL (use with recommended primer).
 2. W.R. Meadows "Pourthane" NS used with recommended primer.
 3. Or equal.
- B. Sealant Type "B": Exterior and/or interior vertical surface sealant (location as approved by manufacturer) for use in joints in concrete, metal and similar materials, conforming to ASTM C920 Type II, Class A, in color selected. Acceptable products are:
1. One part polyurethane: Tremco "Vulkem" No. 116 (approved for exterior use only).
 2. One part polyurethane: Sika Sealant Division Sikaflex Ia.
 3. Or equal.
- C. Sealant Type "C": Paintable silicone sealant suitable for sealing cracks, voids, joints, etc. in exterior or interior surfaces that are to be painted or left unpainted. Acceptable products are:
1. G.E. Paintable Silicone Sealant.
 2. Dow Corning Paintable Silicone Sealant.
 3. Or equal.
- D. Sealant Type "D": Silicone sealant meeting Fed. Spec. TT S 001543A, Class A for use in expansion joints in concrete. Acceptable products are:
1. Dow Corning 795 Silicone.
 2. G.E. Silpruf SCS2000.
 3. Or equal.
- E. Sealant Type "E": Mildew Resistant Silicone Sealant: One part silicone sealant for sealing non-porous interior surfaces where conditions of high humidity and temperature extremes exist. Acceptable products are:
1. Dow Corning 786 Mildew Resistant Silicone Sealant.
 2. General Electric SCS1700 Sanitary Sealant.
 3. Or equal.

- F. Sealant Type "F": Two-component, modified polyurethane sealant intended to resist up to five parts per million of chlorine or ozone in water, for interior and exterior use. Acceptable products are:
 - 1. Sika Corp. "Sikaflex-2C."
 - 2. Polymeric Systems, Inc. PSI-270/RC 270.
 - 3. Or equal.
- G. Sealant Backup: Closed Cell Polyethylene rod stock. Acceptable products are:
 - 1. Dow Corning "Ethafoam."
 - 2. Nomaco, HBR Backer Rod.
 - 3. Or equal.

PART 3 - EXECUTION

3.01 CONDITION OF SUBSTRATE

- A. Allow concrete and masonry to cure for at least 28 days before applying sealants.
- B. Inspect substrates to receive sealant work for:
 - 1. Deviation beyond allowable tolerance for joint width and required clear joint depth. Joint width shall not be less than ¼ inch or the width shown.
 - 2. Presence of contaminants, which cannot be removed by normal joint cleaning.
 - 3. Presence of moisture. Joint surfaces shall be dry.
- C. Do not start work until all unsatisfactory conditions have been corrected.

3.02 PREPARATION OF SURFACES

- A. Clean surfaces that the sealant is to adhere:
 - 1. For Concrete and Masonry: Sandblast joint surfaces taking care to protect exposed finish surfaces.
 - 2. For Metal: Sand or scrape and solvent clean with a non-film forming solvent.
- B. Ensure that cleaned surfaces are not contaminated before applying sealant.
- C. Where deemed necessary, use manufacturer's recommended primers for porous and non-porous substrates and/or surfaces.

3.03 APPLICATION

- A. Follow sealant manufacturer's published instructions.
- B. Install sealant backup the proper distance from face of joint for joint proportioned in accordance with sealant manufacturer's recommendations. Use polyethylene rod stock larger than joint so that backup can be firmly held in place.
- C. Apply primer and/or cleaner conditioner recommended by sealant manufacturer for substrate. Avoid getting primer on the face of material or on areas that will not be covered by sealant.
- D. Mask edges of joint with masking tape where required to avoid contamination of exposed surfaces adjacent to joint.

- E. Apply self-leveling sealant by pouring, pumping, or with a caulking gun. When using a pump or caulking gun, fill joint from the bottom up to avoid air entrapment. Fill joint flush with surface of adjacent material without overfilling or spilling sealant on exposed surfaces.
- F. Apply vertical grade sealants by hand or power operated caulking gun. Use a caulking tip the proper width for the joint required. Fill the joint from the bottom up to insure a fully filled joint without entrapped air bubbles or voids. Use lubricant recommended by sealant manufacturer to tool joints. Force sealant against sides and bottom of joint and into all crevices; press out air bubbles and voids. Tool the sealant surface smooth and flush with adjacent surfaces for butt joints or to an even, straight-sided fillet of uniform width and slope for fillet joints.
- G. Where the substrate or adjacent sealants are incompatible with the specified sealant, submit a sealant suitable for the required use and of equivalent life expectancy to the specified sealant.

3.04 EXPANSION JOINTS

- A. Apply sealant in expansion joints when the joint opening width is approximately halfway between dimensional extremes of thermal movement.
- B. Place sealant backer rod the proper distance from face of joint to ensure that sealant bead depth is never more than half the bead width at any time between dimensional extremes of joint.

3.05 CLEANUP

- A. Upon completion, remove protective masking and clean any sealant from adjacent finished surfaces beyond edge of joint.

END OF SECTION

SECTION 08110

HOLLOW METAL WORK

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. All hollow metal work including:
 - a. Doors and frames.

1.02 REFERENCES

- A. American National Standards Institute (ANSI):
 - 1. ANSI A250.4 Test Procedure and Acceptance Criteria for Physical Endurance for Steel Doors, Frames and Frame Anchors
 - 2. ANSI A250.8 Specifications for Standard Steel Doors and Frames
 - 3. ANSI Z97.1 American National Standard for Glazing Materials Used in Buildings - Safety Performance Specifications and Methods of Test
- B. ASTM International (ASTM):
 - 1. ASTM A1008 Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable
 - 2. ASTM A653 Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
 - 3. ASTM A1011 Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength
 - 4. ASTM C 1172 Standard Specification for Laminated Architectural Flat Glass
 - 5. ASTM E283 Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
- C. Washington State Building Code Council (WSBCC):
 - 1. 2015 Washington State Building Code (based on 2015 International Building Code)
- D. National Association of Architectural Metal Manufacturer's (NAAMM) "Guide Specification for Commercial Laminated Core Hollow Metal Doors and Frames, HMMA 867-16.
- E. Steel Door Institute (SDI):
 - 1. ANSI/SDI A250.4 Standard Test Procedure and Acceptance Criteria for Physical Endurance for Steel Doors, Frames and Frame Anchors.

- F. Underwriters Laboratories, Inc.:
 - 1. UL 1784 Standard for Air Leakage Tests of Door Assemblies and Other Opening Protectives

1.03 SUBMITTALS

- A. Product Data: Fully describe all products proposed for use. Include data and details on door construction including internal reinforcement and door edge construction.
- B. Shop Drawings: Submit custom prepared project-specific shop drawings showing dimensions and details. Include a schedule showing locations of doors and frames complete with listing of types and styles. Field measure before ordering. Provide frames with throat opening size required by field conditions regardless of size shown on drawings. Review of door frame submittal DOES NOT include review of throat opening dimension for compatibility with field requirements or Contract Documents.
- C. Manufacturers' Certificates of Compliance: Before delivery of doors, frames, and accessories, submit certificates from the manufacturer attesting that doors, frames, and accessories meet the requirements of the referenced standards.
- D. Product Certificates: Signed by manufacturers of glass and glazing products certifying that products furnished comply with requirements.
 - 1. Qualification Data: For installers.
 - 2. Product Test Reports: For each type of glazing.
 - 3. Warranties: Special warranties specified in this Section.

1.04 QUALITY ASSURANCE

- A. Regulatory Requirements:
 - 1. Comply with the following:
 - a. 2018 Washington State Building Code.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Delivery: Inspect doors, frames, and accessories delivered to the site for damage. Unload and store with a minimum of handling. During delivery, strap door frames of welded unit construction together in pairs with the head of one frame inverted for bracing. Replace doors and frames damaged during delivery.
- B. Provide a bottom spreader bar tack welded to frames to maintain jamb alignment until frames are installed.
- C. Storage: Store doors and frames carefully on platforms under cover in dry and accessible locations, which are adequately ventilated and free from dust or water and which permit easy access for inspection and handling. Avoid the use of non-vented plastic or canvas shelters that create a humidity chamber.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Acceptable manufacturers include Forderer Hollow Metal Products; Republic; Steelcraft; or equal.

2.02 MANUFACTURED UNITS

- A. Frames, Galvannealed:
 - 1. Fabricate from carbon steel sheet that has been coated by a continuous hot-dip process and further treated to convert the zinc coating into a zinc-iron alloy meeting ASTM A653 A60.
 - 2. Minimum zinc coating: 0.60 total both sides ounces per square foot of metal surface.
 - 3. Metal thickness: .067 in. or heavier where noted.
- B. Doors, Galvannealed:
 - 1. Fabricate face sheets and edge channels from carbon steel sheet that has been coated by a continuous hot-dip process and further treated to convert the zinc coating into a zinc-iron alloy meeting ASTM A653 A60 or A1008 commercial class 0.60.
 - 2. Minimum Zinc Coating: 0.60 ounces per square foot of metal surface.
 - 3. Metal Thickness: .053 in. or heavier where noted.
- C. Jamb Anchors:
 - 1. Provide the number of anchors required by the fire rating but not less than the following number for each jamb.
 - a. Frames up to 7'-6" high, three anchors.
 - b. Frames 7'-6" to 8'-0" high, four anchors.
 - c. Frames over 8'-0" high, four anchors plus one additional anchor for each 2 feet or fraction thereof above 8 feet.
 - d. Provide head anchors at 2-foot centers for openings wider than 3 feet.
 - 2. Frames in Masonry Walls: Provide adjustable tee strap, jamb anchors. Metal thickness: .053 in. minimum.
 - 3. Provide special anchors when specified or detailed.
- D. Floor Anchors: 0.053 in. minimum thickness, welded to frame at each jamb or mullion, punch for two 3/8-inch-diameter anchor bolts. Additional jamb anchors do not waive the requirement for floor anchors.

2.03 FABRICATION

- A. General: Fabricate in the shop. Accurately fit all work and fabricate in a manner to produce smooth, even surfaces free from warp, wave, buckle, and other defects. Make square corners and angles unless shown otherwise on the Drawings. Set members in proper alignment, with edges straight and clean. Make provisions for hardware at locations in accordance with prevailing accepted standards, and as shown on the Drawings.
- B. Galvannealed Doors and Frames, Where Required: All exterior doors and frames shall be galvannealed. All other doors and components noted, specified, or scheduled "Galvanized" shall be galvannealed.
- C. Preparation for Hardware: Make to hardware templates and physical hardware. Locate center of panic hardware pushbars, doorknobs, and lever handles 38 inches above the floor. Locations shall be coordinated between frames and doors, as shown on the Drawings, and all applicable accessibility and other code requirements. Punch stops of all frames for silencers, three in latching stop for single doors, two in head of double door frames.
- D. Frames: Fully welded, seamless construction with no visible seams or joints, strong, rigid, and constructed so as not to bind, sag, twist or otherwise fail in use.

Provide frames with throat opening dimension required to meet field requirements regardless of throat size shown.

1. Frame members: Form each frame member from one piece of sheet steel.
2. Joints: Miter corner joints, including integral stops, reinforce and weld continuously full length of joint. Fit other joints neatly and weld continuously full length of joint.
3. Jamb anchors: Weld to inside jamb.
4. Floor anchors: Weld to bottom of door frame jambs.
5. Spreaders: Connect removable steel channel spreader ties across bottoms of welded door frames to hold rigid during shipping and until they are secured in place in the work.
6. Hardware reinforcing: Weld in place, comply with NAAMM HMMA 867-16 standards. Shop drill and tap for template hardware. Field-drill and tap for surface mounted hardware.
 - a. Templates: Obtain from finish hardware manufacturer.
 - b. Hinges: 7-gauge steel, 1-1/4 inches wide by not less than 10 inches long. Prepare for full mortise hinges.
 - c. Strikes: 12-gauge steel, 1-1/2 inches wide with minimum lap of 2 inches beyond cutout.
 - d. Closers: 12-gauge steel, length to accommodate closer. Provide reinforcing at two locations on each frame for installation of either regular or parallel arm closers, whether or not closers are scheduled.
 - e. Plaster guards: 24-gauge steel, provide at strike and hinge reinforcing.
 - f. Flush bolts: 12-gauge steel.
7. At exterior locations and where noted, provide shop welded 0.53 in. galvanized steel rain hood at head of door frame.

E. Doors:

1. Type: SDI Type III, extra heavy duty, fully welded style 2 full flush hollow steel construction for interior doors and exterior doors. Doors shall have no visible joints or seams on exposed faces and vertical edges.
2. Top and bottom rails: .053 in. channel; fully flush design, continuous welded to face sheets.
3. Face sheet (or face panel) reinforcing shall meet the requirements of ANSI A250.4 for twist strength. The following methods are acceptable:
 - a. Continuous vertical stiffeners of not lighter than .026 in. steel, spaced not to exceed 6 inches on centers and spot welded to both face sheets at intervals not greater than 6 inches. Fill all voids with insulation.
 - b. An inner grid system consisting of vertical and horizontal members of not lighter than .042 in. steel, welded or interlocked for maximum strength and spaced not to exceed an average of 12 inches in either direction, and spot welded to both face sheets at intervals not greater than 6 inches. Fill all voids with insulation.
 - c. A continuous formed sheet steel truss core, full height and width, spot welded to face sheet at intervals not greater than 6 inches in both directions. Fill all voids with insulation.
 - d. Doors required to have a maximum temperature rise on the protected side shall have insulating cores as required to achieve the specified performance.
4. Edge profile: Bevel vertical edges of stiles 1/8-inch in 2 inches.
5. Door thickness: 1-3/4 inches or thicker as noted.
6. Clearances: 3/32-inch clearance at jambs and head and 3/8-inch clearance at bottom; 1/4-inch clear between door and threshold where threshold occurs.

- Provide required clearance between door and stop to accommodate smoke gasket.
7. Exterior doors: Provide a watertight flush closing channel at the top edge. Provide weep holes in the bottom closure to permit escape of entrapped moisture.
 8. Door cutouts: Cut outs for door openings shall be spaced at least the distance away from door edges or recesses for hardware that is required to maintain door fire rating and guarantee. All cut outs shall be made in the shop fabricating the doors.
 9. Hardware reinforcing: Comply with NAAMM HMMA 867-16 Standards. Shop drill and tap for template hardware. For surface mounted hardware, drill and tap in the field.
 - a. Hinge: .167 in.
 - b. Lockset: .093 in.
 - c. Flush bolt: .093 in.
 - d. Closer: .152 in.
 10. Provide reinforcement for closers both sides of all interior doors whether closers are scheduled or not.

2.04 FINISHES

- A. Refer to Section 09900 for surface preparation, pretreatment, primers, and application techniques.
- B. Apply one shop coat of rust inhibiting primer to all ferrous metal not scheduled to be galvanized.

2.05 GALVANIZING REPAIR

- A. Repair damaged galvanizing by heated substrate repair method. Repair materials shall be Galv Bar as manufactured by US Alloy Company; or Gal-Viz as manufactured by The Harris Products Group; or equal.
 1. Heat substrate to 600°F, or apply hot process touch-up material right after welding before metal has cooled below 600°F.
 2. Rub bar of specified galvanize repair material over surface of hot substrate to apply a uniform coating of zinc. Wire brush hot coating with a clean wire brush to smooth out and bond zinc coating to substrate.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Frames: Set accurately in position, plumbed, aligned and braced securely until permanent anchors are set. Anchor bottom of frames securely to floors. Secure wall anchors to adjoining construction as indicated or required.
- B. Hanging Doors: Set accurately, snug against all stops and free from hinge bind. If shimming is required use sheet brass shims. Install hardware and weatherstripping. Adjust closing and latching speed of door closers for smooth operation, self-closing and automatic positive latching. Fasten with matching machine screws or bolts at all points where fasteners are indicated or required. Leave hardware in perfect working order. Clean and polish.

- C. Remove locksets, kickplates, etc. for field painting of doors. Replace hardware after painting work is completed.
- D. Repair damaged galvanizing by the heated substrate repair method using galvanized touch-up material specified in Part 2 of this Section.

END OF SECTION

SECTION 08330
OVERHEAD COILING DOORS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Section Includes:
 - 1. Manual-operated insulated overhead coiling doors with factory finish.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. A 123 Standard Specification for Zinc (Hot-Dipped Galvanized) Coatings on Iron and Steel Products
 - 2. A 653 Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
 - 3. E 84 Standard Test Method for Surface Burning Characteristics of Building Materials
 - 4. E 90 Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements
- B. Washington State Building Code Council (WSBCC):
 - 1. 2015 Washington State Building Code (based on 2015 International Building Code)
- C. Underwriters Laboratories (UL):
 - 1. UL 1784 - Standard for Air Leakage Tests of Door Assemblies and Other Opening Protectives

1.03 SUBMITTALS

- A. Section Includes:
 - 1. Product Data: Describe every product or item proposed for use:
 - a. Preparation instructions and recommendations.
 - b. Storage and handling requirements and recommendations.
 - c. Details of construction and fabrication.
 - d. Installation methods.
 - 2. Shop Drawings: Prepare especially for the project, showing elevations at 1/4-inch = 1'-0" and details at 3-inch = 1'-0", or larger if necessary, for clarity. Field measure openings and verify clearance prior to preparing shop drawings. Show connections to adjacent construction.
 - 3. Samples: Full range of manufacturer's colors (including custom colors) for Factory Finish.
 - 4. Manufacturer's Certificates: Certify products meet or exceed specified requirements.
 - 5. Operation and Maintenance Data: Submit lubrication requirements and frequency, and periodic adjustments required.

1.04 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Provide overhead coiling doors manufactured by a firm specializing in overhead coiling industrial doors with a minimum of five (5) years' experience.
 - 2. Install door using a Specialty Contractor, with a minimum of five (5) years' experience, engaged exclusively in providing and installing overhead coiling and other industrial doors and who is approved by the door manufacturer.
- B. Regulatory Requirements:
 - 1. Comply with the following:
 - a. Applicable Federal and State Occupational Safety and Health Regulations (OSHA)
 - b. 2018 Washington State Building Code (based on 2018 International Building Code).

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Store products in manufacturer's unopened packaging until ready for installation.
- B. Protect materials from exposure to moisture. Do not deliver until after wet work is complete and dry.
- C. Store materials in a dry, warm, ventilated weathertight location.

1.06 PROJECT CONDITIONS

- A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's absolute limits.

1.07 COORDINATION

- A. Coordinate Work with other operations and installation of adjacent materials to avoid damage to installed materials.

1.08 WARRANTY

- A. Manufacturer's Warranty: Provide manufacturer's two-year limited warranty. System warranty of all parts and components of the system except counterbalance spring and finish for 3 years or 20,000 cycles, whichever comes first.

PART 2 - PRODUCTS

2.01 MANUAL OPERATED OVERHEAD COILING DOOR

- A. Acceptable Manufacturers: Manual-operated door as manufactured by the Cookson Company, equivalent by Overhead Door Corporation; or equal.
- B. Construction and Features:
 - 1. Galvanized coating: Hot-dip galvanized steel components. Hot-dip galvanize sheet steel thinner than 1/8-inch with a zinc coating of at least 1.25 ounce per square foot in accordance with ASTM A653. Hot-dip galvanized steel 1/8-inch thick and heavier in accordance with ASTM A123.
 - 2. Curtain: Double skin interlocking roll formed interior and exterior metal slats filled with 7/8-inch thick closed cell pressure foamed in place urethane

insulation with a Flame Spread Index of 0 and a Smoke Developed Index of 10 as tested per ASTM E84. Curtain assembly materials to meet the foam plastic insulation requirements of the 2018 WSBC®, section 2603. Slat to have an R value of 8.0 as calculated using the ASHRAE Handbook of Fundamentals. Sound Transmission Class (STC) rating to be minimum 30 for the curtain and up to 22 for the entire assembly, as tested per ASTM E90. Fabricate interlocking slats from not less than 18-gauge galvanized copper bearing strip steel in a flat face pattern, No. 4 slat by Cookson Company; equivalent by Overhead Door Corporation; or equal. Reinforce bottom slat with two structural steel angles, minimum 1/8-inch thickness, back-to-back. Design door to withstand wind load of 20 pounds per square foot. Support load of barrel and curtain by two grease-sealed ball bearings.

3. Guides: Fabricate from hot-rolled structural steel angles bolted with 3/8 inch-diameter bolts to form a slot of sufficient depth to retain curtain in guides during periods of heavy wind pressure. Make wall angles continuous. Flare the top of each guide to facilitate entry of curtain and cast-iron stops. Provide galvanized steel bolts, anchor bolts, nuts, and washers. Galvanize guides and remove any bumps on curtain contact surfaces.
 4. Brackets: Fabricate from steel plate of not less than 5/16-inch thickness. Bolt brackets to wall angle with a minimum of two 1/2-inch-diameter bolts.
 5. Hood: Fabricate from one piece of 24-gauge galvanized steel sheet. Form to fit curvature of brackets with sufficient beads or flanges to prevent deflection. Provide a neoprene wind baffle in constant contact with the full width of the curtain coil.
 6. Windlocks: Provide wind locks at both ends of alternating slats to prevent pull out of slats from side guides.
 7. Gears: Cast iron with teeth cast from machine cut patterns. Provide not less than 3-inch pitch diameter for pinion gears. Design gear ratio for a maximum manual effort of not more than 35 pounds.
 8. Provide galvanized chain operator with provisions for padlocking chain operator 4 feet above the floor.
 9. Barrel: Fabricate from steel tubing not less than 4 inches in diameter, designed to limit maximum deflection to 0.03-inch per foot of span. Provide oil-tempered torsion springs capable of correctly counterbalancing the weight of the curtain. Provide adjustable springs by means of an exterior wheel.
 10. Weatherstrip at side guides to properly seal door perimeter without affecting ease of operation. Provide flexible neoprene strip at door bottom.
- C. Factory Finish: The finish on the door curtain, guides, hood, and bottom bar shall be factory applied coating; Cookson ColorCote or equal consisting of the following:
1. Hot dipped galvanized G-90 coating consistent with ASTM A-653.
 2. Bonderized coating for prime coat adhesion.
 3. Factory applied thermosetting powder coating applied with a minimum thickness of 2 mils. The color shall be selected by the Owner and shall be chosen from manufacturer's full-range (standard and custom) of color charts.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install doors using manufacturer's trained and authorized specialist.

- B. Install, adjust, and test doors in accordance with manufacturer's printed instructions.
- C. Attach guides to concrete walls with machine bolts in concrete anchors. Attach guides to steel construction using drilled and tapped machine bolts. Use anchorage devices to securely fasten assembly to wall construction and building framing without distortion or stress. Securely and rigidly brace components suspended from structure. Secure guides to structural members only. Fit and align assembly including hardware; level and plumb, to provide smooth operation.
- D. Seal bottom of door guides to the floor to prevent water and wind leakage at base of door guides.
- E. Coordinate work with other trades.

3.02 CLEANING

- A. Clean curtain and components using non-abrasive materials and methods recommended by manufacturer.
- B. Remove labels and visible markings.
- C. Touch-up, repair, or replace damaged products before Substantial Completion.

3.03 PROTECTION

- A. Protect installed products until completion of project.

END OF SECTION

SECTION 08700

FINISH HARDWARE

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Furnish and install all commercial finish hardware.
 - 2. Door hardware includes, but is not necessarily limited to, the following:
 - a. Mechanical door hardware.
 - 3. Coordination, preparation, and installation of Finish Hardware by a certified Architectural Hardware Consultant (AHC).

1.02 REFERENCES

- A. American National Standards Institute (ANSI) and Builders Hardware Manufacturer's Association (BHMA) Product standards for all specified items:
 - 1. A156.1 Butts and Hinges
 - 2. A156.2 Bored and Preassembled Locks and Latches
 - 3. A156.3 Exit Devices
 - 4. A156.4 Door Controls-Closers
 - 5. A156.5 Auxiliary Locks and Associated Products
 - 6. A156.6 Architectural Door Trim
 - 7. A156.7 Template Hinge Dimensions.
 - 8. A156.8 Door Controls-Overhead Holders
 - 9. A156.13 Mortise Locks and Latches
 - 10. A156.15 Closer Holder Release Devices
 - 11. A156.16 Auxiliary Hardware
 - 12. A156.18 Materials and Finishes
- B. Americans with Disabilities Act (ADA):
 - 1. 2010 ADA Standards for Accessible Design
- C. Door and Hardware Institute (DHI):
 - 1. Basic Architectural Hardware
 - 2. Abbreviations and Symbols
- D. Underwriters Laboratories Inc.:
 - 1. UL 10B Fire Tests of Door Assemblies
 - 2. UL 10C Standard for Positive Pressure Fire Tests of Door Assemblies
 - 3. UL 305 Panic Hardware
 - 4. UL 1784 Standard for Air Leakage Tests of Door Assemblies and Other Opening Protectives
- E. National Fire Protection Association:
 - 1. NFPA 80 Standard for Fire Doors, Fire Windows
 - 2. NFPA 105 Standard for Smoke Door Assemblies and Other Opening Protectives
 - 3. NFPA 252 Standard Methods of Fire Tests of Door Assemblies

1.03 SUBMITTALS

- A. Product Data: Fully describe every product proposed for use. Clearly identify substitutions or changes, as a result of coordinating hardware components.
- B. Shop Drawings: Submit hardware list and schedule prepared by a certified Architectural Hardware Consultant in accordance with DHI recommendations. The Owner's review of schedule shall neither be construed as a complete check nor shall it relieve the Contractor of responsibility for errors, deviations, or omissions from the specified requirements to provide complete door hardware for the Project. Organize the hardware list and schedule in the same order as the Door Hardware Schedule at the end of Part 3 of this specification Section. Include the following information:
 - 1. Type, style, function, size, label, hand, and finish of each door hardware item.
 - 2. Manufacturer of each item.
 - 3. Fastenings and other pertinent information.
 - 4. Location of each door hardware set; cross-referenced to the Door Hardware Schedule.
 - 5. Explanation of abbreviations, symbols, and codes used in the schedule.
 - 6. Mounting locations for door hardware. Supply templates to door and frame manufacturers to enable proper and accurate sizing and locations of cutouts for hardware.
 - 7. Manufacturer's Instructions: For mounting, installing and adjusting hardware. Installation instructions shall be available at jobsite during construction for reference.
 - 8. Door and frame sizes, materials, hand, and door rating.
 - 9. Description of electrified door hardware sequences of operation and interfaces with other building control systems.
- C. Door Hardware Schedule: Prepared by or under the supervision of Installer, detailing fabrication and assembly of door hardware, as well as installation procedures and diagrams. Coordinate final door hardware schedule with doors, frames, and related work to ensure proper size, thickness, hand, function, and finish of door hardware.
- D. Keying Schedule: Contact Owner representative for information regarding Owner's keyway system. Prepared under the supervision of the Owner, separate schedule detailing final keying instructions for locksets and cylinders in writing. Include keying system explanation, door numbers, key set symbols, hardware set numbers and special instructions. Owner to approve submitted keying schedule prior to the ordering of permanent cylinders.
- E. Warranties: Submit special warranties as specified in this Section.
- F. Maintenance Tools and Instructions: Furnish a complete set of specialized tools and maintenance instructions for the Owner's continued adjustment, maintenance, removal and replacement of door hardware. For each type of door hardware to include in maintenance manuals
- G. Product Test Reports:
 - 1. For compliance with accessibility requirements, based on evaluation of comprehensive tests performed by manufacturer and witnessed by a qualified testing agency, for door hardware on doors located in accessible routes.
 - 2. Indicating compliance with cycle testing requirements, based on evaluation of comprehensive tests performed by manufacturer and witnessed by a qualified independent testing agency.

- H. Operating and Maintenance Manuals: Provide manufacturers operating and maintenance manuals for each item comprising the complete door hardware installation in quantity as required in Division 01, Closeout Submittals. The manual to include the name, address, and contact information of the manufacturers providing the hardware and their nearest service representatives. Include final hardware and keying schedule. The final copies delivered after completion of the installation test to include "as built" modifications made during installation, checkout, and acceptance.

1.04 QUALITY ASSURANCE

- A. Hardware Supplier:
 - 1. Engaged in supplying builder's hardware for commercial projects of similar nature and comparable size for at least 5 years.
 - 2. Has a full-time certified Architectural Hardware Consultant (AHC) on staff that will prepare the hardware submittal and supervise installation of all finish hardware.
- B. Architectural Hardware Consultant (AHC) Qualifications: A person who is experienced in providing consulting services for door hardware installations that are comparable in material, design, and extent to that indicated for this Project and who is currently certified by DHI as follows:
 - 1. For door hardware, an Architectural Openings Consultant (AOC).
- C. Perform Work in accordance with the following requirements:
 - 1. ANSI/BHMA A156 Series
 - 2. NFPA 80
 - 3. UL 305
- D. Regulatory Requirements:
 - 1. 2018 Washington State Building Code (WSBC), shall be used as the primary regulatory requirement for access individuals with disabilities. Federal and other State disabled access requirements shall be followed for conditions not regulated by the WSBC.
 - 2. 2010 ADA Standards for Accessible Design.
 - 3. Underwriters' Laboratories' requirements for fire-rated assemblies.
- E. SOURCE LIMITATIONS: Obtain each type and variety of Door Hardware specified from a single source and qualified supplier unless otherwise indicated.
- F. MEANS OF EGRESS DOORS: Latches do not require more than 15 lbf to release the latch. Locks do not require use of a key, tool, or special knowledge for operation.
- G. KEYING CONFERENCE: Conduct conference at Project site. In addition to Owner and Contractor, conference participants shall also include Installer's Architectural Hardware Consultant and Owner's security consultant. Incorporate keying conference decisions into final keying schedule after reviewing door hardware keying system including, but not limited to, the following:
 - 1. Function of building, flow of traffic, purpose of each area, degree of security required, and plans for future expansion.
 - 2. Preliminary key system schematic diagram.
 - 3. Requirements for key control system.
 - 4. Requirements for access control.
 - 5. Address for delivery of permanent keys, cores, access control credentials, software and related accessories.

1.05 SPECIAL WARRANTY

- A. Door Hardware:
 - 1. Structural failures including excessive deflection, cracking, or breakage.
 - 2. Faulty operation of doors and door hardware.
 - 3. Deterioration of metals, metal finishes, and other materials beyond normal weathering and use.
 - 4. Electrical component defects and failures within the systems operation.
- B. Standard Warranty Period: One (1) year from date of Substantial Completion, unless otherwise indicated.
 - 1. Exit Devices: 5 years.
 - 2. Closer: 10 years.

1.06 MAINTENANCE SERVICE

- A. Maintenance and Instructions: Furnish a complete set of specialized tools and maintenance instructions as needed for Owner's continued adjustment, maintenance, and removal and replacement of door hardware.

1.07 DELIVERY

- A. Deliver hardware with items for each opening packed together, complete and ready for installation with necessary fittings, trim, fasteners and accessories. Mark packages with opening number for identification.
- B. Deliver permanent keys, cylinders, cores, and related accessories directly to Owner via registered mail or overnight package service. Instructions for delivery to the Owner shall be established at the Keying Conference. Deliver templates and installation instructions.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Provide hardware that complies with applicable building code requirements. Provide all hardware, smoke gaskets, and thresholds listed for a fire assembly of the required rating for all doors required to be fire rated.
- B. Provide hardware that fits perfectly, is of uniform color, and is free of imperfections affecting serviceability or marring appearance.
- C. Deliver hardware in a timely manner as required by the Contractor's Schedule. Furnish materials or templates to others when required for factory installation or preparation.
- D. Provide adequate functioning hardware for all doors whether scheduled or not.
- E. Where the hardware manufacturer's product number specified does not provide hardware meeting fire codes, condition of use, function, hand, mounting conditions, strikes, stops, keepers or fasteners required for a satisfactory installation, provide items of equivalent quality or better meeting applicable project conditions.
- F. Hardware shall be from one manufacturer for each item specified in Part 2.
- G. Coordinate with the work of other trades in furnishing and placing finish hardware.

2.02 HARDWARE

- A. Fasteners: Furnish all necessary screws, bolts or other fastenings of suitable size and type to anchor the hardware in position for heavy use and long life; provide fasteners that match the material and finish of the hardware. Where necessary, provide expansion shields, sex bolts, screws, or other anchors appropriate for substrate that the hardware is installed on. Provide machine screws and soft metal expansion shields to fasten hardware to concrete, masonry, plaster, and similar materials. Plastic or fiber inserts are not acceptable.
- B. Finish: Provide all steel hardware with the following finish:
 - 1. US32D (630) satin stainless steel.
 - 2. Aluminum hardware shall be clear anodized unless otherwise noted.
- C. Locksets:
 - 1. Cylindrical Locksets: BHMA A156.2 Heavy duty, with interior parts of stainless steel and other noncorrosive metals. Provide key-in-knob, 6-pin cylinders to match Owner's keyway. Schlage Series "C" with stainless steel mechanism with lever handle (lever shall be curved with a return to within ½ of the door), "Rhodes;" Corbin Russwin "CL3100;" or equal. Provide UL-rated latch bolts for fire-rated doors.
 - 2. Mortise Locksets: BHMA A156.13 Heavy duty, with 6-pin cylinder matching Owner's system. Schlage "L" Series; Corbin 9700 Series; or equal. Provide lever handles (lever shall be curved with a return to within ½ of the door). Design: Schlage 03; Corbin ML2000 Series; or equal.
 - 3. Backset: 2-3/4 inches.
 - 4. Strikes: Furnish standard strikes with curved lip extended to protect trim from being marred by latch bolt. Provide dust boxes. Verify whether standard or ANSI cutouts are provided in metal frames.
 - 5. Cylinder Guards: Free-spinning, tapered, to prevent the forced unscrewing of the lock cylinder. Keedex or equal.
- D. Keys and Keying:
 - 1. All keyed locksets and padlocks shall be supplied with interchangeable core cylinders to match the Owner's interchangeable core and keying system
 - 2. All cylinders shall be supplied with temporary construction cores for Contractor's use. Permanent cores shall be delivered directly to the Owner's Representative.
 - 3. Tag keys with location, and schedule heading number and deliver them to Owner upon completion of work. Deliver permanent keys directly to Owner.
- E. Furnish construction keying. Provide construction master keyed cylinders or temporary keyed construction cores. Provide construction master keys in quantity as required by project Contractor. Replace construction cores with permanent cores. Furnish permanent cores for installation as directed under specified "Keying Conference". Deliver two (2) extra keys directly to the Owner's Representative. Retain construction keys and cores for future lockout purposes. Padlocks:
 - 1. Solid brass or stainless steel, with case hardened steel shackle, minimum 1-inch clearance, with 9-inch-long chain.
 - 2. Keying: Interchangeable 6-pin cylinders matching Owner's keyway.
- F. Hinges:
 - 1. Butts, Full Mortised. Conform to ANSI/BHMA A156.1. Provide heavy weight, 5-knuckle ball bearing stainless steel butts for interior doors and heavy weight 5-knuckle stainless steel ball bearing butts for exterior doors.

2. Stanley FBB199 for interior doors, Stanley FBB199 for exterior doors, McKinney, or equal.
 3. Provide non-removable pins for all exterior outswinging doors.
 4. Unless otherwise specified, determine the size of the butts by the following table:
 - a. Doors 1-¾-inch thick and up to 42-inch wide to have 4-½-inch.
 - b. Doors 2-inch-thick, and 1-¾-inch doors over 42-inch wide to have 5-inch extra heavy.
 5. Provide widths sufficient to clear trim projection when door swings 180 degrees.
 6. Provide three (3) hinges to 90-inch high for each door leaf:
 - a. Four (4) hinges to 120-inch high for each door leaf.
 - b. Five (5) hinges to 150-inch high for each door leaf.
 - c. Six (6) hinges to 180-inch high for each door leaf.
- G. Closers: Provide heavy-duty door closers of one manufacturer; non-handed double arm, with metal covers full rack and pinion type ANSI/BHMA A156.4 Grade 1 with steel spring and non-gumming, non-freezing hydraulic fluid; non-sized adjustable for interior doors to 5 feet wide and exterior doors to 4 feet wide (cylinder sizes 1 through 6).
1. Provide controls for regulating closing, latching speeds and back check non-handed double arm. Provide all closers with a cushion stop built into closer arm that can be adjusted to stop door opening at a pre-set angle. Provide closers designed with spring power adjustment required for easy opening usable by the physically disabled; 8.5 [5] pounds for exterior doors and 5 pounds for interior doors.
 2. Provide parallel-arm closers at reverse bevel doors and where doors swing full 180 degrees.
 3. Include all through bolts, mounting brackets, mounting plates, shoes, and accessories required for proper function and installation.
 4. Furnish hold open arms when specified. Provide maximum degree of opening attainable consistent with closer function specified.
 5. Provide plated finish on metal cover, arm, and fasteners.
 - a. Acceptable Manufacturers:
 - 1) LCN 4111 Series or equal; plated finish.
- H. Exit Devices, Touch bar type: Heavy-duty type UL listed for accident hazard and capable of meeting UL "A" label rating, rim latch or mortise design with ¾-inch anti-friction latch bolt. Latch bolt shall retract when horizontal pressure is exerted on touch bar. Latch bolts on vertical rod devices shall remain retracted until door closes. Plate all exposed surfaces to match hardware finishes. Provide stainless steel touch bars, US32D finish.
- I. Doorstop, Floor-Mounted: Stainless steel or solid brass plated to match hardware. Provide risers to increase height as required to suit conditions.
- J. Doorstop, Wall-Mounted: Stainless steel or solid brass plated to match hardware. Furnish with durable high-grade shock-resistant rubber bumper.
- K. Doorstop/Holder, Floor-or Wall-Mounted: Provide a strike with a hinged hook that fits flush with the strike when unit is acting as a stop only. The hook is manually lifted to engage the hold-open lug. When released, the hook drops back flush with the strike. Provide in stainless steel or solid brass finished or plated to match hardware. Note: UL requirements do not permit hold-open feature on fire-rated door assemblies.

- L. Kickplates: All material shall be stainless steel, bronze or brass finished to match hardware, 0.050 gauge with beveled edges, 12-inch high x 1-1/2-inch narrower than single door or 1-inch narrower than pairs of doors.
- M. Thresholds: Furnish thresholds to match those used at adjacent existing doors.
- N. Silencers: Pneumatic rubber, installed in metal frame stops. Furnish three for single doors and two for pair of doors. Omit silencers where door seal occurs and for exterior doors.
- O. Weatherstripping: Provide door seal at all exterior doors: 3/16 inch by 3/8 inch closed-cell PVC with adhesive back tape. Pemko 241, Reese, or equal.
- P. Manual Flush Bolts: Provide concealed manual top and bottom flush bolts on the active leaf of pairs of doors. Provide bolts designed to be mounted in the edge of the door with concealed vertical rod activators, having a 5/8-inch throw and a 7/8-inch adjustment and a spring snap lever action. Provide dustproof strike for bottom flush bolt. Glynn-Johnson #FB-6 for metal doors.
- Q. Mortised Drop Bottom: Fully mortised, plunger activated, automatic drop bottom, extruded tempered aluminum, clear anodized finish, grey sponge neoprene inserts, stainless steel fasteners suitable for hollow metal doors. Pemko 434PKL, Reese, or equal. Door Shoe Sweep: L-Shaped Aluminum with neoprene sweep insert and integral rain drip. Pemko 216 A PK; Reese, or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. General: Contractor is responsible for the proper location, fit and operation of all finish hardware items under the appropriate headings. Install finish hardware according to the Drawings, Specifications and finish hardware manufacturer's instruction. Place and adjust stops and or shim hinges to provide clearance for smoketight gaskets and to prevent doors from binding on stops or frames.
 - 1. Examine scheduled openings, with Installer present, for compliance with requirements for installation tolerances, labeled fire door assembly construction, wall and floor construction, and other conditions affecting performance.
 - 2. Notify Engineer of any discrepancies or conflicts between the door schedule, door types, drawings and scheduled hardware. Proceed only after unsatisfactory conditions have been corrected and such discrepancies or conflicts have been resolved in writing.
- B. Make the right-hand door or right-hand reverse door the active leaf of a pair of doors, unless indicated otherwise.
- C. Mounting Heights: Mount door hardware at the following heights unless specifically indicated otherwise on the Drawings.
 - 1. Locksets and latchsets: 38 inches above finish floor to center of lever.
 - 2. Deadbolts: Not more than 44 inches above finish floor to operating trim.
 - 3. Exit Devices: 40 inches above finish floor to center of touch bar.
- D. Fitting: Properly cut, drill, shape, reinforce, and otherwise fabricate items upon which finish hardware is to be installed according to templates, physical hardware and finish hardware manufacturer's instructions to ensure proper attachment and function.

- E. Key Control System: Tag keys and place them on markers and hooks in key control system cabinet, as determined by final keying schedule.
- F. Adjustment: Install all lock cylinders to accept keys with the teeth facing up. Adjust, shim, align all hardware to operate smoothly without binding or rubbing and so that self-closing and automatic closing doors will latch automatically.
- G. Doorstops/Holders/Keepers, Cane Bolts:
 - 1. Where physical conditions do not permit installation of the specified doorstop, holder, or keeper without creating a tripping hazard, provide a suitable item of comparable quality that will perform the intended function and can be installed such as a wall-mounted or surface overhead door-mounted device.
 - 2. Locate doorstops, holders, and keepers so doors will be held open in the maximum open position.

3.02 ADJUSTING

- A. Adjust and check each operating item of door hardware and each door to ensure proper operation and function of every hardware component. Replace hardware components that cannot be adjusted to operate as intended.
- B. Adjust door closers to compensate for building pressures and operation of forced air mechanical equipment to comply with accessibility requirements.
- C. Initial Adjustment: Adjust and check each operating item of door hardware and each door to ensure proper operation or function of every unit. Replace units that cannot be adjusted to operate as intended. Adjust door control devices to compensate for final operation of heating and ventilating equipment and to comply with referenced accessibility requirements.
 - 1. Door Closers: Adjust sweep period to comply with accessibility requirements and requirements of authorities having jurisdiction.
- D. Occupancy Adjustment: Approximately 6 months after date of Substantial Completion, Installer's Architectural Hardware Consultant shall examine and readjust each item of door hardware, including adjusting operating forces, as necessary to ensure function of doors and door hardware.
- E. Defective Installation: Appearance, installation, attachment, and operation of finish hardware shall be subject to review by the Owner. Hardware that is scratched, broken, dirty, improperly painted, binds or fails to function shall be replaced.

3.03 CLEANING AND PROTECTION

- A. Clean adjacent surfaces soiled by door hardware installation. Clean hardware components as necessary to restore proper finish.
- B. Provide protection during subsequent work progress to maintain conditions that ensure door hardware is in perfect working order and without damage or deterioration at the time of Substantial Completion.

3.04 HARDWARE SCHEDULE

- A. The Contractor is responsible for providing all finish hardware together with all components, accessories, and fasteners necessary for a complete and smooth operating installation.
- B. The door hardware sets represent the design intent and direction of the owner and architect. They are a guideline only and should not be considered a detailed hardware schedule. Discrepancies, conflicting hardware, and missing items should

be brought to the attention of the architect with corrections made prior to the bidding process. Omitted items not included in a hardware set should be scheduled with the appropriate additional hardware required for proper application and functionality.

- C. The supplier is responsible for handing and sizing all products as listed in the door hardware sets. Quantities listed are for each pair of doors, or for each single door.
- D. Only one manufacturer per product may be used on the project.
- E. Items in the following hardware schedule are referenced for standards of quality and utility.

Item	1st Manufacturer	2nd Manufacturer
Butts, hinges	Stanley	Hager, or equal
Locksets, latches, cylinders, padlocks	Schlage	Corbin
Closers	LCN	Sargent, or equal
Exit devices	Von Duprin	Sargent, or equal
Silencers, stops, holders	Glynn-Johnson	Builder's Brass, or equal
Flush bolts, strikes	Ives, Glynn-Johnson	Builder's Brass, or equal
Door Shoe with Drip, Automatic Door Bottom with drip	Pemko	Reese, or equal
Thresholds	Pemko	Reese, or equal

- F. Schedule of Hardware Groups:
 - 1. Hardware Group 1 (Doors 01 and 03)
Each door shall have:
1-1/2 pair butt hinges
1 mortise exit device, ANSI function 09
1 door closer
1 kickplate
1 door shoe
1 set weatherseal gasketing
1 door stop/holder
1 threshold
 - 2. Hardware Group 2 (Door 02)
Each door shall have:
1 padlock

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SECTION 09250

GYPSUM WALLBOARD

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Provide gypsum board ceiling construction. Provide taping and finishing of gypsum board ready for paint or other finish coatings.

1.02 REFERENCES

A. ASTM International (ASTM):

1. ASTM C36 – Standard Specification for Gypsum Wallboard.
2. ASTM C475 – Standard Specification for Joint compounds and Joint Tape for Finishing Gypsum Board.
3. ASTM C514 – Standard Specification for Nails for the Application of Gypsum Wallboard.
4. ASTM C557 – Standard Specification for Adhesives for Fastening Gypsum Wallboard in Wood Framing.
5. ASTM C630 – Standard Specification for Water-Resistant Gypsum Backing Board.
6. ASTM C840 – Standard Specification for Application and Finishing of Gypsum Board.
7. ASTM C1002 – Steel Drill Screws for the Application of Gypsum Board.
8. ASTM E119 – Standard Test Methods for Fire Tests of Building Construction and Materials

B. Gypsum Association:

1. GA 216-07: Recommended Specifications for the Application and Finishing of Gypsum Board.

1.03 SUBMITTALS

- ###### A. Submit Product Data giving manufacturer's technical data for all materials and systems proposed for use.

- ###### B. For all assemblies required to be fire-rated for which a "Listed Design" is not provided in this Section, submit Drawings and Specifications of an appropriate design that has been tested and is "Listed" by a Nationally Recognized Fire Testing Agency such as Underwriters Laboratory; Warnock Hersey; or approved equal.

1.04 QUALITY CONTROL

- ###### A. Comply with the more restrictive or conservative of the following.

- B. Comply with the following regulatory requirements:
 - 1. Washington State Building Code (WSBC), 2015 edition, especially Chapter 47, and referenced standards.
 - 2. Where fire-rated assemblies are required comply with detail specifications stated in the "Assembly Listing."
- C. Where fire-rated assemblies are required comply with detail specifications for a specific assembly that has been tested in accordance with ASTM E119 or other applicable ASTM standards and has been given a fire rating and by a nationally recognized fire testing laboratory acceptable to the Building Official, Fire Marshal and other regulating agencies having jurisdiction such as the UL Fire Resistance Directory, ICBO Evaluation Reports, or Gypsum Association "Fire Resistance and Sound Control Manual.
- D. Comply with Gypsum Association GA-216-07, "Recommended Specifications for the Application and Finishing of Gypsum Board".
- E. Comply with ANSI Standard Specifications A97.1 "Applications and Finishing of Wallboard."

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials in original packages, containers or bundles bearing brand and manufacturer's name.
- B. Store all materials in protected dry storage areas. Neatly stack in flat position on spacers to prevent sagging and contact with concrete slabs.

PART 2 - PRODUCTS

2.01 DRYWALL MATERIALS

- A. Gypsum Board: 5/8-inch, Type X, fire-rated, moisture-resistant, tapered edges, 4 feet wide by longest lengths available to keep end joints to a minimum, meeting Federal Specification SS L-30D, Type III, Grade X, Class I and ASTM C36. Georgia-Pacific Tough Rock; United States Gypsum (USG) sheetrock Firecode "C"; National Gypsum (NG) Fire-shield; or approved equal.

2.02 ACCESSORIES

- A. Corner Bead: At all exterior corners, galvanized steel, 1-1/4 x 1-1/4 Dur-A-Bead #103; United States Gypsum; National Gypsum; or approved equal.
- B. Edge Trim: Use metal trim in exposed locations at intersection of drywall with other materials, and as shown, U.S. Gypsum "J" Mld #200A or "L" Mld #200B; National Gypsum; or approved equal.
- C. Rigid Furring Channels: Galvanized hat-shaped channels for furring out walls and ceilings.
 - 1. Minimum Base-Steel Thickness: 0.0296 inch.
 - 2. Depth: 7/8 inch.

2.03 FASTENERS

- A. Gypsum Board to Metal Supports: ASTM C1002, self-tapping bugle head screws, 1-inch-long for single layer; 1-5/8 long for second layer.
 - 1. Use Type S screws to 25-gauge supports.
 - 2. Use Type S 12 screws to 20-gauge or heavier supports.

2.04 JOINT TREATMENT AND FINISHING

- A. Reinforcing Tape: USG Perf-A-Tape; NG Gold Bond; or approved equal.
- B. Taping Compound: USG Ready-to-use joint compound-tapping; NG Gold Bond; or approved equal.
- C. Topping Compound: USG Ready-to-use joint compound-topping; NG Gold Bond; or approved equal.

PART 3 - EXECUTION

3.01 GYPSUM BOARD INSTALLATION

- A. Install gypsum board systems in accordance with ASTM C840 and GA 216.
- B. General: Where fire-rated ceilings are required, install gypsum board in accordance with requirements for a fire-rated assembly that has been tested and "Listed" by a nationally recognized fire testing agency in accordance with ASTM E119.
- C. Edge and ends of gypsum board shall be in moderate contact. Attach gypsum boards to framing members with screws. For non-rated assemblies, space screws at 8 inches on center on edges of gypsum board for vertical surfaces and at 7 inches on center for horizontal surfaces. Space screws at 12 inches on center at intermediate members. Stagger fasteners in adjacent edges at joints. Drive fasteners until their heads are slightly below the surface of the gypsum board, but without breaking the cover. After all fasteners have been installed hammer on walls to detect loose fasteners and push on gypsum board adjacent to fasteners to detect movements. Drive loose fasteners tight or replace them with other fasteners approximately 1-½ inches away and remove loose fasteners.
- D. Install edge trim at exposed edges, where gypsum board abuts or joins other materials and where shown. Attach edge trim with fasteners 9 inches on center.
- E. Cut openings for outlet boxes, pipes and similar items with a saw, router, or other device that produces a clean, tight fitting hole without tearing the paper face or back and without fracturing the gypsum core.
- F. Install control or expansion joints as required and/or recommended by manufacturer.

3.02 FINISHING AND JOINT TREATMENT

- A. Mix and size joint compound in accordance with manufacturer's instructions. Spread a thin layer of compound over joint and embed tape in compound leaving sufficient

compound under tape to provide proper bond. Spot nail heads. Reinforce interior angles with perforated tape neatly folded to form straight, true corner. Reinforce exterior corners with specified corner bead. Backer board shall be taped and screwheads spotted prior to installing face layer.

- B. Allow compound to dry overnight. Sand lightly. Cover tape with topping cement spread evenly and slightly beyond tapered edge of wallboard. Apply second coat to screwheads. Feather all edges of topping compound.
- C. Allow compound to dry and then sand lightly. Apply a final skim coat of topping cement. Feather edges 8 inches to 10 inches each side of joint. Feather out final coat at screwheads to 10-inch-diameter.
- D. Sand to true even surface with very fine paper. Avoid heavy pressure that might scuff paper face of wallboard. Leave ready for painting.

3.03 LEVELS OF GYPSUM BOARD FINISH

- A. All exposed gypsum board intended to receive a painted finish shall have a Level 4 finish unless a different level of finish is indicated on the Finish Schedule. All concealed gypsum board shall have a Level 1 finish minimum.
- B. Description of Levels of Finish (From GA-214):
 - 1. Level 1: All joints and interior angles shall have tape embedded in joint compound. Surface shall be free of excess joint compound. Tool marks and ridges are acceptable.
 - 2. Level 2: All joints and interior angles shall have tape embedded in joint compound and one separate coat of joint compound applied over all joints, angles, fastener heads, and accessories. Surface shall be free of excess joint compound. Tool marks and ridges are acceptable. Apply a skim coat of topping cement to the entire surface of all MR (GR) green moisture resistant gypsum board.
 - 3. Level 3: All joints and interior angles shall have tape embedded in joint compound and two separate coats of joint compound applied over all joints, angles, fastener heads, and accessories. All joint compound shall be smooth and free of tool marks and ridges. Note: It is recommended that the prepared surface be coated with a primer/sealer prior to the application of final finishes. See painting/wallcovering specification in this regard.
 - 4. Level 4: All joints and interior angles shall have tape embedded in joint compound and three separate coats of joint compound applied over all joints, angles, fastener heads, and accessories. All joint compound shall be smooth and free of tool marks and ridges. Note: It is recommended that the prepared surface be coated with a primer/sealer prior the application of final finishes. See painting/wallcovering specification in this regard.

END OF SECTION

SECTION 09679

CHEMICAL RESISTANT EPOXY COATING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Chemical-resistant, pigmented epoxy-based resin seamless coating system with urethane topcoat for application on floor and wall/base surfaces of secondary containment spill areas.

1.02 REFERENCES

A. ASTM International (ASTM):

1. C321 Standard Test Method for Bond Strength of Chemical-Resistant Mortars
2. D638 Standard Test Method for Tensile Properties of Plastic
3. D695 Standard Test Method for Compressive Properties of Rigid Plastics
4. D822/D822M Standard Practice for Filtered Open-Flame Carbon-Arc Exposures of Paint and Related Coatings
5. D4060 Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser
6. E162 Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source

1.03 SUBMITTALS

A. Submit the following:

1. Product Data: Fully describe all products proposed for use.
2. Samples: Finished flooring and standard line of colors and textures. Include a 3- by 3-inch square sample of the proposed system. Sample color, texture, and thickness shall be representative of overall appearance of finished system subject to normal tolerances.
3. Test Reports: Independent laboratory test results of specified physical characteristics.
4. Installer's Qualifications:
 - a. Material manufacturer's written approval of installer including verification of the coating manufacturer's training of the installer.
 - b. Provide a list of at least five similar installations completed by installer within last 2 years. Provide contact names of the facility owner's personnel knowledgeable of the installation with their current telephone numbers, along with background data on the coating system installed with the reference.
 - c. Installer's Jobsite Foreman's Qualifications
5. Submit a list of similar installations performed by the foreman in the last five (5) years.
6. Submit training record of the foreman by the coating manufacturer.
7. Written verification of SSPC certified concrete coating inspector for this project.

8. If admixtures or curing compounds are proposed for use, the Contractor shall submit a written statement to the Engineer that the use of the proposed admixtures and curing compounds will not interfere with the bond or cure of the specified coating system. The written statement shall be signed by the Contractor, coating applicator, and coating manufacturer.
9. System shall be in compliance with low VOC and/or the Indoor Air Quality requirements per Washington State and Federal regulations.

1.04 QUALITY ASSURANCE

- A. Qualifications:
 1. The coating work shall be provided by a licensed specialty contractor who is engaged exclusively in the installation of chemical resistant epoxy coatings, has satisfactorily completed at least five similar installations within the last 2 years, and approved by the chemical resistant epoxy coating material manufacturer.
 2. The applicator's foreman shall have received trained by the coating manufacturer in the installation of similar coating systems.
 3. The applicator's foreman, or the applicator's QC personnel, or the chemical resistant coating manufacturer's representative shall be a SSPC certified concrete coating inspector. The SSPC certified concrete coating inspector shall visit the site as required to sign off on the surface preparation and coating installation.
 4. Qualified journeymen proficient in epoxy coating application shall perform all work.
- B. Comply with the manufacturer's recommendations and installation instructions of the coating material.

1.05 PRODUCT DELIVERY

- A. Deliver materials in manufacturer's labeled, unopened containers, clearly identified with the product type and batch number.
- B. Copies of Material Safety Data Sheets (MSDS) for all components shall be kept on site for review by the Engineer or other personnel.

1.06 PROJECT CONDITIONS

- A. Unless approved, in writing, by Contractor, coating applicator, and coating manufacturer, do not use admixtures in concrete slabs to receive epoxy coating, which might interfere with bond or cure of epoxy coating. Do not use concrete curing compounds; any concrete curing compound used to be removed in its entirety prior to epoxy coating applications
- B. Maintain substrate temperature at 70°F for at least 48 hours before and after installation.
- C. Concrete surfaces on grade shall have been constructed with a 15-mil vapor barrier to protect against the effects of vapor transmission and possible delamination of the system.

1.07 WARRANTY AND SPECIAL GUARANTEE

- A. The warranty for all products and work shall comply with the requirements of the Contractor's General Warranty and Guarantee described in the General Conditions and the Supplementary Conditions.

- B. Special Guarantee: In addition to the General Warranty and Guarantee, provide a written two (2) year special guarantee signed by the installer, material manufacturer, and Contractor covering the repair or replacement of the entire coating system to correct shrinkage cracks, bond failure, or surface deterioration resulting from causes other than abuse. Refer to Section 01700, Subsection 1.07.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Provide a coating system consisting of a bond coat, a liquid applied membrane, a base coat and two topping coats consisting of epoxy resins which cure to a hard, dense finish, having the physical characteristics specified in paragraph 2.03 of this Section.
- B. Manufacturers: Dex-O-Tex by Crossfield Products Corporation; Stonhard Stonchem 600 Epoxy System; Dur-A-Guard by Dur-A-Flex Inc.; Sherwin-Williams Protective and Marine Coatings General Polymers; or equal.

2.02 SYSTEM DESCRIPTION

- A. Products of the first named maker are used to establish the type and quality of product required. Equivalent products by other makers may be submitted for evaluation.
- B. System:
1. Substrate preparation as recommended by manufacturer.
 2. Primer: Vapor Control Primer 200 or Vapor Control Primer 100 Type II
 3. Second coat: Cheminert SC Membrane
 4. Base coat: Posi-Tred CR; include aluminum oxide grit with floor coat.
 5. Top coat: Clear Posi-Tred CR (two coats).

2.03 PHYSICAL CHARACTERISTICS

- A. The primer shall have the following physical characteristics when fully cured:
1. Adhesion, ASTM D4541: > 400 psi
 2. Compressive Strength, ASTM D695: 12,000 psi
 3. Tensile Strength, ASTM D638: 4,200 psi
 4. Tensile Elongation, ASTM D638: 2.7%
 5. Microbial Resistance, ASTM G21: Passes Rating 1
 6. Alkali resistance, ASTM D1308: resistant
 7. Moisture Vapor Emissivity, ASTM E96: 0.158 Perms
- B. The membrane shall have the following physical characteristics when fully cured:
1. Compressive Strength, ASTM D695: 4,000 psi
 2. Tensile Strength, ASTM D638: 1,500 psi
 3. Tensile Elongation, ASTM D638: 96%
 4. Hardness, ASTM D2240, Shore D: 35 to 40
 5. Flammability, ASTM D635: Self Extinguishing, bonded to concrete
 6. Water absorption, ASTM D570: < 0.2%
 7. Tear Strength, ASTM D638: 120 lb/in
 8. Microbial Resistance, ASTM G21: Passes Rating 1
- C. The top coats shall have the following physical characteristics when fully cured:
1. Surface Hardness, ASTM D2240, Shore D: 80 to 85

2. Tensile strength, ASTM D638: 1,200 psi
 3. Flexibility, ASTM D1737, No loosening
 4. Adhesion, ASTM D4541, > 400 psi
 5. Adhesion (Crosshatch), ASTM D3359, 5B (no loosening)
 6. Thermal Shock Resistance, ASTM D1211: No failure
 7. Water Adsorption, MIL-D-3134, 7-day immersion: Nil
 8. Coefficient of Static Friction Rubber Shoe Surface, MIL-D-3134, (saltwater solution on surface): 0.95 static friction, 0.89 sliding friction
 9. Fire Resistance, ASTM E648, FTMS, NFPA 253, SBSIR 75-950, Critical Radiant Heat Flux: > 1.07 watts/cm
 10. Microbial Resistance, ASTM G21: Passes Rating 1.
- D. Chemical Resistance:
1. Provide a coating system that shows little or no damage after 72-hour immersion in concentrated Hydrochloric Acid, 95% Sulfuric Acid, 25% Hydrofluosilicic Acid, 50% Sodium Hydroxide, gasolines, and similar chemicals.
 2. Provide a floor system that shows little or no damage from acids, alkalis, salts and solvents when tested in accordance with a test procedure similar to Crossfield Corporation Laboratories' test procedure using 36 different chemicals.

PART 3 - EXECUTION

3.01 INSPECTION

- A. Allow concrete slabs to cure for at least 28 days before applying epoxy coating.
- B. Verify that concrete surfaces are dry. Test concrete with 4-hour rubber mat test.
- C. Examine substrates for defects that will adversely affect the execution and quality of the work.
- D. Do not start the work until all unsatisfactory conditions are corrected.

3.02 PREPARATION

- A. Remove the entire as-cast surface of the concrete substrate by shotblasting or sandblasting, if permitted by local regulations.
- B. Mask or protect adjacent surfaces not intended to receive coating.

3.03 APPLICATION SCHEDULE

- A. Provide secondary containments coatings for the following locations:

Room	Area Coated	Chemicals
Chemical Storage Room 100	Concrete Floor and Base Surfaces.	12.5% Sodium Hypochlorite (NaOCl),
		50% Sodium Hydroxide (NaOH)
Pump Basin 101	Concrete Floor and Base Surfaces	12.5% Sodium Hypochlorite (NaOCl),
		50% Sodium Hydroxide (NaOH)

Room	Area Coated	Chemicals
Tank Fill Station	Concrete Floor and Base Surfaces	12.5% Sodium Hypochlorite (NaOCl),
		50% Sodium Hydroxide (NaOH)

3.04 INSTALLATION

- A. Install in strict conformance with the manufacturer's requirements.
- B. Fill joints and cracks as required by the manufacturer.
- C. Apply bond coat/negative side moisture vapor barrier at the rate of 7 mils. Use VaporControl Primer 200 if MVER is less than 10 lb/1,000 SF/ 24 hours or VaporControl Primer 100 Type II is less than or equal to 15.0 lb/1,000 SF/24 hours.
- D. Apply membrane coat at a minimum thickness of 30 mils to the floor and other horizontal surfaces. Apply two membrane coats at a rate of 8 to 10 mils per coat to vertical surfaces.
- E. Where specified apply epoxy intermediate coat over the membrane by trowel to a minimum thickness of 3/16 inch. Screed and finish surface to be level and flat within 1/16-inch when tested with an 8-foot straight edge.
- F. Apply first Posi-Tred CR coating at a thickness of 10 to 12 mils to the floor and other horizontal surfaces and at a minimum thickness of 6 mils to the vertical surfaces.
- G. Apply pre-engineered slip resistant aluminum oxide aggregate at a fine profile to the floor surface. It is not necessary to apply the slip resistant grit to pipe trenches, sumps or walls.
- H. Apply 12 mils DFT clear Posi-Tred CR topcoat.
- I. Provide a 1/4-inch radius at all inside corners.
- J. Coating installation shall be a first class application with no runs.

3.05 PROTECTION

- A. Protect epoxy coating from damage by subsequent construction operations. Prohibit all foot and wheel traffic for at least seven (7) days. Cover horizontal and vertical surfaces with heavy-duty, nonstaining construction paper, taped in place for at least 7 days.
- B. Just before final acceptance, remove paper and wipe surfaces clean with damp cloths.

END OF SECTION

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SECTION 09900

PAINTING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. A painter's finish on all exterior and interior surfaces, except:
 - a. Integrally finished materials such as glass, concrete masonry units, concrete floors, laminated plastic, etc.
 - b. Factory finished items such as acoustic panels, acoustic tile, exposed T-grid suspension systems, toilet partitions, anodized aluminum, light fixtures, etc.
2. Painter's top coat or refinishing coat in a color to match adjacent surfaces on:
 - a. Miscellaneous mechanical and electrical items that are furnished with a factory finish that does not match the color of surrounding surfaces such as panelboards, air supply or return registers, fire extinguisher cabinets, hose reel cabinets, access doors and similar items that are located in finished walls or ceilings.
3. Prime coat paint on all exposed and concealed surfaces of sheet metal flashings prior to installation. See also Section 07600.

1.02 REFERENCES

- A. Where standards of surface preparation are described by citing SSPC specification numbers reference is made to "Systems and Specifications" Volume 2 published by The Coatings Society at SSPC.

1.03 SUBMITTALS

- A. Contractor Qualifications: Submit a list of at least five projects completed in the past five (5) years where High-Performance Coatings, similar to those required for this project, were applied by the Specialty Painting Contractor proposed for this project.
- B. Product Data:
1. Submit complete technical data on all materials to be used on the project for review prior to ordering material. Include manufacturer's brand name and type of material for each coat of each system to be used.
 2. The Contractor shall base his bid on using the products specified. If the products specified are not available in formulations that meet applicable Air Quality Management District regulations on maximum VOC levels, the Contractor shall submit products of equivalent quality and function that comply with regulations in effect at that time.
 3. If products manufactured by makers other than the first named product by the first named maker listed in Part 2 of this Section are submitted, submit supporting performance test results prepared by an independent paint testing laboratory for comparison with the performance of the first named product by the first named maker.

4. If the Contractor's second submittal of a proposed equivalent material is not favorably reviewed the Contractor will be back-charged by the Owner for the cost of subsequent reviews.
- C. Manufacturer's Certification: That products furnished meet applicable Air Quality Management District regulations as to allowable VOC content for the place of application and use intended.
- D. Samples: For paints, submit two 8-1/2 by 11-inch brush-outs of each paint system and each color on cardboard.

1.04 QUALITY ASSURANCE

- A. Contractor Qualifications: The Contractor is cautioned that the application of High Performance Architectural Coatings (HPAC) specified under this Section requires special skill, knowledge and equipment. In submitting his bid, the Contractor represents that he is skilled and experienced applying these coatings, has studied the material manufacturer's application requirements for the materials specified, agrees that the materials are suitable for intended use, and has included in his bid the cost of all labor and material required to achieve a successful coating system that meets the performance requirements of the contract documents.
- B. Regulatory Requirements: All work, material, procedures and practices under this Section shall conform with requirements of the Federal Standard 40 CFR on air quality control, and the requirements of the local Air Resources Board or Air Quality Management District having jurisdiction. Coatings or primers applied at locations other than the project site shall be done in accordance with local air quality regulations in effect at the place the coating is applied.

