RECLAMATION DISTRICT 2035/WOODLAND-DAVIS CLEAN WATER AGENCY
JOINT INTAKE AND FISH SCREEN PROJECT

CONTRACT DOCUMENTS
VOLUME 1 – PROCUREMENT AND CONTRACTING REQUIREMENTS,
AND TECHNICAL SPECIFICATIONS
VOLUME 2 - DRAWINGS

VOLUME 1B

MWH Americas, Inc.
3321 Power Inn Road, Suite 300
Sacramento, CA 95826
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## PROCUREMENT AND CONTRACTING REQUIREMENTS

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## VOLUME 1C

### APPENDICES

- **APPENDIX A** Geotechnical Investigation – Pile Capacity Analysis (September 27, 2012)
- **APPENDIX B** Geotechnical Investigation – Railroad Crossing Investigation (April 2012)
- **APPENDIX C** Geotechnical Investigation – Addendum (August 12, 2011)
- **APPENDIX D** Geotechnical Investigation (September 2010)
- **APPENDIX E** Phase I Environmental Site Assessment
- **APPENDIX F** RD 2035 Hydrology and Hydraulics Update
- **APPENDIX G** Permits
- **APPENDIX H** SDWSRF Construction Phase Documents
- **APPENDIX I** CWSRF Construction Phase Documents
PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide plumbing piping and specialties, complete and operable, as indicated in accordance with the Contract Documents.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 013300 – Contractor Submittals.

B. Shop Drawings

   1. General arrangement drawings of system components.
   2. Catalog cuts and other manufacturer information for products.
   3. Anchorage calculations, stamped and signed by an Engineer in the State of California and complying with the Occupancy Category IV Facilities and the design parameters listed in section 2.2 below.

C. Samples: Electrically-fused test joint for drainage and vent piping.

1.3 WORKMANSHIP AND MATERIALS

A. WORK shall in strict accordance with the California Plumbing Code and any other authorities having jurisdiction.

B. The CONTRACTOR shall have required certifications and shall be thoroughly familiar with the local codes.

C. The CONTRACTOR shall obtain and pay for necessary permits.

D. Protection

   1. Care shall be taken at all times to protect floors, stairways, and walls during the make-up and installation of piping and equipment.
   2. The CONTRACTOR shall remove stains and repair damage before final acceptance of the WORK.

E. Identifying Marks

   1. If the ENGINEER finds materials that have identifying marks removed or lack such marks completely, such items will be rejected until the CONTRACTOR has furnished proof that said items conform to the Specifications.
   2. Adequacy and extent of such proof will be determined by the ENGINEER.
PART 2 -- PRODUCTS

2.1 GENERAL

A. Plumbing piping, fixtures, specialties, and equipment shall be as recommended by the manufacturer for the intended usage.

B. Floor drains or floor sinks shall be provided for equipment drains.

C. No equipment drains shall discharge to floor slabs.

D. Any pipe, plumbing fitting or fixture, solder, or flux used in the installation or repair of any public water system or any plumbing in a facility providing water for human consumption, shall be “lead free” except when necessary for the repair of leaded joints of cast iron pipes.

   1. Lead free means not more than 0.2 percent lead when used with respect to solder and flux, not more than 8 percent when used with respect to pipes and pipe fittings, and not more than 4 percent with respect to plumbing fixtures.

2.2 PLUMBING SUPPORTS AND FOUNDATIONS

A. Plumbing Supports: Unless otherwise indicated, plumbing supports, anchors, and restrainers shall be adequately designed for static, dynamic, wind, and seismic loads as stated in the 2010 California Building Code (CBC), Chapter 16 and ASCE 7-05. Submitted design calculations for equipment supports and anchorage shall bear the signature and seal of an Registered Professional Engineer licensed in the State of California, unless otherwise indicated. Calculations shall account for forces and distribution of forces on supporting structures resulting from normal operation, normal operation plus seismic loadings, normal operation plus wind loadings, as well as the other load combinations stated the 2010 CBC.

   1. Wall-mounted equipment weighing more than 250 pounds or which is within 18-inches above the floor shall be provided with fabricated steel supports. Pedestals shall be of welded steel. If the supported equipment is a panel or cabinet or is enclosed with removable sides, the pedestal shall match the supported equipment in appearance and dimensions.

B. Wind Load: The wind load shall be calculated in accordance with ASCE 7-05, Chapter 6, using the following design parameters:

   1. Wind Speed: 85 mph

   2. Exposure: D

   3. Importance Factor: $I_w = 1.15$

C. Seismic Loads: The seismic lateral and vertical forces shall be calculated in accordance with the ASCE 7-05, Chapters 11 and 13, using the following design parameters:

   1. Site Class: D

   2. Seismic Use Group IV
3. Seismic Design Category (SDC) D
4. Seismic Importance Factor: \( I_e = 1.5 \)
5. Short Period Spectral Acceleration \( S_s = 0.67 \, g \)
6. 1 Second Period Spectral Acceleration \( S_1 = 0.27 \, g \)

D. Anchors: The Anchorage of all plumbing and associated piping is to comply with the requirements of Occupancy Category IV facilities. Anchor bolts shall be in accordance with Section 05 50 00 - Miscellaneous Metalwork, and shall be designed to resist the above loads. Anchor bolt calculations shall clearly show that the capacity of the anchor and the capacity of the concrete that the anchor is embedded in are adequate to resist all loads stated in the 2010 CBC and ASCE 7-05, including lateral wind and lateral and vertical seismic loads. Reduction factors associated with edge distance, embed length, and bolt spacing shall all be considered and based on the actual dimensions of the concrete that resists the anchorage forces. Anchor bolt details shall include required bolt diameter, embed, and edge distances. Further, the design of Anchors shall consider the ductility requirements stated in ASCE 7-05, Chapter 13, Section 13.4.2 and Chapter 15, Section 15.7.3. Anchor bolt calculations and details shall be submitted and shall bear the signature and seal of a Registered Professional Engineer licensed in the State of California.

2.3 CAST IRON PIPING AND FITTINGS FOR SANITARY DRAIN, STORM DRAIN AND VENTS

A. Cast iron sanitary, storm, vent pipe, and fittings shall be manufactured in accordance with and shall meet the requirements of ASTM A 74 - Cast Iron Soil Pipe and Fittings.

B. Dimensions of cast iron soil pipe and fittings shall be as given in Table 2 of ASTM A 74.

C. Hub-less cast iron soil pipe and fittings with Clamp-All type pipe couplings, or equal, shall be used for above ground sanitary, storm, and vent piping where approved for use by local authorities.

D. Hub-less cast iron soil pipe and fittings shall meet CISPI Standard 301.

E. Pipe couplings shall have high-torque capacity and shall meet FM standard 1680.

F. Copper tubing and fittings for potable and service water 3-inch and smaller shall be Type K copper tube with soldered fittings.

G. Flashing

1. Vent piping passing through the roof shall be flashed.

2. Flashing shall extend a minimum 12 inches from the outer surface of the pipe in each direction.

3. Flashing shall be fabricated from one piece of spun, heavy, 0.064 prime aluminum or 4-pound lead sheet.
2.4 INSULATION

A. Cold water piping, valves, fittings, and exposed horizontal sanitary, storm, and vent piping shall be provided with one-inch-thick insulation in accordance with the requirements of Section 230700 – Pipe, Ductwork, and Equipment Insulation.

B. Coverings

1. Cover valves, flanges, fittings, and ends-of-insulation with a pre-molded high- and low-temperature PVC fitting cover, end cap, or similar pre-formed unit.

2. The pre-formed covers shall be sized to receive the same thickness of insulation as used in the adjacent piping and shall be in accordance with Section 230700 – Pipe, Ductwork, and Equipment Insulation.

C. Exposed Piping

1. Exposed supply and drain piping for lavatories shall be insulated under the wash basins in order to prevent burns and abrasions to handicapped persons.

2. Removable insulated covers shall be Plumberex Specialty Products Handy-Shield type, or equal.

2.5 HANGERS, SUPPORTS, AND MISCELLANEOUS METAL WORK

A. General

1. For utility piping such as cold water, hot water, and sanitary drain pipes located inside the building, the CONTRACTOR shall provide hangers and supports for vertical, axial, and seismic loads in accordance with the Code.

2. No perforated strap hangers nor wire supports will be permitted.

3. The CONTRACTOR shall obtain the services of a registered mechanical or structural professional engineer for design of the supports, and the Shop Drawings showing installation shall be stamped by the registered engineer.

4. Pipe supports shall be as indicated in Section 431052 – Pipe Supports and the requirements in section 2.2 above.

B. Hangers supporting insulated piping shall be sized to fit the pipe plus the insulation.

C. Insulation at support points shall be provided with metal shields in order to prevent damage to the insulation.

D. Spacing

1. Pipe support spacing for steel and cast iron pipe shall be as indicated in Section 431052 – Pipe Supports.

2. Copper tube support spacing shall be not more than 6 feet between supports.

E. Rod sizes for pipe hangers shall be as recommended by the hanger manufacturer.
F. Pipe hangers used to support uninsulated copper tube shall be constructed of copper or copper-plated.

G. Vertical piping shall be supported at the base with fittings made for this purpose or shall be supported from the nearest horizontal member or floor with a riser extension pipe clamp.

H. Inserts
   1. Anchors that are installed into existing concrete shall be Grinnel Figure 117, Modern Figure 740, or equal, expansion case inserts.
   2. Drill clean holes for the insertion of case and patch concrete around the hole, as required.
   3. Continuous-slotted concrete inserts, if used, shall be Crawford Figure 148, Fee & Mason Figure 9000, or equal.
   4. The CONTRACTOR shall provide secondary angle supports between main inserts in order to handle the loads which can be properly supported by such arrangement.
   5. Concrete inserts shall be as indicated in Section 431052 – Pipe Supports.
   6. Inserts shall be galvanized.

2.6 PIPE SLEEVES
   A. Sleeves shall be constructed from Schedule 40 galvanized steel pipe, one size larger than the pipe passing through, or where pipe is insulated, one size larger than the pipe plus insulation.
   B. At exposed wall or ceiling surfaces, install a suitable chromium plated brass wall plate approved by the ENGINEER.

2.7 FLOOR DRAINS IN CONCRETE FLOORS
   A. Floor drains in concrete floors shall be constructed of cast iron, in the sizes indicated, and provided with sediment buckets.
   B. Each floor drain located on an upper floor shall have a clamping collar, with 4-lb sheet lead flashing 12 inches minimum all around.
   C. Where lead flashing does not comply with the Code, use epoxy waterproofing material and submit a Shop Drawing for review.
   D. Manufacturers, or Equal
      2. Jay R. Smith Mfg. Co., Fig. 2350
2.8 CLEANOUTS

A. Cleanouts shall be heavy plugs with tapered shoulders against caulked lead or heavy brass plugs.

B. Where underground or concealed, cleanouts shall be brought to floor level and to accessible locations with access covers and frames.

C. Manufacturers, or Equal

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D. Cleanouts shall have a minimum diameter of 3 inches.

E. Stack cleanouts shall be installed at the base of each stack.

F. Cleanouts shall be fabricated from galvanized cast iron with ABS plastic cleanout plugs.

2.9 HOSE BIBBS AND HYDRANTS

A. Hose bibbs and hydrants in exposed locations subject to freezing shall be the non-freeze type.

B. Hose bibbs connected to a non-potable water supply shall be provided with plastic or stainless steel warning signs reading "DO NOT DRINK" in clearly legible letters, permanently attached at the hose bibb.

C. Hose bibbs shall be provided with vacuum breakers as furnished by Crane Co., American Standard, or equal.

D. Manufacturers, or Equal

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2.10 SHOCK ABSORBERS

A. Building cold and hot water piping that is connecting self-closing faucets, quick-action valves, water closets, emergency showers, washers, and dishwashers, shall be protected by shock absorbers located at each fixture or battery of fixtures.

B. Shock absorbers shall be corrosion-resistant, permanently sealed, and shall be sized and installed to the manufacturer’s printed recommendations.

C. Manufacturers, or Equal

1. Josam "SHOKTROLS"

2. Jay R. Smith "HYDROTROL"

3. Zurn, Model Z-1022

2.11 WALL-MOUNTED HOSE RACKS

A. The CONTRACTOR shall provide wall-mounted hose racks at the indicated locations.

B. Racks shall be of welded steel construction, minimum 8-gauge sheet steel, hot-dip galvanized after fabrication, and shall have a capacity to hold 100 feet of the indicated hose.

C. Racks located in the open shall be supported from two 2-by-2-by-1/4-inch galvanized steel angle posts set in a concrete base or as indicated.

2.12 HOSES AND NOZZLES

A. The CONTRACTOR shall furnish the following lengths of hose:

   1. Provide 6 each 75-ft lengths of 3/4-inch hose.

B. Each length of hose shall be provided with male and female connectors and a nozzle.

C. Hoses shall be fabricated from seamless extruded rubber with a dacron cotton exterior designed for a working pressure of at least 200 psig.

D. Nozzles

   1. Nozzles shall be capable of complete shut-off and shall produce a solid straight stream and up to a 90-degree conical fog.

   2. Nozzle material shall be polished brass.
3. Nozzles shall be provided with rubber bumpers.

E. Nozzle Manufacturers, or Equal


2. Fire-End and Croker Corp.

3. Halprin Supply Co.

4. Western Fire Equipment Co.

2.13 BACKFLOW PREVENTER

A. Provide reduced pressure backflow prevention units where indicated.

B. The units shall be of bronze body construction, with celcon check seats and stainless steel relief valve seats, shafts, and bolts.

C. The units shall be provided with tight-seating check valve and relief assemblies, and bronze bodies with non rising stem ball valve test cocks.

D. The units shall be Watts Regulator Co., No. 909 Series, or equal.

E. Installation shall meet local code requirements.

F. Backflow preventers for automatic sprinkler systems shall be in accordance with the requirements of Section 433052 – Miscellaneous Valves.

2.14 PAINTING

A. Ferrous metal, except finished, galvanized, and machined surfaces, shall have surfaces prepared and primed in the shop in accordance with the requirements of Section 099600 – Protective Coating.

B. Prime colors shall be compatible with finish coats that are applied in the field.

C. Self-contained units such as wall-mounted hose racks shall be supplied with factory-applied finish coats of baked enamel.

D. Field painting shall comply with the requirements of Section 099600 – Protective Coating.

PART 3 -- EXECUTION

3.1 PREPARATION

A. The CONTRACTOR shall coordinate the roughing-in process with provisions for wall and floor sleeves, pipe inserts, and cutting of roof and floor penetrations, such that drain lines will have the required invert elevations and slopes.
3.2 OPENINGS

A. New Construction

1. The CONTRACTOR shall provide necessary openings in walls, floors, and roofs for the passage of piping and plumbing equipment within and into the building.

2. Openings shall be as indicated or as required to provide passage for the plumbing WORK.

3.3 INSTALLATION AND APPLICATION

A. The CONTRACTOR shall provide plumbing specialties in accordance with manufacturer’s printed instructions.

B. Pipe shall be arranged in a neat and orderly manner to occupy the minimum amount of space and so that the pipe will not obstruct passageways and movement of building occupants or interfere with normal operation and maintenance of any equipment.

C. Pipe shall be carefully placed and properly sloped and shall be neatly and firmly supported by hangers or supports.

D. Piping in buildings shall be as close to the ceilings or walls as possible unless indicated otherwise.

E. Joints

1. Screwed joints shall be made with joint compound and be tight and leakproof.

2. A sufficient number of brass-to-ferrous metal seat unions shall be placed in lines such that any pipe, valve, or piece of equipment may be easily disconnected.

F. Drainage and Sanitary Lines

1. Drainage and sanitary lines shall be properly run, trapped, and vented in order to conform to Code requirements.

2. Changes in direction shall be made with “Y” branch fittings and shall be of the same size as the pipe.

3. Changes in pipe size shall be made with reducing fittings.

4. The minimum depth of cover shall be 3 feet.

G. Horizontal soil, drain, and waste pipes shall be provided with a slope of at least 1/4 inch per foot, unless indicated otherwise.

H. Floor drains and cleanouts shall be installed such that the tops of the drains are flush with the finished floor.

I. Plug each natural gas outlet, including valves, with a threaded plug or cap immediately after installation, and retain the plugs until continuing piping or equipment connections are completed.
3.4 EQUIPMENT DAMAGE AND REMOVAL

A. The CONTRACTOR’s operations shall be carried out in such a manner as to guard against damage to those portions of the structure and equipment that are to remain in the finished WORK.

B. Any damage caused by the CONTRACTOR or Subcontractor through their operations shall be repaired to the satisfaction of the ENGINEER.

3.5 TESTING

A. The CONTRACTOR shall perform such tests as are required by local ordinances and Codes in the presence of a local governing authority inspector to show that piping is tight, leak-free, and otherwise satisfactory, and shall also perform such tests as the ENGINEER may direct to insure that fixtures and equipment operate properly.

B. The CONTRACTOR shall pay the costs to perform such tests and the costs of making changes or repairs until the WORK is acceptable to the governing authorities.

3.6 DISINFECTION

A. After potable water supply lines are successfully tested, they shall be disinfected by introducing an HTH solution, liquid chlorine, or chlorine solution of sufficient strength.

B. The line shall then be filled with water and maintained under not less than 10 psig pressure, for not less than 48 hours, during which period each valve on the line shall be opened and closed several times, after which it shall be flushed clean and then tested by the OWNER.

C. This procedure shall be repeated as often as necessary until the line is pronounced safe for use by the OWNER.

D. No cross-connection between the water main and any pipe not yet disinfected will be permitted.

- END OF SECTION -
PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide heating, ventilating, and air conditioning systems and associated equipment complete with supports, mounting frames, ventilators, ductwork, piping, louvers, panels, filters, grilles, electric drive units and controls, mechanical equipment, electrical work, appurtenances, testing, and balancing, as indicated in accordance with the Contract Documents.

B. The equipment shall be installed ready for operation.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Codes, as referenced herein, are indicated in Section 014219 – Reference Standards.

B. The WORK and materials shall be in full accordance with the latest rules and regulations or publications of the State Energy Resources Conservation and Development Commission, the State Fire Marshall, the Industrial Safety Orders, the Health and Safety Rules (Air Conditioning systems), the local plumbing code, the local building code, and other local codes.

C. Nothing in the Contract Documents shall be construed to permit WORK in violation of the above codes, rules and regulations.

D. In the absence of applicable codes, the installation and workmanship shall follow the standards set by the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).

1.3 CONTRACTOR SUBMITTALS

A. Shop Drawings

1. Submit complete shop drawings and certificates, test reports, affidavits of compliance, for all equipment, ductwork and piping systems, in accordance with the requirements in Section 013300 – Contractor Submittals, and as indicated in the individual equipment, piping or ductwork Sections.

2. Construction Drawings

   a. The HVAC Drawings define the general layout, configuration, routing, size and the general intent of the design. and are not fabrication drawings.

   b. It shall be the CONTRACTOR's responsibility to develop the Shop Drawings required for the construction of the HVAC system.

3. The Shop Drawings shall include all necessary dimensions and details regarding equipment, pipe and ductwork joints, fittings, valves, appurtenances, design calculations, and material lists.
4. The submittals shall include detailed layout, spool, or fabrication drawings which shall show all fittings, and supports as necessary to accommodate the equipment as a complete and functional system. The shop drawing submittals for all equipment and tributary pipe lengths weighing over 400 lbs, and mounted to floors, ceiling, walls or on roofs, are to include calculations that show the wind and/or seismic forces (lateral, uplift, downward) and all connections to carry these forces in the structure. The calculations are to include an analysis using the parameters in Section 2.2 below.

B. Equipment Numbers

1. Equipment is identified by assigned numbers for reference and location purposes in the Contract Documents.

2. Indicate the appropriate equipment numbers on the Shop Drawings and other submittals.

C. Furnish certified fan curves for each fan.

D. Acoustic Louver Certification: The manufacturer shall submit certified data from a laboratory, substantiating the specified performance of the acoustic louvers.

1.4 WARRANTY

A. Air conditioners, heaters, fans, ventilators, grilles, and the like, that are provided by the CONTRACTOR shall carry the manufacturer’s standard warranty.

B. Warranties shall be furnished to the ENGINEER upon final acceptance of the completed systems by the OWNER.

C. Refrigerant compressors shall carry a manufacturer's 5-year warranty.

D. Control System

1. The temperature and equipment control system shall be warranted free from defects in workmanship and material under normal use and service for a period of one year after acceptance by the ENGINEER.

2. Equipment that proves to be defective in workmanship or material during the warranty period shall be adjusted, repaired, or replaced by the automatic control manufacturer as part of the Contract.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Quality

1. Mechanisms and other parts shall be amply proportioned for the stresses which may occur during operation and for any other stresses which may occur during fabrication and erection.
2. Individual parts furnished which are alike in all units shall be alike in workmanship, design, and materials, and shall be of the manufacturer's top-line, industrial-commercial grade.

B. Supports

1. Equipment and appurtenances shall be firmly anchored or connected to supporting members.

2. Equipment shall be supported on restrained spring-type vibration isolators.

3. Supports as required for the proper installation of the equipment, but not forming an integral part of the building structure, shall be provided unless otherwise indicated.

C. Noise and Vibration Control

1. The system shall be free of objectionable vibrations and noise.

2. Provide flexible connections in ducts and piping connections to fans, compressors, and other vibrating equipment.

2.2 EQUIPMENT SUPPORTS AND FOUNDATIONS

A. Equipment Supports: Unless otherwise indicated, equipment supports, anchors, and restrainers shall be adequately designed for static, dynamic, wind, and seismic loads as stated in the 2010 California Building Code (CBC), Chapter 16 and ASCE 7-05. Submitted design calculations for equipment supports and anchorage shall bear the signature and seal of an Registered Professional Engineer licensed in the State of California, unless otherwise indicated. Calculations shall account for forces and distribution of forces on supporting structures resulting from normal operation, normal operation plus seismic loadings, normal operation plus wind loadings, as well as the other load combinations stated the 2010 CBC.

1. Wall-mounted equipment weighing more than 250 pounds or which is within 18-inches above the floor shall be provided with fabricated steel supports. Pedestals shall be of welded steel. If the supported equipment is a panel or cabinet or is enclosed with removable sides, the pedestal shall match the supported equipment in appearance and dimensions.

B. Wind Load: The wind load shall be calculated in accordance with ASCE 7-05, Chapter 6, using the following design parameters:

1. Wind Speed: 85 mph

2. Exposure: D

3. Importance Factor: \( I_w = 1.15 \)

C. Seismic Loads: The seismic lateral and vertical forces shall be calculated in accordance with the ASCE 7-05, Chapters 11 and 13, using the following design parameters:

1. Site Class: D
2. Seismic Use Group  IV
3. Seismic Design Category (SDC)  D
4. Seismic Importance Factor:  \( I_e = 1.5 \)
5. Short Period Spectral Acceleration  \( S_s = 0.67 \text{ g} \)
6. 1 Second Period Spectral Acceleration  \( S_1 = 0.27 \text{ g} \)

D. **Anchors:** The Anchorage of the Equipment, including all Roof Top Units (RTUs) and related Duct Work are to comply with the requirements of Occupancy Category IV facilities. Anchor bolts shall be in accordance with Section 05 50 00 - Miscellaneous Metalwork, and shall be designed to resist the above loads. Anchor bolt calculations shall clearly show that the capacity of the anchor and the capacity of the concrete that the anchor is embedded in are adequate to resist all loads stated in the 2010 CBC and ASCE 7-05, including lateral wind and lateral and vertical seismic loads. Reduction factors associated with edge distance, embed length, and bolt spacing shall all be considered and based on the actual dimensions of the concrete that resists the anchorage forces. Anchor bolt details shall include required bolt diameter, embed, and edge distances. Further, the design of Anchors shall consider the ductility requirements stated in ASCE 7-05, Chapter 13, Section 13.4.2 and Chapter 15, Section 15.7.3. Anchor bolt calculations and details shall be submitted and shall bear the signature and seal of a Registered Professional Engineer licensed in the State of California.