1.05 WARNING

- A. The Contractor is advised that the application, mixing and/or cleaning of paint and finishing material may be hazardous. The Contractor shall take all necessary precautions to ensure the safety of workers and property. This includes, but is not limited to, the use of NIOSH-approved respirators, and all applicable personal protective equipment (PPE), for example, cloth coveralls, eye protection, gloves and head coverings.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver all materials in unopened containers with manufacturer's label. Label shall state VOC content.
- B. Store in assigned area. Maintain storage area clean and fire safe. Dispose of used rags and clean buckets daily. Store solvents in closed approved storage containers.
- C. Submerge solvent soaked rags in water.

1.07 PROJECT CONDITIONS

- A. Environmental Requirements:
 - 1. Provide ambient temperatures recommended by manufacturer of material to be applied.
 - 2. Provide adequate ventilation.
 - 3. Provide 40- to 50-foot candles of illumination on all surfaces in areas to be painted including floors, walls and ceiling that may not require painting.
 - 4. Use temporary dust barriers to close off areas being painted from areas where other work is being performed.

1.08 COLORS AND COLOR SAMPLES

- A. Before starting work, obtain color schedule and samples of colors selected for this project by the Architect. The colors selected may not be standard colors for the manufacturer whose materials are being used in which case custom colors shall be mixed to match the samples provided by the Architect. "Deep tone" highly pigmented accent colors may be selected for up to 10% of the area painted.
- B. Colors are to be factory or machine mixed, using light-fast colorants proportioned by accurate measurement into a proper tinting base. The color formula for each color shall be submitted to facilitate future color matching.
- C. Exterior deep tone colors are to be factory ground into the pigment for maximum color fastness.

PART 2 - PRODUCTS

2.01 MATERIALS - GENERAL

- A. Coatings used shall be "top of the line" and of the type recommended by the manufacturer for the intended use and substrate.
- B. Applicable Air Quality Management District regulations prohibit the manufacture, sale or application of Architectural Coatings and Specialty Coatings having greater than stipulated levels of volatile organic compounds.
- C. If the Contractor applies any coatings for which it has not submitted certificates indicating the VOC content and that the product complies with applicable Air Quality Management District regulations, or if it applies coatings that have been modified or thinned other than as recommended by the manufacturer, the Contractor shall be responsible for any fines, costs, remedies, or legal actions that may result.
- D. The Contractor shall not submit or use any material containing Trichlorethylene III because of its potential cancer-causing properties. If any of the materials specified in this Section contain trichlorethylene, they shall be considered deleted from this Specification.

2.02 SPECIALTY COATINGS: PRIMERS, STAINS, SEALERS AND CLEARS

- A. Products and makers listed establish type of material and level of quality. Equivalent products manufactured by Glidden Professional Paints, Sherwin-Williams, or equal may be submitted for review.
- B. Specialty Coatings: Coatings listed under this category include primers, sealers, stains and clear coatings. All products provided shall comply with the maximum allowable VOC limit assigned to that category of product by the Air Quality Management District having jurisdiction.
 - 1. LATEX UNIVERSAL RUST INHIBITING PRIMER
Primer for galvanized metal, shop primed steel, etc. Maximum allowable VOC limit 350. Glidden Professional Acrylic Enamel Devflex 4020PF, Sherwin-Williams Pro Industrial Pro-Cryl Universal Acrylic Primer B66W01310, or equal.
 - 2. CHROMATE METAL PRIMER
Maximum allowable VOC limit 350. N/A. Otherwise, Glidden Devguard 4160, Sherwin Williams DTM Acrylic Primer/Finish, or equal.
 - 3. INTERIOR LATEX PRIMER SEALER
Latex primer sealer for interior walls, concrete block and concrete. Maximum allowable VOC limit 350. Glidden PVA Drywall Primer and Sealer, Sherwin-Williams PVA Drywall Primer & Sealer, or equal.
 - 4. ALKYD PHENOLIC GALVANIZED METAL PRIMER
Solvent thinned, alkyd phenolic galvanized metal primer. Maximum allowable VOC limit 450. XIM 360 Gray NT Primer, Tnemec-Zinc Series 90-97, Glidden Devguard 4160, Sherwin-Williams Sherwin Williams DTM Acrylic Primer/Finish, or equal.
 - 5. CONCRETE AND MASONRY PRIMER / SEALER
Sherwin-Williams PREPRITE® ProBlock Interior / Exterior Latex Primer / Sealer, or equal.

2.03 ARCHITECTURAL COATINGS

- A. Coatings listed under this category consist of decorative and protective coatings used to protect surfaces and provide color for buildings and other structures. Most paints and enamels fall under this category. All products used under this category must comply with a VOC limit of 350 unless otherwise noted.
- B. Products and makers listed establish type of material and level of quality. Equivalent products manufactured by Glidden, Sherwin-Williams, Devoe Coatings, or equal may be submitted for review.
 - 1. HIGH GLOSS EXTERIOR LATEX ENAMEL
100% acrylic latex exterior enamel with excellent color and gloss retention and excellent weather resistance. Devoe Coatings Interior/Exterior Waterborne Acrylic Gloss Enamel Devflex No. 4208QD, Sherwin-Williams SuperPaint Exterior Acrylic Latex High Gloss A85 Series Paint, or equal.
 - 2. SEMI-GLOSS EXTERIOR LATEX ENAMEL
100% acrylic latex (medium gloss) exterior house and trim enamel with excellent color and gloss retention and weather resistance. Glidden Premium Exterior Semi-Gloss Paint, Sherwin-Williams SuperPaint Exterior Latex Gloss A84 Series, or equal.

3. SEMI-GLOSS INTERIOR LATEX:
Sheen 35-45 at 60°, scrubbable. Sherwin Williams Emerald Interior Latex Semi-Gloss K38 Series; Glidden Premium Interior Latex Semi-Gloss ; or equal.
4. SEMI-GLOSS ACRYLIC LATEX INTERIOR ENAMEL
Sherwin-Williams ProClassic® Interior Acrylic Latex Enamel Series, Glidden Diamond™ Interior Latex Semi-Gloss, or equal.
5. EGG SHELL ACRYLIC LATEX INTERIOR ENAMEL
Sherwin-Williams ProClassic® Interior Acrylic Enamel Satin Series, Glidden Diamond™ Interior Latex Satin, or equal.
6. HIGH GLOSS INDUSTRIAL ENAMEL
Sherwin-Williams Industrial Enamel B54 Series, Devco Coatings Devguard 4308, or equal.

PART 3 - EXECUTION

3.01 CONDITION OF SURFACES TO BE PAINTED

- A. Examine areas to receive work of this Section. Make certain that surfaces are even, smooth, sound, clean, dry, and free from defects or substances that might affect application.
- B. Arrange for repairs or major cleaning as required. Starting work indicates acceptance of surfaces as satisfactory to achieve required result.

3.02 PREPARATION OF SURFACES

- A. Check that hardware, trim, plates, lighting fixtures and similar items have been removed before starting work; coordinate with work under sections installing such items. Check that equipment adjacent to walls shall be disconnected and moved to permit wall surfaces to be painted before starting work under this Section.
- B. Wash metal surfaces with solvent or cleaner to remove dirt or grease and clean off rust or scale with wire brush or sandpaper.
- C. Bare or Shop Coated Steel: Remove rust and scale by wire brushing or sandblasting; wash with solvent or cleaner.
- D. Galvanized Steel: Etch with phosphoric solution such as Watco "Galvaprime", Endura "Galva-prep", or equal; flush surface clean with water and allow to dry.
- E. Prepare all surfaces in accordance with the more stringent of the coating material manufacturer's recommendations, other requirements in this paragraph 3.02 or referenced or applicable requirements for surface preparation in "Systems and Specifications", Volume 2, published by The Coatings Society, at SSPC.org and summarized below:
 1. SSPC-SP1 - Solvent Cleaning: Removal of all oil, grease, soil, drawing compound, cutting compound and other soluble contaminants from the surfaces with solvents and/or commercial cleaners by wiping, dipping, steam cleaning, or vapor degreasing.

2. SSPC-SP2 - Hand Tool Cleaning: Removal of all loose mill scale, rust, paint and other loose detrimental foreign matter by the use of non-powered hand tools.
3. SSPC-SP3 - Power Tool Cleaning: Removal of all loose mill scale, rust, paint and other loose detrimental foreign matter by the use of power-operated portable tools.
4. SSPC-SP5 – White Metal Blast Cleaning: Cleaning of a steel surface, previously painted or unpainted, to white metal condition through the use of abrasive blast media. The surface should, without magnification, be free of all visible oil, grease, dust dirt, mill scale, rust, coating, oxides, corrosion products, and other foreign matter.
5. SSPC- SP6 - Commercial Blast Cleaning: Removal of all oil, grease, dirt, dust, mill scale, rust, paint, oxides, corrosion products and other foreign matter by compressed air nozzle blasting, centrifugal wheels or other required methods. Remaining discoloration stains shall not exceed 33-1/3% of each square inch of surface.
6. SSPC-SP7 - Brush-Off Blast Cleaning: Removal of all oil, grease, dirt, dust, loose-mill scale and loose paint by compressed air nozzle blasting. Centrifugal wheels or other required means.
7. SSPC-SP11 – Power Tool Cleaning to Bare Metal: Removal of all stains from mill scale, rust or paint using power tools to take a surface to bare metal, while ensuring a minimum surface profile of 1 mil. Used in situations where abrasive blasting is not possible or feasible.
8. SSPC-SP13 – Surface Preparation of Concrete: Preparation of concrete surfaces prior to the application of bonded coating or lining systems by the removal of all surface contaminants including laitance, loose concrete and dust. Standard covers requirements for thermal, mechanical and chemical application methods.

F. Dust all surfaces and wipe clean with a tack rag just prior to coating.

3.03 APPLICATION

- A. Apply all material in strict accordance with manufacturer's instructions. Apply first coat immediately after surface preparation.
- B. Do not apply coatings when temperature is below 55°F. Do not apply exterior coatings in damp or rainy weather.
- C. Brush out each coat to a uniform, even coating; lay material on in one direction and brush out at right angles. Special application techniques may be required for new coatings with low VOC content. Apply such coatings in strict accordance with manufacturer's detailed instructions. Allow material to dry 48 hours between coats unless longer period specified by manufacturer.
- D. Paint items and surfaces before installation that will be difficult or impossible to paint after installation.
- E. Apply not less than the number of coats specified. Apply additional coats if required for uniform coverage and full hiding. Apply finishes in their factory original consistencies. Do not thin unless specifically recommended by the manufacturer.

- F. Finish work shall be uniform in color, full coverage, smooth and free of sags and brush marks
- G. Do all cutting in to a sharp, true line. Repaint if necessary to correct over runs.
- H. Do not paint over Underwriters' labels, fusible links, sprinkler heads, or fire alarm devices.
- I. Paint access panels, electrical panels, air registers and similar items prior to installation to prevent edges from peeling or chipping when panels are removed.
- J. Repaint factory finished electrical panels, air registers, and other items to match adjacent painted surfaces.

3.04 PROTECTION, CLEANING, AND COMPLETION

- A. Protect finish work by suitable covering or other method as job progresses.
- B. Remove paint spots from floors, glass and other surfaces, upon completion of work. Remove rubbish, empty containers and other accumulated materials from premises. Leave work in clean, orderly, acceptable condition.
- C. Check work of this Section at completion of project. Touch-up or refinish marred or damaged surfaces. Replace glass damaged by operations under this Section. Leave entire area with finish free from imperfections.

3.05 PAINTING SYSTEMS: ARCHITECTURAL COATING SYSTEMS

- A. See Notes on Drawings for additional location of surfaces to receive paint systems.
- B. Characteristics of paint materials are described in Part 2 of this Section. First-named products are listed in this Schedule. Equivalent products by other manufacturers may be submitted for review in accordance with paragraphs 1.03 and 2.02 of this Section.
- C. System "A": EXTERIOR/INTERIOR HIGH-GLOSS LATEX ENAMEL
 - 1. First Coat:
 - a. Shop primed ferrous metal: Touch-up with ALKYD RUST INHIBITING PRIMER. Devoe Coatings Multi-Purpose Tank and Structural Primer Devguard No. 4160.
 - b. Or, where shop prime coat is not suitable for overcoating with latex systems, re-prime entire surface with ALKYD PHENOLIC PRIMER. Devoe Coatings All Purpose Metal and Galvanized Primer Devguard No. 4160.
 - c. Unprimed ferrous metal: ALKYD RUST INHIBITING PRIMER.
 - d. Galvanized Metal: Pretreat with phosphate solution and prime with ALKYD PHENOLIC GALVANIZED METAL PRIMER. XIM 360 Gray NT Primer.
 - e. Wood: ALKYD EXTERIOR WOOD PRIMER. Sherwin-Williams Exterior Latex Wood Primer B42W08041.
 - 2. Second and Third Coats:
 - a. Two coats of HIGH GLOSS EXTERIOR LATEX ENAMEL. Devoe Coatings Interior-Exterior Waterborne Acrylic Gloss Enamel, Devflex No. 4208QD.

- D. System "B": EXTERIOR/INTERIOR SEMI-GLOSS LATEX ENAMEL.
1. First Coat:
 - a. Shop primed ferrous metal: Touch-up with ALKYD RUST INHIBITING PRIMER. Devoe Coatings Multi-Purpose Tank and Structural Primer Devguard No. 4160. Where shop prime coat is not suitable for overcoating with latex system, re-prime entire surface with ALKYD PHENOLIC PRIMER. Devoe Coatings Multi-Purpose Tank and Structural Primer Devguard No. 4160.
 - b. Unprimed ferrous metal: ALKYD RUST INHIBITING PRIMER. Devoe Coatings Multi-Purpose Tank and Structural Primer Devguard No. 4160.
 - c. Galvanized Metal: Pretreat with phosphate solution in accordance with paragraph 3.02D and prime with ALKYD PHENOLIC GALVANIZED METAL PRIMER. XIM 360 Gray NT Primer.
 - d. Aluminum: Pretreat with metal etch and prime over aluminum. XIM 360 Gray NT Primer, Devoe Coatings Multi-Purpose Tank and Structural Primer Devguard No. 4160
 2. Second and Third Coats: Two coats of SEMI-GLOSS EXTERIOR LATEX ENAMEL Sherwin-Williams SuperPaint Exterior Latex Gloss A84 Series.
- E. System "C": SEMI-GLOSS ACRYLIC LATEX INTERIOR ENAMEL
1. First Coat:
 - a. On gypsum board: PVA SEALER. Glidden PVA Drywall Primer and Sealer.
 - b. Galvanized metal: Pretreat with phosphate solution in accordance with paragraph 3.02D and prime with ALKYD PHENOLIC GALVANIZED METAL PRIMER. XIM 360 Gray NT Primer, Devoe Coatings Multi-Purpose Tank and Structural Primer Devguard No. 4160.
 2. Second and Third Coats: SEMI-GLOSS ACRYLIC INTERIOR ENAMEL: Sherwin-Williams ProClassic® Interior Acrylic Latex Enamel Series
- F. System "D": EGGSHELL ACRYLIC LATEX INTERIOR ENAMEL
1. First Coat:
 - a. On gypsum board: PVA SEALER: Glidden PVA Drywall Primer and Sealer.
 - b. On plywood: Wood Primer: Sherwin-Williams Exterior Latex Wood Primer No. B42W08041.
 - b. On metal: ALKYD RUST INHIBITING PRIMER. Devoe Coatings Multi-Purpose Tank and Structural Primer Devguard No. 4160.
 2. Second and Third Coats: EGGSHELL ACRYLIC LATEX INTERIOR ENAMEL. Sherwin-Williams ProClassic® Interior Acrylic Enamel Satin Series.
- G. System "E": ACRYLIC LATEX MASONRY PAINT for Exterior Concrete or Concrete Block:
1. Surface Preparation: Very light brush-off blasting to create a fine tooth: SSPC-SP 7.
 2. First Coat:
 - a. On Concrete: CONCRETE AND MASONRY PRIMER SEALER, applied at the rate recommended by the manufacturer. Sherwin-Williams PREPRITE® ProBlock Interior / Exterior Latex Primer / Sealer.
 - b. On Concrete Block: LATEX BLOCK FILLER. Sherwin-Williams PREPRITE® Interior/Exterior Latex Block Filler B25W00025.

3. Second and Third Coats: FLAT ACRYLIC EXTERIOR MASONRY PAINT, applied at the rate recommended by the manufacturer. Sherwin-Williams SuperPaint Exterior Latex Flat A80 Series.

3.06 FINISH PAINT SCHEDULE (at areas of New Work only)

	Walls – Eggshell Acrylic Latex Interior Enamel	Floor – High Performance Coating; see Specification Section 09960	Base	Ceiling – Eggshell Acrylic Latex Interior Enamel	Doors – Exterior/Interior Semi-Gloss Latex Enamel	Walls – Exterior/Interior Semi-Gloss Latex Enamel
ODOR CONTROL BUILDING						
Chemical Room		✓		✓	✓	✓
Pump Basin		✓		✓	✓	✓
Odor Control Room		✓		✓	✓	✓

END OF SECTION

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SECTION 10050
BUILDING SPECIALTIES

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Fire extinguisher brackets and fire extinguishers.
 - 2. Rubber switchboard mats.

1.02 SUBMITTALS

- A. Product Data: Fully describe all products proposed for use.
- B. Manufacturer's Instructions: For installation of all items.

PART 2 - PRODUCTS

2.01 FIRE EXTINGUISHER WALL BRACKET AND FIRE EXTINGUISHERS

- A. Provide three (3) surface mount manufacturer's standard wall mount fire extinguisher brackets, each to support 20 lb. multi-purpose 4A60BC Fire Extinguishers. Provide one (1) extinguisher for each bracket. Shell of extinguishers shall be painted OSHA Red. All extinguishers shall be by one manufacturer and shall have a State and/or local Fire Marshal's inspection and fill tag dated within 90 days of project acceptance and issued by the State and/or local Fire Marshal of the State in which the extinguisher is installed. Fire extinguisher locations as shown on Drawings. Larsen Architectural Series; J. L. Industries; or equal.

2.02 RUBBER SWITCHBOARD MATS

- A. Provide corrugated fiber reinforced rubber mats, which conform to ASTM D178-01, Type I, oil resistant. Mats shall meet OSHA requirements. Mats for low voltage (below 1 kV) switchboards and switchgear and motor control centers shall be rated for protection for 17,000 volts minimum to ground. Mats for medium voltage (1 kV to 15 kV) switchgear shall be rated 17,000 volts. Test voltage: 30,000 volts.
- B. Mat shall be a minimum of 1/4-inch-thick and black in color with beveled edges. Mats shall extend the full width of the equipment (minimum 30 inches). Mats shall be 4 feet deep in front of low voltage equipment and 6 feet deep in front of medium voltage equipment. Provide mats for all switchboards and motor control centers whether shown or not.
- C. Installation: Install at locations shown on the Drawings and in front of all switchboards and motor control centers.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Fire Extinguishers: Comply with NFPA Standard No. 10. Install brackets, and mount extinguishers where directed or where shown on Drawings.
- B. Install rubber switchboard mats as described in Part 2 and where directed by Owner.

END OF SECTION

SECTION 10200

LOUVERS

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes: Wall louvers.

1.02 REFERENCES

- A. Sheet Metal and Air Conditioning Contractors National Association (SMACNA)
 - 1. Architectural Sheet Metal Manual
- B. Air Control Division of the Air Movement and Control Association (AMCA)
 - 1. AMCA-500-L-12 Laboratory Methods of Testing Louvers for Rating
 - 2. AMCA-511 Certified Ratings Program – Product Rating Manual for Air Control Devices
- C. National Association of Architectural Metal Manufacturers (NAAMM)
 - 1. AMP 500 Metal Finishes Manual

1.03 SUBMITTALS

- A. Submit the following:
 - 1. Product Data: Fully describe all items proposed for use.
 - 2. Shop Drawings: Custom prepared for this project.
 - 3. Certified Test Data: Air and acoustic performance of louvers.

1.04 QUALITY ASSURANCE

- A. Comply with details and standards in the “Architectural Sheet Metal Manual” published by Sheet Metal and Air Conditioning Contractors National Association (SMACNA).
- B. Comply with AMCA Standard 500-L-12 for measuring air performance, water penetration and air leakage and Standard 511 for the AMCA Certified Ratings Program.

PART 2 - PRODUCTS

2.01 STATIONARY EXTRUDED ALUMINUM FRAMED CONTINUOUS BLADE LOUVERS

- A. Manufacturer: Louver style K6774 exposed vertical mullion type manufactured by Airolite; Construction Specialties; or equal.

- B. Design Criteria: Design and test louvers to AMCA Standard 500 for air performance and water penetration. Test a 4 by 4-foot louver with a minimum free area of 7.89 square feet to pass at least 800 FPM through the free area at a pressure drop not exceeding 0.15 in W.G. Limit water penetration to 10 ounces of water per square foot of free area when tested at 720 FPM for 15 minutes per AMCA Standard 500.

2.02 MATERIALS / FABRICATION

- A. Provide extruded aluminum framed continuous blade louvers with exposed jambs and mullions 4 inches deep with blades spaced 3 inches on center. Use aluminum alloy 6063-T52 for all parts.
- B. Use extruded blades, 12-gauge (0.81 inch) thick, having a downward turned stiffening leg along the front bottom edge and an up turned leg with a forward-facing lip to stop water migration along the top rear edge. Use blades that have an extruded hood on their bottom surface to interlock with mullion support brackets. Set louver blades at a 30-degree angle for exhaust and 45-degree angle for intake.
- C. Contain louver blades in a frame made of 3/4-inch by 4-inch extruded aluminum "C" sections.
- D. Provide louvers that have all joints concealed.
- E. Continuously weld all joints in the louver assembly using a shielded arc process.
- F. Provide aluminum insect screens in folded extruded aluminum frames. Where fan housing/mounting board is attached to the interior side of louver, provide holder for screen frame that can be built into mounting board support and so arranged that by removing the fan housing/mounting board, screen can be slid out for cleaning without disassembling louver and supports. Where there is no ductwork attached to interior of louver, provide a holder for insect screen frame designed so that screen can be removed for cleaning and replaced without using tools.
- G. Provide all related break shape and extruded aluminum sills, flashings, and sub-frames. Flashings shall be 0.050 or thicker as indicated.
- H. Provide matching 1/8-inch-thick dark bronze anodized aluminum backing plates to cover the rear of decorative louvers and portions of louvers outside of air intake or exhaust ductwork.
- I. Provide all required aluminum angles, tees, plates, and other shapes required for a complete installation.

2.03 FINISH

- A. Finish all parts with an anodized finish at least 0.7 mils thick conforming to NAAMM AA-M10C22A44. Color as selected from manufacturer's standard anodized colors.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Protect all aluminum in contact with steel or galvanized metal with a coating of bituminous paint.
- B. Install louvers as shown in the Contract Drawings and as shown in Plates 137B and 139A of the 4th edition of the SMACNA Architectural Sheet Metal manual.
- C. Provide insect screens on all louvers. Install on the interior side. Use stainless steel screws throughout.
- D. Install sill flashing as shown detailed and as required to provide a watertight installation.
- E. Install sheet metal drip at head of louvers where shown.
- F. Apply sealant "B" all around frame, at joint with interior and exterior wall surfaces.

END OF SECTION

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SECTION 10400
IDENTIFYING DEVICES

PART 1 - GENERAL

1.01 SUMMARY

- A. Section includes: Room Signs, Decals and Tags.

1.02 REFERENCES

- A. American National Standards Institute / American Society of Mechanical Engineers (ANSI/ASME), ASME A13.1 - 2015, "Scheme for the Identification of Piping Systems."
- B. American National Standards Institute (ANSI), ICC A117.1 - 2009, "Accessible and Usable Buildings and Facilities".
- C. Washington State Building Code Council (WSBCC):
 - 1. 2015 Washington State Building Code (based on 2015 International Building Code).
- D. National Fire Protection Association (NFPA) NFPA 704, "Standard System for the Identification of the Hazards of Materials for Emergency Response".

1.03 SUBMITTALS

- A. Product Data: Fully describe all items proposed for use.
- B. Shop Drawings: Scaled drawings or images of custom-made signs, showing style and size of lettering and colors.
- C. Samples: Provide one full size representative sample of each signage type, made of the specified material, from Part 2 of this Specification. Provide manufacturer's standard color palette for each selection.

1.04 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with the following:
 - 1. Americans with Disabilities Act (ADA).
 - 2. 2015 Washington State Building Code (WSBC)
 - 3. Federal and Washington State Occupational Safety and Health Act (OSHA): Referenced sections, specifications for accident prevention signs and tags and exit signs.
- B. Comply with the manufacturer's published recommendation for installation of materials used.

PART 2 - PRODUCTS

2.01 SIGNS

A. Architectural Signs:

1. Office/Facility Signs:

- a. Vomar Products, Inc.; ES 100 Series; Apco Graphics IM System; or equal.
- b. Sign characteristics:
 - 1) Material: Integral color acrylic.
 - 2) Frame and plaque in contrasting colors separated by a 1/16-inch reveal. Colors as selected from manufacturer's standard palette. Rectangular shape unless noted otherwise. Self-adhesive backing.
 - 3) Text Helvetica Bold all caps: Size shown.
 - 4) Sign size shall be as shown unless a larger size is required to accommodate lettering.
 - 5) Braille: All signs to include contracted (Grade 2) braille and comply with ICC A117.1-2009 Chapter 7 Communication Elements and Features.
- c. Schedule of signs required:

Quantity	Text	Text Height	Size (Inches)	Comments
2	Chemical Room	3/4	9Wx5-1/2 H	Provide one sign at one exterior door face
1	Odor Control Room	3/4	9Wx5-1/2 H	Provide one sign at one exterior door face

2.02 SAFETY SIGNAGE

A. Hazard Alerting Signage (CAUTION, WARNING, DANGER):

1. Refer to the Signage Schedule at the end of this section to identify the sign types and quantities for the project.
2. Manufacturer: Seton Nameplate Company; W.H. Brady Company; or equal.
3. Signage Design:
 - a. Size: 14 inches wide by 10 inches high
 - b. Material: 60-mil rigid plastic, coated for weather and vandalism protection
 - c. Text, format, and color:
 - 1) Conforming to OSHA 1910.145(d), Specifications for Accident Prevention Sign Design.
 - 2) Text as scheduled below.
 - d. Provide eyelet holes at each corner for mounting.
4. Text as scheduled below:

Quantity	Text
2	AUTHORIZED PERSONNEL ONLY
2	CAUTION EQUIPMENT STARTS AUTOMATICALLY

B. Fire Equipment Location Signs:

1. One-way Fire Equipment Location Signs:

- a. Manufacturer: Seton Nameplate Company; W.H. Brady Company; or equal.
- b. Size: 18 inch height (approximate size).
- c. Material: 60-mil rigid plastic, coated for weather and vandalism protection. Provide eyelet holes at each corner for mounting.
- d. Text: Bright, fade-resistant red on white downward facing directional arrow on red field. Text is shown on schedule below.
- e. Schedule of signs required:

Text	Quantity		
	1-way	2-way	3-way
"FIRE EXTINGUISHER"	3	—	—

C. Security and General Policy Safety (NOTICE) Signs

1. Notice (Informational) Signs:

- a. Manufacturer: Seton Nameplate Company; W.H. Brady Company; or equal.
- b. Size: 14 inches wide by 10 inches high.
- c. Material: 60 mil rigid plastic, coated for weather and vandalism protection
- d. Provide eyelet holes at each corner for mounting.
- e. Schedule of signs required:

Quantity	Text
1	NOTICE KEEP OUT EMPLOYEES ONLY

D. Egress Path Marking Signs:

1. Exit Signs:

- a. Seton Nameplate Company; W.H. Brady Company; or equal.
- b. Size: 14 inches wide by 10 inches high.
- c. Material: 60 mil rigid plastic, coated for weather and vandalism protection.
- d. Text:
 - 1) Conforming to OSHA 1910.145(d)(5) and 1910.37.
 - 2) Red text and symbols on white field as scheduled below.


2. Provide eyelet holes at each corner for mounting.

- a. Schedule of signs required:

Quantity	Text/Symbol
1	EMERGENCY EXIT ONLY

2.03 CHEMICAL HAZARD AND HAZMAT COMMUNICATION

A. Chemical Hazard and GHS Signs

Sign Type (product number)	Symbol	Material	Quantity	
			12"x12"	6"x6"
CORROSIVE (Seton L3512)		Adhesive Vinyl	2	2
		Rigid Plastic	4	---
		Magnetic	---	---

B. NFPA Fire Hazards of Materials Signs

1. Seton Nameplate Company; W.H. Brady Company; or equal.
2. Sign characteristics: Four-color background, blue, red, yellow, white; diamond shape; 7-1/2 inches by 7-1/2 inches; 3-inch-high black hazard numerals scheduled below; conform to NFPA No. 704, Standard System for the Identification of the Hazards of Materials for Emergency Response.
3. Material: Semi-rigid plastic with adhesive back.
4. Where mounted to concrete or other porous materials provide 3/4-inch-thick AB Marine grade Douglas Fir plywood backing, sealed edges, and painted. Eyelet holes at corners for mounting.
5. Schedule of signs required:

Quantity	Hazardous Material	Blue (Health)	Red (Fire)	Yellow (Reactivity)	White (Specific Hazard)
4	Caustic (Sodium Hypochlorite)	3	0	0	OX
4	Caustic (Sodium Hydroxide)	3	0	1	--
2	Magnesium Hydroxide	0	0	0	--

2.04 PIPE MARKERS

- A. Seton Nameplate Company; SetMark, W.H. Brady Company; Piper Marker System 1; or equal.
- B. Pipe Markers conforming to ANSI A13.1. See paragraph 3.03 for required locations.
- C. Material: Acrylic plastic snap-around type or pressure sensitive vinyl, temperature tolerance range of -40°F to 250°F, non-fade, colored fields, lengths as shown below.

- D. Text: Non-fade ink, lettering size, as shown below:

Outside Diameter of Pipe (Inches)	Length of Color Field (Inches)	Size of Letters (Inches)
3/4 to 1-1/4	8	1/2
1-1/2 to 2	8	3/4
2-1/2 to 6	12	1-1/4
8 to 10	24	2-1/2
Over 10	36	3-1/2

- E. Provide directional arrows to indicate flow direction. See paragraph 3.03.

- F. Pipe Marker Schedule:

Text	Field Color	Letter Color
Recycled Water	Purple	Black
Utility (Non-Potable) Water	Yellow	Black
Process Drain	Yellow	Black
Vent	Yellow	Black
Fire Sprinkler Water	Red	White
Potable Water	Green	White
Hot Water	Green	White
Magnesium Hydroxide	Orange	Black
Sodium Hydroxide	Orange	Black
Sodium Hypochlorite	Orange	Black

PART 3 - EXECUTION

3.01 SIGN INSTALLATION

- A. Install signs where directed by the Engineer.
- B. Install signs after painting surfaces to receive signs. Follow manufacturer's written installation instructions.
- C. Use fasteners as follows:
1. To concrete and masonry materials: 4-1/4 inches diameter expansion anchors.
 2. To sheet metal (gauges 28 to 6) #10 sheet metal screws.
 3. To plywood backing boards: #10 wood screws.
 4. To machinery: Fasteners as suitable.

3.02 PIPE MARKERS

- A. Pipe Markers shall be applied where piping enters or leaves the wall or floor of a structure, adjacent to tanks or other hydraulic containments, at each valve, at each piping change in direction, and shall be applied along piping runs not exceeding 16 feet on center.
- B. Directional Arrows: Point in the direction of flow.

- C. Locate pipe markers for easy reading. Where pipes are located above normal line of vision, the lettering and directional arrows shall be placed below the horizontal centerline of the pipe. Where pipes are below normal line of vision, lettering and directional arrows shall be above the horizontal centerline of the pipe.

END OF SECTION

SECTION 11001

GENERAL EQUIPMENT AND MECHANICAL REQUIREMENTS

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes: The general requirements for all the Equipment and Mechanical work in the scope of the Project, included in Divisions 11, 13, and 15 and elsewhere wherever specifically mentioned in these Specifications.
- B. Direct the attention of all subcontractors and suppliers of equipment and related appurtenances for the work to the applicable provisions in the Contract Documents wherever they may occur.

1.02 REFERENCES

- A. American Gear Manufacturers Association (AGMA).
- B. American Institute of Steel Construction (AISC).
- C. Hydraulic Institute.
- D. National Electrical Manufacturers Association (NEMA).
- E. Occupational Safety and Health Act (OSHA).

1.03 STANDARDS FOR THE WORK

- A. Complete Systems: Provide pipe, fittings, wiring, and supports to produce complete, operable systems with all elements properly interconnected. If a specific dimensioned location is not shown for interconnections or smaller system elements, select appropriate locations and show them on Shop Drawing submittals for review.
- B. Provide equipment and material new and without imperfections. Erect in a neat and workmanlike manner; aligned, leveled, cleaned and adjusted for satisfactory operation; installed in accordance with the recommendations of the manufacturers and the best standard practices for this type of work so that connecting and disconnecting of piping and accessories can be readily made and so that all parts are easily accessible for inspection, operation, maintenance, and repair. Locate oil and lubrication fittings clear of and away from guards, base, and equipment and within reach from the operating floor. Coordinate location of all motor connections in order to properly orient encased electrical conduits. In order to meet these requirements with equipment as furnished, minor deviation from the Drawings may be made as favorably reviewed by the Engineer.
- C. The recommendations and instructions of the manufacturers of products used in the work are hereby made part of these Specifications, except as they may be superseded by other requirements of these Specifications.

1.04 SUBMITTALS

- A. Shop Drawings: Show sizes and arrangement of equipment, foundations, and anchor bolts required; performance characteristics; fan curves and pump curves; control diagrams; wiring diagrams; motor data sheets; methods of assembly; pipe

hanging details; ductwork layouts; and connections to other work. Date and sign drawings as certified for use in construction of this project. The arrangement of mechanical equipment and appurtenant piping shown on the Drawings may be varied as necessary to fit the favorably reviewed certified manufacturer's installation drawings. However, manufacturers' drawings shall not deviate in substance from the Contract Drawings and Specifications as to location, size, type, and design of equipment. The following minimum requirements shall accompany all equipment submissions:

1. Overall dimensions.
 2. Mounting arrangement and dimensions.
 3. Description of materials.
 4. Connection sizes and orientation.
 5. Capacity and location of lifting eyes.
 6. Motor arrangement showing location of electrical connections.
 7. Rating data - Mechanical and Electrical as applicable.
 8. Detail electrical wiring diagrams, showing component designation and rating.
 9. Seismic design certifications and anchorage descriptions as required by Section 01190.
 10. Motor data as specified in Section 11002.
 11. List of special tools and/or spare parts to be furnished, if any.
- B. Each piece of equipment, for which certified witnessed or non-witnessed performance tests are required, shall be accompanied by a completed form containing at least the following information:
1. Owner's name and location of project.
 2. Contractor's name and subcontractor if applicable.
 3. Name of item being submitted.
 4. Specification reference by section, paragraph and page.
 5. Data on item (manufacturer, general descriptive data, dimensions, size of connections, speeds, performance curves, serial number). A specific list of the test results plus a list, which shows the values that differ from Specifications.
 6. Motor data, type, voltage, frequency, phase, full load amperes, starting method, frame size, enclosure insulation type (NEMA Code letter), dimensions, service factor, serial number.
 7. Date and signature of person certifying the performance.
- C. Operations and Maintenance Manuals: Prepare and submit manuals covering installation, operation and maintenance of all equipment and machinery specified in Divisions 11, 13, and 15.
- D. Manufacturers' Affidavits: Where called for in the Specifications, each equipment manufacturer, or their authorized representative, shall submit an affidavit conforming to the requirements of Section 01650.

1.05 RESPONSIBILITY AND CARE OF EQUIPMENT

- A. The Contractor shall be responsible for the equipment included in this Contract until it has been finally inspected, tested, and accepted in accordance with the requirements of these Specifications.
- B. The Contractor shall make his own provisions for properly storing and protecting all material and equipment against theft, injury, or damage from any and all causes. Damaged material and equipment shall not be used in the work.

PART 2 - PRODUCTS

2.01 DESIGN

- A. General: Design all equipment for the service intended, of rugged construction, of ample strength for all stresses which may occur during fabrication, transportation, erection, and during continuous or intermittent operation. Adequately stay, brace and anchor, and install equipment in a neat and workmanlike manner. Give consideration to appearance and safety, as well as utility, in the design of details. Use cathodically compatible materials of construction.
- B. Seismic: Refer to Section 01190 of the Specifications for the seismic design criteria.
- C. Controls: Unless noted otherwise, the design of the electric control of any equipment system and/or equipment package shall be the responsibility of the manufacturer of the equipment system and/or equipment package. The elementary control diagrams as shown on the Electrical Drawings and the diagrams shown on the Instrumentation Drawings are illustrative of control and monitoring requirements pertaining to various equipment of this project. The manufacturers shall design their own functional electric control devices and circuitry, in consultation with the specific elementary control diagrams and other project specifications, to meet the equipment control requirements. All such systems and package controls shall be furnished by the equipment manufacturer, except that controls shown in motor control centers and process controllers, remote control devices, and their interconnecting wiring shall be provided under Divisions 16 and 17. Provide heating, ventilating, and air conditioning controls, both 24-volt and line voltage type, by a HVAC controls specialist.

2.02 MATERIALS AND STANDARD SPECIFICATIONS

- A. Materials: Design, fabricate, and assemble equipment and systems with new materials and in accordance with acceptable modern engineering and shop practices. Manufacture individual parts to standard sizes and gauges so repair parts can be installed in the field.
- B. Uniformity: Unless otherwise specified, equipment or material of the same type or classification used for the same purpose shall be the product of the same manufacturer and shall be the same model.

2.03 LUBRICATION

- A. Provide lubricants of types recommended by equipment manufacturers, in quantities sufficient for consumption prior to completion, testing and final acceptance.

2.04 STRUCTURAL METAL FRAMING

- A. Details of fabrication shall be in accordance with Section 05500.
- B. Weld submerged steel surfaces which butt or bear against each other, to seal the surfaces against the penetration of the liquid. Weld all gaps between adjacent submerged steel surfaces less than 1/32-inch wide to seal the surfaces. Weld size shall be not less than the thickness of the thinnest member of the lapped or joined assembly.

2.05 EQUIPMENT BASES AND BEDPLATES

- A. Mount equipment assemblies on a single heavy cast iron or welded steel bedplate unless otherwise shown or specified. Provide bases and bedplates with machined support pads, tapered dowels for alignment or mating of adjacent items, adequate openings to facilitate grouting, and openings for electrical conduits. Round or chamfer and grind smooth all corners. Continuously weld seams and contact edges between steel plates and shapes, and grind welds smooth. Do not support machinery or piping on bedplates other than that which is factory installed. Provide jacking screws in equipment bases and bedplates to aid in leveling prior to grouting. Mount all equipment bases and baseplates on reinforced concrete pads at least 3 inches high.

2.06 ANCHORS

- A. Each equipment manufacturer shall furnish an anchor bolt pattern and the required anchor bolts, nuts, and washers of adequate design for securing bases and bedplates to concrete bases. Provide anchor bolts of length to allow for 1-1/2-inch of grout under baseplates and adequate anchorage into structural concrete unless otherwise shown or specified.
- B. Provide anchor and assembly bolts and nuts of ample size and strength for the purpose intended. All bolts shall be standard machine bolts, with cold pressed hexagon nuts. Provide suitable degauling compounds for bronze and stainless steel threaded components. Any space wholly or partially underground, or having a wall or ceiling forming part of a water channel, is classified as a moist location. Unless otherwise specified or noted on the Drawings, provide materials as follows:
 - 1. Bolts and nuts in submerged locations or submerged and embedded in concrete or buried in earth: Type 304 stainless steel.
 - 2. Bolts and nuts for supports or equipment in dry or moist locations: Galvanized steel (hot-dipped), with oversize nuts.
 - 3. Use other bolting materials where specifically called for in the Specifications or on the Drawings.
- C. Anchor all motor-driven equipment with cast-in-place anchor bolts or drilled-in anchors set with epoxy adhesive. Do not provide expansion type anchors for motor-driven equipment.
- D. Anchor all non-motor-driven equipment with cast-in-place anchor bolts or drilled-in anchors set with epoxy adhesive except that, where specifically allowed by note on the Drawings, expansion type anchors may be used.

2.07 SAFETY GUARDS

- A. Cover belt or chain drives, fan blades, couplings, nip points, exposed shafts, and other moving or rotating parts on all sides with safety guards conforming to all federal, state, and local codes and regulations pertaining; conform to the most restrictive requirement. Design guards for easy installation and removal, complete with necessary supports, accessories, and fasteners, all hot-dip galvanized. Design guards in outdoor locations to prevent entrance of rain and dripping water. Provide tachometer test opening in line with ends of shafts. Typically, guards shall be expanded metal on a structural steel frame except that outdoor guards may be of solid material. Provide hinged doors with latch for service and lubrication access.

- B. Cover all pipes, manifolds, heaters, and other surfaces which have a surface temperature sufficient to burn human tissue with a thermal insulating material or otherwise guard against contact.
- C. Guards to comply with OSHA and local requirements.

2.08 LIFTING EYES

- A. Supply all equipment weighing over 100 pounds with lifting eyes. Parts of equipment assemblies which are normally serviced separately, such as motors, to have lifting eyes of their own.

2.09 DRIVES

- A. General: Provide all drive units with an AGMA rating and service factor suitable for 24 hours per day operation under the operating load.
- B. Electric Motors: Conform to the requirements of Section 11002.
- C. V-Belt Drives: Equip each V-belt drive with suitable tension adjustment. Provide drives having a service factor of at least 1.6 with arc length correction at maximum torque using nameplate rating of driving motor.

2.10 NAMEPLATES

- A. Manufacturer's Nameplate: Furnish each piece of equipment and its driver with a corrosion-resistant metal nameplate fastened to the item in a readily readable position. This nameplate to contain the manufacturer's name, equipment rating, capacity, size, model, serial number, and speed. All information written or printed to be in English.
- B. Direction of Rotation: Furnish each piece of rotating equipment with a direction of rotation arrow.
- C. Functional Identification: Label each piece of equipment using a plastic laminate label with the functional name and number of the equipment.
 - 1. Fasten labels to the equipment, its base, or other acceptable location:
 - a. Letters: At least 1/2-inch high with the border trim on all sides not less than 1/4 inch.
 - b. Color: Green background with white letters.
 - c. Fasteners: Brass or stainless steel screwed into inserts, anchor shields, or tapped holes in equipment or base.

2.11 PROTECTION AGAINST ELECTROLYSIS

- A. Where dissimilar metals are used in conjunction with each other, provide suitable insulation between adjacent surfaces so as to eliminate direct contact and any resultant electrolysis. Connections of dissimilar piping materials shall utilize dielectric unions, flanges, couplings, or bushings.

2.12 SPECIAL TOOLS

- A. For each type of equipment to be furnished, provide a complete set of all special tools (including grease guns or other lubricating devices) which may be necessary for the adjustment, operation, and maintenance of such equipment.

2.13 FINISHES

- A. Factory Painting: On pumps, motors, drives, starters, control panels, and other similar self-contained or enclosed components, apply a factory protective paint system unless otherwise noted. Paint or otherwise protect surfaces that are inaccessible after assembly by a method which provides protection for the life of the equipment.
- B. Shop Priming: Except where field sandblasting is required, apply one or more shop coats of metal primer on surfaces to be finish painted at the site, of sufficient thickness to protect surfaces until finished. Primer shall be compatible with finish coat.
- C. Rust Preventive: Coat machined, polished, other ferrous surfaces, and non-ferrous surfaces which are not to be painted with rust preventive compound.

2.14 NOISE AND VIBRATION

- A. Mechanical and electrical equipment, as installed in this project, shall not create sound levels that are in excess of that permitted by OSHA for 8 hours per day worker exposure unless otherwise noted for the specific piece of equipment involved. If the required sound level cannot be achieved by bare equipment in its designated environment, provide sound attenuating enclosures. Sound attenuating enclosures shall have necessary ventilation to prevent equipment overheating and shall be constructed for easy removal to permit maintenance. Devices necessary for day-to-day operation shall pierce the enclosure or otherwise be accessible without need to remove the enclosure.
- B. Equipment which when operating has obvious excessive vibrations shall be repaired or replaced as directed by the Engineer. Baseline vibration measurements shall be made where specified.

2.15 FACTORY TESTS

- A. Perform factory tests for each piece of equipment where specifically called for in the section specifying that equipment. Note that factory tests are inherent in many reference standards. The requirement for a factory test in a referenced standard is hereby made a part of these Specifications. Conduct factory tests at the same speeds and other conditions at which the equipment will operate in the field, except as noted.
- B. Where specifically noted, performance tests may be witnessed by the Engineer or his representative. Inform the Engineer in sufficient time to allow arrangements to be made for witness of such tests. When non-witnessed tests are performed, supply certified results.
- C. Perform factory testing of pumps in accordance with the requirements and standards of the Hydraulic Institute.
- D. Tests of other equipment shall conform to the requirements set forth in these Specifications.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Inspect each item of equipment for damage, defects, completeness, and correct operation before installing.

3.02 PREPARATION

- A. Prior to installing equipment, ensure that the areas are clean. Maintain the areas in a broom-clean condition during installation operations. Clean, condition, and service equipment in accordance with the approved Instruction Manuals and specific recommendations of the equipment manufacturer.

3.03 INSTALLATION

- A. Structural Fabrications: Conform to the AISC Code and Specification referenced in Article "Structural Steel Fabrications," and conform to Section 05500.
- B. Equipment: Conform to approved Operations and Maintenance Manuals. Employ skilled craftsmen experienced in installation of the types of equipment specified. Use specialized tools and equipment, such as precision machinist levels, dial indicators, gauges, and micrometers, as applicable. Produce acceptable installations free of vibration or other defects. Align and pin to common bedplate equipment and drivers connected by flexible couplings.
- C. Anchor Bolts: Deliver bolts with templates or setting drawings and verify that bolts are correctly located before structural concrete is placed.
- D. Base and Bedplate Grouting: Do not place grout until initial fitting and alignment of connected piping is completed. Level and align equipment on the concrete foundations, then entirely fill the space under base or bedplates with grout. Bevel exposed grout at 45 degree angle, except round exposed grout at horizontal surfaces for drainage. Trowel or point exposed grout to a smooth, dense finish and damp cure with burlap for 3 days. When grout is fully hardened, remove jacking screws and tighten nuts on anchor bolts. Check the installation for alignment and level, and perform approved corrective work as required to conform to the tolerances given in the applicable Instruction Manual.
 - 1. Make an allowance of at least 1-1/2 inches for grout under the equipment bases, whether or not shown on the Drawings. Use steel shims to level and adjust the bases. Shims may be left embedded in the grout, in which case they shall be installed neatly and so as to be as inconspicuous as possible in the completed work. Unless otherwise approved, all grout shall be a favorably reviewed non-shrink, non-metallic grout.
 - 2. Grout: Dimensionally stable, inorganic, premixed and resistant to acids, alkalies, and salt water, and unaffected by water and oil. It shall have high strength even when used as a pourable mixture, and shall bond well with steel and cured concrete or be compatible with a suitable bonding agent which shall then be used to effect the bond. Use in strict accordance with the manufacturer's recommendations. Provide Five Star Grout as manufactured by U.S. Grout Corporation, Bonsal Construction Grout as manufactured by Bonsal Company, or equal. Submit for favorable review by the Engineer prior to use.
 - 3. Where practicable, place the grout through the grout holes in the equipment base and work outward and under the edges of the base and across the

rough top of the concrete foundation to a peripheral form so constructed as to provide a suitable chamfer around the top edge of the finished foundation.

- E. Architectural Metals: Handrails, guardrails, stairs, and other architectural metals furnished as a part of equipment shall conform to the requirements of Division 5.

3.04 EQUIPMENT STARTUP AND ADJUSTMENT

- A. Arrange for an authorized factory-trained representative of the company or companies supplying the various items of equipment to check the installation and adjust and test the equipment. Said representative shall be experienced and knowledgeable of the equipment being tested. Furthermore, the representative shall assist and instruct the operating staff in adjusting and operating the equipment during the initial plant operation period.
 - 1. Provide initial lubrication for all equipment.
 - 2. Test and demonstrate to the Engineer that all equipment operates properly, and specified performance has been attained. For pumps, include measurement of suction and discharge pressure at the pump and measurement of pumping rate by volumetric means or through a suitably calibrated meter for two points on the performance curve. For adjustable-speed pumps, conduct tests at a minimum of two speeds. Furnish any test equipment or measuring devices required which are not part of the permanent installation.
 - 3. In addition, demonstrate that the entire facility is in full operating condition prior to the acceptance of the work. Should any equipment or part thereof fail to operate as intended, immediately remove and replace it, all at the Contractor's expense. Pay for all tests involved in this Section.
 - 4. Pressure test equipment and connections thereto as required by these Specifications.

3.05 PERFORMANCE TESTS

- A. Upon completion of the work, and after all systems are set and balanced, conduct performance tests in accordance with Division 1 and other applicable sections of these Specifications. Submit test conditions, test data and results to the Engineer for review.

3.06 SOUND LEVEL TESTING

- A. Measure the sound level developed by all mechanical and electrical equipment provided. Perform testing as required by the technical specifications during the final operation test program with all equipment operating. Use OSHA approved instrument and record the highest sound level developed when measured according to OSHA standards in each room and space. Deliver a copy of records to the Engineer.

3.07 TOOLS, LOOSE PARTS, AND LUBRICANTS

- A. Tools and Loose Parts Supplied: Provide an inventory of tools and loose parts required to be supplied under the project. Turn over inventory and parts to the Owner. The Owner's written acknowledgment of receipt is required for project completion. Loose parts are defined as items such as special tools, keys, safety equipment, and portable equipment. Refer to Section 01700 and relevant technical sections of these Specifications for additional instructions.

- B. Recommended Spare Parts: Furnish a complete list of recommended spare parts and supplies for each equipment furnished with current prices and a source of supply.
- C. Provide a list of all recommended lubricants not listed in the Operations and Maintenance Manuals.

END OF SECTION

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SECTION 11002

ELECTRIC MOTOR DRIVES

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes: Provide motors to drive equipment specified in other sections and Divisions, including, but not limited to, Divisions 11, 13, 15, and 16. Refer to driven equipment sections for additional requirements. Requirements of the driven equipment Specifications shall take precedence over the requirements of this Section, where conflict occurs. This Section applies to all electric motors furnished for this project, unless otherwise noted.

1.02 REFERENCE STANDARDS

- A. National Electrical Manufacturers Association (NEMA) Standard:
 - 1. MG 1 Motors and Generators
- B. Institute of Electrical and Electronics Engineers (IEEE) Standard:
 - 1. 112 Test Procedure for Polyphase Induction Motors and Generators
- C. Underwriters Laboratories (UL) Publication: Recognized Component Directory

1.03 SUBMITTALS

- A. For each motor, include the following data in the shop drawing submittal for the driven equipment, as part of the driven equipment's Product Review submittals:
 - 1. Machine name and specification number of driven machine.
 - 2. Manufacturer's name.
 - 3. Motor model and dimension drawing, including motor weight.
 - 4. Manufacturer's type and frame designation.
 - 5. Nominal Horsepower output.
 - 6. Time rating.
 - 7. Maximum ambient temperature rating.
 - 8. Winding Insulation class and temperature rise class.
 - 9. RPM at full load.
 - 10. Voltage, number of phases, frequency and full load amperes.
 - 11. Code letter for locked rotor kVA.
 - 12. Service factor at 40°C ambient.
 - 13. NEMA design letter.
 - 14. Enclosure type.
 - 15. Bearing data including lubrication requirements, type and frequency.
 - 16. KW input power and power factor at 75% and 100% of rated horsepower output.
 - 17. Guaranteed minimum full load efficiency. Also, nominal efficiencies at 1/2 and 3/4 load.
 - 18. Type of thermal protection or overtemperature protection, if included.
 - 19. Wiring diagram for devices such as motor leak detection, temperature or zero speed switches, as applicable.
 - 20. If utilized with a variable frequency controller, verify motor is inverter duty type. Include minimum speed at which motor may be operated for the driven machinery. Provide shaft grounding information and details.

21. Power factor at 1/2, 3/4 and full load.
 22. Recommended size for power factor correction capacitors to improve power factor to 0.95 percent lagging when operated at full load.
- B. If water cooling is required for motor thrust bearings, the Shop Drawing submittals shall indicate this requirement.

1.04 COORDINATION

- A. General: Coordinate motors with driven equipment requirements. Unless otherwise specified, equipment manufacturers or suppliers shall select and provide motors for their equipment in conformance with these Specifications. Give particular attention to coordination of requirements for:
1. Power.
 2. Starting torque.
 3. Speed.
 4. Bearing load.
 5. Ambient temperature.
 6. Frequency of starting.
 7. Moisture exposure.
 8. Adjustable speed control, where applicable.
- B. Suppliers of motors to be used with adjustable speed systems shall:
1. Provide all relevant motor data to the adjustable speed control manufacturer for analysis. Provide motors in conformance with and compatible with the adjustable speed control manufacturer's equipment and requirements.
 2. Provide all relevant motor data to the pump manufacturer for vibration, reed critical frequency and other required analyses.

1.05 SPECIFIC REQUIREMENTS

- A. The following motor characteristics are specified with the driven equipment in all cases:
1. Speed.
 2. Horsepower or supplier responsibility to determine.
 3. Horizontal or vertical arrangement.
 4. Indoor or outdoor location.
- B. Additional motor characteristics are specified with the driven equipment only where the required motor differs from the typical characteristics described below or where additional properties or characteristics are required that are not specified in this Section.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Motors shall be designed, built, and installed in the driven equipment, to provide long, trouble-free life in industrial service and shall be rated in conformance with NEMA MG1. Motors rated 100 horsepower or less and rated 600V or less shall be listed in UL Recognized Component Directory or shall be listed and labeled by other organizations acceptable to the authority having code enforcement jurisdiction.

- B. Unless otherwise specified with the driven equipment, provide motors with the following typical characteristics:
1. NEMA Design: Electric motors shall be NEMA Design B unless otherwise indicated. In no case shall starting torque or breakdown torque be less than the value in NEMA MG 1. Motors shall be suitable for the indicated starting method.
 2. Voltage Ratings:
 - a. 1/2 horsepower or less: 115 volts, single phase, 60 Hz, capacitor start. Small fan motors may be split phase or shaded pole type if standard for the equipment. Dual voltage motors rated 115/230 volts, 115/208 volts, or 120-240 volts are acceptable, provided leads are brought out to the conduit box.
 - b. Above 1/2 horsepower: 460 volts, three phase, 60 Hz, squirrel cage induction motors. Dual voltage motors rated 230/460 volts or 208/230/460 volts are acceptable, provided every lead is brought out to the conduit box.
 3. All motors shall have a service factor of 1.15 in an ambient temperature of 40°C.
 - a. Exceptions: Motors, which have special enclosures or winding configurations, may carry a Unity (1.0) Service Factor. Examples are totally enclosed, explosion proof, or submersible motors.
 4. Windings shall be copper.
 5. Horizontal motors 3 HP and larger and every vertical motor shall have split-type cast metal conduit boxes. Motors shall be provided with oversized conduit boxes. Motors other than open drip-proof shall be gasketed.
 6. Provide ground lug inside the terminal box.
 7. Provide lifting eye on each motor weighing more than 50 pounds.
 8. Each motor shall be suitable for six starts per hour (5 minutes on and 5 minutes off, continuously) when powering the specific driven equipment required for this project.
 9. Each motor shall have an overall sound power level at no load not greater than given in NEMA MG1-Part 9.
 10. Inverter duty motors shall be provided with shaft grounding rings. Rings shall be factory installed, and shall be by Aegis, or equal. The motor warranty shall include coverage against VFD-induced bearing damage or failure.
 11. Motors, which have special operating characteristics such as multi-speed, high torque/high slip, short time intermittent ratings shall be nameplated to show how these characteristics differ from standard design.
- C. Motors used with variable frequency drives shall have inverter duty complying with NEMA MG-1, Section IV, Part 31, and shall be clearly identified as "Inverter Duty."
- D. Increased circuit breaker, magnetic starter, and conductor and conduit capacities required for motors larger than the indicated sizes shall be provided as part of the Contractors work.
- E. Two speed motors shall be of the two-winding type,
- F. Exempt Motors: Motors for valve operators, submersible pumps, or motors which are an integral part of standard manufactured equipment, i.e., non-NEMA mounting, common shaft with driven element, or part of domestic or commercial use apparatus may be excepted from these requirements to the extent that such variation reflects a necessary condition of motor service or a requirement of the driven equipment.

2.02 NAMEPLATE

- A. Provide stainless steel nameplate for each motor, attached to the motor by stainless steel screws or drive pins. Nameplates shall indicate clearly the information required by NEMA MG1, Part 10 and Part 12.

2.03 ENCLOSURE TYPE BY LOCATION

- A. Unless otherwise specified with the driven equipment, provide motors with the following typical enclosures:
 - 1. Indoors and non-hazardous: Horizontal motors shall be open, drip-proof; vertical motors shall be drip-proof with guard.
 - 2. Outdoors and non-hazardous: Vertical motors shall be weather-protected type I. Horizontal motors shall be totally enclosed, fan cooled. All motors shall have the following features:
 - a. Bearing protection.
 - b. Anti-corrosion treatment of external hardware and internal metal parts.
 - c. Weatherproof terminal box with gaskets between the motor, terminal box, and terminal box cover.
 - d. Guard screens on ventilation openings.
 - e. Moderate moisture resistant insulation, specified hereinafter.
 - f. Interior and exterior corrosion protection coatings.
- B. Special attention to leads into terminal box. When specifically called for in the Specifications for the driven equipment or required by Code, provide the following enclosure types:
 - 1. Hazardous locations: Motors for use in hazardous locations shall have enclosures suitable for the classification indicated. Such motors shall be U.L. listed and be stamped as such.
 - 2. Severe duty: Motors shall have the following features:
 - a. Totally enclosed, fan cooled enclosure.
 - b. Stainless steel nameplate.
 - c. Cast iron housing, bearing brackets, and fan guard.
 - d. Cast iron conduit box with threaded conduit entrance.
 - e. Corrosion resistant fan.
 - f. Corrosion resistant hardware.
 - g. Automatic breather/drain.
 - h. Ground lug.
 - i. Regreasable bearings.
 - j. Provision for excluding water and dust from bearings.
 - k. Class F insulation.
 - l. Service factor of 1.15.
 - m. Epoxy coating on all external surfaces.
 - 3. Submersible: Submersible motors shall comply with the following:
 - a. Air-filled or oil-filled squirrel cage induction type.
 - b. Service factor of 1.15 or better.
 - c. Class F insulation, Class B temperature rise.
 - d. Rated for six (6) starts per hour.
 - e. Listed by either UL or FM for Class 1, Division 1, Groups C and D hazardous locations.
 - f. Suitable for operating in free air continuously (i.e., not submerged in sewage).
 - g. Bearing B10 life 18,000 hours minimum.

- h. Tungsten carbide seals.
- i. Lower bearings of either the ball or roller type.
- j. If required by the manufacturer to not void the motor warranty, provide a moisture detection system and a motor winding thermostat system. These systems shall be complete, including all necessary interfaces, control panels, conduits, and wires, even though these may not be shown on the Drawings.

2.04 INSULATION

- A. Three phase motors shall be provided with Class F insulation, rated to operate at a maximum ambient temperature of 40 degrees C and at the altitudes where the motors will be installed and operated, without exceeding Class B temperature rise limits stated in NEMA MG 1-12.44. Single phase motors shall have Class F insulation with temperature rise not to exceed the insulation class. Motors to be operated from adjustable frequency drives shall be provided with insulation systems to withstand 1,600-volt spikes, with dV/dT as defined in NEMA MG 1-31. The adjustable frequency drive manufacturer shall coordinate with the motor manufacturer to determine when additional dV/dT protection is required. Where required, it shall be furnished and installed as per the manufacturer's written instructions.
- B. Where called for in the Specifications for the driven equipment, provide the following type of insulation:
 - 1. Moderate Moisture Resistant: Provide extra dip and bake of epoxy or polyester varnish to resist somewhat higher than normal moisture in the atmosphere.

2.05 MOTOR HORSEPOWER

- A. The maximum permissible motor loading:
 - 1. Motors with service factor 1.15 or greater: 100% of nameplate horsepower.
 - 2. Motors with service factor less than 1.15: 90% of nameplate horsepower.
- B. Probable motor horsepower ratings have been specified or shown on the Drawings. Changes from the specified horsepower may be accepted, if necessary, to assure that motors do not exceed their maximum permissible loading, as defined above, under normal operation. Motor horsepower shall not be less than those specified in driven equipment sections. If a larger horsepower rating is required by the driven equipment, provide all changes required to motor starting and control equipment and to the conduit and wiring system without any additional cost to the Owner.

2.06 EFFICIENCY

- A. For motors 1 Horsepower and Larger:
 - 1. Provide NEMA premium efficient units. Motors shall be stamped with the efficiency on the nameplate with the caption "NEMA Nominal Efficiency" or "NEMA Nom. Eff." Premium efficiency motors shall have nominal and minimum efficiencies at full load not less than those listed in Table 11002-1. Both efficiencies shall be included in the Shop Drawing submittal.
- B. Efficiencies shall be determined by using the IEEE 112, Test Method B using segregated loss determination.

- C. Single-phase fractional horsepower motors 1/4 HP through 3/4 HP motors shall be high-efficiency split-capacitor types having minimum efficiency ratings of not less than 64% and power factors of not less than 94.5%.

TABLE 11002-1

OPEN DRIP-PROOF (ODP)						
FULL-LOAD EFFICIENCIES OF NEMA PREMIUM EFFICIENCY MOTORS RATED 600 VOLTS OR LESS						
	2 POLE		4 POLE		6 POLE	
HP	Nom. Effic.	Min. Effic.	Nom. Effic.	Min. Effic.	Nom. Effic.	Min. Effic.
1	77.0	74.0	85.5	82.5	82.5	80.0
1.5	84.0	81.5	86.5	84.0	86.5	84.0
2	85.5	82.5	86.5	84.0	87.5	85.5
3	85.5	82.5	89.5	87.5	88.5	86.5
5	86.5	84.0	89.5	87.5	89.5	87.5
7.5	88.5	86.5	91.0	89.5	90.2	88.5
10	89.5	87.5	91.7	90.2	91.7	90.2
15	90.2	88.5	93.0	91.7	91.7	90.2
20	91.0	89.5	93.0	91.7	92.4	91.0
25	91.7	90.2	93.6	92.4	93.0	91.7
30	91.7	90.2	94.1	93.0	93.6	92.4
40	92.4	91.0	94.1	93.0	94.1	93.0
50	93.0	91.7	94.5	93.6	94.1	93.0
60	93.6	92.4	95.0	94.1	94.5	93.6
75	93.6	92.4	95.0	94.1	94.5	93.6
100	93.6	92.4	95.4	94.5	95.0	94.1
125	94.1	93.0	95.4	94.5	95.0	94.1
150	94.1	93.0	95.8	95.0	95.4	94.5
200	95.0	94.1	95.8	95.0	95.4	94.5
250	95.0	94.1	95.8	95.0	95.4	94.5
300	95.4	94.5	95.8	95.0	95.4	94.5
350	95.4	94.5	95.8	95.0	95.4	94.5
400	95.8	95.0	95.8	95.0	95.8	95.0
450	96.2	95.4	96.2	95.4	96.2	95.4
500	96.2	95.4	96.2	95.4	96.2	95.4

Source: NEMA MG1 - 2011, Table 12-12

TOTALLY ENCLOSED - FAN COOLED (TEFC)						
FULL-LOAD EFFICIENCIES OF NEMA PREMIUM EFFICIENCY MOTORS RATED 600 VOLTS OR LESS						
	2 POLE		4 POLE		6 POLE	
HP	Nom. Effic.	Min. Effic.	Nom. Effic.	Min. Effic.	Nom. Effic.	Min. Effic.
1	77.0	74.0	85.5	82.5	82.5	80.0
1.5	84.0	81.5	86.5	84.0	87.5	85.5
2	85.5	82.5	86.5	84.0	88.5	86.5
3	86.5	84.0	89.5	87.5	89.5	87.5
5	88.5	86.5	89.5	87.5	89.5	87.5
7.5	89.5	87.5	91.7	90.2	91.0	89.5
10	90.2	88.5	91.7	90.2	91.0	89.5
15	91.0	89.5	92.4	91.0	91.7	90.2
20	91.0	89.5	93.0	91.7	91.7	90.2
25	91.7	90.2	93.6	92.4	93.0	91.7
30	91.7	90.2	93.6	92.4	93.0	91.7
40	92.4	91.0	94.1	93.0	94.1	93.0
50	93.0	91.7	94.5	93.6	94.1	93.0
60	93.6	92.4	95.0	94.1	94.5	93.6
75	93.6	92.4	95.4	94.5	94.5	93.6
100	94.1	93.0	95.4	94.5	95.0	94.1
125	95.0	94.1	95.4	94.5	95.0	94.1
150	95.0	94.1	95.8	95.0	95.8	95.0
200	95.4	94.5	96.2	95.4	95.8	95.0
250	95.8	95.0	96.2	95.4	95.8	95.0
300	95.8	95.0	96.2	95.4	95.8	95.0
350	95.8	95.0	96.2	95.4	95.8	95.0
400	95.8	95.0	96.2	95.4	95.8	95.0
450	95.8	95.0	96.2	95.4	95.8	95.0
500	95.8	95.0	96.2	95.4	95.8	95.0

Source: NEMA MG1 - 2011, Table 12-12

2.07 MOTOR THERMAL PROTECTION

- A. Single Phase Motors: Single phase 120, 208, or 230 volt motors shall have integral thermal overload protection or shall be inherently current limited.
- B. In each motor to be used with adjustable speed drives, in all motors 60 horsepower and larger, or where called for in the Specifications for the driven equipment, provide integral thermostats or other approved devices to protect the motor from overheating. Thermostats shall be snap action, bi-metallic, temperature actuated switch. Thermostats shall be normally closed and the switch point shall be precalibrated by the manufacturer. Thermostats shall be rated 125 Vac, 1 amp.
- C. Provide resistance temperature detectors (RTD's) for all motors 200 horsepower and larger. RTD's shall be 100 ohm, platinum. Provide two RTD's per phase, and one RTD on the upper and lower bearings.

2.08 SPACE HEATERS

- A. On all outdoor motors, where called for in the Specifications for the driven equipment, or where shown on the Drawings provide space heaters or solid-state motor winding heating systems for motors. Heaters shall be 120 or 240 volts, single-phase, as required by the control circuit voltage. Heater wattage and voltage ratings shall be indicated on motor nameplate.

2.09 MOTOR BEARINGS

- A. General: Bearings shall conform to Section 11001 – General Equipment and Mechanical Requirements, except as indicated herein.
- B. Motors greater than 2 HP shall have bearings designed for 17,500 hours (belted) or 100,000 hours (coupled) L-10 life.
- C. Fractional Horsepower: Motors with fractional horsepower through 2 HP shall be provided with lubricated-for-life ball bearings.
- D. Horizontal Motors Over 2 HP: Motors larger than 2 HP shall be provided with relubricatable ball bearings. Lubrication shall be per manufacturer's recommendation for smooth operation and long life of the bearings.
- E. Vertical Motors Over 2 HP: Vertical motors larger than 2 HP shall be provided with relubricatable ball, spherical, roller, or plate type thrust bearings. Lubrication shall be per manufacturer's recommendation for smooth operation and long life of the bearings.
- F. Water Cooled Motors: If water cooling is required for the thrust bearings, cooling water lines shall be provided complete with shut-off valve, strainer, solenoid valve, flow indicator, thermometer, throttling valve, and, (where subject to freezing), insulation with heat tracing.
- G. Inverter Duty Motors: Provide an insulated bearing to prevent circulating bearing currents.

2.10 MANUFACTURERS, OR EQUAL

- A. U.S. Motors
- B. General Electric
- C. WEG

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install motors in driven equipment in conformance with motor manufacturer's recommendations and requirements. Motor nameplate shall be visible when installed on the driven equipment. Where applicable, shaft grounding devices shall be connected to the grounding system in accordance with the manufacturer's recommendations.
- B. Related electrical WORK involving connections, controls, switches, and disconnects shall be performed in accordance with the applicable sections of Division 16.

3.02 FACTORY TESTS

- A. Motors shall be factory tested in conformance with IEEE 112, IEEE 43 - Recommended Practice for Testing Resistance of Rotating Machinery, and NEMA MG-2. Except where specific testing or witnessed shop tests are required by the specifications for driven equipment, factory test reports may be copies of routine test reports of electrically duplicate motors. Test report shall indicate test procedure and instrumentation used to measure and record data. Test report shall be certified by the motor manufacturer's test personnel and be submitted to the ENGINEER.

3.03 FIELD TESTING

- A. The Contractor shall perform the following field tests:
 - 1. Inspect each motor installation for any deviation from rated voltage, phase, frequency, and improper installation.
 - 2. Visually check for proper phase and ground connections. Verify that multi-voltage motors are connected for proper voltage. Verify shaft grounding devices are properly grounded.
 - 3. Check winding and bearing temperature detectors and space heaters for functional operation.
 - 4. Test for proper rotation prior to connection to the driven equipment.
 - 5. Visually check that motor overload heaters are properly sized and that MCP breaker settings are correct for the motor installed.
 - 6. Test insulation (megger test) of new and re-used motors in accordance with NEMA MG-1. Test voltage shall be 1000 VAC plus twice the rated voltage of the motor.

END OF SECTION

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SECTION 11213

SUBMERSIBLE PROPELLER PUMP

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes: Variable speed compatible, submersible, horizontal propeller pump complete with motor and all appurtenances to make a complete system for pumping mixed liquor.
- B. Work included in this Section:
 - 1. Contractor to furnish and install one (1) pump and appurtenances and coordinate submittals, and startup and testing services.
 - 2. Contractor shall install the pump on the existing guide rails and pump mounting assembly. Contractor shall terminate the pump power and control cable into the existing junction box. The existing pump was installed in 2001 and is a Flyght P 4660 63-1258.
 - 3. Any modifications needed to the existing facility to accommodate installation and operation of the submitted pump shall be the responsibility of the contractor.
- C. Related Sections:
 - 1. Section 01300: Submittals
 - 2. Section 11002: Electric Motor Drives

1.02 SUBMITTALS

- A. Shop Drawings and Product Data: Submit the following as a single complete initial submittal in accordance with Section 01300:
 - 1. Product data fully describing all items proposed for use to demonstrate that the equipment conforms to the Specifications, including drawings, specifications, installation and design details, catalogue cut-sheets. Include a list of materials of construction for all components.
 - 2. Motor data.
 - 3. Pump curve. For variable speed pumps, show the family of curves for every 10 Hz interval superimposed over the system curve.
 - 4. System layouts and/or schematics, including connection and installation details of discharge chutes.
 - 5. Elementary and connection wiring diagrams clearly showing external connections to other equipment.
 - 6. Control description and control logic diagram.
 - 7. Verification that the submitted pump is compatible with the existing system including in channel connections and power and control wiring.
- B. Manuals: The Contractor shall furnish manufacturer's installation, lubrication, operation and maintenance manuals, bulletins, and spare parts lists.
- C. Affidavits: The Contractor shall furnish affidavits from the Manufacturer stating that the pumps have been properly installed and tested, and each is ready for full time operation.

- D. Performance Testing: Certified non-witnessed factory performance tests in accordance with Hydraulics Institute Standards are required for each pump. Obtain favorable review from the Engineer prior to shipment of the pump.
- E. Pump Removal and Installation Plan: Contractor shall submit a coordination plan to remove the existing pump and disconnect the electrical terminations. Time is of the essence for this work, so the plan must include all elements of this work needed to remove the existing pump and install the new pump as quickly as possible.

1.03 QUALITY ASSURANCE

- A. All equipment furnished under this Section shall: 1) be of a manufacturer who has been regularly engaged in the design and manufacture of the equipment for at least 5 years; and 2) be demonstrated to the satisfaction of the Engineer that the quality is equal to equipment made by those manufacturers specifically named herein.

1.04 WARRANTY

- A. The Manufacturer of the equipment shall warrant for one (1) year from date of startup, not to exceed eighteen (18) months from date of shipment, that all equipment provided by the Manufacturer will be free from defects in material and workmanship. In the event a component fails to perform as specified or is proven defective in service during the warranty period, the Manufacturer shall repair or replace, at their discretion, such defective part.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Submersible propeller pumps shall be as manufactured by Flygt or equal.

2.02 SUBMERSIBLE PROPELLER PUMP

- A. Pumps Specified herein shall operate without clogging or fouling caused by material in the pumped fluid within the range of service specified. Mixed liquor may be expected to contain gross waste solids, organic solids, animal fats, industrial solvents, emulsified oils and greases, and detergents. The pump shall be capable of operating in the range of capacity specified on a continuous basis with no detrimental effects to the pump or motor. The pump shall be designed to operate without overload at any point along the pump's entire operating curve. The design of the pump shall be such that it will not be damaged by reversed rotation caused by backflow on the pump.

B. Pump Schedule: The pump operating characteristics shall be as follows.

Pump Title	Mixed Liquor Recirculation Pump
Pump Number	P321
Pumped Liquid	Mixed Liquor (0.2 to 0.5% solids)
Pumped Liquid Temperature	20°C Maximum 10°C Minimum
Pump Type	Variable Speed
Maximum capacity at 100% speed or less	6,000 gpm @ 3.5 ft TDH
Maximum Speed	580 RPM
Adjustable Speed Range	36-60 Hz
Nominal Motor Horsepower	15 HP
Suction Side Flare Fitting	24-inch
Basis of Design	Flyght PP-4660

C. Pump Construction

1. General: Submersible propeller pumps shall be axial flow propeller type, single stage, horizontal, with submersible pump and motor integrated into a single unit, semi permanently installed to a discharge pipe. The pump shall be a heavy duty, horizontally mounted axial flow tube type design. The pump, including all power train components shall be designed for variable speed operation. All components shall be capable of operating in a continuously submerged condition to a depth of 20 feet. Pump components shall have smooth surfaces devoid of irregularities or sharp transitions which could incite cavitation or trap air and debris. All mating surfaces where watertight sealing is required shall be machined and fitted with O-rings. The pump shall slide onto the seating flange coupled to the inlet end of the existing discharge pipe. The weight of the pump shall hold it in place without bolting. The pump shall be fitted with a lifting handle for lifting the pump out of the aeration basin with manufacturer provided davit crane. Design shall permit pump removal while the aeration basin is in operation.
2. Shroud and Seal Casing: The pump shroud and seal casing shall be cast iron (ASTM A48 Class 35B or 40) or stainless steel (ASTM A276 Type 304). Cast iron shrouds shall be provided with Type 304 stainless steel insert and protective collar. The drive unit and shroud assembly shall be equipped with a lifting handle suitable for lifting the pump off the discharge pipe.
3. Propeller and Shaft: The propeller shall be stainless steel (ASTM A276 Type 316) equipped with fixed pitch blades. Pump shafts shall be stainless steel (ASTM A276 Type 329 or 420). The rotating assembly shall be statically and dynamically balanced and shall operate at less than 80 percent of its critical speed. Shafts shall be supported by bearings with minimum L10 life of 100,000 hours continuous operation at any condition within the range specified.
4. Mechanical seals: Pumps shall be provided with two mechanical seals running in an oil bath. Seal faces shall be silicon carbide. A moisture sensor shall be provided in the seal chamber which shall activate an alarm upon seal failure.
5. Gearbox: If needed to drive the pump, a cast iron (ASTM A48 Class 30) gear box shall be provided. The pump shaft on pumps with gear boxes shall be driven through a planetary gear reduction system, with input gear shaft

mounted on needle bearings lubricated by the gear lubricant. Bearings shall be rated for a minimum L10 life of 100,000 hours.

6. Motors: The motors shall be submersible, inverter duty rated motors conforming to the requirements of Section 11002 and having an L10 bearing life of 100,000 hours. Integral thermostats shall be provided to protect the motor from overheating. Thermostats shall be normally closed.
7. Cable: Power and control cables shall be of sufficient length for termination in existing junction box. The cable entry design shall insure that no entry of moisture internal to the pump's motor is possible even if the power cable is severed under water. The cable entry seal design shall preclude specific torque requirements to ensure a watertight seal and shall be comprised of a cylindrical elastomer grommet having a close tolerance fit against the cable outside diameter and the entry inside diameter. The cable entry junction chamber and motor shall be separated by a stator lead sealing gland, terminal board or epoxy barrier. The cable shall be capable of continuous submergence underwater without loss of watertight integrity to a depth of 65 feet. A cable support grip shall be supplied with the cable. Power and control cables shall include:
 - a. Three cables for power.
 - b. Grounding cable.
 - c. Two conductors for temperature and leakage sensors.
8. Coatings: All castings must be blasted before coating. All wet surfaces are to be coated with two-pack oxyrane ester Duasolid 50. The total layer thickness should be at least 120 microns. Zink dust primer shall not be used.
9. Factory Testing: Each completed and assembled pump/motor unit shall undergo the following factory tests at the manufacturer's plant prior to shipment. The Manufacturer shall provide on demand a copy of the quality control plan for these tests and an ISO 9001 factory certificate:
 - a. Hydraulic performance test
 - b. No-Leak seal integrity test
 - c. Electrical integrity test

2.03 SPARE PARTS

- A. The following spare parts shall be provided:
 1. Mechanical seal set.
 2. Shaft bearing set.
 3. Special tools and equipment needed for maintenance and installation.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Equipment shall be installed in strict conformance with the manufacturer's installation instructions and in accordance with the approved Pump Removal and Replacement Plan.
- B. Contractor shall leave the existing pump to the Owner to be a shelf spare. Owner will clean, organize, and store the pump once successful field testing has been completed per 3.04 A.

3.02 FIELD SERVICE

- A. The manufacturer of the pump shall supply a competent field service engineer to thoroughly check and inspect the pump during installation, place the pump in operation, participate in field startup and testing procedures, and make necessary adjustments. A minimum of 8 hours field services shall be provided.

3.03 FIELD PAINTING

- A. Pump and appurtenances shall be touched up as required and in accordance with manufacturer's instructions.

3.04 FIELD TESTING

- A. Each pump shall be field tested by a factory representative to verify that they are operating properly and are able to pump the design flow rate. Field testing shall be observed by the Engineer.

END OF SECTION

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SECTION 11240

CHEMICAL FEED EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

- A. General: Furnish complete, tested, and operating equipment as shown on the Drawings and specified herein.
- B. This section includes equipment for multiple chemical systems. Pump sizes, pump and accessory materials, and design demands are provided for each system.
- C. The section also includes specification of a pre-fabricated metering pump system for the Magnesium Hydroxide Metering Pump Skid and a pre-fabricated pump enclosure (Enclosure) for the skid. The complete scope of supply for this pre-fabricated metering pump system and enclosure is shown on sheet I-101 and includes, but not limited to, a mounting plate for the peristaltic metering pump, calibration column, pressure relief valve, pressure gauge assembly, flow switch, and 3W flushing system assembly for the metering pumps. The pre-fabricated enclosure includes, but not limited to, walls, roof, vents, insulation, door, distribution panelboard, junction box, disconnect switch, transformer, lights, switches, receptacles, fan, heater, vents with hood and associated controls.
- C. The section also includes specification of a pre-fabricated metering pump system for the Sodium Hydroxide Metering Pump Skid and splash guard enclosure. The complete scope of supply for this pre-fabricated metering pump system is shown on sheet I-201 and includes mounting plate for the peristaltic metering pump, calibration column, pulsation dampener, pressure relief valve, pressure gauge assembly, drain, and isolation valves for the metering pump.
- D. The section also includes specification of a pre-fabricated metering pump system for the Sodium Hypochlorite Metering Pump Skid. The complete scope of supply for this pre-fabricated metering pump system is shown on sheet I-203 and includes a skid mounted frame installed within a clam-shell style low density polyethylene (LDPE) spill containment enclosure, mounting plate for the peristaltic metering pump, calibration column, pulsation dampener, pressure relief valve, pressure gauge assembly, drain, and isolation valves for the metering pump.
- E. Except as indicated herein, the Chemical Feed Equipment Supplier has unit responsibility for the pump skids and the enclosure for the Magnesium Hydroxide feed system.
- E. All other material specified and shown outside of the pump skid or Enclosure on the Drawings shall be provided loose and installed in the field by the General Contractor.
- F. The Contractor shall protect all temporary chemical feed systems in operation throughout the duration of the project. See Section 01140 for work sequence requirements.

1.02 SUBMITTALS

- A. Shop Drawings and Product Data: Submit the following information as a single complete initial submittal in accordance with Section 01300:
1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
 2. Where applicable, a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this Section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
 3. Submit product data fully describing all items proposed for use to demonstrate that the equipment conforms to the specifications including, but not limited to, the following:
 - a. Motor data in accordance with Section 11002 and wiring diagrams.
 - b. Pump layouts, dimensions, and anchor bolt locations.
 - c. Pump performance curves.
 - d. Materials of construction with chemical compatibility charts and data to demonstrate all materials of construction are compatible with chemical used.
 4. Submit dimensional plans and sections of the proposed equipment and pump skid installed in place if the pump and skid layout deviates from what is shown on the Drawings. Include any additional layout and installation requirements of the proposed equipment.
 5. Submit dimensional plans and sections of the enclosure proposed for the magnesium hydroxide pump skid system including, but not limited to, the following:
 - a. Complete installation instructions, with points of electrical connection requirements clearly shown.
 - b. Wiring diagrams for the terminal panel at the enclosure.
 - c. Product information on fan, heater, vents with hood and associated controls and switches.
 5. Material Safety Data Sheets (MSDS) for each chemical to be used during testing of each chemical feed system.
 6. Complete warranty information in accordance with Paragraph 1.04.

- B. Operation and Maintenance Manuals: Furnish manufacturer's installation, lubrication, operation and maintenance manuals, bulletins, and spare parts lists in electronic format (.pdf files) on compact disc.
- C. Seismic Anchorage Design for pump skids and Enclosure, including layout and calculations, signed and sealed by a Professional Engineer registered in the State of Washington, and conforming to the requirements of Section 01190. All seismic anchorage calculations shall be submitted together as one single package under Section 01190.
- D. Submit certification from the manufacturer that the equipment is capable of resisting seismic loads. Refer to Section 11001 for additional information on certification. Loading shall be as described in Section 01190. Seismic certifications shall be submitted as with the seismic anchorage calculations as a single package under Section 01190.
- E. Field Performance Testing and Affidavit: Provide performance testing of each of the three chemical feed system as described in Section 11001 and as described in Part 3 of this Section. Following Performance Testing, the Contractor shall submit certification from the supplier stating that the pumps have been properly installed and tested, and each is ready for full-time operation. Certificate shall conform to the requirements of Section 01650. All performance test records, affidavits, etc. shall be submitted in one single package under Section 01650. een properly installed, adjusted, and tested and is ready for full-time operation.

1.03 QUALITY ASSURANCE

- A. All products furnished under this Section shall be from manufacturers who have been regularly engaged in the manufacture of the pumps specified for at least 5 years.
- B. All pumps are to be manufactured and supplied by a single manufacturer.
- C. All components and equipment shall be suitable for bulk (as delivered) chemicals specified as follows in percentage by weight of solution (approximate):

Chemical	Concentration	Specific Gravity
Sodium Hypochlorite	12.5%	1.18
Sodium Hydroxide	50%	1.50
Magnesium Hydroxide (Slurry)	60%	1.45

- D. Comply with the Following Regulatory Standards:
 - 1. Uniform Fire Code, especially Article 80, Hazardous Materials with local amendments, if any.
 - 2. Uniform Building Code, especially Chapter 9, with local amendments, if any.

1.04 WARRANTY

- A. The warranty for all products and work shall comply with the requirements of the Contractor's General Warranty and Guarantee described in the General Conditions and the Supplementary Conditions.

PART 2 - PRODUCTS

2.01 CHEMICAL FEED PUMPS

- A. General: Provide six (6) horizontal seal-less peristaltic type tube pumps complete with all accessories as specified herein. Pumps shall be self-priming, valveless/glandless with no dynamic seals in contact with the pumped fluid. Pump shall be capable of running dry without damage to pump or hose. Pump shall provide a suction capability of up to 30 feet of water. Pump shall be Blue White; or equal.

B. Pump Schedules:

Qty	Service	Capacity GPH		Pump Max Discharge Pressure PSI	Volt/ Phase	Basis of Design
		Min.	Max.			
2	Magnesium Hydroxide (MHD) Alkalinity Addition and pH Adjustment	3.7	30	55	120/1	Blue-White Flex-Pro M4
2	Sodium Hydroxide (SHD) Backup pH Adjustment Odor Control Unit	2	7	55	120/1	Blue-White Flex-Pro M3
2	Sodium Hypochlorite (SHP) Bulking Control Odor Control Unit	0.8	6	55	120/1	Blue-White Flex-Pro M3

- C. Materials of Construction: All equipment and accessories in contact with the pumped fluid shall be chemically and physically compatible.

Chemical:	Magnesium Hydroxide (60%)	Sodium Hydroxide (50%)	Sodium Hypochlorite (12.5%)
Pump Head	PBT	PBT	PBT
Cover	Polycarbonate	Polycarbonate	Polycarbonate
Rotor	PBT	PBT	PBT
Shoes	PVDF	PVDF	PVDF
Frame and Hardware	316 SS	SS 316L	316 SS
Inserts	PVDF	PVDF	PVDF
Gaskets	PTFE/Viton	PTFE	PTFE
Tube	Flex-A-Prene®	Flex-A-Prene®	Flex-A-Prene®
Skid	Polypropylene	Polypropylene	Polypropylene
Connection Fittings	½" ID Flexible Tubing	½" ID Flexible Tubing	½" ID Flexible Tubing

- D. Accessories: Provide one spare hose for each chemical service.

- E. Motors: Drive motors shall be 115 VAC, 1-phase, TEFC severe duty. Additional requirements shall be as specified in Section 11002.

F. Controls:

1. Pumps must meet the following minimum requirements for operator interface functionality. Pumps not meeting this minimum functionality will not be accepted.
 - a. Backlit graphical LCD to display local/remote status, pump speed, running status, flow rate, and programming functions.
 - b. Keypad for start, stop, speed increment, speed decrement, forward/reverse direction, rapid prime, and programming.
 - c. Menu driven on screen programming of manual or auto control, flow and remote signal calibration, and general programming.
 - d. Programmable "Auto Restart" feature to resume pump status in the event of power outage interruption.
 - e. Programmable "Keypad Lock" to allow operator lockout of all keys except emergency start/stop.
 - f. Programmable "Maximum Speed" to allow operator to set the maximum speed of the pump.
2. Controls: Supply auto control features to meet the following minimum functionality requirements. Pumps not meeting this minimum functionality will not be accepted.
 - a. Pump Inputs:
 - 1) Speed Control: Analog 4-20mA with input signal trimmable and speed scaleable over any part of the drive speed range.
 - 2) Start/Stop Control: Dry contact rated for 120 VAC. Configurable command allowing open to equal run or open to equal stopped. Configurable to allow a keypad start/stop override in Manual mode.
 - b. Pump Outputs:
 - 1) Three relay contacts rated for a maximum current of 2A at 120V, normally open and normally closed software configurable to indicate the following:
 - a) Running/Stopped Status
 - b) Auto/Manual Status
 - c) General Alarm Status
 - 2) Speed output: Analog 4-20 mA.

2.02 PUMP SKID

- A. Skid Frame: The pump, piping, and appurtenances shown on Drawings shall be provided with a polypropylene frame and backplate to support the metering pumps and components. The pumps shall be supported via a shelf attached to the skid system. The shelf shall provide clean and clear access to the pump head and pump LCD display. Skid frame and backplate shall be mounted on the concrete floor within the containment area or within the pump skid enclosure as shown on the Drawings. Provide anchor holes and hardware for mounting.

2.03 CHEMICAL FEED ACCESSORIES

- A. General: Materials of construction shall be satisfactory for continuous exposure to the hereinbefore-listed chemicals. Solvent welding of any accessories or accessory components specified herein shall be in accordance with ASTM F 493, and solvent weld cement shall be IPS Weld-On 724 CPVC by Harrington Plastics; or equal. Primer shall be IPS Weld-On P-70, or equal. All connections to calibration cylinders, valves, and appurtenances shall be flanged or true union unless noted otherwise; threaded connections are not acceptable unless specifically indicated.

- B. All flanged or true union joints and valves for the exposed SHD and SHP shall be provided with a protective spray shield.
- C. Safety Shields: TFE coated fiberglass, OSHA orange border with see-through shield for inspection of leaks. Ramco Vue-Gard; or equal.
- D. SHD, SHP, and MHD piping:
 - 1. SHD, SHP and MHD piping and flexible tubing are not within the scope of supply of the Chemical Feed Equipment Supplier. Refer to Section 15050 for piping and tubing requirements. Exception - feed pump flexible connections are within the scope of supply of the Chemical Feed Equipment Supplier. Refer to requirements for feed pump flexible connections below.
- E. Calibration Cylinders: Provide 2,000 mL graduated calibration cylinders for Magnesium Hydroxide and 500-mL cylinders for Sodium Hydroxide and Sodium Hypochlorite with 150-lb socket-welded flanged-end connections on top and bottom (threaded connections are not acceptable). Provide anti-splash caps for each calibration cylinder. All materials shall be clear PVC. Manufacturer shall be Griffco Valve Inc., or equal.
- F. Valves and Appurtenances for Pumping System
 - 1. Pressure Relief Valve (PRV):
 - a. Type: Angle Pattern.
 - b. Body, Seat, Diaphragm Materials:
 - 1) Magnesium Hydroxide and Sodium Hypochlorite: CPVC with Viton/PTFE diaphragm
 - 2) Sodium Hydroxide – PVC with EPDM/PTFE diaphragm
 - c. Pressure Range: 0 - 60 psi
 - d. Pressure Rating: 150 psi (minimum)
 - e. Connections: ½-inch flanged, 150-lb ANSI
 - f. Comply with Hydraulic Institute Standards, API 675 accessory requirements
 - g. Valves shall be field adjustable and installed where shown on the Drawings and/or as recommended by manufacturer.
 - h. Manufacturer: Griffco Valve Inc. G-Series, or equal.
 - 2. Pulsation Dampeners:
 - a. Materials:
 - 1) Sodium Hypochlorite: CPVC wetted parts, PTFE diaphragm, polypropylene non-wetted housing.
 - 2) Sodium Hydroxide: PVC wetted parts, PTFE diaphragm, polypropylene non-wetted housing.
 - b. Connection Type: 1/2-inch, flanged-inlet connection, 150-lb ANSI
 - c. Gas volume: 10 in³
 - d. Accessories: Glycerin filled PVDF pressure gauge with 2½-inch dial
 - e. Pressure rating: 150 psig minimum.
 - f. Manufacturer shall be Blacoh Fluid Control; or equal.
 - 3. Flushing Connection:
 - a. Where a flushing/drain connection is shown on the Drawings, provide a diaphragm isolation valve, 1/2-inch socketx FPT SCH 80 encapsulated reinforced female adapter, and MPT plug. The plug and adapter shall be distributed by Harrington Plastics; or equal.
 - 4. Flexible Pump Connections: Provide connectors to transition from tubing to rigid piping for the suction and discharge of each pump. Material of connectors shall

be compatible with pumped fluid. Connections shall have crimped or barbed/clamped 150-lb ANSI flanged end connections and be pressure rated for 150 psi minimum. Manufacturer shall be Nylobrade HP, or equal.

G. Valves and Appurtenances for Flushing Water Assembly

1. Flushing water assembly for Magnesium Hydroxide Pump System shall be supplied by the Chemical Feed Equipment supplier as shown on Sheet I-101 and as specified herein.
2. Provide ball valves, strainers, pressure regulating valves, check valves as specified for Valve System C in Section 15050.
3. Provide rotameters and flow switches as required per Section 17120.
4. Solenoid Valves: Valves shall be for 150-psi water pressure, 120-Volt ac service, with a watertight enclosure and NPT end-connections. Valve body shall be brass, seats Buna-N, with stainless steel plug. Valves shall be normally closed except where noted otherwise. Provide manual override control. Valves shall be ASCO Bulletin 8211; Skinner L or R Series; or equal.
5. Valves and appurtenances specified above shall be mounted on the pump skid as shown on Drawings. Flushing water assembly shall be pre-plumbed using piping specified for the 3W system in Section 15050.

2.04 MAGNESIUM HYDROXIDE PUMP ENCLOSURE

A. General:

1. The Magnesium Hydroxide Pump Enclosure (Enclosure) shall be a pre-fabricated fiberglass structure that is shipped to the site pre-assembled to the extent practical. The Magnesium Hydroxide Pump Skid shall be housed in the pre-fabricated Enclosure.
2. The Enclosure shall be no greater than 8'-0" W x 3'-5" x 8'-6" H. The Enclosure shall provide clean and clear access to the pump head and pump LCD display and other maintenance components associated with the pump system and Enclosure.
3. The Enclosure shall comply with codes as identified herein and as are applicable to the design and construction of the building.
4. The Enclosure shall be fabricated by ShelterWorks or approved equal.

B. Special Guarantee: The fiberglass Enclosure shall be warranted for 25 years from defects such as delamination, corrosion, UV degradation, leaks, cracks, failed hardware, and other structurally related defects.

C. Regulatory Requirements:

1. Design and construction of the Enclosure shall comply with the Washington State Building Code, which is comprised of the following code editions listed below with City of Monroe and Washington State Amendments:
 - a. 2015 International Building Code (IBC)
 - b. 2015 International Mechanical Code (IMC)
 - c. 2015 International Fire Code (IFC)
 - d. 2015 Uniform Plumbing Code (UPC)
 - e. 2015 Washington State Energy Code (Energy Code)
2. Electrical work within the Enclosure shall comply with the 2017 National Electric Code with Washington State Amendments.

- D. The Enclosure shall be designed based on Chapter 16 of the IBC and also the following:
1. Dead Load: As Calculated
 2. Roof Live Load: 25 psf uniform, 400 lbs point load
 3. Floor Live Load: 125 psf uniform, 400 lbs point load
 4. Wind Load: 1.15 importance factor, 115 mph wind speed (3 second gust), exposure "D"
 5. Snow Load: 15 psf uniform (ground), 1.1 importance factor, 0.9 exposure factor, 1.2 thermal factor
 6. Seismic Load: 1.5 importance factor, site class "D", seismic category "D", occupancy category IV with the following site specific coefficients:
 - a. Mapped Spectral Acceleration SS: 1.286
 - b. Mapped Spectral Acceleration S1: 0.487
 - c. Spectral Response Coefficient SDS: 0.857
 - d. Spectral Response Coefficient SD1: 0.491
- E. Enclosure Structure:
1. The structural frame shall be rigid and consist of structural shapes designed to meet the loading criteria listed above.
 2. Enclosure walls shall be mounted to a rigid base frame that includes chemical containment and plumbing drains. Wall connections to the base and roof connections to the walls shall be sealed to provide a weatherproof interface.
 3. All hardware shall be stainless steel in accordance with ASTM F593 and F594.
 4. The walls, roof, and doors shall be insulated to comply with the requirements of a semi-heated space in accordance with the Energy Code.
 5. Walls shall be comprised of an exterior and interior fiberglass skin bonded together with fiberglass I-beams spaced no more than 12 inches apart. The void space between the exterior and interior skins shall be filled with a foam core for insulation and the skins shall be finished with a gel coat for color and UV resistance. Walls having equipment attached to them shall include OSB plywood underneath the interior skin fiberglass skin to provide reinforcement and added strength for equipment mounting. Additionally, properties of the walls shall include the following:
 - a. The walls shall incorporate a minimum 15-minute fire barrier between the interior of the building and the foam insulation.
 - b. Fiberglass resin shall be fire retardant and self-extinguishing per ASTM E84, Class 1 (flame spread).
 - c. Insulation shall be minimum 1.5-inch, R-12 polyisocyanurate foam with low flame spread (≤ 25), Elfoam P200 or equal.
 - d. Interior gel coat shall be fire retardant.
 6. Provide sloped roof so the splash water can drain to the drain channel behind the Enclosure. Roofing material shall be certified "Class C" in accordance with ASTM E108.
 7. All finishes and exterior materials shall be weatherproof and resistant to degradation from UV light.
 8. Prior to shipment, clean the structure to remove dust, debris, grease, and other foreign matter. Provide material to the Contractor for field touch up and repair of coatings and materials.
 9. Colors shall be selected by the Owner based on the manufacturer's standard colors.

F. Enclosure Appurtenances:

1. Doors: The doors shall be a double door configuration. Provide an insulated fiberglass door with seamless integrated door jamb and rain drip edge. Width of doors shall be at least 6'-0" wide and 6'-8" tall with minimum 15-inch by 15-inch window. Window shall be made of double-paned tempered glass. Door hardware and hinges shall be stainless steel. Door handles shall be a drop handle type made of 304 stainless steel and shall include a place for a padlock. A door holder shall be used to prevent door closure during high winds.
2. Knock-Out Panels and Bulkheads: Provide knock-out panels and or bulkheads for penetrations of piping and conduits for process, electrical and communications/control connections. Bulkheads shall consist of a wall area with no foam core to allow penetrations through the fiberglass without exposing the core.
3. Enclosure Floor: The floor shall consist of FRP encapsulated plywood with non-skid walking surface. The floor shall provide liquid tight containment and any liquid collected shall be drained through a drain opening near the bottom backside wall. The pump skid system shall be anchored through the enclosure floor to the concrete pad.

G. Enclosure Electrical

1. General: All electrical components shall be Allen-Bradley or Square D.
2. Electrical Power Supply: Power supply to the Pump Enclosure shall be 120-volt, single-phase. Provide an external fused service-entrance-rated disconnect switch, 60 Amp minimum, for the power supply to the Enclosure. Provide a circuit breaker sized. Electrical items inside the Enclosure shall be rated NEMA 1 and items located on the building exterior shall be rated NEMA 3R.
3. Electrical Distribution: Provide a NEMA 1 panelboard mounted at Enclosure with circuit breakers sized to provide 120/240-volt single-phase power. Provide a total of 12 circuits per the Panel (LP-3) Schedule shown on the Drawings.
 - a. Conduit and wiring connecting the following items to the panelboard shall be factory installed and tested by the manufacturer:
 - 1) Two (2) metering pumps
 - 2) Enclosure lighting and receptacles
 - 3) Enclosure heating
 - 4) Enclosure ventilation
 - b. Conduit and wiring connecting the remaining items to the panelboard shall be installed and tested in the field by the electrical contractor.
4. Instrumentation Power and Controls: Conduit and wiring connection to the Remote I/O panel shall be installed and tested in the field by the electrical contractor.
5. Lighting: Provide LED lighting for the interior space connected to a light switch and an exterior LED light with a photocell above the doorway.
6. Receptacles: Provide at least two interior 120-volt receptacles inside the Enclosure.
7. Locations: The electrical equipment shall be arranged to avoid water splashing on the electrical equipment.

H. Enclosure Heating and Ventilation:

1. Heater: Provide a corrosion resistant heater sized to keep the building interior temperature at or above 50 degrees Fahrenheit when outdoor temperatures are 0 degrees Fahrenheit.

2. Ventilation: Provide corrosion resistant fan, vents and rain hoods for ventilation of the building. The vents shall gravity louvers and insect screens. The fan shall be sized to provide at least 1 cfm of ventilation capacity per square foot of building area.
3. Controls: Provide switches for manual control of the heater and fan and thermostats for automatic control of the heater to maintain interior temperatures above 50 degrees Fahrenheit.

PART 3 - EXECUTION

3.01 FIELD INSTALLATION

- A. The chemical feed equipment shall be installed in strict conformance with the manufacturer's installation instructions and favorably reviewed shop drawings. Install the pumps on wall-mounted pump support base as shown on the Drawings.

3.02 IDENTIFICATION

- A. Identification of the health, flammability, and reactivity of each chemical shall be affixed above each chemical feed area. See Specification Section 11001.

3.03 FIELD SERVICE

- A. The pump manufacturer shall supply a competent field service engineer to thoroughly check and inspect the pumps after installation, place the pumps in operation, make necessary adjustments, calibrate instruments, and conduct field tests. The services required shall also include on-the-job training of operators including safety procedures, operating instructions, and preventive maintenance procedures. Furnish the minimum number of hours of field services specified herein. Additional visits to the site, as often as necessary, will be provided to achieve satisfactory installation and operation in the opinion of the Owner.
- B. Installation, Startup and Performance Testing: Provide an engineer or technician from the chemical feed equipment supplier for a minimum of sixteen (16) hours to thoroughly check and inspect the equipment after installation, place the equipment in operation, make necessary adjustments, calibrate instruments, and conduct field tests, record the results of testing, and issue a manufacturer's affidavit of proper installation as described herein.
- C. Training: Provide eight (8) hours of additional service by an engineer or technician from the chemical feed equipment supplier to train plant personnel in system operation, maintenance, and safety procedures.
- D. Durations specified in Field Services do not include travel time to or from the project site or additional time required for retesting. If there are difficulties in operation of the equipment due to the design, fabrication, or installation, additional service shall be provided at no cost to the Owner.

3.04 FIELD TESTING

- A. The manufacturer shall thoroughly test all equipment in the factory before shipping. After field services described in Section 3.03 are performed and all of the piping has pass pressure testing, the Contractor shall field test all equipment specified in this Section. Pumps shall be tested in the manual mode of operation using water, and run continuously for an 8-hour period. Testing of control systems required for automatic operation of the pumps shall be performed separately and is described in other Sections.
- B. Each chemical system shall be tested against a closed discharge solution line to test pressure relief valve operation. This shall be performed for each chemical pump and shall be witnessed by the Owner. Only after satisfactory testing with water and complete draining and removal of water from the chemical system, and thorough drying, which may require blowing dry air through the pipelines, may the final test with chemical be allowed to proceed. After draining the test water, hand wipe, dry, and blow dry air through chemical feed pipelines to leave the chemical pipelines clean, dry, and ready for conveyance of the chemical; then test each chemical feed system in all operational and alarm modes to show conformance with these Specifications. Provide sufficient chemicals (approximately 5 gallons per system), for the tests. The chemicals used shall be favorably reviewed by the Engineer prior to the test. Each chemical metering pump shall be calibrated and tested throughout its pumping range. The MSDS for each chemical shall be on hand during the testing of the chemical feed system.
- C. The Contractor shall be responsible for the disposal of the test material(s).

END OF SECTION

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SECTION 13416

CHEMICAL STORAGE TANKS

PART 1 - GENERAL

1.01 SUMMARY

- A. This Section describes indoor, single-wall, con-bottom polyethylene tanks for Sodium Hydroxide and Sodium Hypochlorite. Provide complete, tested, and operating tanks as shown on the Drawings and as specified herein, including shipping any "over-sized" loads to the project site.

1.02 REFERENCES

- A. ASTM International (ASTM).
 - 1. C177 Test Method for Steady State Heat Flux Measurements and Thermal Transmission Properties
 - 2. C273 Test Method for Shear Properties in Flatwise Plane of Flat Sandwich Constructions or Sandwich Cores
 - 3. D638 Tensile Properties of Plastics
 - 4. D618 Conditioning Plastics and Electrical Insulating Materials for Testing
 - 5. D746 Impact Brittleness Temperature
 - 6. D790 Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
 - 7. D883 Standard Definitions of Terms Relating to Plastics
 - 8. D1505 Density of Plastics by the Density-Gradient Technique
 - 9. D1525 Test Method for Vicat Softening Temperature of Plastics
 - 10. D1621 Test Method for Compressive Properties of Rigid Cellular Plastics
 - 11. D1622 Test Method for Apparent Density of Rigid Cellular Plastics
 - 12. D1623 Test Method for Tensile and Tensile Adhesion Properties of Rigid Cellular Plastics
 - 13. D1693 ESCR Specification Thickness 0.125" F50-10% Igepal
 - 14. D1998 Standard Specification for Polyethylene Upright Storage Tanks
 - 15. D3892 Practice for Packaging/Packing of Plastics
 - 16. E84 Test Method for Surface Burning Characteristics of Building Materials
 - 17. F412 Definitions of Terms Relating to Plastic Piping Systems
- B. ANSI Standards: B-16.5, Pipe Flanges and Flanged Fittings
- C. Occupational Safety and Health Administration (OSHA) Standards: 29 CFR 1910.106, Occupational Safety and Health Administration, Flammable and Combustible Liquids
- D. IBC Code: International Building Code, Washington Adopted Edition
- E. ARM (Association of Rotational Molders) Standards: Low Temperature Impact Resistance (Falling Dart Test Procedure)

1.03 SUBMITTALS

- A. Shop Drawings: Submit the following as a single complete initial submittal in accordance with Section 01300 in the Product Review category. Sufficient data

shall be included to show that the products conform to Specification requirements. Provide the following additional information:

1. Shop drawings showing tank dimensions, orientation of tank fittings, nozzles, vents, manways, and other appurtenances.
2. Details of tank construction and fittings. Indicate wall thicknesses.
3. Anchorage and lateral restraint details and calculations prepared by and stamped by a structural engineer, registered in the State of Washington.
4. Tank design calculations as specified, including material properties used in design and loading conditions (handling, vertical loading, discontinuity, and seismic loading).
5. Tank manufacturer's corrosion resistance charts for the specified chemicals of the chemical concentrations indicated below, in percentage by weight of solution:

Chemical	Concentration	Approximate Specific Gravity
Sodium Hypochlorite	12.5%	1.18
Sodium Hydroxide	50%	1.50

6. Form of warranty.
- B. Submit results of shop testing for review. Do not ship tanks until favorable review of tests is received.
- C. Submit results of field testing.
- D. Manuals: Furnish manufacturer's installation, operation and maintenance manuals, bulletins, and spare parts lists. Furnish a local 24-hour emergency number for repairs in case of tank damage.
- E. Affidavits: Furnish affidavits from the manufacturer stating that the tanks have been installed to the manufacturer's requirements and are ready for full-time storage of the specified chemicals.
- F. Submit chain-of-custody certification.

1.04 QUALITY ASSURANCE

- A. Products of the same material furnished under this Section shall be supplied by a single manufacturer who has been regularly engaged in the design and manufacture of the tanks for a minimum of 10 years. Demonstrate to the satisfaction of the Engineer that the quality is equal to tanks made by the manufacturers named herein.
- B. Products shall be manufactured at a manufacturing facility that meets or exceeds ISO 9000 quality standards.
- C. Comply with the following Reference Standard: Standard Specification for Polyethylene Upright Storage Tanks, ASTM D 1998 except as modified herein.
- D. Comply with the following Regulatory Standards:
1. International Fire Code, Chapter 50, Hazardous Materials - General Provisions and Chapter 54 - Corrosive Materials, with local amendments, if any.
 2. International Building Code, with local amendments, if any.

- E. Tank shall be manufactured from new materials and shall not be stored for more than 3 months prior to delivery.
- F. Impact test results must meet the requirements of ASTM D 1998, Section 11 - Test Methods.

1.05 WARRANTY

- A. The tank shall be warranted for Two (2) years for 100% replacement against defects in materials, workmanship, and chemical attack and an additional three (3) years prorated warranty for a total warranty of five (5) years. Copy of warranty must be present on tank or on invoice with instruction sheets accompanying fittings.

PART 2 - PRODUCTS

2.01 MANUFACTURER

- A. Tanks shall be as manufactured by Poly Processing; Snyder Industries, Inc; or equal.

2.02 POLYETHYLENE STORAGE TANKS

- A. Tanks shall comply with ASTM D 1998 Polyethylene Upright Storage Tanks, except where modified in this specification.
- B. Tanks shall be designed in accordance with Section 01190 - Seismic Requirements, and other superimposed mechanical conditions as described.
- C. In addition to the minimum design requirements as specified, the tanks shall be designed for the stated specific gravity conditions, maximum ambient temperature of 100°F, and maximum operating temperature of 115°F. All components shall be compatible with the chemicals specified in Paragraph 1.03-A.5.
- D. Resin used in the tank manufacture shall be high-density cross-linkable polyethylene (XLPE) PAXON 7000 Series as manufactured by ExxonMobile Chemical; or equal. For sodium hypochlorite tank(s), provide a medium density resin with four times the anti-oxidant properties of standard polyethylene. The tank material shall be rotationally molded and meet or exceed the following properties:

Property	Cross-linked Polyethylene Value	ASTM Test
Density, gm/cc	0.938-0.944	D1505
Environmental Stress Cracking Resistance, F50, hours	>1,000	D1693
Tensile Strength, Ultimate psi, 2-inch/minimum	2,600	D638 Type IV Specimen
Elongation at Break, % 2-inch minimum	400	D638 Type IV Specimen
Vicat Softening Point	~248°F	D1525

Property	Cross-linked Polyethylene Value	ASTM Test
Impact Brittleness temperature	<-180°F	D746
Flexural Modulus, psi	100,000	D790

- E. Each tank shall have weatherability equal to PAXON 7000 Series for cross-linked with 0.5% UV stabilizer. Manufacturer shall have the capability of providing history of tanks made of specified resin with 3 or more year's exposure to sunlight.
- F. Wall thickness for a given hoop stress is to be calculated in accordance with ASTM D 1998. Tanks shall be designed using a hoop stress no greater than 600 psi. Wall thickness calculations shall assume that all tank contents have a specific gravity of not less than 2.2
- G. Manufacturer shall have the capability of issuing gel test results using the method described in ASTM D 1998. The percentage gel level for Cross-link Polyethylene Tanks on the inside 1/8-inch of the wall shall be a minimum of 60%.
- H. Tank colors shall be natural (unpigmented). When pigments are added they shall not exceed 0.25% (dry blended) of the total weight.
- I. Manways shall be 17-in. diameter or smaller coarse threaded lid.
- J. Fittings shall be of the following type as suitable for the service:
 - 1. Fittings shall be compression type, tank adapters with standard National Pipe Thread to be compatible with associated plumbing. Fittings shall be made vertical on sloping tank tops. Compression type fittings are not permitted for submerged service or below the top head of the tank.
 - 2. Bolted Fittings shall be double flange fittings with two 150-lb flanges. Use bolts with internal polyethylene injection molded encapsulated heads compatible with the chemical stored. Provide gaskets for bolts sealing surface on inner flange.
 - 3. Gaskets shall be a minimum of ¼-inch thickness and constructed of 40-50 durometer EPDM and 60-70 durometer Viton.
 - 4. Fitting, gasket, and bolt materials shall be as follows:

Chemical	Fitting Material	Gasket Material	Bolt Material
Caustic Soda (Sodium Hydroxide)	PVC	EPDM	316 SS
Sodium Hypochlorite	PVC	Viton	Titanium

- 5. All tank fitting attachments on the lower sidewalls shall be equipped with flexible couplers designed to deflect based upon tank loading, chemical temperature, and storage time duration. Tank piping flexible couplers shall be designed to allow 4% design movement.

2.03 SEISMIC RESTRAINT

- A. Tank supports and restraint system shall be supplied and the design for same certified by a Structural Engineer registered in the State of Washington. Design shall conform to the most recent edition of the IBC, refer to Section 01190. All components of the restraint system for sodium hypochlorite and sulfuric acid tanks shall be Hastelloy C. All components of the restraint system for sodium hydroxide tanks shall be 316 stainless steel.

2.04 CHEMICAL STORAGE TANK SCHEDULE:

Tank	T-310	T-315
Service	Sodium Hydroxide	Sodium Hypochlorite
Resin Type	XLPE	XLPE
Volume (gals)	735	735
Diameter (max.)	5'-1"	5'-1"
Height (max.)	8'-11"	8'-11"
Type	Cone-bottom / Flat Dome	Cone-bottom / Flat Dome
Connections		
Fill	2-inch flanged, top	2-inch flanged, top
Discharge/Drain	2-inch flanged, cone-bottom	2-inch flanged, cone-bottom
Level Sensor	3-inch flanged, top	3-inch flanged, top
Vent	4-inch flanged, top	4-inch flanged, top
Overflow	2-inch flanged, top sidewall	2-inch flanged, top sidewall
Manway (min.)	17-inch diameter	17-inch diameter
Accessory Notes		
Tank support frame and restraint system	YES	YES
Ladder	NO	NO

2.05 SHOP TESTING

- A. Perform gel and impact tests in accordance with ASTM D1998 on samples cut from each polyethylene chemical storage tank.
- B. Submit certified shop test results to the Engineer, whether or not tests were witnessed by the Engineer. Do not ship tanks until favorable review of shop testing submittal is received.

PART 3 - EXECUTION

3.01 DELIVERY, STORAGE, AND HANDLING

- A. Provide all shipping and other arrangements required to transport tanks to the project site and ship tanks per manufacturer's recommendations.
- B. The tanks shall be marked with adhesive-backed laminated tags or engraved stainless steel tank ID plate to identify the product, date (month and year) of manufacture, capacity, and serial number.
- C. All packing, packaging, and marking provisions of ASTM Practice D3892 shall apply.
- D. All fittings shall be installed and, if necessary, removed for shipping and shipped separately.
- E. Upon arrival at the destination, inspect for damage in transit. If damage has occurred, the manufacturer shall be notified prior to tank installation.

3.02 INSTALLATION

- A. Install tanks and fittings in strict accordance with the manufacturer's instructions and with favorably reviewed shop drawings.

3.03 IDENTIFICATION

- A. Identification of the health, flammability, and reactivity of hazardous materials is required for each tank.

3.04 FIELD TESTING

- A. Notification: Provide the Engineer two (2) working days' notice prior to field tests so that the Engineer may elect to witness the testing.
- B. Field Testing: Provide a 48-hour static leak test for each tank. The tanks shall be leak tested with water to the overfill level. A passing test result shall be no leakage from the tank. If a leak is detected, the tank shall be repaired or replaced in a manner satisfactory to the Engineer. Such repairs shall be performed only by the tank manufacturer, at no additional cost to the Owner. After repairs, retest the tank until a passing result is achieved. Demonstrate that all tank accessories are working properly.

3.05 CLEANING

- A. After satisfactory completion of field testing, drain the testing water. Rinse the inside of the tanks with clean, potable water. Hand wipe and dry as required to leave the tank interior clean, dry, and ready for storage of the chemical. Clean the tank exterior and accessories and leave in good condition.

END OF SECTION

SECTION 13418

MAGNESIUM HYDROXIDE STORAGE TANK

PART 1 - GENERAL

1.01 SUMMARY

- A. This Section specifies the welded steel storage tank for magnesium hydroxide. Provide a complete, tested, and operating tank as shown on the Drawings and as specified herein, including shipping any "over-sized" loads to the project site.

1.02 REFERENCES

- A. American Iron and Steel Institute (AISI)
- B. ASTM International Standard Specifications (ASTM):
 - 1. ASTM A53 Pipe, Steel, Black and Hot-Dipped, Zinc Coated, Welded and Seamless
 - 2. ASTM A123 Zinc (Hot-Dipped Galvanized) Coatings on Iron and Steel Products
 - 3. ASTM A234 Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
 - 4. ASTM B633 Electrodeposited Coatings of Zinc on Iron and Steel
- C. American Welding Society (AWS):
 - 1. AWS D1.1 Structural Welding Code
 - 2. AWS D10.4 Recommended Practices for Welding Austenitic Chromium-Nickel Stainless Steel Piping and Tubing
- D. American Water Works Association Standards (AWWA):
 - 1. AWWA D100 Welded Steel Tanks for Water Storage
 - 2. AWWA D102 Coating Steel Water Storage Tanks
 - 3. AWWA C652 Disinfection of Water Storage Facilities
 - 4. AWWA C200 Steel Water Pipe
 - 5. AWWA C205 Cement-Mortar Protective Lining and Coating for Steel Water Pipe
 - 6. AWWA C207 Steel Pipe Flanges for Waterworks Service
 - 7. AWWA C208 Dimensions for Fabricated Steel Water Pipe Fittings
 - 8. AWWA C213 Fusion Epoxy Lining and Coating for Steel Water Pipe
- E. American Society of Mechanical Engineers (ASME):
 - 1. ASME B16.9 Factory-Made Wrought Steel Buttwelding Fittings
- F. American Petroleum Institute (API):
 - 1. API 650 Welded Steel Tanks for Oil Storage
- G. Occupation Safety and Health Standards OSHA 29 CFR Part 1910.
- H. Steel Plate Fabrication Association (SPFA)

1.03 SUBMITTALS

- A. The following information shall be submitted in accordance with Section 01300:
1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration
 2. Drawings showing tank dimensions and weight and orientation of nozzles, manways, wall thickness, fittings, an OSHA compliant ladder and handrail for roof access, mixer supports and penetration, interior baffles, and other appurtenances.
 3. Drawings shall indicate type and grade of material, profile, size, spacing, and locations of the tank shell, nozzles, structural members, sheet, plate, connections, attachments, fasteners, and all other details required to fabricate the tanks and associated components.
 4. Details of anchor chairs including bolt specification and placement method; as well as for type and number of anchor bolts.
 5. Details of welded joints indicating welding procedure specification numbers and nondestructive testing requirements. Indicate WPS numbers and NDT numbers in tails of combined welding/NDT symbols per ANSI/AWS A2.4.
 6. Shop Drawings shall conform to AISC Structural Steel Detailing Practice.
 7. Product Data: Fabricator shall submit product data, including manufacturer's product sheets, for specified products.
 8. Coatings, Liners, and Finishes: Fabricator shall submit manufacturer's literature and Material Safety Data Sheets (MSDS) on all materials to be used in coating and painting operations, including, but not limited to coatings, paints, thinners, solvents, and cleaning fluids. Fabricator shall maintain copies of MSDS's at their shop and at the jobsite at all times. Fabricator shall be responsible for storage of coating materials in accordance with manufacturer's requirements.
 9. Signed and sealed anchor design calculations and drawings per requirements of Section 01190 and 11001 signed by a registered professional engineer in the state of Washington. The number of anchors required shall be determined by the anchor designer. Anchorage shall be designed in accordance with ASCE 7-10; and the International Building Code, latest edition.
 10. Certification the tank has been designed to meet all specified loading conditions including, but not limited to, the following:
 - a. Dead Loads.
 - b. Live Loads.
 - c. Environmental Loads (seismic, wind and snow loadings).
 - d. Mixer Loads.

- e. Dynamic effects due to fluid inside the tank. Provide a design based on a 10:1 safety factor.
 - f. Anchor design and configuration detail.
11. Tank and mixer manufacturer's corrosion resistance charts for the specified chemicals of the chemical concentrations indicated below, in percentage by weight of solution:

Chemical	Concentration	Specific Gravity	Viscosity
Magnesium Hydroxide Slurry	57-61% (60% Typical)	1.45-1.5	500-1000 cP

A MSDS for AMALGAM-60® by IER (Magnesium Hydroxide) is provided in Appendix A to these specifications. This is the likely chemical to be used in this system.

- 12. Mixer product data fully describing all items proposed for use to demonstrate that the equipment conforms to the specifications including, but not limited to, the following:
 - a. Mixer installation drawing.
 - b. Mixer gearbox assembly drawing.
 - c. Impeller assembly drawing.
 - d. Mixer Design Loads for torque, bending moment and vertical downward loads.
 - e. Mixer materials of construction including chemical compatibility data.
 - 13. Mixer motor data as specified in Section 11002.
 - 14. Manufacturer's warranty.
- B. Submit results of shop testing for review. Do not ship tanks until favorable review of tests is received.
- 1. Manufacturer's instructions for coating system.
 - 2. Manufacturer's Certificate of Compliance.
 - 3. Fabricator or Manufacturer's Inspection Report in accordance with Section 7.3 of API650.
 - 4. Mill or shop inspection reports in accordance with Section 7.3 of API 650.
 - 5. Welder's certifications in accordance with AWS B2.1 or ASME Boiler and Pressure Vessel Code Section IX requirements.
 - 6. Test Reports:
 - a. Mill test reports for steel tank plates.
 - b. Mill test reports for structural steel.
 - c. Certified weld inspection reports.
 - 7. Credentials and Statements of Qualification of Fabricator and Subcontract or personnel:
 - a. Tank manufacturer/fabricator
 - b. Welder/welder operator
 - c. Weld testing agency
 - d. Certified Welding Inspector
 - e. Nondestructive weld testing (NDT) personnel
 - 8. Welding Documentation:
 - a. Shop and field welding procedure specifications (WPSs) and supporting welding procedure qualification records (PQRs).
 - b. NDT procedure specifications.

- c. Welder Documentation in accordance with AWSB2.1 or ASME Boiler and Pressure Vessel Code Section IX requirements.

- C. Submit results of field testing as specified herein.
- D. Manuals: Furnish manufacturer's installation, operation and maintenance manuals, bulletins, and spare parts lists. Furnish a local 24-hour emergency number for repairs in case of tank damage.
- E. Affidavits: Furnish affidavits from the manufacturer stating that the tanks have been installed to the manufacturer's requirements and are ready for full-time storage of the specified chemicals.
- F. Submit chain-of-custody certification.

1.04 QUALITY ASSURANCE

- A. Products of the same material furnished under this Section shall be supplied by a single manufacturer who has been regularly engaged in the design and manufacture of the tanks for a minimum of 10 years. Demonstrate to the satisfaction of the Engineer that the quality is equal to tanks made by the manufacturers named herein.
- B. Tank shall be manufactured from new materials and shall not be stored for more than 3 months prior to delivery.

1.05 WARRANTY

- A. Manufacturer shall provide full 5-year warranty for tank.

PART 2 - PRODUCTS

2.01 MANUFACTURER

- A. The tanks shall be by a manufacturer regularly engaged in the fabrication of steel chemical storage tanks for a minimum of five years. Provide products by one of the following manufacturers:
 - 1. Associated Construction & Engineering, Inc. (949-455-2682, Larry Wombles)
 - 2. T. Bailey, Inc. (360-202-4185; Russ Gibbs).
 - 3. Or approved Equal.

2.02 STEEL TANK

- A. Tank

Description	Magnesium Hydroxide Storage Tank T-230
Service	53% - 65% Magnesium Hydroxide
Nominal Capacity	8,038 gallons
Diameter	10'-6"
Location	Outdoor (10 to 100 °F)

- B. Materials: ASTM A36 Carbon Steel
- C. Construct tanks in accordance with the following standards, except as modified herein:
 - 1. API 650
- D. Design Factors
 - 1. Design metal temperature: 200°F
 - 2. Design specific gravity: 1.45
- E. Connections: Provide connections as shown on the Drawings. Provide flanged nozzles with ASTM A36 carbon steel flanges. Design and reinforce the nozzles for the anticipated loads. Provide gusset reinforcements as required. All nozzles shall be plumb and aligned perpendicular or normal to the plane of the tank wall. Seal weld the inside of slip on flanges.
 - 1. Provide Class 150 ANSI B16.5 raised face flanges where connecting to pipe and valves.
 - 2. Provide flat face flanges where required for vent piping, spray ball and ultrasonic level sensor.
 - 3. Tank overflow shall be 4-inch below the nominal capacity level to leave the spray ball above chemical level all the time.
- F. Provide integral hold down lugs, lifting lugs, and Type 316 stainless steel anchor bolts as required.
- G. Provide 316 stainless steel tank identification label on exterior surface, containing tank design criteria and manufacturer's name.
- H. Minimum Tank Thickness: Per API 650 plus 1/16th inch corrosion allowance.
- I. Tank shall be constructed with flat bottom and interior baffles to improve mixing for the stored chemical with the viscosity.
- J. Provide ASTM A36 carbon steel ladder and handrails as shown on the drawings. Comply with OSHA requirements.
- K. Fittings shall be of the following type as suitable for the service:
 - 1. Fittings shall be made vertical on sloping tank tops.
 - 2. Required tanks fittings or appurtenances include, but are not limited to:
 - a. Two 36-inch diameter manways (top and side)
 - b. 2-inch diameter fill connection (top)
 - c. 3-inch diameter vent connection (top)
 - d. 6-inch diameter ultrasonic level sensor connection (top)
 - e. Mixer connection (top)
 - f. 3-inch overflow connection (top side)
 - g. 3-inch diameter drain connection (bottom side)
 - h. Two 1-inch diameter outlet connections (bottom side)
 - 3. Sufficient steel standoffs on the tank for accessories including:
 - a. Fill pipe (outside tank)
 - b. Overflow pipe (outside tank)

- L. Tank Coatings: Tank interior and exterior, ladder, handrail, ports and all parts and fasteners shall be coated.
1. Apply all coatings in strict conformance with the coating manufacturer's instructions and the requirements to Section 09900. Grind all welds and sharp edges smooth and correct any imperfections prior to application of the protective coatings: All welds shall be ground to a radius compatible with the lining and shall be free of porosity.
 - 2.. Shop coat the tank interiors and all appurtenant metal accessories (other than stainless steel or fusion bonded epoxy) specified herein within the vessel with the following coating system.
 - a. Near white sandblast conforming to SSPC-SP10.
 - b. 15 to 20 mils dry film.
 - c. Prime coat per coating manufacturer's recommended dry film thickness. Prime coat shall be an epoxy primer compatible with the specified finish coats.
 - d. Finish: Two or more coats at manufacturer's recommended dry film thickness per coat to achieve the specified system thickness.
 - e. Tnemec Series 104, Amercoat 395FD or approved equal.
 3. Shop coat the tank exterior and all appurtenant metal accessories (other than stainless steel or fusion bonded epoxy) specified herein with the following coating system.
 - a. Commercial sandblast conforming to SSPC-SP6.
 - b. Prime coat with 3 to 4 mils dry film thickness (DFT) of zinc rich primer. Tnemec Series 90-97, Amercoat 68HS or approved equal.
 - c. Intermediate coat or primer epoxy coat at 5-6 mils DFT: Tnemec Series V69, Amercoat 385 or approved equal.
 - d. Finish coat of polyurethane at 2-3 mils DFT: Tnemec Series 1075, Amercoat 450H or approved equal.
 4. Test all interior coatings for pinholes with a low voltage electrical resistance meter per NACE SP0188. Check coating thickness with a magnetic thickness gauge. Repair all deficiencies in film integrity and thickness. Certify to the Owner that all deficiencies were corrected prior to shipment.

2.03 TANK MIXER

- A. Provide a mixer complete with motor, gear box, shaft, impellers, and proper supports at the tank. The mixer shall be capable of keeping the contents of the tank completely mixed. The tank mixer shall be a top entry flange mount mixer integrally designed and in conjunction with the tank manufacturer and in coordination with a potential chemical supplier (See Appendix A for a potential chemical and supplier). The tank manufacturer shall coordinate opening for the mixer and fabrication of the mixer support flange with the mixer supplier. The mixer shall have two impellers to keep solids in suspension and the slurry well mixed.
- B. Mixer shall be designed for the following parameters:

Parameter	Mixer
Service	Magnesium Hydroxide
Approx. Tank Dimensions	Per Tank Manufacturer
Approx. Mixer Mounting Elevation	Per Tank Manufacturer
Maximum Tank Depth	Per Tank Manufacturer
Normal Minimum Tank Depth	48 inches
Mixer Shutoff Tank Depth	24 inches

Parameter	Mixer
Liquid Specific Gravity	1.5
Typical Liquid Viscosity	500-1000 cps
Maximum Motor Size	5 HP
Maximum Impeller Speed	70 RPM
Minimum Impeller Diameter	Per Tank Manufacturer
Minimum Shaft Diameter	2.5"

C. Mixer shall have the following components:

1. Motor: 5 HP, TEFC, minimum 5:1 Turndown, 230/460V, 3Ph, Severe Duty, Premium Efficiency Motor. See Section 11002 for future requirements.
2. Gearbox: Each drive unit shall consist of a cast-iron, heavy duty, speed reducing gear box and motor with integral mounting plate and lifting lugs. The gear box shall be directly connected through a flexible coupling to the electric motor. The gear box shall be specifically designed for mixing service and shall be capable of 24 hr/day continuous operation in an outdoor environment and compatible with the stored chemical. The mechanical rating of the gear box shall be at least 1.5 times the motor nameplate. The gear box shall bear an AGMA nameplate.
 - a. All drives shall be double or triple reduction helical gear combination. All gearing shall be AGMA Quality 10 as a minimum. Worm gears, belt and/or chain drives are not acceptable. The gearing shall be designed to withstand normal and shock loads that are transmitted to the gear drive from the lower shaft and impeller assembly.
 - b. General maintenance (specifically including replacement of all anti-friction bearings, all oil seals, and lubricant maintenance) shall not require removal of the gear box from the base mount.
 - c. Bearings shall be anti-friction roller type, oil lubricated, and have a minimum L-10 bearing rating of 100,000 hours. All bearings shall be submerged in the lubricating oil. The output shaft bearings shall be sized based on the actual (not average) thrust and bending loads generated by the shaft and impeller assembly. The use of submerged bearings is not permitted.
 - d. The gear box shall be lubricated with synthetic oil. All gearing must be completely immersed in lubricant. Lubrication system shall not require any oil pumps, priming, heaters, or other special effort or equipment.
 - e. The thermal rating of the speed reducer shall exceed the design mechanical rating to eliminate the need for external cooling. External cooling devices are not allowed.
 - h. The mixer shaft shall be connected to the output shaft of the gear box by means of a removable coupling located above the mounting surface. The rigid coupling shall be designed to minimize run out to less than ¼ inch per 10 feet of shaft length.
3. Control: None.
4. Mount: Flange Mount, 8-inch CL150, 304SS Wetted
5. Seal: Viton Lip Seal not pressure/vacuum rated.
6. Shaft: 2.5" x min 140" Length, 316SS, No Polish Included. The shaft shall be totally overhung. When turned over by hand, impeller shaft runout shall not exceed ¼ inch per 10 feet of length.
7. Provide two impellers. Impeller shall be a three bladed high-efficiency and bolted to a keyed hub to the shaft. Impeller hubs and blades shall be 316 SS.

2.04 SHOP TESTING

- A. Provide the Engineer with five (5) working days' notice prior to shop testing so that the Engineer may elect to witness testing. The Contractor shall assume that a witness test is required for the tank. Submit certified shop test results to the Engineer, whether or not tests were witnessed by the Engineer. Do not ship tanks until favorable review of shop testing submittal is received.

2.05 INSULATION

- A. Provide flexible closed celled foamed plastic as specified per Section 15080. Apply 2 coats of manufacturer's finish for UV protection at a minimum and flexible non-metallic cladding. Armacell AP Amaflex and Armacell Arma-Chek®R; or approved equal.

PART 3 - EXECUTION

3.01 DELIVERY STORAGE, AND HANDLING

- A. Provide all shipping and other arrangements required to transport tank and mixer to the project site and ship tank and mixer per manufacturer's recommendations.
- B. The tank shall be marked with adhesive-backed laminated tags or engraved stainless steel tank ID plate to identify the product, date (month and year) of manufacture, capacity, and serial number.
- C. All fittings shall be installed and, if necessary, removed for shipping and shipped separately.
- D. Upon arrival at the destination, inspect for damage in transit. If damage has occurred, the manufacturer shall be notified prior to tank installation.

3.02 INSTALLATION

- A. Install tank, mixer, and fittings in strict accordance with the manufacturer's instructions and with favorably reviewed shop drawings.

3.03 FIELD TESTING

- A. Notification: Provide the Engineer two (2) working days notice prior to field tests so that the Engineer may elect to witness the testing.
- B. Field Testing: Provide a seven (7)-day static leak test for the tank. The tank shall be leak tested with water to the overfill level. A passing test result shall be no leakage from the tank. If a leak is detected, the tank shall be repaired or replaced in a manner satisfactory to the Engineer. Such repairs shall be performed only by the tank manufacturer, at no additional cost to the Owner. After repairs, retest the tank until a passing result is achieved. Demonstrate that all tank accessories are working properly.