E. **Equipment Foundations:** Mechanical equipment, tanks, control cabinets, enclosures, and related equipment shall be mounted on minimum 3 ½-inch high concrete bases, unless otherwise indicated. Equipment foundations are indicated on Drawings. The CONTRACTOR, through the equipment manufacturer, shall verify the size and weight of equipment foundation to insure compatibility with equipment. The dimensions of all concrete bases shall be sufficient to provide the edge distances required by the anchor bolt calculations.

2.3 **MOTORS**

A. Motors provided with the equipment shall conform to the latest IEEE and NEMA requirements for mechanical and electrical characteristics, including service factors.

B. Motors shall be in conformance with the requirements of Section 260510 – Electric Motors.

C. Each motor shall bear the manufacturer’s nameplate with complete motor data.

D. Each motor shall be of ample size and construction to continuously carry the loads which might be imposed by the equipment throughout the full range of operation of the equipment.

E. The maximum motor loading shall be less than or equal to the nameplate horsepower rating, exclusive of the service factor.
2.4 ELECTRICAL WORK

A. The WORK of this section shall include:

1. Provide controls, sensors and control panels relating to the HVAC systems, including starters, thermostats, motorized dampers, louver operators and other equipment as indicated.

2. Provide control wiring of 120-volt and less as indicated in this Section and in conformance the requirements of Division 26 – Electrical and Division 40 – Instrumentation and Control.

B. The WORK of Division 26 shall include:

1. Provide local power disconnects, where required.

2. Provide circuit breakers, starters in motor control centers, and 120-, 208-, 240- and 480-volt power feeders from the starters and circuit breakers to the HVAC equipment, as indicated.

C. Starters, whether as an integral or separate part of the equipment, shall be in accordance with the requirements of Section 262900 – Low-Voltage Motor Control Centers.

D. Enclosures shall be of the same NEMA class as the electrical equipment in the same area.

E. Starters shall be of the same manufacturer as the starters indicated under Section 262900 – Low-Voltage Motor Control Centers.

F. Low-voltage control wiring shall be in accordance with the National Electric Code.

G. Control wiring for line voltage 120-volt and higher shall be in conformance with the requirements of Section 260519 – Wires and Cables.

H. Control Panels shall be in conformance with the requirements of Section 260515 – Local Control Panels and Miscellaneous Electrical Devices.

I. Conduit shall be in conformance with the requirements of Section 260533 – Electrical Raceway Systems and Section 260543 – Underground Raceway Systems.

2.5 FLASHING

A. Equipment that passes through roofs of buildings or structures shall be provided with flashing as indicated.

B. Flashing shall be in conformance with the requirements of Section 076300 – Flashing and Sheet Metal.

2.6 HANGERS AND SUPPORTS

A. Provide all necessary hangers, supports, concrete inserts, anchors and guides for material and equipment to be installed.
B. No perforated strap hangers and no wire supports will be accepted.

C. Insulation Allowance
   1. Hangers supporting insulated pipe shall be sized to fit the pipe plus the insulation.
   2. The insulation at support points shall be provided with a metal shield in order to prevent damage to the insulation.

D. Anchors and guides shall be constructed of steel, in accordance with approved Shop Drawings, and as indicated.

E. Pipe hangers used to support uninsulated copper piping shall be copper-plated.

F. Anchors
   1. Anchorages shall be obtained by welding lugs onto the pipe and providing abutting surfaces against the lugs to restrict longitudinal movement.
   2. Anchors shall be designed such that the pipe may be removed by removing bolts; no welding of pipe to the anchor will be accepted.
   3. Bolting materials shall be cadmium-plated.

G. Guides shall be located not more than 20 feet from each expansion loop or joint.

H. Horizontal runs of pipe shall be provided with supports spaced such that the sag of the unsupported length will not create any pockets in the piping (weight of fluid included).

I. Pipe support lengths shall be in conformance with the requirements of Section 431052 – Pipe Supports.

J. Vertical Piping
   1. Vertical piping shall be:
      a. Supported at the base with fittings made for this purpose; or
      b. Supported from the nearest horizontal member or floor with a riser extension pipe clamp.
   2. Provide a riser extension clamp at each floor.

K. Hangers for ductwork and equipment shall be as indicated and in accordance with the guidelines of the Sheet Metal and Air Conditioning Contractors National Association (SMACNA).

L. Inserts shall be galvanized.
2.7 MOTORIZED DAMPERS

A. General
   1. Provide the motorized opposed blade dampers as indicated.
   2. Damper sizes and capacities shall be as indicated on the Drawings.

B. Design and Construction
   1. The damper and frames shall be fabricated from aluminum with a minimum thickness of B&S 12-gauge.
   2. The aluminum blades shall be provided with interlocking edges, with one center and two edge crimps, and brass bearings.
   3. The frame shall be of welded channel construction, and shall be provided with lugs and mounting brackets for damper operators.
   4. The dampers shall be provided with felt or rubber seals at their edges in order to minimize air infiltration when closed.

C. Motors
   1. Damper motors shall be electric with necessary linkages for positioning the damper blades.
   2. The motors shall be powered open and spring-closed, unless otherwise indicated.

2.8 BACKDRAFT OR GRAVITY DAMPERS

A. General
   1. Provide backdraft dampers on the exhaust fans and ventilators where indicated.
   2. Damper sizes and capacities shall be as indicated on the Drawings.

B. Design and Construction
   1. The dampers shall be of the multi-blade type, with soft-seating gaskets for minimizing noise and air leakage when closed.
   2. Blades shall be constructed of 16-gauge aluminum, and shall be of an air foil design.
   3. Frames shall be fabricated from 16-gauge extruded aluminum alloy.
   4. The frames shall be totally out of the air stream, and arranged for flange mounting.
   5. The dampers shall be designed to operate at 0.05 inch w.g. S.P., or less.
   6. Blades shall be individually counterbalanced, and shall be provided with non-ferrous pins turning in nylon bearings.
C. Damper Manufacturers, or Equal
   1. Air Balance, Inc.
   2. Air Dynamic
   3. Ruskin, Model BD2A1

2.9 VOLUME CONTROL DAMPERS (MANUAL AND MOTORIZED)

A. General
   1. Provide volume control dampers in accessible locations in branch supply ducts and at each exhaust air opening, in order to properly regulate the volume of air delivered or withdrawn from each inlet and outlet, and as indicated.

   2. Damper sizes and capacities shall be as indicated on the Drawings.

B. Construction
   1. The volume dampers shall be of the opposed blade type.
   2. The dampers shall be constructed of aluminum, of B & S 14-gauge thickness.
   3. The dampers shall be suitably reinforced with sturdy control shafts.
   4. Ductwork shall be reinforced to double thickness at damper shaft openings.

C. Air Extractor Type: The volume control dampers indicated to be of the air extractor type shall be constructed of stainless steel, of 20-gauge for frames and of 24-gauge thickness for blades.

D. No splitter dampers will be accepted.

E. Manual control dampers shall be provided with mechanisms for adjustment and locking into position after being set.

F. Motors
   1. Damper motors shall be electric with either modulating or 2-position control and necessary linkages.
   2. The motors shall be powered open and spring-closed, unless otherwise indicated.

2.10 REGISTERS, GRILLES AND DIFFUSERS

A. General
   1. Provide supply and return registers and grilles, and all supply diffusers as indicated.
   2. The sizes, capacities, and deflection of each unit shall be as indicated on the Drawings.
B. The following schedule shall be followed:

<table>
<thead>
<tr>
<th>Supply Grilles (SG)</th>
<th>Titus Model 301FS Aluminum; Tuttle and Bailey; or equal: with 1/2&quot; x 1/2&quot; x 1/2&quot; aluminum grid and no dampers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Return Grilles (RG)</td>
<td>Titus Model 50-F; Tuttle and Bailey; or equal: with 1/2&quot; x 1/2&quot; x 1/2&quot; aluminum grid and no dampers</td>
</tr>
<tr>
<td>Return Registers (RR)</td>
<td>Titus Model 350FL; Tuttle and Bailey; or equal</td>
</tr>
<tr>
<td>Supply Registers (SR)</td>
<td>Titus Model 272FL; Tuttle and Bailey; or equal: with opposed-blade dampers</td>
</tr>
</tbody>
</table>

C. Registers, grilles and diffusers shall be constructed of aluminum.

D. The finish shall be a white baked-on enamel.

E. Accessory equipment shall be constructed of aluminum, or steel if aluminum is not available, and provided with a white baked-on enamel.

F. The proper border style shall be selected by the CONTRACTOR to suit the installation conditions.

G. Registers, grilles, and diffusers located in corrosive atmospheres, as indicated, shall be painted with a special protective coating in accordance with the requirements of Section 099600 – Protective Coating.

2.11 ACOUSTIC LOUVERS

A. General

1. Provide acoustic louvers as indicated.

2. Provide louvers complete with aluminum bird screen.

3. Sizes and capacities shall be as indicated on the Drawings.

B. Performance

1. Acoustic louvers shall have a minimum noise reduction of 14 dB at octave band No. 3.

2. Submit certified data from a laboratory substantiating the acoustical performance.

3. Static pressure drop shall not exceed 0.06 inches w.c. at 900 fpm.

C. Construction

1. The louvers shall be of aluminum construction.

2. Frame and blade faces shall be 0.060-inch wall thickness
3. Air-side blades shall be perforated 0.040 inch thick and packed with 3.5-lb density fiberglass or with inert, vermin- and moisture-proof mineral fiber.

4. Mount louvers flush with exterior wall, and caulk mounting frames in order to provide weather-tight connections.

D. Finish

1. Provide louvers with a Kynar® 500, or equal, finish.

2. The color of the louver shall be submitted for the ENGINEER's approval.

E. Acoustic Louver Manufacturers, or Equal

1. Ruskin Model ALC845AL

2. Industrial Acoustics Co., Model LP

2.12 VIBRATION ISOLATORS

A. General

1. Provide vibration control isolation all rotating equipment except electric motors.

2. Where rotating units are part of factory-assembled package units, such as a package air handling unit, provide the isolator under the unit casing.

B. Support suspended equipment by a combination of spring and fiberglass isolation hangers, incorporating minimum 2-inch thick neoprene jacketed fiberglass inserts in series with springs, encased in steel brackets.

C. Mount floor-mounted or platform-mounted built-up or package air handling units on structural steel or concrete bases with isolator springs and brackets.

D. Springs used in the vibration isolators shall have approximately one inch of deflection under load, and shall have a minimum additional travel of 50 percent between the design height and the solid height.

E. All isolation equipment shall be provided in strict compliance with the manufacturer's recommendations.

F. Pads

1. For vibration isolation between HVAC equipment and supports and where indicated, provide 3/4-inch-thick rubber pads for full contact between equipment and support

2. The pads shall be Mason Industries, Super W Pads, or equal.
2.13 ROOF CURBS AND ROOF EQUIPMENT SUPPORTS

A. Curbs

1. Roof curbs for all roof openings for roof mounted exhaust fans and air intakes and
exhausts, unless otherwise indicated, shall be of the raised cant type with a
minimum 12-inch height above the roof line.

2. The curbs shall be pitched at the base for roof pitches in excess of 3/8 inch per foot.

3. Provide a minimum 4-inch raised cant unless otherwise indicated.

4. The curbs shall be of a box design, constructed from 20-gauge galvanized steel with
continuous welded seams, full mitered angle seam corners, and factory-installed
wood nailers.

5. Insulate the curbs with a minimum of 1-1/2-inch thick, 3 lbs./cu.ft. density rigid board
fiberglass.

6. Roof curbs shall be provided with an 18-gauge stainless steel liner set in mastic,
and extended the full height of curb if the duct does not extend to the top of the
curb.

7. The roof curbs shall be supplied by the manufacturer of the equipment being
provided.

8. Roof Curb Manufacturers, or Equal
   a. Pate Model PC-5
   b. Thycurb

B. Equipment Supports

1. Provide roof equipment supports for roof-mounted equipment.

2. Construct the supports from 18 gauge galvanized steel, with continuous welded
seams, an integral base plate, a wood nailer with a one-inch overhang to
accommodate insulation, and counter flashing with lag screws.

3. Provide the supports with a raised cant of not less than 4 inches and a minimum of
15 inches high.

4. The length and width of the units shall conform to the support requirements of the
equipment being supported.

5. Roof Equipment Supports Manufacturers, or Equal
   a. Pate Model PC-5
   b. Thycurb
2.14 TEMPERATURE AND EQUIPMENT CONTROL

A. General

1. Design and provide a complete electric-electronic system of automatic temperature control as indicated.

2. The temperature control equipment and devices shall be furnished by Johnson Controls, Honeywell, or Barber Colman.

B. Wiring and Switches

1. Provide wiring incidental to the temperature control system, including electrical interlock.

2. Furnish detailed wiring diagrams along with necessary supervision.

3. Provide control wiring (line voltage or low voltage) as required to complete the temperature control system (by interconnecting starters, thermostats, PE switches, relays, and like devices) in accordance with the requirements of Section 260000 – Electrical Work, General.

4. Provide HOA switches in accordance with the requirements of Section 260515 – Local Control Panels and Miscellaneous Electrical Devices.

5. Switches shall be UL-listed and of a type to meet the current and voltage requirements of the particular application.

C. Thermostats

1. Room thermostats shall be of the digital type, provided with heating and cooling setpoints.

2. Adjustment shall be accomplished by pressing the thermostat UP or DOWN arrows.

3. Comfort Setpoints: adjustable from 66 to 80 degrees F

4. Setback Setpoints: adjustable from 55 to 70 degrees F for heating setback; adjustable from 75 to 90 degrees F for cooling setback

5. Automatic Setback Time Period:
   a. 7-day setback programming;
   b. up to 2 automatic setback comfort time periods per day;
   c. built-in setback override, adjustable from 10 minutes to 40 hours;
   d. 7-day electric time clock; and
   e. heat/cool/fan annunciators to indicate equipment operation and automatic heating/cooling changeover
6. The thermostats shall meet the Energy Conservation Standard approval where required by the State having jurisdiction over the Project.

7. Provide an insulating back where exterior wall mounting is indicated.

8. Provide guards for room thermostats installed in areas other than administrative offices or control rooms.

D. Relays

1. Provide 2-position relays, capacity relays, sequencing relays, and other controls as necessary in order to provide a properly operating automatic control system.

2. Relays shall be UL-listed and of a type to meet the current and voltage requirements of the particular application.

E. Control Panels

1. General
   a. Control panels shall be provided with relays, control switches, transformers, pilot lights, timers, time clocks, step controllers, gages, thermostats (unless otherwise indicated), and other accessories necessary for the particular system.
   b. The panels shall be of aluminum construction with a baked enamel finish, and shall be provided with a hinged front door and locking handle.
   c. Manual switches and direct-reading gauges shall be flush-mounted on the front face, and identified by engraved and riveted Bakelite or laminated plastic nameplates with white letters on black background.
   d. Manual switches shall be of heavy-duty, oil-tight construction.

2. Wiring
   a. Control devices shall be prewired internally.
   b. Wires leaving the panel shall be terminated at separate numbered terminal strips.
   c. Provide individual connectors for every item of mechanical equipment, integral and remote pilot lights, and other devices described for each panel.
   d. Power requirements shall be as indicated on the Electrical Drawings.
   e. Identify wires by color coding or numerical tags at both ends.
   f. Wire each control device to the terminal strip without splices.
   g. Provide integral circuit protection for panel-mounted control devices.
   h. Wire each panel with a single 20-amp, 120-volt, ac feeder in accordance with the requirements of Section 260515 – Local Control Panels and Miscellaneous Electrical Devices.
3. Diagrams: Secure the panel electrical wiring diagrams to the inside of the panel door.

2.15 PAINTING

A. Painting of the equipment and materials shall comply with the requirements of Section 099600 – Protective Coating.

B. Touch-Ups

1. Touch up factory-painted surfaces that are rusted or scratched.

2. Clean finishes to be touched up to bright metal, prime with a corrosion inhibitor, and finish with a coating to match the original finish.

PART 3 -- EXECUTION

3.1 GENERAL

A. Openings - New Construction

1. Provide necessary openings in walls, floors and roofs for the passage of heating and ventilating equipment in the buildings.

2. Openings shall be as indicated or as required to provide passage for heating and ventilating WORK.

3. Provide hanger and support inserts into masonry or structural steel as required for proper completion of the WORK.

3.2 VIBRATION ISOLATORS

A. Install isolation equipment in strict compliance with the manufacturer’s recommendations.

3.3 TEMPERATURE AND EQUIPMENT CONTROL

A. After completion of the installation, use trained personnel to adjust thermostats and sensors in the motors and other provided equipment, and place them in complete operating condition subject to the approval of the ENGINEER.

B. Instruct the operating personnel in the operation of the control system.

3.4 BALANCING AND TESTING

A. **General:** After the installation work is complete, an independent BALANCING

B. **SUBCONTRACTOR** shall make all necessary adjustments of volume dampers, volume controllers, exhaust blowers, exhaust fans, supply blowers, supply and return registers, and heating units. The CONTRACTOR shall provide all labor, tools, testing equipment and appliances for the necessary testing and adjustment required.

1. The BALANCING SUBCONTRACTOR shall be one who has at least five years of balancing experience with experience in at least five projects of this type. The
CONTRACTOR shall forward to the ENGINEER an experience resume and project resume for approval of the BALANCING SUBCONTRACTOR.

2. The BALANCING SUBCONTRACTOR shall not be associated with any firms doing engineering and/or construction work in HVAC and/or Plumbing.

3. The BALANCING SUBCONTRACTOR shall use the balancing methods approved by the Associated Air Balance Council.

4. The BALANCING SUBCONTRACTOR shall send a copy of all correspondence and reports, as they are written, pertaining to this project, directly to the ENGINEER.

C. The CONTRACTOR shall demonstrate to the OWNER, in an extensive operating test covering every component of the installation, that the entire heating, ventilating and air conditioning system meets the requirements of the Contract Drawings and Specifications and is in first class condition and ready for continuous, satisfactory operation. Any repairs and revisions necessary to make the system operative shall be done by the CONTRACTOR at no additional cost to the OWNER.

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PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide pipe and equipment insulation, complete and in place, as indicated in accordance with the Contract Documents.

B. In addition to the insulation indicated, the CONTRACTOR shall insulate cold or hot piping and exhausts that could be hazardous to personnel upon contact.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Federal Specifications
   HH-1-558B Insulation Blocks, Boards, Blankets, Felts, Sleev ing (Pipe and Tube Covering), and Pipe Fitting Covering, Thermal (Mineral Fiber, Industrial Type)

B. Commercial Standards
   ASTM C 547 Mineral Fiber Pipe Insulation
   TM E 84 Test Method for Surface Burning Characteristics of Building Materials

1.3 CONTRACTOR SUBMITTALS

A. Submit complete Shop Drawings of thermal insulation, with manufacturer's data on materials, covering, jackets, and finish, in accordance with the requirements of Section 013300 – Contractor Submittals.

B. Furnish the following certifications:
   1. Certification from the heating system manufacturer that the insulation has been installed in accordance with the manufacturer's recommendations.
   2. Certification from the acoustic insulation/duct lining manufacturer that the lining has the indicated sound absorption coefficients.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Components of the insulation, including covering, mastics, and adhesives, shall have a flame-spread rating of not greater than 25 and a smoke development rating of not greater than 50.

B. Ratings shall be as established by tests in accordance with ASTM E 84, and the above federal and commercial specification standards.

C. Insulation shall be applied in strict accordance with the manufacturer's instructions.
2.2 DUCTWORK INSULATION

A. Supply ductwork and outside air ductwork shall be insulated as indicated under this Section.

B. Insulation shall be provided for air duct systems operating at internal air temperatures up to 250 degrees F.

C. The finished duct system shall meet the requirements of NFPA 90A and 90B.

D. Duct wrap insulation shall meet the requirements of ASTM C 1290, Type III, to a maximum service temperature of 250 degrees F.

E. Facing material shall meet the requirements of ASTM C 1136, Type II, when surface burning characteristics are determined in accordance with ASTM E 84 with the foil surface of the material exposed to the flame.

F. Density and Thickness
   1. Density: 1.5 lbs per cu ft
   2. Thickness: 1-1/2 inches or 2 inches, as indicated

G. The duct wrap insulation shall consist of a blanket of glass fibers factory-laminated to a reinforced foil/kraft (FRK) vapor retarder facing, with a 2-inch-wide (minimum) stapling and taping flange on one edge.

H. The duct wrap insulation shall provide installed R-values as indicated in the following table:

<table>
<thead>
<tr>
<th>Density, lbs/cu ft</th>
<th>Nominal Thickness, inches</th>
<th>R-value(^{1,2}), (hour) (sq ft) (degree F) per BTU</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.50</td>
<td>1-1/2</td>
<td>6.0</td>
</tr>
<tr>
<td>1.50</td>
<td>2</td>
<td>8.0</td>
</tr>
</tbody>
</table>

\(^1\) at 75 degrees F mean temperature
\(^2\) assumes 25 percent compression of insulation

I. Exposed Ductwork
   1. Ductwork with exterior insulation which is exposed to the weather shall be protected with an aluminum-magnesium alloy jacket having a minimum thickness of 0.016 inch.
   2. The jacketing shall include built-in isolation felt.
   3. The jacket shall be lapped at least 3 inches at joints, and secured with stainless steel bands on 6-inch centers.
J. Duct Lining

1. The fiberglass ductwork lining shall be one-inch thick, and shall have a density 1-1/2-lbs/cu ft.

2. The liner shall have a flame spread rating of 25 or less, a smoke development rating of 50 or less, an average thermal conductivity not to exceed 0.23 BTU-inch per (hour) (square foot) (degree F) at a mean temperature of 75 degrees F, and shall be suitable for duct velocities up to 5,000 FPM.

3. The liner shall have sound absorption coefficients as follows:

<table>
<thead>
<tr>
<th>Frequency, Hertz</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1000</th>
<th>2000</th>
<th>4000</th>
<th>NRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sound absorption coefficient</td>
<td>0.15</td>
<td>0.55</td>
<td>0.71</td>
<td>0.94</td>
<td>1.03</td>
<td>1.05</td>
<td>0.80</td>
</tr>
</tbody>
</table>

4. The indicated duct sizes are the airway dimensions of the duct system which does not include provisions for the duct liner; therefore, the CONTRACTOR shall add the duct liner thickness to the indicated duct sizes.

K. Manufacturers, or Equal

1. Manville Products Corporation, Linacoustic-HP

2. Owens-Corning

PART 3 -- EXECUTION

3.1 GENERAL

A. Insulation and liners shall be installed by a qualified insulation contractor in strict accordance with the manufacturer’s recommendations.

3.2 INSULATION OF STRAIGHT DUCT AND FITTINGS

A. Before applying the duct wrap, air ducts shall be clean, dry and tightly sealed at joints and seams.

B. Portions of the duct designated to receive duct wrap shall be completely covered with duct wrap.

C. Remove a 2-inch piece of insulation from the facing at the end of the piece of duct wrap to form an overlapping stapling and taping flap.

D. Install duct wrap insulation with facing outside such that the tape flap overlaps the insulation and facing at the other end of the piece of duct wrap.

E. Adjacent sections of the duct wrap insulation shall be tightly butted and overlapped with the 2-inch stapling and taping flap.

F. If the duct is rectangular or square, install insulation such that it is not excessively compressed at corners.
G. Seams shall be stapled approximately 6 inches on center, using 1/2-inch steel outward clinching staples.

H. Seams and joints shall be sealed with pressure-sensitive tape matching the insulation facing (either plain foil or FRK backing stock) or glass fabric and mastic.

I. Cloth duct tape of color or finish using reclaimed rubber adhesives will not be accepted for use on duct wrap insulation.

J. Where rectangular ducts are 24 inches or greater in width, the duct wrap insulation shall be additionally secured to the bottom of the duct with mechanical fasteners such as pins and speed clip washers, spaced on 18-inch centers (maximum) to prevent the insulation from sagging.