- C. Provide the services of a competent manufacturer's field service engineer to thoroughly check and inspect the mixer after installation, place the mixer in operation and make necessary adjustments, and instruct plant personnel in proper operating and maintenance procedures. A minimum of 2 hours of onsite training shall be provided.

3.04 CLEANING

- A. After satisfactory completion of field testing, drain the testing water. Rinse the inside of the tank with clean, potable water. Hand wipe and dry as required to leave the tank interior clean, dry, and ready for storage of the chemical. Clean the tank exterior and accessories and leave in good condition.

END OF SECTION

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Inland Environmental Resources

1717 S Rustle St Suite 104, Spokane WA 99224

800-331-3314

Fax: 888-331-3314

SAFETY DATA SHEET – AMALGAM-60

Page 1 of 7

According to U.S. Code of Federal Regulations 29 CFR 1910.1200, Hazard Communication.

1. Identification

Product identifier used on the label:

AMALGAM-60 (Magnesium Hydroxide Slurry)

Other means of identification:

Aqueous slurry of magnesium hydroxide, hydrated magnesia, milk of magnesia

Recommended use of the chemical and restriction on use:

Industrial chemical process, acid neutralization, wastewater treatment

Details of the distributor of the safety data sheet:

Company name: Inland Environmental Resources, Inc.

Address: 1717 S Rustle St Suite 104
Spokane, WA 99224

Telephone: 800-331-3314

Emergency telephone number:

800-535-5053 INFOTRAC

2. Hazards Identification

Classification of the substance or mixture in accordance with paragraph (d) of 29 CFR 1910.1200:

Not classified.

Signal word:

No signal word.

GHS hazard statements:

Not applicable.

Symbols:

No symbol.

GHS precautionary statements:

None.

Other hazards identified during classification process:

No additional information available.

3. Composition / Information on Ingredients

Substance/mixture:

Substance

Other means of identification:

Aqueous slurry of magnesium hydroxide, hydrated magnesia, milk of magnesia

Components:

INGREDIENT NAME	CONCENTRATION*	CAS NUMBER
Magnesium hydroxide	57-61%	1309-42-8
Oxides and hydroxides of calcium, iron, aluminum, silicon	1-3%	Mixture
Water	Balance	7732-18-5

*Any concentration shown as a range is to protect confidentiality or is due to batch variation.

There are no additional ingredients present which, within the current knowledge of the distributor and in the concentrations applicable, are classified as hazardous to health or the environment.

Occupational exposure limits are listed in Section 8.

4. First-Aid Measures

Show this safety data sheet to the doctor in attendance.

Description of necessary measures:

Inhalation	If symptoms of exposure are experienced (see Hazards Identification), remove victim to fresh air. Obtain medical attention.
Skin contact	Not expected to cause a problem. However, if irritation occurs, flush affected area with water. If irritation persists, obtain medical attention.
Eye contact	If irritation occurs, immediately flush eyes with water for at least 10 minutes. Obtain medical attention.
Ingestion	Never give anything by mouth to an unconscious person. If conscious, rinse mouth with and/or drink water. Obtain medical attention.

Most important symptoms/effects, acute and delayed:

The product presents a very low health risk. Dust generated from the dried product is classified as a nuisance dust. Dried product dust is classified as a "nuisance particulate, not otherwise regulated" as specified by ACGIH and OSHA. The excessive, long-term inhalation of mineral dusts may contribute to the development of industrial bronchitis, reduced breathing capacity, and may lead to the increased susceptibility to lung disease.

Inhalation	May irritate the respiratory tract on prolonged or repeated contact. May aggravate pre-existing respiratory conditions.
Skin contact	Repeated or prolonged contact may cause irritation.
Eye contact	Particulate is a physical eye irritant.
Ingestion	Ingestion is unlikely. If ingested in sufficient quantity, may cause gastrointestinal disturbances. Symptoms may include irritation, nausea, vomiting, abdominal pain and diarrhea.

Indication of immediate medical attention and special treatment needed, if necessary:

None.

5. Fire-Fighting Measures

Suitable and unsuitable extinguishing media:

Use extinguishing media appropriate to combustibles in vicinity of fire.

Specific hazards arising from the chemical:

Not applicable.

Special protective equipment and precautions for fire-fighters:

Firefighters should wear NIOSH-approved, positive pressure, self-contained breathing apparatus and full protective clothing when appropriate.

Further information:NEPA Rating:

Health – 1

Flammability – 0

Instability – 0



6. Accidental Release Measures

Personal precautions, protective equipment and emergency procedures:

Use personal protective equipment as required. If conditions warrant, clean-up personnel should wear approved respiratory protection, gloves and goggles to prevent irritation from contact and/or inhalation.

Methods and materials for containment and cleaning up:

Pick up spills without creating dust from dried product. Place material into container, and cover. Hold in sealed container for disposal.

Environmental precautions:

There are no ingredients present which, within the current knowledge of the distributor and in the concentrations applicable, are classified as hazardous to the environment.

7. Handling and Storage

Precautions for safe handling:

Product may present a nuisance dust hazard if allowed to dry out. Avoid inhalation of dust. Clean area frequently to avoid dust buildup. Wear applicable personal protective equipment as indicated in Section 8.

Conditions for safe storage, including any incompatibilities:

Store in an agitated tank to prevent settling of solids. Do not store in aluminum tank. Do not allow product to freeze.

Materials to avoid:

Keep away from incompatible materials such as interhalogens and strong acids.

8. Exposure Controls/Personal Protection

Exposure limits:

United States:

INGREDIENT NAME	SOURCE	TWA	FORM
Water	No exposure limits noted		
Magnesium hydroxide	ACGIH TLV	10 mg/m ³	Total particulate
	OSHA PEL	15 mg/m ³	Total particulate

Appropriate engineering controls:

Wherever possible, use engineering controls to minimize inhalation of dried product dust. Engineering controls may include process enclosure and/or local exhaust ventilation.

Individual protection measures, personal protective equipment:Skin protection:

Protective gloves and long sleeve clothing are recommended when repeated or prolonged contact with the slurry is likely.

Respiratory protection:

If adequate engineering controls are not available, wear respirator approved by NIOSH/MSHA in accordance with requirements of 29 CFR 1910.134 for dried product dust, as applicable. In conditions of oxygen deficiency, or where airborne concentrations of dried product dust exceed 100 mg/m³, wear positive pressure or pressure demand supplied air respiratory protection or SCBA.

Eye protection:

Safety glasses are recommended.

9. Physical and Chemical Properties

Appearance – physical state	Aqueous slurry
Appearance – color	White to light brown
Odor	Odorless
Odor threshold	Not applicable
pH	10.5-11.2
Melting point/freezing point	Decomposes to MgO @ 350°C
Initial boiling point & boiling range	100°C (water)
Flash point	Not applicable
Evaporation rate	Same as water
Flammability (solid, gas)	Not flammable
Lower & upper explosive (flammable) limits	Not applicable
Vapor pressure	Not applicable
Vapor density (Air=1)	Not applicable
Relative density	12.1-12.5 lbs/gal @ 25°C
Solubility	0.0009 g/100 ml @ 20°C
Partition coefficient: n-octanol/water	Not applicable
Auto-ignition temperature	Not applicable
Decomposition temperature	Not applicable
Specific gravity	1.45-1.5 g/mL
Viscosity	500-1000 cP
% Volatiles	0

10. Stability and Reactivity**Reactivity:**

Not applicable.

Chemical stability:

Stable under normal storage conditions.

Possibility of hazardous reactions:

Excessive heat may be generated in the presence of strong acids.

Conditions to avoid:

Avoid excessive temperatures, which will cause product to produce steam and/or decompose to magnesium oxide. Do not store in aluminum container, as product may produce hydrogen gas.

Incompatible materials:

Strong acids, maleic anhydride, aluminum metal, interhalogens (e.g. bromine pentafluoride, chlorine tri-fluoride),

phosphorous pentachloride

Hazardous decomposition products:

Product may present a nuisance dust hazard if allowed to dry out. Product will decompose to magnesium oxide in temperatures in excess of 350°C. Steam may be generated upon heating.

Hazardous Polymerization:

Does not occur.

11. Toxicological Information

Toxicological effects and available data used to identify those effects:

Information on likely routes of exposure:

Inhalation	No
Ingestion	Yes
Skin contact	Yes
Eye contact	Yes

Symptoms related to the physical, chemical and toxicological characteristics:

Inhalation	No data available.
Ingestion	May cause gastrointestinal disturbances.
Skin contact	May cause irritancy of skin or nasal passages.
Eye contact	May cause irritancy of eyes.

Delayed and immediate effects and also chronic effects from short- and long-term exposure:

Inhalation	No data available.
Ingestion	May cause gastrointestinal disturbances.
Skin contact	May cause irritancy of skin or nasal passages.
Eye contact	May cause irritancy of eyes.

Numerical measures of toxicity (acute toxicity estimates):

No data available.

Carcinogen status:

INGREDIENT NAME	NTP LIST	IARC MONOGRAPHS	OSHA
Magnesium hydroxide	No	No	No

12. Ecological Information

Ecotoxicity:

No data available.

Persistence and degradability:

No data available.

Bioaccumulative potential:

No data available.

Mobility in soil:

No data available.

Other adverse effects:

No data available.

13. Disposal Considerations

Description of waste residue(s):

This product does not meet the criteria of a hazardous waste, and is suitable for landfill disposal once the water is evaporated or adsorbed.

Safe handling & method(s) of disposal of waste residue(s) & contaminated packing:

Dispose of in accordance with all applicable federal, state, local and provincial environment regulations.

14. Transport Information

This product is not regulated by U.S. DOT, Canadian TGD, and IMDG. This product is not listed as a marine pollutant.

Transport in bulk (according to Annex II of MARPOL 73/78 and IBC Code):

This product is not regulated for transportation. No special requirements. No UN number assigned.

Special precautions:

This product must not be transported in tanks constructed of aluminum.

15. Regulatory Information

U.S. federal safety, health and environmental regulations:United States inventory (Toxic Substances Control Act [TSCA] 8b):

Magnesium hydroxide is listed on the Chemical Substances Inventory of the TSCA.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (40 CFR 302.4):

Magnesium hydroxide is not listed as a hazardous substance.

Superfund Amendments & Reauthorization Act (SARA) 302 Extremely Hazardous Substances:

Magnesium hydroxide is not listed as an extremely hazardous substance.

Superfund Amendments & Reauthorization Act (SARA) 304 Emergency Release Notification:

Notification is not required for magnesium hydroxide.

Superfund Amendments & Reauthorization Act (SARA) 311 OSHA Hazard Communications Standard:

FIRE HAZARD	SUDDEN RELEASE OF PRESSURE	REACTIVE	IMMEDIATE (ACUTE) HEALTH HAZARD	DELAYED (CHRONIC) HEALTH HAZARD
No	No	No	No	No

Superfund Amendments & Reauthorization Act (SARA) 312 OSHA Hazard Chemical Inventory Reporting:

SDS, chemical inventory, and Tier I/II reporting are not applicable for magnesium hydroxide.

Superfund Amendments & Reauthorization Act (SARA) 313 Toxic Release Inventory:

Magnesium hydroxide is not subject to Form R reporting.

Clean Air Act (CAA) Section 112 (r) Air Pollutants:

Magnesium hydroxide is not listed as an air pollutant under the U.S. Clean Air Act, Section 112 (r) (40 CFR 61).

U.S. state safety, health and environmental regulations:California Proposition 65:

This product does not contain any chemicals known to State of California to cause cancer, birth defects or any other reproductive harm.

16. Other Information

Date of preparation:

This Safety Data Sheet was prepared by Inland Environmental Resources, Inc. on September 3, 2020.

Changes to previous version:

Section 1 Address.

Inland Environmental Resources, Inc. provides the foregoing information in good faith and makes no representations as to its comprehensiveness or accuracy. This document is intended only as a guide to the appropriate precautionary handling of the material by a properly trained person using the product. Individuals receiving the information must exercise their independent judgment in determining its appropriateness for a particular purpose.

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SECTION 15050

PIPING, VALVES, AND ACCESSORIES

PART 1 - GENERAL

1.01 SUMMARY

- A. Section includes: Provide all piping, including fittings, valves, supports, and accessories as shown on the Drawings, described in the Specifications and as required to completely interconnect all equipment with piping for complete and operable systems, including equipment drains.

1.02 REFERENCES

- A. Air-Conditioning and Refrigeration Institute (ARI)
- B. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
- C. ASTM International (ASTM)
- D. American Society of Mechanical Engineers (ASME)
- E. American National Standards Institute (ANSI)
- F. American Water Works Association (AWWA)
- G. American Welding Society (AWS)
- H. Cast Iron Soil Pipe Institute (CISPI)
- I. U.S. Department of Transportation (DOT)
- J. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS)
- K. National Fire Protection Association (NFPA)

1.03 SUBMITTALS

- A. Shop Drawings:
 - 1. Verify by excavation, inspection, and measurement all installation conditions, including existing utilities and structures, for all pipe before preparation of Shop Drawings. Submit field measurements and photos with Shop Drawings where exposed conditions are significantly different than indicated on the Drawings.
 - 2. Layouts and Schematics: Submit detailed installation drawings of all piping. Schematics may be submitted for piping 4 inches and smaller. The Drawings and schematics shall include: pipe support locations and types, fittings, valves, dielectric couplings/unions/flange kits, and other appurtenances.
 - 3. Submit data to show that the following items conform to the Specification requirements:
 - a. Pipe, fittings, and accessories.
 - b. Pipe couplings and flexible pipe pieces.
 - c. Valves and Accessories.
 - 4. Pipe, fittings, and joint fabrication details for welded steel pipe.
 - 5. Submit procedures for welding field joints of welded steel pipe and welder qualifications.

6. Submit samples of gaskets and other materials where required by the detailed specifications.
 7. Submit certified test reports as required herein and by the referenced standard specifications.
 8. All items utilized on systems supplying or producing potable water, including, but not limited to, pipe and valve linings, solvent cements, welding materials, gaskets and gasket lubricants, and additives in concrete or cement mortar shall comply with the Safe Drinking Water Act and NSF requirements for use in water systems in accordance with Section 64591 of the California Water Works Standards. Submit proof of NSF certification for each item.
 9. Testing data for welded joints.
 10. Submit leak and pressure testing plan in accordance with the requirements in paragraph 3.09.
 11. Submit shop drawings for leak and pressure testing apparatus including, but not limited to, temporary bulkheads necessary for testing of new pipelines.
- B. Manuals: Furnish manufacturer's installation and operation manuals, bulletins, and spare parts lists for the following items:
1. Valves 4 inches and larger and all actuated valves.
 2. Air Valves.
 3. Pneumatic/motorized actuators, including positioners and I/P converters. Include the actuator manuals for the valves requiring them.
 4. Strainers, motorized or automatic washing.
 5. Filters.
 6. Pressure regulators.
 7. Rotameters
- C. Affidavits: Furnish affidavits from the manufacturers for the following equipment:
1. Motorized valves.
 2. All motorized or calibrated equipment.
- D. Field test reports as required in Part 3.

1.04 QUALITY ASSURANCE

- A. Materials and equipment furnished under this Section shall be of manufacturers who have been regularly engaged in the design and manufacture of the materials and equipment for a period of at least 5 years. Demonstrate to the satisfaction of the Engineer that the quality is equal to the materials and equipment made by the manufacturers specifically named herein, if an alternate manufacturer is proposed.
- B. Factory Quality Control: The Contractor shall test all products as noted herein and by the reference specifications.
- C. Field Quality Control:
1. The Owner will:
 - a. Inspect field welds and test the welds if it is deemed necessary.
 2. The Contractor shall:
 - a. Perform leakage tests.
 - b. Be responsible for the costs of additional inspection and retesting by the Owner resulting from noncompliance.

1.05 PIPING SYSTEMS

- A. The various piping systems are identified by a multi-letter code on the Drawings. Unless otherwise shown on the Drawings, each system shall be constructed using

the materials indicated for that system in the Pipe Schedule and herein. Piping materials are identified by type designation in the schedule unless otherwise noted, and most valves and accessories are identified by a valve and accessory system unless otherwise noted. The Piping Schedule is shown on Drawing 01G05.

1.06 APPURTENANCES

- A. Furnish and install all necessary guides, inserts, anchors and assembly bolts, washers and nuts, hangers, supports, gaskets, couplings and flanges; all other appurtenant items shown on the Drawings, specified or required for the proper installation and operation of the piping; devices included in or on the piping equipment; and piping accessories.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Pipe and valve sizes are nominal inside diameter unless otherwise noted.
- B. Construct vents of materials specified for the pipe system for which they serve.
- C. All materials delivered to the job site shall be new, free from defects, and marked to identify the material, class, and other appropriate data such as thickness for piping.
- D. Acceptance of materials shall be subject to strength and quality testing in addition to inspection of the completed product. Acceptance of installed piping systems shall be based on inspection and leakage tests as specified hereinafter.
- E. Cutoff Flanges: Provide at all pipe or sleeve penetrations where cast into wall for pipes 4 inches and greater in nominal diameter, and at all penetrations of 3-inch and smaller nominal diameter pipe in wet or potentially wet locations as indicated on the Drawings. Cutoff flange outside diameter shall be at least a standard connection flange's outside diameter except that for pipe 30-inch-diameter and larger, nominal size, cutoff flange outside diameter may be 6 inches greater than outside pipe diameter. Cutoff flange shall be at least $\frac{1}{4}$ inch thick and shall be continuously welded (or cast) onto the pipe.
- F. Connections between dissimilar metals, valves, accessories, or pipe supports shall be made using a dielectric coupling, union, or flange kit. Dielectric couplings, unions, and flange kits are typically not shown on the Drawings and shall be located by the Contractor.

2.02 GENERAL MATERIAL REQUIREMENTS

- A. Gaskets: Except where specified otherwise, gaskets shall be NBR (Nitrile or Buna-N).
- B. Bolts and Tie Rods: Unless specified otherwise herein, flange bolts and nuts, coupling bolts and nuts, tie rods, and other hardware shall be as follows:
 - 1. Exposed:
 - a. Stainless Steel Piping: 316 stainless steel, minimum tensile strength 60,000 psi.
 - b. Other Services: Hot dip galvanized steel.
 - 2. Submerged: Type 316 stainless steel, minimum tensile strength 60,000 psi.
 - 3. Concrete Encased: Electroplated zinc or cadmium steel.

4. Buried: Type 316 stainless steel, minimum tensile strength: 60,000 psi.
 5. Apply an anti-galling compound to the threads of stainless steel bolts.
- C. Flexible Sealant: Flexible sealant for pipe joints, where shown on the Drawings, shall be a two-component polysulfide, non-sag; Sikaflex 2C, Dualthane, or equal.
- D. Fusion Epoxy Coating: AWWA C213; except application shall be by fluid bed only unless the greatest dimension of the article to be coated exceeds 10 feet, in which case electrostatic spray or flocking application may be used.

2.03 PIPING MATERIALS

- A. Pipe and Fitting Designation: Piping materials are identified by a "Type" designation in these Specifications. The "Type" designation identifies not only the pipe itself, but the associated fittings and appurtenances and the installation and test procedures described for that "Type." The designation of a particular type shall indicate a complete installation including fittings, joints, cleaning, and testing. The pipe and fitting materials for each type designation shall be as specified herein and summarized in the Pipe Type Schedule.
- B. Pipe Schedule: Piping systems and their corresponding piping and valve systems are listed on G5 of the Drawings.
- C. Pipe Type Schedule: Pipe material, joints and fittings shall be as summarized below. A detailed specification of each pipe type follows. (The detailed specification supersedes the schedule in case of any conflicts.)

Pipe Type	Pipe Description	Field Joints	Fittings
CUP	Copper	Solder or Flare	Wrought Copper or Bronze
HDPE	High Density Polyethylene, Water	Heat Weld	Polyethylene
PTFE	PTFE Tube	Compression	Compression
PVC	PVC, Schedule 80	Threaded or Solvent Weld	PVC, Schedule 80
SS	Stainless Steel	Flanged or Weld	Stainless Steel

- D. CU Pipe: Applicable Service Conditions: 1W hot water and tepid water
1. Pipe: Copper, ASTM B88.
 - a. Buried: Type K (soft drawn).
 - b. Exposed: Type L (hard drawn).
 2. Joints:
 - a. Buried: Soldered or flared.
 - b. Exposed: Soldered.
 3. Solder: ASTM B32, Alloy Grade SN 94, SN 95, or SN 96. Solder and flux shall contain less than 0.2% lead.
 4. Fittings:
 - a. Soldered: Wrought copper, ASTM B73 for materials and ANSI B16.22 for dimensions; or cast bronze, ASTM B62 for materials and ANSI B16.18 for dimensions.
 - b. Flared: AWWA C800 and ANSI B16.26.
- E. HDPE Pipe: Applicable Service Conditions: Double containment pipe for buried sodium hypochlorite pipe.
1. Pipe: High molecular weight, high density, polyethylene pipe, ASTM D3350.
 - a. Cell Classification: PE 4710 Black.

- b. Dimension Ratio (DR): 11 rated to 200 psi working pressure under AWWA C906.
 - c. Pipe shall be iron pipe size, minimum coil length of 500 feet.
 - d. Submit manufacturer's certification, including AWWA C906 affidavit of compliance that pipe and fitting complies with the Specifications.
 - 2. Joints: Butt fusion, ASTM D2657, except mechanical where required to connect with other pipe, valve or equipment materials.
 - a. Butt Fusion Joints: The tensile strength of the joint at yield shall not be less than the pipe. Joints shall be made with equipment acceptable to the manufacturer. The equipment operators shall have been trained by certified fusion technicians. Submit description of the equipment and methods for favorable review.
 - b. Pipe joints shall be de-beaded following the manufacturer's specified cooling period after joint welding. De-beading shall consist of continuous strip removal and shall not damage the joint.
 - c. Mechanical Joints: Joint shall consist of a flange adaptor fitting butt-fused to the pipe, a back-up ring of Type 316 stainless steel made to ANSI B16.1 dimensional standards (with modified pressure rating), bolts of Type 316 stainless steel, and chloroprene gaskets.
 - 3. Fittings: Molded fittings to ASTM D3261 required where available of the same material as the pipe, with DR no greater than the pipe, and with a pressure rating of 1.4 times the pipe rated pressure. Manufacturer shall conduct X-ray inspection on samples from each molded fitting production lot. Fabricated fittings shall comply with AWWA C906 and ASTM F2206 and shall only be used where molded fittings are unavailable. Fitting shall be produced by the same manufacturer as the pipe.
- F. PTFE (Tubing): Applicable Service Conditions: Magnesium hydroxide, sodium hypochlorite, sodium hydroxide service at pump skids as shown on Drawings.
 - 1. Tube: Polytetrafluoroethylene
 - 2. Fittings: Compression fittings utilizing an outer nut which is tightened to force the olive to close in onto and secure the tubing.
 - 3. Minimum working pressure: 70 psi
 - 4. Install in accordance with tube and fitting manufacturer's instructions.
 - 5. Safety Shields: TFE coated fiberglass, OSHA orange border with see-through shield for inspection of leaks. Ramco Vue-Gard; or equal.
 - a. Provide Safety Shields installed under System U-4 at all transitions between tubing and hard pipe.
- G. PVC Pipe: Applicable Service Conditions: Cold water (1W), utility water (2W), recycled plant water (3W), drain, magnesium hydroxide, sodium hypochlorite, except as noted on the Drawings.
 - 1. Pipe: Schedule 80 polyvinyl chloride (PVC), gray, normal impact, Type 12454 B, ASTM D1784 and ASTM D1785. Pipe shall bear the National Sanitation Foundation (NSF) label.
 - 2. Joints: Solvent weld, except flanged or threaded permitted where required at equipment connections and where required on the Drawings. Use Military Specification T-27730A tape for threaded joints.
 - 3. Fittings: Solvent weld, socket type, of same material as the pipe, Schedule 80, ASTM D2467.
 - 4. Cement: Solvent weld, use ASTM F-493, IPS724 CPVC by Harrington Plastics; no equal.

5. Pipe Cleaner: As recommended by the pipe manufacturer for the schedule and size to be joined.
 6. Safety Shields: Provide for exposed sodium hypochlorite pipe. TFE coated fiberglass, OSHA orange border with see-through shield for inspection of leaks. Ramco Vue-Gard; or equal.
 - a. Provide Safety Shields for all Valves and Fittings installed.
 7. Provide double containment of piping as shown on the Drawings and conform to the specifications for double-containment piping herein.
- H. SSP Type: Sodium hydroxide
1. Pipe: caustic pipe shall be A312, TP316L only, Schedule 40S for screwed joints and pipe 6 inches and smaller.
 2. Joints: Butt welded, except where screwed or flanged joints are required adjacent to valves or equipment. Cut or rolled groove connections, AWWA C606.
 3. Fittings: Wrought stainless steel, ASTM A403, TP 316L fittings only, ANSI B16.9 for dimensions.
 4. Flanges: Welding neck or slip-on, raised face, ASTM A182, TP316L, ANSI B16.5 for dimensions. Class 150, drilling to match adjacent accessories or valves.
 5. Gaskets: Full face gasket per ANSI B16.21, reinforced PTFE.
 6. Safety Shields: Provide for exposed sodium hydroxide pipe. TFE coated fiberglass, OSHA orange border with see-through shield for inspection of leaks. Ramco Vue-Gard; or equal.
 - a. Provide Safety Shields for all Valves and Fittings installed.
- I. Double Containment
1. Double containment of piping is required for all chemical piping spanning overhead across walking paths, doorways, for all buried and exposed tubing, and for all piping so indicated in the pipe schedule or elsewhere in the Drawings and Specifications.
 - a. Size: Provide Schedule 80 PVC containment pipes as follows, except buried sodium hypochlorite contained in HDPE pipe:

<u>Carrier Pipe</u>	<u>Containment Pipe</u>
1/2-inch	4-inch
1-inch	4-inch
 - b. Joints: Solvent weld except flanged where required. Use two-piece hinged couplings as specified below where necessary. Do not make-up joints until successful completion of leak tests of primary carrier pipe.
 - c. The double containment pipe system shall meet the requirements for underground transport of hazardous chemicals in accordance with EPA Standard 40 CFR, Part 280. Carrier pipe shall be positioned concentrically within the containment pipe. Interstitial supporting devices (spacers) shall be Centra-Guide supports of polypropylene, suitable for installation within secondary containment piping. The design shall allow continuous drainage in the annular space to the drain points.
 2. Fittings: Clear PVC two-piece, hinged, injection bonded containment fittings. Termination couplings shall be hubless type of PVC rubber with 316 stainless steel clamps. Fittings shall be Contain-It by Georg Fischer; or equal.
 3. Double containment piping for buried sodium hypochlorite service shall consist of 1/2-inch braided flexible chemical hose pulled through a 4-inch

HDPE containment pipe with both ends with a ½-inch quick connect. This will facilitate easy removal and replacement of the carrier tubing if a leakage is detected.

2.04 PIPE COUPLINGS AND FLEXIBLE PIPE PIECES

- A. General: For typical pipe joints refer to pipe material specifications. Other joint devices shall be furnished where called for on the Drawings and as specified below.
- B. Flexible Connectors:
 - 1. Service: Chemical:
 - a. Type: Molded, flowing arch, rubber expansion joints with full rubber flanges and retainer rings.
 - b. Materials:
 - 1) Tube: Seamless FEP or Teflon lining extending to the outer edge of the flange, completely fused to the body
 - 2) Body: Chlorobutyl with nylon or polyester reinforcing.
 - 3) Cover: Chlorobutyl, Teflon. FEP; or Hypalon
 - 4) Retainer rings. Stainless steel.
 - c. Pressure Rating: 250 psi.
 - d. Manufacturers: Garlock EZ-FLO, or equal.
 - 2. Restraint: Provide stainless steel control rod-compression sleeve assemblies for all flexible spools, except where pipelines cross structural expansion joints or where specifically omitted by note in the Drawings. Number and size of control rods shall be as required for the test pressure of the pipe system or 50 psi, whichever is greater.
 - 3. Provide full size intermediate metal pipe flanges where rubber spool connects with wafer style valves, lug style valves or other pipeline items that do not have full-face metal flanges.
- C. Braided Flexible Chemical Hose: For use with all chemical piping at tanks and buried sodium hypochlorite line.
 - 1. Size: 3/4-inch NPS
 - 2. Braid: Stainless steel type 316.
 - 3. Liner: Convuluted-bore PTFE liner. The liner shall be extruded tubing made from Teflon® PTFE resin. The resin shall be unprocessed and unpigmented. Standard liner is non-conductive.
 - 4. End Fittings: 316 stainless steel flanges with flare-through liner.
 - 5. Gaskets: Teflon® with torque value compatible with the hose (i.e., 25 ft-lb/bolt).
 - 6. Minimum Bend Radius: 7.5-inches.
 - 7. Working Pressure: 250 psi at 70° F.
 - 8. Vacuum: Full at 70° F.
 - 9. Manufacturer: Resistoflex Type CBF.

2.05 VALVES AND ACCESSORIES

- A. Valve and Accessory System Designation: Most valves and accessories to be furnished and installed are identified by a valve and accessory system designated by a letter symbol in the Piping Schedule.
- B. General Requirements for Valves:
 - 1. All valves of each type shall be the product of one manufacturer.

2. All exposed valves shall be furnished with operators, handwheels, levers, or other suitable type wrench including handles as specified herein or as shown on the Drawings. Valves 4-inch and larger located more than 7 feet above the floor level shall be furnished with chain operators. Chains shall be galvanized and shall extend to within 3 feet of the floor. Provide hook so that chain may be stored clear of walkways. All buried valves shall be provided with 2-inch-square operating nut and valve boxes.
 3. All threaded stem valves shall open by turning the valve stem counter-clockwise.
 4. All exposed valves and valve operators shall have a non-bleeding shop coat, unless otherwise specified.
- C. General Requirements for Accessories: Pressure Gauges: Provide shutoff valves for all pressure gauges. Conform to additional requirements in this Section below.
- D. Valve and Accessory Systems: See Pipe Schedule on Sheet G-002.
1. **Valve and Accessory System A: 1W hot water and tepid water**
 - a. Ball Valves through size 4-inch in metal piping:
 - 1) Rating: 400 psi WOG.
 - 2) Type: Lever.
 - 3) Connections: Threaded.
 - 4) Materials: Bronze body, chrome-plated ball, Teflon seats.
 - 5) Manufacturers: Apollo 70-100; Watts B-6000; or equal.
 - b. Provide other accessories as required per Section 15080.
 2. **Valve and Accessory System C: All except 1W hot water/tepid water and sodium hydroxide**
 - a. Ball Valves Through 4-inch Size specifically for sodium hypochlorite:
 - 1) Rating: 150 psi at 75°F.
 - 2) Type: Double union.
 - 3) Connections: Socket, except flanged or true union for chemicals.
 - 4) Materials: PVC body, teflon seats. EPDM O-ring seals, except Viton O-ring seals and vented balls for SHP.
 - 5) Valve position indicators: Direct mount, low profile, intrinsically safe valve position indicator. Stonel QN-2S-C-02-SGA, or equal.
 - 6) Manufacturers: Chemtrol, George Fisher, R&G Sloane, or equal.
 - 7) Actuators:
 - a) Type: Manual, except where specified otherwise, or shown otherwise on Drawings. Provide local, visual, valve position indicators on all actuators. Provide manual override on all motor actuators.
 - b) Type: where electric motor actuators are shown on the Drawings:
 - (1) Actuator shall be light-weight, suitable for plastic or SS ball valves.
 - (2) Size actuator to provide 200 percent of maximum torque at the valve's fully rated pressure.
 - (3) Provide motor, limit switches and gearing within a NEMA 4X enclosure. Motor shall be reversible for use with 120V single-phase power. Unit shall accept remote open and close dry contacts and shall include position indicating limit switches for remote indication of open and closed positions. Provide two SPDT 24 Vdc coils relays, one to open and one to close.

- (4) Electric actuator shall come equipped with a local remote station. Local remote station shall have hand/off/auto position selector switch and open/close position selector switch with visual light indication. Provide two extra two extra limit switches with cams in the local remote station for feedback outputs.
 - (5) Provide local remote station within a NEMA 4X enclosure and stainless steel trim.
 - (6) Manufacturers: Asahi/America Series 92 Electric Actuator w/ Local Remote Station; or equal.
 - 8) Solenoid Valve: 3-way, 120 VAC solenoid with a mechanical override. ASCO, or equal.
- b. Check Valves Double Union Type:
 - 1) Rating: 150 psi at 75°F.
 - 2) Type: Ball for horizontal or vertical service.
 - 3) Connections: Union ends for socket weld.
 - 4) Materials: PVC body, Viton O-ring seals and seats Manufacturers: Chemtrol True Union BC, Plastiline No.8611, or equal.
- c. Strainers:
 - 1) Rating: 150 psi.
 - 2) Type: Wye-type basket strainers. Strainer screen size as recommended by feed pump supplier.
 - 3) Connections: Threaded.
 - 4) Materials: PVC.
 - 5) Manufacturers: Chemtrol, GF, or equal.
 - 6) Installation: Each to be installed with ball valve blowoff and piping to drain.
- d. Pressure Gauges:
 - 1) Complete installation, unless otherwise shown, shall include valve isolation at the main, a diaphragm seal made, a snubber if over 5 psi operating pressure and gauge. Provide a support plate to the nearest flange.
 - 2) Isolation valves shall be Type 316 stainless steel needle valves (unless ball valves are shown on the Drawings); Ashcroft 7004L; Trerice 735 or 740; WIKA Type 910.11.200; or equal.
 - 3) Diaphragm Seal: Shall be for slurry service with flushing connection. Body shall be stainless steel. Diaphragm shall be oversized and be removable and made of Tantalum. Complete unit shall be Trerice Series 600, Ashcroft Model 100; or equal.
 - 4) Porous pressure snubbers shall be stainless steel for the specific service involved. Porosity of media shall be suitable for the fill fluid and range of operating pressures. Pressure snubbers shall be Ashcroft 25-1112S or 50-1112S; Trerice No. 872; WIKA Type 910.12.100 or equal.
 - 5) Pressure gauges shall have a dial size not less than 4-½ inches, phenolic or polypropylene case, stainless steel movement, phosphor bronze or stainless steel bourdon tube, 0.5% accuracy (ASME B40.100 Grade 2A), friction mounted adjustable pointer, black figures on white dial, glass or acrylic window. Label face of dial to identify unit of measurement. If vibration is present: gauge case shall be liquid filled with glycerin or silicone. Process connection size shall be as shown on Drawings (1/2 NPT

- recommended). Complete gauge shall be Ashcroft 1279; Trerice Series 450; WIKA Type 222.34; or equal.
- 6) Installation: All protectors and gauge bourdon tubes shall be evacuated of air, silicone filled at the factory and factory calibrated.
 - e. Degassing Valves: Installation to be at high point of pipeline and include routing vent port piping to drainage.
 - 1) Body: CPVC
 - 2) Elastomers: FKM
 - 3) Additional Wetted Materials: Polypropylene
 - 4) Maximum operating pressure: 100 psi
 - 5) Connections: ½-inch socket weld inlet and 1/8-inch NPT vent port. Plumb vent port to nearest drain.
 - 6) Manufacturer: ACCU-VENT, or equal.
 - f. Pressure Reducing Valves:
 - 1) For Water:
 - a) Self-Contained: Watts No. U5B for low flows or 223B for flows to 170 gpm; Cashco Model D for low flows or Model 8310 HP, LP DS for flows to 170 gpm.
 - b) Provide strainers with stainless steel screens for each pressure reducing valve unless otherwise noted.
 - c) Sizes, capacities, and pressures shall be as noted on the Drawings.
 - g. Pressure Relief Valves
 - 1) Body: PVC
 - 2) Elastomers: PTFE
 - 3) Additional Wetted Materials: Polypropylene
 - 4) Maximum operating pressure: 100 psi
 - 5) Connections: ½-inch NPT inlet and 1/8-inch NPT vent port. Plumb vent port to nearest drain.
 - h. Calibration chambers, pulsation dampeners and pressure relief valves for chemical service shall be as specified in Section 11240.
3. **Valve and Accessory System D: Sodium Hydroxide**
- a. Ball Valves
 - 1) Rating: 275 psi WOG.
 - 2) Body: Constructed of CF8M stainless steel. Two-piece split body design.
 - 3) Ball: Full port, solid stainless steel
 - 4) Stem: Blowout proof 316 stainless steel.
 - 5) Connections: ANSI Class 150 raised-face flanges.
 - 6) Stem packing: Two PTFE O-rings
 - 7) Bonnet style: Integral design with travel stops
 - 8) Seat: PTFE
 - 9) Manufacturer: Apollo Valves 87A-200, or equal.
 - b. Pressure Relief Valve
 - 1) Body, seat, ball and ball guide: 316 stainless steel
 - 2) Diaphragm and seat gasket: PTFE
 - 3) Pressure setting: Externally adjustable from 0 to 200 psi. Setting as required by the pump manufacturer.
 - 4) Plumb vent port to nearest drain.
 - 5) Model: Milton Roy H series or equal.

- c. Strainers
 - 1) Rating: 150 psi
 - 2) Type: Wye-type basket strainers.
 - 3) Connections: Flanged, Class 150 raised face
 - 4) Materials: 316 stainless steel
 - 5) Screen: 1.6 mm perforations
 - 6) Model: Spirax/Sarco Figure 36 or equal
 - 7) Accessories: Install with ball valve blowoff.
 - d. Pressure Gauges: As specified for System C except with Diaphragm made of Hastelloy B-2.
 - e. Calibration chambers, pulsation dampeners and pressure relief valves for chemical service shall be as specified in Section 11240.
- E. Miscellaneous Valves and Accessories:
- 1. Link-Type Seals: Link-type seals shall be interlocking synthetic rubber links connected by 316 stainless steel bolts and nuts to form a continuous belt. Tightening of the bolts shall expand the rubber to form a watertight seal of the annular space between a pipe and the hole or sleeve in the wall. Provide silicone link seal with Aeration Air system piping and nitrile link seal with all other services.
 - 2. Hose Bibbs:
 - a. Indoor: Nibco Model 55; Arrowhead Brass Model 353; or equal.
 - b. Outdoor (Non-freezing type): J.R. Smith 5913; Zurn Z-1385; or equal.
 - c. Hose Racks: Suitable for 50 feet of ¾-inch hose.
 - 3. Tank Spray Balls: Provide a stationary 316L SS spray balls for rinsing the tank. 1-inch inlet tube, 15-40 psi operating pressure, 45 gpm capacity at 30 psi, without internal strainer, Tankjet® 63225 by Spraying Systems Co.; or equal.
 - 4. Chemical Fill Quick-Disconnects: Consists of a check valve, diaphragm isolation valve, strainer, and a male/female coupling with cam seated washer type seal. Valves and strainers shall be in accordance with System C above, with the exception that horizontal mounting requires use of a diaphragm check valve. The couplings shall be Monel. Couplings shall be "Kamvalock" by OPW or equivalent. Coordinate coupling size with Owner for compatibility with local supplier's chemical delivery equipment.
 - 5. Chemical Sample/Flushing Connections: Consist of type 316 stainless steel NPT male fitting on the outlet side of a ball or diaphragm valve. Provide a 5-foot length of wire reinforced, rubber covered Teflon hose with crimped couplings, male on one end and female on the other.
 - 6. Concrete Vaults and Valve Boxes: Precast reinforced concrete, of the size and orientation shown on the Drawings. Unless otherwise shown or noted, all vaults, boxes and their covers shall be designed for H20 AASHTO wheel loads. Steel lids shall be galvanized. Provide Christy, Brooks, or equal.
 - 7. Valve Tags: Plastic, fiberglass, or plastic material, 2-inch square with grommeted hole. The tags shall be attached to valves with a brass jack chain. For buried installations use a nylon strap. Lettering shall be stamped or cut into the tag at least 3/16-inch high. Provide valve tags for all valves and appurtenances with tag numbers on the Drawings. Provide valve tags for all buried valves.
 - 8. Dielectric couplings: HART 316 stainless steel industrial dielectric couplings, or equal.

9. Insulating Flange Kit: Type D, E, or F double insulating flange set with washers and sleeves; APS, Pikotek, GF, or equal. Gasket type (full, raised, ring) shall match gasket specified for connecting pipes.
10. Valve and Fitting Safety Shields: Provide safety shields around valves and fittings outside of chemical pump and tank areas.
 - a. TFE coated fiberglass, OSHA orange border with see-through shield for inspection of leaks. Plumb safety shield to nearest drain. Ramco Vue-Gard; or equal.
11. Caustic Area Safety Curtain: Provide chemical resistant safety curtain surrounding caustic pump area as shown on the Drawings. See Section 11240 for Curtain specifications.
12. Pipe Escutcheons:
 - a. Manufactured wall, ceiling, and floor plates; cast brass, polished chrome plated, with set-screw, deep pattern type where required to conceal protruding fittings and sleeves.
 - b. Inside Diameter: Closely fit around pipe, tube, and insulation of insulated piping.
 - c. Outside Diameter: Completely cover opening.
 - d. One-piece design for piping to plumbing fixtures and to equipment in finished spaces.
 - e. Split concealed hinge type for piping not serving plumbing fixtures or equipment in finished spaces.

PART 3 - EXECUTION

3.01 PIPING INSTALLATION

- A. General Handling and Placing:
 1. Exercise great care to prevent injury to or scoring of the pipe lining and coating, as applicable, during handling, transportation, or storage. Handle fusion epoxy coated pipe and ceramic epoxy lined pipe in accordance with AWWA C213. Do not store pipe on rough ground and do not roll the pipe on the coating. Any damaged pipe sections, specials, or fittings shall be repaired or replaced at the expense of the Contractor as satisfactory to the Engineer.
 2. Carefully inspect each pipe, fitting, valve and accessory before installation to ensure there is no defective workmanship or obstructions. Inspect the interior and exterior protective coatings and patch all damaged areas in the field or replace to the satisfaction of the Engineer.
 3. Place or erect all piping to accurate line and grade and backfill, support, hang, or brace against movement as specified or shown on the Drawings, or as required for proper installation. Remove all dirt and foreign matter from the pipe interior prior to installation and thoroughly clean all joints before joining.
 4. Use reducing fittings where any change in pipe size occurs. Do not use bushings unless specifically noted on the Drawings. Use eccentric reducing fittings wherever necessary to provide free drainage of lines.
 5. Cover polyvinyl chloride and high density polyethylene (HDPE) pipe stored outside for more than 2 months with canvas or other opaque material. Provide for air circulation under the covering.
 6. Certain installation requirements are contained in Section 15400 and Section 15800.

B. General Buried Piping Installation:

1. Trenching, bedding, and backfill for buried piping shall be as shown on the Drawings and as specified in Section 02300.
2. Where pipe grade elevations are shown on the Drawings, install the pipe with straight grades between the indicated elevations.
3. Where no pipe grade elevations are shown on the Drawings, install buried piping with at least 3 feet of cover to finished grade. Where piping crosses under buried electrical ducts, provide at least 4 feet 6 inches of cover. Provide 12 inches minimum separation between the buried pipes and ducts.
4. Provide each pipe with a firm, uniform bearing for its full length in the trench except at field joints. Do not lay pipe in water or when trench conditions or weather are unsuitable for such work.
5. Protect buried piping against thrust by use of restrained pipe joints. All exposed free pipe ends shall be securely braced. Cap or plug pipe ends that are left for future connections as shown on the Drawings and in a manner favorably reviewed by the Engineer.
6. Where piping leaves a structure or concrete encasement, provide a joint capable of angular deflection within 12 inches of the structure for pipes 12-inch and smaller or as shown on the Drawings for larger pipe sizes. Conform to details on the Drawings where such details are shown.
7. Snake buried CPVC and HDPE pressure pipe from side to side in the trench in long sweeps.
8. Concrete Encasements: All piping and conduits except plumbing lines installed under slabs or footings on earth or crushed rock shall be encased in concrete not less than 6-inch thickness on all sides and extending up to the bottom of the slab or footing, unless otherwise specifically noted on the Drawings. Encasement shall extend to within 6 inches of the first pipe joint beyond the slab or footing. Provide concrete encasement whether or not the encasement is shown on the Drawings. Provide encasement under slabs on earth or crushed rock even if the structure is supported on piles, caissons, or footings. Provide continuous concrete cradles where shown.
9. Double Containment for Buried Chemical Tubing: Enclose buried chemical tubing within HDPE Pipe. Terminate at watertight junction boxes.
10. Do not pull bell and spigot, gasketed joints more than 50% of the maximum deflection permitted by the pipe manufacturer.

C. General Exposed Piping Installation:

1. Unless shown otherwise, install piping parallel to building lines, plumb and level.
2. Install piping without springing or forcing the pipe in a manner that would set up stresses in the pipe, valves, or connected equipment.
3. Set all pipe flanges level, plumb, and aligned. All flanged fittings shall be true and perpendicular to the axis of the pipe. All bolt holes in flanges shall straddle vertical centerline of pipes.
4. Flexibility and Expansion: Provide flexible couplings, flexible hose, or flexible spools for all piping connections to motor driven equipment and where otherwise shown. The Contractor may install additional flexible couplings at favorably reviewed locations to facilitate piping installation, provided that he submits complete details describing location, pipe supports, and hydraulic thrust protection. Anchor piping subject to expansion or contraction in a manner permitting strains to be evenly distributed. Sleeves for branches through walls from adjacent mains shall be of sufficient size to allow for free side motion of covered pipe in sleeves.

5. Install unions or flexible connections where shown on the Drawings, and at all non-motor-driven equipment to facilitate removal of the equipment.
 6. Provide valves wherever equipment drain connections are furnished and carry the discharge pipe to the nearest floor drain, drain trench or sump. Where no receptacle for drain exists, install drain piping to 1-inch above the floor. Drain piping and valve materials shall conform to the requirements of the system served.
 7. Where piping conveying liquids passes over motor control centers, electrical panels, and other electrical devices, install a protective drainage tray below the piping.
- D. Pipe Welding:
1. General: Unless specified otherwise, shop and field welding of pipe shall conform to ANSI B31.1 as amended by this paragraph.
 2. All field and shop welding shall be done by the electric arc process unless otherwise specified. All field welding shall be done in passes not thicker than ¼-inch. Size and type of electrodes, and current and voltages used, shall be subject to the favorable review of the Engineer. Give particular attention to the alignment of edges to be joined, so that complete fusion and penetration will be effected throughout the bottom of the weld. Welds shall contain no valleys or undercuts in the center or edges of the weld. Thoroughly clean each pass, except the final one, of dirt, slag, and flux before the succeeding bead is applied.
 3. Clean completed field welds of pipe joints of dirt, slag and flux, and then visually inspect. Completely chip out all defects in welds discovered during field inspection in a manner that will permit proper and complete repair by welding subject to the favorable review of the Engineer. Under no circumstances will caulking of defective welds be permitted.
 4. All welding shall be done by experienced, skilled operators familiar with the methods and materials to be used. Hand welding will be done only by welders qualified under the standard qualification procedure of Section IX of the ASME Boiler and Pressure Vessel Code. The Contractor shall conduct tests of his welders, when required by the Engineer, in accordance with that code and in the presence of the Engineer. An independent testing laboratory, favorably reviewed by the Engineer, shall supervise the testing and determine the quality of the test work. Weld specimens in the same positions as those in which the welder is to qualify his work. The Engineer may require test specimens at any time. Any welder whose work is found unsatisfactory shall not remain employed on this Contract, regardless of the quality of his earlier work. Each hand weld specimen shall be plainly marked with the welder's identifying symbol. The Contractor shall furnish all materials required and pay all costs for qualifying welders.
 5. Field welds shall follow as closely as possible to the laying operation. All field welds shall be complete before lining or coating of the joints in steel pipe is begun. Where pipe is fusion epoxy lined and/or coated, follow AWWA C-213 procedures for field welded joints.
 6. A single, continuous, watertight, full fillet weld shall be the minimum required at all field joints. Double welded joints are required on all piping specifically noted to be double welded.
 7. See also installation specifics for welding of pipe.

E. Installation Specifics:

1. CUP Pipe:

- a. Bends shall be made in a manner that does not crimp or flatten pipe.
- b. Dielectric unions shall be installed at connections with ferrous piping.
- c. Pipe shall have joints squarely cut clean, soldered joints shall be properly fluxed and heated before solder is placed in the joint. Joints must be driven up tight before solder is added. Compression and flared joints shall be made up in accordance with the fitting manufacturer's installation instructions. Brazing shall be in accordance with ANSI B31.1.
- d. Install piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building. Provide space to permit insulation applications, with 1-inch clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.
- e. Install drains at low points in mains, risers, and branch lines consisting of a tee fitting, $\frac{3}{4}$ -inch ball valve, and short $\frac{3}{4}$ -inch threaded nipple and cap.
- f. Exterior Wall Penetrations: Seal pipe penetrations through exterior walls using steel sleeves and mechanical sleeve seals.
- g. Fire Barrier Penetrations: Where pipes pass through fire rated walls, partitions, ceilings, and floors, maintain the fire rated integrity.
- h. Install branch connections to mains using tee fittings in main with take-off out the bottom of the main, except for up-feed risers, which shall have take-off out the top of the main line.
- i. Install strainers on the supply side of each control valve, pressure reducing valve, pressure regulating valve, solenoid valve, inline pump, and elsewhere as indicated. Install nipple and ball valve in blowdown connection of strainers 2 inches and larger.

2. HDPE Type:

- a. Handling and laying of pipe and fittings shall be in accordance with the manufacturer's instructions, PPI guidelines, AWWA M55, and as specified herein to line and grades as shown on the Drawings.
- b. Pipe and fittings shall not be dropped. All pipe and fittings shall be examined before laying and no piece shall be installed which is found to be defective. Any damage to the pipe shall be repaired as directed by the manufacturer and approved by the Owner. If any defective pipe is discovered after it has been laid, it shall be removed and replaced with a sound pipe in a satisfactory manner at the Contractor's expense. Any pipe with gouges exceeding 5% of the nominal wall thickness will be rejected.
- c. All pipe and fittings shall be thoroughly cleaned before laying, shall be kept clean until they are used in the work.
- d. The Contractor shall not drag the pipe. Rollers or other such devices shall be used to reduce dragging of the pipe. Damage to pipe caused by dragging is the responsibility of the Contractor and cause for replacement of damaged portion as determined by the Owner. If, in the opinion of the Owner, the pipe may have been dragged to an extent where damage may have occurred to the pipe wall, the Contractor will rotate the pipe in a manner which will facilitate inspection.

- e. As much as practicable, the print line on the pipe shall be installed facing upward to facilitate identification of the pipe when initially installed.
- f. Pipe fused above ground shall be carefully handled to avoid damage to the pipe. Chains or cable type chokers will not be allowed when lifting sections of pipe. Nylon or other wide fabric slings or other similar lifting apparatus with spreader bars shall be used where necessary.
- g. Prior to installing a pipe section, the bedding material shall be brought to grade along the entire length of the section to be installed.
- h. The joining method shall be the thermal butt fusion method and shall be performed in strict accordance with these Specifications, PPI guidelines, and the pipe manufacturer's recommendations. Should there be a conflict between these Specifications and the pipe manufacturer's recommendations, the more stringent requirement shall govern. The butt fusion equipment used in the joining procedures shall be capable of meeting all conditions and procedures recommended by the pipe manufacturer, including but not limited to, temperature requirements, alignment, and interfacial fusion pressure and automatic recording of parameters for joining.
- i. Heat fusion joining shall be complete, efficient, and match the outer diameter of the two pipes being heat fused. Any offset or mismatch shall not exceed 10% of the minimum wall thickness. In all cases, heat fusion pipe joints shall have a joint weld strength equal to or greater than the tensile strength of the pipe.
- j. Submit detailed fusion joint reports as recorded by the heat fusion machine for all joints. Submit a report to the Owner's Inspector the same day the fusion is made. Submit a formal report of all fusions to the Owner's Project Manager on a weekly basis, no later than 4:00 p.m. each Friday. If any joint as indicated by these reports is found to be unsatisfactory, the Contractor shall remove portions of the pipe containing such joint and install a new pipe piece as required and approved by the Owner.
- k. The first fusion shall be a trial fusion to be performed in the field in the presence of the Owner. The trial fusion shall be allowed to cool completely, then fusion test straps shall be cut out. The test strap shall be the longer of 12 inches or 30 times the wall thickness in length with the fusion in the center, and 1-inch minimum or 1.5 times the wall thickness in width. Then, the test strap shall be bent until the ends of the strap touch. If the fusion fails at the joint, or if the joint exhibits cracking or crazing, a new trial fusion shall be made, cooled completely, and tested. Butt fusion of the pipe to be installed shall not commence until the trial fusion has passed the bend back test.
- l. Following the successful initial trial fusion, the bend back test shall be performed once every fiftieth joint.
- m. Bending of the pipe to achieve horizontal or vertical changes in direction is allowed. The minimum bending radius, measured along the centerline axis of the pipe is 50 times the nominal pipe size.
- n. Flange connections shall be in accordance with the manufacturer's requirements. Flange bolts shall not be used to draw the connection into alignment. Bolt threads shall be lubricated, and flat washers shall be used under nuts. Tighten bolts evenly according to the pipe manufacturer's tightening pattern and torque step recommendations.

- Retighten flange connections at least one hour after the initial tightening using the pipe manufacturer's tightening pattern and torque step recommendations.
- o. Install tracer wire and warning tape in accordance with Section 02505.
 - p. All HDPE pipe must be at the temperature of the surrounding soil at the time of backfilling and compaction.
3. PVC Pipe:
- a. Install pipe in accordance with the manufacturer's instructions.
 - b. Place PVC pipe within the installation areas at least 24 hours prior to installation to permit temperature equalization.
 - c. Cut pipe ends squarely, ream and deburr inside and out.
 - d. Clean pipe ends and bells of dirt, grease, and other foreign materials prior to making the joint.
 - e. Solvent Weld Joints: Clean pipe ends and sockets and join in strict conformance with the pipe manufacturer's instructions. Make joints in accordance with ASTM D2855. Handle solvent cements and primers in accordance with ASTM F402.
 - f. Containment fittings for chemical and chemical solution lines shall be installed and tested in accordance with manufacturers' instructions. Install containment pipe with position clips at 3-foot centers and at fittings during installation of carrier pipe. Do not make joints until after successful leak tests of carrier pipes.
 - g. PVC-Pipe: Threaded connections shall use a short nipple, threaded at one end, socket at the other. Provide thread sealant in accordance with the pipe manufacturer's recommendations. Take care not to overtighten the connection.
 - h. PVC-1 Pipe: No work shall be performed until the pipe manufacturer provides onsite installation training and certifies the installers are trained per ASTM D-2855. The Owner's inspector shall be present for the training session.
4. SSP Type:
- a. Install and weld in accordance with CGA G-4.4 and ANSI B31.1. Back purge all welds with cover gas. Seal weld all slip-on flanges.
 - b. Provide anti-seize compound on threaded connections.
 - c. Temporarily plug or cap all points of connection to exclude moisture, dust or other contaminants or impurities prior to being connected.
 - d. Install spray shields at all flanged joints on sodium hydroxide piping.

3.02 COUPLING INSTALLATION

- A. Flange Coupling Adaptors: Prior to installation, thoroughly clean oil, scale, rust, and dirt from the pipe to provide a clean seat for the gasket. Wipe gaskets clean before they are installed. If necessary, flexible couplings and flanged coupling adapter gaskets may be lubricated with soapy water or manufacturer's standard lubricant before installation on the pipe ends. Install in accordance with the manufacturer's recommendations. Tighten bolts progressively, drawing up bolt on opposite sides a little at a time until all bolts have a uniform tightness. Workers tightening bolts shall be equipped with torque-limiting wrenches or other favorably reviewed type.
- B. Tie Rods: Except where double-nutting is required, install the nuts snug. Tighten the nuts gradually and equally at opposite sides of the pipe until snug to prevent misalignment and to ensure that all rods carry equal loads. If double-nutting is

required, double-nut each end of each tie rod. The space between the pairs of nuts shall be ½-inch greater than the distance between the lugs. Provide double-nutting at buried locations and where otherwise required on the Drawings.

- C. Flexible Rubber Spools:
 - 1. Install in accordance with manufacturer's instructions. Unless otherwise shown on the Drawings, install flat with one-half the maximum expansion.
 - 2. Connect rubber spools only to full-face metal flanges.
 - 3. Install control rod-compression sleeve assemblies with control rod nuts snug, to relieve stress on adjacent pipe, except at buried locations. Comply with manufacturer's instructions.

3.03 INSTALLATION OF VALVES AND ACCESSORIES

- A. Use reducing fittings where any change in pipe size occurs between valves or accessories and the attached pipeline. Bushings shall not be used, unless specifically noted on the Drawings. Use eccentric reducing fittings wherever necessary to provide free drainage of lines.
- B. Install valves and accessories such that all parts are easily accessible for maintenance and operation. Provide valve boxes for buried valves.
- C. Where valve handwheels are shown on the Drawings, valve orientation shall be as shown. Where valve handwheels are not shown, orient valves to permit easy access to the handwheels or handles and to avoid interferences.
- D. Install pressure gauges and thermometers in a position to permit reading them from a point approximately 5 feet above floor level, except that pump pressure gauges shall be installed close to the pump elevation.
- E. Rigidly support pressure switches and connect them to piping and equipment using a suitable flexible linkage that will not permit transmission of vibrations from the piping or equipment to the pressure switches.
- F. Provide a union adjacent to each screwed end valve and accessory with additional unions as necessary to facilitate removal.
- G. Provide a shutoff valve below each pressure gauge, protective device or air valve unless otherwise specified.
- H. Connections between dissimilar metals, valves, accessories, or pipe supports shall be made using a dielectric coupling, union, or flange.
- I. Where valves or other pipeline items require metal full-face connecting flanges, provide intermediate flanges if the connecting flange is not adequate.
- J. All insulated piping passing through walls or slabs shall be sleeved and insulation shall run continuously through the sleeves and shall allow for 1/8-inch annular clearance between outside of insulation and sleeve wall.
 - i. Provide a suitable chrome plated escutcheon on pipes passing through walls, floors, ceilings, and partitions in finished areas.
- K. Install link-type seals in cast-in-place metal sleeves or in smooth core drilled holes unless otherwise shown in the Drawings. Grout both sides flush with non-shrink grout unless otherwise shown on the Drawings.
- L. Install butterfly valves in accordance with AWWA C504, Appendix A, Sections A.2 through A.5, inclusive.

3.04 PIPE AND VALVE IDENTIFICATION

- A. General: Identify all exposed piping in this project by painting, banding, system name labels, and direction arrows. The color and banding shall be as selected by the Engineer and as indicated in Section 10400. Identify all buried valves and exposed valves with tags as specified below.
- B. Exposed Pipe Identification: Before painting, banding, and labeling, pipes shall be identified by the Contractor with temporary wired-on cardboard tags showing the proposed marking for review by the Engineer.
- C. Piping: Paint all exposed pipes with the appropriate paint system as specified in Section 09900.
- D. Exposed Valves: Any valve with a tag number in the Drawings shall be provided with a valve tag identifying the pipeline contents, its valve number, and its service. Contents shall be as designated in the Piping Schedule.
- E. Buried Valves: Provide all buried valves with a valve tag identifying the pipeline contents. Contents shall be as designated in the Piping Schedule.
- F. Provide access panel markers for valves and control devices concealed behind access panels and above suspended ceilings. Locate markers on access doors and on ceiling T-bars.
 - 1. Markers for Ceiling T-bar Installation: Blue, pressure-sensitive, self-adhesive, at least 3 mils thick, 3/8-inch diameter.
 - 2. Markers for Access Doors: 1/16-inch thick, engraved plastic-laminate, with abbreviated terms and numbers corresponding to the concealed item. Provide 1/8-inch center attachment hole.

3.05 FIELD QUALITY CONTROL

- A. The Engineer will:
 - 1. Inspect field welds and test the welds if it is deemed necessary.
- B. Factory Quality Control: The Contractor shall test all products as required herein and by the reference specifications.
- C. The Contractor shall:
 - 1. Perform leakage tests.
 - 2. Be responsible for the costs of additional inspection and retesting by the Owner resulting from non-compliance.

3.06 CLEANING

- A. Prior to testing, thoroughly clean the inside of each completed piping system of all dirt, loose scale, sand, and other foreign material. Cleaning shall be by sweeping, flushing with water, or blowing with compressed air, as appropriate for the size and type of pipe. Flushing shall achieve a velocity of at least 3 feet per second. The Contractor shall install temporary strainers, temporarily disconnect equipment, or take other appropriate measures to protect equipment while cleaning piping. Cleaning shall be completed after any pipeline repairs.

3.07 FIELD TESTING

- A. General: Perform leakage tests on all pipe installed in this project. Furnish all equipment, material, personnel and supplies to perform the tests and make all taps and other necessary temporary connections. The test pressure, allowable leakage

and test medium shall be as specified and as shown in the following Paragraphs. Test pressure shall be measured at the highest point on the line, except that pressure at lowest point shall not exceed pipe manufacturer's rated test pressure, unless specifically noted otherwise. Leakage tests shall be performed on all piping at a time agreed upon and in the presence of the Engineer. All visible leaks shall be repaired, regardless of the test results.

- B. Buried Piping: The leakage test for buried piping shall be made after all pipes are installed and backfilled. However, the Contractor may conduct preliminary tests prior to backfill. If the Contractor elects to conduct preliminary tests, provide any necessary temporary thrust restraint.
- C. Exposed Piping: All supports, anchors and blocks shall be installed prior to the leakage test. No temporary supports or blocking shall be installed for final test.
- D. Encased Piping: The leakage test for encased piping shall be made after all pipe is installed and encased, and before any structures are constructed above it. However, the Contractor may conduct preliminary tests prior to encasement. If the Contractor elects to conduct preliminary tests, provide any necessary temporary thrust restraint.
- E. Accessories: It shall be the responsibility of the Contractor to block off or remove equipment, valves, gauges, etc., which are not designed to withstand the full test pressure.
- F. Testing Apparatus: Provide pipe taps, nozzles and connections as necessary in piping to permit testing including valves to isolate the new system, addition of test media, and draining lines and disposal of water, as is necessary. These openings shall be plugged in a manner favorably reviewed by the Engineer after use. Provide all required temporary bulkheads.
- G. Pneumatic Testing: Piping tested by air or another gas shall show no reduction of pressure during the test period after corrections have been made for changes in temperature in conformance with the following relationship:

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

Where T_1 and T_2 are the absolute temperatures of the gas in the pipe and P_1 and P_2 are the absolute pressures. The subscript "1" denotes the starting conditions and the subscript "2" denotes the final conditions.

- H. Precautions for Pneumatic Testing: Where air or another gas is called for as the test medium, the Contractor shall take special precautions to protect personnel. During the initial pressurization of a pipeline to the specified test pressure, personnel shall be protected by suitable barriers between them and the pipeline under test.
- I. Correction of Defects: If leakage exceeds the allowable, the installation shall be repaired or replaced and leakage tests shall be repeated as necessary until conformance to the leakage test requirements specified herein have been fulfilled. All visible leaks shall be repaired even if the pipeline passes the allowable leakage test.
- J. Drying: Gas lines tested with water shall be drained and blown dry with air or oil-free nitrogen gas.

- K. Reports: The Contractor shall keep records of each piping test, including:
1. Description and identification of piping tested.
 2. Test pressure.
 3. Date of test.
 4. Witnessing by Contractor and Engineer.
 5. Test evaluation.
 6. Remarks, to include such items as:
 - a. Leaks (type, location).
 - b. Repairs made on leaks.
 7. Test reports shall be submitted to the Engineer.
- L. Venting: Where not shown on the Drawings, the Contractor may install valved "tees" at high points on piping to permit venting of air. Valves shall be capped after testing is completed.
- M. Testing Specifics: Unless specified otherwise, test each system for 4 hours. The test medium for all services shall be water. Allowable leakage for all services is zero for the duration of the 4-hour test: Water used for testing may be disposed of to the treatment plant in coordination with the Owner and plant staff.
1. CUP Pipe:
 - a. Duration: 4 hours.
 - b. Pressure: 150 psi.
 - c. Medium: Water.
 - d. Allowable Leakage: None.
 2. HDPE Pipe: See requirement for Double Containment.
 3. PTFE Tube:
 - a. Duration: 4 hours.
 - b. Pressure: 70 psi.
 - c. Medium: Water.
 - d. Allowable Leakage: None.
 4. PVC Pipe:
 - a. Duration: 4 hours.
 - b. Pressure: 150 psi.
 - c. Medium: Water.
 - d. Allowable Leakage: None.
 5. PVC Double Containment for chemical piping.
 - a. Duration: 4 hours.
 - b. Pressure: 5 psi.
 - c. Medium: Air.
 - d. Allowable Leakage: None.
 6. SS Pipe:
 - a. Duration: 4 hours.
 - b. Pressure: 150 psi.
 - c. Medium: Water.
 - d. Allowable Leakage: None.

END OF SECTION

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SECTION 15060

PIPE SUPPORTS

PART 1 - GENERAL

1.01 SUMMARY

- A. Section includes: Provide all pipe supports as shown on the Drawings, described in the Specifications.