K. Where a vapor retarder is indicated, seal tears, punctures and other penetrations of the duct wrap facing using one of the above methods to provide a vapor-tight system.

L. Damaged Insulation

1. The CONTRACTOR shall replace insulation that has been damaged or removed by modifications to the existing ductwork.

2. The replacement insulation shall be new and joints between new and existing insulation shall be made water-tight.

3.3 DUCTWORK INSPECTION

A. After completing the installation of the duct wrap and before operations are to commence, visually inspect the system and verify that it has been installed correctly.

B. Open system dampers and turn on fans to blow scraps and other loose pieces of material out of the duct system; allow for a means of removal of such material.

C. Check the duct system to ensure that there are no air leaks through joints.

3.4 FIBERGLASS INSULATION

A. Fiberglass insulation shall be securely held in place before the final covering is applied.

B. A scrim fabric, similar to a 20 x 10 thread count mesh and 100 percent fiberglass, shall be pasted in place to hold the pipe insulation securely to the pipe.

C. The scrim fabric shall be at least 4-inches wide, with at least 2 applications per length of pipe insulation, and one at each joint.

3.5 JACKETING

A. Joints shall be neatly finished with no ragged ends.

B. When finished, the covering shall show no exposed staples or other binding used during installation.

C. Staples, if used, shall be stainless steel.
3.6 LAGGING FABRIC

A. The final lagging fabric shall be neatly pasted in place with a 3-inch longitudinal overlap using a **Luben No. 9 adhesive**, or equal.

B. Each transverse joint shall have a 3-inch butt strip of the same fiberglass fabric.

C. Final joints shall be neatly finished with no ragged ends and the covering shall present a neat, uniform surface when finished.

D. The fabric shall show no exposed staples or other binding used during construction; staples, if used, shall be stainless steel.

3.7 COMPRESSION COUPLINGS AND EXPANSION JOINTS

A. The rigid insulation blocks shall be held in place with stainless steel bands, approximately 1/2 inch wide by 0.015 inch thick.

B. After banding, the blocks shall be finished with a trowel coat of insulating cement to filling voids, and troweled to a smooth, neat finish.

C. The installation shall then be covered with an acoustical insulation consisting of a fiberglass fabric weighing 24.6 oz. per sq yd, and coated with a loaded vinyl weighing 83.4 oz. per sq yd.

D. The acoustical insulation shall be **Alpha-Sonic Style No. 75**, or equal.

E. The acoustical insulation shall be covered with a 100-percent fiberglass lagging fabric as indicated.

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PART 1 -- GENERAL

1.1 PRODUCTS FURNISHED AND INSTALLED UNDER THIS SECTION

A. Section 23 - Ductwork Accessories - The HVAC Sub-Contractor shall:

1. Furnish and install all automatic dampers and provide necessary blank off plates or transitions required to install dampers that are smaller than duct size.

2. Assemble multiple section dampers with required interconnecting and jackshaft linkage and extend required number of shafts through duct for external mounting of damper motors.

3. Furnish and install all necessary sheet metal baffle plates to eliminate stratification and provide the air volumes specified. Locate baffles by experimentation. Fix and seal permanently in place only after stratification problems have been eliminated.

4. Furnish and install airflow stations specified under this section.

5. Furnish and install access doors or other approved means of access through ducts for service to control equipment.

B. Section 26 Electrical - The Electrical Sub-Contractor shall:

1. Furnish and install and connect all power wiring. Power wiring shall be defined as:

   a. Wiring of all power feeds through all disconnect starters and variable speed controllers to electric motors.

   b. Wiring of 120 VAC normal/emergency power feeds to all temperature control panels.

   c. Power wiring to 120/277-volt single-phase motors shown on electrical plans and all VAV boxes shown (with or without fan motors).

   d. A dedicated 120 VAC outlet for the graphics interface computer and printer station as shown on the plans.

1.2 RELATED SECTIONS

A. The General Conditions of the Contract, Supplementary Conditions, and General Requirements are a part of this specification and shall be used in conjunction with this section as a part of the contract documents. Consult them for further instructions pertaining to this work. The Contractor is bound by the provisions of Division 0 and Division 1.

B. The following sections constitute related work:

1. Section 1 - Submittal Requirements
2. Section 1 - Commissioning
3. Section 23 - Heating Ventilation and Air Conditioning
4. Section 23 - Heat-Generation Equipment
5. Section 23 - Air Handling Equipment
6. Section 23 - Air Conditioning Equipment
7. Section 23 - Air Distribution
8. Section 23 - Test and Balance
9. Section 26 - Basic Electrical requirements
10. Section 26 - Wiring Methods
11. Section 26 - Electrical Power (Uninterruptible Power Supplies, Variable Frequency Drives)
12. Section 26 - Emergency Systems
13. Section 26 - Fire Alarm and Detection System

1.3 CODES AND STANDARDS

A. All WORK, materials, and equipment shall comply with the rules and regulations of all codes and ordinances of the local, state, and federal authorities having jurisdiction.

B. Such codes, when more restrictive, shall take precedence over the Contract Documents.

C. The installation shall comply with the following codes:
   1. National Electric Code (NEC)
   2. International Building Code (IBC)
   3. International Mechanical Code (IMC)
   5. All BAS DDC controllers and local user displays shall be UL-listed under Standard UL 916, category PAZX and Standard ULC C100, category UUKL7.
   6. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference and labeled as such.

1.4 SYSTEM DESCRIPTION

A. Performance Standards
   1. The system shall conform to the minimum standards indicated in Tables 1 and 2, below.
2. Information transmission and display times shall be based upon network, rather than modem, connections.

3. Programmable controllers shall be capable of executing DDC PID control loops at a selectable frequency adjustable down to once per second.

4. The CONTRACTOR shall be responsible for selecting execution times consistent with the mechanical process under control.

5. The system shall report all values with an end-to-end accuracy as listed or better than those listed in Table 1.

6. Control loops shall maintain measured variable at set point within the tolerances listed in Table 2.

Table 1 - Reporting Accuracy

<table>
<thead>
<tr>
<th>MEASURED VARIABLE</th>
<th>REPORTED ACCURACY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space Temperature</td>
<td>plus or minus one degree F</td>
</tr>
<tr>
<td>Ducted Air</td>
<td>plus or minus one degree F</td>
</tr>
<tr>
<td>Outside Air</td>
<td>plus or minus 2 degrees F</td>
</tr>
<tr>
<td>Dew Point</td>
<td>plus or minus 3 degrees F</td>
</tr>
<tr>
<td>Water Temperature</td>
<td>plus or minus one degree F</td>
</tr>
<tr>
<td>Delta-T</td>
<td>plus or minus 0.25 degree F</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>plus or minus 5 percent RH</td>
</tr>
<tr>
<td>Water Flow</td>
<td>plus or minus 5 percent of full scale</td>
</tr>
<tr>
<td>Airflow (terminal)</td>
<td>plus or minus 10 percent of full scale (see Note 1)</td>
</tr>
<tr>
<td>Airflow (measuring stations)</td>
<td>plus or minus 5 percent of full scale</td>
</tr>
<tr>
<td>Airflow (pressurized spaces)</td>
<td>plus or minus 3 percent of full scale</td>
</tr>
<tr>
<td>Air Pressure (ducts)</td>
<td>plus or minus 0.1 inch w.g.</td>
</tr>
<tr>
<td>Air Pressure (space)</td>
<td>plus or minus 0.01 inch w.g.</td>
</tr>
<tr>
<td>Water Pressure</td>
<td>plus or minus 2 percent of full scale (see Note 2)</td>
</tr>
<tr>
<td>Electrical (A, V, W, Power Factor)</td>
<td>5 percent of reading (see Note 3)</td>
</tr>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>plus or minus 5 percent of reading</td>
</tr>
<tr>
<td>Carbon Dioxide (CO2)</td>
<td>plus or minus 50 ppm</td>
</tr>
</tbody>
</table>

Note 1: 10 percent to 100 percent of full scale
Note 2: for both absolute and differential pressure
Note 3: not including utility-supplied meters
Table 2 - Control Stability and Accuracy

<table>
<thead>
<tr>
<th>CONTROLLED VARIABLE</th>
<th>CONTROL ACCURACY</th>
<th>RANGE OF MEDIUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airflow</td>
<td>plus or minus 10 percent of full scale</td>
<td>-----</td>
</tr>
<tr>
<td>Space Temperature</td>
<td>plus or minus 2.0 degrees F</td>
<td>-----</td>
</tr>
<tr>
<td>Duct Temperature</td>
<td>plus or minus 3 degrees F</td>
<td>-----</td>
</tr>
<tr>
<td>Humidity</td>
<td>plus or minus 5 percent RH</td>
<td>-----</td>
</tr>
</tbody>
</table>

1.5 SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 013300 – Contractor Submittals.

B. No WORK may begin on any segment of the Project until submittals have been successfully reviewed for conformity with the design intent.

C. Submittals shall include:

1. Direct Digital Control System Hardware
   a. A complete bill of materials of equipment to be used, indicating quantity, manufacturer, model number, and other relevant technical data.
   b. Manufacturer’s description and technical data, such as performance curves, product specification sheets, and installation and maintenance instructions for the following items and other relevant items not listed:
      1) Direct Digital Controller (controller panels)
      2) Transducers/Transmitters
      3) Sensors (including accuracy data)
      4) Actuators
      5) Valves
      6) Relays/Switches
      7) Control Panels
      8) Power Supply
      9) Batteries
     10) Wiring
2. Wiring diagrams and layouts for each control panel, showing all termination numbers.

3. Schematic diagrams for all field sensors and controllers, and floor plans of all sensor locations and control hardware.

4. Diagrams
   a. Submit schematic diagrams for all control, communication, and power wiring.
   b. Submit a schematic drawing of the central system installation. Show all interface wiring to the control system.
   c. Submit riser diagrams of wiring between central control unit and all control panels.

D. Controlled Systems

1. Schematic Diagrams
   a. Submit a schematic diagram of each controlled system.
   b. Indicate all control points labeled, with point names shown or listed.
   c. Graphically show the location of all control elements in the system.

2. Schematic Wiring Diagrams
   a. Submit a schematic wiring diagram for each controlled system.
   b. Label all elements.
   c. Where a control element is the same as that shown on the control system schematic, it shall be labeled with the same name.
   d. Label all terminals.

3. Instrument List
   a. Submit an instrumentation list for each controlled system.
   b. Each element of the controlled system shall be listed in table format.
   c. The table shall show element name, type of device, manufacturer, model number, and product data sheet number.

4. Description
   a. A complete description of the operation of the control system, including sequences of operation.
   b. Include and reference a schematic diagram of the controlled system.
5. I/O
   a. Submit a points list for each system controller, including both inputs and outputs (I/O), point number, the controlled device associated with the I/O point, and the location of the I/O device.
   b. Submit software flag points, alarm points, and trend log points.

6. Quantities of items submitted will be reviewed but shall be the responsibility of the CONTRACTOR.

1.6 QUALITY ASSURANCE
   A. All products used in this project installation shall be new and currently under manufacture, and shall be the version currently being sold by the manufacturer for use in new installations.
   B. This installation shall not be used as a test site for any new products unless explicitly approved by the OWNER in writing. Spare parts shall be available for at least five years after completion of this contract.

1.7 WARRANTY
   A. Labor and materials for the control system specified shall be warranted free from defects for a period of 12 months after final completion and OWNER receives beneficial use of the system.
   B. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to the OWNER.
   C. The CONTRACTOR shall respond to the OWNER's request for warranty service within 24 hours during normal business hours.
   D. All WORK shall have a single warranty date, even when the OWNER has received beneficial use due to an early system start-up.
   E. If the WORK specified is split into multiple contracts or a multi-phase contract, then each contract or phase shall have a separate warranty start date and period.

PART 2 -- PRODUCTS
   A. Temperature Controls
      1. Temperature Control Panels furnished and installed by the HVAC Sub-Subcontractor shall be in accordance with specification 16485. Temperature control Panels provided by HVAC equipment manufacturers shall be in accordance with specification 17202.
      2. The temperature control system shall be as indicated on contract documents and shall consist of DDC controllers.
      3. HVAC Sub-Subcontractor shall be responsible for the installation, calibration and operator training as necessary for a complete and full operating temperature control system.
4. The temperature control system shall be a complete stand-alone building automation system, modular in construction and not requiring a central computer for operation or programming.

5. All programming shall be possible from a keypad/display on any field panel or from a remote computer.

6. Systems which do not have a keypad/display capability shall be provided with a minimum of 3 portable interfaces with required cables and software.

B. BAS Components

1. The basic elements of the Building Automation System (BAS) structure shall be built from only standard components kept in inventory by the BAS supplier.

2. The components shall not require customizing other than setting jumpers and switches, and adding firmware modules, software modules or software programming to perform required functions.

3. The BAS shall possess a fully modular architecture, permitting expansion through the addition of more DDCP units, sensors, actuators, and operator terminals.

4. Expansion beyond this must be able to be accomplished in additional panels or expansion modules without abandoning any initial equipment.

C. Direct Digital Control Panel

1. The Direct Digital Control Panel’s (DDCP’s) software shall include a complete operating system, control algorithm application packages, and a complete custom control, calculation application package to accomplish the indicated sequence of operation.

2. In addition to pre-programmed package software, DDCP controllers shall be provided with field-flexible programming capabilities without the use of external equipment such as EPROM programmers in order to meet the indicated requirements.

3. Each DDCP shall be capable of performing all specified control functions in a completely independent manner.

4. Each DDCP unit shall be capable of sharing point information with other such units, such that control sequences or control loops executed at one control unit may receive input signals from sensors connected to other units within the network.

D. Programming

1. Control software shall utilize “block” programming techniques connecting tested control blocks to form control sequencing.

2. Line-by-line programming requiring complete definition will not be accepted as a programming technique.

3. The programmer shall fill in the control parameters for each block to perform the required control sequence.
2.2 CONTROLLER SOFTWARE

A. Each intelligent field panel shall be completely user programmable, and shall include the indicated programs installed in the base operating system.

B. Alarms

1. The alarm program shall provide for alarm reporting in the following 4 distinct categories:
   a. Fire
   b. Maintenance
   c. Performance
   d. Equipment

2. Classification by category shall permit alarms of a specific class to be reported to different locations and cause different system actions.

3. The total number of alarms in each category shall be displayed at the field panel.

4. Alarms shall be sorted as unacknowledged or acknowledged in the order of occurrence.

C. Analog Input Scaling

1. Analog inputs shall be scaled and labeled to read out in engineering units of the variable being measured (e.g., DEG., CFM, etc.).

D. Analog Outputs

1. Each analog output shall be user programmable to be direct or reverse acting and vary the output between 2 and 10 VDC.

2. The panel shall allow the user to program minimum and maximum output levels as well as a manual fixed output level.

3. The analog output shall be assignable to operate based on any physical input or calculated value on the network.

E. System Calendar

1. Each panel other than Application Specific Controllers (such as Terminal Controllers) shall be provided with a 365/366 day battery-backed clock, with an automatic daylight savings time switch-over on the day entered.

F. PID Control

1. In order to provide precise control, each analog output shall be programmable with a proportional plus integral plus derivative (PID) program.

2. Individual constants shall be programmable for the P, I, and D functions.
3. The integral time interval shall be user programmable.

4. The current proportional term, the integral term, and the PID sum shall be dynamically displayed on the screen to provide assistance to start-up and service personnel in tuning the system.

G. The diagnostics program in each panel shall monitor and report system status.

2.3 BUILDING CONTROLLERS

A. General

1. Provide an adequate number of Building Controllers to achieve the indicated performance.

2. Each controller shall meet the following requirements.
   a. The Building Controller shall be provided with sufficient memory to support its operating system, database, and programming requirements.
   b. Controllers that perform scheduling shall be provided with a real-time clock.

B. Communication

1. The Building Controller shall be provided with a service communication port for connection to a portable operator terminal.

C. Environment

1. Building Controller hardware shall be suitable for the anticipated ambient conditions.

2. Controllers used outdoors or in wet ambient conditions shall be mounted within waterproof enclosures, and shall be rated for operation at minus 40 degrees F to plus 150 degrees F.

3. Controllers used in conditioned space shall be mounted in dust-protective enclosures, and shall be rated for operation at 32 degrees F to 120 degrees F.

D. Keypad

1. Provide a local keypad and display or a connection for a portable operator terminal for each Building Controller.

2. The keypad shall be provided for interrogating and editing data.

3. An optional system security password shall be available to prevent unauthorized use of the keypad and display.

4. If the manufacturer does not provide this keypad and display, provide a portable operator terminal.

E. Serviceability

1. Provide diagnostic LEDs for power, communication, and processor.
2. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

F. Memory

1. The Building Controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.

2. Applications shall be maintained in flash memory.

G. Immunity to Power and Noise

1. The controller shall operate at 90 percent to 110 percent of its nominal voltage rating, and shall perform an orderly shutdown below 80 percent nominal voltage.

2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 3 feet.

2.4 INPUT/OUTPUT INTERFACE

A. Hardwired inputs and outputs may tie into the system through building controllers, advanced application controllers, or application-specific controllers.

B. Input points and output points shall be protected such that shorting of the point to itself, to another point, or to ground will cause no damage to the controller.

C. All input and output points shall be protected from voltage up to 24 V of any duration, such that contact with this voltage will cause no damage to the controller.

D. Binary Inputs

1. Provide binary inputs to allow the monitoring of ON-OFF signals from remote devices.

2. The binary inputs shall provide a wetting current of at least 12 mA in order to be compatible with commonly available control devices, and shall be protected against the effects of contact bounce and noise.

3. Binary inputs shall sense “dry contact” closure without external power (other than that provided by the controller) being applied.

2.5 AUXILIARY CONTROL DEVICES

A. General

1. All materials and equipment used shall be standard components, of regular manufacture for this application.

2. All systems and components shall have been thoroughly tested and proven in actual use.

3. Exceptions to the indicated requirements will not be accepted.
B. Valve Actuators

1. Electronic valve actuators shall be suitable for direct-coupled mounting to the valve bonnet.
2. Valve actuators shall be properly sized to provide sufficient torque to position the valve throughout its operating range.
3. All globe valve actuators shall be of the spring return type.
4. Where butterfly valves are indicated, double-acting non-spring return actuators may be used.
5. Unless otherwise indicated, provide normally open valves for heating water applications and normally closed valves for chilled water applications.

C. Damper Actuators

1. Electronic damper actuators shall be of the direct-couple rotary type, suitable for mounting directly on the damper end shaft.
2. Electronic damper actuators shall be properly sized to provide sufficient torque to position the damper throughout its operating range.
3. On dampers with multiple sections, provide one actuator per section.
4. Damper actuators used on economizers and outside air dampers shall be of the spring return type.

D. Control Panels

1. All direct digital controllers mounted on HVAC equipment located indoors shall be installed in NEMA 4X enclosures.
2. All direct digital controllers mounted on HVAC equipment located outdoors shall be installed in NEMA 3R enclosures.
3. Enclosures shall be of suitable size to accommodate power supplies, relays, and accessories as required for the application.
4. Each enclosure shall include a subpanel for direct mounting of the enclosed devices, including matched key locks for all enclosures.
5. Construction
   a. Control panels shall contain all relays, control switches, transformers, pilot lights, timers, time clocks, step controllers, gages, [[thermostats]], and other accessories as necessary for the particular system.
   b. The panels shall be constructed of aluminum with a baked enamel finish, and shall include a hinged front door with locking handle.
   c. All manual switches and direct-reading gauges shall be flush-mounted on the front face, and identified by engraved and riveted Bakelite or laminated plastic nameplates with white letters on black background.
d. Manual switches shall be of heavy-duty, oil-tight construction.

6. Wiring

a. Control devices shall be pre-wired internally.

b. Terminate all wires leaving the panel at separate numbered terminal strips.

c. Provide individual connectors for every item of mechanical equipment, all integral and remote pilot lights, and other devices indicated for each panel.

d. Power and control circuit requirements shall be as indicated on the Electrical Drawings.

e. Identify all wires by color coding or numerical tags at both ends.

f. Wire each control device without splices to the terminal strip.

g. Provide integral circuit protection for all panel-mounted control devices.

h. Wire each panel with a single 20-amp, 120-volt, AC feeder in accordance with the requirements of Section 16485 – Local Control Stations and Miscellaneous Electrical Devices.

7. Panel electrical wiring diagrams shall be secured to the inside of the panel door.

E. Thermostats - Line Voltage

1. Materials: cold-rolled steel; beige thermoplastic; liquid sensing element

2. Contact Rating

   a. 6 amps running; 36 amps locked rotor; 120 VAC
   b. 3.5 amps running; 21 amps locked rotor; 208 VAC
   c. 3.0 amps running; 8 amps locked rotor; 240 VAC

3. Switch Action: single-pole, double-throw; open on rising temperature

4. Sensing Element: coiled bulb and capillary

5. Range: 0 to 130 degrees F

6. Manufacturer, or Equal

   a. Dry Locations (no hose valves or open water processes in room): Johnson Controls Model A19BAC-1 in NEMA 1 enclosure

   b. Wet (hose valves or open water processes in room) or Outdoor Locations: Johnson Controls Model A19PRC-1 in NEMA 4X enclosure.
F. Duct and Well Temperature Sensors
   1. Sensors for duct and water temperature sensing shall incorporate either RTD or thermistor sensing devices.
   2. The sensing element accuracy shall be 0.1 percent or better over the sensor span.
   3. Where the element is being used for sensing mixed air or coil discharge temperatures or the duct cross sectional area is in excess of 10 square feet, the element shall be of the averaging type.
   4. Immersion sensors shall use matched Type 316 stainless steel bulb wells.
   5. Provide duct and immersion sensors with conduit connection housings.
   6. Provide sensors with adequate standoffs for insulation installation.

G. Occupancy Sensors
   1. Occupancy sensors shall be provided with occupancy-sensing sensitivity adjustment, and an adjustable off-delay timer with a range encompassing 30 seconds to 15 minutes.
   2. Occupancy sensors shall be rated for operation in ambient air temperatures from 50 to 110 degrees F.
   3. Occupancy sensors shall be of the passive infrared type, and shall be provided with a multi-level, multi-segmented viewing lens and a conical field of view with a viewing angle of 180 degrees and a detection of at least 20 feet.
   4. Passive infrared occupancy sensors shall provide field-adjustable background light-level adjustment with an adjustment range suitable to the light level in the sensed area.
   5. Passive infrared sensors shall be immune to false triggering from radio frequency interference and other electromagnetic interference.

H. Selector Switches
   1. Selector switches shall be of the 2- or 3-position, knob or key type as required by the sequence of operation.
   2. Selector switches shall be of oil-tight construction and fitted with snap-fit contact blocks rated for 10A, 600 VAC/DC operation.
   3. Provide labels indicating switch position.

I. Pushbutton Switches
   1. Pushbutton switches shall be of either the maintained or momentary type as required by the sequence of operation.
   2. Pushbutton switches shall be of oil-tight construction and fitted with snap-fit contact blocks rated for 10A, 600 VAC/DC operation.
3. Provide labels indicating switch function.

J. Pilot Lights
   1. Provide pilot lights as required by the sequence of operation.
   2. Pilot lights shall utilize multi-colored dome lenses and replaceable LED lamps.
   3. Provide labels indicating light function.

2.6 WIRING AND RACEWAYS
   A. Provide copper wiring, plenum cable, and raceways as indicated in the applicable Sections of Division 26 – Electrical.
   B. All insulated wire shall be copper conductor, and UL-labeled for 90-degree C minimum service.

2.7 CONTROL SYSTEM CONTRACTORS AND MANUFACTURERS, OR EQUAL
   A. Johnson Controls
   B. Barber-Coleman
   C. Landis & Staefa
   D. Honeywell
   E. York International; Delta
   F. The above list of manufacturers applies to controller software, custom application programming language, building controllers, custom application controllers; and application specific controllers; all other indicated products (e.g., sensors, valves, dampers and actuators) need not necessarily be manufactured by the above manufacturers.

PART 3 -- EXECUTION

3.1 EXAMINATION
   A. The Drawings shall be thoroughly examined for control device and equipment locations, and any discrepancies, conflicts, or omissions shall be reported to the ENGINEER for resolution before rough-in work is started.
   B. Inspect the Project Site to verify that the equipment may be installed as indicated, and report any discrepancies, conflicts, or omissions to the ENGINEER for resolution before rough-in work is started.
   C. Examine the Contract Documents for other parts of the WORK, and if head room or space conditions appear inadequate, report these discrepancies to the ENGINEER and obtain written instructions for any changes that may be necessary to accommodate the WORK with the work of others.
   D. Changes in the WORK made necessary by the failure or neglect of the CONTRACTOR to report such discrepancies shall be considered to be part of the Contract.
3.2 COORDINATION

A. Site

1. Where the WORK will be installed in close proximity to, or will interfere with, the work of other trades, the CONTRACTOR shall assist in accommodating space conditions to make a satisfactory adjustment.

2. If the CONTRACTOR installs the WORK before coordinating with other trades, so as to cause any interference with the work of other trades, the CONTRACTOR shall make the necessary changes in the WORK in order to correct the condition as part of the Contract.

3. Coordinate and schedule the WORK with all other work in the same area, or with work that is dependent upon other work, in order to facilitate mutual progress.

B. Coordination with Other Controls

1. Other controls and control devices that are to be part of or integrated into the control system specified in this section. These controls shall be integrated into the system and coordinated by the contractor as follows:

2. All communication media and equipment shall be provided as specified in Part 2, “Communication” of this Specification.

3. Each supplier of a control product is responsible for the configuration, programming, startup, and testing of that product to meet the sequences of operation described in this Section.

4. The HVAC Sub-Contractor shall coordinate and resolve any incompatibility issues that arise between the control products provided under this section and those provided under other sections or divisions of this specification.

5. The HVAC Sub-Contractor is responsible for the integration of control products provided by multiple suppliers regardless of where this integration is described within the contract documents.

3.3 GENERAL WORKMANSHIP

A. Install equipment, piping, wiring, and raceway parallel to building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.

B. Provide sufficient slack and flexible connections to allow for vibration isolation of piping and equipment.

C. Install all equipment in readily accessible locations as defined by the National Electrical Code (NEC).

D. Verify the integrity of all wiring to ensure continuity and freedom from shorts and grounds.

E. All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and shall be executed in strict adherence to local codes and standard practices.
3.4 WIRING FOR CONTROL SYSTEMS

A. Furnish and install all wire, conduit, raceways, and cable systems as required for the complete operation of the Building Management and Control System in accordance with the requirements of Section 16120 – Wire and Cable.

3.5 FIBER OPTIC CABLE

A. Maximum pulling tensions as specified by the cable manufacturer shall not be exceeded during installation.

B. Post-installation residual cable tension shall be within cable manufacturer's specifications.

C. All cabling and associated components shall be installed in accordance with the manufacturers' instructions.

D. Maintain minimum cable and unjacketed fiber bend radii, as specified by the cable manufacturer.

3.6 SENSOR INSTALLATION

A. Install sensors in accordance with the manufacturer's recommendations.

B. Mount sensors rigidly and adequately for the environment within which the sensor operates.

C. Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.

D. All wires attached to sensors shall be air-sealed in their raceways or in the wall in order to stop air transmitted from other areas from affecting sensor readings.

E. Averaging Sensors
   1. Sensors used in mixing plenums and hot and cold decks shall be of the averaging type.
   2. Averaging sensors shall be installed in a serpentine manner vertically across the duct.
   3. Support each bend with a capillary clip.

F. Temperature Sensors
   1. All pipe-mounted temperature sensors shall be installed in wells.
   2. Install all liquid temperature sensors with heat-conducting fluid in thermal wells.

G. Pressure Transducers
   1. The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.
2. All pressure transducers, other than those controlling VAV boxes, shall be located in field device panels and not on the equipment monitored or on ductwork.

3. Mount transducers in a vibration-free location accessible for service without the need for ladders or special equipment.

4. All air and water differential pressure sensors shall be provided with gauge tees mounted adjacent to the taps, and water gauges shall be provided with shutoff valves installed before the tee.

3.7 ACTUATORS

A. Mount and link control damper actuators according to manufacturer's instructions.

B. To compress seals when spring-return actuators are used on normally closed dampers, the actuator shall be powered to an approximately 5-degree open position, the damper closed manually, and then the linkage tightened.

C. Check the operation of damper/actuator combination in order to confirm that the actuator modulates damper smoothly throughout the stroke to both OPEN and CLOSED positions.

D. Provide all mounting hardware and linkages for the actuator installation.

E. Electric and Electronic Actuators

1. Dampers
   a. Actuators shall be direct-mounted on the damper shaft or jackshaft unless indicated as a linkage installation.
   b. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5 degrees available for tightening the damper seals.
   c. Actuators shall be mounted in accordance with the manufacturer's recommendations.

2. Valves
   a. Actuators shall be connected to valves with adapters approved by the actuator manufacturer.
   b. The actuators and adapters shall be mounted in accordance with the actuator manufacturer's recommendations.

3.8 CONTROLLERS

A. General

1. Provide a separate controller for each AHU or other HVAC system.

2. A DDC controller may control more than one system provided that all points associated with the system are assigned to the same DDC controller.
3. Control of an AHU or other mechanical equipment item shall not be split between multiple controllers; points used for control loop reset, such as outside air or space temperature, are exempt from this requirement.

B. Building Controllers and Custom Application Controllers

1. Building controllers and custom application controllers shall be selected to provide a minimum of 15 percent spare I/O point capacity for each point type found at each location.

2. If input points are not universal, 15 percent of each type shall be required, and if outputs are not universal, 15 percent of each type is required.

3. A minimum of one spare is required for each type of point used.

4. The future use of spare capacity shall require providing the field device, field wiring, point database definition, and custom software.

5. No additional controller boards or point modules shall be required to implement use of such spare points.

3.9 PROGRAMMING

A. Provide sufficient internal memory for the specified sequences of operation and trend logging.

B. Provide a minimum of 25 percent of available memory free for future use.

C. BACnet Points

1. Provide a detailed BACnet points list.

2. In addition to standard I/O information, the BACnet points list shall contain the proposed I/O names and BACnet object description.

3. The proposed I/O names and object descriptions are subject to change as directed by the ENGINEER.

4. Deliver an as-built list of the BACnet points with actual names and BACnet object addresses to the OWNER at Project completion.

D. Software Programming

1. Provide programming for the system and adhere to the indicated sequences of operation.

2. Provide all other system programming necessary for the operation of the system but not indicated in this Section.

3. Embed into the control program sufficient comment statements to clearly describe each section of the program, reflecting the language used in the sequences of operation.
3.10 CONTROL SYSTEM CHECKOUT AND TESTING

A. Start-up Testing

1. All testing listed in this article shall be performed by the CONTRACTOR and shall make up part of the necessary verification of an operating control system.

2. This testing shall be completed before the ENGINEER is notified of the system demonstration.

B. Furnish all labor and test apparatus required to calibrate and prepare for service of all instruments, controls, and accessory equipment furnished under this Section.

C. Verify that all control wiring is properly connected, free of shorts and ground faults, and that terminations are tight.

D. Enable the control systems and verify calibration of all input devices individually.

E. Perform calibration procedures according to manufacturers' recommendations.

F. Verify that all binary output devices (e.g., relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.

G. Verify that all analog output devices (e.g., I/Ps, actuators, etc.) are functional, that start and span are correct, and that direction and normal positions are correct.

H. Control Valves

1. Check all control valves and automatic dampers in order to ensure proper action and closure.

2. Make any necessary adjustments to valve stem and damper blade travel.

I. Verify that the system operation adheres to the sequences of operation.

J. Simulate and observe all modes of operation by overriding and varying inputs and schedules.

K. Tune all PID loops and optimize START/STOP routines.

L. Alarms and Interlocks

1. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.

2. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.

3. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.
3.11 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

A. Demonstration

1. Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and compliance with this Section.

2. These tests shall occur after the CONTRACTOR has completed the installation, started up the system, and performed tests.

3.12 TRAINING

A. Provide a minimum of 2 on-Site or classroom training sessions, 4 hours each, throughout the Contract period for personnel designated by the OWNER.

-END OF SECTION-
PART 1 – GENERAL

1.1 THE REQUIREMENT

A. Provide ductwork, complete and operable, as indicated in accordance with the Contract Documents.

B. Furnish design calculations used to determine duct wall thickness and reinforcements.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

AMCA 500 Test Methods for Louvers, Dampers, and Shutters

ASTM D 638 Standard Test Method for Tensile Properties of Plastics


ASTM D 2240 Standard Test Method for Rubber Property - Durometer Hardness

ASTM D 2310 Standard Classification for Machine-Made “Fiberglass” (Reinforced Thermosetting Resin) Pipe

ASTM D 2563 Standard Practice for Classifying Visual Defects in Glass-Reinforced Plastic Laminate Parts

ASTM D 2992 Standard Practice for Obtaining Hydrostatic or Pressure Design Basis for “Fiberglass” (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings

ASTM D 2996 Filament-Wound “Fiberglass” (Glass-Fiber-Reinforced Thermosetting Resin) Pipe


SMACNA Thermoset FRP Duct Construction Manual

A. Codes and Standards, General

1. Perform and provide the WORK in full accordance with the latest rules and regulations or publications of the State Energy Resources Conservation and Development Commission, the State Fire Marshall, the Industrial Safety Orders the Health and Safety Rules (Air Conditioning systems), the local Plumbing Code, the local Building Code, and other local codes.

2. In the absence of applicable codes, follow the installation and workmanship standards set by the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).

4. Where conflict between these standards arises, the most stringent criterion shall control. Ducts shall be listed for use without the necessity for internal fire protection sprinklers or any devices relied on to cut off air flow in the event of fire by Factory Mutual Research Standard 4922.


8. Comply with SMACNA's "HVAC Duct Construction Standards, Metal and Flexible" for fabrication and installation of metal duct, and SMACNA's "Round Industrial Duct Construction Standards" intended for use by designers of industrial ventilation systems.

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 013300 – Contractor Submittals.

B. Shop Drawings

1. The HVAC design drawings define the general layout, configuration, routing, size, and the general intent of the design and are not fabrication drawings. CONTRACTOR's shall be responsibility to develop the shop drawings required for the construction of the HVAC system(s).

2. Submit detailed fabrication drawings with layouts and all necessary dimensions and details on equipment, and ductwork. Show all fittings, and supports necessary to accommodate the equipment provided in a complete and functional system. Show main and branch runs, fittings, offsets, takeoffs, accessories, supports, anchorage, point loads and seismic restraints, and dimensions of sub-assemblies to be shipped.

1.4 QUALITY ASSURANCE

A. Qualifications, General

1. Ductwork shall be fabricated and installed by experienced workers who have experience with fabrication, and installation of ductwork.

2. Work and materials shall be in full accordance with the latest rules and regulations or publications of the State Energy Resources Conservation and Development Commission, the State Fire Marshall, the Industrial Safety Orders, the Health and Safety Rules (Air Conditioning systems), the local Plumbing Code, the local Building Code, and other local codes.

3. Nothing in the Contract Documents shall be construed to permit work in violation of the above codes, rules and regulations.
4. In the absence of applicable codes, the installation and workmanship shall follow the standards set by the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE). Use firms regularly engaged in the manufacture of ETFE coated stainless steel duct products of types, materials, and sizes required.

5. The manufacturer shall perform their own sheet metal fabrication and coating processes.

6. The OWNER shall have the right to tour the manufacturer's plant any time that fabrication is being performed on duct intended for the Project.

7. Installer Qualifications: The installation contractor shall have at least 3 years of successful experience on duct projects, specifically industrial exhaust systems.

B. Inspection and Testing: All ductwork shall be inspected and approved by a qualified QC person in order to ensure proper welding and dimensional tolerances. The Inspector shall provide a written approval to the resident engineer or owner, stating that the ductwork has been inspect and is free of any defects.

1.5 DELIVERY, STORAGE, AND HANDLING

A. General

1. Duct, fittings, and dampers shall be protected from damage and shall be supported by minimum 4-inch wide strapping to avoid damage due to flex strains and point loading during shipping and installation.

2. Debris and other extraneous material shall not be allowed to enter the duct.

3. Duct, fittings, and dampers shall not be thrown or dropped.

B. Material Protection

1. Protect coated duct from damage due to normal handling during shipment and storage.

2. Protection shall be applied to ends of the duct in order to prevent dirt and moisture from entering ducts and fittings.

3. Protection must be of suitable strength and material to withstand tearing and puncture.

4. Multiple pieces may be bolted together at the factory to provide protection and limit the number of open ends requiring protection.

C. Consignee must inspect shipment upon delivery and note any and all damages and discrepancies on bill of lading and notify manufacturer within 24 hours.

D. Coated Duct

1. Coated duct shall not be stored in an area where it will have a chance to be damaged from traffic or debris.

2. All coated duct shall be stored on cardboard, Styrofoam, or similar material.
3. Where possible, store coated duct inside and protect from dirt and debris.

4. Where necessary to store outside, store coated duct above grade and enclose with waterproof wrapping in order to protect from dirt and debris.

5. If the coating is scratched during shipping or handling it must be inspected using the methods described in Part 2 - Products.

6. Contact the manufacturer for approved repair procedures.

1.6 WARRANTY

A. Provide the ductwork manufacturer’s standard warranty.

B. Furnish the warranty to the ENGINEER upon final acceptance of the completed systems by the OWNER.

PART 2 -- PRODUCTS

2.1 HANGERS AND SUPPORTS

A. Ductwork shall be firmly anchored or connected to supporting members.

B. Provide necessary hangers, supports, concrete inserts, and anchors for material and equipment to be installed.

C. No perforated strap hangers nor wire supports will be accepted.

D. Construct the anchors and inserts of 304 stainless steel.

E. Locate hangers and supports not greater than 10 feet from each expansion loop or joint.

F. Provide hangers and supports for ductwork and equipment in accordance with SMACNA standards.

2.2 ALUMINUM DUCTWORK

A. General

1. Provide air-tight and well-braced ductwork.

2. Carefully support the ductwork in horizontal runs, with rod and angle supports at no greater than 8-foot intervals.

3. Run ductwork as close as possible to the indicated layouts.

B. Construction


2. Tape the joints on concealed ducts with pressure-less tape and adhesive, except for welded and soldered joints.

3. Ductwork materials shall be aluminum, unless otherwise indicated.
4. Provide the following duct gauges, as a minimum:

<table>
<thead>
<tr>
<th>Maximum Dimension of Duct (inches)</th>
<th>Aluminum B and S Gauge</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 and less</td>
<td>24</td>
</tr>
<tr>
<td>13 through 30</td>
<td>22</td>
</tr>
<tr>
<td>31 through 54</td>
<td>20</td>
</tr>
<tr>
<td>55 through 84</td>
<td>18</td>
</tr>
</tbody>
</table>

5. All low pressure ductwork shall be designed for 3 inches vacuum and pressure and be constructed of sheet metal of not less than the gauge designated in table above, and gauge designations provided by Brown and Sharpe Standards.

6. Radius of bends shall be not less than 1.5 duct diameters, unless otherwise indicated.

7. Provide turning vanes on all mitered elbows and extractors, as required and indicated.

8. Except where accepted by the ENGINEER, provide fan discharge connections and ductwork reductions with duct side slopes not exceeding 30 degrees.

9. Properly insulate aluminum duct and supports from concrete or dissimilar metals by an applied bituminous coating or by rubber gaskets at contact points.

10. Construct interior partitions from aluminum, in accordance with the latest ASHRAE guide recommendations for construction for high-pressure rectangular duct work.

11. Construct the units in accordance with the ASHRAE guide recommendations for high-pressure ductwork.

12. Seams shall be lock-formed and mastic-filled.

13. Provide rectangular casing seams in the corners of the silencer shell in order to provide maximum unit strength and rigidity.

14. Provide interior partitions with die-formed entrance and exit shapes in order to provide the maximum aerodynamic efficiency and minimum self-noise characteristics in the sound attenuator.

15. Blunt noses or squared off partitions will not be accepted.

16. Use solid galvanized steel to attach the interior partitions to the casing, welded to the outer casing.

17. Attachment of the interior partitions to the tracks shall be such that a minimum of 4 thicknesses of metal exist at this location.
18. The track assembly shall stiffen the exterior casing, provide a reinforced attachment detail for the interior partitions, and shall maintain a uniform airspace width along the length of the silencer for consistent aerodynamic and acoustic performance.

19. In addition to the above attachments, secure the interior partitions to the outer casing with welded nose clips at both ends of the sound attenuator.

20. Achieve airtight construction by the use of a duct-sealing compound applied at the Site.

21. Sound traps shall not fail structurally when subjected to a differential air pressure of 8 inches w.g. inside-to-outside of casing.

C. Seams

1. Provide double-locked seams.

2. Provide rectangular ducts with longer than a 12-inch dimension with full-perimeter standing seams not less than one inch high.

3. Provide reinforcements at intervals not greater than 30 inches along the duct.

4. No "S" seams will be accepted.

D. Low-Pressure Ductwork

1. Design all low-pressure ductwork for 3 inches vacuum and pressure.

2. Construct low-pressure ductwork of sheet aluminum of not less than 18-gauge, where the largest dimension of a duct is 12 inches or less in width or diameter, and not less than 16-gauge for widths or diameters larger than 12 inches.

3. Gauge designations refer to Brown and Sharpe Standards.

E. Access Doors

1. Provide access doors in the ductwork at all fire dampers, motorized and back draft dampers, filters, and as indicated.

2. Provide doors with the following features:
   a. continuously hinged;
   b. double-skinned;
   c. constructed of either 22-gauge galvanized steel or 20-gauge aluminum to match the ductwork material;
   d. one cam lock for sizes up to 16 inches square or 2 cam locks for sizes over 16 inches square;
   e. match insulation thickness in door with ductwork insulation; and,
   f. foam sealing gaskets on all four sides.

F. Flexible Connections

1. Attach the equipment to the ducts through using flexible connections in order to facilitate removal of the units and for sound isolation.

2. Provide flexible connectors consisting of heavy duct canvas or woven glass fabric, silicon-coated.

3. Canvas connectors shall be composed of a heavy cotton that is impregnated for waterproofing and fire retardance.

4. Use glass fabric where temperatures exceed 200 degrees F.

5. The weight of the canvas shall be 20 ounces per sq yd.

6. The weight of the glass fabric shall be approximately 12 ounces per sq yd.

7. Flexible duct shall be insulated.

8. The maximum length of flexible duct shall not exceed 10 feet.

9. Flexible duct connections shall be composed of banded or flanged 8-oz canvas, reinforced plastic, or equal, at each point where a blower unit is connected to a duct.

10. Maintain a minimum clearance of 3 inches between the duct and the source of vibration.

11. Provide materials that join and support the flexible duct in accordance with the latest edition of SMACNA.

G. Supports

1. Provide aluminum angles with 304 stainless steel threaded hanger rods as supports for horizontal ducts and plenums.

2. Supports for vertical ducts shall be aluminum of the angle bracket type.

3. Sufficiently brace inlet ducts to withstand the maximum negative pressure.

H. Seismic Restraints

1. Design the duct supports and restraints for static, dynamic, and seismic loads in Zone 4 in accordance with the Californai Building Code.

2. Seismic restraints shall not induce stresses in the ductwork caused by thermal expansion and contraction.

I. Duct Dimensions: Increase sheet metal duct dimensions by 2 inches for internally lined ducts.
J. Corrosion-Resistant Ducts
   1. Provide exhaust hoods as indicated, constructed of Type 316 stainless steel.
   2. Fabricate the stainless steel ducts of the same gauge as the galvanized steel ducts.

K. Balancing Dampers
   1. Provide butterfly or multi-blade dampers as indicated and required in order to balance the air quantities to their indicated values.
   2. Provide a locking quadrant on each manual damper, with easy access for operation.

L. Inspection Doors
   1. Provide duct inspection doors consisting of a 12-inch by 16-inch steel frame with gasketing around its periphery, and either a hinged glass or a removable visual panel.
   2. Doors shall be constructed of *Plexiglas, Lucite*, or equal.
   3. On smaller ducts, provide separate 6-inch by 8-inch doors with 6-inch by 6-inch visual panels.
   4. Provide duct inspection doors at each duct-mounted fire damper and electric duct heater.

M. Bird Screens
   1. Provide removable bird screens on outside air intakes and exhaust air discharges to outside air.
   2. Secure the screens in frames constructed of the same metal as the screens.
   3. The bird screens shall be 1/2-inch mesh by 14-gauge, and shall be of same material and finish as duct, hood, louver, or equipment to which the screens are attached.

N. Turning Vanes
   1. Square-turn elbows shall be fitted with shop-fabricated double-blade turning vanes mounted inside the rails.
   2. Construction shall be of the same material as the ductwork and shall be rigid enough to prevent vibration at high air flow.

O. Air Extractors
   1. Provide an air extractor on each take-off from the main supply duct adjacent to a diffuser, register, or grille, where a splitter is not used.
   2. Provide extractors with synchronized steel curved blades, heavy side rails, and a screw operator.
3. Air Extractors Manufacturer, or Equal
   a. Carnes
   b. Tuttle and Bailey

PART 3 -- EXECUTION

3.1 GENERAL

A. Floor, Wall and Roof Openings for New Construction
   1. Provide necessary openings in walls, floors and roofs for the passage of heating and ventilating equipment in buildings.
   2. The openings shall be as indicated, or as required to provide passage for the heating and ventilating WORK.
   3. Provide hanger and support inserts into masonry or structural steel as required for proper completion of the WORK.

B. Floor, Wall and Roof Openings for Existing Construction
   1. Provide openings for piping and equipment as required in the existing construction, whether or not they are specifically indicated.
   2. Cut the openings in a neat and orderly manner without damaging existing structures. Do not overcut corners.
   3. Patch openings to match the existing construction.
   4. Provide and assume responsibility for hangers and supporting members in the existing masonry or structural steel as required for proper completion of the WORK.

C. Interior and Exterior Wall Penetrations
   1. Where ducts pass through exterior walls, interior partitions or pass through walls dividing two separate controlled areas, conceal the space between construction openings and the duct with sheet metal flanges of the same gauge as the duct.
   2. Overlap the opening on 4 sides by at least 1-1/2 inches.

3.2 INSTALLATION

A. General
   1. Field Measurements
      a. Duct lengths shall be determined from measurements taken at the Site.
      b. The indicated dimensions are approximate and shall not be used for fabrication.
   2. Install ducts as indicated.
3. Necessary provisions shall be taken into consideration during fabrication and installation of ductwork to provide for expansion and contraction.

4. Ductwork shall be free from vibration when in operation.

5. Provide necessary vibration isolation devices.

6. Apply antiseize compound to bolt threads.

7. Provide smooth bends or internal turning vanes at elbows, tees, and other points where the air flow changes direction.

8. The inside of duct, specials, and fittings shall be smooth, clean, and free from blisters, sand and dirt.

9. Ductwork shall be airtight.

10. Joints shall be carefully and neatly constructed, as indicated and as recommended by the manufacturer.

11. Flanges
   
   a. Tighten flange bolts sufficiently to slightly compress the gasket and make a seal, but not so tightly as to distort the flanges.
   
   b. Provide a flat washer under each nut and bolt head.

12. Dampers
   
   a. Position the dampers to fit into the connecting ductwork at the indicated locations.
   
   b. Install axles in the horizontal position unless otherwise necessary for proper operation of the damper.

13. Supports and Hangers
   
   a. Support the ductwork in accordance with the manufacturer's recommendations and as indicated.
   
   b. Duct supports shall comply with SMACNA Standards and applicable code requirements.
   
   c. Supports and hangers shall transmit loads into the building structural frame through a system of intermediate beams and struts as necessary to comply with the indicated requirements.
   
   d. Supports or hangers employing clip angles or similar devices for attachment to the duct will not be accepted.
   
   e. Design the supports to resist IBC seismic forces.
14. Alignment and Elevation
   a. Provide ductwork to the indicated lines and elevations, and slope as indicated to facilitate water drainage.
   b. Use laser beam equipment or surveying instruments to maintain alignment and elevation.
   c. If laser beam equipment is used, perform periodic elevation measurements with surveying instruments in order to verify accuracy.