1.02 REFERENCES

- A. American Institute of Steel Construction (AISC), Manual of Steel Construction
- B. American Society of Mechanical Engineers (ASME), ASME B31 Code for Pressure Piping
- C. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
- D. ASTM International (ASTM)
- E. Manufacturers Standardization Society (MSS):
 - 1. MSS SP-58: Pipe Hangers and Supports - Materials, Design, and Manufacture
 - 2. MSS SP-69: Pipe Hangers and Supports - Selection and Application
 - 3. MSS SP-89: Pipe Hangers and Supports - Fabrication and Installation Practices
- F. American National Standards Institute (ANSI)
- G. American Water Works Association (AWWA)
- H. National Fire Protection Association (NFPA)
- I. SMACNA Guidelines for Seismic Restraints of Mechanical Systems and Plumbing Piping Systems

1.03 SUBMITTALS

- A. Shop Drawings:
 - 1. Layouts and Schematics: Submit detailed installation drawings of all piping. Schematics may be submitted for piping 4 inches and smaller. The Drawings and schematics shall include: pipe support locations and types, fittings, valves, other appurtenances.
 - 2. Submit data to show that the following items conform to the Specification requirements:
 - a. Fabricated pipe supports and other pipe supports.
 - 3. Submit certified test reports as required herein and by the referenced standard specifications.
- B. Provide seismic anchorage design for Contractor designed pipe supports in accordance with Section 01190, including layout and calculations, signed and sealed by a Professional Civil or Structural Engineer registered in the State of Washington.

1.04 QUALITY ASSURANCE

- A. Materials and equipment furnished under this Section shall be of manufacturers who have been regularly engaged in the design and manufacture of the materials and equipment for a period of at least 5 years. Demonstrate to the satisfaction of the Engineer that the quality is equal to the materials and equipment made by the manufacturers specifically named herein, if an alternate manufacturer is proposed.

1.05 APPURTENANCES

- A. Furnish and install all necessary anchors and assembly bolts, washers and nuts, hangers, and supports; all other appurtenant items shown on the Drawings, specified, or required for the proper installation and operation of the pipe supports.

1.06 PIPE SUPPORTS

- A. General:
 - 1. Piping 6 Inches and Larger: Pipe supports are shown on the Drawings for piping 6 inches and larger in diameter, where the piping is shown on layout drawings. Each pipe support used is designed to resist seismic loading except where the support is of the sliding type for thermal expansion. Other supports are provided to resist axial seismic loading of pipes designed for thermal expansion. Pipe supports that are considered seismic resistant are so noted on the pipe support detail sheets on the Drawings. The location and types of supports and braces are indicative and may be modified by the Contractor to suit field conditions, provided the modified support system conforms to the design criteria stated herein, and receives the favorable review of the Engineer. Where piping is shown schematically only, it shall be the Contractor's responsibility to support all such piping in accordance with the design criteria stated herein and using support details shown on the Drawings. Pipe supports have been designed assuming flanged joints on ductile iron pipe and steel pipe, unless otherwise indicated on the Drawings. If groove type mechanical couplings are used as an alternative, provide additional supports where required, particularly to resist rotation. Shop drawings of these additional supports shall be favorably reviewed by the Engineer prior to installation.
 - 2. Piping Less Than 6 Inches: Pipe supports are generally not shown for piping less than 6 inches in diameter. Where supports are not shown, it shall be the Contractor's responsibility to support all such piping in accordance with the design criteria stated hereinafter and the support details shown on the Drawings. Piping 2 ½ inches and larger and all piping for hazardous chemicals shall be supported with pipe supports designed to resist seismic loads. Hazardous chemical piping includes sodium hypochlorite and sodium hydroxide. Piping smaller than 2 ½ inches with non-hazardous contents may be supported with non-seismic resistant supports.
 - 3. Where not detailed or otherwise indicated, pipe support types and spacing shall be in accordance with the Manufacturer's Standardization Society (MSS) Standard Practice No. SP 58 and No. SP 69, except as superseded by the requirements of these Specifications. Hangers and supports used as components of a fire protection system shall comply with NFPA Standard No. 13 and be listed and labeled by UL and FM.

B. Pipe Support System Design:

1. Design Loads: Pipe suspension shall be such as to prevent excessive stress or excessive variation in supporting force while system is in operation. Pipe supports shall support the sum of the weight of the pipe, fittings, appurtenances, and contents. In addition, the pipe shall be anchored to resist internal pressure forces tending to separate any unrestrained joint at pressures 1-½ times the maximum working pressure for the applicable service.
2. Seismic Loads: Refer to Section 01190.
3. Location: All piping shall be supported in a manner that will prevent undue strain on any valve, fitting, or piece of equipment. In addition, pipe supports shall be provided at changes in direction or elevation, adjacent to flexible couplings, at all non-rigid joints, at hose bibbs, and where otherwise shown. Where piping connects to equipment, it shall be supported by a pipe support and not by the equipment.
 - a. Maximum support spacing shall conform to the following table:

Pipe Size Inches	Pipe Material	Maximum Spacing Feet
1-inch and smaller	Iron or Steel Copper Plastic Tubing	6 4-1/2 continuous continuous
1-¼-inch to 2-inch	Iron or Steel Copper or Plastic	8 5
2-½-inch to 4-inch	Iron or Steel Copper or Plastic	10 6
6-inch to 8-inch	Iron or Steel Plastic	12 8
10-inch and larger	Iron or Steel	15

- b. Piping penetrations through concrete walls and slabs are considered to resist seismic loading, provided penetrations are for pipes 3 inches in diameter and larger and are complete with a wall flange.
 - c. Branch piping is not considered to provide resistance to seismic forces.
 4. Anchors: Anchors for connecting pipe supports to concrete shall be in accordance with Section 05120.
 5. Thermal Expansion Allowance:
 - a. Provide one rigid pipe support for each straight run of pipe and between each pair of flexible couplings, flexible connectors, or expansion loops for pipes listed below. Provide other supports at the required spacing that allow sliding or rolling, as noted, along the pipe axis:
 - 1) PVC pipe larger than 1 inch in diameter (sliding inside PVC sleeve).
 - 2) Domestic hot water (rolling).
 - b. Provide vertical support only, that is, no lateral support, within 4 feet of an angle or tee for pipes listed above.

PART 2 - PRODUCTS

2.01 GENERAL MATERIAL REQUIREMENTS

- A. Unless specified otherwise herein bolts, nuts, and other hardware for pipe supports shall be as follows:

1. Chemical Service Area: Type 316 stainless steel, minimum tensile strength: 60,000 psi.
2. Exposed: Electroplated zinc or cadmium steel.
3. Apply an anti-galling compound to the threads of stainless steel bolts.

2.02 PIPE SUPPORTS

- A. Manufacture and Design: Pipe supports shall to the maximum extent possible be standard factory fabricated units conforming to the typical supports and braces shown in the Drawings and as specified below. Where required support cannot be provided by standard factory fabricated units, and is not detailed on the Drawings, the Contractor shall provide special pipe supports. Supports shall be manufactured or special fabrications or combination as shown on the Drawings or specified. Special fabrications shall be in conformance with Section 05500. Provide $\frac{3}{4}$ inch chamfer on corners of all support elements and file or grind smooth. Supports designated to allow axial pipe movement shall have smooth and even contact surfaces.
- B. Manufacturers:
 1. Anvil International
 2. Eaton B-Line
 3. Or equal.
- C. The shield shall consist of an insulation layer encircling the entire circumference of the pipe and a steel jacket encircling the insulation layer.
- D. Materials:
 1. All support systems shall be hot dip galvanized steel except where noted otherwise or specified otherwise.
 2. All support systems that are submerged or that are located within a tank, channel, or other structure designed to hold chemicals, below the top of surrounding walkway elevation or tank wall top, or otherwise called out on the Drawings, shall be Type 316 stainless steel.
 3. All support systems for stainless steel piping shall be Type 316 stainless steel.
- E. Insulation Protection Shields:
 1. Provide insulation protection shields at all pipe supports for insulated piping.
 2. The shield shall consist of an insulation layer encircling the entire circumference of the pipe and a steel jacket encircling the insulation layer.
 3. The thermal shield shall be the same thickness as the piping system insulation specified in Section 15080.
 4. The standard shield shall be used for hot systems and the vapor barrier shield shall be used for cold systems.
 5. Stainless steel band clamps shall be used where specified to ensure against slippage between the pipe wall and the thermal shield.
- F. Provide plastic caps with rounded corners on all exposed ends of channels.

PART 3 - EXECUTION

3.01 INSTALLATION OF PIPE SUPPORTS

- A. General:
 1. Install and adjust supports for each pipeline such that the pipeline is true to the indicated line and grade.

2. Locate anchors and braces for any single support on a continuous structure; that is, not on two sides of a structural expansion joint.
 3. Tighten clamps to develop full friction along the pipeline except where loose fitting clamps are called for.
 4. Adjust hangers and supports to obtain required pipe slope and elevation. Shims made of material that is compatible with the piping material may be used. Adjust stanchions prior to grouting their baseplates.
- B. Electrolytic Protection: Pipe supports serving copper pipe or tubing shall be dielectrically insulated from the pipe by dielectric sleeves or plastic pipe wrap at the point of contact.

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SECTION 15080

PIPING INSULATION AND HEAT TRACING

PART 1 - GENERAL

1.01 SUMMARY

- A. Provide heat tracing, insulation and accessories for piping systems and designated equipment.

1.02 REFERENCES

- A. ASTM International (ASTM) Standards:
 - 1. B209 Aluminum and Aluminum-Alloy Sheet and Plate
 - 2. C533 Calcium Silicate Block and Pipe Thermal Insulation
 - 3. C534 Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
 - 4. C547 Mineral Fiberglass Insulation.
 - 5. C552 Cellular Glass Thermal Insulation
 - 6. E84 Surface Burn Characteristics of Building Materials
 - 7. E96 Test for Water Vapor Transmission of Materials
- B. National Fire Protection Association (NFPA) Standards
- C. NEMA ICS 1-88 Industrial Control Systems
- D. Underwriters' Laboratories, Inc. (UL) Publications:
 - 1. 723 Test Hazard Classification of Building Materials.

1.03 FIRE RESISTANCE

- A. Insulation. Smoke-developed ratings per NFPA 255, ASTM E 84 and UL 723 testing requirements to be as follows.
 - 1. Fiberglass with jacket not to exceed a flame-spread rating of 50.
- B. Tape, Adhesives, Vapor Barrier Materials, and Jackets. Flame-spread ratings not to exceed 25.
- C. Factory-Applied Items/Materials. Test these items as assembled. Provide Certificates of Compliance from an approved testing laboratory if not UL approved. Flame-proofing treatments which are subject to deterioration are not acceptable.
- D. Field-Applied Items/Materials. These items may be tested individually. Provide Certificates of Compliance from an approved testing laboratory if not UL approved; flame-proofing treatments which are subject to deterioration are not acceptable.
- E. Exempt Items/Materials. The following are exempt from the fire-resistance ratings:
 - 1. Nylon duct insulation anchors.
 - 2. Treated wood insulation inserts.
 - 3. PVC fittings and valve covers.

1.04 THICKNESS

- A. Normal thickness of insulation is defined as the thickness of the basic insulating medium not including finishing coats.

1.05 APPROVED TESTING LABORATORIES

- A. Approved testing laboratories include:
 - 1. Underwriters' Laboratories, Inc. (UL).
 - 2. Canadian Standards Association (CSA), where acceptable to local authorities.

1.06 EXPOSED VERSUS CONCEALED INSULATION

- A. Exposed is defined as Work exposed to the view of occupants in normally occupied areas and in equipment rooms.
- B. Concealed is defined as Work located in ceiling spaces, chases, and other locations not exposed to view.

1.07 SUBMITTALS

- A. Shop Drawings and Product Data: Submit the following as a single complete submittal in accordance with Section 01300:
 - 1. Thermal insulation product data fully describing all items proposed for use to demonstrate that the equipment conforms to the Specifications.
- B. Affidavits: Submit affidavits from the manufacturer stating that the equipment has been properly installed, adjusted, and tested and is ready for full-time operation.

1.08 QUALITY ASSURANCE

- A. Qualifications: Materials and equipment furnished under this Section shall be supplied by a manufacturer who has been regularly engaged in the design and manufacture of the equipment for at least five years. Demonstrate to the satisfaction of the Engineer that the quality is equal to equipment made by those manufacturers named herein, if an alternate manufacturer is proposed.

PART 2 - PRODUCTS

2.01 THERMAL INSULATION AND HEAT TAPE FOR PLUMBING AND PIPING

- A. General:
 - 1. Delivery: Deliver insulation materials to the job in original packages with manufacturer's "R" values clearly shown. Provide certification of compliance.
 - 2. Warning: The Contractor is warned that working with fiberglass or rock wool materials may constitute a serious health hazard. The Contractor shall take all necessary precautions to ensure the safety of the workers.
 - 3. Shields: Insulation protection shields are required per paragraph 3.01F.
 - 4. The following table summarizes the insulation system by use and service:

System	Location	Service	Insulation System	Insulation Thickness (Inches)
1W, HW (Hot Water) (P)	All buildings	E	A	1-inch
1W, TW (Tepid Water) (P)	Exposed pipe inside and outside buildings	E	A	1-inch
1W, CW (Cold Water) (P) 2W	All exposed pipe in buildings	E	A	½-inch
2W, 3W	Direct Buried	B	B	½-inch
3W	Exposed pipe outside buildings	E	C	3/8-inch
MHD, SHD	Exposed pipe outside buildings	E	A	1-inch
Magnesium Hydroxide Storage Tank	Exposed tank outside buildings	E	G	1-inch

For System: P = Potable Water

For Service: E = Exposed including concealed space

B = Buried

B. Insulation System A:

1. Material: Insulation shall be a pre-molded fiberglass with a maximum "K" factor of 0.25 at 70°F and having a factory-applied jacket. Fittings shall be insulated with insulating cement or mitered section of pre-molded fiberglass.
2. Fittings shall be covered with a Zeston, Thermazip, or equal jacket. Pipe insulation shall be Johns Manville "Micro-Lok" with foil scrim kraft jacket, with laps and butt straps secured with Benjamin Foster or Arobol adhesive; Owens Corning Fiberglas Type 25 ASJ/SSL; or equal.
3. Insulation exposed to the weather shall have, in addition, an aluminum waterproof jacket alloy 3003 (0.024-inch); Childers, Alcorjac, or equal.

C. Insulation System B:

1. Insulation: Fiberglass with a density of 7.25 pounds per cubic foot; or foamed urethane with 1.8 pounds per cubic foot density. Insulation shall have a maximum "K" factor of 0.25.
2. Casing: Factory installed, standard product of a manufacturer having successful experience in the manufacture and installation of the design casing. Casing shall be a glass fiber reinforced isophthalic polyester resin having glass fibers dispersed throughout the casing. Casing shall not be less than 1/8 inch thickness. A waterproof impenetrable barrier shall be incorporated between the casing and the insulation. Casing shall be designed for a fluid within the carrier pipe to be not less than 250°F. The complete insulation and casing system shall be manufactured by Rickwil; Perma-Pipe; or equal.
3. Field joints in the pipeline after welding and successful testing shall have an insulation and casing system applied in accordance with the casing

manufacturer's instructions to form a watertight insulation enclosure of equal insulation and protection qualities as the pre-insulated pipe.

D. Insulation System C:

1. Material: Insulation shall be nominal 3/8 inch wall thickness flexible closed celled foamed plastic. Insulation shall have a "K" factor of not more than 0.30 at 70°F. Insulation shall have a usage range from -30°F to 220°F. Insulation shall be Armstrong Armaflex 22; Johns-Manville Aerotube; or equal.
2. Application: Seal all slit and butt joints with adhesive supplied by manufacturer. Fittings shall be covered with mitered insulation according to manufacturer's recommended procedures and sealed with adhesive. Insulation shall have first class appearance.
3. Finish: Finish all exposed insulation with two coats of manufacturer supplied finish in a color selected by the Owner's representative.

E. Insulation System G:

1. Material: Insulation shall be nominal 1-inch wall thickness flexible closed celled foamed plastic. Insulation shall have a "K" factor of not more than 0.30 at 70°F. Insulation shall have a usage range from -30°F to 220°F. Insulation shall be Armacell AP Armaflex; or equal.
2. Application: Seal all slit and butt joints with adhesive supplied by manufacturer. Fittings shall be covered with mitered insulation according to manufacturer's recommended procedures and sealed with adhesive. Insulation shall have first class appearance.
3. Finish: Finish all exposed insulation with two coats of manufacturer supplied finish for UV protection at a minimum in a color selected by the Owner's representative.
4. Insulation exposed to the weather shall have, in addition, a non-metallic cladding; Arma-Check R flexible non-metallic, or equal.

F. Electric Heat Tape:

1. Heating cables shall be self-regulating heating cable to be applied directly to the surface of piping. Cable shall be braided and protected from exposure with a fluoropolymer outer jacket. Heating cable and components must be U.L. approved and rated for installation in a NEC Class 1, Division 1, 2 location.
 - a. For piping 4 inches or less: Cable shall be 5 watts per foot capacity using 120-volt, single-phase electrical wiring.
 - b. Maximum loading per heat trace controller shall not exceed 16A unless otherwise specified in this Section. Conform to Manufacturer's recommendations for maximum thermal rating and maximum amperage per heat trace controller where these recommendations are less than those specified in this Section
2. Operation of the heating cable shall be line sensing and be sized to maintain a minimum temperature of 40°F.
3. System shall include all necessary components including power connection kits, integral line sensing and ambient sensing thermostats, end seals, pipe straps, and labels. Power connection kit shall at a minimum include a signal light and a NEMA 4X enclosure. End seals shall be lighted to indicate power on/off. Pipe straps shall be either nylon straps or fiberglass tape.
4. Circuits and power supply locations for the heat trace system are identified on the Drawings. Provide any additional conduit, wire, or other accessories required to provide the required heat tracing.

5. Heat cable and accessories shall be Chromalox, Raychem, or approved equal.
6. Chemical Piping:
 - a. Provide UL-approved electric heat tape for the flowing chemical pipes.
 - 1) SHD pipe between wall penetration at the odor control building and penetration at the slab
 - 2) SHD pipe after grade penetration near the secondary clarifier No. 1 and vertical injection line.
 - 3) SHD pipe after grade penetration near the secondary clarifier No. 2 and vertical injection line.
 - 4) All MHD piping exposed between the chemical storage tank, pump enclosure and primary effluent distribution box.
 - b. Tape shall be self-regulating (150°F max.) approximately 4 watts per foot capacity. The heat tape and associated controls shall maintain the pipe at a minimum temperature of 50°F using 120-volt, single-phase electrical service.
 - c. Accessories shall include temperature control with thermostat, remote sensing bulb, cable ties, and strap adhesive.
 - d. Control unit shall be mounted adjacent to the respective chemical storage tank ladder and shall include a power disconnect, signal light and temperature adjustment. Installation shall be strictly in accordance with manufacturer's instructions.
 - e. Heat tape shall be Chemelex; Chromolox; or equal.

PART 3 - EXECUTION

3.01 INSTALLATION OF INSULATION

- A. General: Apply insulation material, accessories, and finishes according to the manufacturer's printed instructions.
 1. Apply insulation only after piping has been tested and certified as ready for operation, and after heat tracing elements have been installed where applicable.
 2. Seal joints and seams to maintain vapor barrier.
 3. Seal penetrations for hangers, supports, and anchors.
 4. Keep insulation material dry during application.
 5. Apply vapor barrier on seams, joints, over staples, and at end butt to fittings.
 6. Install with all joints tightly butted.
 7. Tuck and tuft all edges of insulation.
 8. Install insulation to allow easy access to piping or equipment for inspection and repairs.
 9. Carefully bevel and seal insulation around unit or equipment nameplates.
 10. Remove all loose dirt, rust, all other loose foreign material, moisture, and frost from surfaces prior to installing insulation.
 11. Seal all raw edges of insulation at unions, flanges, etc.
- B. Roof Penetrations: Apply insulation for interior applications to a point even with the top of the roof flashing. Seal with vapor barrier coating. Apply insulation for exterior applications butted tightly to interior insulation ends. Extend metal jacket for exterior insulation outside roof flashing at least 2 inches below top of roof flashing. Seal metal jacket to roof flashing with vapor barrier coating.

- C. Interior Walls and Partitions Penetration: Apply insulation continuously through walls and partitions, except fire-rated walls. Apply aluminum jacket with factory-applied moisture barrier over insulation. Extend 2 inches from both surfaces of wall on partition. Secure aluminum jacket with metal bands at both ends. Seal ends of jacket with vapor barrier coating. Seal around penetration with joint sealer.
- D. Whenever possible, slip insulation on pipe before making connections. Seal joints with adhesive. Where the slip-on technique is not possible, cut one side longitudinally and apply to the pipe. Seal seams and joints with adhesive.
- E. Cover exterior insulation, except for metal-jacketed insulation with PVC fitting covers and seal circumferential joints with butt strips. Paint all exterior PVC covering.
- F. Provide insulation protection shields at all pipe supports for insulated piping. Refer to Section 15060.

3.02 INSTALLATION OF HEAT TRACING

- A. Install in accordance with the manufacturer's instructions.
- B. Fasten heat tracer tape to pipe and valves as recommended by the manufacturer at intervals not exceeding 1 foot. Spiral winding is only permitted around vertical piping.
- C. The cable must be capable of being cut in field without affecting heat output of the finished installation.
- D. Insulation shall be installed after heating cable is in place and deemed functional.
- E. Affix labels on surface indicating heat-traced pipe.

END OF SECTION

SECTION 15330

DELUGE FIRE SUPPRESSION SPRINKLER SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes: Furnish all labor, materials, equipment, services, permits, and incidentals required to provide complete, integrated and operating, fire sprinkler system protection for the buildings and structures in this project identified in Appendix A at the end of this Section. Materials and equipment to be supplied shall be new and commercial quality.
- B. The fire alarm system control panel, fire detection devices, manual alarm and system disabling devices shall be specified in Section 16721 of these Specifications.

1.02 REFERENCES

- A. National Fire Protection Association (NFPA):
 - 1. NFPA 13 Installation of Sprinkler Systems
 - 2. NFPA 25 Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems
 - 3. NFPA 72 National Fire Alarm and Signaling Code
- B. International Fire Code (IFC), 2018 edition, and state amendments – Washington Administrative Code, Chapter 51-54A
- C. International Building Code (WSBC), 2018 edition, and state amendments – Washington Administrative Code, Chapter 51-50
- D. National Electric Code (NEC), 2017 edition
- E. Underwriters' Laboratories Inc. (UL)
- F. Factory Mutual Systems (FM)

1.03 SYSTEM DESCRIPTION

- A. Fire Sprinkler Protection System: Provide automatic, hydraulically designed, water-based, deluge fire suppression sprinkler protection system to meet the requirements of all governing local codes and as required by the Washington Administrative Code. System shall be suppression type utilizing open sprinklers. Refer to the fire sprinkler schedule in Appendix A at the end of this Section, and the Drawings for design requirements.
- B. Scope: The scope of work includes provision of an automatic operated fire protection and supervisory system including but not limited to:
 - 1. Design drawings and hydraulic calculations.
 - 2. All pipes and fittings.
 - 3. Fire sprinklers.
 - 4. Pipe hangers with seismic restraint.
 - 5. Compressed Air supply
 - 6. Deluge system riser, including:
 - a. Electric-actuated water supply valve
 - b. Controls, annunciation system, and wiring.

- c. System control valve.
 - d. Riser valve.
 - e. Alarm Devices
 - 7. Private fire service mains
 - 8. Inspector's test connection and accessories.
 - 9. Record drawings.
 - 10. Tests.
- C. Performance Requirements: System performance requirements shall meet or exceed requirements of local authority having jurisdiction.

1.04 SUBMITTALS

- A. Material List: Submit a complete list of all materials, equipment, and accessories proposed for installation, in compliance with the Drawings and Specifications. This list shall include catalog identification numbers, drawings, cut sheets, and other descriptive data and material necessary to completely define all components of the work.
- B. Shop Drawings and Product Data:
 - 1. After receiving tentative favorable review of equipment and materials on the material and equipment list, and before installation, the Contractor shall submit the following as a single complete initial submittal in accordance with Section 01300:
 - a. Product data fully describing all items proposed for use to demonstrate that the equipment conforms to the Contract Documents.
 - b. Seismic separation assemblies, sway bracing assemblies, and related sketches.
 - c. Fire sprinkler system layout, including riser diagram, pipe sizes and layout.
 - d. Conduit and conductor layout and schedule for all electrical and signal needed from the fire alarm to the corresponding equipment according to Section 16721.
 - 2. Four sets of plans for the Fire Sprinkler systems shall be submitted by a Washington state licensed Level III Fire Sprinkler Contractor to Snohomish County Fire District No. 7 prior to installation.
- C. Hydraulic Calculations: The Contractor shall submit for review all hydraulic calculations including detailed work sheets and graph sheets. All work shall be in strict conformance with WAC requirements.
- D. Manuals: Furnish manufacturer's installation, lubrication, operation and maintenance manuals, bulletins, and spare parts lists.
- E. Affidavits: Furnish affidavits from the manufacturer stating that the equipment has been properly installed and tested and is ready for full-time operation.
- F. Performance Testing: Submit results of a performance test witnessed by the Engineer demonstrating satisfactory operation of the fire protection system equipment, showing it has been properly installed, adjusted, and is ready for full-time operation.
- G. Record Drawings: At the completion of contracted work, as defined in the Specifications and Drawings, submit a complete set of record drawings. Submit record drawings of the same size as original working drawings. Record drawings shall show the installed fire protection sprinkler system configuration and include

the mechanical, electrical, control, and alarm systems. Record drawings shall show as-built conditions.

1.05 QUALITY ASSURANCE

- A. Qualifications: Equipment furnished under this Section shall be supplied by a manufacturer who has been regularly engaged in the design and manufacture of the equipment for at least 10 years. Demonstrate to the satisfaction of the Engineer that the quality is equal to equipment made by those manufacturers named herein.
- B. Permits and Inspection: Permits and inspection shall be in accordance with the General Conditions and Special Conditions.
- C. Contractor License: The contractor designing and installing the Fire Protection System shall be licensed in accordance with the Department of Labor and Industries, State of Washington, and shall be skilled and regularly engaged in the design, fabrication, installation and testing of fire sprinkler systems and have a Level III fire sprinkler contractor's license.
- D. Regulatory Requirements: All work and supplied equipment shall conform to the current edition of the following applicable codes and standards:
 - 1. IFC, with state and local amendments.
 - 2. IBC, with state and local amendments.
 - 3. NEC.

1.06 WASHINGTON INDUSTRIAL SAFETY AND HEALTH ACT (WISHA) DELIVERY, STORAGE AND HANDLING

- A. Immediately upon delivery to job site, place materials in area protected from weather. Use non-marring slings for loading, unloading, and handling units to prevent rope or cable damage to surfaces and protective wrappings.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Provide a complete, automatic, electric-actuated deluge system as indicated on the Drawings, which shall require the following before water is admitted to the system:
 - 1. Activation of an addressable heat detector which shall initiate a separate alarm signal within the Fire Alarm Terminal Unit.
 - 2. When this action has occurred, the terminal unit shall activate the solenoid valve allowing water to flow through the deluge water supply valve.
- B. A deluge sprinkler system shall serve the Chemical Storage Room of the Odor Control Building, as noted in Appendix A at the end of this Section and on the Drawings. System shall be installed in conformance with the current edition of IFC Section 903.3 and NFPA 13- Standard for Installation of Sprinkler Systems. All materials utilized shall be UL listed and Factory Mutual approved. All materials installed shall adhere to the manufacturer's installation guidelines.
- C. Provide and install in accordance with criteria and area densities for the deluge system indicated on the Drawings and in Appendix A.

2.02 FIRE SPRINKLERS AND SPRINKLER PIPING

- A. Sprinkler Piping and Fittings: Piping and fittings used in the installation of the fire sprinkler system(s) shall be listed in NFPA 13 as an acceptable material for use in a fire sprinkler system. All system piping shall be metallic and shall be protected against corrosion.
 - 1. Galvanized pipe:
 - a. Pipe: Galvanized steel, ASTM A53, Schedule 40.
 - b. Fittings: Galvanized malleable iron, screwed, ASTM A197 for materials, ANSI B16.3, (150 psi) for dimensions.
 - c. Threads: ANSI B1.20.1
 - d. Unions: Galvanized malleable iron, ASTM A197 for materials and ANSI B16.39 for dimensions, with brass seats.
 - e. Thread compound: Permatex No. 2, Crane equivalent; or equal, or Teflon tape.
 - f. Mechanical grooved-end fittings and couplings, listed by UL, may be used where permitted by the Authority Having Jurisdiction.
- B. Fire Sprinklers: Fire sprinklers shall be of one manufacturer throughout the building. No mixing of sprinkler brands shall be permitted. Sprinklers shall be of all brass frame construction utilizing a coated metal-to-metal seating mechanism. Sprinklers utilizing non-metal parts in the sealing portion of the sprinkler are strictly prohibited. Sprinkler orifices shall be standard nominal 1/2-inch with K factors of 5.5. Sprinkler type, operating element, orientation, and temperature rating shall be as specified in Appendix A 'Wet Pipe Fire Sprinkler Schedule' at the end of this Specification.
- C. Inspector's Test Connection:
 - 1. A listed test and drain valve, installed at the system riser, shall be permitted at the direction of the Authority Having Jurisdiction.
- D. Hangers and Supports: Sprinkler piping shall be substantially supported to the building structure with appropriate hangers and supports. Materials used in the installation or construction of hangers and supports shall be listed and approved for such application. Hangers or supports not specifically listed for service shall be designed and bear the seal of a professional fire protection engineer registered in the State of California.
- E. Sleeves: Piping sleeves shall be provided where piping passes through metal panels, masonry or concrete walls, or floors. Sleeves extending through floors, load bearing walls, and sleeves through fire barriers shall be continuous and fabricated from Schedule 40 steel pipe with welded anchor lugs. Molded linear polyethylene liners or similar materials shall form all other removable sleeves. Diameter of sleeves shall be large enough to accommodate pipe, and additionally provide a minimum (3/8-inch) clearance. Sleeve shall accommodate mechanical and thermal motion of pipe to preclude transmission of vibration to walls and generation of noise.

2.03 ELECTRIC-ACTUATED, DELUGE FIRE SPRINKLER RISER ASSEMBLY

- A. General: Fire sprinkler riser assembly to be installed where indicated on the Drawings to serve the areas noted on the Drawings. Install riser assembly with the following appurtenances listed below for the electric-actuated deluge sprinkler system. All products listed under this item (paragraph 2.03) shall be supplied as a

package from a single system supplier. System Supplier shall be Tyco Fire Protection, Reliable Automatic Sprinkler, or equal.

- B. System Control (Ball) Valve: System control valve shall be a listed bronze, full-port ball valve with geared, handwheel operator. Control valve shall be UL listed and Factory Mutual approved for fire protection installations. System control valve shall be rated for normal system pressure, but in no case less than 175 psi. Provide integral valve supervisory switch as specified under the 'Annunciation System' of this Section.
- C. Deluge Water Supply (Riser) Valve and Trim Package:
 - 1. Riser Valve: Riser valve shall be UL listed and Factory Mutual approved. Valve shall be a hydraulically operated, diaphragm-type valve. Valve shall be of straight-through design activated by (solenoid) electric actuation trim. Valve construction shall be of ductile iron body and cover, and elastomer diaphragm. Alarm valve shall be listed for installation in the vertical or horizontal position. Alarm valve shall be equipped with pressure gauge connections on the system side and supply side of the valve clapper. Alarm valve shall be equipped with an external bypass to eliminate false water flow alarms. Alarm valve trim piping to be externally galvanized. Maximum water working pressure to 250 psi. Valve to be Tyco Fire Protection Model DV-5, Reliable Automatic Sprinkler Model DDV
 - 2. Valve Trim: The valve trim shall be compatible to the riser valve, pre-plumbed, including accessory piping, manual valves, check valves, gauges, strainers for required operation.
 - a. Main Drain Valve: Riser valve shall be equipped with main drain and shall be sized in conformance with NFPA 13.
 - b. Gauges: Shall be Underwriters Laboratory listed and Factory Mutual approved for fire protection sprinkler service.
 - c. Drains: System main drain and auxiliary drain sizes shall be in conformance with NFPA 13. Auxiliary drain valves shall be installed when trapped water will be collected. A plugged or capped outlet will not substitute for a drain valve. Drains piped through an exterior wall shall be piped in galvanized piping where it extends through the wall. The exterior drain shall terminate at a turned down galvanized 45° elbow to discharge at a splashblock provided by others.
 - 3. Release System:
 - a. Automatic Riser valve releasing devices shall be a two-way, normally closed, pilot operated electric solenoid valve for its intended use, and a low-pressure pneumatic actuator.
 - 1) Solenoid Valve: The deluge valve priming water release device shall be an electrically operated solenoid valve. The solenoid valve shall be constructed of a ½-inch brass body with a stainless steel core tube, core, plug, nut and springs. The solenoid valve shall have a maximum working pressure of 250 PSI. The solenoid valve shall be UL Listed for its intended use.
 - b. Emergency (Manual) Release Panel: A manual emergency release valve shall be plumbed into the valve trim. Valve actuation shall bypass solenoid valve actuation and allow water flow into sprinkler piping.
- D. Annunciation System:
 - 1. General: Products noted under this paragraph shall be designed for operation with and draw power from the Fire Alarm Control System specified under Section 16721.

2. Valve Supervisory Switch: Provide a valve supervisory switch containing one set of SPDT contacts and designed for mounting on the system control valve. Switch shall be System Sensor OSY2; Potter Signal OSYSU-1; or equal.
3. Water Flow Indicating Pressure Switch: Sprinkler system water flow will activate an alarm at the Fire Alarm Terminal Unit by means of an alarm pressure switch, supplied as part of the riser assembly package. The alarm pressure switch shall have a minimum sensing range of 5-15 psi, include two sets of SPDT (Form C) contacts, and be compatible with system devices. Alarm pressure switch shall have the ability to be wired for Class A or Class B service. Alarm Pressure Switch to be System Sensor EPS10; Potter Signal, Model PS10; or approved equal.
 - a. Inlet piping to the pressure switch shall be monitored by an isolation ball valve and supervisory switch assembly. Switch shall indicate when the valve is not in 'full-open' position and send 'fault' signal to the Fire Alarm Terminal Unit. Switch shall include one set of SPDT contacts. Switch enclosure shall be UL listed and Factory Mutual approved and rated for outdoor installation. Potter Signal Model RBVS, or equal.
4. Alarm Bell: Bell shall ring to provide local, audible indication of sprinkler system actuation. Bell circuit shall be 24 VDC and wired in series with one set of contacts from the water flow alarm switch. Electronic termination shall be in a NEMA 4X Enclosure. Bell shall be mounted on exterior face of building as noted on the Drawings. Bell shall be rated at 95 dBA or greater at a distance of 10 feet. Bell shall be System Sensor SSM24 Series; Potter Signal PBD24 Series; or approved equal.

2.04 PRIVATE FIRE SERVICE MAINS (FIRELINES)

- A. General: Piping, valves and accessories within this paragraph shall be UL listed and FM approved for fire protection service.
- B. Pipe and Fitting System: Refer to Section 15050, Type GSP (above grade) and Type PVC-1 (buried) pipe, and Piping Schedule on the Drawings.
- C. Valves: Provide valves in accordance with Section 15050, valve systems 'A' and 'C'.

2.05 ACCESSORIES

- A. Provide the appropriate accessories and fittings to conform to the requirements of the CFC, NFPA 13 and local ordinances.
- B. Provide signage to meet the requirements of the CFC, NFPA 13, and local ordinances.

2.06 FINISHES

- A. The system control valve and riser valve shall be supplied with a factory-applied epoxy coating. Accessory pipe, fittings, and controls for the riser assembly shall be supplied with the manufacturer's standard factory paint finish.
- B. Pipe and fittings used for the riser pipe assembly and fire sprinkler piping shall be coated in accordance with Section 09900.
- C. No fire sprinkler shall have a field-applied coating or protective finish.

2.07 SPARE PARTS

- A. Supply a minimum of two spare fire sprinklers of each type noted in the Appendix.

2.08 SPECIAL TOOLS

- A. Furnish special tools that are necessary for the replacement of parts or adjustment of equipment.

PART 3 - EXECUTION

3.01 GENERAL

- A. The Contractor shall examine the site and observe the conditions under which the work will be done and note other circumstances which will affect the work. No allowance will be made subsequently in this connection for any error, omission, or negligence on the Contractor's part.
- B. The design and installation of the automatic sprinkler system shall be complete with all necessary accessories for proper operation.

3.02 INSTALLATION

- A. Piping:
 - 1. Persons who are regularly engaged in this type of work shall install the entire system.
 - 2. The installation of hangers and pipe supports shall adhere to the requirements set forth in NFPA 13, Standard for Installation of Sprinkler Systems.
 - 3. All piping and equipment shall meet the seismic anchorage requirements of Section 01190.
 - 4. Coordinate or modify sprinkler system layout with other trades so the fire sprinkler system does not interfere with light fixtures, mechanical ductwork, piping, electrical cable trays, conduit, etc. (light fixtures, mechanical ductwork, and piping have the right-of-way.) In areas where there are finished, lay-in, modular type ceilings, heads shall be located at centerline of lay-in panel.
- B. Pipe Penetrations: Provide watertight seals at external wall and floor surface penetrations. Provide fire-rated seals at wall and floor penetrations to maintain fire rated separations noted on the Drawings. See Division 7 of these Specifications for sealant assemblies.
- C. Wall Escutcheons: Escutcheons shall be provided at all penetrations of piping at exterior walls and into finished areas. Where finished areas are separated by partitions through which piping passes, escutcheons shall be provided on both sides of the partition. Escutcheons shall be one-piece, chrome plated in all occupied spaces and shall conceal openings in building construction. All escutcheons shall be firmly attached.
- D. Painting:
 - 1. All manufacturers' standard finish equipment surfaces damaged during construction shall be brought to as-new condition by touchup or repainting to the satisfaction of the Owner, or replaced with new undamaged equipment at no additional cost to the Owner.

2. Excluding the fire sprinklers, all above-grade piping, valves and appurtenances installed below the ceiling/roof shall be painted as specified in Section 09900.
- E. Electrical Work:
1. All conduit, wire, and fittings required for the operation of electrically monitored fire alarm equipment described under this Section shall be provided and installed as specified in Division 16.
 2. All conduits shall be properly identified.

3.03 FIELD TESTING

- A. Upon completion and prior to acceptance of the installation, the Contractor shall subject the system to tests required by NFPA 13 and local authority having jurisdiction. Representatives of local authority having jurisdiction and Owner's representative shall witness all tests. The Contractor shall furnish the Owner with copies of all certificates.

3.04 FIELD SERVICE

- A. The Fire Sprinkler System manufacturer shall supply a competent field service representative to thoroughly check and inspect the Fire Sprinkler System after installation, place the Fire Sprinkler System in operation, make necessary adjustments, calibrate instruments, and conduct field tests. The services required shall also include on-the-job training of operators including safety procedures, operating instructions, and preventive maintenance procedures. Furnish a minimum of 1 man-day of field services.

END OF SECTION

APPENDIX A
Wet Pipe Fire Sprinkler Schedule

Building	Area (Room #)	Coverage (Sq Ft) ³	Hazard Classification	Operating Element (Temperature Rating)	Orifice Type	Sprinkler Type	Basis of Design
Odor Control Building	Chemical Storage Room	~200	Ordinary Hazard, Group I	None	Standard ¹ (k=5.6)	Upright	Reliable F1FR56

Notes:

- ¹ Provide factory-applied corrosion-resistant coating for sprinklers
- ² or equivalent product by Tyco Fire Protection.
- ³ Contractor shall determine exact coverage square footage from the Project Drawings.

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SECTION 15400

PLUMBING

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Plumbing fixtures and accessories.
 - 2. Piping, valves, and accessories.

1.02 REFERENCE STANDARDS

- A. American National Standards Institute (ANSI) Publication:
 - 1. Z21.10.1 Storage Water Heaters
 - 2. A117.1 Specifications for Making Buildings and Facilities Accessible to and Usable by the Physically Handicapped
 - 3. ANSI Z358.1 Emergency Eye Wash and Shower Equipment
- B. Underwriters Laboratories Inc. Standards:
 - 1. U.L. 174 Standards for Safety
- C. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):
 - 1. Seismic Restraint Manual, Guidelines for Mechanical Systems.
- D. All state and local building codes including plumbing, mechanical, fire, building, and electrical.

1.03 SUBMITTALS

- A. Submit in accordance with Section 01300.
- B. Submit manufacturer's information with materials, dimensions, and data to show that the products conform to the specification requirements. All products in this Section shall be included in a single initial submittal.
- C. Submit operation and maintenance manuals where available from manufacturers.

1.04 QUALITY ASSURANCE

- A. Codes: Comply with the rules and regulations of authorities having jurisdiction over the work specified herein, including the applicable Plumbing Code with amendments.
- B. Permits and inspections shall be in accordance with General Conditions.
- C. The Drawings shall be taken in a sense as diagrammatic. Size of pipes and general method of running them are shown, but it is not intended to show every offset and fitting nor every structural difficulty that may be encountered.
- D. ADA compliance means that the plumbing item is accessible and usable by persons with disabilities.

1.05 SEISMIC PROTECTION

- A. Provide equipment and piping with seismic protection as specified and as recommended by "Guidelines for Seismic Restraints of Mechanical Systems and Plumbing Piping System," latest edition by SMACNA.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Provide equipment and materials conforming to the standards and manufacturers' serial numbers shown, or equal.

2.02 PLUMBING FIXTURES AND ACCESSORIES

- A. Emergency Shower and Eyewash Unit:
 - 1. Eyewash and Shower Combination Unit, Freeze-Proof: ANSI Z358.1 compliant. Provide unit with stainless steel stanchion, galvanized pipe, and fittings, containing polyethylene insulation and ABS jacket casing. Provide self-regulating, electric heat trace cable system, ABS shower head, self-draining eyewash assembly. Haws Model 8317CTFP; Guardian Model GFR3110; or equal. Provide accessory flow switch with spare contacts and alarm horn/light system
- B. Water Heater: Provide a seismic restraint for water heater.
 - 1. WH-001: Electric tank-type water heater:
 - a. Electric storage type, nominal 80-gallon tank, insulated, glass lined, enclosed controls, UL approved. Elements shall be 12,000 watts and operate on 480-volt, 3 phase power.
 - b. AO Smith Model DEN; or equal.
- C. Recirculation Pump for Domestic Hot Water System: Pump shall be Grundfos model UP; or equal, all bronze construction for service with power cord for 115-volt, 1 phase, 60 Hz electric service. Include automatic timer accessory. Refer to Mechanical Schedules for additional unit performance.
- D. Tempered Water Mixing Valve: 30 gpm with ASSE 1071 certification for use with emergency shower, adjustable output temperature range of 65-90 F, bronze body with stainless steel internals. Bradley S19-2150, Speakman STW-362, or equal. Provide accessory surface mount cabinet.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install escutcheons secured to pipe with set-screw where pipes or tubing pass through exposed walls or ceilings.
- B. Provide all fixtures with traps and vents unless otherwise indicated on the Drawings.
- C. Provide unions or flanges where equipment is installed in piping. Also provide dielectric unions or couplings at points of connection of ferrous to non-ferrous metal piping.

- D. Provide a shut-off stop valve in the branch of every water, air, gas, or vacuum pipe service upstream of every fixture or outlet.
- E. Provide identification nameplates for each item of mechanical equipment. Refer to Section 11001.
- F. Furnish and install all supports, bracing and blocking required for the proper installation of the plumbing work specified herein.
- G. Water hammer arrestors shall be installed in water systems upstream of each solenoid valve, quick closing valve, and emergency shower.
- H. Provide valves where equipment drain connections are furnished and carry the discharge pipe to the nearest floor drain, drain trench or sump. Where no receptacle for drain exists, install drain piping to 1 inch above the floor. Drain piping and valve materials shall conform to the requirements of the system served.

3.02 TEST AND INSPECTION

- A. Test the systems and arrange for inspection by the proper authorities.
- B. Water piping shall be hydraulically tested at not less than working pressure psig and demonstrated to be leak-free for a one-hour test period or greater if required by Section 15050.
- C. Waste, drain, and vent piping shall be tested in conformance with the Uniform Plumbing Code with local amendments.

END OF SECTION

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SECTION 15800

HEATING, VENTILATING, AND AIR CONDITIONING

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Furnish all labor, materials, equipment, services, and incidentals required to provide complete, integrated, and operating, Heating, Ventilating, and Air Conditioning Systems for the buildings and structures in this project. Materials and equipment to be supplied shall be new, of the best quality as specified and as shown on the Drawings.
- B. Work Included in This Section:
 - 1. Ductwork and accessories
 - 2. Fans
 - 3. Electric Unit Heaters
 - 4. Temperature Control Systems
 - 5. Testing, Adjusting, and Balancing.

1.02 SUBMITTALS

- A. Provide shop drawings and technical literature covering all equipment and accessories being furnished under this Section and in accordance with Sections 01300 and 11001. The data shall include information to demonstrate compliance with all requirements of these Specifications.
- B. Submit signed and sealed structural calculations and detailed drawings for the attachments and anchorage to the structure of the equipment and appurtenances in this section: Calculations shall conform to the requirements of Section 01190.
- C. Manuals: Furnish manufacturer's installation, lubrication and maintenance manuals, bulletins, and parts lists. Furnish separate list of recommended spare parts.
- D. Affidavits: Furnish affidavits from the manufacturers stating that the equipment has been properly installed and tested and each is ready for full time operation.
- E. Submit fabrication drawings for ductwork, including duct supports.

1.03 QUALITY ASSURANCE

- A. Codes: Comply with all rules and regulations of authorities having jurisdiction over the work specified herein.
- B. Permits and inspection shall be in accordance with General Conditions.
- C. All equipment furnished under this Section shall 1) be of a design and manufacturer who has been regularly engaged in the design and manufacture of the equipment and 2) be demonstrated to the satisfaction of the Design Consultant that the quality is equal to equipment made by those manufacturers specifically named herein.
- D. The Drawings shall be taken in a sense as diagrammatic. Size of ducts and pipes including general method of running them are shown, but it is not intended to show every offset and fitting nor every structural difficulty that may be encountered.

1.04 WARRANTY

- A. The warranty for all products and work shall comply with the requirements of the Contractor's General Warranty and Guarantee described in the General Conditions and the Supplementary Conditions.

1.05 SEISMIC PROTECTION

- A. Equipment specified in this Section is classified as essential for seismic protection as specified in Division 1. Conform to the seismic requirements in Section 01190.

PART 2 - PRODUCTS

2.01 DUCTWORK

- A. Flexible Duct Connections: Flexible connections in ducts shall be made of neoprene fiberglass cloth, installed in folds, and of sufficient length to accommodate the maximum deflection resulting from vibration and contraction without causing strain. Minimum length in folded position shall be 4 inches. Flexible duct connections shall be Ventfabrics Inc. "Ventglas;" Duro-Dyne Corp.; "Neoprene;" or equal.
- B. Rectangular Ductwork: Ductwork shall be galvanized steel. Except as indicated otherwise, fabricate rectangular ducts of galvanized sheet steel in accordance with SMACNA "HVAC Duct Construction Standards," Tables 1-3 through 1-19, including associated details. Conform to requirements of referenced standard for metal thickness, reinforcing types and intervals, tie rod applications, and joint types and intervals.
 - 1. Materials: Free from visual imperfections such as roller marks, seam marks, pitting, stains, and discolorations.
 - 2. Size ductwork as indicated on Drawings, coordinate with structure and other installations.
 - 3. Duct lengths: Appropriate to reinforcement and rigidity class required for pressure classification.
 - 4. Low pressure duct construction:
 - a. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible. Divergence upstream of equipment shall not exceed 30 degrees, convergence downstream shall not exceed 45 degrees.
 - 5. Rectangular duct transitions: Fabricate transitions in accordance with SMACNA "HVAC Duct Construction Standard," Figures 2-1 through 2-10.
- C. Duct sealant (for sealing joints) shall be Arabol and Canvas; Hardcast; or equal.

2.02 FANS

- A. Wall Exhaust Fans
 - 1. General: Wall exhaust fans shall be factory fabricated aluminum assemblies, upblast, spark resistant construction, having fan, fan-motor, aluminum bird screen, wall mounting frame, spun aluminum hood, and aluminum rub ring. Fan wheel shall be aluminum construction, non-overloading, backward inclined centrifugal type, statically and dynamically balanced in accordance with AMCA 204-05. Fan shaft shall be ground and polished solid steel with anti-corrosive coating. Fasteners shall be 300 series stainless steel. Where specified, corrosion-resistant, factory applied coatings shall be Heresite or Hi-Pro Polyester applied in strict conformance with the paint manufacturer's instructions.

2. Motor
 - a. Constant-speed fan units: Permanently lubricated, sealed ball bearing motors
 - b. Variable-speed fan units: Fan shall incorporate electronically-commutated motor with DC voltage regulation for speed adjustment. Provide voltage regulation system for unit speed control described in paragraph 2.2.C. Provide variable speed control system.
 3. Manufacturers: Centrifugal direct-drive roof exhaust fans shall be Greenheck Model CUE; Loren Cook Model ACW or equal.
- B. Inline Centrifugal Fans
1. General: In-line centrifugal fans shall be factory-fabricated assemblies having fan, fan-motor, and fan housing. Fans shall bear the AMCA seal and shall be furnished with outlet guard. Housing shall be square design, heavy gauge galvanized steel, provided with duct collars, provided with one (1) removable access panels sized and arranged to permit easy access to all interior components, and universally adjustable mounting brackets for horizontal and vertical mounting. Fan wheel shall be constructed of aluminum, centrifugal backward inclined with wheel core, matched to inlet cone, statically and dynamically balanced. Provide with each unit for hanging or base mounting isolators as required, neoprene or spring type. Provide disconnect switch with each unit, provide factory wiring from motor to junction box. Factory applied coatings shall be Heresite or Hi-Pro Polyester applied in strict conformance with the paint manufacturer's instructions.
 2. Motor and Control
 - a. Constant-speed fan units: Permanently lubricated, sealed ball bearing motors.
 - b. Variable-speed fan units: Fan shall incorporate electronically-commutated motor with DC voltage regulation for speed adjustment. Provide voltage regulation system for unit speed control described in paragraph 2.2.C.
 3. Manufacturers: Inline centrifugal fans shall be Greenheck Model SQ; Loren Cook Model SQN-D; or equal.
- C. Voltage Regulation System: Voltage regulation system shall be provided as accessories to variable-speed fan units, specified above. The voltage regulation system products described below shall be supplied from the fan manufacturer. Greenheck 'VariGreen', Loren Cook 'Vari-Flow', or equal.
1. Transformer: Provide accessory 120VAC/24 VDC transformer for generating 'remote' DC power supply and sending a regulated 0-10 VDC power supply to motor.
 2. Temperature/Humidity Control: Control to be a packaged indoor air quality control unit designed to regulate fan speed in order to maintain temperature and/or relative humidity in a space where noted in Paragraph 3.2 - HVAC Control Descriptions. Unit shall provide field programming capability of fan speed. Control unit shall display space temperature and identify fan status. Control unit shall include a Proportional Integral Derivative (PID) feedback loop and shall have labeled terminal strips for easy wiring.
 3. Constant Pressure Control: Control to be a packaged pressure control unit designed to regulate fan speed in order to maintain constant pressure within a space where noted in Paragraph 3.2 - HVAC Control Descriptions. Unit shall provide field programming capability of fan speed. Control to be a packaged constant pressure control designed to regulate fan speed based on demand. Control shall include a Proportional Integral Derivative (PID) feedback loop and

shall have all components prewired to labeled terminal strips for easy wiring. System shall include the appropriate pressure tap and preset pressure transducer. Installation shall include (room) pressure tap and control box with integral pressure transducer.

- D. See Fan Schedule on the Drawings for specific requirements and accessories.

2.03 ELECTRIC UNIT HEATERS

- A. Electric Unit Heaters: Electric unit heaters shall be factory fabricated unit heater assembly bearing the UL LLC label. Heaters shall be assembled in heavy gauge steel cabinets, shall have horizontal air flow discharge, and shall be furnished with wall or ceiling mounting support brackets, contactors, relays, transformers, thermostats, internal wiring, adjustable air flow louvers, and interwiring between the components. Thermostats shall be integral to the unit. Unit heaters shall be Reznor Model EGHB; or equal.
- B. See Electric Heater Schedule on the Drawings for specific requirements.

PART 3 - EXECUTION

3.01 GENERAL

- A. Protection: Fully protect all unfinished parts of the materials and equipment against damage from whatever cause during the progress of the work and until final completion. All materials and equipment shall be covered while in storage and during construction in such manner that no finished surfaces shall be damaged or marred and all moving parts shall be kept perfectly clean and dry.
- B. Installation shall be in strict accordance with the best practice of the several trades and with the respective manufacturer's instructions and recommendations. Installation shall include furnishing the required oil and grease for initial operation in accordance with the manufacturer's instructions.
- C. All sheet metal ductwork shall be erected in a first class and workmanlike manner and shall be in accordance with the SMACNA "HVAC Duct Construction Standards" and as specified above. No ductwork shall be fabricated or installed until it has been carefully coordinated with other trades. All transverse duct joints shall be taped airtight. Duct dimensions shown are "net" inside clear. Each air supply outlet and each air return or outside air intake shall have either an integral volume control device or shall be furnished with a volume damper.
- D. Testing and Adjusting Equipment and Controls:
 - 1. The equipment and controls of this Section shall be completely tested, adjusted, and placed in operating condition.
 - 2. Retest equipment and controls, as necessary, during the progress of the work. No work shall be covered until it is properly tested and made tight.
 - 3. Supply the testing apparatus and make all necessary connections for applying the tests.
 - 4. When about to turn the apparatus over to the City, put all parts of the apparatus in perfect working order and thoroughly clean out all parts of the equipment.
- E. Testing, Adjusting and Balancing of Heating, Ventilating and Air Conditioning Systems:
 - 1. All heating, ventilating, and air conditioning systems installed under this Section shall be carefully adjusted by a qualified Air Balancing Contractor to deliver and

exhaust air quantities as shown on the Drawings or described herein while maintaining the spaces served at the design temperature. A final balancing report shall be submitted to the Design Consultant showing the air flow CFMs, fan statics and motor amperages.

2. After the systems have been completely installed, all equipment shall be carefully tested and adjusted. Adjust all dampers, registers, and air diffusers for air flow and make an accurate velometer test of air quantities delivered and removed from each opening. Any readjustments in the motors, drives, units, controls, and other equipment found to be necessary in the opinion of the Design Consultant shall be made without additional cost and the entire system shall be placed in a satisfactory operating condition subject to the approval of the Design Consultant.
3. Air readings must be taken at each inlet and outlet, and fan speeds and dampers regulated until proper air volumes and diffusion are obtained at each inlet and outlet. Amperage and voltage readings shall be taken and noted, together with the nameplate amperage on the motors.

3.02 HVAC CONTROL DESCRIPTIONS

A. Odor Control Room:

1. The Odor Control Room shall be continuously ventilated by Wall Exhaust Fan (EF-001) to reduce the electrical space classification from Class 1, Division 1 to Class 1, Division 2. The fan shall be equipped with an indoor air temperature controller. The fan will be controlled by indoor air temperature controller with the fans always maintaining at least 900 CFM, and ramp up to capacity listed in Equipment Schedule drawing to maintain a temperature setpoint of 80°F. A flow switch shall be provided for the fan, see Sections 17120 and 17331 for details.
2. The Odor Control Room shall be continuously provided with supply air by Inline Centrifugal Fan (SF-001). The fan shall be equipped with a room constant pressure controller. The fan will be controlled by room constant pressure controller with the fan always maintaining at least 900 CFM, and ramp up to capacity listed in Equipment Schedule drawing to maintain a neutral pressure setpoint. A flow switch shall be provided for the fan, see Sections 17120 and 17331 for details.
3. The Odor Control Room shall be heated by an Electric Unit Heater (UH-001) with integral thermostat to maintain a temperature setpoint of 60°F.

- #### B. Chemical Storage Room:
- The Chemical Storage Room shall be continuously ventilated by Wall Exhaust Fan (EF-002). Supply air shall be continuously provided by Inline Centrifugal Fan (SF-001). Both fans shall be equipped with a single ON/OFF hand switch. The Chemical Storage room shall be heated by an Electric Unit Heater (UH-002) to maintain a temperature setpoint of 60°F.

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SECTION 16010

GENERAL ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Work Included:

1. Provide all required labor, project equipment and materials, tools, construction equipment, safety equipment, transportation, and test equipment, and satisfactorily complete all electrical work shown on the Drawings, included in these Specifications, or required for a complete and fully operating facility. In addition, provide wiring for the equipment that will be provided under other Divisions of these Specifications.
2. Provide conduit, wire and field connections for all motors, motor controllers, control devices, control panels and electrical equipment furnished under other Divisions. Coordinate with the supplier of electrical equipment specified under other Divisions.
3. Provide all conduit, wiring and terminations for all field-mounted instruments furnished and mounted under other Divisions, including process instrumentation primary elements, transmitters, local indicators and control panels. This also includes lightning and surge protection equipment wiring at process instrumentation transmitters if required. Contractor shall install vendor furnished cables specified under other Divisions.
4. Provide a complete raceway system for the specialty cable systems. Install the specialty cable systems in accordance with the system manufacturer's installation instructions. Review of the raceway layout, prior to installation, with the system supplier and cable manufacturer to ensure raceway compatibility with the system and materials being furnished. Where redundant cables are furnished, install them in separate raceways.
5. Provide raceway and power wiring for all heating, ventilation and air conditioning equipment furnished under other related Divisions. Refer to HVAC drawings and related specifications for power requirements.
6. Auxiliary Devices: Provide conduit and wire for power and control for all auxiliary devices such as solenoid valves, pressure switches, and instruments that are included as part of a manufacturer's packaged system (i.e., all systems specified in Divisions 11 through 15). Contractor shall be responsible for conduit and wire to these auxiliary devices even if not specifically shown on the Drawings or specified herein.
7. Provide concrete, excavation, backfill and steel reinforcement required for encasement, installation or construction of the WORK of the various Sections of Division 16 as a part of the WORK under the respective Sections, including duct banks, manholes, handholes, equipment housekeeping pads and light pole bases.

- ###### B. Safety: Conduct operations in accordance with NFPA 70E, Standard for Electrical Safety Requirements for Employee Workspaces.

1.02 CODE COMPLIANCE AND REFERENCE STANDARDS

- A. Electric equipment, materials and installation shall comply with the National Electrical Code (NEC) and with the latest edition of the following codes and standards:
 - 1. National Electrical Safety Code (NESC)
 - 2. Occupational Safety and Health Administration (OSHA)
 - 3. National Fire Protection Association (NFPA)
 - 4. National Electrical Manufacturers Association (NEMA)
 - 5. American National Standards Institute (ANSI)
 - 6. Insulated Cable Engineers Association (ICEA)
 - 7. Instrument Society of America (ISA)
 - 8. Underwriters Laboratories (UL)
 - 9. Factory Mutual (FM)
 - 10. Institute of Electrical and Electronics Engineers
 - 11. American Society of Testing Materials (ASTM)
 - 12. Local Telephone Company requirements
 - 13. Local Utility Company requirements
- B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.
- C. All materials and equipment for which a UL standard exists, shall bear a UL label. No such material or equipment shall be brought onsite without a UL label affixed.
- D. If the issue of priority is due to a conflict or discrepancy between the provisions of the Contract Documents and any referenced standard, or code of any technical society, organization or association, the provisions of the Contract Documents will take precedence if they are more stringent or presumptively cause a higher level of performance. If there is any conflict or discrepancy between standard specifications, or codes of any technical society, organization or association, or between Laws and Regulations, the higher performance requirement shall be binding on the Contractor, unless otherwise directed by the Owner/Engineer.
- E. In accordance with the intent of the Contract Documents, the Contractor accepts the fact that compliance with the priority order specified shall not justify an increase in Contract Price or an extension in Contract Time nor limit in any way, the Contractor's responsibility to comply with all Laws and Regulations at all times.

1.03 SUBMITTALS

- A. Shop Drawings shall be custom prepared for this project and submitted as listed in each of the Electrical Specification Sections. Shop drawings shall include the following:
 - 1. Complete materials list stating manufacturer, brand name and catalog number of each item or class of material.
 - 2. Shop drawings for grounding work not specifically indicated on the drawings but required under the NEC.
 - 3. Front, side and rear elevations along with top views with required dimensional data.
 - 4. Location of conduit entrances and access plates.
 - 5. Catalog cuts defining component data.
 - 6. Connection diagrams, terminal numbers, internal wiring diagrams, conductor size and cable numbers.
 - 7. Method of anchoring, seismic requirements and weight.

8. Types of materials and finish.
 9. Nameplates.
 10. Temperature limitations, as applicable.
 11. Voltage requirements, phase and current, as applicable.
 12. Front and rear access requirements.
 13. Test reports.
- B. O&M Manuals and other documentation, shall be submitted in accordance with these contract documents. The manuals shall be prepared specifically for this installation and shall include catalog data sheets, drawings, equipment lists, descriptions, parts lists, etc. to instruct operating and maintenance personnel unfamiliar with such equipment. All manuals and other documentation shall be submitted as listed in each of the Electrical Specification Sections and include the following:
1. A comprehensive index.
 2. A complete "As-built" set of approved shop drawings.
 3. A complete list of the equipment supplied, including serial numbers, ranges and pertinent data.
 4. A table listing of the "as left" settings for all timing relays and alarm and trip set points.
 5. System schematic drawings "As-Built", illustrating all components, piping and electrical connections of the system supplied under this Section.
 6. Detailed service, maintenance and operation instructions for each item supplied.
 7. Special maintenance requirements particular to this system shall be clearly defined, along with special calibration and test procedures.
 8. The operating instructions shall also incorporate a functional description of the entire system, with references to the systems schematic drawings and instructions.
 9. Complete parts list with stock numbers, including spare parts.
- C. Record Drawings shall be promptly furnished when the equipment installation is complete. Payment may be withheld until Record Drawings have been furnished and approved.
- D. At the time of delivery of the equipment, the Contractor shall have an approved shop drawing in his possession for the Owner's Inspector and/or Owner's Engineer for verification.
- E. As-Built Drawings: As the work progresses, legibly record all field changes on a set of Project Contract Drawings, hereinafter called "As-Built Drawings". The As-Built Drawings and specifications shall be kept up to date throughout the project. As-Built Drawings shall accurately show the installed condition of the following items at a minimum:
1. One-line Diagram(s).
 2. Raceways and pullboxes.
 3. Conductor sizes and conduit fills.
 4. Panelboard Schedule(s).
 5. Control Wiring Diagram(s).
 6. Luminaire Schedule(s)
 7. Luminaire, receptacle and switch outlet locations.
 8. Underground raceway and duct bank routing including manhole/handhole locations.

9. Plan view, sizes and locations of switchgear, switchboards, distribution transformers, motor control centers, and panelboards.

1.04 TESTS

- A. The Contractor shall be responsible for factory and field tests indicated in Division 16, as required by the Engineer and as required by other authorities having jurisdiction.
- B. Furnish necessary testing equipment.
- C. Pay the costs of the tests, including replacement parts and labor due to damage resulting from damaged equipment or from testing and correction of a faulty installation.
- D. Reporting
 1. Where test reporting is indicated, submit proof-of-design test reports for mass-produced equipment with the Shop Drawings.
 2. Submit factory performance test reports for custom-manufactured equipment for approval prior to shipment.
 3. Submit field test reports for review prior to Substantial Completion.
- E. Remove and replace equipment or material that fails a test, or, if the Engineer approves, repair and retest for compliance.
- F. Connections to equipment or materials with a factory warranty shall be as recommended by the manufacturer and shall be performed in a manner that does not void the warranty.

1.05 PERMITS AND INSPECTIONS

- A. Obtain permits and pay all fees required for permits inspections.
- B. The Engineer may inspect the fabricated equipment at the factory before shipment to job site. Provide the Engineer with sufficient prior notice so that an inspection can be arranged at the factory.
- C. Inspection of the equipment at the factory by the Engineer will be made after the manufacturer has performed satisfactory checks, adjustments, tests, and operations.
- D. Favorable review of the equipment at the factory only allows the manufacturer to ship the equipment to the project site. The Contractor shall be responsible for the proper installation and satisfactory startup operation of the equipment to the satisfaction of the manufacturer and the Engineer.

1.06 COORDINATION

- A. Coordinate the electrical work with the other trades, code authorities, utilities, and the Owner.
- B. Where connections must be made to existing installations, properly schedule all the required work with the Owner, including the power shutdown periods. Schedule and carry out shutdowns so as to cause the least disruption to operation of the plant and privately owned facilities.
- C. Submit a written sequencing request indicating the sequence and duration of activities to be performed during the plant shutdown.

- D. Switching, safety tagging and other project related tasks required for shutdown or to isolate existing equipment, shall be performed by the Owner.
- E. In no case shall the Contractor begin any work in, on or adjacent to existing equipment without written authorization from the Engineer.
- F. Modifications
 1. Perform modifications or alterations to existing electrical facilities as required to successfully install and integrate the proposed electrical equipment as indicated.
 2. Perform modifications to existing equipment, panels and cabinets in a professional manner. Repair coatings of existing equipment to match existing.
 3. The costs for modifications to existing electrical facilities that are required for a complete and operable system shall be included as part of the Work.
- G. Existing Utilities
 1. Exercise extreme caution when digging trenches to not damage existing underground utilities.
 2. The cost of repairs of damages caused during construction shall be included as a part of the Work.
- H. Field Verifications
 1. Visit the site before submitting a Bid to become better acquainted with the Work of this Contract.
 2. The lack of knowledge will not be accepted as justification for extra compensation to perform the Work.
 3. The Contractor shall be responsible for identifying available existing circuit breakers in lighting panel for the intended use as required.
 4. The Contractor shall be responsible for field verifying the available space in switchgear, switchboards and/or motor control centers to integrate new overcurrent protective devices meeting the requirements of these Specifications.
 5. The cost for the above field verifications shall be included as part of the Work.
- I. Installation of Temporary Power
 1. To facilitate the continuous operation of existing equipment, provide temporary equipment as indicated.
 2. Submit installation and connection details for favorable review and acceptance by the Engineer.
 3. Costs associated with these temporary installations shall be included as part of the Work.
 4. Temporary wiring and equipment shall remain the property of the Contractor unless indicated otherwise.