B. Control Dampers
1. General
   a. Coordinate damper submittals for type, quantity, and size in order to ensure compatibility with sheet metal design.
   b. Follow the manufacturer's instructions for field installation of control dampers.
   c. Unless specifically designed for vertical blade application, mount the dampers with the blade axis horizontal.

2. Duct Openings
   a. Duct openings shall be free of obstructions and irregularities that might interfere with blade or linkage rotation or actuator mounting.
   b. Duct openings shall measure 3/4 inch larger than damper dimensions, and shall be square, straight, and level.

3. Damper Sections
   a. Individual damper sections, as well as entire multiple section assemblies, shall be completely square and free of racking, twisting, and bending.
   b. Measuring the damper sections diagonally from upper corners to opposite lower corners of each damper section, both dimensions shall be within 1/8 inch of each other.

4. Shafts
   a. Install an extended shaft or jackshaft in accordance with the manufacturer's instructions.
   b. If a sticker on the damper face shows recommended extended shaft location, attach the shaft on the labeled side of damper to that blade.

5. Operation
   a. Damper blades, axels, and linkage shall operate without binding.
   b. After installation but before system operation, cycle the damper in order to ensure proper operation.
c. On multiple section assemblies, sections shall open and close simultaneously.

6. Provide a visible and accessible indication of damper position on the drive shaft end.

7. Support ductwork or damper actuator in areas of damper when required in order to prevent sagging due to damper or damper actuator weight.

8. After installing low-leakage dampers with seals, caulk between the frame and the duct or opening in order to prevent leakage around the perimeter of damper.

C. Smoke Dampers

1. Coordinate smoke damper and smoke/fire damper installations, wiring, and checkout in order to ensure that the dampers function properly and that they respond to the proper fire alarm system general, zone, and detector trips.

2. Immediately report discrepancies to the ENGINEER not less than 14 Days prior to inspection by the code authority having jurisdiction.

3. Routing

   a. Locate coated stainless steel duct runs, except as otherwise indicated, vertically and horizontally, and avoid diagonal runs wherever possible.

   b. Locate runs as indicated by diagrams, details and notations or, if not otherwise indicated, run duct in the shortest route that does not obstruct usable space or block access for servicing the building and equipment.

   c. Hold ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of the building.

   d. Wherever possible in finished and occupied spaces, conceal the duct from view, by locating in mechanical shafts, hollow wall construction, or above suspended ceilings.

   e. Do not encase horizontal runs in solid partitions, except if indicated.

   f. Coordinate the layout with suspended ceiling and lighting layouts and similar finish WORK.

4. Electric Equipment Spaces

   a. Do not route duct through or directly over transformers, electrical equipment and electrical enclosures.

3.3 DUCT CLEANING

A. The ducts shall be blown clean of dust and debris using compressed air.

B. Do not use system fans for duct cleaning.

- END OF SECTION -
PART 1 – GENERAL

1.1 THE REQUIREMENT

A. Provide fans, blowers, ventilators, and appurtenances, complete and operable, as indicated in accordance with the Contract Documents.

B. Where 2 or more fans, blowers, ventilators or appurtenances of the same type or size are required, they shall be furnished by the same manufacturer.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 01300 – Contractor Submittals.

B. **Shop Drawings:** Submit certified fan curves for each fan

C. **O&M Data:** Submittals shall include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.

1.3 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts:

1. Drive Belts: Provide one for each fan.

1.4 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. Air Moving and Conditioning Association (AMCA)


5. National Fire Protection Association (NFPA)
   a. 70, National Electric Code (NEC).
b. 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.

6. Occupational Safety and Health Act (OSHA).


1.5 MOTORS

A. All motors shall conform to the latest IEEE and NEMA requirements for mechanical and electrical characteristics, including service factors.

B. Motors shall be in accordance with the requirements of Section 16460 – Electric Motors.

C. Each motor shall bear the manufacturer’s nameplate with complete motor data.

D. Each motor shall be of ample size and construction to carry continuously all loads which might be imposed by the piece of equipment it drives throughout the full range of operation of the equipment, and the maximum motor loading shall in all cases be less than or equal to the nameplate horsepower rating, exclusive of the service factor.

E. All 2-speed motors shall be 2-winding motors.

PART 2 -- PRODUCTS

2.1 BELT DRIVEN LOUVERED CENTRIFUGAL ROOF EXHAUST FANS

A. Provide louvered belt driven, penthouse-type exhaust fans as indicated.

B. Roof exhaust fans shall be of the centrifugal, belt driven type. Hood construction shall be of heavy extruded aluminum louvers with mitered and welded corners. The hood shall be aluminum and hingeable for service.

C. The fan wheel shall be centrifugal backward inclined, constructed of aluminum and shall include a wheel cone carefully matched to the inlet cone for precise running tolerances. Wheels shall overlap the spun venturi for maximum performance. Wheels shall be statically and dynamically balanced to assure smooth and vibration-free operation.

D. Motors shall be of the heavy duty type with permanently lubricated, sealed ball bearings. The wheel shaft shall be ground and polished steel and shall be mounted in heavy duty, permanently sealed pillow block ball bearings. Drives shall be sized for a minimum of 150% of driven horsepower. Pulleys shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts. The motor pulley shall be adjustable for final system balancing. The entire drive assembly shall be mounted on vibration isolators.

E. All fans shall bear the AMCA Certified Ratings Seal for both sound and air.

F. Fans shall be Model LBP as manufactured by Greenheck.

G. Manufacturer, or Equal

1. Greenheck, Model LBP

2. Cook
3. New York Blower
4. Equal

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Fans, blowers, ventilators, and hoods shall be installed in strict accordance with the manufacturer’s recommendations.

B. Pipe the housing drains to the nearest utility drain.

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SECTION 236000 - AIR CONDITIONING EQUIPMENT

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. Provide air conditioning units and appurtenances, complete and operable, in accordance with the Contract Documents.

B. Where two or more air conditioning units or appurtenances of the same type or size are required, they shall be furnished by the same Manufacturer.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 013300 – Contractor Submittals.

B. The submittals shall include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.

C. Furnish a certified fan curve for each fan.

1.3 CODE REQUIREMENTS

A. The WORK shall be in strict accordance with the State Mechanical Code, the State of California, Cities of Woodland and Davis, and other authorities having jurisdiction.

B. Obtain the required certifications and become thoroughly familiar with the local codes.

C. Obtain and pay for all necessary permits.

1.4 REFERENCES

AMCA: Air Movement and Control Association

ANSI: American National Standards Institute

ARI: Air Conditioning and Refrigeration Institute

NFPA: National Fire Protection Association

SMACNA: Sheet Metal and Air conditioning Contractors’ National Association

ASHRAE: American Society of Heating, Refrigeration and Air Conditioning Engineers

DOE: Department Of Energy

CSA: Canadian Standards Association

BAS: Building Automation Solutions

AMCA 99 Standard Handbook

AMCA 210 Laboratory Methods of Testing Fans for Rating Purposes
PART 2 -- PRODUCTS

2.1 PACKAGED AIR CONDITIONING UNITS

A. General

B. Furnish as shown on plans, Single zone Heating and Cooling Unit(s). Unit performance and electrical characteristics shall be per the job schedule.

C. Configuration: Fabricate as detailed on prints and drawings:

1. Return plenum / economizer section
2. Filter section
3. Cooling coil section
4. Supply fan section
5. Condensing unit section
D. The complete unit shall be cETLus listed.

E. Each unit shall be specifically designed for outdoor rooftop application and include a weatherproof cabinet. Each unit shall be completely factory assembled and shipped in one piece. Packaged units shall be shipped fully charged with R-410 Refrigerant and oil.

F. The unit shall undergo a complete factory run test prior to shipment. The factory test shall include a refrigeration circuit run test, a unit control system operations checkout, a unit refrigerant leak test and a final unit inspection.

G. All units shall have decals and tags to indicate caution areas and aid unit service. Unit nameplates shall be fixed to the main control panel door. Electrical wiring diagrams shall be attached to the control panels. Installation, operating and maintenance bulletins and start-up forms shall be supplied with each unit.

H. Performance: All scheduled EER, IEER, capacities and face areas are minimum accepted values. All scheduled amps, kW, and HP are maximum accepted values that allow scheduled capacity to be met.

I. Warranty: The manufacturer shall provide 12-month parts only warranty. Defective parts shall be repaired or replaced during the warranty period at no charge. The warranty period shall commence at startup or six months after shipment, whichever occurs first.

2.2 CABINET, CASING, AND FRAME

A. Panel construction shall be double-wall construction for all panels. All floor panels shall have a solid galvanized steel inner liner on the air stream side of the unit to protect insulation during service and maintenance. Insulation shall be a minimum of 1” thick with an R-value of 7.0, and shall be 2 part injected foam. Panel design shall include no exposed insulation edges. Unit cabinet shall be designed to operate at total static pressures up to 5.0 inches w.g.

B. Exterior surfaces shall be constructed of pre-painted galvanized steel for aesthetics and long term durability. Paint finish to include a base primer with a high quality, polyester resin topcoat of a neutral beige color. Finished panel surfaces to withstand a minimum 750-hour salt spray test in accordance with ASTM B117 standard for salt spray resistance.

C. Service doors shall be provided on the fan section, filter section, control panel section, and heating vestibule in order to provide user access to unit components. All service access doors shall be mounted on multiple, stainless steel hinges and shall be secured by a latch system. Removable service panels secured by multiple mechanical fasteners are not acceptable.

D. The unit base shall overhang the roof curb for positive water runoff and shall seat on the roof curb gasket to provide a positive, weathertight seal. Lifting brackets shall be provided on the unit base to accept cable or chain hooks for rigging the equipment.

2.3 ECONOMIZER SECTION

A. Unit shall be provided with an outdoor air economizer section. The economizer section shall include outdoor, return, and exhaust air dampers. The economizer operation shall be fully integral to the mechanical cooling and allow up to 100% of mechanical cooling if needed to maintain the cooling discharge air temperature. The outdoor air hood shall be factory installed and constructed from galvanized steel finished with the same durable
paint finish as the main unit. The hood shall include moisture eliminator filters to drain water away from the entering air stream. The outside and return air dampers shall be sized to handle 100% of the supply air volume. The dampers shall be parallel blade design. Damper blades shall be gasketed with side seals to provide an air leakage rate of 4 cfm / square foot of damper area at 1” differential pressure per ASHRAE 90.1 Energy Standard. A barometric exhaust damper shall be provided to exhaust air out of the back of the unit. A bird screen shall be provided to prevent infiltration of rain and foreign materials. Exhaust damper blades shall be lined with vinyl gasketing on contact edges. Control of the dampers shall be by a factory installed direct coupled actuator. Damper actuator shall be of the modulating, spring return type. A comparative enthalpy control shall be provided to sense and compare enthalpy in both the outdoor and return air streams to determine if outdoor air is suitable for “free” cooling. If outdoor air is suitable for “free” cooling, the outdoor air dampers shall modulate in response to the unit’s temperature control system.

2.4 FILTERS

A. Unit shall be provided with a draw-through filter section. The filter rack shall be designed to accept a 2” prefilter and a 4” final filter. The unit design shall have a hinged access door for the filter section. The manufacturer shall ship the rooftop unit with 2” construction filters. The contractor shall furnish and install, at building occupancy, the final set of filters per the contract documents.

2.5 COOLING COIL

A. The indoor coil section shall be installed in a draw through configuration, upstream of the supply air fan. The coil section shall be complete with a factory piped cooling coil and an ASHRAE 62.1 compliant double sloped drain pan.

B. The direct expansion (DX) cooling coils shall be fabricated of seamless high efficiency copper tubing that is mechanically expanded into high efficiency aluminum plate fins. Coils shall be a multi-row, staggered tube design with a minimum of 3 rows. All cooling coils shall have an interlaced coil circuiting that keeps the full coil face active at all load conditions. All coils shall be factory leak tested with high pressure air under water.

C. The cooling coil shall have an electronic controlled expansion valve. The unit controller shall control the expansion valve to maintain liquid subcooling and the superheat of the refrigerant system.

D. The refrigerant suction lines shall be fully insulated from the expansion valve to the compressors.

E. The drain pan shall be stainless steel and positively sloped. The slope of the drain pan shall be in two directions and comply with ASHRAE Standard 62.1. The drain pan shall have a minimum slope of 1/8” per foot to provide positive draining. The drain pan shall extend beyond the leaving side of the coil. The drain pan shall have a threaded drain connection extending through the unit base.

2.6 SUPPLY FAN

A. Supply fan shall be a single width, single inlet (SWSI) airfoil centrifugal fan. The fan wheel shall be Class II construction with aluminum fan blades that are continuously welded to the hub plate and end rim. The supply fan shall be a direct drive fan mounted to the motor shaft.
B. Fan assembly shall be a slide out assembly for servicing and maintenance

C. All fan assemblies shall be statically and dynamically balanced at the factory, including a final trim balance, prior to shipment.

D. The fan motor shall be a totally enclosed EC motor that is speed controlled by the rooftop unit controller. The motor shall include thermal overload protection and protect the motor in the case of excessive motor temperatures. The motor shall have phase failure protection and prevent the motor from operation in the event of a loss of phase. Motors shall be premium efficiency.

E. The supply fan shall be capable of airflow modulation from 30% to 100% of the scheduled designed airflow. The fan shall not operate in a state of surge at any point within the modulation range.

2.7 HEATING SECTION

A. The rooftop unit shall include an electrical resistance heating coil section. Staged electric heating coil modules shall be factory installed downstream of the supply air fan in the heating section of the rooftop unit. Heating coils shall be constructed of a low watt density, nickel - chromium alloy resistance wire with intermediate supports that include ceramic bushings. The electrical contactors shall be of the full line-breaking type with all the electrical power legs being disconnected when the contactors are not energized. All electrical circuit wiring shall be designed with copper conductors, aluminum wires are not acceptable. Heating element branch circuits shall be individually fused to a maximum of 48 Amps per NEC requirements. The power supply for the electric heater shall be factory wired into the units main power block or disconnect switch.

B. The heating modules shall have an automatic reset, high temperature limit safety protection. A secondary high limit protection shall also be provided that requires a manual reset. An airflow switch shall be provided with the heating module to prevent the electric heater from operating in the event of no airflow.

C. The electric heater elements shall be controlled by the factory installed DDC unit control system. The heater shall have 4 stages of control.

D. Field installed heating modules shall require a field ETL certification. Duct heaters mounted within the rooftop unit in the field shall not be acceptable. The manufacturer’s rooftop unit ETL certification shall cover the complete unit including the electric heating modules.

2.8 HEAT PUMP HEATING

A. The evaporator coil, condenser coil, compressors and refrigerant circuit shall be designed for heatpump operation. The refrigerant circuit shall contain a 4 way reversing valve for the heatpump operation. The outdoor coil shall have an electronic expansion valve to control the refrigerant flow. The unit controller shall modulate the expansion valve to maintain compressor operation within the compressor operational envelope.

B. The refrigerant system shall have a pump-down cycle.

C. The unit shall have an electric resistance heating coil for auxiliary heating. When the heatpump operation cannot maintain the discharge air temperature setpoint the electric heating coil shall temper the airstream to the discharge air temperature setpoint.
2.9 CONDENSING SECTION

A. Outdoor coils shall have seamless copper tubes, mechanically bonded into aluminum plate-type fins. The fins shall have full drawn collars to completely cover the tubes. A sub-cooling coil shall be an integral part of the main outdoor air coil. Each outdoor air coil shall be factory leak tested with high-pressure air under water.

B. Fan motors shall be an ECM type motor for proportional control. The unit controller shall proportionally control the speed of the condenser fan motors to maintain the head pressure of the refrigerant circuit from ambient condition of 0~125°F. Mechanical cooling shall be provided to 25°F. The motor shall include thermal overload protection and protect the motor in the case of excessive motor temperatures. The motor shall have phase failure protection and prevent the motor from operation in the event of a loss of phase.

C. The condenser fan shall be low noise blade design. Fan blade design shall be a dynamic profile for low tip speed. Fan blade shall be of a composite material.

D. The unit shall have scroll compressors. One of the compressors shall be an inverter compressor providing proportional control. The unit controller shall control the speed of the compressor to maintain the discharge air temperature.

E. Pressure transducers shall be provided for the suction pressure and head pressure. Temperature sensor shall be provided for the suction temperature and the refrigerant discharge temperature of the compressors. All of the above devices shall be an input to the unit controller and the values be displayed at the unit controller.

F. Refrigerant circuit shall have a bypass valve between the suction and discharge refrigerant lines for low head pressure compressor starting and increased compressor reliability. When there is a call for mechanical cooling the bypass valve shall open to equalizing the suction and discharge pressures. When pressures are equalized the bypass valve shall close and the compressor shall be allowed to start.

G. Each circuit shall be dehydrated and factory charged with R-410A Refrigerant and oil.

2.10 ELECTRICAL

A. Unit wiring shall comply with NEC requirements and with all applicable UL standards. All electrical components shall be UL recognized where applicable. All wiring and electrical components provided with the unit shall be number and color-coded and labeled according to the electrical diagram provided for easy identification. The unit shall be provided with a factory wired weatherproof control panel. Unit shall have a single point power terminal block for main power connection. A terminal board shall be provided for low voltage control wiring. Branch short circuit protection, 115-volt control circuit transformer and fuse, system switches, and a high temperature sensor shall also be provided with the unit. Each compressor and condenser fan motor shall be furnished with contactors and inherent thermal overload protection. Supply fan motors shall have contactors and external overload protection. Knockouts shall be provided in the bottom of the main control panels for field wiring entrance.

B. A single non-fused disconnect switch shall be provided for disconnecting electrical power at the unit. Disconnect switches shall be mounted internally to the control panel and operated by an externally mounted handle.
2.11 CONTROLS

A. Provide a complete integrated microprocessor based Direct Digital Control (DDC) system to control all unit functions including temperature control, scheduling, monitoring, unit safety protection, including compressor minimum run and minimum off times, and diagnostics. This system shall consist of all required temperature sensors, pressure sensors, controller and keypad/display operator interface. All MCBs and sensors shall be factory mounted, wired and tested.

B. The stand-alone DDC controllers shall not be dependent on communications with any on-site or remote PC or master control panel for proper unit operation. The microprocessor shall maintain existing set points and operate stand alone if the unit loses either direct connect or network communications. The microprocessor memory shall be protected from voltage fluctuations as well as any extended power failures. All factory and user set schedules and control points shall be maintained in nonvolatile memory. No settings shall be lost, even during extended power shutdowns.

C. The DDC control system shall permit starting and stopping of the unit locally or remotely. The control system shall be capable of providing a remote alarm indication. The unit control system shall provide for outside air damper actuation, emergency shutdown, remote heat enable/disable, remote cool enable/disable, heat indication, cool indication, and fan operation.

D. All digital inputs and outputs shall be protected against damage from transients or incorrect voltages. All field wiring shall be terminated at a separate, clearly marked terminal strip.

E. The DDC controller shall have a built-in time schedule. The schedule shall be programmable from the unit keypad interface. The schedule shall be maintained in nonvolatile memory to insure that it is not lost during a power failure. There shall be one start/stop per day and a separate holiday schedule. The controller shall accept up to sixteen holidays each with up to a 5-day duration. Each unit shall also have the ability to accept a time schedule via BAS network communications.

F. The keypad interface shall allow convenient navigation and access to all control functions. The unit keypad/display character format shall be 4 lines x 20 characters. All control settings shall be password protected against unauthorized changes. For ease of service, the display format shall be English language readout. Coded formats with look-up tables will not be accepted. The user interaction with the display shall provide the following information as a minimum:

1. Return air temperature.
2. Discharge air temperature.
3. Outdoor air temperature.
4. Space air temperature.
5. Outdoor enthalpy, high/low.
6. Compressor suction temperature and pressure.
7. Compressor head pressure and temperature.
8. Expansion valve position.
10. Inverter compressor speed.
11. Dirty filter indication.
12. Airflow verification.
13. Cooling status.
14. Control temperature (Changeover).
15. Cooling status/capacity.
16. Unit status.
17. All time schedules.
18. Active alarms with time and date.
19. Previous alarms with time and date.
20. Optimal start.
22. System operating hours.
   a. Fan
   b. Exhaust fan
   c. Cooling
   d. Individual compressor
   e. Heating
   f. Economizer
   g. Tenant override

G. The user interaction with the keypad shall provide the following:

1. Controls mode
   a. Off manual
   b. Auto
   c. Heat/Cool
   d. Cool only
e. Heat only
f. Fan only

2. Occupancy mode
   a. Auto
   b. Occupied
   c. Unoccupied
   d. Tenant override

3. Unit operation changeover control
   a. Return air temperature
   b. Space temperature
   c. Network signal

4. Cooling and heating change-over temperature with deadband

5. Cooling discharge air temperature (DAT)

6. Supply reset options
   a. Return air temperature
   b. Outdoor air temperature
   c. Space temperature
   d. Airflow (VAV)
   e. Network signal
   f. External (0-10 vdc)
   g. External (0-20 mA)

7. Temperature alarm limits
   a. High supply air temperature
   b. Low supply air temperature
   c. High return air temperature

8. Lockout control for compressors.

9. Compressor interstage timers

10. Night setback and setup space temperature.
11. Building static pressure.
12. Economizer changeover
   a. Enthalpy
   b. Drybulb temperature
13. Currently time and date
14. Tenant override time
15. Occupied/unoccupied time schedule
16. One event schedule
17. Holiday dates and duration
18. Adjustable set points
19. Service mode
   a. Timers normal (all time delays normal)
   b. Timers fast (all time delays 20 sec)

H. If the unit is to be programmed with a night setback or setup function, an optional space sensor shall be provided. Space sensors shall be available to support field selectable features. Sensor options shall include:

1. Zone sensor with tenant override switch
2. Zone sensor with tenant override switch plus heating and cooling set point adjustment. (Space Comfort Control systems only)

I. To increase the efficiency of the cooling system the DDC controller shall include a discharge air temperature reset program for part load operating conditions. The discharge air temperature shall be controlled between a minimum and a maximum discharge air temperature (DAT) based on one of the following inputs:

1. Airflow
2. Outside air temperature
3. Space temperature
4. Return air temperature
5. External signal of 1-5 vdc
6. External signal of 0-20 mA
7. Network signal
2.12 ROOF CURB

A. A prefabricated heavy gauge galvanized steel, mounting curb shall be provided for field assembly on the roof decking prior to unit shipment. The roof curb shall be a full perimeter type with complete perimeter support of the air handling section and condensing section. The curb shall be a minimum of 14" high and include a nominal 2" x 4" wood nailing strip. Gasket shall be provided for field mounting between the unit base and roof curb.

B. Manufacturers, or Equal

1. Daikin Applied, Model No. DPS012A
2. AAON
3. Carrier

PART 3 -- GENERAL

3.1 INSTALLATION

A. All air conditioning equipment shall be installed in strict accordance with the manufacturer's recommendations.
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PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. Provide the electrical WORK, complete and operable, as indicated in accordance with the Contract Documents.

B. The provisions of this Section shall apply to all Sections in Division 26, except as otherwise indicated.

C. The WORK of this Section is required for operation of electrically-driven equipment provided under Specifications in other Divisions.

D. The CONTRACTOR'S attention is directed to the requirement for proper coordination of the WORK of this Section with the WORK of equipment Specifications, the WORK of instrumentation Sections, and the WORK of Section 260510 – Electric Motors.

E. Concrete, excavation, backfill, and steel reinforcement required for encasement, installation, or construction of the WORK of the various Sections of Division 26 is included as a part of the WORK under the respective Sections, including duct banks, manholes, handholes, equipment housekeeping pads, and light pole bases.

F. Equipment supports and foundations shall be in conformance with the requirements of Section 410000 – Equipment General Provisions.