1.07 LOCATIONS

- A. General: Use equipment, materials and wiring methods suitable for the types of locations in which they are located, as defined in Paragraph B. herein.
- B. Definitions of Types of Locations:
 1. Dry Locations: All those indoor areas which do not fall within the definitions below for Wet, Damp, Hazardous, or Corrosive Locations and which are not otherwise designated on the Drawings.
 2. Wet Locations: All locations exposed to the weather, whether under a roof or not, unless otherwise designated on the Drawings.

3. Damp Locations: All spaces wholly or partially underground, or having a wall or ceiling forming part of a channel or tank, unless otherwise designated on the Drawings.
 4. Hazardous Locations: All areas in which fire or explosion hazards may exist, normally or accidentally, due to flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers or flyings. These areas are shown on the Drawings, together with the Class and Division designations as defined in the NEC, determining the enclosure types and wiring methods required.
 5. Corrosive Locations: Areas where chlorine or sulfur dioxide gas under pressure, sulfuric acid, ferric chloride, or sodium hypochlorite are stored or processed. These areas are shown on the Drawings.
- C. Unless otherwise specified herein or shown on the Drawings, electrical enclosures and associated installations shall have the following ratings:
1. NEMA 1 gasketed or 12 for dry, non-process indoor above grade locations.
 2. NEMA 3R for outdoor installations identified not to be hazardous or corrosive.
 3. NEMA 4X enclosures of Type 304 or 316 stainless steel in corrosive areas except in chlorine and HFS areas where non-metallic enclosures shall be provided.
 4. NEMA 6 or 6P enclosures for submersible, indoor or outdoor use. Enclosures for temporary submersion shall be rated NEMA 6 and prolonged submersion shall be rated 6P at limited depth.
- D. Equipment, materials, and installation in areas designated as hazardous on the Drawings shall comply with NEC Articles 500, 501, 502, and 503.
- E. Equipment and materials installed in areas designated as hazardous on the Drawings shall be UL Listed for the appropriate hazardous area classification.

1.08 PHASE BALANCING

- A. The Drawings do not attempt to balance the electrical loads across the phases. Circuits on motor control centers and panelboards shall be field connected to result in evenly distributed loads across all three phases.
- B. Field balancing of circuits shall not alter the conductor color coding requirements defined in Section 16120.

1.09 SIZE OF EQUIPMENT

- A. Investigate each space in the structure through which equipment must pass to reach its final location. Coordinate shipping splits with the manufacturer to permit safe handling and passage through restricted areas in the structure.
- B. The equipment shall be kept upright at all times during storage and handling. When equipment must be tilted for passage through restricted areas, brace the equipment to ensure the tilting does not impair the functional integrity of the equipment

PART 2 - PRODUCTS

2.01 GENERAL

- A. Products that are specified by manufacturer, trade name or catalog number establish a standard of quality and do not prohibit the use of equal products of

other manufacturers provided they are favorably reviewed by the Engineer prior to installation.

- B. It is the intent of these Specifications and Drawings to secure high quality in all materials and equipment in order to facilitate operation and maintenance of the facility. All equipment and materials shall be new and the products of reputable suppliers having adequate experience in the manufacture of these particular items. For uniformity, only one manufacturer will be accepted for each type of product. All equipment shall be designed for the service intended and shall be of rugged construction, of ample strength for all stresses, which may occur during fabrication, transportation, erection, and continuous or intermittent operation. All equipment shall be adequately stayed, braced and anchored and shall be installed in a neat and workmanlike manner. Appearance and safety, as well as utility, shall be given consideration in the design of details.
- C. All components and devices installed shall be standard items of industrial grade, unless otherwise noted, and shall be of sturdy and durable construction suitable for long, trouble-free service. Light-duty, fragile, and competitive grade devices of doubtful durability shall not be used.
- D. Where a NEMA enclosure type is indicated in a non-hazardous location, use that type of enclosure despite the fact that certain modifications such as cutouts for control devices may negate the NEMA rating.
- E. Temperature Ratings of Equipment Terminations and lugs shall be rated for use with 75-degree C conductors. Wire sizes in the Contract Documents are based on NEC ampacity tables using the 75-degree C ratings.

2.02 MOUNTING HARDWARE

- A. Miscellaneous Hardware
 - 1. Provide nuts, bolts and washers constructed of stainless steel.
 - 2. Provide threaded rods for trapeze supports constructed from continuous threaded galvanized steel, 3/8-inch diameter minimum.
 - 3. Struts
 - a. Construct struts for mounting of conduits and equipment of stainless steel OR galvanized steel.
 - b. Where contact with concrete or dissimilar metals may cause galvanic corrosion, use suitable non-metallic insulators in order to prevent such corrosion.
 - c. Strut manufacturer shall be Unistrut, B-Line or approved equal.
 - 4. Provide plastic protective end caps for all exposed strut ends. End caps shall be manufactured by Unistrut P2860-33 or approved equal
 - 5. Provide stainless steel expansion anchors for attaching equipment to concrete walls, floors and ceilings. Expansion anchors shall be manufactured by Power Fasteners, Inc and be the "Power-Bolt" or "Power-Stud" series or approved equal.

2.03 LENS COLOR SCHEME

- A. Indicating light lens colors shall be red for "Run", "Open" or "On"; green for "Stop", "Close" or "Off"; and amber for alarm.

2.04 NAMEPLATES

- A. For each piece of electrical equipment, provide a manufacturer's nameplate showing his name, location, the pertinent ratings, and the model designation.
- B. Identify each piece of equipment and related controls with a rigid laminated engraved phenolic nameplate. Engrave nameplates with the inscriptions indicated on the Drawings and, if not so indicated, with the equipment name. Securely fasten nameplates in place using fasteners constructed of brass, cadmium plated steel or stainless steel and screwed into inserts or tapped holes as required. Where no inscription is indicated on the Drawings, furnish nameplates with an appropriate inscription furnished by the Engineer upon prior request by the Contractor.
- C. Provide engraved characters of the block style, with no characters smaller than 1/8 inch top to bottom.
- D. Each control device, including pushbuttons, control switches, and indicating lights, shall have an integral legend plate or nameplate indicating the device function. These shall be inscribed as indicated on the Drawings or as favorably reviewed by the Engineer.

2.05 PAINTING

- A. Equipment: Refer to each electrical equipment section of these Specifications for painting requirements of equipment enclosures. Repair any final paint finish, which has been damaged or is otherwise unsatisfactory, to the satisfaction of the Engineer.
- B. Wiring System: Paint all exposed conduits, boxes and fittings to match the color of the surface to which they are affixed. Paint finishes shall include proper surface preparation, prime coat, and a final finish coat, and shall conform to Section 09960.

PART 3 - EXECUTION

3.01 REQUIREMENTS

- A. All electrical installations shall conform to the codes and standards outlined in this Section.

3.02 WORKMANSHIP

- A. Assign a qualified representative who shall supervise the electrical construction work from beginning to completion and final acceptance.
- B. Perform all labor using qualified craftsmen, who have had experience on similar projects. Provide first-class workmanship for all installations.
- C. Ensure that all equipment and materials fit properly in their installations.
- D. Perform any required work to correct improperly fit installations at no additional expense to the Owner.
- E. Provide materials and incidental required for a complete and operable system, even if not required explicitly by the Contract Documents.
- F. Typical incidentals are terminal lugs not furnished with vendor-supplied equipment, compression connectors for cables, splices, junction and terminal boxes, and

control wiring required by vendor-furnished equipment to connect with other equipment indicated in the Contract Documents.

3.03 EXCAVATION AND BACKFILL

- A. Provide the excavations for electrical equipment foundations and trenches for conduits as shown on the Drawings.
- B. Exercise caution during all excavation work and avoid damage to existing underground pipes. Exercise extreme caution when working near existing electrical conduits and facilities. Field verify the location of all electrical facilities before proceeding with any nearby work.
- C. Refer to Division 2, Earthwork, of these Specifications for all excavation and backfilling work.

3.04 CONCRETE

- A. Where shown on the Drawings or specified, provide the required concrete installations for conduit encasement and equipment foundations.
- B. Refer to Division 3, Concrete, of these Specifications for all concrete work.

3.05 CONDUCTOR IDENTIFICATION

- A. Identify all wires and cables in conformance with the requirements of Sections 16120, 16122, and 16124. This requirement applies to all equipment provided under this contract, regardless of Division, as well as to all conductors provided or worked on during this contract.

3.06 CUTTING, DRILLING, AND WELDING

- A. Provide any cutting, drilling, and welding that is required for the electrical construction work.
- B. Structural members shall not be cut or drilled, except when favorably reviewed by the Engineer. Use a core drill wherever it is necessary to drill through concrete or masonry.
- C. Provide the required welding for equipment supports. Conduits and fittings shall not be welded to structural steel.
- D. Perform patch work with the same materials as the surrounding area and finish to match, as specified in Division 3 of these Specifications.

3.07 METAL PANELS

- A. Mount all metal panels which are mounted on or abutting concrete walls in damp locations or any outside walls 1/4 inch from the wall and paint the back sides of the panels with a high build epoxy primer. Film thickness shall be 10 mils minimum.

3.08 PROTECTIVE DEVICE COORDINATION

- A. Provide the services of a recognized independent testing laboratory or coordination analysis consultant for the proper system coordination of the protective devices furnished on this project. Submit the name and the qualifications of the laboratory or consultant for review by the Engineer; qualifications must include professional registration of proposed personnel as electrical engineers.

- B. The protective device on the line side closest to the fault or abnormal conditions shall isolate the problem portion of the system and minimize damage in that portion. The rest of the system shall be maintained in normal service. The coordination shall be in conformance with the recommendations of latest IEEE Standard 242.
- C. Submit the analysis that shall include impedance and short circuit calculations, list of any assumptions made in the analysis, the recommended settings of the protective devices, and the system time/current characteristic curves. The submittal shall be made so as to allow time for review and resubmittal, if necessary, before the implementation of final settings and adjustments by the testing laboratory.

3.09 FIELD TESTS

- A. Perform tests in accordance with applicable procedures as described in NETA Acceptance Testing Specifications.
- B. Give 2-week notice to the Owner/Engineer prior to any test to permit witnessing the test.
- C. Provide the services of a recognized independent testing laboratory and pay all costs of performing the inspections and tests as specified herein.
- D. The testing laboratory shall provide all materials, equipment, labor and technical supervision to perform such tests and inspections. It is the intent of these tests to ensure that all electrical equipment is operational within industry and manufacturer's tolerances and is installed in accordance with the Contract Documents and manufacturer's instructions. The tests and inspections shall determine the suitability for energization.
- E. The testing laboratory shall meet federal OSHA criteria for accreditation of testing laboratories, Title 29, Part 1907. Membership in the International Electrical Testing Association (NETA) constitutes proof of meeting such criteria. The testing laboratory shall submit proof of these qualifications to the Engineer for review. Testing laboratory shall be Electrical Testing and Controls, Electro-Test, Power Systems, or approved equal.
- F. The testing laboratory shall have a calibration program, which maintains all applicable test instrumentation within, rated accuracy. The accuracy shall be traceable to the National Bureau of Standards in an unbroken chain. Instruments shall be calibrated in accordance with the following frequency schedule:
 - 1. Field instruments: 6 months maximum
 - 2. Laboratory instruments: 12 months
 - 3. Leased specialty equipment: 12 monthsDate calibration labels shall be visible on all test equipment.
- G. Where testing pursuant to NETA requirements is required in these specifications, submit a test report which includes the following:
 - 1. Name of project, name of person performing test, and date of test
 - 2. Description of equipment tested
 - 3. Description of test
 - 4. List of test equipment used and calibration date
 - 5. Test results
 - 6. Conclusions and recommendations
 - 7. Appendix, including appropriate test forms

The test report shall be bound and its contents certified. Submit the completed report directly to the Engineer no later than thirty (30) days after completion of the test unless directed otherwise. Number of reports to be submitted for review shall be the same as the number required for shop drawing submittals.

- H. Safety practices shall include, but are not limited to, the following requirements:
 - 1. Occupational Safety and Health Act of 1970, OSHA.
 - 2. Accident Prevention Manual for Industrial Operations, Seventh Edition, National Safety Council, Chapter 4.
 - 3. Applicable state and local safety operating procedures.
- I. All field tests shall be performed with apparatus de-energized except where otherwise specifically required by Section 7 of the latest Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems published by NETA. The testing laboratory shall have a designated safety representative who shall be present on the project and supervise operations with respect to safety. Circuits operating in excess of 600 volts between conductors shall have conductors shorted to ground by a hot-line grounded device approved for the purpose. In all cases, work shall not proceed until the safety representative has determined that it is safe to do so. The testing laboratory shall have available sufficient protective barriers and warning signs to conduct specified test safely.
- J. Electrical equipment and materials furnished and installed by the Contractor, and the testing equipment listed below shall be tested in accordance with the "Inspection and Test Procedures" and "System Function Tests" (Section 7) of the latest Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems published by NETA. Tests shall not include any tests listed as optional in the aforementioned NETA Specifications unless specifically noted in respective equipment specifications for this project.
- K. Retesting will be required for all unsatisfactory tests after the equipment or system has been repaired. Retest all related equipment and systems if required by the Engineer. Repair and retest equipment and systems, which have been satisfactorily tested but later, fail, until satisfactory performance is obtained.
- L. Putting Equipment and Cables into Service: Submittal and favorable review of the specified factory and field tests shall occur before the Contractor is permitted to place the respective equipment or cable into service.
- M. Miscellaneous Tests
 - 1. Insulation Resistance, Continuity, Rotation: Perform routine insulation resistance, continuity and rotation tests for all distribution and utilization equipment including all motors 1/2 horsepower and larger prior and in addition to tests performed by the testing laboratory specified herein. Supply a suitable and stable source of test power to the test laboratory at each test site. The testing laboratory shall specify requirements. Notify the testing laboratory when equipment becomes available for acceptance tests. Work shall be coordinated to expedite project scheduling. All testing shall be performed in the presence of the Engineer. The testing laboratory shall be responsible for implementing all final settings and adjustments on protective devices and tap changes. Any system material or workmanship that is found defective on the basis of acceptance tests shall be reported directly to the Engineer. The testing laboratory shall maintain a written record of all tests and upon completion of project, assemble and certify a final test report.

2. Motor Current: Measure and record current in each phase for each new motor. Include measurement of the motor terminal voltages and motor currents when the motor is being operated at normal operating loads. For motors that are part of variable frequency drive systems, use true-RMS-reading instruments in making the measurements.
3. Operational Tests: Operationally test all circuits to demonstrate that the circuits and equipment have been properly installed, adjusted and are ready for full-time service. Demonstrate the proper functioning of circuits in all modes of operation, including alarm conditions, and demonstrate satisfactory interfacing with the data acquisition and alarm systems.

3.10 EQUIPMENT PROTECTION

- A. Exercise care at all times after installation of equipment, motor control centers, etc., to keep out foreign matter, dust, dirt, debris, or moisture. Use protective sheet-metal covers, canvas, heat lamps, etc., as needed to ensure equipment protection.

3.11 CLEANING EQUIPMENT

- A. Before final acceptance, thoroughly clean the electrical Work of cement, plaster, and other materials.
- B. Clean out and vacuum all construction debris from the bottom of all equipment.
- C. Provide and touch-up to original condition any factory painting that has been marred or scratched during shipment or installation, using paint furnished by the equipment manufacturer.
- D. Remove temporary tags, markers, stickers, and the like.
- E. Remove all oil and grease spots with a non-flammable cleaning solvent by carefully wiping and scraping cracks and corners.
- F. Dispose of cleaning debris and refuse offsite.

END OF SECTION

SECTION 16110

ELECTRICAL RACEWAY SYSTEMS

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. Furnish and install complete raceway systems as shown on the drawings and as specified herein.
- B. Raceways and conductors that are listed on the conduit and cable schedules are generally not shown on the Drawings, except where they are required to pass through a restricted or designated space and the Contractor would benefit from additional information. Conduit block diagrams indicate exposed conduits as solid lines and shall be run near the ceilings or along walls of the areas through which they pass and shall be routed to avoid interferences with HVAC ducts, cranes and hoists, lighting fixtures, doors and hatches, etc. Conduit block diagrams indicate concealed or buried conduits as dashed lines and shall be run in underground duct banks, center of concrete floor slabs, in partitions, or above hung ceilings as required.
- C. In the event that individual equipment loads provided are larger than indicated in the Contract Documents, revise raceways, conductors, starters, overload elements, and branch circuit protectors as necessary in order to control and protect the increased connected load in conformance to NEC requirements as part of the Work.

1.02 REFERENCE STANDARDS

- A. American National Standards Institute (ANSI) Publications:
 - 1. C80.1 Specification for Zinc Coated Rigid Steel Conduit
 - 2. C80.5 Specifications for Rigid Aluminum Conduit
- B. Federal Specifications (FS):
 - 1. FS W C 1094 W C 1094A Conduit and Conduit Fittings, Plastic, Rigid
 - 2. FS WW C 540 WW C 540A Conduit, Metal, Rigid, (Electrical, Aluminum)
 - 3. WW C 540C Conduit, Metal, Rigid & Coupling, Elbow & Nipple, Electrical Conduit, Aluminum
 - 4. FS WW C 566 WW C 566C Flexible Metal Conduit
- C. National Electrical Manufacturers Association (NEMA) Publications:
 - 1. RN 1 Polyvinyl Chloride Externally Coated Galvanized Rigid Steel Conduit and Electrical Metallic Tubing
 - 2. TC2 Electrical Polyvinyl Chloride (PVC) Conduit
 - 3. TC 6 PVC and ABS Plastic Utilities Duct for Underground Installation
 - 4. TC14 Reinforced Thermosetting Resin Conduit (RTRC) and Fittings
- D. Underwriters Laboratories (UL) Standards:
 - 1. 6 Rigid Metal Electrical Conduit
 - 2. 6A Electrical Rigid Metal Conduit – Aluminum, Red Brass and Stainless Steel
 - 3. 360 Liquid-Tight Flexible Metal Conduit
 - 4. 651 Electrical Rigid Nonmetallic Conduit and Fittings

- 5. 651A Type EB and A Rigid PVC Conduit and HDPE Conduit
- 6. 2515 Aboveground Reinforced Thermosetting Resin Conduit

1.03 SUBMITTALS

- A. Submit complete catalog cuts of raceways, fittings, boxes, supports, and mounting hardware, marked where applicable to show proposed materials and finishes.
- B. Prepare as-built drawings of encased concealed and exposed raceways, ducts, raceways, junction boxes, pull boxes, and electrical and instrumentation equipment.

1.04 LOCATIONS

- A. Refer to Section 16010 for definitions of types of locations.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Pull and junction boxes, fittings and other indicated enclosures that are dedicated to the raceway system shall comply with the requirements of this Section.
- B. Provide exposed conduit of 3/4-inch minimum trade size and encased conduit of 1-inch minimum trade size.
- C. The use of short sections of 1/2-inch flexible conduit for final termination of field control devices and instrumentation is permitted. They may not be longer than 36 inches in length and may only transition to the smaller size junction boxes or condulets at the field device.

2.02 CONDUIT, RACEWAYS

- A. Galvanized Rigid Steel Conduit (GRS) shall be manufactured from mild steel, hot-dip galvanized inside and out, conforming to ANSI C80.1 and UL 6. Couplings shall be threaded type. Manufacturers shall be Allied Tube and Conduit, Wheatland Tube, or approved equal.
- B. PVC coated rigid steel conduit (PGRS) shall meet the requirements of GRS above. A PVC coating shall be bonded to the outer surface with a thickness not less than 40 mils. The inside surfaces and threads of the conduit shall be provided with a 2-mil urethane coating. PGRS shall be manufactured in accordance with UL-6, ANSO C80.1 and NEMA RN1. Manufacturers shall be Robroy Industries Perma-Cote or Plasti-Bond series, Thomas & Betts Ocal Blue, or approved equal.
- C. Liquidtight Flexible Conduit shall be constructed of a flexible galvanized metal core with a sunlight-resistant thermoplastic outer jacket. Conduit shall be manufactured in accordance with UL 360. Flexible conduit in hazardous areas shall be rated for the Class, Division and Group in which its installed. Manufacturers shall be Anaconda Sealtite, Electriflex Liquatite, or approved equal.
- D. Rigid Nonmetallic Conduit: Rigid nonmetallic conduit shall be PVC Schedule 40 (PVC 40) or PVC Schedule 80 (PVC 80) and sunlight resistant. Conduit shall be approved for underground use and for use with 90°C wires, and shall conform to NEMA TC-2 and UL 651. Manufacturers shall be Carlon, Cantex, or approved equal.

- E. Fiberglass conduit shall be manufactured using the single circuit filament winding process. The resin shall be epoxy-based, with no fillers. All additives for increasing flame spread and lowering smoke density shall be halogen free. Conduit shall be manufactured in accordance with NEMA TC 14. Manufacturers shall be Champion Fiberglass, United Fiberglass or approved equal.

2.03 CONDUIT SUPPORTS

- A. For indoor, dry locations, supports for individual conduits shall be galvanized malleable iron one-hole type with conduit back spacer. All other locations shall be Type 316 stainless steel.
- B. For indoor, dry locations, supports for multiple conduits shall be hot-dip galvanized Unistrut or Superstrut channels, or equal. All associated hardware shall be hot-dip galvanized. All other locations shall be Type 316 stainless steel.
- C. All channels, strut, threaded rods, nuts, and clamps in corrosive areas shall be of epoxy resin reinforced fiberglass material. Provide Robroy, Superstrut, or equal.

2.04 FITTINGS

- A. General
 - 1. For use with metallic conduit, provide cast and malleable iron fittings of the threaded type with 5 full threads.
 - 2. Fittings
 - a. Provide fittings with neoprene gaskets and non-magnetic stainless steel screws.
 - b. Attach covers by means of holes tapped into the body of the fittings.
 - c. Covers for fittings attached by means of clips or clamps will not be accepted.
 - 3. Terminations
 - a. In outdoor areas, terminate conduit in rain-tight hubs as manufactured by Myers, O.Z. Gedney, Appleton or approved equal.
 - b. In other than outdoor areas, provide sealed locknuts and bushings.
- B. Fittings for use with rigid steel shall be hot dipped galvanized steel or galvanized cast ferrous metal; access fittings shall have gasketed cast covers and be Crouse-Hinds Condulets, Appleton Unilets, or equal. Provide threaded-type couplings and connectors; set-screw type and compression-type are not acceptable.
- C. Fittings for use with PVC-coated GRS conduit shall be PVC-coated that are the products of the same manufacturer as the conduit. Both male and female threads and internal surfaces shall contain a 2-mil urethane coating.
- D. Fittings for use with rigid nonmetallic conduit shall be PVC and have solvent-weld-type conduit connections. Boxes shall be manufactured of PVC or fiberglass reinforced polyester (FRP). Manufacturers shall be Carlon, Crouse-Hinds, Hoffman or approved equal. If such are not available, then the Specification for PVC coated galvanized rigid steel fittings shall apply.
- E. Fittings for flexible conduit shall be Appleton Type ST, O.Z. Gedney Series 4Q, or approved equal.
- F. Fittings for use with fiberglass conduit shall be fiberglass and as recommended by the conduit manufacturer.
- G. Combination expansion-deflection fittings with internal grounding shall be installed where conduit movement is expected in more than one dimension, and where

conduits transition out of structures in locations where differential settlement may occur. Combination expansion/deflection fittings shall be manufactured by Crouse-Hinds Type XJGD or approved equal.

- H. Expansion fittings with internal grounding shall be installed wherever exposed raceway cross building expansion joints. Expansion fittings shall be Crouse Hinds Type XLGSA or approved equal.
- I. Union couplings for conduits shall be the Erickson type and shall be Appleton Type EC, O.Z. Gedney 3-piece Series 4, or approved equal. Threadless couplings shall not be used.
- J. Bushings:
 - 1. Bushings shall be the insulated type.
 - 2. Bushings for rigid steel conduit shall be hot dip galvanized insulated grounding type, O.Z. Gedney Type HBLG, Appleton Type GIB, or approved equal.
- K. Conduit seals in areas where chlorine, ammonia, sulfur dioxide and/or hydrofluosilicic areas shall be Link Seal or approved equal.

2.05 BOXES

- A. Boxes specified herein are for use with raceway systems only. Boxes used for housing electrical and instrumentation equipment shall be as described elsewhere in these Specifications.
- B. NEMA 1 Areas: NEMA 1 terminal boxes, junction boxes, pull boxes, etc. shall be either sheet or cast malleable iron or aluminum depending on raceway material. Boxes shall be suitable for wall mounting or have feet where self-standing. Boxes shall have continuously welded seams and welds shall be ground smooth. Box bodies shall be flanged and shall not have holes or knockouts. Box bodies shall not be less than 14 gauge metal and covers shall not be less than 12 gauge metal. All boxes shall have hinged gasketed doors with quarter turn latches or 3-point latch (single operator) system on enclosures larger than 36 inches wide or 32 inches tall. Terminal boxes shall be furnished with terminal mounting straps and brackets. Terminal blocks shall be NEMA type, not less than 20A, 600V. Boxes shall be Concept Series as manufactured by Hoffman Engineering Co. or approved equal.
- C. NEMA 4X Areas: NEMA 4X terminal boxes, junction boxes, pull boxes, etc. shall be Type 304 or 316 stainless steel. Boxes shall be suitable for wall mounting or have feet where self-standing. Boxes shall have continuously welded seams and welds shall be ground smooth. Box bodies shall be flanged and shall not have holes or knockouts. Box bodies shall not be less than 14 gauge metal and covers shall not be less than 12 gauge metal. All boxes shall have hinged gasketed doors with quarter turn latches or 3-point latch (single operator) system on enclosures larger than 36 inches wide or 32 inches tall. Terminal boxes shall be furnished with terminal mounting straps and brackets. Terminal blocks shall be NEMA type, not less than 20A, 600V. Boxes shall be Concept Series as manufactured by Hoffman Engineering Co. or approved equal.
- D. Boxes for use in chemically corrosive areas shall be of rigid PVC. Construction shall be the same as specified for NEMA 4X areas as specified above.

2.06 WIREWAYS AND AUXILIARY GUTTERS

- A. General: Wireways shall consist of a prefabricated channel-shaped trough with hinged or removable covers, associated fittings, and supports. Straight sections shall not be longer than 5 feet. Separate power, control, signal, and communications cables by grounded metallic dividers in wireways or run in separate wireways. Cross-sectional dimensions shall be as indicated on the Drawings. Fittings shall consist of elbows, tees, crosses, and closing plates as required.
- B. Interior Locations: All components shall be constructed from sheet steel not less than 14 gauge and coated with a corrosion-resistant gray paint. Covers shall be held closed with hinges and clamps.
- C. Exterior Locations: Wireway and associated fittings shall be NEMA rated for the area in which it is to be installed. Wireways shall be supplied with gasketed closing end plates and gasketed hinged covers.
- D. Corrosive Locations: In corrosive locations provide enclosure type boxes for use as wireways. Enclosures and associated fittings shall meet NEMA 4X classifications and shall be manufactured from reinforced injection molded fiberglass or formed and welded stainless steel and shall have gasketed closing plates and hinged and gasketed covers with spring loaded latches.
- E. Ground the steel and aluminum wireway bodies. Provide steel dividers with steel wireways or aluminum dividers with aluminum wireways, and ground by means of an individual grounding conductor.
- F. Terminate conduits in all wet and damp locations with rain-tight hubs as manufactured by O.Z. Gedney, Myers or approved equal. In finished areas, provide sealed locknuts and bushings.

2.07 CONDUIT SEALANTS

- A. Moisture Barrier Types: Sealant shall be a non-toxic, non-shrink, non-hardening, putty type hand applied material providing an effective barrier under submerged conditions.
- B. Fire Retardant Types: Fire stop material shall be a reusable, non-toxic, asbestos-free, expanding, putty type material with a 3-hour rating in accordance with UL 1479. Provide products indicated by the manufacturer to be suitable for the type and size of penetration.

PART 3 - EXECUTION

3.01 CONDUIT, RACEWAY AND FITTING INSTALLATION

- A. No wire shall be pulled until the raceway system is complete in all details; in the case of concealed work, until all rough plastering or masonry has been completed; in the case of exposed work, until the raceway system has been completed in every detail.
- B. From pull point to pull point, the sum of the angles of all of the bends and offsets shall not exceed 270 degrees.
- C. Coat threads with a conductive lubricant before assembly.

- D. Provide joints that are tight, thoroughly grounded, secure, and free of obstructions by use of a mandrel. Adequately ream the conduit in order to prevent damage to the wires and cables inside. Use strap wrenches and vises to install the conduit in order to prevent wrench marks on the conduit. Any conduit with wrench marks shall be replaced.
- E. The ends of all conduits shall be tightly plugged to exclude dust and moisture during construction. Duxseal, or 3M seal spray shall be used in all applications. Plugging with tape is prohibited, even for short periods of time.
- F. For power, control, and signal circuits, provide conduit per Conduit Use Tables below, unless specifically indicated otherwise on the Drawings:
 - 1. Exception: For raceways leaving a building above grade and then going below grade, provide PVC-coated GRS from a point 3 feet above grade to a point 5 feet from the building wall.
- G. Unless boxes have cast, threaded hubs, provide insulated type metallic grounding bushings for metallic conduits at all boxes. Bond together all conduits to provide continuity of the equipment grounding system. Size bonding conductor per NEC.
- H. Provide flexible conduit in lengths of not more than 36 inches at connections to motors, valves, and any equipment subject to vibration or relative movement. All flexible conduits, regardless of length or manufacturer rating, shall have a dedicated ground bonding conductor pulled through, whether it is included in the conduit fill schedules or not.
- I. Conduits embedded in concrete floors on grade shall be installed between grids of reinforcing steel, or shall be encased below the floors, provided the concrete is thickened in a manner satisfactory to the Engineer. Installation of conduit below the bottom of this slab is not acceptable; embedding or encasing is required.
- J. Damage to PVC coating of coated conduits or fittings shall be repaired with factory-approved PVC patching material to the original factory condition.
- K. Install fiberglass conduit in accordance with the manufacturer's instructions. Connections between sections of conduit may be either glued or threaded, at the Contractor's option.
- L. Underground Raceways: Slope all underground raceways to provide drainage; for example, slope conduit from equipment located inside a building to the handhole located outside the building. For additional requirements see Section 16402.
- M. Conduit Supports: Properly support all conduits as required by the NEC. Run all conduits exposed except where the Drawings indicate that they are to be embedded in the floor slab, walls, or ceiling, or to be installed underground.
 - 1. Exposed Conduits:
 - a. Support exposed conduits within 1 foot of any outlet and at intervals not exceeding NEC requirements; wherever possible, group conduits together and support on common supports. Support exposed conduits fastened to the surface of the concrete structure by one-hole clamps, or with channels. Use conduit spacers with one-hole clamps. Coordinate conduit locations with piping, equipment, fixtures, and with structural and architectural elements. Conduits attached to walls or columns shall be as unobtrusive as possible and shall avoid windows. Run all exposed conduits parallel to building lines. No diagonal runs will be accepted. Bends in parallel runs shall be concentric and shall be run straight and true.

- b. Group together exposed conduits in horizontal runs located away from walls and support on trapeze hangers. Arrange such conduits uniformly and neatly. Trapeze hangers shall consist of channels of adequate size, suspended by means of minimum 3/8" diameter rods or other suitable means from the ceiling or from pipe hangers. Install such runs so as not to interfere with the operation of valves or any other equipment, and keep at least 6 inches clear of any pipe which may operate at more than 100°F. Treat cut surfaces or damaged ends with corrosion-resistant coatings such as "Devcon Z", prepared by Subox Coatings; "Galvanox Type I", prepared by Pedley-Knowles; or approved equal. Application shall follow manufacturer's recommendation.
- N. All penetrations through walls into or out of corrosive locations, as defined in Section 16010 shall be made gas-tight. In concrete walls, pour concrete after the conduit is in place, if possible. If not, core drill concrete or CMU walls, install conduit and caulk around it with non-shrink grout. Install conduit seal in each conduit near the penetration.
- O. All conduit penetrations through interior walls and floors shall be sealed with fire retardant type conduit sealant.
- P. Conduit Seals:
1. Moisture Seals: Provide in accordance with NEC Paragraph 300.5(g).
 2. Gas Seals: Provide in accordance with NEC Paragraph 501.5.
- Q. Aluminum conduit shall not be installed underground or encased in concrete. If necessary to run through concrete, install in a non-metallic conduit sleeve or use PVC coated conduit.
- R. Rigid PVC conduit shall be stored on a flat surface and shielded from the sun.

CONDUIT USE TABLE 1

Circuit Type	Inside Buildings						
	Exposed			Concealed			
	Standard	Corrosive	Hazardous	Above Suspended Ceilings	In Stud Walls	Embedded In Concrete	Slab On Grade
Power & 120 Vac Control	GRS or Aluminum**	PVC Coated GRS or Aluminum**	PVC Coated GRS or Aluminum**	PVC-80 or GRS	GRS	PVC-40 or PVC-80	PVC-40 or PVC-80
Signal	GRS or Aluminum**	PVC Coated GRS or Aluminum**	PVC Coated GRS or Aluminum**	GRS	GRS	GRS	GRS

CONDUIT USE TABLE 2

Circuit Type	Outside Buildings			Transition
	Exposed	Buried In Soil	Duct Bank Encased In Concrete	Within 5 Feet of Building
Power & 120 Vac Control	PVC Coated GRS, Aluminum** or Fiberglass**	PVC Coated GRS	PVC-40	PVC Coated GRS
Signal	PVC Coated GRS, Aluminum** or Fiberglass**	PVC Coated GRS	GRS	PVC Coated GRS

* Provide ground wire sized per NEC requirements for all circuits.

** Aluminum and/or Fiberglass may be used in corrosive locations where environmental conditions warrant its use.

Notes:

1. Generally, the Conduit Use Tables apply.
2. Signal circuits are those subject to RF interference or induced current. MSPs, TSPs, telephone cable, coaxial cable, and manufacturer's cables specially designed for low level signals are all presumed to be part of signal circuits.
3. Provide fiberglass conduit where indicated on the Drawings.

3.02 WIREWAY INSTALLATION

- A. Straight sections and fittings shall be solidly bolted together to be mechanically rigid and electrically continuous. Dead ends shall be closed. Unused conduit openings shall be plugged.
- B. Wireways shall be supported every 5 feet.
- C. Wireways and auxiliary gutters shall not contain wiring or control devices and shall not extend over 30 feet in length.

END OF SECTION

SECTION 16120

LOW VOLTAGE WIRE AND CABLE

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. Furnish labor, materials, equipment, and incidentals necessary to install wire and cable specified under this Section. Electrical work shall be in accordance with Specification 16010 – General Electrical Requirements.
- B. Work shall include building wire, cable, wiring connections and terminations, and modular wiring systems.

1.02 REFERENCE STANDARDS

- A. ASTM International (ASTM):
 - 1. B3-74 Specification for Soft or Annealed Copper Wire
 - 2. B8-77 Specification for Concentric Lay Stranded Copper Conductors, Hard, Medium-Hard, or Soft
 - 3. B173-71 Specification for Rope Lay Stranded Copper Conductors Having Concentric Stranded Members
- B. Insulated Cable Engineers Association (ICEA):
 - 1. S-66-524 Cross-Linked Thermosetting Polyethylene Insulated Wire and Cable
- C. International Electrical Testing Association (NETA);
 - 1. ATS Acceptance Testing Specifications
- D. National Electrical Manufacturers Association
 - 1. WC-3 Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
 - 2. WC-5 Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
- E. Underwriters Laboratories (UL) Standards:
 - 1. 62 Flexible Cords and Fixture Wire
 - 2. 510 Insulating Tape
 - 3. 1063 Stranded Conductors for Machine Tool Wire

1.03 SUBMITTALS

- A. Submit the following material or equipment data:
 - 1. Each type of cable and wire to be used.
 - 2. Cable and wire splices.
 - 3. Wire markers.

1.04 DELIVERY, STORAGE AND HANDLING

- A. The Contractor shall protect all cable and wire from being damaged at all times.
- B. Cable ends shall be protected from water entry in accordance with the manufacturer's recommended procedures. Cable ends shall not be left open in manholes or other locations subject to submergence. If the cable ends become

submerged prior to splicing or termination, the cables shall be replaced in their entirety.

- C. Cables shall be pulled into raceways in accordance with the manufacturer's requirements. Under no circumstances shall cable pulling tensions exceed the manufacturer's written instructions.
- D. Pulling tensions on raceway cables shall be within the limits recommended by the cable manufacturer. Wire pulling lubricant, where needed, shall be UL approved.

PART 2 - PRODUCTS

2.01 CONDUCTORS

- A. General: Conductors, include grounding conductors, shall be stranded copper. Aluminum conductor and/or solid conductor wire and cable will not be permitted. Insulation shall bear the UL label, the manufacturer's trademark, and identify the type, voltage, and conductor size. Conductors except flexible cords and cables, fixture wires, and conductors that form an integral part of equipment such as motors and controllers shall conform to the requirements of Article 310 of the National Electric Code, latest edition, for current carrying capacity. Flexible cords and cables shall conform to Article 400, and fixture wires shall conform to Article 402. Wiring shall have wire markers at each end.
- B. Power and Control Conductors, 600 Volts and Below:
 - 1. Solid copper wires shall be 600-volt Type XHHW, sizes #12 and #10 AWG for use with lighting and receptacle circuits only.
 - 2. Stranded copper wire for power circuits shall be 600-volt Type XHHW or RHW, Class B stranding, sizes #12 AWG and larger.
 - 3. Stranded copper wire for control circuits shall be 600-volt Type XHHW or RHW, Class B stranding, size #14 AWG.
 - 4. Control wires inside panels and cabinets shall be machine tool grade type MTW, UL approved, rated for 90 degrees C at dry locations.
 - 5. Fixture wire shall be 600-volt, silicone rubber insulated, 200°C, UL Type SF 2, with stranded copper conductors.
 - 6. Cords shall be 600-volt, 2 conductor plus ground, Type SO, hard service, of adequate length and with grounding type plug attached, rated in amperes as shown on the Drawings.
 - 7. Conductors for feeders as defined in Article 100 of the NEC shall be sized to prevent a voltage drop exceeding 3 percent at the farthest outlet of power, heating, and lighting loads, or combinations of such loads, and where the maximum total voltage drop on both feeders and branch circuits to the farthest connected load does not exceed 5 percent.
 - 8. Conductors for branch circuits as defined in Article 100 of the NEC shall be sized to prevent voltage drop exceeding 3 percent at the farthest connected load or combinations of such loads and where the maximum total voltage drop on both feeders and branch circuits to the farthest connected load does not exceed 5 percent.

2.02 SPLICES AND TERMINATIONS OF CONDUCTORS

A. Splices:

1. Wire and Cable Splicing Materials and Applications:
 - a. For Lighting Systems and Power Outlets: Wire nuts shall be twist-on type insulated connectors utilizing an outer insulating cover and a means for connecting and holding the conductors firmly. They shall be UL listed and suitable for connecting two to four solid copper conductors of #14 or #12 AWG size or two or three #10 AWG solid copper conductors.
 - b. All Equipment: Crimp type connectors shall be insulated type with nylon jacket, suitable for the size and material of the wires and the number of wires to be spliced and for use with either solid or stranded conductors. They shall be UL listed.
 - c. Division 16 Equipment and Power Conductors: Bolted pressure connectors shall be suitable for the size and material of the conductors to be spliced. They shall be UL listed and of the split bolt or bolted split sleeve type in which the bolt or set screw does not bear directly on the conductor.
 - d. All Equipment: Epoxy splice kits shall include epoxy resin, hardener, and mold, and shall be suitable for use in wet locations and hazardous locations.
2. Terminal Cabinets: Provide terminal cabinets per Section 17510. Termination system shall include insulated, crimp-type connectors. Coordinate the lug and boards for correct fit. All terminations shall include marker sleeves.

B. Terminations:

1. Low Voltage Terminations:
 - a. Crimp type terminals shall be UL listed, self-insulating sleeve type, with ring or rectangular type tongue, suitable for the size and material of the wire to be terminated, and for use with either solid or stranded conductors.
 - b. Terminal lugs shall be UL listed and of the split bolt or bolted split sleeve type in which the bolt or set screw does not bear directly on the conductor. Tongues shall have NEMA standard drilling.
 - c. Crimp with manufacturer recommended ratchet-type tool with calibrated dies. Hand crimping tools are not acceptable.
- C. Tape used for splices and terminations shall be compatible with the insulation and jacket of the cable and shall be of plastic material. Tape shall conform with UL 510. Varnished cambric, rubber and thermoplastic tape shall be used for all split-bolt terminations.
- D. Wire markers shall be heat shrink type (Raychem; T&B; or equal). Wire identification numbers shall be permanently imprinted on the markers. In locations which are not practical for heat shrink type labels, such as conduit bodies and small pull boxes, machine-printed, adhesive backed wire markers shall be used. Markers shall be custom-printed with the full identification string. Individual character markers and clip-on wire markers are not acceptable.

PART 3 - EXECUTION

3.01 CONDUCTOR INSTALLATION

- A. The Contractor shall provide, terminate, and test all power, control, and instrumentation conductors.
- B. The Contractor shall, as a minimum, provide the number of control wires listed in the conduit schedule or on the Contract Drawings. Excess wires shall be treated as spares for future use.
- C. Conductors shall not be pulled into any raceway until raceway has been cleared of moisture and debris.
- D. Wire in panels, cabinets, and wireways shall be neatly grouped using nylon tie straps, and shall be neatly fanned out to terminals.
- E. Single conductor cable in cable trays shall be No. 1/0 or larger and shall be of a type listed and marked for use in cable trays. Tray cable smaller than 1/0 shall be multi-conductor, with outer jacket.
- F. Provide the following types and sizes of conductors for the uses indicated for 600 volts or less:
 - 1. Solid Copper, Sizes #12 and #10 AWG: As shown on the Drawings for circuits for receptacles, switches and light fixtures with screw-type terminals.
 - 2. Stranded Copper, Size #14 AWG and Larger, Individual Conductors or CC: As shown on the Drawings for the control of motors or other equipment. Size #14 shall not be used for power supplies to any equipment.
 - 3. Stranded Copper, Sizes #12 AWG and Larger: As shown on the drawings for motors and other power circuits.
 - 4. Stranded Copper, #6 AWG and Larger.
 - 5. Fixture Wire: For connections to all fixtures in which the temperature may exceed the rating of branch circuit conductors.
- G. Color Coding: All wire shall be coded with specific colors infused in the conductor insulation at the time of manufacture. If a conductor is specified in a gauge not available with integrally colored insulation, it shall be marked by the Contractor at the time of installation using colored electrical coding tape or an approved marking paint. Where tape or paint is used as the conductor identification system, it shall clearly distinguish the conductor over its entire exposed length in all junction boxes, manholes, conduit bodies, or other accessible intermediate locations, and at every termination. All wiring shall conform to the following wiring color code:

SYSTEM	CONDUCTOR	COLOR
120/240 Volt AC, 1-Phase, 3 Wire	Neutral Line 1 Line 2	White Black Red
120/208 Volt AC, 3-Phase, 4 Wire;	Neutral Phase A Phase B Phase C	White Black Red Blue
277/480 Volt AC, 3-Phase 4 Wire	Neutral Phase A Phase B Phase C	Grey Brown Orange Yellow

SYSTEM	CONDUCTOR	COLOR
All Systems	Earth, System, or Equipment Ground	Green Insulation, Green w/ Yellow Tracer, or Bare Conductor
120 Volt AC Control Power Circuits (In field or in Control Cabinets)	Neutral Line 1 Line 2	White Black Red
120 Volt AC UPS-derived Control Power (secondary side)	Neutral Line	White w/ Red Tracer Red w/ White Tracer
24 VAC Control Power Circuits (In field or in Cabinets)	Neutral Line	White or Grey, with Yellow Tracer Brown
12 or 24 Volt DC Control Wiring (PLC Discrete I/O, etc.)	DC Negative DC Positive DC Switched (DI/DO)	Yellow Orange Blue
120 Volt AC Control Wiring inside or outside cabinets to/from PLC Discrete I/O	Common or Neutral 120 VAC discrete inputs 120 VAC relay or discrete outputs	White or Grey, w/ Blue Tracer Blue Red
Instrumentation Twisted-shielded Cabling (PLC Analog I/O @ 4-20mA, or 1-5 Volt DC, etc.) Process Signals to/from Transmitters, Analyzers, etc.	Negative Polarity Positive Polarity (1st Conductor) Positive Polarity (2nd Conductor) Shield Drain Wire	Black White (or clear) Red Bare Conductor, or covered w/ heat-shrink tubing of a unique color
Instrumentation wiring in cabinets (PLC Analog I/O from field terminations of shielded cables).	PLC Analog Input Connections PLC Analog Output Connections	Grey Brown

- H. Exercise care in pulling wires and cables into conduit or wireways so as to avoid kinking, putting undue stress on the cables or otherwise abrading them. No grease will be permitted in pulling cables. Only soapstone, talc, or UL listed pulling compound will be permitted. The raceway construction shall be complete and protected from the weather before cable is pulled into it. Swab conduits before installing cables and exercise care in pulling, to avoid damage to conductors.
- I. Wrap all cables in manholes with fireproofing tape. Extend tape 1-inch into ducts.
- J. Cable bending radius shall be per applicable code. Install feeder cables in one continuous length unless splices are favorably reviewed.
- K. Provide an equipment grounding conductor, whether or not it is shown on the Drawings, in any flexible conduit or any raceway in which all or any portion of a run consists of non-metallic duct or conduit. For flexible conduit, an external bonding jumper is an acceptable alternative.
- L. In panels, bundle incoming wire and cables, No. 6 AWG and smaller, lace at intervals not greater than 6 inches, neatly spread into trees and connect to their

respective terminals. Allow sufficient slack in cables for alterations in terminal connections. Perform lacing with plastic cable ties or linen lacing twine. Where plastic panel wiring duct is provided for cable runs, lacing is not necessary when the cable is properly installed in the duct.

- M. For cables crossing hinges, utilize extra flexible stranded wire, make up into groups not exceeding 12, and arrange so that they will be protected from chafing and excess flexing when the hinged member is moved.

3.02 CONDUCTOR SPLICES AND TERMINATIONS

- A. Splices: Install all conductors without splices unless necessary for installation, as determined by the Engineer. Splices, when permitted, and terminations shall be in accordance with the splice or termination kit manufacturer's instructions. Splice or terminate wire and cable as follows:
 - 1. Watertight Splices: Splices in concrete pullboxes, for any type of cable or wire, shall be watertight and rated for continuous submergence. Make splices in low voltage cables using epoxy resin splicing kits rated for application up to 600 volts.
- B. Terminations:
 - 1. Terminate stranded #14 wire using crimp type terminals where not terminated in a box lug type terminal. Terminals must be coordinated with type of terminal board where provided.
 - 2. Excess control wire shall be long enough to terminate at any terminal block in the enclosure, be properly taped, be identified with origin and be neatly coiled.

3.03 CONDUCTOR IDENTIFICATION

- A. Except for interior lighting and receptacle circuits, identify each wire or cable at each termination and in each pullbox, junction box, handhole, and manhole using numbered and lettered wire markers. All electrically common conductors shall have the same number. Each electrically different conductor shall be uniquely numbered. Identify panelboard circuits using the panelboard identification and circuit number. Identify motor control circuits using the equipment identification number assigned to the control unit by the motor control center manufacturer and the motor control unit terminal number. Identify other circuits as shown in the circuit schedule or as favorably reviewed by the Engineer.
- B. Conductors between terminals of different numbers shall have both terminal numbers shown at each conductor end. The terminal number closest to the end of the wire shall be the same as the terminal number.

3.04 FIELD TESTS

- A. Refer to Specification 16950 – Electrical Tests for all cable testing requirements.

END OF SECTION

SECTION 16124

SIGNAL CABLE

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Provisions: Applicable provisions of Section 16010 become a part of this Section as if repeated herein.
- B. Related Work Described Elsewhere:
 - 1. Division 17: Instrumentation and Controls

1.02 REFERENCE STANDARDS

- A. American National Standards Institute (ANSI)/Telecommunications Industry Association (TIA):
 - 1. 568-C.2 Balanced Twisted-Pair Telecommunications Cabling and Components Standards
- B. ASTM International (ASTM):
 - 1. B8-11 Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
- C. Institute of Electrical and Electronic Engineers (IEEE):
 - 1. 1143 Shielding Practice for Low Voltage Cables, Guide on
- D. Insulated Cable Engineers Association (ICEA)
 - 1. S-73-532 Standard for Control, Thermocouple, Extension, and Instrumentation Cable
- E. National Fire Protection Association (NFPA):
 - 1. 262 Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces
- F. Underwriters Laboratories Incorporated (UL):
 - 1. 13 Standard for Power-Limited Circuit Cables
 - 2. 83 Thermoplastic-Insulated Wires and Cables
 - 3. 444 Communications Cables
 - 4. 1666 Standard for Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts

1.03 SUBMITTALS

- A. Submit material or equipment data in accordance with the Product Information category of the General Conditions and the submittal requirements of Section 16010.

PART 2 - PRODUCTS

2.01 INSTRUMENTATION CABLE

- A. Provide UL listed, twisted pair instrumentation Tray Cable (TC) conforming to ICEA S-73-532, and suitable for transmission of 4-20mA analog, low voltage signals.

- B. The cable shall be two-conductor (2/C), three-conductor (3/C), four-conductor (4/C), or more as indicated on the Drawings.
- C. Each conductor in the cable shall be #16 AWG 7x24 stranded bare copper, or as indicated on the Drawings.
- D. Conductor insulation: Polyvinyl Chloride/Nylon.
- E. Shield: Aluminum Foil, 100 percent coverage.
- F. Drain wire: #18 AWG, stranded, tinned copper.
- G. Jacket material: Polyvinyl Chloride, minimum thickness 0.047 inch.
- H. Insulation shall be rated at 300 volts.
- I. Temperature rating: UL dry, 90 degrees C; UL web, 75 degrees C
- J. Instrumentation cable installed in underground conduits shall be rated as suitable for the application.
- K. Instrumentation cable shall be Belden 3090A, 3091A, or approved equal.

2.02 ETHERNET (TCP/IP) CABLE

- A. Office/Admin use:
 - 1. Provide UL listed, Category 6 unshielded twisted pair (UTP) Ethernet cable conforming to ANSI/TIA-568-C.2 and suitable for use indoors.
 - 2. Conductors: 4 pairs of #23 AWG solid bare copper
 - 3. Conductor insulation: Fluorinated Ethylene Propylene
 - 4. Jacket material: Polyvinyl Chloride, factory marked at regular intervals indicating verifying organization and performance level.
 - 5. Insulation shall be 300-volt class.
 - 6. Insulation temperature range: 0 to 50 degrees C
 - 7. Electrical Characteristics: Maximum attenuation of 20 dB per 100 meters at 100 MHz and 33 dB per 100 meters at 250 MHz
 - 8. Terminations/Connectors: Cables shall terminate in Category 6 RJ-45 crimp connectors with strain-relief boots, or at Category 6 punch down blocks at both ends.
 - 9. Cable shall be plenum-rated for flammability in accordance with NFPA 262, and suitable for use as riser cable.
 - 10. Ethernet cable installed in underground conduits shall be rated as suitable for the application.
 - 11. Office/Admin area Ethernet cable shall be Belden 1874A or approved equal.
- B. Industrial use, unshielded:
 - 1. Provide UL listed, Category 6 unshielded twisted pair (UTP) Ethernet cable conforming to ANSI/TIA-568-C.2 and suitable for use in harsh environments.
 - 2. Conductors: 4 pairs of #23 AWG solid bare copper
 - 3. Conductor insulation: Fluorinated Ethylene Propylene, minimum thickness 0.01 inches
 - 4. Jacket material: Fluorinated Ethylene Propylene, factory marked at regular intervals indicating verifying organization and performance level. Minimum thickness 0.03 inch.
 - 5. Insulation shall be 300-volt class.
 - 6. Insulation temperature range: -55 to +150 degrees C
 - 7. Electrical Characteristics: Cable shall have a maximum attenuation of 20 dB per 100 meters at 100 MHz and 33 dB per 100 meters at 250 MHz.

8. Terminations/Connectors: Cables shall terminate in Category 6 RJ-45 crimp connectors with strain-relief boots, or at Category 6 punch down blocks at both ends.
 9. Cable shall be plenum-rated for flammability in accordance with NFPA 262, and suitable for use as riser cable.
 10. Ethernet cable installed in underground conduits shall be rated as suitable for the application.
 11. Industrial, unshielded Ethernet cable shall be Belden 7931A or approved equal.
- C. Industrial use, shielded:
1. Provide UL listed, Category 6 shielded twisted pair (STP) Ethernet cable conforming to ANSI/TIA-568-C.2 and suitable for use in electrically noisy environments.
 2. Conductors: 4 pairs of #23 AWG solid bare copper.
 3. Conductor insulation: Polypropylene, minimum thickness 0.01 inch.
 4. Inner jacket material: Polyvinyl Chloride, minimum thickness 0.02 inch.
 5. Shield: Aluminum Foil, 100 percent coverage.
 6. Drain wire: #24 AWG, stranded, tinned copper.
 7. Outer jacket material: Industrial grade Polyvinyl Chloride, factory marked at regular intervals indicating verifying organization and performance level. Minimum thickness 0.03 inch.
 8. Insulation shall be 300-volt class.
 9. Insulation temperature range: -25 to +75 degrees C.
 10. Electrical Characteristics: Cable shall have a maximum attenuation of 20 dB per 100 meters at 100 MHz and 33 dB per 100 meters at 250 MHz.
 11. Terminations/Connectors: Cables shall terminate in ruggedized Category 6 RJ-45 connectors, or at Category 6 punch down blocks at both ends. Connector body shall be diecast zinc alloy, and nickel plated for corrosion resistance. Contacts shall be gold plated.
 12. Cable shall be riser-rated for flammability in accordance with UL 1666, not suitable for use in plenum spaces.
 13. Ethernet cable installed in underground conduits shall be rated as suitable for the application.
 14. Industrial, shielded network cable shall be Belden 7953A or approved equal.

2.03 SPECIAL CABLES

- A. Cables for proprietary control or fieldbus protocols over a TCP/IP network shall be Ethernet cables.
- B. Cables required for computer systems, control equipment, or other special systems not listed above shall be provided in accordance with the system manufacturer's requirements.

PART 3 - EXECUTION

3.01 CABLE INSTALLATION

- A. Signal cable shall be installed by personnel who have a minimum of 3 years' experience in terminating and splicing shielded twisted pair cables and coaxial cables.

- B. Adequate care shall be exercised by the installers to prevent cable damage or sheath distortion. Bending radius shall not be less than 10 times the cable outside diameter.
- C. Raceways shall be swabbed before installation of cable to remove moisture and debris.
- D. Cables shall be continuous from initiation to termination without splices except where specifically indicated.
- E. Cable shielding shall be grounded at one end only of the cable. Bonding shall be to a single ground point only. Bonding from cable to cable in multiple run installations shall not be permitted.
- F. Heat shrinkable sleeving shall be installed on all cables to insulate shielding at the ungrounded cable terminations.
- G. Signal cable shall not be run in the same raceway with power and control wiring except where specifically indicated.
- H. Where installed in control consoles containing power circuits, cables shall be routed a minimum of 2 inches distant. Color coding shall be strictly observed throughout the installation.
- I. Cable in panels, cabinets, and wireways shall be neatly grouped using nylon tie straps, and shall be fanned out to terminals.
- J. Manufacturer's cable pulling tension shall not be exceeded.
- K. Pulling lubricant shall be UL approved.

3.02 CONDUCTOR SPLICES AND TERMINATIONS

- A. Splices: Install all conductors without splices unless necessary for installation, as determined by the Engineer. Splices, where approved, and terminations shall be in accordance with the splice or termination kit manufacturer's instructions.
- B. Terminations:
 - 1. Crimp-type terminals shall be UL listed, self-insulating, sleeve type with ring or rectangular tongue, suitable for size and material of the wire to be terminated and for use with either stranded or solid wire. Spade type lugs are acceptable with telephone cable systems only.
 - 2. Crimp with manufacturer's recommended ratchet-type tool with calibrated dyes. Hand crimping tools are not acceptable.
 - 3. Coaxial cable and connectors shall be terminated in accordance with the manufacturer's instructions.

3.03 CONDUCTOR IDENTIFICATION

- A. Identify each wire or cable at each termination, in each pullbox, and in each handhole using numbered and lettered wire markers. All electrically common conductors shall have the same number. Each electrically different conductor shall be uniquely numbered. Identify panelboard circuits using the panelboard identification and circuit number. Identify motor control circuits using the equipment identification number assigned to the control unit by the motor control center manufacturer and the motor control unit terminal number. Identify other circuits as shown in the circuit schedule or as favorably reviewed by the Engineer.

Conductor numbering shall be coordinated with the Interconnection Diagrams specified in Division 17.

- B. Conductors between terminals of different numbers shall have both terminal numbers shown at each conductor end. The terminal number closest to the end of the wire shall be the same as the terminal number.

3.04 FIELD TESTS

- A. Perform testing in accordance with Section 16950 – Electrical Tests.

END OF SECTION

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SECTION 16140

WIRING DEVICES

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Provisions: Applicable provisions of Section 16010 become a part of this Section as if repeated herein.
- B. Work Included:
 - 1. Installation, connection and furnishing all single, duplex, GFI and special purpose receptacles complete with wall plates and/or covers as shown on the Drawings.
 - 2. Installation, connection and furnishing of all single pole, three-way, pilot light and momentary position toggle switches complete with wall plates and or handle operators as shown on the Drawings.

1.02 REFERENCE STANDARDS

- A. American National Standards Institute (ANSI) Publication:
 - 1. C73 Plugs and Receptacles
 - 2. C73a Plugs and Receptacles
 - 3. 568 Communication Cables
- B. Federal Specifications (FS):
 - 1. W-C-596 D & E General Specifications for Cable Outlet Electrical Connector
 - 2. W-S-896 D & E General Specifications for Flush Mounted Toggle and Lock Switches
- C. National Electrical Manufacturers Association (NEMA) Publications:
 - 1. WD 1 General Color Requirements for Wiring Devices
 - 2. WD 6 Wiring Devices - Dimensional Specifications
- D. Underwriters Laboratories (UL) Standards:
 - 1. 20 General-Use Snap Switches
 - 2. 498 Standard for Attachment Plugs and Receptacles
 - 3. 514 Electrical Outlet Boxes
 - 4. 943 Ground-Fault Circuit-Interruptioners

1.03 SUBMITTALS

- A. Submit material or equipment data in accordance with the Product Information category of the General Requirements and the submittal requirements of Section 16010.
- B. Submit complete catalog cuts of switches, receptacles, enclosures, covers, and appurtenances, marked to clearly identify the proposed materials.
- C. Submit documentation showing that the proposed materials comply with the requirements of the NEC and UL.

1.04 LOCATIONS

- A. Refer to Section 16010, General Electrical Requirements, for definitions of types of locations.

PART 2 - PRODUCTS

2.01 RECEPTACLES

- A. General: Receptacles shall be heavy duty, high abuse, grounding type conforming to NEMA configurations, NEMA WD1 and UL 514 Standards.
- B. Single and Duplex Receptacles:
 - 1. Receptacles shall be of back and side wire design utilizing screw type terminals. Receptacles shall be rated 20 ampere, two-pole, 3-wire, 120-volt, NEMA 5-20 configuration, self-grounding. Color shall be brown in industrial areas and ivory or white in office and laboratory areas. Power contacts shall be a T-type design and shall be brass. Ground contacts shall be brass.
 - 2. Devices shall have a nylon composition face with a nylon or melamine body. Units shall comply with Federal Specification W-C-596E and meet UL 498 test requirements. Receptacles shall be Hubbell HBL Series; Daniel Woodhead; or equal.
- C. Special Purpose Receptacles: Receptacles shall be of the amperage, voltage and NEMA configuration indicated on the Drawing. Compliance to standards and tests shall be as listed in Item B above.
- D. GFI Receptacles:
 - 1. Device shall be rated 20 ampere, 2-pole, 3-wire, 120-volt, conforming to NEMA WD-1 configuration. Face shall be nylon composition meeting UL 498 test standards. Unit shall have test and reset push buttons. Reset push button shall have a visible indicator band to indicated tripped condition.
 - 2. GFCI component shall meet UL 498 Class A standards with a tripping time of 1/40 second at 5 milliamperes current unbalance. Operating range shall extend from 31°F to 158°F. Unit shall have transient voltage protection and shall be ceramic encapsulated for protection against moisture.
 - 3. Provide Hubbell 5362SG, Daniel Woodhead, or equal.
- E. Isolated Ground Receptacles: Units shall comply with standards listed in Item B above, but shall have the ground contacts well isolated from the body mounting strap and shall be connected only to the separate grounding screw. Face color shall be orange to identify this feature. Provide Hubbell Catalog No. IG5262, IG5362; Daniel Woodhead; or equal.
- F. Corrosion Resistant Receptacles: Units shall comply with standards listed in Item B above, but shall also have tin-nickel plated brass connecting equipment and stainless steel hardware. Receptacle face color shall be yellow to identify the device as having these special qualities. Provide Hubbell Catalog No. HBL52CM62 and HBL53CM62; Daniel Woodhead; or equal.
- G. Load Break Power Receptacles: Special purpose receptacles shall be of the amperage and voltage rating, number of poles, and pin configuration indicated on the Drawings. Units shall be supplied with matching plugs and shall be capable of interrupting, without any device damage, the full amperage rating.

- H. Surface Multiple Outlet Assemblies: Units shall have outlets on center-to-center spacing as indicated on the Drawings. Assembly shall conform to Article 353 of the NEC and receptacles shall conform to the standards listed in Item A above.

2.02 SWITCHES

- A. Line Voltage Types: Switches shall be rated 20 amperes at 120 or 277 Volts ac only. Units shall be flush mounted, self-grounding, quiet operating toggle devices. Handle color shall be brown in industrial areas and white or ivory in office and laboratory areas. Units shall conform to Federal Specifications W-S-896 D and E, UL 20, and NEMA WD1 standards. Hubbell PRO Series; Daniel Woodhead; or equal.
- B. Low Voltage Types: Switches shall meet all the requirements listed in Item A above except to be rated at 15 amperes for switching 24 Volts dc. Devices shall be three-position, momentary contact, spring return, center "off" configuration.

2.03 PLATES

- A. General: Plates shall be of the style and color to match the wiring devices, and of the required number of gangs. Plates shall conform with NEMA WD1, UL 514, and ANSI C73. Plates on finished walls shall be non-metallic or stainless steel. Plates on unfinished walls and on fittings shall be of zinc plated steel or cast metal having rounded corners and beveled edges.
- B. Non-Metallic: Plates shall be smooth finish with contoured edges and shall be nylon or fiberglass.
- C. Stainless Steel: Plates shall be 0.035 inches thick with beveled edges and shall be manufactured from No. 302 alloy having a brushed or satin finish.
- D. Galvanized: Plates shall be galvanized sheet steel raised 1/2 inch, with rounded corners.
- E. Cast Metal: Plates shall be cast or malleable iron covers with gaskets so as to be moisture resistant or weatherproof.
- F. Blank Plates: Cover plates for future telephone or television outlets shall match adjacent device wall plates in appearance.
- G. Damp or Wet and Corrosive Locations: Plates shall be provided with a hinged non-metallic cover/enclosure marked with "Suitable for Wet Locations when in use" and "UL Listed." Provide a gasket between the enclosure and the mounting surface, and between the hinged cover and mounting plate/base. The cover shall be TayMac Specification Grade; or equal.

PART 3 - EXECUTION

3.01 INSTALLATION OF WIRING DEVICES

- A. Rigidly attach wiring devices in accordance with the NEC and as indicated, avoiding interference with other equipment.
- B. Dry Locations: The device shall be installed in flush mounted boxes with washers as required to bring the device mounting strap level with the surface of the finished wall.

- C. Damp or Wet Exterior Locations: Install only wiring devices approved for outdoor service in these locations.
- D. Mounting Heights: Locations of wall outlets shall be measured from the finished floor to the center of the outlet box. Boxes shall be adjusted so that the front edge of the box shall not be further back from the finished wall plane than 1/4 inch. Boxes shall be adjusted so that they do not project beyond the finished wall. Boxes located in CMU walls are to be located bottom or top at the mortar line closest to the dimension listed. Height above finished floor shall be according to elevation view in drawings.
- E. Damp or Wet Interior Locations: Install only wiring devices approved for outdoor service. Adjust boxes so that front edge will be 1/4 inch beyond the rear edge of the finished wall. Use metal tubing sleeves to bring device mounting straps flush with the front edge of the finished wall.
- F. Receptacles:
 - 1. Receptacles shall be grounded by a grounding conductor, not by a yoke or screw contact.
 - 2. Receptacles shall be oriented so that the grounding slot is located at the top of the outlet.
 - 3. Receptacles shall be installed with connections pigtailed (spliced) to the branch circuit wiring so that removal of the receptacle will not lose neutral continuity and branch circuit power will not be lost to other receptacles on the same circuit.

3.02 INSTALLATION OF WALL PLATES

- A. General: Plates shall match the style of the device and shall be plumb within 1/16-inch of the vertical or horizontal.
- B. Interior Dry Locations: Install plates so that all four edges are in continuous contact with the finished wall surfaces. Plaster filling will not be permitted. Do not use oversize plates or sectional plates.
- C. Exterior and/or Wet Locations: Install plates with gaskets on wiring devices in such a manner as to provide a raintight weatherproof installation. Cover type shall match box type.
- D. Future Locations: Install blanking cover plates on all unused outlets.

3.03 GROUNDING

- A. Devices including switches and receptacles, shall be grounded in accordance with NEC, Article 250, and Specification 16450.
- B. Switches and associated metal plates shall be grounded through the switch mounting yoke, outlet box, and raceway system.
- C. Flush Receptacles
 - 1. Flush receptacles and their metal plates shall be grounded through positive ground connections to the outlet box and grounding system.
 - 2. Maintain the ground to each receptacle by a spring-loaded grounding contact to the mounting screw, or by a grounding jumper, each making a positive connection to the outlet box and grounding system at all times.

- D. Receptacles served from an uninterruptible power supply shall be provided with an isolated grounding conductor from the serving power panelboard.

3.04 TESTS

- A. See Specification 16950 for Testing Requirements.

END OF SECTION

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SECTION 16721

FIRE ALARM CONTROL SYSTEM

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Provisions: Applicable provisions of Section 16010 become a part of this Section as if repeated herein.
- B. Work Included:
 - 1. Furnish conventional (non-addressable) fire alarm control panel, heat detectors, manual pull stations, and annunciators to provide a complete fire alarm detection system.
 - 2. System shall be capable of integrating initiating devices from fire suppression sprinkler system specified in Section 15330.

1.02 RELATED WORK DESCRIBED ELSEWHERE

- A. Section 15330: Deluge Fire Suppression Sprinkler System

1.03 REFERENCE STANDARDS

- A. American National Standards Institute (ANSI) Publication:
 - 1. C2 National Electrical Safety Code
- B. National Fire Protection Association (NFPA) Publications:
 - 1. 13 Installation of Sprinkler Systems
 - 2. 70 National Electrical Code
 - 3. 72A Local Protective Signalling Systems
 - 4. 72D Proprietary Signalling Systems
 - 5. 72E Automatic Fire Detectors
 - 6. 101 Life Safety Code

1.04 SUBMITTALS

- A. Submit material or equipment data in accordance with the Product Review category of the General Conditions and the submittal requirements of Section 16010.
- B. Shop Drawings: Shop drawings shall include wiring diagrams, elementary diagrams and complete descriptions of components.
- C. As-Built Diagrams and Manuals: Upon completion of work and prior to final testing and inspection, furnish as-built drawings showing the exact sequence of all initiating devices as they were installed in the circuits.
- D. Software: Provide all hardware, software, programming tools and documentation necessary to modify the fire alarm system on site. Modification includes addition and deletion of devices, circuits, zones and changes to system operation and custom label changes for devices or zones. The system structure and software shall place no limit on the type or extent of software modifications on-site. Modification of software shall not require power-down of the system or loss of system fire protection while modifications are being made.

1.05 GUARANTY

- A. All work performed and all material and equipment furnished under this contract shall be free from defects and shall remain so for a period of at least one (1) year from the date of acceptance.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All equipment shall be listed by the State Fire Marshal, UL listed, FM listed, and tested by a nationally recognized fire test laboratory.

2.02 EQUIPMENT AND MATERIAL, GENERAL

- A. All equipment and components shall be new, and the manufacturer's current model. The materials, appliances, equipment, and devices shall be tested and listed by a nationally recognized approvals agency for use as part of a fire protective signaling system, meeting the National Fire Alarm Code.
- B. All equipment and components shall be installed in strict compliance with manufacturers' recommendations. Consult the manufacturer's installation manuals for all wiring diagrams, schematics, physical equipment sizes, etc., before beginning system installation.
- C. All equipment shall be attached to walls and ceiling/floor assemblies and shall be held firmly in place (e.g., detectors shall not be supported solely by suspended ceilings). Fasteners and supports shall be adequate to support the required load.
- D. All equipment must be available "over the counter" through the Security Equipment Distributor (SED) market and can be installed by dealerships independent of the manufacturer.

2.03 CONDUIT AND WIRE

- A. Conduit
 - 1. Conduit shall be in accordance with The National Electrical Code (NEC), local and state requirements.
 - 2. Where required, all wiring shall be installed in conduit or raceway. Conduit fill shall not exceed 40 percent of interior cross-sectional area where three or more cables are contained within a single conduit.
 - 3. Cable must be separated from any open conductors of power, or Class 1 circuits, and shall not be placed in any conduit, junction box or raceway containing these conductors, per NEC Article 760-29.
 - 4. With the exception of telephone connections, wiring for 24-volt DC control, alarm notification, emergency communication and similar power-limited auxiliary functions may be run in the same conduit as initiating and signaling line circuits. All circuits shall be provided with transient suppression devices and the system shall be designed to permit simultaneous operation of all circuits without interference or loss of signals.
 - 5. Conduit shall not enter the fire alarm control panel, or any other remotely mounted control panel equipment or backboxes, except where conduit entry is specified by the FACP manufacturer.
 - 6. Conduit shall be 3/4-inch (19.1 mm) minimum.

- B. Wire:
 - 1. All fire alarm system wiring shall be new.
 - 2. Wiring shall be in accordance with local, state, and national codes (e.g., NEC Article 760) and as recommended by the manufacturer of the fire alarm system. Number and size of conductors shall be as recommended by the fire alarm system manufacturer, but not less than 18 AWG (1.02 mm) for Initiating Device Circuits and 14 AWG (1.63 mm) for Notification Appliance Circuits.
 - 3. All wire and cable shall be listed and/or approved by a recognized testing agency for use with a protective signaling system.
 - 4. Wire and cable not installed in conduit shall have a fire resistance rating suitable for the installation as indicated in NEC 760 (e.g., FPLR).
 - 5. All field wiring shall be electrically supervised for open circuit and ground fault.
- C. Terminal Boxes, Junction Boxes, and Cabinets:
 - 1. All boxes and cabinets shall be UL listed for their purpose.
- D. The fire alarm control panel shall be connected to a separate dedicated branch circuit, maximum 20 amperes. This circuit shall be labeled at the main power distribution panel as FIRE ALARM. Fire alarm control panel primary power wiring shall be 12 AWG. The control panel cabinet shall be grounded securely to either a cold water pipe or grounding rod. The control panel enclosure shall feature a quick removal chassis to facilitate rapid replacement of the FACP electronics.

2.04 CONTROL PANEL

- A. The FACP shall be a Fire-Lite Model MRP-2001 and shall communicate with and control the following types of equipment used to make up the system: detectors, manual release stations, alarm notification appliances, releasing components, and other system controlled devices.
 - 1. The control panel shall be a UL listed and FM approved microprocessor-controlled Pre-action/Deluge Control Panel.
 - 2. It shall be field programmable to perform the following options: Cross-Zone, Dual Hazard, and Discharge Timer.
 - 3. Function: The control panel shall perform the following functions:
 - a. Supervise and monitor all initiating device circuits and alarm notification circuits for trouble and alarm conditions.
 - b. Supervise the release solenoid(s).
 - c. Detect the operation of any initiating device circuit and the location of the alarm condition. Operate all notification appliances and release devices as designed.
 - d. Visually and audibly annunciate any trouble, supervisory or alarm condition on panel display.
- B. System Capacity: The Control Panel shall include six programmable initiating device circuits, four programmable output circuits, three programmable Form-C relays, A 7.0 Amp integral power supply and 80-character LCD.
 - 1. The IDCs (Initiating Device Circuits) shall be individually programmable as conventional two-wire smoke detector circuits, as well as any dry contact input device. Examples of dry contact input devices include four-wire smoke detectors, manual pull stations, heat detectors, pressure switches, and waterflow switches. The IDCs shall support Style D (Class A) operation by adding an expansion board. The IDCs shall support conventional two-wire smoke detectors, as well as conventional smoke detectors capable of

generating a maintenance signal when the detector becomes dirty and a separate supervisory 'freeze' signal when ambient temperature falls below the detector rating of approximately 45 degrees F.

2. The four programmable outputs shall be individually programmable as conventional supervised NACs (Notification Appliance Circuits) or for releasing solenoids. Each NAC may be individually programmed as any of the following: Silence Inhibit, Auto-Silence, Strobe Synchronization, Selective Silence (horn-strobe mute), Temporal or Steady Signal, Silenceable or Non-silenceable, or Release Stage Sounder. The system shall also provide resettable and non-resettable output power for general use.
3. The FACP shall be capable of coding Notification Appliance Circuits in March Time Code (120 PPM), Temporal (NFPA 72), and California Code. Main panel notification circuits (NACs 1, 2, 3 & 4) shall also automatically synchronize any of the following manufacturer's notification appliances connected to them: System Sensor, Wheelock, Gentex, Faraday and Amseco, with no need for additional synchronization modules.
4. The three programmable relays shall be individually programmable as Alarm, Trouble, Supervisory, Discharge, and AC Power Loss. When programmed as a Trouble relay, the relay shall be fail-safe.
5. The on-board power supply shall be capable of 7.0 Amps of regulated, filtered power.

C. System Display

The system shall have six LED indicators as well as an 80-character LCD (Liquid Crystal Display). The LCD shall be capable of displaying a custom description for each input and output circuit. The system LEDs shall indicate the status of the following system parameters:

AC POWER	Green LED
FIRE ALARM	Red LED
DISCHARGE	Red LED
SUPERVISORY	Yellow LED
TROUBLE	Yellow LED
ALARM SILENCED	Yellow LED

1. The main system display shall be an integral, 80-character LCD with a keypad. The keypad shall have full programming capability without requiring the use of a laptop computer.
2. The FACP shall include a history log with a 256-event storage. The history shall be accessible from the main system display.
3. The system shall include a real-time clock/calendar with daylight savings time control.

D. System Control Switch Operation.

1. ACK/Step Silence Switch:
 - a. Activation of the control panel tone silence switch in response to alarms troubles and supervisory conditions shall silence the local panel piezo electric signal and change the LED from flashing mode to steady-ON mode. Occurrence of any new conditions in the system shall cause the control panel to resound the Local Piezo sounder and repeat the alarm, trouble, or supervisory sequences.
 - b. Depression of the Acknowledge switch shall also silence all remote annunciator piezo sounders.

2. Alarm Silence Switch: Activation of the alarm signal silence switch shall cause all alarm notification appliances to return to the normal condition after an alarm condition.
 3. System Reset Switch: Activation of the System Reset Switch shall cause all electronically-latched initiating devices, as well as all associated output devices and circuits, to return to their normal condition. Holding system reset switch down shall perform a LAMP TEST function and will activate the piezo sounder.
 4. Drill Activate Switch: The Drill activate switch shall activate both notification circuits and alarm relays in the system. Drill function shall latch until the panel is silenced or reset.
 5. Lamp Test: The System RESET switch shall also function as a Lamp Test switch and shall activate all system LEDs and light each segment of the liquid crystal display.
- E. System Operation
1. Zone Status LEDs: The alarm, supervisory, or trouble LED(s) shall flash until event(s) have been acknowledged LED(s) shall then illuminate steady. Any subsequent alarm, supervisory or trouble will flash the new event only.
 2. Supervisory: A short circuit on this zone shall cause the supervisory LED and zone 4 yellow LED to flash, and shall activate the supervisory notification circuit. An open circuit shall report as a zone trouble.
 3. Zone Disable: Disable/Enable shall be accomplished for any input circuit by a special sequence of the 4 control switches. If a zone has been disabled, an alarm shall activate the red zone LED, but not the piezo or any output circuit.
- F. Programming and System Commissioning
1. The FACP shall have a configuration option which allows the user to program the FACP with one of seven factory preprogrammed templates or one custom template which can be programmed by the user. Templates shall include:
 - SINGLE HAZARD - 3 ZONE
 - CROSS-ZONE WITH MANUAL RELEASE SWITCH
 - DUAL HAZARD - COMBINED RELEASE
 - DUAL HAZARD - SPLIT RELEASE
 - SINGLE HAZARD - 3 ZONES AND LOW PRESSURE
 - SINGLE HAZARD - 2 ZONES CROSS-ZONES WITH ALL ACTIVE
 - SINGLE HAZARD - DUAL ZONE
- G. The control panel shall support the following modules:
1. 80-character Remote LCD Annunciator which mimics the FACP main display.
 2. I/O LED Driver which provides LED outputs for connection to a custom graphics annunciator.
 3. Printer Module which provides a serial output for connection to a UL listed event printer.
 4. Relay Module which provides 10 form C relays
 5. LED Annunciator Module which mounts on the FACP door and provides three LEDs for each zone: Alarm, Trouble and Supervisory.
 6. Optional Digital Communicator (complies with NFPA 72).
 7. Optional transmitter module which complies with NFPA-72 Auxiliary and Remote Station Protective Signaling systems.
 8. Optional Class A Converter Module.

- H. The control panel shall also include the following functions:
1. Output circuits shall be protected against false activations by using a 2-step electronic activation circuit.
 2. Battery/Earth fault supervision shall be provided.
 3. Adjustable discharge timer shall be available, 10 to 15 minutes.
 4. Cross zone option shall be available (two zones in alarm before release).
 5. Dual hazard option shall be available (separate initiating and release groups).
 6. 7 AH to 26 AH battery options shall be available, providing up to 90 hours standby.
 7. Watchdog timer to supervise microprocessor shall be provided.
- I. Remote Field Charging Power Supply
1. The remote field charging power supply shall be a Fire-Lite FCPS-24S6 or FCPS-24S8. The FCPS-24S6/8 shall be used to provide power to audio visual devices or any other device on the system whenever the power requirements exceed those provided by the FACP.
 2. The FCPS-24S6 shall offer up to 6.0 amps continuous current of regulated, filtered, 24-volt power. It shall include an integral charger designed to charge 7.0- to 18.0-amp hour batteries and to support 60-hour standby.
 3. The FCPS-24S8 shall offer up to 8.0 amps continuous current of regulated, filtered, 24-volt power. It shall include an integral charger designed to charge 7.0 to 18.0 amp hour batteries and to support 60-hour standby.
 4. The Field Charging Power Supply shall provide regulated and filtered 24 VDC power to four notification appliance circuits configured as either four Class B (Style Y) or Class A (Style Z, with ZNAC-4 option module). Alternately, the four outputs may be configured as all non-resettable, all resettable, or two non-resettable and two resettable.
 5. The Field Charging Power Supply shall include an attractive surface mount backbox.
 6. The Field Charging Power Supply shall include the ability to delay the AC fail delay per NFPA requirements.
 7. The Field Charging Power Supply shall include power limited circuitry, per UL standards.
 8. The Field Charging Power Supply shall provide UL-Listed NAC synchronization using System Sensor, Wheelock, or Gentex "Commander2" appliances.
- J. Stand Alone Voice Evacuation Control Panel
1. A stand-alone Voice Evacuation Control Panel shall be available from the same manufacturer of the main fire alarm system.
 2. This Voice Control Panel shall work stand alone or as a slave to the Main Control Panel.
 3. Shall have as minimum requirements:
 - a. Integral 25 Watt, 25 Vrms audio amplifier.
 - b. Speaker circuit that can be wired either Class A or B.
 - c. Integral Digital Message Generator with a capacity of up to 60 seconds. The Digital Message Generator shall be capable of primary and secondary messages (30 seconds each). These messages shall field programmable without the use of additional equipment.
 - d. Built in alert tone generators with steady, slow woop, high/low and chime tone field programmable.
 - e. Integral Diagnostic LEDs for Power, System Trouble, Message Generator Trouble, Tone Generator Trouble, and Alarm.

4. The Voice Control Panel shall be fully supervised including microphone, amplifier output, message generator, speaker wiring, and tone generators.
 5. Speaker outputs shall be fully power-limited.
- K. Power Supply
1. The power supply for the control panel shall be integral to the control panel itself, and shall provide all control panel and peripheral device power needs.
 2. Input power shall be 120 VAC, 60 HZ. The power supply shall provide an integral battery charger for use with batteries up to 26 AH. The FACP shall also be available in 220/240VAC, 60 Hz.
 3. It shall provide 7.0 amperes of regulated 24 VDC power for release solenoids and notification devices, Four-Wire smoke detector power 24 VDC up to 400 mA, non-resettable power 24 VDC up to 400 mA.
 4. The power supply shall be designed to meet UL and NFPA requirements for power-limited operation on all notification and initiating circuits.
 5. Positive-temperature-coefficient thermistors, circuit breakers, fuses, or other over-current protection shall be provided on all power outputs.
- L. Mechanical Design:
1. The control panel shall be housed in a cabinet designed for mounting directly to a wall or vertical surface. The back box and door shall be constructed of 0.060 steel with provisions for electrical conduit connections into the sides and top. The door shall provide a key lock and shall include a glass or other transparent opening for viewing of all indicators. The cabinet shall be approximately 5.25 inches (13.34 cm) deep and 16.8 inches (42.67 cm) wide. Height shall be approximately 19.25 inches (48.90 cm). An optional trim ring shall be used for flush mounting of cabinet. Space shall be provided in the cabinet for 7 AH or 18 AH batteries. If 26 AH batteries are used, a separate battery enclosure shall be available from the same manufacturer.

2.05 BATTERIES

- A. Shall be 12 volt, Gell-Cell type (2 required).
- B. Battery shall have sufficient capacity to power the fire alarm system for not less than 90 hours plus 5 minutes of alarm upon a normal AC power failure.
- C. The batteries are to be completely maintenance free. No liquids are required. Fluid level checks refilling, spills and leakage shall not be required.

2.06 SYSTEM COMPONENTS

- A. Horns, Strobes, and Horn/Strobes
 1. General: All horns, strobes and horn/strobes shall be System Sensor SpectrAlert Advance series. Horns, strobes, and horn/strobes shall mount to a standard 4 x 4 x 1½-inch back box, 4-inch octagon back box or double-gang back box. Two-wire products shall also mount to a single-gang 2 x 4 x 1 7/8-inch back box. A universal mounting plate shall be used for mounting ceiling and wall products. The notification appliance circuit wiring shall terminate at the universal mounting plate. Indoor SpectrAlert Advance products shall operate between 32 and 120 degrees Fahrenheit from a regulated DC, or full-wave rectified, unfiltered power supply. Strobes and horn/strobes shall have field-selectable candela settings including 15, 15/75, 30, 75, 95, 110, 115, 135, 150, 177, 185.

2. Horn/Strobe Combination: The horn/strobe shall be a System Sensor SpectrAlert Advance Model P2R listed to UL 1971 and UL 464 and shall be approved for fire protective service. The horn/strobe shall be wired as a primary-signaling notification appliance and comply with the Americans with Disabilities Act requirements for visible signaling appliances, flashing at 1Hz over the strobe's entire operating voltage range. The strobe light shall consist of a xenon flash tube and associated lens/reflector system. The horn shall have three audibility options and an option to switch between a temporal three-pattern and a non-temporal (continuous) pattern. These options are set by a multiple position switch. On four-wire products, the strobe shall be powered independently of the sounder. The horn on horn/strobe models shall operate on a coded or non-coded power supply.
 3. Outdoor Horns, Strobes, and Horn/Strobes: SpectrAlert Advance outdoor horns, strobes and horn/strobes shall be listed for outdoor use by UL and shall operate between minus 40 degrees and 151 degrees Fahrenheit. The products shall be listed for use with a System Sensor outdoor/weatherproof back box with half inch and three-fourths inch conduit entries.
 4. Synchronization Requirements: All Horns, Strobes, and Horn/Strobes shall be synchronized without the need for additional synchronization hardware or modules. Synchronization shall be provided by the MRP-2001 FACP Power Supply or from an additional field power supply. All Horns, Strobes, and Horn/Strobes shall be synchronized at 1Hz and horns at temporal three. Also, while operating the strobes, the FACP shall silence the horns on horn/strobe models over a single pair of wires.
- B. Manual Fire Alarm Stations
1. Manual Fire Alarm Stations shall be FIRE-LITE BG-12 series and be non-code, with a key- or hex-operated reset lock in order that they may be tested, and so designed that after actual Emergency Operation, they cannot be restored to normal except by use of a key or hex. An operated station shall automatically condition itself so as to be visually detected as activated.
 2. Manual stations shall be constructed of red colored LEXAN (or polycarbonate equivalent) with clearly visible operating instructions provided on the cover. The word FIRE shall appear on the front of the stations in white letters, 1.00 inch (2.54 cm) or larger.
 3. Stations shall be suitable for surface mounting on matching backbox SB-10 or SB-I/O; or semi-flush mounting on a standard single-gang, double-gang, or 4-inch (10.16 cm) square electrical box, and shall be installed within the limits defined by the Americans with Disabilities Act (ADA) or per national/local requirements. Manual Stations shall be Underwriters Laboratories listed.
- C. Automatic Conventional Heat Detectors
1. Mechanical heat detector shall be a System Sensor 5600 series model, listed to Underwriters Laboratories UL 521 for Heat Detectors for Fire Protective Signaling Systems.
 2. The detector shall be either a single-circuit or a dual-circuit type, normally open. The detector shall be rated for activation at either 135°F (57°C) or 194°F (90°C), and shall activate by means of a fixed temperature thermal sensor, or a combination fixed temperature/rate-of-rise thermal sensor. The rate-of-rise element shall be activated by a rapid rise in temperature, approximately 15°F (8.3°C) per minute.
 3. The detector shall include a reversible mounting bracket for mounting to 3½-inch and 4-inch octagonal, single gang, and 4-inch square back boxes

- with a square-to-round plaster ring. Wiring connections shall be made by means of SEMS screws that shall accommodate 14–22AWG wire.
4. The detector shall contain alphanumeric markings on the exterior of the housing to identify its temperature rating and activation method.
 5. The rate-of-rise element of combination fixed temperature/rate-of-rise models shall be restorable, to allow for field-testing. The detectors shall include an external collector that shall drop upon activation to identify the unit in alarm.
- D. Waterflow Switches:
1. Waterflow Switches shall be an integral, mechanical, non-coded, non-accumulative retard type.
 2. Waterflow Switches shall have an alarm transmission delay time which is conveniently adjustable from 0 to 60 seconds. Initial settings shall be 30-45 seconds.
 3. All waterflow switches shall come from a single manufacturer and series.
 4. Waterflow switches shall be provided and connected under this section but installed by the mechanical contractor.
 5. Where possible, locate waterflow switches a minimum of 1 foot (305 mm) from a fitting which changes the direction of the flow and a minimum of 3 feet (914 mm) from a valve.
- E. Sprinkler and Standpipe Valve Supervisory Switches:
1. Each sprinkler system water supply control valve riser, zone control valve, and standpipe system riser control valve shall be equipped with a supervisory switch. Standpipe hose valves, and test and drain valves shall not be equipped with supervisory switches.
 2. PIV (post indicator valve) or main gate valves shall be equipped with a supervisory switch.
 3. The switch shall be mounted so as not to interfere with the normal operation of the valve and adjusted to operate within two revolutions toward the closed position of the valve control, or when the stem has moved no more than one-fifth of the distance from its normal position.
 4. The supervisory switch shall be contained in a weatherproof aluminum housing, which shall provide a 3/4-inch (19 mm) conduit entrance and incorporate the necessary facilities for attachment to the valves.
 5. The switch housing shall be finished in red baked enamel.
 6. The entire installed assembly shall be tamper-proof and arranged to cause a switch operation if the housing cover is removed, or if the unit is removed from its mounting.
 7. Valve supervisory switches shall be provided and connected under this section and installed by mechanical contractor.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation shall not begin until the State Fire Marshal Listing for all equipment and plans and specifications have been approved by the Fire Marshal's office in County and the State of Washington Fire Marshal's Office.
- B. Installation of wiring and equipment shall conform to Article 760 of NFPA 70 and Article 210 of NFPA Standard No. 72.

- C. Minimum conductor size shall be #16 AWG for the alarm initiating circuits and #14 AWG for output circuits to audio/visual annunciators.
- D. All wiring shall be in conduit. Terminations in control panels shall be made on terminal strips with a separate point for each conductor.
- E. Mount all end of line resistor boxes where they will be readily accessible at all times and at 54 inches above the finished floor.
- F. Install no automatic detection equipment on its ceiling mounting plate until the associated room has been painted and cleaned. A minimum of 2% or two (whichever is larger) automatic detection elements shall be given to the Owner as spares.
- G. Installation shall be in accordance with the NEC, NFPA 72, local and state codes, as shown on the Drawings, and as recommended by the major equipment manufacturer.
- H. All fire detection and alarm system devices, control panels and remote annunciators shall be flush mounted when located in finished areas and may be surface mounted when located in unfinished areas.
- I. At the final inspection, a factory trained representative of the manufacturer of the major equipment shall perform the tests in Section 3.02 TESTING.

3.02 TESTING

- A. Provide the service of a competent, factory-trained engineer or technician authorized by the manufacturer of the fire alarm equipment to technically supervise and participate during all the adjustments and tests for the system.
 - 1. Before energizing the cables and wires, check for correct connections and test for short circuits, ground faults, continuity, and insulation.
 - 2. Close each sprinkler system flow valve and verify proper supervisory alarm at the FACP.
 - 3. Verify activation of all flow switches.
 - 4. Open initiating device circuits and verify that the trouble signal actuates.
 - 5. Open and short notification appliance circuits and verify that trouble signal actuates.
 - 6. Ground device circuits and verify response of trouble signals.
 - 7. Open release solenoids and verify response of trouble signals.
 - 8. Check presence and audibility of tone at all alarm notification devices.
 - 9. Check installation and supervision of heat detectors to ascertain that they will function as specified.
 - 10. Conduct tests to verify trouble indications for common mode failures, such as alternating current power failure.
 - 11. Each of the alarm conditions that the system is required to detect should be introduced on the system. Verify the proper receipt and that the release solenoid(s) will activate.
- B. Software Modifications: Provide the services of a qualified technician to perform all system software modifications, upgrades, or changes. Response time of the technician to the site shall not exceed 4 hours.
- C. Any equipment proving defective shall be immediately replaced with new equipment at no additional cost to the Owner.

3.03 FINAL INSPECTION

- A. At the final inspection, a factory trained representative of the manufacturer of the major equipment shall demonstrate that the systems function properly in every respect.

3.04 INSTRUCTION

- A. Provide instruction as required to the building personnel. "Hands-on" demonstrations of the operation of all system components and the entire system shall be provided.

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SECTION 17010

INSTRUMENTATION AND CONTROLS, GENERAL REQUIREMENTS

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Work Included:
 - 1. Provide all tools, equipment, materials, and supplies and be responsible for all labor required to complete the installation, startup and operational testing of a complete and operable Instrumentation and Control (I&C) System as indicated on the Drawings and as specified herein.
 - 2. Provide all the necessary equipment components and interconnections along with the services of manufacturers' engineering representatives necessary to ensure that the Owner receives a completely integrated and operational I&C system as herein specified.
 - 3. Provide all terminations for wiring at field mounted instruments, equipment enclosures, alarm and status contacts.
 - 4. Provide all Instrumentation and Control wire required for a fully functioning Instrumentation and Controls System as shown on the Drawings except for wire specifically specified in Division 16. See Section 16010.
- B. Work Specified in Other Divisions:
 - 1. Process piping, installation of inline instrumentation, and other mechanical work and equipment as specified in Divisions 11, 13, or 15.
 - 2. Division 16 work, including all instrumentation and controls conduit, and only that wire specified in Division 16. Refer to Division 16 Specifications for specific requirements for wire, conduit, grounding, and other electrical equipment.
 - 3. General mechanical requirements as specified in Section 11001.
- C. Definitions:
 - 1. INSTRUMENTATION DETAILS: These are general instrumentation details for the project that the Contractor shall adhere to when installing instruments applicable to where the situation is encountered. Any deviations from these details shall require written notice to the Engineer/Owner prior to installation.

1.02 REFERENCE STANDARDS

- A. American National Standard Institute (ANSI) Publications:
 - 1. Y14.15a Drafting Practice
 - 2. C62.1 Surge Arrestors
- B. Instrumentation Society of America (ISA) Publications:
 - 1. S5.4 Instrument Loop Diagrams
 - 2. S20 Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves

1.03 I&C SUBCONTRACTOR QUALIFICATIONS

- A. I&C Subcontractor shall be an electrical contractor who has demonstrated experience in purchasing, calibrating, fabricating, installing, and testing the Instrumentation and Control (I&C) products listed in this Specification Section. Normally, I&C Subcontractor is a systems house regularly engaged in the business

of panel fabrication, control component procurement, programmable logic controller and personal computer (PC) application in the process control industry.

- B. The I&C Subcontractor has been regularly engaged for a period greater than 5 years in performing all aspects of the type of work specified in this Section and shown on the Drawings and must be qualified as specified below.
- C. The I&C Subcontractor shall submit:
 - 1. Proof in the form of names and references of jobs over the past 5 years where this work was accomplished
 - 2. Present samples and an explanation of representative work performed
 - 3. Submit the name and qualifications (resumes) of the proposed employees of the firm who would be responsible for the day-to-day work
 - 4. An explanation of how the I&C Subcontractor will carry out and implement the responsibilities described in Paragraph 1.04 below.
- D. Under this section, the I&C Contractor shall furnish the following:
 - 1. Instrumentation equipment (Section 17110, 17120, and 17140)
 - 2. Control panels (Section 17510).
 - 3. Spare parts.
 - 4. Special tools and test equipment required by the supplier.
 - 5. Installation and testing.
 - 6. Documentation.
 - 7. Operator training.
 - 8. Warranty (1 year).
 - 9. Shipping and receiving.
- E. All calibration and final checkout of the process control and instrumentation system shall be witnessed by the Owner's Representative to determine whether the system complies with the contract documents.

1.04 I&C SUBCONTRACTOR SYSTEM RESPONSIBILITIES

- A. General: The I&C equipment as specified in this Division shall be considered an integrated system. Entire system installation including calibration, verification, startup, operation testing, and training shall be performed by qualified personnel, possessing all the necessary skills and equipment, and who have had experience performing similar installations. Instrumentation and control systems drawings are diagrammatic only; it is the responsibility of the Contractor to obtain technical data, determine performance requirements, develop instrumentation detail installation designs, and coordinate the selection of specified equipment with Contractor supplied equipment to meet the design conditions stated.
 - 1. Owner will hire the Plant-Wide SCADA I&C Contractor. Plant-Wide SCADA I&C Contractor shall be Quality Control Corporation (QCC). Contact person is Ben Dearden, 425.967.7107, email is bend@quality-controls.com.
 - 2. I&C Subcontractor shall coordinate with QCC creating timelines to provide necessary information to complete the project.
 - 3. I&C Subcontractor has the discretion to utilize QCC beyond the existing plant SCADA. See Section 1.05 for description of Plant wide SCADA I&C Contractor responsibilities.
- B. System Responsibilities:
 - 1. Instrumentation and control system drawings are diagrammatic only. Ensure that all components of the instrumentation system, including primary measuring, indicating, transmitting, receiving, recording, totalizing, controlling,

- and alarming devices and all appurtenances are completely compatible and shall function as outlined and shall furnish and install such additional equipment, accessories, etc., as are necessary to meet these objectives at no cost to the Owner.
2. Compatibility: See that all components of the instrumentation system, including equipment specified under other Divisions, are completely compatible and function properly as a system. Provide such additional equipment, accessories, etc., as are necessary to meet these objectives at no cost to the Owner.
 3. Coordination: For control components, devices, and systems specified in other Divisions or shown on the Drawings.
 - a. Provide technical advice to mechanical and electrical subcontractors as necessary regarding their installation of instruments.
 - b. Verify the correctness of installation of all instruments.
 - c. Verify that the proper type, size, and number of control wires with their conduits are provided.
 - d. Verify that proper electric power circuits provided for all components and systems.
 - e. Resolve all manufacturers' installation discrepancies between requirements and the detail requirements of the Drawings and Specifications.
 - f. Supervise final signal connections to all process instrumentation and control equipment.
 - g. Adjust, startup, and test all process instrumentation and control equipment.
 - h. Coordinate work with control system that are provided by vendors.
 - i. Provide specified documentation and training.
 4. Performance: While the Drawings provide sufficient information to establish the form and function of the systems and their relationships, the responsibility for system integration and performance rests solely with the Contractor. The Engineer may provide technical instruction and guidance where needed.
 5. Site and Instrument Inspection: Inspect site for conformance to Drawings, paying special attention to space allocation and dimensions required. Inspect completed work and verify that it is ready for installation of instruments and equipment. Inspect each instrument and piece of equipment for damage, defects, completeness, and correct operation before installing.

1.05 PLANT-WIDE SCADA I&C CONTRACTOR RESPONSIBILITIES

- A. The Plant-wide SCADA I&C Contractor shall be responsible for the existing plant SCADA system and development and coordination of the new PLC system with the existing SCADA system. Primarily responsibilities include:
 1. Purchase and install new software upgrades for the existing SCADA computers.
 2. Provide SCADA screen layouts for the existing SCADA computers and the new PLC and HMIs prior to I&C Contractor programming. Refer to Section 17330A.1 for SCADA screens required for this Work.
 3. Programming and developing all SCADA screens on the existing Plant-wide computers and HMI related to the new Contract Documents.
 4. Review I&C submittals and provide comments to the Engineer prior to response to the Contractor.
 5. Setup and integration of new networking devices with existing plant SCADA network.

6. Provide training of Plant Staff on new SCADA screens.
7. Perform field testing of SCADA network and screens.
8. Responsibilities will be completed within 4 weeks of Notification of Readiness according to Section 01650.

1.06 SUBMITTALS

- A. Refer to Section 01300 for required method of preparation and transmittal and conform to requirements herein.
- B. Shop Drawings: Submit shop drawings (diagrams) for review in complete bound sets indexed by Specification number, with exterior tabs marked by subject. Submit manufacturer's catalog cuts for each item for which shop drawings are not required. Manufacturer's catalog cuts, specifications or data sheets shall be clearly marked to delineate the options or styles to be furnished. Show dimensions, physical configurations, methods of connecting instruments together, mounting details, and wiring schematics. Drawings shall be complete with device tag numbers, wire numbers and terminal board numbers. Submit fabrication details, nameplate legends, and control panel internal wiring and piping schematic drawings. Submit panel graphic drawings where applicable. Include material lists and/or bills of material.
 1. Elementary Diagrams: Submit an elementary diagram (also known as a schematic diagram - see Sketch 17010-3) for control, protection, and monitoring circuits. Elementary diagrams are not required for lighting, communications and those systems clearly defined on the single line diagram. Show all interconnections between power sources, apparatus, and device elements of a particular system or equipment, and all interlocks with other systems in a manner which fully indicates circuit function and operation. Refer to the Drawings for functional and operational requirements.
- C. Specification Forms:
 1. Submit completed Specification Forms per ISA S20, including those instrumentation and control components directly related to process control, but specified in other Divisions of these Specifications.
 2. Include on each form the assigned tag numbers, manufacturer's part numbers, and device data. More than one tag numbered item may be included on a sheet.
- D. As-Built Drawings: Submit a revised set of shop drawings that incorporates all change orders and modifications made during performance of the work. In addition to updated loop diagrams, interconnect diagrams and elementary diagrams, submit equipment and device wiring diagrams (see Sketch 17010-4) and other drawings as necessary to depict the "as-built" condition of equipment. Include all installed field and panel conduit and piping/tubing runs and routing, tray systems, supports, mounting details, interconnection diagrams with cable, wire, tube and termination numbers. Coordinate all drawings with the conductor identification requirements in Section 16120 and Section 16124. Submit a copy of CAD produced drawings on USB in AutoCAD DWG format and transmit over email PDF shop drawing.
- E. Operation and Maintenance Manuals: Furnish Operation and Maintenance Manuals, including Instruction Manuals and Part Lists, for equipment provided under Division 17 as required by Division 1. Obtain data from manufacturers, and format and bind as specified. Obtain distribution method instructions from the Owner or his representative.

1. Schedule: Deliver at least two (2) copies of manuals in 3-ring binders (8-1/2 by 11-inch format) not later than the equipment shipment date.
 2. Contents: Include in manuals not less than the following information, as applicable, for each instrument, equipment, subsystem and/or control loop:
 - a. General, introduction and overall description, purpose, functions, simplified theory of operations, etc.
 - b. Specifications (including equipment specification data sheet as described above under Shop Drawings), sufficiently detailed for reordering exact duplicates of the original items.
 - c. Installation instructions, procedures, sequences, tolerances, and precautions.
 - d. Operational procedures.
 - e. Shutdown procedures.
 - f. Maintenance, calibration, and repair instructions.
 - g. Parts list and spare parts recommendations.
 - h. Calibration curves, rating tables, and any other data showing the relationship of the variable inputs and the calibrated output of all measuring devices and controlled equipment.
 3. Format:
 - a. Use drawings and pictorials to illustrate the text to the extent necessary to insure a clear, concise presentation. If manuals have been written to cover a family of similar instruments or equipment, strike out inapplicable information in a neat fashion or emphasize applicable portion by heavily weighted arrows, circles or boxes; whichever provides the clearest and neatest presentation.
 - b. Group manuals by system control panels, including field instrumentation connected or associated with the panel. Where identical instruments are used in more than one control loop or subsystem, include only one instruction manual, per panel grouping; however, an index by tag number for all instruments shall identify its location in that manual.
 - c. Provide control loop and/or subsystem operational descriptions to identify the function of each instrument and its relation to the other instruments in the loop.
 4. Binding: Bind each manual in a cover which indicates the panel or process area to which it applies, manufacturer's name, local address and telephone number, and year of purchase. Punch and bind manuals in standard three ring binders and include system name and subcontractor's name on binding.
- F. Accessory and Maintenance Materials: Submit data for the following items:
1. Special Tools and Accessories: Special tools, instruments, and accessories for maintaining instruments and equipment requiring periodic repair and adjustment as specified elsewhere herein. Also, furnish special lifting and handling devices for equipment requiring such devices.
 2. Maintenance Materials and Spare Parts: Submit a list of manufacturer recommended spare parts for each item specified. Refer to other sections of these Specifications.
- G. Test Reports: Submit the following test reports as described herein:
1. Instrument Calibration Data Sheets (para. 2.13)
 2. Factory Testing of Control Panels (para. 2.14)
 3. Instrument Verification Report (para. 3.08.B)
 4. Final Operational Testing (para. 3.08.C).

- H. Demonstration and Final Operation Test Plan and Results: Submit a document that outlines all procedures to be used in final operational testing of instrument and control systems. Include a description of each system, the scope of testing, test methods and materials, testing instruments and recorders, a list of functional parameters to be recorded on each item, and Shop Drawings showing temporary bypasses, jumpers, and devices.

1.07 QUALITY ASSURANCE

- A. Standard of Quality: The Contractor shall provide equipment of the types and sizes specified which has been demonstrated to operate successfully. Provide equipment which is new and of recent proven design.

1.08 INSPECTIONS

- A. The Engineer may inspect the fabricated equipment at the factory before shipment to job site. Provide the Engineer with sufficient prior notice so that an inspection can be arranged at the factory.
- B. Inspection of the equipment at the factory by the Engineer will be made after the manufacturer has performed satisfactory checks, adjustments, tests and operations.
- C. Favorable review of the equipment at the factory only allows the manufacturer to ship the equipment to the project site. The Contractor shall be responsible for the proper installation and satisfactory startup operation of the equipment to the satisfaction of the manufacturer and the Engineer.

1.09 DRAWINGS

- A. Drawings: The Instrumentation Drawings are diagrammatic; exact locations of instrumentation products shall be determined in the field by the Engineer. Except where special details are used to illustrate the method of installation of a particular piece or type of equipment or material, the requirements or descriptions in this Specification shall take precedence in the event of conflict.
 - 1. Locations of equipment, inserts, anchors, motors, panels, pull boxes, manholes, conduits, stub-ups, fittings, power and convenience outlets, and ground wells are approximate unless dimensioned; verify locations with the Engineer prior to installation. Field verify scaled dimensions on Drawings.
 - 2. Review the Drawings and Specification Divisions of other trades and perform the instrumentation work that will be required for the installations.
 - 3. Should there be a need to deviate from the Instrumentation Drawings and Specifications, submit written details and reasons for all changes to the Engineer for favorable review.
 - 4. Resolution of varying interpretations of the Contract Documents shall conform to Division 0, General and Supplementary Conditions.
 - 5. The Drawings provide details of installation and supersede the manufacturer's recommendation where a conflict exists.

1.10 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. Box, crate, or otherwise enclose and protect instruments and equipment during shipment, handling, and storage. Keep all equipment dry and covered from exposure to weather, moisture, corrosive liquids and gases or any element that could degrade the equipment. Protect painted surfaces against impact, abrasion, discoloration, and other damage. Notify the Engineer in writing in the event that

any equipment or material is damaged. Obtain prior favorable review by the Engineer before making repairs to damaged products.

1.11 INSTRUMENT SCHEDULE

Type	Description	Range	P&ID	Spec Section	Spec Para.
LT-232	Radar Level Transmitter, Magnesium Hydroxide Storage Tank	0-15 feet	I-101	17140	2.01
LSH-270	Level Switch High, Magnesium Hydroxide Contained Area Sump	-	I-101	17140	2.02
FSL-250	Flow Switch Low, MHD Metering Pump No.1 Discharge Line (NOTE 3, 4)	TBD	I-101	17120	2.01
FSL-250	Flow Switch Low, MHD Metering Pump No.2 Discharge Line (NOTE 3, 4)	TBD	I-101	17120	2.01
FI-2351	Rotameter. Flushing Water to Tank Spray Ball (NOTE 3))	0-40 gpm-	I-101	17120	2.02
FI-251	Rotameter. Flushing Water to MHD Suction line (NOTE 3)	0-15 gpm	I-101	17120	2.02
FI-252	Rotameter. Flushing Water to MHD Discharge line (NOTE 3)	0-15 gpm	I-101	17120	2.02
LT-310	Radar Level Transmitter, Sodium Hydroxide Storage Tank	0-10 feet	I-201	17140	2.01
FI-330	Rotameter. Carrier Water to SHD Discharge line	0-10 gpm	I-201	17120	2.02
LSH-300	Level Switch High, Chemical Storage Room Sump	-	I-201	17140	2.02
LSH-301	Level Switch High, Odor Control Room Chemical Sump	-	I-201	17140	2.02
LT-315	Radar Level Transmitter, Sodium Hypochlorite Storage Tank	0-10 feet	I-202	17140	2.01
FI-350	Rotameter. Dilution Water to SHP Injection Line	0-10 gpm-	I-202	17120	2.02

Notes:

1. Instrument Schedule is not intended to represent a bill of material or a complete list of all required instruments.
2. Setpoints are indicated in the control strategies. If setpoints are not identified in the control strategies, they will be confirmed during submittal review.
3. Instruments provided by Pump Manufacturer. Coordinate ranges and setpoints with manufacturer.
4. Connection of these instruments with the Control Panel shall be provided by the Contractor. Integration of these instruments with the PLC and SCADA shall be done by Plant Wide SCADA I&C Contractor.

PART 2 - PRODUCTS

2.01 MATERIALS AND STANDARD SPECIFICATIONS

- A. Provide instruments, equipment and materials suitable for service conditions and meeting standard specifications such as ANSI, ASTM, ISA, and SAMA. The intent of this Specification is to secure instruments and equipment of a uniform quality and manufacture throughout the plant. All instruments in the plant of the same type shall be made by the same manufacturer.

2.02 NAMEPLATES

- A. For each piece of equipment, provide a manufacturer's nameplate showing his name, location, the pertinent ratings and the model designation.
- B. Identify each piece of equipment and related controls with a rigid laminated engraved phenolic nameplate. Engrave nameplates with the inscriptions indicated on the Drawings and, if not so indicated, with the equipment name. Securely fasten nameplates in place using two stainless steel screws or, where favorably reviewed by the Engineer, with epoxy cement. Where no inscription is indicated on the Drawings, furnish nameplates with an appropriate inscription furnished by the Engineer upon prior request by the Contractor.

- C. Each control device, including pushbuttons, control switches, and indicating lights, shall have an integral legend plate or nameplate indicating the device function. These shall be inscribed as indicated on the Drawings or as favorably reviewed by the Engineer.
- D. Provide CAUTION or SAFETY nameplates to alert operators of special conditions that may result in faulty equipment operations. Devices containing batteries that must be replaced periodically must be clearly identified. Nameplates are not required if the device senses and displays a low battery warning.

2.03 NAME TAGS

- A. All instrumentation and equipment items or systems shall be identified by name tags. Field equipment shall be tagged with the assigned instrumentation tag number listed in the Instrument Schedule.
- B. Name tags shall be stainless steel with engraved or stamped black characters of 3/16-inch minimum height. Tags shall be attached to equipment with a tag holder and stainless steel band with a worm screw clamping device. Use 20-gauge stainless steel wire where banding is impractical. For field panels or large equipment cases use stainless steel screws; however, such permanent attachment shall not be on an ordinarily replaceable part.

2.04 FIELD-MOUNTED EQUIPMENT

- A. All instrument and control equipment mounted outside of protective structures shall be equipped with suitable surge arresting devices to protect the equipment from damage due to electrical transients induced in the interconnecting lines from lightning discharges or nearby electrical devices. Protective devices used on 120 Vac inputs to field mounted equipment shall be secondary valve surge protectors conforming to the requirements of ANSI C62.1.

2.05 EQUIPMENT OPERATING CONDITIONS

- A. All equipment shall be rated for normal operating performance with varying operating conditions over the following minimum ranges:
 - 1. Electrical Power: 120 Vac \pm 10%, 60 Hz, unregulated, except where specifically stated otherwise on the Drawings or in the Specifications, or when two-wire, loop-powered devices are specified.
 - 2. Field Instruments:
 - a. Outdoor Areas:
Ambient Temperature: +15°F to +120°F
Ambient Relative Humidity: 5% to 100%
Weather: Rain, sleet, snow and ice
 - b. Indoor Unheated Areas:
Ambient Temperature: +40°F to +120°F
Ambient Relative Humidity: 5% to 95%, non-condensing
 - c. Indoor Environmentally Controlled Areas:
Ambient Temperature: +60°F to +104°F
Ambient Relative Humidity: 10% to 90%, non-condensing

2.06 EQUIPMENT LOCATIONS

- A. Provide equipment and materials suitable for the types of locations in which they are located as defined under Division 16. All equipment specified for field mounting shall be weatherproof and splash proof as a minimum. If electrical or

electronic components are contained within the equipment, they shall be housed in NEMA 3R gasketed cases, NEMA 4X in corrosive locations, and NEMA 7 in hazardous locations unless noted otherwise on the Drawings.

2.07 ANALOG SIGNAL INDICATED UNITS

- A. For all instruments with local or remote indicators, provide indicators scaled in actual engineering units, i.e., gallons per minute, feet, psi, etc., rather than 0 to 100%, unless noted otherwise on the Drawings or Instrument Schedule.

2.08 SIGNAL TRANSMISSION

- A. Analog:
 - 1. Signal transmission between electric or electronic instruments shall be 4-20 mA and shall operate at 24 Vdc. Signal output from all transmitters and controllers shall be current regulated and shall not be affected by changes in load resistance within the unit's rating. Where practical, milliampere signals from the field shall be converted to a voltage signal at the external terminals of each panel, and all instruments within a panel shall be parallel wired.
 - 2. Nonstandard transmission systems such as impulse duration, pulse rate, and voltage regulated will not be permitted except where specifically noted in the Instrument Schedule or shown on the Drawings. When transmitters with nonstandard outputs do occur, their output shall be converted to 4-20 mA prior to transmission.
- B. Discrete: All alarm and status signals shall be 120 Vac unless specified otherwise on the Instrument Schedule. Proprietary data highway or serial bit transmissions such as RS232C shall be allowed to the extent shown on the Drawings.

2.09 PANEL/RACK/ENCLOSURE BAY POWER SUPPLIES

- A. Provide each main rack and/or enclosure bay with a separate isolation transformer to prevent ground loops between the instrument and electrical power grounds. These transformers may be nonshielded control power type.
- B. For each two-wire transmitter, provide a 24 Vdc regulated 50 mA power supply with 120 Vac input. Output voltage may be 24 Vdc $\pm 5\%$ manufacturing tolerance at no load, but shall hold within 1% from no load to full load at 120 Vac $\pm 10\%$ input. Line to-load regulation shall be within 0.1% from no-load to full load. Ripple shall be less than 15 mV peak-to-peak.
- C. Manufacturer: Provide Model AP9046 instrument loop power supply as manufactured by Action Instruments with plug-in mounting base, equivalent capacity Lambda power supply with terminal blocks for external connections, or equal.

2.10 PAINTING

- A. Factory paint all instruments and equipment except where installed in pipelines. Where instrument panels are installed adjacent to electrical control panels provided under Division 16, provide instrument panels of identical color to that of electrical control panels. Paint as required in Division 9 for structural supports, brackets, etc. Repair damaged factory paint to satisfaction of the Engineer. Feathering, priming and painting shall produce a reasonable match to the surrounding paint work.

2.11 FASTENERS

- A. Fasteners for securing equipment to walls, floors and the like shall be either hot-dip galvanized after fabrication or stainless steel. Provide stainless steel fasteners in corrosive locations. When fastening to existing walls, floors, and the like, provide capsule anchors, not expansion shields. Size capsule anchors to meet load requirements. Minimum size capsule anchor bolt is 3/8 inch.

2.12 TUBING, PIPE, FITTINGS, AND SUPPORTS

- A. General: Instrument tubing listed below is required for all instruments and control valves. Select the appropriate tubing materials to satisfy service conditions except where specifically shown on Installation Detail Drawing.
 - 1. Copper Tubing: Soft-annealed copper tubing shall be 1/4-inch O.D. x 0.030-inch wall, 3/8-inch O.D. x 0.032-inch wall, or 1/2-inch O.D. x 0.032-inch wall as shown on the Drawings. Copper tubing shall be seamless copper, Type DHP, bright annealed after coiling, dehydrated and sealed in 50-foot aluminum coils, per ASTM B75. Use for instrument or valve connections only.
 - 2. Copper Tubing: Hard drawn copper tubing shall be in accordance with ASTM B88. Sizes shall be 3/8-inch standard: 3/8-inch O.D. x 0.030-inch wall; 1/2-inch standard: 1/2 inch O.D. x 0.035 inch wall; or 5/8 inch standard: 5/8-inch O.D. x 0.040-inch wall in 20-foot straight lengths with plastic capped ends. Use for header or branch service only.
 - 3. Stainless Steel: Stainless tubing shall be Type 304 seamless, cold drawn and annealed per ASTM A269. Sizes shall be 1/4-inch O.D. x 0.045-inch wall, 3/8-inch O.D. x 0.035-inch wall or 1/2-inch O.D. x 0.035-inch wall. Use for instrument or valve connections.
 - 4. Pneumatic Tubing: Pneumatic tubing for panel internals shall be 1/4- or 3/8-inch O.D. rigidwall, clear polyethylene, 125 psi rating. Tubing shall be supported in plastic duct or conduit where appropriate. Use for enclosed or indoor instrument or valve connections.
 - 5. Fittings:
 - a. Copper Tube: Solder joint fittings shall be seamless wrought copper per ASTM B75. Compression fittings shall be Brass equal to Imperial or Swagelok.
 - b. Stainless Steel Tube: Weld joint fittings shall be Type 304 stainless. Compression fittings shall be Type 316 stainless steel equal to Imperial or Swagelok.
 - c. Supports for Tubing: Supports located in areas exposed to the weather or corrosive atmosphere shall be Type 304 stainless steel Unistrut or equal or made of steel conforming to ASTM A276. Supports not exposed to the weather or corrosive atmosphere shall be carbon steel painted.
 - d. Weld joint fittings shall be permitted for header and branch service only. Instrument and valve connections shall be compression-type only. Use unions on as necessary to simplify instrument removal.
 - 6. Valves:
 - a. Pipe, Pipe Fittings and Valves: Main-line piping material and root valves for instrumentation shall be as specified in Section 15050.
 - b. Instrument valves shall be 1/4-inch, 3/8-inch, or 1/2-inch from Whitey or Hoke to match tubing material and size.

2.13 INSTRUMENT CALIBRATION

- A. Each field instrument shall be calibrated at 0%, 25%, 50%, 75%, and 100% of span using test instruments to simulate inputs and read outputs that are rated to an accuracy of at least 5 times greater than the specified accuracy of the instrument being calibrated. Such test instruments have accuracies traceable to the National Institute of Standards and Technology (NIST).
- B. Submit a written report to the Engineer on each instrument. This report shall include a laboratory calibration sheet or the manufacturer's standards calibration sheet on each instrument and calibration reading as finally adjusted within tolerances.
- C. The Contractor may, at his option, choose to perform calibration on an instrument by acquiring the services of an independent test laboratory, or by obtaining the required test instruments and performing the calibration.

2.14 FACTORY TESTING OF CONTROL PANELS

- A. All fabricated equipment shall be tested before it leaves the factory. At the factory, verify wiring continuity and equipment operation by simulating input and output.
- B. Factory testing of control panels/devices/equipment shall be accomplished. Refer to individual Specification sections for tests requiring favorable review.
- C. Upon completion of factory testing, submit a report certifying the control panels/devices/equipment are operable and meet the Specifications.

PART 3 - EXECUTION

3.01 MOUNTINGS

- A. Mount and install equipment as indicated. Mount field instruments on pipe mounts or other similar means in accordance with suppliers' recommendation. Where mounted in control panels, mount according to requirements of that section.
- B. Equipment specified for field mounting shall be suitable for direct pipe mounting or surface mounting, surface-mounted indicators and equipment with calibration adjustments or requiring periodic inspection shall be mounted not lower than 3 feet 6 inches nor higher than 6 feet above walkways, platforms, catwalks, and the like.
- C. Note that applicable specifications require detail drawings showing seismic sway bracing design and anchorage requirements for their equipment. Seismic zone requirements are specified in Division 1.
- D. All devices shall be accessible to operators for servicing, operating, reading, etc. Provide permanent platforms to assure devices are continuously accessible.

3.02 PROCESS CONNECTIONS

- A. Provide instrument impulse tubing (see Part 2) to meet the intended process service and ambient environmental condition for corrosion resistance, etc. Install impulse tubing with a continuous slope according to service to promote self-draining or venting back to the process. Terminate connection to process lines or vessels in a service rated roof valve, provided under other Divisions, that will permit closing off the impulse line or removal of the element without requiring shut

down of the process. Include blowdown of drip legs and valves for terminations of impulse lines at the instruments.

- B. Process vessels, line penetrations, and root valves shall be furnished and installed under other Divisions of these Specifications. Instrument tubing and valve manifolds are installed as part of this Specification.

3.03 FIELD WIRING

- A. Ring out signal wiring prior to termination and perform surge withstand tests where required (see Section 16010, Part 3 for methods). Verify wire number and terminations are satisfactory as designated on the Loop and Interconnect Diagrams. Verify all terminations are tight and shields are uniformly grounded at one location.

3.04 ELECTROMAGNETIC INTERFERENCE (EMI)

- A. Construction shall proceed in a manner which minimizes the introduction of noise (RFI/EMI) into the I&C System.
- B. Cross signal wires and wires carrying ac power or control signals at right angles.
- C. Separate signal wires from wires carrying ac power or switched ac/dc control signals within control panels, terminal cabinets, telemetry equipment, multiplexer cabinets, and data loggers as much as possible. Provide the following minimum separations within such equipment unless indicated otherwise on the Drawings:

Power Wiring Capacity	Separation (Inches)
120 volts ac or 10 amps	12
240 volts ac or 50 amps	18
480 volts ac or 200 amps	24
4,160 volts ac or 800 amps	48

3.05 SIGNAL GROUNDING

- A. Proper grounding of equipment and systems in this Division is critical to proper equipment operation.
- B. A single-point grounding system for instrument signals is required for all instrument panels. This instrument single point grounding system does not use building steel or conduit systems for its ground path.
 - 1. Ground all signal shields, signal grounds, and power supplies at an isolated signal bus within each instrument panel, rack, or enclosure. See Section 17510 for isolated bus requirements. The shields at the far ends of these signal cables must be disconnected (floated) from any ground to prevent ground loops.
 - 2. Do not connect the rack or enclosure frames to the signal grounding buses.
 - 3. Connect each isolated signal ground bus within each panel using a stranded, insulated copper wire of size 6 AWG or larger directly to a system ground rod installed per the Drawings.
- C. If more than one instrument panel or rack is installed side-by-side, locate an isolated system grounding plate in one of the panels (see Section 17510 for requirements).

1. Connect all the isolated signal buses in such instrument panel or rack radially to the system ground plate using a stranded, insulated copper wire of size 8 AWG or larger.
2. Do not use conduit, cable raceways or building steel to distribute the grounding connections; use dedicated wires as specified above. Install a single conduit containing a #2 AWG insulated ground wire from the insulated grounding plate directly to a system ground rod installed per the Drawings. See Division 16 for conduit requirements.

3.06 PREPARATION

- A. Ensure that installation areas are clean and that concrete or masonry operations are completed prior to installing instruments and equipment. Maintain the areas in a broom-clean condition during installation operations.
- B. Panels shall be protected during construction to prevent damage to front panel devices and prevent dust accumulation in the intervals. Other protective measures (lamp, strip heaters, etc.) shall be included as weather conditions dictate.

3.07 FIELD TESTING

- A. General: The purpose of the field testing is to verify instruments are calibrated and operationally performing their intended function. Provide the services of factory trained and experienced engineers to perform verification and operational testing as prescribed below. Since the initial calibration of instruments may not satisfy the final operation of system, perform recalibration or adjust setpoints as required to satisfy the performance requirements of the system. Notify the Engineer and Owner in writing a minimum of 48 hours prior to the proposed date for commencing final operational testing and acceptance.
- B. System Verification Testing: Verify that each instrument shown on the Instrument Schedule is operating and calibrated as specified in the Instrument Schedule by simulating inputs at the primary element in each system loop and verify performance at loop output devices (i.e. recorder, indicator, alarm, etc., except controllers). Simulate inputs at 0%, 25%, 50%, 75%, and 100% of span or with on-off inputs, as applicable. During system verification:
 1. Make initial or provisional settings on levels, alarms, etc. listed in the Instrument Schedule.
 2. Verify controllers by observing that the final control element moves in the proper direction to correct the process variable as compared to the set point.
 3. Cause malfunctions to sound alarms or switch to standby to check system operation.
 4. Check all loop instruments thoroughly for correct operation.
 5. Control Strategy Tests
 - a. Control strategy testing is the responsibility of the Contractor after the Plant Wide SCADA I&C Contractor has completed their responsibilities according to Section 1.05. The Contractor shall provide full-time staff to support and conduct these tests. The Contractor shall operate all field equipment, inject simulated field signals, record results observed in the field, check the proper operation of field equipment, and promptly correct any deficiencies or problems found with Contractor-supplied equipment or work. The Contractor is responsible for performing all

- testing activities including test plans, test forms, test documentation, and test reporting.
- b. Fully test control strategies to ensure specified operation.
- 6. Immediately correct all defects and malfunctions disclosed by tests.
- 7. Submit a report certifying completion of verification of each instrument system. This report shall include a data sheet on each instrument tested that indicates instrument tolerances, instrument calibration verification, data and initial settings made to devices.
- C. Operational Testing during Startup: Upon completion of instrument verification, test all systems under process conditions in the presence of the Owner or designated representative. The intent of this test is to demonstrate and certify the operational interrelationship of plant instrumentation and control systems. This testing shall include, but not be limited to:
 - 1. Making final adjustments to levels, alarms, etc.
 - 2. Optimum tuning of controllers.
 - 3. Checking all alarms, failure interlocks, and operational interlocks.
 - 4. Verifying all computer input and outputs and CRT displays are fully functional.
 - 5. Test local area and wide area networks connecting SCADA server, workstations, and peripherals.
 - 6. Test the transfer of SCADA data across the network.
 - 7. Test functions of graphic displays on the SCADA workstations
 - 8. Immediately correcting all defects and malfunctions and retesting.
 - 9. Submit the witnessed test results and a transmittal letter indicating that all required systems have been tested satisfactorily and the systems meet all the functional requirements of their applicable specifications.

3.08 INSTRUCTION OF OWNER'S PERSONNEL

- A. Provide the services of a factory trained and field experienced instrumentation engineer to conduct group training of up to four of the Owner's designated personnel in the operation of each instrument system. This training shall be for the time period of 8 hours and shall be performed during the operational testing period. Include instruction covering basic system theory, operating principles and adjustments, routine maintenance and repair, and "hands on" operation. The text for this training shall be the Operation and Maintenance Manuals furnished under these Specifications.

END OF SECTION

SECTION 17110

ANALYTICAL INSTRUMENTS

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Provisions: Requirements of Division 1 and Section 17010 form a part of this Section.
- B. Work Included: This Section specifies analytical instruments for process instrumentation, auxiliary equipment and supplies directly related to the installation of and operation of these analytical instruments, to perform the required functions in conjunction with information and equipment specified in other sections of Division 17. See Section 17010; this is the Schedule referred to herein. This Schedule shall not be construed as Bills of Material or as a complete listing of all required devices.

1.02 SUBMITTALS

- A. Shop drawings to be submitted in this Section shall be made in one package under the Product Review category of Shop Drawings.
- B. Shop Drawings: In addition to the requirements of Section 17010, shop drawings shall include for each type of instrument: supply voltage and frequency, electrical load, accuracy, description of operation, operating instructions, and calibration procedure.
- C. Installation Method: Provide proposed method of mounting sensors or probes and instruments with submittal.
- D. Parts List: Submit a Parts List with current net prices and a list of recommended spares.

1.03 QUALITY ASSURANCE

- A. Manufacturer: In addition to the requirements of Section 17010, analytical instruments furnished shall be manufactured by firms regularly and currently engaged in the design and manufacture of similar equipment. All equipment furnished shall be new and of current design.
- B. Maintainability: All equipment shall be designed for ease of maintenance and repair, and access to critical parts shall not require a major disassembly. Internal field adjustments where permitted or required herein shall be easily accessible upon removal of a panel or cover.
- C. Materials and Installation: Materials and installation shall comply with the requirements of the current editions of referenced electrical codes and standards, and the codes and standards referred to shall be used for establishing the minimum quality of the materials and equipment supplied and installed. All equipment of the same type shall be products of the same manufacturer. Capacities of all equipment shall not be less than that indicated on the Drawings or specified.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17010 - Instrumentation and Controls, General Requirements.

1.05 WARRANTY

- A. As specified in Section 17010 - Instrumentation and Controls, General Requirements.

1.06 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all these supplies before project substantial completion.

PART 2 - PRODUCTS

2.01 NITRATE SENSOR

- A. General:
 - 1. The sensor shall be a continuous-reading sensor utilizing 2-beam ultraviolet absorption for measurement of nitrate. The measurement interval shall be user adjustable between 1 and 30 minutes and having the ability to average up to 12 signals.
 - 2. The sensor shall compensate for interference from turbidity and organics. The sensor shall not require reagents to make measurements and shall include an automated wiper for cleaning.
 - 3. Provide two sensors. One sensor is to be installed in Anoxic Zone 4 of Aeration Basin No. 1. The other sensor is to be installed in Anoxic Zone 4 of Aeration Basin No. 2.
- B. Performance Requirements:
 - 1. Measuring range: 0 to 50 milligrams per liter (mg/L).
 - 2. Accuracy: $\pm 0.3\%$ of reading or ± 0.5 mg/L, whichever is greater.
 - 3. Resolution: 0.1 mg/L
 - 4. Measurement Interval: 1 minute.
 - 5. Response time: 1 minute.
 - 6. Calibration Method: Standard solutions.
 - 7. Operational Temperature: 2 to 40 degrees Celsius.
 - 8. Measuring Units: Selectable as milligrams per liter of nitrate (NO_3) or nitrate-nitrogen ($\text{NO}_3\text{-N}$).
- C. Construction: Stainless steel housing, stainless steel wiper axle, silicon wiper and quartz measuring window. Sensors shall be suitable for continuous submersion in the aeration basins.
- D. Power Supply: From transmitter through the sensor cable.
- E. Transmitter: Each sensor shall be connected to a separate existing Hach SC1000 transmitter.
- F. Accessories:
 - 1. 100-foot long extension cable.

2. Tank mounting hardware consisting of stainless steel mounting pole, mounting bracket, and hardware.
- G. Manufacturer: NITRATAX plus sc by Hach. No equal.
- H. Spare Parts: Provide the following spare parts:
 1. 2 packs of spare wipers.
 2. 4 calibration standards.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 INSTALLATION

- A. Install the instrument in accordance with the manufacturer's instructions and as specified in Section 17010 - Instrumentation and Controls, General Requirements.

3.03 FIELD QUALITY CONTROL

- A. As specified in Section 17010 - Instrumentation and Controls, General Requirements.
- B. Provide manufacturer's services to perform installation inspection, start-up, and calibration/verification.

3.04 ADJUSTING

- A. As specified in Section 17950 - Testing, Calibration, and Commissioning.

3.05 CLEANING

- A. As specified in Section 17010 - Instrumentation and Controls, General Requirements.

3.06 DEMONSTRATION AND TRAINING

- A. As specified in Section 17010 - Instrumentation and Controls, General Requirements.

END OF SECTION

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SECTION 17120

FLOW MEASUREMENT

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Requirements of Division 1 and Sections 17010 and 11001 form a part of this Section. This Section specifies flow measurement devices for process instrumentation, auxiliary equipment and supplies directly related to the installation of and operation of these flow measurement devices, to perform the required functions in conjunction with information and equipment specified in other sections of Division 17.
- B. Provide all instruments identified in the Contract Drawings.

1.02 SUBMITTALS

- A. Shop drawings to be submitted in this Section shall be made in one package under the Product Review Category of Shop Drawings.
- B. Shop Drawings:
 - 1. In addition to the requirements of section 17010 , shop drawings shall include for each type of instrument: supply voltage and frequency, electrical load, accuracy, description of operation, operating instructions, and calibration procedure.
 - 2. Furnish Shop Drawings for each item of mechanical equipment presenting sufficient data to determine compliance to these Specifications. Submit completed ISA S20 forms for each device and physical dimensions. Also submit manufacturer's recommended upstream and downstream straight piping lengths, recommended location of any pressure taps, and estimates of pressure losses through the device.
- C. Installation Method: The proposed method of mounting sensors and instruments shall accompany all shop drawings.
- D. Parts List: Submit a Parts List with current net prices and a list of recommended spares.
- E. Factory Testing and Calibration:
 - 1. All meters shall be factory tested. Perform a factory test and/or provide certification of calibration from an independent test laboratory. Calibration curves based on factory and/or laboratory testing (see option below) shall be provided for the Engineer's favorable review. Furnish calibration curves in units of output (inches or rpm/gpm) versus measured flow. Upon receipt of the Engineer's favorable review, the Contractor may have the meters shipped to the job site.
 - 2. As an option to laboratory testing each meter, the calibration curves of six (6) "like devices" may be substituted provided the calibration data is available from at least one identical device (pipe size, flow range, and type plus accessories such as extension registers).