1.2 REFERENCE STANDARDS

NEC (NFPA 70) National Electrical Code 2008
NETA International Electrical Testing Association
NEMA 250 Enclosure for Electrical Equipment (1000 Volts Maximum)
Title 8, Subchapter 5, California Administrative Code Electrical Safety Orders

A. Electrical equipment shall be listed by and shall bear the label of Underwriters' Laboratories, Inc. (UL) or an independent testing laboratory acceptable to the local code enforcement agency having jurisdiction.

B. Installation of electrical equipment and materials shall comply with OSHA Safety and Health Standards (29 CFR 1910 and 29 CFR 1926, as applicable), state building standards, and applicable local codes and regulations.

C. Where the requirements of the specifications conflict with UL, NEMA, NFPA, or other applicable standards, the more stringent requirements shall govern.

1.3 SIGNAGE AND MARKINGS

A. Identification: Provide danger, caution, and warning signs and equipment identification markings in accordance with applicable federal, state, OSHA, and NEC requirements.
B. **Local Disconnect Switches:** Legibly mark each local disconnect switch for motors and equipment in order to indicate its purpose, unless the purpose is indicated by the location and arrangement. All disconnects shall bear a nameplate.

C. **Warning Signs**

1. **600 Volts Nominal, or Less**
   
a. Mark entrances to rooms and other guarded locations that contain live parts with conspicuous signs prohibiting unqualified persons from entering.

2. **Greater than 600 Volts**
   
a. Buildings, rooms, or enclosures containing exposed live parts or exposed conductors operating at greater than 600 volts nominal shall be lockable.
   
b. Provide permanent and conspicuous warning signs reading as follows: DANGER – HIGH VOLTAGE – KEEP OUT.

3. Mark indoor electrical installations that are open to unqualified persons and contain metal-enclosed switchgear, unit substations, transformers, and other similar associated equipment over 600 volts nominal, with appropriate caution signs.

4. **Outside Branch Circuits and Feeders over 600 Volts**
   
a. Post warning signs in plain view where unauthorized persons might come in contact with live parts: WARNING – HIGH VOLTAGE – KEEP OUT.

D. **Isolating Switches:** Provide isolating switches not interlocked with an approved circuit-interrupting device with a sign warning against opening them under load.

### 1.4 PUBLIC UTILITIES REQUIREMENTS

A. Contact the serving utility and verify compliance with requirements before construction.

B. Coordinate schedules and payments for WORK by utilities. The Contractor shall provide temporary electrical power during construction for site offices and construction activities. The associated cost shall be part of the WORK.

C. Where conduits and conductors in the WORK are indicated to be larger, heavier schedule, or have greater protective coating than utility requirements, provide the larger size, heavier schedule, or greater protection.

D. Provide electrical service as indicated and as required by the serving utility.

E. Verify and provide service conduits, fittings, transformer pad, grounding devices, termination kits, and service wires not provided by the serving utility.

F. Verify with the utility the exact location of each service point and type of service, and pay charges levied by the serving utilities as part of the WORK. The Contractor shall pay all utility bill prior to acceptance of the WORK. The Owner will pay for all utility bills after Field Acceptance. The electrical utility wheeling the power for WAPA is PG&E. PG&E installation requirements apply to the service up to the transformer primary. WAPA’s meter shall be installed on the primary feeder serving the facility.
1.5 PERMITS AND INSPECTION

A. Obtain permits and pay inspection fees according to the General Conditions.

B. Pay connection and turn-on service charges required by the utility companies.

1.6 CONTRACTOR SUBMITTALS

A. General

1. Furnish submittals in accordance with the requirements of Section 013300 – Contractor Submittals.

2. Custom-prepare Shop Drawings.

3. Drawings or data indicating "optional" or "as required" equipment will not be accepted.

4. Cross out options not proposed or delete from the Shop Drawings.

B. Shop Drawings: Include the following:

1. Complete material lists stating manufacturer and brand name of each item or class of material.

2. Shop Drawings for grounding WORK not specifically indicated.

3. Front, side, rear elevations, and top views with dimensional data.

4. Location of conduit entrances and access plates.

5. Component data.

6. Connection diagrams, terminal numbers, internal wiring diagrams, conductor size, and cable numbers.

7. Method of anchoring, seismic requirements, weight.

8. Types of materials and finish.


10. Temperature limitations, as applicable.

11. Voltage requirement, phase, and current, as applicable.

12. Front and rear access requirements.

13. Test reports.

14. Grounding requirements.

15. Anchorage and support calculations in accordance with specification section 410000 – Equipment General Provisions, stamped and signed by an Engineer registered in the State of California.
C. Catalog Cuts

1. Submit catalog cuts or photocopies of applicable pages of bulletins or brochures for mass produced, non-custom manufactured material.

2. Stamp the catalog data sheets in order to indicate the Project name, applicable Specifications Section and Paragraph, model number, and options.

D. Materials and Equipment Schedules

1. Within 30 Days of the commencement date in the Notice to Proceed, deliver to the ENGINEER a complete list of materials, equipment, apparatus, and fixtures that are proposed for use.

2. Include in the list the type, size, name of manufacturers, catalog number, and such other information as required to identify the item.

E. Technical Manuals

1. Submit complete information in accordance with the requirements of Section 013300 – Contractor Submittals.

2. As-Built Drawings
   a. Prepare as-built drawings, showing invert and top elevations and routing of duct banks, concealed, and concealed below-grade electrical installations.
   b. Furnish the drawings to the ENGINEER in accordance with the requirements of Section 013300 – Contractor Submittals.

F. Interconnection Diagrams Drawings

1. The Contractor shall prepare and submit interconnection diagrams prior to cable installation for approval.

2. Cable installation shall commence after the interconnection diagrams have been approved and all installed raceways are tagged.

1.7 AREA DESIGNATIONS

A. General

1. Designations for raceway system enclosures shall comply with the requirements of Section 260533 – Electrical Raceway Systems.

2. Designations for electrical WORK specifically indicated in other Sections shall comply with the requirements of those Sections unless indicated otherwise.

3. Designations for other electrical WORK not included in the above Paragraphs shall be as follows:
### AREA

<table>
<thead>
<tr>
<th>NEMA ENCLOSURE CLASSIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>Pump Room</td>
</tr>
<tr>
<td>Fish Screen</td>
</tr>
<tr>
<td>Outdoors/Roof</td>
</tr>
<tr>
<td>Discharge structure</td>
</tr>
</tbody>
</table>

4. Designations for electrical WORK not included in the above Paragraphs shall be NEMA 4X.

5. Installations in hazardous locations shall conform strictly to the requirements of the indicated Class, Group, and Division.

### B. Material Requirements

1. Provide sealing fittings in chlorine and hydrofluosilicic (HFS) acid areas.

2. Construct NEMA 4X enclosures of Type 304 or 316 stainless steel.

3. Do not coat NEMA 4X enclosures.

4. Construct NEMA 1, 3R, and 12 enclosures of steel, and prime and coat with ANSI 61 light grey paint.

5. Exposed enclosures shall be equipped with sun shields, environmental controls for condensation control and to keep equipment within its temperature limitations. Sun shields shall be painted white with corrosion protection paint.

### 1.8 TESTS

A. The CONTRACTOR shall be responsible for factory and field tests indicated in Division 26, as required by the ENGINEER, and as required by other authorities having jurisdiction.

B. Furnish necessary testing equipment. Testing and checkout work shall be performed by qualified personnel skilled in the particular testing. Qualified individuals shall have at least five years of experience on similar tests. Specialized testing shall employ NETA certified testers.

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 retested for compliance.

F. Corrections 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.

1.9 DEMOLITION AND RELATED WORK

A. General

1. Perform electrical demolition WORK as indicated. Demolition of existing electrical facilities shall commence after the new fish screen and pump station are in service.

2. The CONTRACTOR is cautioned that demolition WORK may also be indicated on non-electrical Drawings.

3. Coordinate with all trades regarding electrical de-energization, disconnection, and removal, and the overall sequence of construction.

B. Electrical Requirements for Removed Equipment

1. Remove dedicated wiring and conduits back to the source. Removal includes buried and exposed conduit for the existing diversion station that is in the levee prism.

2. Remove and dispose the main circuit breaker in the switch shack next to the existing substation.

3. Remove electrical wiring and gear from the existing pump station building.

4. Encased Conduits
   a. Remove wiring routed through encased conduits.
   b. Cut encased conduits flush to the floor.

5. Coordinate with WAPA to move the power meter currently on the high voltage side. The meter will be moved to the new facility feeder.

C. Removed materials and equipment not indicated to be returned to the OWNER shall, upon removal, become the CONTRACTOR’S property and shall be disposed of off-Site.

D. Coordinate with PG&E for existing utility poles removal if these are owned by PG&E.

E. Remove and relocate material and equipment indicated to be relocated or reused, and reinstall with care in order to prevent damage. The WAPA current and potential transformers, and the existing power meter shall be salvaged and re-installed on the new feeder to the new pump station.

F. Place materials indicated to be returned to the OWNER in boxes, with the contents clearly marked, and store at a location determined by the ENGINEER.
1.10 CONSTRUCTION SEQUENCING

A. General

1. Because the continuance of irrigation during demolition is critical, the CONTRACTOR shall carefully examine the WORK to be provided in, on, or adjacent to existing equipment.

2. Schedule the WORK, subject to OWNER's approval, to minimize required shutdown time.

3. Submit a written sequencing request, including the sequence and duration of activities to be performed during plant shutdown.

4. Switching, safety tagging, and the like, as required for plant shutdown or to isolate existing equipment, shall be performed by the CONTRACTOR in coordination with the OWNER.

5. In no case shall the CONTRACTOR begin any WORK in, on, or adjacent to existing equipment without written authorization from the ENGINEER.

B. 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.

C. 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 cost for the above verifications shall be included as part of the WORK.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Provide equipment and materials that are new and are the products of experienced and reputable manufacturers in the industry.

B. Provide equipment and materials listed by UL and bearing the UL label, where UL requirements apply.

C. Provide similar items in the WORK as products of the same manufacturer.

D. Provide equipment and materials of industrial grade standard of construction.
E. 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.

F. Protect electrical equipment at all times against mechanical and moisture damage. Electrical equipment shall not be stored out-of-doors. Store equipment in dry areas. Replace any apparatus which has been moisture damaged. Equipment rated for exterior placement might be stored out-of-doors with its heaters energized and out of harm’s way. Desiccant bags and waterproof coverings shall be approved by the Engineer if allowed.

G. On devices indicated to display dates, display the year as 4 digits.

H. Temperature Ratings of Equipment Terminations
   1. Provide terminations and lugs rated for use with 75-degree C conductors.
   2. Wire sizes in the Contract Documents are based on NEC ampacity tables using the 75-degree C ratings.

2.2 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 galvanized steel or stainless steel depending on their location.
      b. Where contact with concrete or dissimilar metals may cause galvanic corrosion, use suitable non-metallic insulators in order to prevent such corrosion.
      c. Use stainless steel strut for free-standing support frames.
      d. Strut Manufacturer, or Equal: Unistrut; B-Line; Superstrut.
   4. End Caps
      a. Provide plastic protective end caps for all exposed strut ends.
      b. End Caps Manufacturer, or Equal: Unistrut, Model P2860; Superstrut A-804NEOP WH.
   5. Anchors
      a. Provide stainless steel expansion anchors for attaching equipment to concrete walls, floors, and ceilings.
      b. Where required the Contractor shall use epoxy type stainless steel anchors. “Power-Bolt”; “Hilti”; or equal.
c. Wood plugs will not be accepted.

d. Anchor Manufacturer, or Equal: “Hilti”; “Power-Bolt” or "Power-Stud" as manufactured by Power Fasteners, Inc.; similar by Star.

2.3 ELECTRICAL IDENTIFICATION

A. Nameplates

1. Fabricate nameplates from white-letter, black-face laminated plastic engraving stock, such as Formica Type ES-1, or equal.

2. Securely fasten each nameplate, using fasteners constructed of stainless steel, and screwed into inserts or tapped holes as required.

3. Provide engraved characters of the block style, with no characters smaller than 1/8 inch top to bottom.

B. Conductor and Equipment Identification

1. Provide imprinted plastic-coated cloth marking devices, such as manufactured by Brady, Thomas & Betts, or equal.

2. Alternatively, provide heat-shrunk plastic tubing, imprinted split-sleeve markers cemented in place.

2.4 PROTECTIVE MATTING

A. Provide full-width, high-voltage switchboard matting in front of indoor switchgear, service equipment, and motor control centers.

B. For 600-volt equipment, provide matting that is 1/4 inch thick and 42 inches wide.

C. Matting Manufacturer, or Equal: W.H. Salisbury and Company; Mats, Inc.; Rhino.

PART 3 -- EXECUTION

3.1 GENERAL

A. Incidentals

1. Provide materials and incidentals required for a complete and operable system, even if not required explicitly by the Contract Documents.

2. 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. Electrical equipment, installed before room finishes are applied, shall be warped with plastic sheeting 10 mil minimum thickness and taped shut to keep the dust out. Measures shall be implemented by the Contractor to mitigate dust ingress and spread into the cabinet. The equipment shall be turned over to the Owner in clean condition inside and outside.
B. Field Control of Location and Arrangement

1. The Drawings diagrammatically indicate the desired location and arrangement of outlets, conduit runs, equipment, and other items.

2. Exact locations shall be determined by the CONTRACTOR in the field, based on the physical size and arrangement of equipment, finished elevations, and other obstructions.

3. Follow the locations on the Drawings, however, as closely as possible.

4. Conduits
   a. Where conduit development drawings or "home runs" are indicated, route the conduits in accordance with those requirements.
   b. Provide exposed or encased routings as indicated, except conceal conduit in finished areas unless indicated otherwise.
   c. Size conduits encased in a slab for conduit OD not to exceed 1/3 of the slab thickness, and lay out and space as to not impede concrete flow.

5. Placement
   a. Install conduit and equipment in such a manner as to avoid obstructions, to preserve headroom, and to keep openings and passageways clear.
   b. Locate luminaires, switches, convenience outlets, and similar items within finished rooms as indicated.
   c. Where exact locations are not indicated, such locations will be determined by the ENGINEER.
   d. If equipment is installed without instruction and must be moved, the cost of moving shall be included as part of the WORK.
   e. Slightly adjust luminaire locations in order to avoid obstructions and to minimize shadows.

6. Circuits
   a. Wherever conduits and wiring for lighting and receptacles are not indicated, it shall be the CONTRACTOR’S responsibility to provide lighting and receptacle-related conduits and wiring as required, based on the actual installed fixture layout and the circuit designations as indicated.
   b. Provide No. 12 AWG minimum wiring, and 3/4-inch minimum conduits (exposed) and one-inch minimum conduits (encased).
   c. Where circuits are combined in the same raceway, derate conductor ampacities in accordance with NEC requirements.
C. Workmanship

1. Install materials and equipment in strict accordance with the printed recommendations of the manufacturer, and using workers skilled in the WORK.

2. Coordinate installation in the field with other trades in order to avoid interferences.

D. Protection of Equipment and Materials

1. Fully protect materials and equipment against damage from any cause.

2. Cover materials and equipment, both in storage and during construction, in such a manner that no finished surfaces will be damaged, marred, or splattered with water, foam, plaster, or paint.

3. Keep moving parts clean and dry.

4. Replace or refinish damaged materials or equipment, including faceplates of panels and switchboard sections, as part of the WORK.

E. Provide power wiring in conduit for the HVAC equipment in accordance with the requirements of Section 230000 – Heating, Ventilating, and Air Conditioning.

F. Provide starters in accordance with the requirements of Section 262900 – Low Voltage Motor Control Center for starters in MCC’S, and with Section 260515 – Local Control Stations and Miscellaneous Electrical Devices for starters not in MCC’S

3.2 CORE DRILLING

A. Perform core drilling as required for the installation of raceways through concrete walls and floors.

B. Base the locations of floor penetrations, as may be required, on field conditions.

C. Verify exact core drilling locations based on equipment actually furnished as well as exact field placement.

D. To the extent possible, identify the existence and locations of encased raceways and other piping in existing walls and floors with the OWNER prior to any core drilling activities.

E. Repair damage to encased conduits, wiring, and piping as part of the WORK.

3.3 CONCRETE HOUSEKEEPING PADS

A. Provide concrete housekeeping pads for indoor floor-standing electrical equipment.

B. Extend housekeeping pads for equipment, including future units, 3-1/2 inches above the surrounding finished floor or grade, and 2 inches larger in both dimensions than the equipment, unless otherwise indicated on the seismic anchoring calculations for the edge distance parameter.

C. Provide concrete housekeeping curbs for conduit stub-ups in indoor locations that are not concealed by equipment enclosures.
D. Extend housekeeping curbs to 3 inches above the finished floor or grade. The housekeeping pad shall conform to detail E-203.

3.4 EQUIPMENT ANCHORING

A. Floor-supported, wall, or ceiling-hung equipment and conductors shall be anchored in place by methods that will meet seismic requirements in the area where the Project is located.

B. Provide wall-mounted panels that weigh more than 500 pounds or that are within 18 inches of the floor with fabricated steel support pedestals.

C. If the supported equipment is a panel or cabinet enclosed within removable side plates, match supported equipment in physical appearance and dimensions.

D. Provide transformers hung from 4-inch stud walls and weighing more than 300 pounds with auxiliary floor supports.

E. Manufacturer's Recommendations
   1. Anchoring methods and leveling criteria in the printed recommendations of the equipment manufacturers are a part of the WORK of this Contract.
   2. Submit such recommendations as Shop Drawings as indicated.

3.5 EQUIPMENT IDENTIFICATION

A. Provide nameplates for panelboards, control and instrumentation panels, starters, switches, and pushbutton stations.

B. In addition to nameplates, equip control devices with standard collar-type legend plates.

C. Identify control devices within enclosures as indicated and similar to the subparagraph above.

D. Provide suitable inscribed finish plates for toggle switches that control loads out of sight of switches and for multi-switch locations of more than 2 switches.

E. Use equipment names and tag numbers, where indicated, on nameplates.

F. Provide printed/typewritten circuit directories for panelboards, that accurately reflect the outlets connected to each circuit.

G. Terminal Blocks
   1. Label termination points on terminal blocks by identifiers on the blocks.
   2. Provide identifiers that have been preprinted by the terminal manufacturer or custom-printed.
   3. Hand-lettered markers will not be accepted.

H. Tag distribution equipment, stand-alone disconnects, starters, and VFDs with appropriate arc-flash labels.
3.6 CLEANING

A. Before final acceptance, thoroughly clean the electrical WORK of cement, plaster, and other materials.

B. Remove temporary tags, markers, stickers, and the like.

C. Remove oil and grease spots with a non-flammable cleaning solvent, by carefully wiping and scraping cracks and corners.

D. Apply touch-up paint to scratches on panels and cabinets.

E. Vacuum-clean electrical cabinets and enclosures.

F. Clean luminaires inside and out.

G. Dispose cleaning debris and refuse off-Site.

- END OF SECTION -
PART 1 – GENERAL

1.1 THE REQUIREMENT

A. This Section specifies the WORK necessary to test, commission, and demonstrate that the electrical work satisfies the criteria of these Specifications and functions as required by the Contract Documents.

B. The WORK of this Section includes furnishing the labor, equipment, and power required to support the testing indicated in other Divisions of these Specifications. Electrical testing indicated herein and functional testing of power and controls not tested under Division 40 - Instrumentation, shall be completed before commencement of the 7 Day test of Section 017500 - Equipment Testing and Plant Startup. This scope may require the CONTRACTOR to activate circuits, shutdown circuits, run equipment, make electrical measurements, replace blown fuses, and install temporary jumpers, etc.

C. The requirements of Section 260000 - Electrical Work, General, apply to the WORK of this Section.

D. Carry out tests indicated herein for individual items of materials and equipment in other Sections. Testing shall be done in accordance with the manufacturer's instructions, these Specifications, and applicable NETA Acceptance Testing Specifications, NEMA, ANSI, NFPA, and ASTM Standards.

E. The field testing shall be performed by a testing firm regularly engaged in the testing of electrical equipment for a minimum of ten (10) years. Testing shall be coordinated with manufacturer’s representatives.

F. All test equipment shall bear a calibration stamp and shall be current at the time of testing. The calibration information and equipment serial number shall be included in the report.

1.2 REFERENCES

A. General

1. The publications listed below form a part of this specification to the extent referenced.

2. Where a date is given for reference standards, the edition of that date shall be used. Where no date is given for reference standards, the latest edition available on the date of the Notice Inviting Bids shall be used.

B. American National Standards Institute (ANSI)

C. Institute of Electrical and Electronics Engineers, Inc. (IEEE)


E. IEEE 576-2000, Recommended Practice for Installation, Termination, and Testing of Insulated Power Cable as Used in Industrial and Commercial Applications
F. InterNational Electrical Testing Association (NETA)

G. NFPA 70, National Electrical Code (NEC)

1.3 SUBMITTALS

A. Submit in accordance with Section 013300, Submittals.

B. Submit complete system test procedures for review. Test procedures shall include but not be limited to:

1. Detailed procedures in sufficient detail to verify conformance with these Specifications.

2. Incorporation of the Test Record Sheets included at the end of this Section.

3. Detailed comprehensive testing schedule including:
   a. Each major piece of electrical distribution equipment.
   b. Each major electrical subsystem.
   c. Duration of each test.
   d. Milestone test completion date.
   e. Ambient Conditions at time of test
   f. Date of test results submittals following completion of the tests.
   g. Names and qualifications of the individual(s) responsible for performing the testing.

C. Following completion of the test submit the completed test results to the Engineer for review. The results shall include a dedicated section with the “as-left” settings of all devices, relays, circuit breakers, etc.

D. Test result shall be submitted in one submittal.

E. Test reports shall be based on NETA’s latest Acceptance Testing Specifications having a sign-off, pass/fail data filed for each line item covered by NETA’s Acceptance Testing Specifications latest edition.

1.4 COMMISSIONING

A. Commissioning during the 7 Day test in Section 017500 shall not be attempted until all subsystems have been found to operate satisfactorily. Commissioning shall only be attempted as a function of normal plant operation in which plant process flows and levels are routine and equipment operates automatically in response to flow and level parameters or computer command, as applicable. Simulation of process parameters shall be considered only upon receipt of a written request by the CONTRACTOR.
B. Motor Current Tabulation

1. The motor current tabulation required by Section 260573 – Protective Device Studies shall reflect the values occurring during commissioning.

2. Switchboard metering values for Ampere and kilowatt-hour shall be recorded every half-hour during the commissioning.

3. Motors which have current/power measurement capabilities shall have this data recorded every 5 minutes while operating during commissioning.

4. Power monitored amperes, voltage, and kilowatts for each phase shall be recorded every 5 minutes during commissioning.

PART 2 -- TESTING & REPORTS

2.1 PRE-ENERGIZATON AND OPERATING TESTS

A. The complete electrical system shall be performance tested when first installed on-site. Each protective, switching, and control circuit shall be adjusted in accordance with the recommendations of the protective device study and tested by actual operation using current injection or equivalent methods as necessary to ensure that each and every such circuit operates correctly to the satisfaction of the authority having jurisdiction.

1. Instrument Transformers. All instrument transformers shall be tested to verify correct polarity and burden.

2. Protective Relays. Each protective relay shall be demonstrated to operate by injecting current or voltage, or both, at the associated instrument transformer output terminal and observing that the associated switching and signaling functions occur correctly and in proper time and sequence to accomplish the protective function intended.

3. Switching Circuits. Each switching circuit shall be observed to operate the associated equipment being switched.

4. Control and Signal Circuits. Each control or signal circuit shall be observed to perform its proper control function or produce a correct signal output.

5. Metering Circuits. All metering circuits shall be verified to operate correctly from voltage and current sources, similarly to protective relay circuits.

6. Acceptance Tests. Complete acceptance tests shall be performed, after the station installation is completed, on all assemblies, equipment, conductors, and control and protective systems, as applicable, to verify the integrity of all the systems.

7. Relays and Metering Utilizing Phase Differences. All relays and metering that use phase differences for operation shall be verified by measuring phase angles at the relay under actual load conditions after operation commences.

B. Test Report: A test report covering the results of the tests required in the Pre-Energization and Operating Tests shall be delivered to the authority having jurisdiction prior to energization. Acceptance Testing shall be in accordance with NETA ATS-2009,
2.2 TEST REQUIREMENTS

A. The following test requirements supplement test and acceptance criteria that may be stated elsewhere.

1. Lighting: Switching, include remote control, if present in system. Circuitry is in accordance with panel schedules. All interior and exterior lighting shall be checked for proper operation.

2. Power Instrumentation: Demonstrate that voltmeter and ammeter switches are functional. Demonstrate that kilowatt meters are within catalog accuracy as installed.

   a. Visual and Mechanical Inspection
      1) Compare equipment nameplate data with drawings and specifications.
      2) Inspect physical and mechanical condition.
      3) Verify tightness of electrical connections.
      4) Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case-shorting contacts, as applicable.
      5) Verify freedom of movement, end play, and alignment of rotating disk(s).

   b. Electrical Tests
      1) Verify accuracy of meters at all cardinal points.
      2) Calibrate watthour meters according to manufacturer’s published data.
      3) Verify all instrument multipliers.
      4) Verify that current transformer and voltage transformer secondary circuits are intact.

3. Demonstrate mechanical and/or electrical interlocking by attempting to subvert the intended sequence.

4. Activate ground fault tripping by operating test features provided with ground current protective systems and by injecting a known and reasonable current in the ground current sensor circuit. In general, ground fault tripping should occur at a ground current equivalent to 20 percent of phase current. Current injection is not required of circuit 400 amperes or less.

5. Low Voltage Cables-600 volts Maximum

   a. Visual and Mechanical Inspection
      1) Compare cable data with drawings and specifications.
2) Inspect exposed sections of cables for physical damage and correct connection in accordance with single-line diagram.

3) Inspect bolted electrical connections for high resistance using one of the following methods:
   a) Use of low-resistance ohmmeter
   b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer’s published data or NETA ATS-2009, Table 100.12.
   c) Perform thermographic survey in accordance with below Section Thermographic Survey.

4) Inspect compression-applied connectors for correct cable match and indentation.

5) Inspect for correct identification and arrangements.

6) Inspect cable jacket insulation and condition.

b. Electrical Tests

1) Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential shall be 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. Test duration shall be one minute.
   a) Motor feeders tested with motors disconnected and controller open.
   b) Motor control circuits tested and verified for proper operation with control stations and overcurrent devices connected.
   c) Panelboard feeders tested with feeder breaker open and panel-board connected. If a lighting transformer is associated with the panelboard, it shall be connected and the test made for both primary and secondary sides.
   d) Conductors of main lighting feeders, including lighting panel with branch circuits open.
   e) Prior to performing insulation resistance tests on cables, verify that they are not connected to a solid state device.
   f) Equipment which may be damaged during this test shall be disconnected.
   g) The Engineer shall be consulted if minimum insulation values cannot be obtained.

2) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

3) Perform continuity test to insure correct cable connection.
c. Test Values – Visual and Mechanical

1) Compare bolted connection resistance to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Bolt-torque levels should be in accordance with NETA ATS-2009, Table 100.12 unless otherwise specified by the manufacturer.

3) Results of the thermographic survey shall be in accordance with the below Section Thermographic Survey.

d. Test Values – Electrical

1) Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Insulation-resistance values shall be in accordance with manufacturer’s published data. In the absence of manufacturer’s published data, use NETA ATS-2009 Table 100.1. Values of insulation resistance less than this table or manufacturer’s recommendations shall be investigated.

3) Cable shall exhibit continuity.

4) Deviations in resistance between parallel conductors shall be investigated.

6. Test ground interrupter (GFI) receptacles and circuit breakers for proper operation by methods sanctioned by the receptacle manufacturer.

7. A functional test and check of electrical components is required prior to performing subsystem testing and commissioning. Compartments and equipment shall be cleaned as required by other provisions of these Specifications before commencement of functional testing. Functional testing shall comprise:

a. Visual and physical check of cables, circuit breakers, transformers, and connections associated with each item of new and modified equipment.

b. Verification that electrical equipment has been labeled with Arc Flash protection boundary and PPE levels, as required by Section 260573 – Protective Device Studies.

c. Setting of protective relays in conformance with results of the Short Circuit Study required by Section 260573 - Protective Device Studies and testing of relays to assure that relays will trip at the current value and time required by the Study.

d. Circuit Breakers

1) Circuit breakers that have adjustable time or pick-up settings for ground current, instantaneous overcurrent, short-time overcurrent, or long-time overcurrent, shall be field-adjusted by a representative of the circuit breaker manufacturer.
2) Time and pickup setting shall correspond to the recommendations of the Short Circuit Study.

3) Setting shall be tabulated and proven for each circuit breaker in its installed position.

4) Test results shall be certified by the person performing the tests and shall be submitted to the ENGINEER.

8. Complete ground testing of grounding electrodes per requirements below prior to operating the equipment.

B. Subsystem testing shall occur after the proper operation of alarm and status contacts has been demonstrated or otherwise accepted by the ENGINEER and after process control devices have been adjusted as accurately as possible. Alarm conditions shall be simulated for each alarm point, and alarm indicators shall be checked for proper operation. It is intended that the CONTRACTOR will adjust limit switches and level switches to their operating points prior to testing and will set pressure switches, flow switches, and timing relays as dictated by operating results.

C. Metering and indication lights for motors and other devices shall be tested for proper operation.

D. All control circuits such as motor, interlock and remote shall be tested for proper operation.

E. After initial settings have been completed, each subsystem shall be operated in the manual mode and it shall be demonstrated that operation is in compliance with the Contract Documents. Once the manual mode of operation has been proven, automatic operation shall be demonstrated to verify such items as proper start and stop sequence of pumps, proper operation of valves, proper speed control, etc.

F. Motor operated valves shall be tested after having been phased and tested for correct motor rotation and after travel and torque limit switches have been adjusted by a representative of the valve manufacturer. Tests shall verify status indication, proper valve travel, and correct command control from local and remote devices.

G. All lighting panels, circuits and fixtures; and power panels, circuits and receptacles shall be tested for proper operation.

H. Provide ground resistance tests on the main grounding electrode or system in the presence of the ENGINEER and submit results

1. Visual and Mechanical Inspection: Verify ground system is in compliance with drawings and specifications.

2. Electrical Tests
   a. Perform fall-of-potential test or alternative in accordance with IEEE Standard 81 on the main grounding electrode or system.
   b. The earth resistance of each ground electrode shall be measured and recorded before electrodes are connected to the grounding loop.
c. Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, and/or derived neutral points.

3. Test Values

a. The resistance between the main grounding electrode and ground shall be no greater than five ohms for commercial or industrial systems and one ohm or less for generating or transmission station grounds unless otherwise specified by the owner.

b. Investigate point-to-point resistance values which exceed 0.5 ohm.

I. Subsystems shall be defined as individual and groups of pumps, conveyor systems, chemical feeders, air conditioning units, ventilation fans, air compressors, etc.

J. Thermographic Survey

1. Visual and Mechanical Inspection

   a. Inspect physical, electrical, and mechanical condition.

   b. Remove all necessary covers prior to thermographic inspection. Utilize appropriate caution, safety devices, and personal protective equipment.

2. Equipment to be inspected shall include all 120 volt and higher current-carrying devices including all switchgear, switchboards, distribution panels, cable and bus connections, motor control centers and starters, disconnect switches, and other critical equipment. Testing of lighting luminaires, field instrumentation, SCADA & PLC’s are not required.

3. Provide report including the following:

   a. Description of equipment to be tested.

   b. Discrepancies.

   c. Temperature difference between the area of concern and the reference area.

   d. Probable cause of temperature difference.

   e. Areas inspected. Identify inaccessible and/or unobservable areas and/or equipment.

   f. Identify load conditions at time of inspection.

   g. Provide photographs and/or thermograms of the deficient area.

   h. Recommended action.

4. Test Parameters

   a. Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1 °C at 30 °C.
b. Equipment shall detect emitted radiation and convert detected radiation to visual signal.

c. Thermographic surveys should be performed during periods of maximum possible loading but not less than 40 percent of rated load of the electrical equipment being inspected. Refer to ANSI/NFPA 70B-2010, Section 11-17 (Infrared Inspection).

5. Test Values: Suggested actions based on temperature rise can be found in Table 100.18.

6. Re-Inspection

   a. All items that are reported deficient in the thermography reports section of the inspection report shall be re-inspected after repairs have been made.

   b. Original specification will apply to re-inspections.

   c. Submit re-inspection reports and indicate that repairs have fixed the anomaly or indicate any remaining anomalies.

   d. Perform a follow-up thermographic survey within 12 months of final acceptance by the owner.

2.3 TEST REPORTS

A. The test report shall include the following:

1. Summary of project.

2. Description of equipment tested.

3. Description of test.

4. Test data.

5. Analysis and recommendations.

B. Test data records shall include the following minimum requirements:

1. Identification of the testing organization.

2. Equipment identification.

3. Humidity, temperature, and other atmospheric conditions that may affect the results of the tests/calibrations.

4. Date of inspections, tests, maintenance, and/or calibrations.

5. Identification of the testing technician.

6. Indication of inspections, tests, maintenance, and/or calibrations to be performed and recorded.

7. Indication of expected results when calibrations are to be performed.
8. Indication of “as-found” and “as-left” results.

9. Sufficient spaces to allow all results and comments to be indicated.

C. The testing firm shall furnish a copy or copies of the complete report to the owner as required in the acceptance contract.

### TABLE 100.18
THERMOGRAPHIC SURVEY
SUGGESTED ACTIONS BASED ON TEMPERATURE RISE

<table>
<thead>
<tr>
<th>Temperature difference ($\Delta T$) based on comparisons between similar components under similar loading.</th>
<th>Temperature difference ($\Delta T$) based upon comparisons between component and ambient air temperatures.</th>
<th>Recommended Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1^\circ C - 3^\circ C$</td>
<td>$1^\circ C - 10^\circ C$</td>
<td>Possible deficiency; warrants investigation</td>
</tr>
<tr>
<td>$4^\circ C - 15^\circ C$</td>
<td>$11^\circ C - 20^\circ C$</td>
<td>Indicates probable deficiency; repair as time permits</td>
</tr>
<tr>
<td>- - - - - -</td>
<td>$21^\circ C - 40^\circ C$</td>
<td>Monitor until corrective measures can be accomplished</td>
</tr>
<tr>
<td>$&gt;15^\circ C$</td>
<td>$&gt;40^\circ C$</td>
<td>Major discrepancy; repair immediately</td>
</tr>
</tbody>
</table>

Temperature specifications vary depending on the exact type of equipment. Even in the same class of equipment (i.e., cables) there are various temperature ratings. Heating is generally related to the square of the current; therefore, the load current will have a major impact on $\Delta T$. In the absence of consensus standards for $\Delta T$, the values in this table will provide reasonable guidelines.


It is a necessary and valid requirement that the person performing the electrical inspection be thoroughly trained and experienced concerning the apparatus and systems being evaluated as well as knowledgeable of thermographic methodology.
### PART 3 -- TEST RECORD SHEETS

The test record sheets listed below shall be used to record testing of electrical equipment and of the electrical installation as required by these specifications. Sample copies of each sheet are attached.

<table>
<thead>
<tr>
<th>Sheet No.</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Insulation Resistance (Power, Control Wire, and Cable) Test Record</td>
</tr>
<tr>
<td>2</td>
<td>Insulation Resistance (Instrument Wire and Cable) Test Record</td>
</tr>
<tr>
<td>3</td>
<td>DC High Potential (Medium Voltage Cable) Test Record</td>
</tr>
<tr>
<td>4</td>
<td>Ground Electrode Testing Test Record</td>
</tr>
<tr>
<td>5</td>
<td>Neutral Grounding Resistor Test Record</td>
</tr>
<tr>
<td>6</td>
<td>Bonding Resistance Readings (Nonelectrical Equipment/Structures) Test Record</td>
</tr>
<tr>
<td>7</td>
<td>Bonding Resistance Readings (Electrical Equipment) Test Record</td>
</tr>
<tr>
<td>8</td>
<td>Insulation Resistance (Transformer) Test Record</td>
</tr>
<tr>
<td>9</td>
<td>Insulation Resistance (Equipment) Test Record</td>
</tr>
<tr>
<td>10</td>
<td>Insulation Resistance (Rotating Equipment) Test Record</td>
</tr>
<tr>
<td>11</td>
<td>Equipment Absorption Ratio and Polarization Index Test Record</td>
</tr>
<tr>
<td>12</td>
<td>Record Feeder Breaker (480 V MCC) Test Record</td>
</tr>
<tr>
<td>13</td>
<td>Breaker/Contactor (480 V MCC) Test Record</td>
</tr>
<tr>
<td>14</td>
<td>460 V Motor Circuit (480 V MCC) Test Record</td>
</tr>
<tr>
<td>15</td>
<td>Medium Voltage Motor Circuit Test Record</td>
</tr>
<tr>
<td>16</td>
<td>Electric Motor Run-In Test Record</td>
</tr>
<tr>
<td>17</td>
<td>Thermographic Test Record</td>
</tr>
</tbody>
</table>
### INSULATION RESISTANCE
(Power, Control Wire, and Cable)

#### TEST RECORD

<table>
<thead>
<tr>
<th>TEST EQUIPMENT</th>
<th>TEST VOLTAGE</th>
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<tbody>
<tr>
<td>TEST EQUIPMENT</td>
<td>TEST VOLTAGE</td>
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</table>

<table>
<thead>
<tr>
<th>AMBIENT TEMPERATURE</th>
<th>°C</th>
<th>°F</th>
<th>DATE</th>
</tr>
</thead>
</table>

**NOTES:**

1. Perform Insulation Resistance Test (megger) between each conductor and all other conductors and metallic sheath for cables with nonshielded conductors. Test between each conductor and shield for multiconductor cables with shielded conductors. Record lowest reading for each cable.

2. Use 1,000-V test set for cable rated 600 volts and 2,500-V test set for cable rated over 600 volts.

3. Readings will vary inversely with temperature and cable length. When the use of temperature correction factors is specified, attach a second sheet with computed values. Indicate on each sheet “measured” or “temperature corrected.”

<table>
<thead>
<tr>
<th>Panel No.</th>
<th>Circuit No.</th>
<th>Feeder No.</th>
<th>Wire Tagging</th>
<th>Cable Rated Voltage</th>
<th>Quantity</th>
<th>Wire or Cable</th>
<th>Insulation Resistance (megohms)</th>
<th>Initials</th>
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</table>

*Minimum acceptable values:

<table>
<thead>
<tr>
<th>Cable Rated Voltage</th>
<th>Test Duration</th>
<th>Resistance for Cable Only</th>
<th>Cable/Wire Size or Amperage (megohms)</th>
<th>Resistance When Cable Connected to Equipment (ohms)</th>
</tr>
</thead>
</table>

**DISTRIBUTION:**

CONTRACTOR/Date

MWH - DECEMBER 2013
1012294 – JOINT INTAKE AND FISH SCREEN PROJECT
ELECTRICAL TESTS
PAGE 260126 - 12
### INSULATION RESISTANCE
**(INSTRUMENT WIRE AND CABLE)**

**TEST RECORD**

<table>
<thead>
<tr>
<th>Cable Number or Instrument Number</th>
<th>Indicate MP or SP Type</th>
<th>Conductor to Conduit (Non-Shielded Cables) (megohms)</th>
<th>Conductor to Conductor (megohms)</th>
<th>Shield to Conductor to Shield (megohms)</th>
<th>Overall Shield to Shield (Multipair Cables Only) (megohms)</th>
<th>Lead and Armor (Multipair Cables Only) (megohms)</th>
<th>Shield to Conduit (Single Pair Cables Only) (megohms)</th>
<th>Initials</th>
</tr>
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</table>

**NOTES:**
1. Record only the lowest value.
2. MP - Multi-pair cable. SP - Single pair cable.
3. Megger with instruments disconnected.
4. Use 250 volt (or lower voltage, when specified) range on DC test set.
5. Readings will vary with temperature and cable length.*

---

**DISTRIBUTION:**

CONTRACTOR/Date  _______
DC HIGH POTENTIAL (MEDIUM VOLTAGE CABLE) 
TEST RECORD

CIRCUIT NUMBER: ___________________________ REF. DWG.: ___________________________
CABLE SIZE: _______ (SQ.MM.) _________ (MCM) FROM: __________________ TO: ____________
NUMBER OF CONDUCTORS: __________________ NO. OF SPLICES: __________________
CABLE LENGTH: ___________________________ MANUFACTURER: ________________________
INSULATION TYPE: __________________________ THICKNESS: ___________________________
JACKET MATERIAL: __________________________
WEATHER: _______ TEMP.: _______ ºC _______ ºF % HUMIDITY: __________ DATE: __________
TEST EQUIPMENT USED: __________________________

NOTES: 1. The test voltage shown below shall be reached in 10 equal voltage increments.
2. After each voltage increase, the leakage current shall be allowed to stabilize during a 1-
minute interval. If 1-minute intervals are insufficient to stabilize the current, the cable shall
be discharged, and the test repeated with new time intervals of greater, but still equal
duration.
3. Record the stabilized leakage current, in microamps, at the end of each time interval.
4. Allow the voltage to remain constant at the full test voltage and record the leakage current
for 5 minutes for unshielded cables and 15 minutes for shielded cables.
5. Read test equipment instruction manual prior to testing cable.
6. When the plotting of test results is specified, attach the second sheet with separate plot for
each phase. Note leakage current, in microamps, on “y” axis. Note step-voltage increase
on “x” axis, followed by time, in minutes, for the dielectric absorption portion of the test.
7. All other phases and shields to be grounded.

Voltage hold time at each step

<table>
<thead>
<tr>
<th>Voltage hold time at each step</th>
<th>__k   V</th>
<th>__k   V</th>
<th>__k   V</th>
<th>___k  V</th>
<th>___k  V</th>
<th>___k  V</th>
<th>___k  V</th>
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</table>

RECORD LEAKAGE CURRENT IN MICROAMPS

<table>
<thead>
<tr>
<th>Time at __Kv</th>
<th>SEC 30</th>
<th>MIN 1</th>
<th>MIN 2</th>
<th>MIN 3</th>
<th>MIN 4</th>
<th>MIN 5</th>
<th>MIN 6</th>
<th>MIN 7</th>
<th>MIN 8</th>
<th>MIN 9</th>
<th>MIN 10</th>
<th>MIN 11</th>
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</table>

CABLE-RATED VOLTAGE (kilovolts) TEST VOLTAGE (kilovolts)

DISTRIBUTION: __________

CONTRACTOR/Date __________
GROUND ELECTRODE TESTING
TEST RECORD

TEST EQUIPMENT: ___________________________ (Note 1) ___________________________ (Note 2)

REFERENCE DRAWING: ___________________________

NOTES: 1. Record resistance-to-earth for each electrode with all other conductors disconnected. Resistance not to exceed 25 ohms for any single anode.
2. Check continuity from each electrode to any test bar or other electrode such that the complete ground loop is tested.

<table>
<thead>
<tr>
<th>Rod Number</th>
<th>Resistance to Earth (ohms)</th>
<th>Ambient Temperature (°C/°F)</th>
<th>Weather</th>
<th>Taps (4)</th>
<th>Initials/Date</th>
</tr>
</thead>
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DISTRIBUTION: ____________________________________________

CONTRACTOR/Date ____________
# NEUTRAL GROUNDING RESISTOR
## TEST RECORD

**TEST EQUIPMENT:** ________________  **TEST VOLTAGE:** ________________

**TEST EQUIPMENT:** ________________  **TEST VOLTAGE:** ________________

**NOTES:**
1. Use 1,000-volt test set for 600-volt equipment and below, 2,500-volt test set for equipment rated over 600 volts.
2. Resistor must be disconnected from ground and neutral during Insulation Resistance (megger) and DC Overpotential Tests.
3. Resistor must be disconnected from neutral during Cold Resistance Test.
4. Apply DC Overpotential Test between terminals and ground for the complete device. (The voltage applied between the terminals of each assembly and its grounded enclosure shall be twice the rated AC voltage plus 1000 V when rated 600 V or less, or 2.25 times the rated AC voltage plus 2000 V when rated over 600 V for 1 minute. This test is a Pass/Fail test based purely on withstand alone.
5. Inspect assembly for damage and missing parts.
6. Check to assure that the center tap ratio is correct, when CT is supplied with resistor.
7. Verify resistor reterminated.

<table>
<thead>
<tr>
<th>Tag No.</th>
<th>Cold Res. (ohms)</th>
<th>Insul. Res. (megohms)*</th>
<th>Overpot. (4)</th>
<th>CT Ratio Pri-Sec</th>
<th>Reterm (4)</th>
<th>Initials/Date</th>
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<tbody>
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*Minimum acceptable values:

**VOLTAGE CLASS**

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<th>(megohms)</th>
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**INSULATION RESISTANCE**

<table>
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<th>(megohms)</th>
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**DISTRIBUTION:**

CONTRACTOR/Date  ____________

MWH - DECEMBER 2013
1012294 – JOINT INTAKE AND FISH SCREEN PROJECT  ELECTRICAL TESTS
PAGE 260126 - 16
BONDING RESISTANCE READINGS  
(NONELECTRICAL EQUIPMENT/STRUCTURES) 
TEST RECORD

TEST EQUIPMENT USED: ____________________  WEATHER: ____________________________

NOTES:  
1. Vessels, tanks, and structural steel bonded to the main grounding system, dedicated ground rod or foundation, as indicated on drawings listed below. 
2. Measure resistance from ground wire tap (or anchor bolt) to tagged equipment frame or structural steel.

<table>
<thead>
<tr>
<th>EQUIPMENT TAG NO. OR STRUCTURE</th>
<th>DRAWING</th>
<th>MEASURED RESISTANCE (ohms)</th>
<th>INITIALS/DATE</th>
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DISTRIBUTION: 

CONTRACTOR/Date  ____________
BONDING RESISTANCE READINGS
(ELECTRICAL EQUIPMENT)
TEST RECORD

TEST EQUIPMENT USED: ___________________ WEATHER: ___________________

NOTES: 1. Electrical equipment bonded to the main grounding system or dedicated ground rod, as indicated on drawings listed below.
2. Measure resistance from ground wire tap to tagged equipment bus bars, tagged equipment enclosures, and any other points indicated on the drawings.

<table>
<thead>
<tr>
<th>EQUIPMENT TAG NO. OR STRUCTURE</th>
<th>DRAWING</th>
<th>MEASURED RESISTANCE (ohms)</th>
<th>INITIALS/DATE</th>
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</table>
### INSULATION RESISTANCE
(TRANSFORMER)
TEST RECORD

**SUBSTATION NO.:** ______________________  **TEST EQUIPMENT:** ______________________

**NOTES:**
1. Use 1,000-V test set for 600-volt equipment and below, 2,500-V test set for equipment rated 601 - 5,000 volts, and 5,000-V test set for equipment rated over 5,000 volts.
2. Test voltage to be applied for 1-minute duration, and reading taken.
3. Neutral must be disconnected from ground during test.
4. Record temperature of surrounding air temperature for dry-type transformers.
5. Readings will vary inversely with temperature. When the use of temperature correction factors is specified, attach second sheet with computed values. Indicate on each sheet “measured” or “temperature corrected.”