3. The flow tube supplier shall provide laboratory calibration data to the transmitter supplier or, where practical, test the flow tube and transmitter as an integral assembly. The integral test shall be accomplished at no extra cost to the customer.
- F. Manuals: Furnish manufacturer's installation, lubrication, operation and maintenance manuals, bulletins, and spare parts lists.
- G. Affidavits: Furnish affidavits from the manufacturers stating that the meters have been properly installed and tested and each is ready for full time operation.

1.03 QUALITY ASSURANCE

- A. Manufacturer: In addition to the requirements of Section 17010, flow measurement devices furnished shall be manufactured by firms regularly and currently engaged in the design and manufacture of similar equipment. All equipment furnished shall be new and of current design.
- B. Maintainability: All equipment shall be designed for ease of maintenance and repair, and access to critical parts shall not require a major disassembly. Internal field adjustments where permitted or required herein shall be easily accessible upon removal of a panel or cover.
- C. Materials and Installation: Materials and installation shall comply with the requirements of the current editions of referenced electrical codes and standards, and the codes and standards referred to shall be used for establishing the minimum quality of the materials and equipment supplied and installed. All equipment of the same type shall be products of the same manufacturer. Capacities of all equipment shall not be less than that indicated on the Drawings or as specified.
 1. Provide instruments suitable for the site conditions including, but not limited to, ambient temperatures, altitude, humidity, material compatibility, and process conditions.

PART 2 – PRODUCTS

2.01 FLOW SWITCHES

- A. Thermal Dispersion Type
 1. General: Thermal type flow switches shall be housed in a NEMA 4X enclosure with NPT electrical conduit connection and shall be of the probe type for threaded insertion in a pipe boss as shown on the Drawings. They shall operate by means of sensing the differential cooling of heated sensor elements caused by flow and no flow condition and shall be all solid state. Operating power shall be 120 Vac at 15 watt maximum. The switches shall be available for pressure up to 2,000 psig and shall be capable of sensing velocities as low as 0.1 fps. Wetted parts shall be 316 stainless steel than 3 seconds. Adjustable range.
 2. Service Conditions: Magnesium hydroxide solution, indoor temperature.
 3. Manufacturer: Fluid Components International, Kayden, Magnetrol or equal.

2.03 ROTAMETERS

A. General:

1. Rotameter shall include aluminum housing and a calibrated borosilicate glass metering tube with float. The float shall be of a material and shape suitable for the process fluid. The tube shall be readily field removable for cleaning. All other wetted parts shall be Type 316 stainless steel, except O-rings shall be Buna-N unless otherwise recommended by the manufacturer for the process fluid specified. Process fluid will be water. End fittings shall be threaded NPT. The metering scale shall be a nominal 125 mm in length or greater with graduations in gpm and the range as specified in the Instrument Schedule. Meters shall have a minimum rangeability of 10:1. Repeatability shall be $\pm 1\%$ of full scale (maximum) for all ranges.
2. Rotameters shall be supplied with a stainless steel needle valve on the discharge for throttling, as shown on the Drawings.
3. Service Conditions: 2W and 3W water, indoor temperature
4. Manufacturer: Rotameters shall be Model GT 1306 manufactured by Brooks; equivalent by Fischer & Porter; or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Provide installation, testing, calibration, verification, and startup instructions in accordance with Sections 15050 and 17010. Coordinate the installation with all trades to ensure the mechanical system is proper for the instrument.
- B. Where instruments are located outdoors provide surge protectors at the transmitters. Provide isolators, relays, conditioners, or other devices as required for a functional system.
- C. Instruments without approved submittals shall not be installed.
- D. The contract drawings and specifications are intended show basic functional requirements. Insufficient detail does not relieve the contractor from the responsibility to provide a complete and functioning system.

3.02 FIELD TESTING

- A. The installation shall be examined to verify the instrument will work properly when installed and the Engineer promptly notified if it does not meet manufacturer recommendations or the specifications.
- B. Verify factory calibration of instruments in accordance with the manufacturer's instructions.
- C. All instrumentation calibration and configuration shall be completed prior to the start of field testing.
- D. Totalizer tests are not to be performed in the field.

END OF SECTION

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SECTION 17140

LEVEL MEASUREMENT

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Provisions: Requirements of Division 1 and Section 17010 form a part of this Section.
- B. Work Included: Level measurement devices for process instrumentation, auxiliary equipment and supplies directly related to the installation of and operation of these level measurement devices, to perform the required functions in conjunction with information and equipment specified in other sections of Division 17. Refer to the Instrument Index in Section 17010 for a listing of required devices.

1.02 SUBMITTALS

- A. Shop drawings to be submitted in this Section shall be made in one package under the Product Review Category of Shop Drawings.
- B. Shop Drawings: In addition to the requirements of Section 17010, shop drawings shall include for each type of instrument: supply voltage and frequency, electrical load, accuracy, description of operation, operating instructions, and calibration procedure.
- C. Installation Method: The proposed method of mounting sensors and instruments shall accompany all shop drawings.
- D. Parts List: Submit a Parts List with current net prices and a list of recommended spares.

1.03 QUALITY ASSURANCE

- A. Manufacturer: In addition to the requirements of General Requirements, level measurement devices furnished shall be manufactured by firms regularly and currently engaged in the design and manufacture of similar equipment. All equipment furnished shall be new and of current design.
- B. Maintainability: All equipment shall be designed for ease of maintenance and repair, and access to critical parts shall not require a major disassembly. Internal field adjustments where permitted or required herein shall be easily accessible upon removal of a panel or cover.
- C. Materials and Installation: Materials and installation shall comply with the requirements of the current editions of referenced electrical codes and standards, and the codes and standards referred to shall be used for establishing the minimum quality of the materials and equipment supplied and installed. All equipment of the same type shall be products of the same manufacturer. Capacities of all equipment shall not be less than that indicated on the Drawings or specified.

PART 2 - PRODUCTS

2.01 LEVEL TRANSMITTER/RADAR TYPE SENSOR

- A. 2-wire radar level instrument shall use total transit time of a microwave reflected off the liquid surface to determine distance to the surface.
- B. The transmitter housing shall have dual compartments and be available in plastic, die cast aluminum with a powder Epoxy coating or 316L Stainless steel based on the application environment.
- C. Unit shall have ATEX, FM, CSA or IECEx approvals as required.
- D. HART with 4 to 20 mA analog output, output shall be available for system integration.
- E. Unit shall employ multi echo tracking algorithms for reliable level measurement.
- F. Process connection shall be available as a NPT or ANSI flange.
- G. Unit shall have a maximum error of + or – 2 mm on measuring ranges of less than 49 feet.
- H. Radar ranging level sensors shall be as manufactured by VegaPuls, Endress-Hauser, Inc.; or equal.

2.02 LEVEL SWITCHES – SUMP

- A. Furnish float-type level switches suitable for sumps.
- B. Switch shall be non-powered type.
- C. Switch shall provide DPDT contacts rated for 5 amps at 120 volts AC.
- D. GEMS or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation, testing, calibration, validation, startup, and instruction shall be in accordance with Section 17010.

END OF SECTION

SECTION 17320

PROCESS CONTROL SYSTEM

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Provide additions to the existing process control system at the Monroe WWTP. This will consist of three related parts:
 - 1. Fabrication and installation of two remote I/O (RIO) panels for two different areas of the plant, to be connected to existing Allen Bradley programmable logic controller (PLC) networks, with local human-machine interface (HMI) panels.
 - 2. Software development and virtual integration of these additional panels into respective Allen Bradley programmable logic controller (PLC) networks. This work shall be performed by the Plant Wide SCADA I&C Contractor according to Section 17010.
 - 3. The Plant Wide SCADA I&C Contractor will also integrate the new nitrate analyzer probes into the existing Hach network.

1.02 QUALIFICATION OF BIDDERS

- A. RIO panel fabrication services shall be from a UL 508A accredited panel builder with facilities within 50 miles of the Monroe WWTP, and 5 years of documented experience manufacturing and servicing control panels for similar facilities.
- B. The qualifications data submitted with the bid will be reviewed by the Design Engineer. The Design Engineer's review comments will be used by the city as one factor in determining the lowest responsive, responsible bidder as of the time of the bid opening. The bidders will not be allowed to change their proposal between the date of the bid opening and the date of the contract award.

1.03 DESCRIPTION

- A. Provide one control panel in the Odor Control room for the new hypochlorite and caustic soda injection equipment plus ancillary equipment modifications.
- B. Provide one control panel at the magnesium hydroxide system for the new magnesium injection equipment.
- C. The scope for the Plant Wide SCADA I&C Contractor shall include:
 - 1. Integrating the RIO in the odor control room into PLC-331.
 - 2. Integrating two new nitrate probes in the aeration basins into existing Hach SC-1000 controllers, through the existing Hach proprietary network, and reconfiguring the network hardware in the PLC-331 cabinet so that PLC-331 will accept these new signals and their respective fail contacts.
 - 3. Integrating the RIO and HMI at the magnesium hydroxide tank into the PLC network at RIO-110 and establishing a remote connection to one of the PLCs on that network.
 - 4. Configuring the plant SCADA console to support items 1-3 above.

1.04 ACCESS

- A. The Owner and the Engineer shall have the right of access to the Contractor's facility and the facilities of his equipment suppliers to inspect materials and parts; to witness inspections, tests and work in progress; and to examine applicable design documents, records and certifications during any stage of design, fabrication, installation, and tests. Office space, supplies, and services required for these surveillance activities shall be furnished by the Contractor and his equipment suppliers.

1.05 SUBMITTALS

- A. The Contractor shall make all submittals as required by the General Conditions and Special Conditions and as specified herein.
- B. Shop Drawings shall include a schematic block diagram for the equipment. Block diagrams shall be to the circuit board level. The diagrams shall also include blocks for major software/firmware routines as necessary to permit an understanding of the total system architecture and hardware and software functional operation. Shop Drawings shall include a bill of materials, front views, assembly drawings, nameplate schedules, electrical schematics and connection drawings and catalog cuts as appropriate. Diagrams shall be prepared in a neat and legible manner on 22 inch by 34-inch vellum sheets or transparent reproducible prints.
 - 1. Process Controller Ladder Diagrams: Provide the following information on each PC ladder or control logic diagram with the shop drawings and the operation and maintenance manuals:
 - a. Physical location of all inputs and outputs, including I/O circuit card location, I/O housing location, and I/O terminal location.
 - b. Output coil references, including coil description, i.e., "Grit Pump 4 Start/Shed," coil address, and reference locations on schematic diagrams where coil is used.
 - c. Output devices and wiring diagrams, including component description, i.e., "Grit Pump 4 Start/Shed Interposing Relay," classification of output, i.e., 120 Vac, contact closure, etc., and wire numbers.
 - d. Input devices and wiring diagrams, including component description, i.e., "Grit Pump 4 Hand-Off-Remote Switch," classification of input, i.e., 120 Vac, contact closure, etc., input address, wire numbers, and reference locations on schematic diagrams where each input is used.
 - e. Rung numbers for each ladder rung.
 - f. Input labels (mnemonics).
 - g. Output labels (mnemonics).
 - h. Differentiation between coils internal to the PC and external from the PC.
 - i. Labels for all internal contacts, which describe their logical functions in the ladder diagram.
 - j. Logical flow from left-to-right and top-to-bottom, with control power and inputs at left side of diagram, CPU in center, outputs and control power return on right.
 - k. References on each ladder diagram to associated drawings.
 - l. Power distribution and wire numbers.

2. In addition to the process controller ladder diagrams, provide the following documentation with the shop drawings and the operation and maintenance manuals:
 - a. Drawing list.
 - b. General notes.
 - c. System interconnections.
 - d. Process controller general arrangement.
 - e. Field device wiring diagrams.
 - f. Enclosure elevations and parts list.
 - g. Enclosure back panel layouts.
 - h. System conduit schedule.
 - i. System conduit routing diagrams and requirements.
 - j. Electrical schematics.
 - k. Control power distribution.
 - l. Logic diagrams, memory and register maps.
 - m. Software flow charts and commented program listings.
 3. All submittals shall be complete, neat and orderly. Submittals shall bear the following identification, as applicable:
 - a. Specification Section reference.
 - b. Equipment description.
 - c. Tag number, as shown on the Drawings.
 - d. Plant area location of equipment.
 - e. Manufacturer and model numbers (may be partial numbers).
 - 1) Should the manufacturer desire to submit equipment or materials other than specified, he shall list each alternate separately with appropriate description of the alternate, advantages of the alternate, impact on overall system configuration and appropriate cost differential.
 - 2) After receipt of favorably reviewed Shop Drawing submittals, the manufacturer shall furnish installation, operation and maintenance documents as published and prepared by the original equipment manufacturer(s). Such documents shall be furnished for each equipment, component, peripheral device, and ancillary hardware item provided with the system.
- C. Operation and maintenance manuals shall include a complete description of all operational features of the system including, but not limited to, a thorough discussion of data acquisition, control algorithms, coding, security and transmission, operator/machine interfacing, sample log printouts, typical CRT screen formats, troubleshooting to the board level, diagnostic aids and a preventive maintenance schedule. Manuals shall include instructions of the manufacturers on installation, lubrication, operating data, troubleshooting, and maintenance. Provide troubleshooting diagrams and flow charts. Procedures shall be provided for various conditions including startup, normal operation in all modes, emergency operation, and shutdown instructions, both short-term and long-term. Spare parts lists with graphic diagrams for identification of parts and sources of supply and ordering information shall be included. Expendable items and spare parts recommended to be kept on hand shall be listed separately. The Contractor shall transmit two copies of this proposed manual to the Engineer. Following favorable review of this preliminary manual by the Engineer, three revised copies (bound in sets) shall be delivered to the Engineer prior to operation or acceptance of the completed project, whichever occurs first.

1. The documentation shall include the following:
 - a. Photographs of major system components.
 - b. Input/output terminal listings.
 - c. Logic and block diagrams.
 - d. Configuration language description.
 - e. Names, addresses and telephone numbers of local equipment manufacturer representatives for each device in the system.
 - f. Listing of expendable materials by form, stock, or model number (e.g., paper, magnetic tape, and ribbons).
- D. Full documentation shall be delivered to the Engineer prior to final acceptance of the work. Standard and specially prepared software documentation shall be amended as required to delineate all modifications and to accurately reflect the final software configuration.
 1. A source listing and flow chart for each program shall be included. All source listings shall include a program abstract including linkages. Comments describing the program flow shall be frequently interspersed throughout each listing.
 2. Provide the following as a minimum:
 - a. Cartridge tape(s) for all standard programs in the system. This tape (or set of tapes) shall contain copies of all programs comprising the Monitor, Scan and Control Packages, High Level compilers, etc.
 - b. Cartridge tape(s) and two sets of computer listings of all configuration data and databases developed for this specific system. Include system build maps, point databases, log databases, etc.
 - c. Cartridge tape(s) and two sets of computer listings for all special software that was written for this particular Contract. Included herein shall be the source and listing documentation for all application programs.
 - d. Cartridge tape(s) containing the entire software system in executable form.
 - e. Three sets of user level reference manuals for all standard software provided.
 - f. Three sets of written as-built documentation for all special software provided.
 - g. Three copies of a detailed Plant Computer Operator's Manual. This manual shall detail all steps required for the plant operator to interface with and run the process through the computer system.

1.06 QUALITY ASSURANCE

- A. All material shall be new, of current manufacture, free from defects, and of the quality specified or shown. Each type of material shall be of the same manufacturer throughout the work. All material shall be the product of established, reputable manufacturers normally engaged in the production of the particular item being furnished.
- B. Equipment shall be suitably packaged by the manufacturer to protect it during shipment, storage and after installation.
- C. Variances: In instances where two codes are at variance, the more restrictive requirements shall apply.

- D. Standards: Equipment shall conform to the applicable EIA, IEEE and NEMA Standards. The revisions of these standards, in effect on the date of issuance of the Contract Documents, shall apply.

PART 2 - PRODUCTS

2.01 RIO SYSTEMS

- A. Input/Output Subsystem:
 - 1. Provide I/O subsystems as shown on the Drawings. I/O subsystems shall be manufactured by Allen Bradley and communicate over Ethernet hardware using Ethernet/IP protocol.
 - 2. Provide HMI panel for the magnesium hydroxide control panel as shown on the drawings. HMI panel shall be manufactured by Allen Bradley and communicate over Ethernet hardware using Ethernet/IP protocol.

PART 3 - EXECUTION

3.01 GENERAL INSTALLATION

- A. All work shall be executed in full accordance with codes and local rulings. Should any work be performed contrary to said rulings, ordinances, or regulations, the Contractor shall bear the full responsibility for such violations and assume all costs arising therefrom.
- B. The Contractor shall coordinate the installation, the placing and location of system components, their connections to the process controller terminal cabinets, and devices, subject to the Engineer's favorable review. He shall be responsible, through the Contractor, to ensure all field wiring for power and signal circuits is correctly done in accordance with best industry practice to insure a satisfactory, functioning installation. The Contractor shall schedule and coordinate his work under this Section with that of other Contractors on the jobsite who will be working concurrently on the Instrumentation, Electrical, and other work.
- C. Coordinate with Plant Wide SCADA I&C Subcontractor for connection to existing PLC and SCADA network, and software integration.

3.02 TRAINING

- A. General: The manufacturer shall provide operator and maintenance training to accomplish the following objectives:
 - 1. To instruct the Owner's personnel in the operation and philosophy of the specific equipment of this system, with emphasis on the daily operating procedures of the system.
 - 2. To instruct the Owner's personnel in the maintenance of any new equipment not currently in use at the facility.

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SECTION 17331

CONTROL NARRATIVES

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Scope: The work under this Section includes the control narratives to be utilized by the equipment installed or modified as part of this project. This includes, but is not limited to, programming requirements for the programmable logic controllers (PLCs), control panels, and the various associated field devices.
- B. Programmable Logic Controller (PLC) and Plant SCADA system programming work shall be completed by the Plant-wide SCADA I&C Contractor hired by the Owner in accordance with Section 17010.
- C. The Contractor shall be responsible for submitting and coordinating delivery, storage, handling, installation, testing, inspection, startup, and training.

PART 2 - PRODUCTS

2.01 PROGRAMMING SOFTWARE

- A. Programming Software for New and Existing PLCs: Supplied by Plant Wide SCADA I&C Contractor.
- B. Plant SCADA Programming Software: Supplied by Plant Wide SCADA I&C Contractor.

PART 3 - EXECUTION

3.01 CONTROL NARRATIVE FOR PH CONTROL SYSTEM

- A. System Overview:
 - 1. **The WWTP can have pH Control with two different methods: Magnesium Hydroxide or Sodium Hydroxide. The operator will select the pH Control Source. Depending on the pH Control Source, the control for the source goes to the corresponding narrative in Section 3.02 or 3.03.**
- B. Control Set Points: The following is a table of control set points and parameters that can be entered and adjusted by the operator within the OIT:

Parameter	Units	Default Value	Adjustable?	Delay?
pH Control Source (Magnesium Hydroxide or Sodium Hydroxide)	N/A	Magnesium Hydroxide (Default Mode)	Yes	No

3.02 CONTROL NARRATIVE FOR MAGNESIUM HYDROXIDE FEED SYSTEM

- A. System Overview:

1. **The Magnesium Hydroxide (MHD) Feed System consists of two redundant feed systems (one duty and one standby) located in a pump enclosure and a tank for chemical storage in a spill contained area. Each MHD feed system consists of a suction line from the tank to the pump, a calibration cylinder, a metering pump, a pressure relief valve, a flow switch, a discharge line to the final dosing point and two flush water systems (one to suction and the other to discharge side). The MHD metering pump doses MHD to the Primary Effluent Distribution Box. The MHD is used for maintaining pH and alkalinity in the following secondary process and maintaining the final pH at or above the discharge limit.**
 2. **The Magnesium Hydroxide Storage Tank is equipped with a mixer, an radar level sensor and a spray ball. The level sensor monitors the amount of chemical remaining in the tank. The mixer keeps the content of the tank mixed. The spray ball supplies spray water to the interior tank wall to wash down chemical fume deposits from the tank wall intermittently.**
 3. **MHD dose is flow-paced based on flow measurements from the existing influent flow transmitter and the feed rate is adjusted to maintain a targeted dose entered by the operator. Alternatively, the MHD can be dosed to maintain a targeted feed rate entered by the operator.**
 4. **The flush water systems for the MHD feed systems and the spray ball are run based on the schedule entered by the operator. Alternatively, the operator can run the flush water system manually at the local control panel.**
 5. **In the event of an alarm condition, the operator can start the redundant pump manually. The operator shall close the manual isolation valves on the suction and discharge lines of the alarmed pump first at the local pump skid. The operator then shall open the manual isolation valves on the suction and discharge lines of the backup pump. After that, the backup pump shall be selected as the duty pump at SCADA.**
 6. **If both pumps and/or tank is in alarm condition, the operator can start the Sodium Hydroxide (SHD) Feed System as a backup pH control system manually as described in Paragraph 3.03 below.**
- B. Control Modes: Normal functions for the different control modes are as follows:
1. Auto: When in Auto, the PLC will automatically control pump start/stop, pump running speed, and mixer start/stop.
 2. Off: When in Off, the pumps and mixer will not run, even if called to start by the PLC.
 3. Hand: When in Hand, the pumps will run at the current speed setting and the mixer will run continuously. Pump speed can be manually adjusted at the AFD.
- C. Control Set Points: The following is a table of control set points and parameters that can be entered and adjusted by the operator within the OIT:

Parameter	Units	Default Value	Adjustable?	Delay?
Duty Pump (P-250 or P-260)	N/A	P-250	Yes	No
Flow Pacing On/Off	N/A	On	Yes	No
Chemical Specific Gravity	N/A	1.50 (MHD)	Yes	No

Parameter	Units	Default Value	Adjustable?	Delay?
Chemical Concentration	%	60% (MHD)	Yes	No
Chemical Dose (Flow Pacing ON)	Mg/L	110 (MHD)	Yes	No
Pumping Rate (Flow Pacing OFF)	gph	9 (MHD)	Yes	No
Minimum Pumping Rate	gph	3	Yes	No
Maximum Pumping Rate	gph	30	Yes	No
Pump Speed Tolerance	%	10	Yes	Yes
Low Low Tank Level	feet	4.0	Yes	Yes
Low Tank Level	Feet	5.0	Yes	Yes
High Tank Level	Feet	11.0	Yes	Yes
High High Tank Level	feet	12.0	Yes	Yes
Mixer On/Off	N/A	On	Yes	No
SV-235 Open Frequency	Days	7	Yes	No
SV-235 Open Duration	seconds	30	Yes	No
SV-255 Open Frequency	Days	3	Yes	No
SV-255 Open Duration	seconds	15	Yes	No
SV-257Open/Close	Days	3	Yes	No
SV-257Open/Close	seconds	15	Yes	No
Waiting Time between SV-257/SV-255 Operation	min	1	Yes	No
SV-265 Open Frequency	Days	3	Yes	No
SV-265 Open Duration	seconds	15	Yes	No
SV-267Open/Close	Days	3	Yes	No
SV-267Open/Close	seconds	15	Yes	No
Waiting Time between SV-267/SV-265 Valve Operation	min	1	Yes	No

- D. SCAD Auto: Below is a description of how the MHD feed system will operate when at least one pump is in Auto. At any point in time, the Operator can adjust the control set points listed above and the change will become effective immediately once the new set point is entered.
1. **If MHD is selected for pH control, the Operator selects the duty pump, either P-250 or P-260.**
 2. **Once the duty pump is selected, a message shall be displayed reminding the operator to field verify the positions of the isolation valves located on both suction and discharge side of the pump selected.**
 3. **Once the operator acknowledges the message, the operator can start the pump.**
 4. **If the duty pump in "Auto" and flow pacing is "ON," the PLC will call to run the duty pump and control the pumping rate to produce a consistent dose to the influent.**

5. **If the duty pump in “Auto” and flow pacing is “OFF,” the PLC will run the chemical feed pump at the entered rate.**
 6. If flow pacing is “ON,” the PLC will calculate the pumping rate necessary to maintain the desired dose with the flow signal received from the existing PLC and the dose, chemical concentration, and specific gravity entered by the operator.
 7. **The speed of the pump will be adjusted to match the calculated pumping rate by comparing the calculated pumping rate with the entered pump curve. The Operator shall be able to modify the pump curve in the OIT. To avoid constant adjustments, the pump speed shall be adjusted only when the speed calculated from the entered pump curve exceeds the allowable deviation for a user-defined duration. At a minimum, there shall be calibration flow rate inputs for 0%, 10%, 30%, 50%, 70%, 90%, and 100% of full pump speed for each pump.**
 8. **The PLC will call only one pump to run at any time. The second pump is a backup unit only.**
 9. **To avoid excessive chemical use, the pumps will not operate above the maximum pumping rate set point, even if the calculated pumping rate is higher.**
 10. **Similarly, to avoid special lubrication requirements for the pump hose, the pumps will not operate below the minimum pumping rate set point, even if the calculated pumping rate is lower.**
 11. **If there is loss of signal for flow pacing, the flow pacing mode is changed to “OFF” by the PLC.**
 12. **The flushing system for the pump is run by the schedule and duration entered by the operator. Once the duty pump is selected and run without any alarm for 10 minutes, the flushing system assigned to that pump will be activated automatically. The SV257 or SV267 runs first based on the entered schedule. At 1 minutes after the SV257 or SV267 are closed, the SV255 or SV265 on the suction side of the pumping system runs based on the entered schedule. If the pump is in alarmed condition, the flushing system will be deactivated by the SCADA.**
 13. **The flushing system for the tank spray ball is run by the schedule and duration entered by the operator. The operator initially activates and starts the flushing system in SCADA so it can be run based on the entered schedule. The operator can disable the flushing system in SCADA.**
 14. The mixer is on continuously unless the operator turns it off in SCADA or at the local hand station.
- E. Interlocks with Associated Equipment
1. **If the level in the MHD Storage Tank (T-230), as measured by the level transmitter (LT-234), reaches a low low level set point, a low low level alarm is issued and the Tank Mixer (M-231) and any running MHD pump is stopped.**
- F. PLC Functions
1. **Monitoring Digital:**
 - a. MHD Metering Pump 1 (P-250) running, auto
 - b. MHD Metering Pump 2 (P-260) running, auto

2. **Monitoring Analog:**
 - a. MHD Metering Pump 1 (P-250) speed
 - b. MHD Metering Pump 2 (P-260) speed
 - c. MHD Storage Tank (T-230) level
3. **Monitoring Trending:**
 - a. MHD Metering Pump 1 (P-250) estimated flow for daily, monthly, and yearly average based on speed feedback from MHD Metering Pump 1 (P-250)
 - b. MHD Metering Pump 2 (P-260) estimated flow for daily, monthly, and yearly average based on speed feedback from MHD Metering Pump 1 (P-250).
4. **Alarming Digital:**
 - a. MHD Metering Pump 1 (P-250) fault
 - b. Flow Switch (FSL-250) if the flow is below the minimum pumping rate
 - c. MHD Metering Pump 2 (P-260) fault
 - d. Flow Switch (FSL-250) if the flow is below the minimum pumping rate
 - e. High level (LSH-270) in the MHD containment sump indicating clogging in drain line.
5. **Alarming Analog:**
 - a. MHD Storage Tank (T-230) high high level
MHD Storage Tank (T-230) high level
 - b. MHD Storage Tank (T-230) low level
MHD Storage Tank (T-230) low low level
 - c. MHD Metering Pump 1 (P-250) high speed (10% more than calculated speed) as measured from the pump speed feedback
 - d. MHD Metering Pump 2 (P-260) high speed (10% more than calculated speed) as measured from the pump speed feedback
 - e. MHD Metering Pump 1 (P-250) low speed (10% less than calculated speed) as measured from the pump speed feedback
 - f. MHD Metering Pump 2 (P-260) low speed (10% more than calculated speed) as measured from the pump speed feedback.
6. **Calculations:**
 - a. Influent flow determined from 1-hour running average from influent flow meters
 - b. MHD Metering Pump 1 (P-250) elapsed runtime determined from running status
 - c. MHD Metering Pump 2 (P-260) elapsed runtime determined from running status
 - d. Required MHD Metering Pump 1 (P-250) pump speed determined from the entered pump curve and required pumping rate.
 - e. Required MHD Metering Pump 2 (P-260) pump speed determined from the entered pump curve and required pumping rate.
 - f. Use the following formulas in the PLC for control as described under SCADA Auto mode:
 - 1) Target Dose, lbs/hr = (Target Concentration, mg/L) x (Influent Flow, MGD) x (8.34 lbs/[MG·mg/L])/24 hr
 - 2) MHD Unit Weight, lbs/gal = (MHD Specific Gravity) x (8.34 lbs/gal) x (Active Concentration,%)
 - 3) Required Pump Rate, gph = (Target Dose, lbs/hr) / (MHD Unit Weight, lbs/gal).

3.03 CONTROL NARRATIVE FOR SODIUM HYDROXIDE FEED SYSTEM

A. System Overview:

1. **The Sodium Hydroxide (SHD) Feed System consists of two metering pumps located in the Odor Control Room and a tank for chemical storage located in the Chemical Storage Room.**
2. **The SHD Metering Pump No.1 (P-320) doses SHD to odor control unit occasionally. The control associated with this system is already built in the existing local control system and no update is needed for the SCADA.**
3. **The SHD Metering Pump No.2 (P-330) can dose SHD to secondary effluent to control the pH in the final effluent if selected by the operator for pH control source.**
4. **The SHD can be dosed to the effluent box of the Secondary Clarifier No.1 and/or to the effluent launder in the Secondary Clarifier No. 2 depending on the position of the isolation valve located at each doing point. The operator can change the position of these isolation valves in the field.**
5. **The Sodium Hydroxide Storage Tank is equipped with a radar level sensor. The level sensor monitors the amount of chemical remaining in the tank.**
6. **The SHD dose is flow-paced based on flow measurements from the existing influent flow transmitter and the feed rate is adjusted to maintain a targeted dose entered by the operator. Alternatively, the SHD can be dosed to maintain a targeted feed rate entered by the operator.**
7. **The dilution water system on the SHD feed system for pH control will be started by the PLC. Alternatively, the operator can start the dilution water system manually.**
8. **Once the alarm condition associated with the MHD feed system is resolved and the feed system is restarted, the operator can stop the SHD feed system.**

B. Control Modes: Normal functions for the different control modes are as follows:

1. **Auto:** When in Auto, the PLC will automatically control pump start/stop and pump running speed.
2. **Off:** When in Off, the pumps will not run, even if called to start by the PLC.
3. **Hand:** When in Hand, the pumps will run at the current speed setting. Pump speed can be manually adjusted at the AFD.

C. Control Set Points: The following is a table of control set points and parameters that can be entered and adjusted by the operator within the OIT:

Parameter	Units	Default Value	Adjustable?	Delay?
Duty Pump (P-330)	N/A	P-330	No	No
Flow Pacing On/Off	N/A	On	Yes	No
Chemical Specific Gravity	N/A	1.54 (SHD)	Yes	No
Chemical Concentration	%	50% (SHD)	Yes	No
Chemical Dose (Flow Pacing ON)	Mg/L	34 (SHD)	Yes	No
Pumping Rate (Flow Pacing OFF)	gph	3 (SHD)	Yes	No

Parameter	Units	Default Value	Adjustable?	Delay?
Minimum Pumping Rate	gph	1	Yes	No
Maximum Pumping Rate	gph	7	Yes	No
Pump Speed Tolerance	%	10	Yes	Yes
Low Low Tank Level	feet	2	Yes	Yes
Low Tank Level	feet	2.5	Yes	Yes
High Tank Level	feet	5.5	Yes	Yes
High High Tank Level	feet	6	Yes	Yes

- D. SCAD Auto: Below is a description of how the SHD feed system will operate when the pump is in Auto. At any point in time, the Operator can adjust the control set points listed above and the change will become effective immediately once the new set point is entered.
1. **Once the SHD is selected as the source for pH control, a message shall be displayed reminding the operator to field verify the positions of the isolation valves located on both suction and discharge side of the SHD feed pump and the isolation valve on the dilution water line.**
 2. **Once the operator acknowledges the message, the PLC opens the solenoid valve on the dilution line first (SV-337) and displays a message to remind the operator to confirm the dilution water supply.**
 3. **Once the operator acknowledges the message, the PLC starts the SHD metering pump.**
 4. If the pump in "Auto" and flow pacing is "ON," the PLC will control the pumping rate to produce a consistent dose to the secondary effluent.
 5. **If the pump in "Auto" and flow pacing is "OFF," the PLC will run the chemical feed pump at the entered rate.**
 6. If flow pacing is "ON," the PLC will calculate the pumping rate necessary to maintain the desired dose with the flow signal received from the existing PLC and the dose, chemical concentration, and specific gravity entered by the operator.
 7. **The speed of the pump will be adjusted to match the calculated pumping rate by comparing the calculated pumping rate with the entered pump curve. The Operator shall be able to modify the pump curve in the OIT. To avoid constant adjustments, the pump speed shall be adjusted only when the speed calculated from the entered pump curve exceeds the allowable deviation for a user-defined duration. At a minimum, there shall be calibration flow rate inputs for 0%, 10%, 30%, 50%, 70%, 90%, and 100% of full pump speed for each pump.**
 8. **The PLC will call only P-330 to run at any time. If the operator wants, the operator can use the other pump to manually dose the SHD for pH control at a set speed.**
 9. **To avoid excessive chemical use, the pumps will not operate above the maximum pumping rate set point, even if the calculated pumping rate is higher.**
 10. **Similarly, to avoid special lubrication requirements for the pump hose, the pumps will not operate below the minimum pumping rate set point, even if the calculated pumping rate is lower.**
 11. **If there is loss of signal for flow pacing, the flow pacing mode is changed to "OFF" by the PLC.**

- E. Interlocks with Associated Equipment
 1. If the level in the SHD Storage Tank (T-310), as measured by the level transmitter (LT-310), reaches a low low level set point, the PLC issues a low low level alarm and stops any SHD pump in running.
 2. **If the level in the pump containment sump in the Odor Control Room, as triggered by the level switch (LSH-301), reaches the level set point, the PLC issues a high-level alarm and shut-off the motorized isolation valve (MOV-312) on the pump suction line and stops any SHD metering pump in running.**
 3. **If the level in the sump in the Chemical Storage Room, as triggered by the level switch (LSH-300), reaches the level set point, the PLC issues a high-level alarm and shut-off the motorized isolation valve (MOV-312) on the pump suction line and stops any SHD metering pump in running.**
- F. PLC Functions
 1. **Monitoring Digital:**
 - a. SHD Metering Pump 2 (P-330) running, auto
 2. **Monitoring Analog:**
 - a. SHD Metering Pump 2 (P-330) speed
 - b. SHD Storage Tank (T-310) level
 3. **Monitoring Trending:**
 - a. SHD Metering Pump 2 (P-330) estimated flow for daily, monthly and yearly average based on speed feedback from SHD Metering Pump 2
 4. **Alarming Digital:**
 - a. SHD Metering Pump 2 (P-330) fault
 - b. High level (LSH-301) in the pump containment sump in the Odor Control Room indicating leakage
 - c. High level (LSH-300) in sump in the Chemical Storage Room indicating leakage
 5. **Alarming Analog:**
 - a. SHD Storage Tank (T-310) high high level
 - b. SHD Storage Tank (T-310) high level
 - c. SHD Storage Tank (T-310) low level
 - d. SHD Storage Tank (T-310) low low level
 - e. SHD Metering Pump 2 (P-330) high speed (10% more than calculated speed) as measured from the pump speed feedback
 - f. SHD Metering Pump 2 (P-330) low speed (10% more than calculated speed) as measured from the pump speed feedback
 6. **Calculations:**
 - a. Effluent flow determined from 1-hour running average from effluent flow in SCADA.
 - b. SHD Metering Pump 1 (P-330) elapsed runtime determined from running status
 - c. Required SHD Metering Pump 2 (P-330) pump speed determined from the entered pump curve and required pumping rate.
 - d. Use the following formulas in the PLC for speed control of SHD Metering Pump 2 as described under SCADA Auto mode:
 - 1) Target Dose, lbs/hr = (Target Concentration, mg/L) x (Effluent Flow, MGD) x (8.34 lbs/[MG·mg/L])/24 hr
 - 2) SHD Unit Weight, lbs/gal = (SHD Specific Gravity) x (8.34 lbs/gal) x (Active Concentration, %)
 - 3) Required Pump Rate, gph = (Target Dose, lbs/hr) / (SHD Unit Weight, lbs/gal)

3.04 CONTROL NARRATIVE FOR SODIUM HYPOCHLORITE FEED SYSTEM

A. System Overview:

1. **The Sodium Hypochlorite (SHP) Feed System consists of two metering pumps located in the Odor Control Room and a tank for chemical storage located in the Chemical Storage Room.**
2. **The SHP Metering Pump No.1 (P-340) doses SHP to odor control unit occasionally. The control associated with this system is already built in the existing local control system and no changes are required for SCADA.**
3. **The SHP Metering Pump No.2 (P-350) can dose SHP to the RAS line located in the Facility Building to control filamentous bacterial growth in the secondary process if started by the operator locally.**
4. **The Sodium Hypochlorite Storage Tank (T-315) is equipped with a radar level sensor (LE-315). The level sensor monitors the amount of chemical remaining in the tank.**
5. **The SHP feed rate is maintained at a targeted feed rate entered by the operator.**
6. **The operator shall start the dilution water system on the SHP feed system in the Facility Building locally.**

B. Control Modes: No automated control will be provided for the RAS chlorination, but some operating conditions will be monitored as described herein.

C. Control Set Points: The following is a table of control set points and parameters that can be entered and adjusted by the operator within the OIT:

Parameter	Units	Default Value	Adjustable?	Delay?
Duty Pump	N/A	P-350	No	No
Low Low Tank Level	feet	2	Yes	Yes
Low Tank Level	feet	2.5	Yes	Yes
High Tank Level	feet	5.5	Yes	Yes
High High Tank Level	feet	6	Yes	Yes

1. The following is a table of control set points and parameters that can be entered and adjusted by the operator at the local control at the pump:

Parameter	Units	Default Value	Adjustable?	Delay?
Pumping Rate	gph	2	Yes	No

D. SCADA Auto: None.

E. Interlocks with Associated Equipment

1. If the level in the SHP Storage Tank (T-315), as measured by the level transmitter (LT 315), reaches a low low level set point, the PLC issues a low low level alarm and stops any SHP pump in running.
2. **If the level in the pump containment sump in the Odor Control Room, as triggered by the level switch (LSH-301), reaches the level set point, the PLC issues a high-level alarm and shut-off the motorized isolation valve (MOV-317) on the pump suction line and stops any SHP pump in running.**

3. **If the level in the sump in the Chemical Storage Room, as triggered by the level switch (LSH-300), reaches the level set point, the PLC issues a high-level alarm and shut-off the motorized isolation valve (MOV-317) on the pump suction line and stops any SHP pump in running.**

F. PLC Functions

1. **Monitoring Digital:**
 - a. SHP Metering Pump 2 (P-350) running
2. **Monitoring Analog:**
 - a. SHP Metering Pump 2 (P-350) speed
 - b. SHP Storage Tank (T-315) level
3. **Monitoring Trending: None.**
4. **Alarming Digital:**
 - a. SHP Metering Pump 2 (P-350) fault
5. **Alarming Analog:**
 - a. SHP Storage Tank (T-315) high high level
 - b. SHP Storage Tank (T-315) high level
 - c. SHP Storage Tank (T-315) low level
 - d. SHP Storage Tank (T-315) low low level
6. **Calculations: None.**

3.05 CONTROL NARRATIVE FOR NITRATE MONITORING AND MIXED LIQUOR RECIRCULATION PUMP CONTROL

A. System Overview:

1. **One nitrate probe will be located in Anoxic Zone 4 of both Aeration Basins No. 1 and 2. Anoxic Zone 4 of Aeration Basin No. 3 will not have a probe, as it is typically only used as a backup basin.**
2. **The two new probes will be connected to existing indicator/transmitters. The purpose of the nitrate probes is to monitor nitrate to ensure anaerobic conditions are avoided in the anoxic zones and to provide automated control of the mixed liquor recirculation pump to maximize denitrification in the anoxic zones, thereby increasing alkalinity recovery and reducing effluent nitrate.**

B. Related Equipment:

1. AE-360 Aeration Basin No. 1, Anoxic Zone 4 Nitrate Probe
2. AIT-360 Aeration Basin No. 1 Indicator/Transmitter (Existing)
3. AE-361 Aeration Basin No. 2, Anoxic Zone 4 Nitrate Probe
4. AIT-361 Aeration Basin No. 2 Indicator/Transmitter (Existing)
5. P-321 Mixed Liquor Recirculation Pump (Existing)
6. LCP-321 P-321 Local Control (Existing)

C. Control Set Points: The following is a table of control set points and parameters that can be entered and adjusted by the operator within the OIT:

Parameter	Units	Default Value	Adjustable?	Delay?
Pump Speed Control Mode (Manual, Flow-Paced, or Nitrate Control)	N/A	Flow-Paced	Yes	No
Duty Pump	N/A	P-321	No	No
Pump Speed	%	100	Yes	No
Recycle Ratio	%	300	Yes	No

Parameter	Units	Default Value	Adjustable?	Delay?
Minimum Pumping Rate	MGD	3.5	Yes	No
Maximum Pumping Rate	MGD	7.5	Yes	No
Active Nitrate Probes	N/A	Both	Yes	No
Time Interval	minutes	10	Yes	No
Speed Change	%	5	Yes	No
Minimum Nitrate Concentration	mg/L	1.0	Yes	Yes
High Nitrate Concentration	mg/L	3.0	Yes	Yes

D. SCADA Auto:

1. Each nitrate probe produces a 4-20 milliamp (mA) signal proportional to its calibration range that is received by the PLC and scaled to provide a measurement of nitrate. The PLC will monitor nitrate concentration, which will be displayed and logged historically in the SCADA system. The daily maximum, minimum and average for each probe will be calculated and logged in SCADA. The PLC will also calculate the combined average nitrate concentration for the two zones over the time interval period associated with the automated nitrate control discussed below. If either Aeration Basin No. 1 or 2 is out of service, the associated nitrate probe can be selected to be ignored in SCADA.
2. The existing mixed liquor recirculation pump (P-321) has a local control panel (LCP-321) with an HOA switch and a VFD in MCC-400N with keypad and separate potentiometer switch. When the HOA switch is in Hand, the City can use the potentiometer switch or VFD keypad to manually change the speed of pump. When in Off, the pump is off. When in Auto, the City may select from the following different control methods via SCADA.
3. Control Model 1 - Remote Manual: When this mode is selected, the operator can enter a set speed for the pump.
4. Control Mode 2 - Flow Paced: When this mode is selected, the operator enters a recycle rate as a percentage of the influent flow (range of 0 to 300%).
 - a. The PLC calculates the required mixed liquor flow based on the measured influent flow and selected percentage for flow pacing. The PLC then estimates the required pump speed based on an input table of pump flow vs. pump speed that is derived from the manufacturer's pump curve.
 - b. If the calculated mixed liquor flow is below the selected minimum pumping rate (adjustable), the PLC will run the pump at the minimum pumping rate.
 - c. If the calculated mixed liquor flow is above the selected maximum pumping rate (adjustable), the PLC will run the pump at the maximum pumping rate.
5. Control Mode 3 - Nitrate Control: When this mode is selected, the mixed liquor recirculation rate is adjusted based on the measured nitrate concentration with the goal of minimizing the recirculation rate to reduce the dissolved oxygen recirculated, thereby increasing denitrification and alkalinity recovery in the anoxic zones, while avoiding anaerobic conditions.
 - a. The operator enters set points for time interval, % speed change, and minimum nitrate concentration (default 1.0 mg/L).

- b. At each time interval, the PLC will adjust the mixed liquor pump speed up or down based on the change in the combined average nitrate concentration and previous action.
 - c. If the last action was a reduction in speed, the combined average measured nitrate concentration for the time interval was reduced compared to the previous average, and the combined average nitrate concentration for the time interval is above the minimum, the speed will again be reduced.
 - d. If the last action was a reduction in speed but there was an increase in the combined average effluent nitrate concentration for the time interval or the combined average nitrate concentration for the time interval is at or below the minimum, the speed will be increased.
 - e. If the last action was an increase in speed, the measured combined average nitrate concentration for the time interval was reduced compared to the previous average, and the combined average nitrate concentration for the time interval is above the minimum, the speed will again be increased.
 - f. If the last action was an increase in speed but there was an increase in the combined average effluent nitrate concentration for the time interval or the combined average nitrate concentration for the time interval is at or below the minimum, the speed will be decreased,
- E. Interlocks with Associated Equipment: None.
- F. PLC Functions: Only new functions needed for the nitrate probe are listed.
 - 1. **Monitoring Digital: None.**
 - 2. **Monitoring Analog:**
 - a. Aeration Basin No. 1, Anoxic Zone 4 Nitrate Concentration (AE/AIT-360)
 - b. Aeration Basin No. 2, Anoxic Zone 4 Nitrate Concentration (AE/AIT-361)
 - 3. **Monitoring Trending:**
 - a. Aeration Basin No. 1, Anoxic Zone 4 estimated nitrate concentration for daily, monthly, and yearly average based on feedback from Nitrate Probe (AE/AIT-360)
 - b. Aeration Basin No. 2, Anoxic Zone 4 estimated nitrate concentration for daily, monthly, and yearly average based on feedback from Nitrate Probe (AE/AIT-361)
 - c. Aeration Basin Anoxic Zone 4 combined nitrate concentration for daily, monthly, and yearly average
 - 4. **Alarming Digital:**
 - a. Aeration Basin No. 1, Anoxic Zone 4 Nitrate Analyzer (AIT-360) fail
 - b. Aeration Basin No. 2, Anoxic Zone 4 Nitrate Analyzer (AIT-361) fail
 - 5. **Alarming Analog:**
 - a. Low nitrate concentration alarm – Below the minimum concentration for a user specified number of time intervals.
 - b. High nitrate concentration alarm – Above the high concentration for a user specified number of time intervals.
 - 6. **Calculations:**
 - a. Combined Aeration Basin Anoxic Zone 4 nitrate concentration

3.06 CONTROL NARRATIVE FOR HVAC SYSTEM MONITORING

- A. System Overview:
1. **The Odor Control Room HVAC System provides the Odor Control Room with ventilation and air flow. The HVAC system includes a supply fan (SF-001) and an exhaust fan (EF-001). The fans are to run continuously. An accessory temperature monitor and speed control are provided for each fan. An accessory flow switch (FSL-001A and FSL-001B) is provided with each fan. The switches are de-activated on 'low flow'.**
 2. There are three GO/NO-GO panels for the Odor Control Room HVAC system, located at each entrance to the room.
 - a. Each panel contains two indicator lights, one red and one green and a manual reset button.
 - b. The green light ('GO' status) is normally lit, indicative of **SF-001 and EF-001** in **normal** operation.
 - c. **The red light ('NO-GO' status) indicates 'low flow' (or loss of airflow) at either SF-001 or EF-001.**
 3. When a low flow alarm is activated, the monitoring panel call to alarm is made and the red light is activated, and the green light is turned off. The red light remains activated for the duration of the alarm condition.
- B. Control:
1. Both supply fan and exhaust fan have **accessory temperature monitor and integral speed control systems**. The fans are normally running. There is no SCADA control associated with **the operation of these fans**.
 2. **If the flow switch at either fan is de-activated:**
 - a. **A 'low flow' input signal is sent to the PLC**
 - b. **The PLC sends a 'low flow' alarm output to the SCADA system**
 - c. **The PLC sends an output to set the three "GO/NO-GO" panels in 'NO-GO' (alarm) status.**
 3. **When both flow switches are activated, the PLC sends an output to set the three "GO/NO-GO" panels in 'GO' status.**
- C. PLC Functions
1. **Monitoring Digital:**
 - a. Supply Fan flow switch input
 - b. Exhaust Fan flow switch input
 2. **Alarming Digital:**
 - a. Supply Fan Low flow
 - b. Exhaust Fan Low flow
 - c. Odor Control Room GO/NO-GO alarm

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SECTION 17510

PANELS

PART 1 - GENERAL

1.01 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 17320: Process Control System

1.02 DESCRIPTION

- A. Provisions: Requirements of Division 1 and Section 17010 form a part of this Section.
- B. Work Included: This Section covers control panels shown on the Electrical or Instrumentation Drawings, or as specified in either Division 16 or 17, and sets minimum standards for all packaged unit panels specified in Divisions 11 to 15, unless modified under those sections.

1.03 REFERENCE STANDARDS

- A. National Electrical Manufacturers Association (NEMA) Publications:
 - 1. ICS 1 General Standards for Industrial Controls and Systems
 - 2. ICS 2 Standards for Industrial Control Devices, Controllers and Assemblies
 - 3. ICS 4 Terminal Blocks for Industrial Control Equipment and Systems
 - 4. ICS 6 Enclosures for Industrial Controls and Systems
- B. Underwriters Laboratories (UL) Publication:
 - 1. 508 Industrial Control Equipment

1.04 SUBMITTALS

- A. Provide submittals in accordance with Section 01300. Shop drawings to be submitted in this Section shall be made in one package under the Product Review Category of Shop Drawings.
- B. Shop Drawings: Submit shop drawings for all control panels, including details for the following items:
 - 1. Electric power wiring schematics.
 - 2. Electric signal wiring schematics.
 - 3. Elementary control diagram.
 - 4. Air supply piping schematics.
 - 5. Pneumatic signal tubing schematics.
 - 6. Fabrication drawings, including a dimensioned outline drawing to scale, showing space for conduits, etc.
 - 7. Seismic design certifications and anchorage descriptions as required by Section 01190.
 - 8. Details of all panel accessories.
 - 9. A detailed Bill of Materials.
 - 10. Panel layouts and nameplate inscriptions.
 - 11. Connections to external equipment.
 - 12. Wire marking scheme.
 - 13. Sunscreen sketch (see Paragraph 2.07)

14. Arrange submissions in a logical manner and on the shop drawings use the device abbreviation identifications and equipment names as shown on the Drawings, in order to expedite and facilitate review by the Engineer.
 15. Where unit arrangement or wiring deviates in any way from that shown on the Drawings, provide a complete record and explanation of such deviations.
- C. Spare Parts List: Include a spare parts list showing recommended parts and quantities as well as complete ordering information for replacement components. Provide instruction books for special control devices and special equipment installed in the control panels. Submit these to the Engineer prior to installation of the equipment.
- D. Manuals: Provide manuals as specified in Section 17010.

1.05 UL LABEL

- A. UL Label:
1. Each control panel and terminal cabinet shall bear the UL 508A label except as noted in the following paragraph. The UL label shall apply to the enclosure, the specific equipment supplied with the enclosure, and the installation and wiring of the equipment within and on the enclosure. If required for UL labeling, provide ground fault interrupters, isolation transformers, fuses, and any other necessary equipment, even though such equipment is not indicated on the Drawings. The fabricator shall be an approved UL listed manufacturer.
 2. Control panel enclosures containing instruments mounted through the enclosure walls or door shall meet all requirements for UL labeling as above, but no UL label is required. This exception applies only if UL Recognized instruments for the intended purpose are not made.

1.06 PRODUCT DELIVERY AND HANDLING

- A. Ship assembled control panels in sections that facilitate handling and field installation.

PART 2 - PRODUCTS

2.01 CONSTRUCTION

- A. General:
1. Provide panels as shown on the Drawings. Panels shall conform to the requirements of NEMA Standards ICS 1 (General Standards for Industrial Controls and Systems) and ICS 2 (Standards for Industrial Control Devices, Controllers and Assemblies). The panels shall be wall-mounted or freestanding floor mounted, as shown. Provide sufficient access to the panels.
 2. The enclosures shall be code gauge steel of adequate strength, when complete, to withstand seismic forces equivalent to those noted in Division 1, General Conditions, Paragraph 1-71. Enclosures shall conform to requirements of NEMA Standard ICS 6 (Enclosures for Industrial Controls and Systems).
 3. The enclosures shall have vertically hinged front doors; provide hinge on side of panel that ensures compliance with the 30-inch rule in NEC Paragraph 110-16(a). Freestanding enclosures shall have doors secured by keyed

three-point latches, except in corrosive locations. Mount the devices through the doors or on recessed plates. Provide nameplates indicated on the Drawings. Each component within the panel shall be securely mounted and arranged for easy servicing, such that all adjustments and component removal can be accomplished without disturbing other components. No fastening devices shall project through the outer surfaces of the cabinet and all components and terminals shall be mounted on mounting pans within the panels.

4. Construction requirements on a specific type of panel are provided in subsequent paragraphs.
- B. Safety Requirements: The electrical supply to each control panel shall be arranged to be disconnected by a single switch or circuit breaker, except for necessary foreign circuits. Any live parts within the control panel fed from foreign control or signal circuits shall be covered or arranged to be disconnected by one of the following methods:
1. Enclosed relays, which are automatically de-energized when the main disconnecting switch is opened.
 2. Door-operated enclosed disconnect switches.
 3. Clearly identified enclosed manually operated disconnect switches, which may be located inside the control panel door, provided the operating handles are isolated or barriered from all open live parts. Each control panel shall be arranged so that adjustments to timing relays or replacement of fuses can be done without exposure to live parts.
- C. Piping and Wiring: Factory wire and pipe control panels. Cable all panel wiring by securing to the panel surfaces with plastic cable ties. Permanently identify each wire at each termination by means of a heatshrink numbered sleeve. Number all electrically common wires the same, and number each electrically different wire uniquely. Provide red wire color for ac wiring, with white neutral and green ground. Provide blue wiring for dc wiring. Wiring shall be 14-gauge, Type MTW or THHN, 600-volt, stranded copper wire. Where wiring crosses hinged surfaces, provide an 18-inch "U" shaped hinge loop of extra flexible wires secured at both ends. Provide ring-type lugs for all panel wiring; spade-type lugs are unacceptable. Use ratchet type crimping tools, which do not release until proper crimp pressure has been applied.
- D. Terminal Blocks: Terminal blocks shall be rated 600 volts for signals greater than 30 V and 300 volts for signals less than 30 V, and shall conform to requirements of NEMA Standard ICS 4 (Terminal Blocks for Industrial Control Equipment and Systems). The terminal block and terminal lug shall be compatible. Provide disconnecting terminals for any circuit within the control panel, which can be energized when the branch circuit feeding the control panel, if any, is off. Provide terminals for all external (field) connections and provide at least 15% spare terminals. Identify each terminal permanently with the same number as the wire being terminated. Terminals shall be Allen-Bradley 1492 Series; Buchanan; or equal.
- E. Nameplates: Provide nameplates as shown on the Drawings, and as specified in Section 17010. A "CAUTION" nameplate shall be attached to the outside of access doors warning of foreign voltages inside the panel (see "Safety Requirements").

- F. Finish:
1. After fabrication, all external welds shall be ground smooth. The entire unit shall be thoroughly degreased, then filled and sanded. All metal surfaces shall be given a rust-inhibiting treatment or passivator, then one coat of synthetic primer, followed by two coats of synthetic enamel. The average overall finish shall be at least 3 mils in thickness. All damage to the finish during installation shall be touched up at the jobsite as approved.
 2. Exterior panel color shall complement adjacent panels and shall be approved by the Owner. Sharp angled horizontal front edges of panels shall be protected by brushed and coated stainless steel angled strip with concealed fasteners.
- G. Size and Supports:
1. Panels shall be of sufficient size to adequately enclose all instruments designated as "panel-mounted" plus ample interior clearance to allow for installation, general servicing, and maintenance of the instruments. Weight of instruments shall be supported by Unistrut; Famet; Caine; or equal, channel supports. Panel size shall be as indicated on the Drawings.
 2. Provide rigid supports for all devices. Supports shall not cause warping or bowing sides or mounting plates.
- H. Mounting:
1. Attachment methods shall be detailed on panel fabrication drawing submittals. Heavy panels shall be attached by anchor bolts embedded in beams supporting the floor. See the Structural Drawings for location of beams. Seismic restraints shall be installed as specified by the manufacturer.
 2. Mounting pans of rigid sheet steel shall be provided for interior components and accessories as required. A steel divider shall separate pneumatic sections from electrical sections. Devices having both electric and pneumatic connections shall be in the pneumatic section and connected to the electric section with waterproof flexible conduit.
- I. Arrangement:
1. The instruments mounted in the panels shall have the nominal size and general arrangement shown. Panel layouts and nameplates shall conform to the approved submittal.
 2. Space shall be provided for instruments indicated as furnished by others to be mounted and wired by the control panel manufacturer. These units shall be shipped to the control panel manufacturer in sufficient time for wiring. Coordination of instrument delivery shall be the responsibility of the Contractor. The instruments and controls to be located on each panel are shown on the instrumentation drawings, electrical schematics, and/or in the individual Specification.
- J. Ventilation:
1. Ventilation shall be provided to prevent internal panel temperatures from exceeding 100°F.
 2. Louvers shall be provided, when required for cooling, near the bottoms and tops on the rear doors and side of panels. 80-mesh screens shall cover the insides of louvers.
 3. Provide a thermostatically controlled fan in each enclosure when louvers cannot dissipate heat adequately or cause sufficient flow to all panel areas.

- Ventilation fans shall be low acoustic type suitable for control rooms. Provide removable cleanable or disposable dust filter for each remote site enclosure.
4. Provide heaters and circulating fans in all outdoor panels to prevent condensation.
 5. Provide air control cooling system for panels requiring less than 1,500 Btu/hr heat dissipation.
 6. Provide air conditioning for panels requiring high heat removal.
- K. Cable Entry Plates:
1. For top entry panels, a gasketed 10-gauge steel cover plate shall be cut that is suitable for the number of conduits. Cable entry plates are not required for bottom, side or back conduit entry unless the Contractor must specifically control the position, size, and location of cutouts.
 2. Cable entry plates shall mount to and be fastened along panel stiffeners and framing segments. Tee nut fasteners are preferred.
- L. Signal Ground Buses:
1. Provide each panel with at least one isolated signal ground bus. Provide a bus 1-inch wide by 1/4-inch thick, running from top to bottom. Provide the bus with tapped holes to accommodate ground connections from various devices in the rack. Provide separate ground buses for analog and discrete/digital signals.
 2. Connect all signal shield grounds within the panel to the ground bus(es) with ring-tongue connectors that bolt to the bus(es).
- M. Signal Ground Plate: For rack, multiple enclosure, or bay systems provide a separate 1/4-inch-thick isolated copper system ground plate. Mount this plate in a location central to all system components.
- N. Panel Lights and Receptacles: Panels shall be internally lighted by fluorescent lamps, provided with guards and a toggle switch located convenient to each access door. One duplex GFI type receptacle shall be provided in each panel section. The lights and receptacles shall be wired to outgoing terminal blocks for 120-volt, 60 Hertz, single-phase supply.

2.02 PANEL HARDWARE

- A. All doors shall be set flush with three-point vault-type key-locking latches in addition to any required screw clamps. A minimum of two sets of keys supplied. Doors shall be labeled with "AUTHORIZED PERSONNEL ONLY" in 1-inch letters.
- B. Hinges shall be piano type. All hardware and handles shall be stainless steel.
- C. Leveling adjustments on each panel section shall be provided on freestanding panels.
- D. Status lights, selector switches, and pushbuttons shall be as specified in Section 16955.
- E. Provide a copy of the elementary control diagram for the control panel, enclosed in plastic and mounted inside the panel.
- F. Control panels and electronic racks shall be supplied with door-operated switches (for control circuit interlocking) and accessories as required by Sections 17200 and 16955.
- G. Where noted on the Drawings, provide rack-out devices and access plates to make panel access easier and safer. Panel fabricators shall add full extension drawer

guides and adjust width of front access plates to assure access to all components and hardware.

- H. Floor stand kits shall not exceed 24 inches in height nor cause the panel to exceed 84 inches in overall height.

2.03 CONTROL PANELS AND ELECTRONIC RACKS

A. General:

1. Control panels of steel shall be formed of cold-rolled sheet steel of sufficient thickness and with stiffening as required for fabrication, shipping, erection, and service.
2. Panels shall be fully enclosed, including top, with no visible seams on the front. Panel front construction shall be minimum 3/16-inch stretcher-leveled, cold-rolled steel with stiffeners as necessary to maintain a flatness of $\pm 1/16$ -inch of any 2-foot span and $\pm 1/8$ -inch over any 8-foot span with all equipment installed. All other sections shall be 12 gauge except doors shall be minimum 14 gauge and shall maintain the same specified flatness when closed and latched. When shown on the Drawings, filler panels shall extend to the ceiling.
3. Cabinets shall be freestanding with adequate internal bracing to support the weight of instruments and wiring. The cabinet design shall be for front access. Doors shall be key locked with a minimum of two sets of keys supplied. Connections to and from the cabinets shall be through conduit through the bottom except when otherwise indicated on the electrical drawings.
4. Heavy-duty industrial quality racks shall be 19- or 24-inch panel. Framing shall be at least 14-gauge cold rolled steel, and continuously welded, rather than spot welded, at the seams of each intersecting joint.

- B. Finish: After fabrication, all external welds shall be ground smooth. The entire unit shall be thoroughly degreased, then filled and sanded. All metal surfaces shall be given a rust-inhibiting treatment or passivator, then one coat of synthetic primer, followed by two coats of synthetic enamel. The average overall finish shall be at least 3 mils in thickness. All damage to the finish during installation shall be touched up at the job site as approved.

- C. Exterior panel color shall complement adjacent panels and shall be approved by the Owner. Sharp angled horizontal front edges of panels shall be protected by brushed and coated stainless steel angled strip with concealed fasteners.

2.04 TERMINAL CABINETS

- A. Construction for these panels when mounted within a weather-protected structure shall be NEMA 12 rated. Panels exposed to the weather shall be NEMA 4 rated. Panels may be constructed of fiberglass or steel. Single door enclosures shall be constructed of 14-gauge steel and their interior panels shall be 12-gauge steel. Multiple door enclosures shall be 10-gauge steel. Bracing and stiffeners shall be provided as required for structural rigidity. Fiberglass panels shall have adequate support for instruments and be structurally sound.
- B. Terminal cabinets shall be designed for wall-mounting or stanchion mounting. Cabinets measuring 4 feet or greater in height and 15 inches or more in depth shall be supplied with floor stand kits.
- C. See Sections 16120 and 16124 for additional requirements.

2.05 CONSOLES

- A. Provide heavy-duty, oil- and dust-tight console made of 14-gauge steel or 11-gauge (1/8-inch) molded fiberglass. All seams shall be welded, and all doors and exterior panels shall have neoprene gaskets. The console shall have hinged door(s) on the front and side and rear access plates as needed for equipment servicing. The hinged door surfaces shall be flush with the front of the body, giving a very smooth appearance.
- B. Consoles shall have a large sloping control panel hinged along the bottom edge, with the captivated panel screws threaded into sealed wells. Provide stops to hold the control panel open. A removable subpanel shall be furnished with the console. The subpanel shall be mounted on studs welded to the inside rear of the console. An inclined body rail shall be welded to each side of the console for supporting terminal straps.
- C. Provide writing desk for the console made of 14-gauge steel, 10 inches deep. The desk shall be attached to the console with screws, which thread into sealed wells.
- D. The finish of the console shall be baked white enamel inside, and outside shall be baked enamel over gray prime over phosphatized surfaces. The top shall be gray prime inside and baked enamel outside; the instrument panels and access panels shall be white enamel inside and baked enamel outside. Desk shall be baked enamel. The terminal straps shall be white enamel.

2.06 MANUFACTURER

- A. Manufacturers of the control panels and terminal cabinets enclosure shall be Hoffman Engineering Company; Circle A-W Products Company; Gibbons Metal Products; or equal.

2.07 SUNSCREENS

- A. General: Sunscreens shall be of simple, rigid construction and shall be able to withstand wind of up to 80 MPH.
- B. Provide sunscreen for the magnesium hydroxide RIO panel to shield the panels from direct sunlight and aid in readability of the installed indicators.
- C. Contractor may consider fastening the screens directly to the panel or connected to separate supports. Submit sketch of sunscreen design to the Engineer for favorable review.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation, testing, calibration, validation, startup and instruction shall be in accordance with Section 17010.
- B. PLC I/O and HMI hardware to be selected by the Plant Wide SCADA I&C Subcontractor for compatibility with the existing PLC and SCADA network. Coordinate with the Plant Wide SCADA I&C Subcontractor.
- C. Install each control panel level and plumb, and secure by the favorably reviewed seismic mounting method. Doors shall swing freely and close tightly.

- D. Provide a 3-inch-high concrete pad for each field-mounted, freestanding control panel. Provide a 3-1/2-inch-high I-beam kick panel for each control-room mounted, freestanding panel.
- E. Carefully repair any damage to the structure, components, or finish to the satisfaction of the Engineer. Clean all nameplates.
- F. Exercise care at all times after installation of control panels to keep out foreign matter, dust, dirt, debris, or moisture. Use protective sheet metal covers, canvas, heat lamps, etc., as needed to ensure equipment protection.
- G. For all metal panels mounted on concrete walls or floors, install 1/8-inch shims, and paint the back sides and bottom of the panels with Mobil Hi-Build Bituminous Coating 35-J-10; Koppers Bitumastic Super Tank Solution; or equal. Film thickness shall be 10 mil minimum.

END OF SECTION