<table>
<thead>
<tr>
<th>Equipment Tag No.</th>
<th>RESISTANCE IN (megahoms) *</th>
<th>Pri Voltage Rating (kV)</th>
<th>Pri-Sec Air</th>
<th>Liquid Temp. (°C/°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Primary</td>
<td>Secondary</td>
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<tr>
<td></td>
<td>∅A to G</td>
<td>∅B to G</td>
<td>∅C to G</td>
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<td>∅A to G</td>
<td>∅B to G</td>
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<td>∅C to G</td>
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</tbody>
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*Minimum acceptable values:

**VOLTAGE CLASS**

<table>
<thead>
<tr>
<th>RESISTANCE (megohms)</th>
</tr>
</thead>
</table>

**TESTER’S INITIALS/DATE** ______________________

**DISTRIBUTION:**

**CONTRACTOR/Date** ______________________
**INSULATION RESISTANCE (EQUIPMENT) TEST RECORD**

TEST EQUIPMENT: ______________________  SUBSTATION: ______________________

AMBIENT TEMPERATURE: _____ ºC _____ ºF  DATE: ______________________

REFERENCE DRAWING: ______________________  REF. SEC.: ______________________

**NOTES:**
1. Use 1,000-V test set for equipment rated 600 volts and below, 2,500/5,000-V test set for equipment rated over 600 volts.
2. For equipment with solid state control circuits, consult manufacturer’s literature for maximum test voltages.

<table>
<thead>
<tr>
<th>Switchgear/MCC (other)</th>
<th>INSULATION RESISTANCE (megohms) *</th>
<th>Test Voltage (kV)</th>
<th>Rated Voltage (kV)</th>
<th>Initials/Date</th>
</tr>
</thead>
<tbody>
<tr>
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<td>∅A to G</td>
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<td>∅B to G</td>
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<td>∅C to G</td>
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<td>∅A to ∅B</td>
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<td>∅B to ∅C</td>
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<td>∅C to ∅A</td>
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</tbody>
</table>

*Minimum acceptable values:

<table>
<thead>
<tr>
<th>EQUIPMENT VOLTAGE CLASS (megohms)</th>
<th>RESISTANCE</th>
</tr>
</thead>
</table>

TESTER'S INITIALS/DATE _______________

DISTRIBUTION: ______________________

CONTRACTOR/Date _______________
INSULATION RESISTANCE (ROTATING EQUIPMENT)
TEST RECORD

TEST EQUIPMENT: ____________________  TEST VOLTAGE: ____________________

AMBIENT TEMPERATURE: _____ °C _____ °F  DATE: __________________________

EQUIP. TEMP., IF KNOWN: _____ °C _____ °F  HOW KNOWN: ____________________

NOTES: 1. Use 1,000-V test set for equipment 600-volt and below, 2,500/5,000-V test set for equipment rated over 600 volts.
2. Test duration shall be 1 minute, note if otherwise: ________________.
3. Isolate all motor leads from one another and from frame, test phase separately, wherever practical.
4. Document testing of low voltage and medium voltage equipment on separate sheets.
5. Readings will vary inversely with temperature. When the use of temperature correction factors is specified, attach second sheet with computed values. Indicate on each sheet "measured" or "temperature corrected."

<table>
<thead>
<tr>
<th>Equipment Tag No.</th>
<th>INSULATION RESISTANCE (megohms) *</th>
<th>Rated Voltage</th>
<th>Equipment Initial/Date</th>
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<td>ΩA to G</td>
<td>ΩB to G</td>
<td>ΩC to G</td>
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<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

*Minimum acceptable values:

<table>
<thead>
<tr>
<th>VOLTAGE CLASS</th>
<th>RESISTANCE (megohms)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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1012294 – JOINT INTAKE AND FISH SCREEN PROJECT
# EQUIPMENT ABSORPTION RATIO
## AND POLARIZATION INDEX

### TEST RECORD

<table>
<thead>
<tr>
<th>Test Equipment</th>
<th>Test Voltage</th>
<th>Ambient Temperature</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>°C °F</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Equipment Temp., if known</th>
<th>Rel. Humidity</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>°C °F</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
1. Perform test as indicated on Test Records for each individual equipment type. Reference the following sheets:
   - Transformers: 8
   - Equipment: 9
   - Motors and Generators: 10
2. Absorption Ratio = \[ \frac{1\text{-Minute Resistance Value}}{30\text{-Second Resistance Value}} \]
3. Polarization Index = \[ \frac{10\text{-Minute Resistance Value}}{1\text{-Minute Resistance Value}} \]

<table>
<thead>
<tr>
<th>OHMS TO GROUND 30-SECOND READING</th>
<th>OHMS TO GROUND 1-MINUTE READING</th>
<th>OHMS TO GROUND 10-MINUTE READING</th>
<th>DIELECTRIC ABSORPTION RATIO</th>
<th>POLARIZATION INDEX</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 A TO GROUND</td>
<td>0 A TO GROUND</td>
<td>0 A TO GROUND</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OHMS TO GROUND 30-SECOND READING</td>
<td>OHMS TO GROUND 1-MINUTE READING</td>
<td>OHMS TO GROUND 10-MINUTE READING</td>
<td>DIELECTRIC ABSORPTION RATIO</td>
<td>POLARIZATION INDEX</td>
</tr>
<tr>
<td>0 B TO GROUND</td>
<td>0 B TO GROUND</td>
<td>0 B TO GROUND</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OHMS TO GROUND 30-SECOND READING</td>
<td>OHMS TO GROUND 1-MINUTE READING</td>
<td>OHMS TO GROUND 10-MINUTE READING</td>
<td>DIELECTRIC ABSORPTION RATIO</td>
<td>POLARIZATION INDEX</td>
</tr>
<tr>
<td>0 C TO GROUND</td>
<td>0 C TO GROUND</td>
<td>0 C TO GROUND</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Tester’s Initials/Date:**

---

**Distribution:**

**Contractor/Date:** ___

Sheet 12
### FEEDER BREAKER (480 V MCC) TEST RECORD

<table>
<thead>
<tr>
<th>EQUIPMENT DESIGNATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOAD (kW/kVA)</td>
</tr>
<tr>
<td>CIRCUIT BREAKER MFG.</td>
</tr>
<tr>
<td>CONDUCTOR SIZE</td>
</tr>
</tbody>
</table>

1. Check nameplate data of breaker against approved vendor drawings.  
2. Check breaker components for cleanliness.  
3. Check mechanical function of breaker.  
4. Check wiring for proper identification.  
5. Check conduits/cables for tagging.  
6. Check components for identification.  
7. Check equipment for conformance of area classification.  
8. Check installation for seals, breathers, and drains.  
9. Verify power conductor continuity.  
10. Check that power cable insulation resistance test (megger) is completed.  

---

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---

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ELECTRICAL TESTS

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### BREAKER/CONTACTOR (480 V MCC)
#### TEST RECORD

**EQUIPMENT DESIGNATION**

<table>
<thead>
<tr>
<th>LOAD (kW/kVA)</th>
<th>VOLTAGE</th>
<th>F.L.A.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIRCUIT BREAKER MFG.</td>
<td>RATING</td>
<td>SETTING</td>
</tr>
<tr>
<td>CONTACTOR MFG.</td>
<td>SIZE</td>
<td></td>
</tr>
<tr>
<td>CONDUCTOR SIZE</td>
<td>POWER</td>
<td>CONTROL</td>
</tr>
</tbody>
</table>

1. Check nameplate data of breaker, contactor fuses and relays against approved vendor drawings.

2. Check main and auxiliary contacts.

3. Check contactor/breaker components for cleanliness.

4. Check control fuses, CPT rating, and coil voltage.

5. Check mechanical function of contactor and breaker.

6. Check wiring for proper identification.

7. Check conduits/cables for tagging.

8. Check components for identification.

9. Check equipment for conformance to area classification.

10. Check installation for seals, breathers, and drains.

11. Verify continuity of all power and control leads.

12. Check that power and control cable Insulation Resistance Test (megger) is completed.


---

**DISTRIBUTION:**

CONTRACTOR/Date

---
460 V MOTOR CIRCUIT (480 V MCC)
TEST RECORD

<table>
<thead>
<tr>
<th>EQUIPMENT DESIGNATION</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>MOTOR TAG NO.</td>
<td>VOLTAGE</td>
</tr>
<tr>
<td>KW/HP</td>
<td>RPM</td>
</tr>
<tr>
<td>CIRCUIT BREAKER MFG.</td>
<td>RATING</td>
</tr>
<tr>
<td>STARTER MFG.</td>
<td>SIZE</td>
</tr>
<tr>
<td>C.T. RATIO</td>
<td>O/L RELAY SETTING</td>
</tr>
<tr>
<td>CONDUCTOR SIZE</td>
<td>POWER</td>
</tr>
</tbody>
</table>

1. Check motor starter for cleanliness.

2. Check nameplate data and tagging of motor starter components for conformance to approved vendor drawings.

3. Check conduits and/or cables for correct tagging.

4. Check equipment and installation for conformance to area classification.

5. Check main and auxiliary contacts of breaker and contactors.

6. Manually check mechanical operation of breaker, contactor, O/L relay, and O/L reset device.

7. Check continuity of power and control cables.

8. Complete functional operation check of the motor control circuit using the contract drawings and approved vendor drawings. Close and open the starter using all control devices.

9. Verify proper operation of motor winding space heater unit.

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ELECTRICAL TESTS  
PAGE 260126 - 25
# MEDIUM VOLTAGE MOTOR CIRCUIT
## TEST RECORD

<table>
<thead>
<tr>
<th>EQUIPMENT DESIGNATION</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>MOTOR DESCRIPTION</td>
<td></td>
</tr>
<tr>
<td>TAG NO.</td>
<td>_____________________</td>
</tr>
<tr>
<td>MANUFACTURER</td>
<td>_____________________</td>
</tr>
<tr>
<td>KW/HP</td>
<td>_____________________</td>
</tr>
<tr>
<td>FLA</td>
<td>_____________________</td>
</tr>
<tr>
<td>SERIAL NUMBER.</td>
<td>_____________________</td>
</tr>
<tr>
<td>SERVICE FACTOR.</td>
<td>_____________________</td>
</tr>
<tr>
<td>RATED VOLTAGE.</td>
<td>_____________________</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>STARTER DESCRIPTION</td>
<td></td>
</tr>
<tr>
<td>MANUFACTURER</td>
<td>_____________________</td>
</tr>
<tr>
<td>CONTACTOR RATING</td>
<td>_____________________</td>
</tr>
<tr>
<td>RATED CURRENT</td>
<td>_____________________</td>
</tr>
<tr>
<td>C.T. RATIO</td>
<td>_____________________</td>
</tr>
<tr>
<td>TYPE</td>
<td>_____________________</td>
</tr>
<tr>
<td>RATED VOLTAGE</td>
<td>_____________________</td>
</tr>
<tr>
<td>O/L RELAY SETTING</td>
<td>_____________________</td>
</tr>
<tr>
<td>FUSE SIZE.</td>
<td>_____________________</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>CONDUCTOR SIZE</td>
<td>POWER</td>
</tr>
<tr>
<td>1. Check motor starter for cleanliness.</td>
<td></td>
</tr>
<tr>
<td>2. Check nameplate data and tagging of motor starter components for conformance to approved vendor drawings.</td>
<td></td>
</tr>
<tr>
<td>3. Check conduits and/or cables for correct tagging.</td>
<td></td>
</tr>
<tr>
<td>4. Check equipment and installation for conformance to area classification.</td>
<td></td>
</tr>
<tr>
<td>5. Check installation for seals, breathers, and drains.</td>
<td></td>
</tr>
<tr>
<td>6. Check main and auxiliary contacts of breaker and contactors.</td>
<td></td>
</tr>
<tr>
<td>7. Check mechanical operation of breakers, contactors, and relay and O/L reset devices.</td>
<td></td>
</tr>
<tr>
<td>8. Check continuity of power and control cables.</td>
<td></td>
</tr>
<tr>
<td>9. Verify calibration and setting of protective relays.</td>
<td></td>
</tr>
<tr>
<td>10. Check wiring to surge arrestors, capacitors, stator RTDs and current transformers.</td>
<td></td>
</tr>
<tr>
<td>11. Complete functional operation check of the motor control circuit using the contract drawings and approved vendor drawings. Close and open the starter using all control devices.</td>
<td></td>
</tr>
</tbody>
</table>

## GENERAL COMMENTS

---

CONTRACTOR/Date _____________
# ELECTRIC MOTOR RUN-IN
## TEST RECORD

**TEST EQUIPMENT:**

**REFERENCE DRAWING:**

**NOTES:**
1. Duration of tests to comply with specifications.

<table>
<thead>
<tr>
<th>TEST</th>
<th>REMARKS</th>
<th>INITIALS/DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RESISTANCE:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bonding resistance measured from motor frame to main ground/earth system tap.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>______________ ohms</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>VOLTAGE:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual voltage measured at Motor Control Center.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>______________ volts</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ROTATION CHECK:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bump motor to verify rotation. Motor to be uncoupled.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>NO LOAD CURRENT:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At beginning of test __________ amps</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At end of test __________ amps</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TEMPERATURE OF BEARING:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check bearing for high temperature:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before start:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 minutes after start</td>
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<td>30 minutes after start</td>
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<tr>
<td>1 hour after start</td>
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</tr>
<tr>
<td>2 hours after start</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 hours after start</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>VIBRATION:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Make visual inspection during run-test. Record any unusual vibration in remarks column.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>NOISE:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Record any unusual noise in remarks column.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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**ELECTRICAL TESTS**

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# THERMOGRAPHIC INSPECTION TEST RECORD

**THERMAL AND ELECTRICAL INFORMATION**

<table>
<thead>
<tr>
<th>THERMAL DATA (°F/°C) AND RISE</th>
<th>MANUAL READINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Phase <strong>/</strong> Reference __°F</td>
<td>A Phase A A/ B Volts __V</td>
</tr>
<tr>
<td>B Phase <strong>/</strong> Temperature C</td>
<td>B Phase A B/C Volts __V</td>
</tr>
<tr>
<td>C Phase <strong>/</strong> ΔT __°F</td>
<td>C Phase A A/C Volts __V</td>
</tr>
<tr>
<td>Neutral <strong>/</strong> or Rise C</td>
<td>Neutral A A/N Volts __V</td>
</tr>
</tbody>
</table>

**PROBLEM DESCRIPTION:**

**RECOMMENDATION:**

**ANOMALY PRIORITY**

- **CRITICAL** - IMMEDIATE ATTENTION SUGGESTED
- **SEVERE** - PROBABLE FAILURE, PROMPT ACTION RECOMMENDED
- **INTERMEDIATE** - MONITOR PROBLEM, SCHEDULE MAINTENANCE
- **MINOR** - SCHEDULE ROUTINE MAINTENANCE AT NEXT OPPORTUNITY

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- END OF SECTION -
PART 1 – GENERAL

1.1 THE REQUIREMENT

A. **General:** The CONTRACTOR shall provide electric motors, accessories, and appurtenances complete and operable, in conformance to the Contract Documents.

B. The provisions of this Section apply to low voltage 3 phase, AC squirrel cage induction motors throughout the Contract Documents, except as indicated otherwise.

C. The CONTRACTOR shall assign to the equipment supplier the responsibility to select suitable electric motors for the equipment. The choice of motor manufacturer shall be subject to review by the ENGINEER. Such review will consider future availability of replacement parts and compatibility with driven equipment.

D. The manufacturer shall have a minimum of 10 years manufacturing experience of manufacturing electrical induction motors. Proof of the manufacturer’s experience shall be included with the submittals.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 013300 - Contractor Submittals.

B. Complete motor data shall be submitted with the driven machinery Shop Drawings. Motor data shall include:

1. Machine name and specification number of driven machine.
2. Motor manufacturer and proof of manufacturing motors for at least 10 years.
3. Motor type or model and dimension drawing. Include motor weight.
4. Nominal horsepower.
5. NEMA design.
7. Frame size.
8. Winding insulation class and temperature rise class.
9. Voltage, phase, and frequency ratings.
10. Service factor.
11. Full load current at rated horsepower for application voltage.
12. Full load speed.
13. Guaranteed minimum full load efficiency. Also nominal efficiencies at 1/2 and 3/4 load.
14. Type of thermal protection or overtemperature protection, if included.

15. Wiring diagram for devices such as motor leak detection, temperature, or zero speed switches, as applicable.

16. Bearing data. Include recommendation for lubricants of relubricatable type bearings.

17. 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.

18. Power factor at 1/2, 3/4 and full load.

19. Recommended size for power factor correction capacitors to improve power factor to 0.95 percent lagging when operated at full load.

C. If water cooling is required for motor thrust bearings, the Shop Drawing submittals shall indicate this requirement.

PART 2 – PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Electric motors driving identical machines shall be identical.

B. Maximum motor loading shall be equal to nameplate horsepower rating or less, exclusive of service factor and be verifiable from the submittal data of the driven machinery.

C. Motor Capacity

1. The CONTRACTOR shall size motors for the larger of the following criteria:

   a. Size motors to continuously carry the maximum load that develops across the full range of driven equipment operation.

   b. Size motors for minimum size indicated.

2. In every case, motor size shall be derated from nameplate values as follows:

   a. Ambient Temperature

      1) For ambient temperatures up to but not exceeding 40 degrees C, no derating is required.

      2) For ambient temperatures exceeding 40 degrees but less than 50 degrees C, derate nameplate HP ratings to 85 percent.

   b. Site Altitude: No derating is required for altitudes less than 3300 feet (1000 meters). Higher altitudes require the following derating factors:
### Altitude Service Factor

<table>
<thead>
<tr>
<th>Altitude</th>
<th>1.0 Service Factor</th>
<th>1.15 Service Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>3300 to 9000 ft</td>
<td>93 percent</td>
<td>100 percent</td>
</tr>
<tr>
<td>9000 to 13,200 ft</td>
<td>91 percent</td>
<td>98 percent</td>
</tr>
</tbody>
</table>

3. 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 WORK.

D. **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.

### 2.2 DESIGN REQUIREMENTS

A. **General:** Electric motors shall comply with NEMA MG-1 - Motor and Generator. Motors used with adjustable frequency drives shall comply with NEMA MG-1, Part 31.

B. **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.

C. **Motor Voltage Ratings:** Low voltage motors shall have voltage ratings in accordance with the following, unless otherwise indicated:

1. Motors below 1/2 HP shall be rated 115 volts, single phase, 60 Hz. Dual voltage motors rated 115/208 volts, 115/230 volts are acceptable, provided leads are brought out to the conduit box.

2. Motors 1/2 HP and larger shall be rated 460 volts, 3 phase, 60 Hz. Dual voltage motors rated 230/460 volts or 208/230/460 volts are acceptable, provided every lead is brought out to the conduit box.

D. **Insulation:** 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 1600 volt spikes, with dV/dt as defined in NEMA MG 1-31.

E. Motors 50 HP or smaller located in non-hazardous areas shall be totally enclosed, fan cooled (TEFC) with a Service Factor of 1.15 unless otherwise indicated.

F. Motors 50 HP and greater located in non-hazardous areas shall be Weather-Protected Type I, with a service factor of 1.15.

G. 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.
H. Motors larger than 50 HP installed outdoors or in unheated areas shall be provided with 120 volt AC space heaters, wired to a terminal strip in a low voltage motor junction box.

I. 400 HP and larger motors be open drip-proof type. The motor shall be air-cooled self-ventilated; any special ventilation modifications shall be included in the bid.

J. The motor shall be capable of starting and operating with the specified solid state reduced voltage starters.

K. The motor shaft drive end shall be coordinated with the driven equipment manufacturer so that the motor and driven equipment align properly.

L. 400 HP motor leads shall be NEMA 2-hole, compression type, and configured for the machine voltage.

M. The motor terminal box shall be oversized to properly accommodate field cables with NEMA 2-hole lugs, termination support, accessories and compliance with NEC installation requirements.

N. Spaces, dimensions, arrangement of motor-driven equipment shall be checked to ensure the heat exhaust of one motor is not feed to the air intake of adjacent motors.

O. Premium Efficiency Motors

1. Motors with a nameplate rating of 1 HP and larger shall be premium efficient units. Motors shall be stamped with the efficiency on the nameplate with the caption "NEMA Nominal Efficiency" or "NEMA Nom. Eff." Such motors shall have efficiencies determined by the test as set forth in ANSI/IEEE 112 - Standard Test Procedure for Polyphase Induction Motors and Generators, Method B.

2. Efficiency: Nominal efficiency and minimum efficiency shall be defined in accordance with the following tables. Both efficiencies shall be included in the Shop Drawing submittal.
## OPEN DRIP-PROOF (ODP)

### FULL-LOAD EFFICIENCIES OF NEMA PREMIUM EFFICIENCY MOTORS

*Rated 600 Volts or Less*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>77.0</td>
<td>74.0</td>
<td>85.5</td>
<td>82.5</td>
<td>82.5</td>
<td>80.0</td>
</tr>
<tr>
<td>1.5</td>
<td>84.0</td>
<td>81.5</td>
<td>86.5</td>
<td>84.0</td>
<td>86.5</td>
<td>81.5</td>
</tr>
<tr>
<td>2</td>
<td>85.5</td>
<td>82.5</td>
<td>86.5</td>
<td>84.0</td>
<td>87.5</td>
<td>81.5</td>
</tr>
<tr>
<td>3</td>
<td>85.5</td>
<td>82.5</td>
<td>89.5</td>
<td>84.0</td>
<td>88.5</td>
<td>86.5</td>
</tr>
<tr>
<td>5</td>
<td>86.5</td>
<td>84.0</td>
<td>89.5</td>
<td>84.0</td>
<td>89.5</td>
<td>87.5</td>
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<tr>
<td>7.5</td>
<td>88.5</td>
<td>86.5</td>
<td>91.0</td>
<td>89.5</td>
<td>90.2</td>
<td>88.5</td>
</tr>
<tr>
<td>10</td>
<td>89.5</td>
<td>87.5</td>
<td>91.7</td>
<td>90.2</td>
<td>91.7</td>
<td>90.2</td>
</tr>
<tr>
<td>15</td>
<td>90.2</td>
<td>88.5</td>
<td>93.0</td>
<td>91.7</td>
<td>91.7</td>
<td>90.2</td>
</tr>
<tr>
<td>20</td>
<td>91.0</td>
<td>89.5</td>
<td>93.0</td>
<td>91.7</td>
<td>92.4</td>
<td>91.0</td>
</tr>
<tr>
<td>25</td>
<td>91.7</td>
<td>90.2</td>
<td>93.6</td>
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*Source: NEMA MG1 - 2003, Table 12-12*
## FULL-LOAD EFFICIENCIES OF NEMA PREMIUM EFFICIENCY MOTORS
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</table>

Source: NEMA MG1 - 2003, Table 12-12
P. Two speed motors shall be of the 2 winding type.

2.3 ACCESSORY REQUIREMENTS

A. General: Horizontal motors 3 HP and larger and every vertical motor shall have split-type cast metal conduit boxes. Motors smaller than 3 HP shall have the manufacturer's standard conduit boxes. Motors other than open drip-proof shall be gasketed.

B. Lifting Devices: Motors weighing 265 lb (120 Kg) or more shall have suitable lifting eyes for installation and removal.

C. Special Requirements: The CONTRACTOR shall refer to individual equipment specifications for special requirements such as motor winding thermal protection or multi-speed windings.

D. Grounding Lugs: Provide motor grounding lug suitable to terminate ground wire, sized as indicated.

E. Nameplate: Motors shall be fitted with permanent stainless steel nameplates indelibly stamped or engraved with NEMA Standard motor data, in conformance with NEMA MG-1-10.40.

F. Where motors are indicated by elementary schematics or specifications to have zero speed switches, the switches shall be factory mounted integral to the motors. Switches shall close contact when the motor is at zero speed.

G. Vertical pump motors shall be equipped with a vibration switch. The vibration switch shall be the type that incorporates a time delay when the system starts and continues to monitor to minimize nuisance shutdown due to short term transient vibration conditions. The vibration switch shall shut down the machine if the time delay elapses and vibration conditions continue. A reset shall be provided to re-enable the unit after a trip event. The vibration switch shall be as manufactured by Robertshaw, part number 576A-A3-C4, or equal. The Contractor shall coordinate with the pump manufacturer the quantity of devices needed and the axis these should be mounted on.

2.4 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. Thermostats: Winding thermostats shall be snap action, bi-metallic, temperature-actuated switch. Thermostats shall be provided with one normally closed contact. The thermostat switch point shall be precalibrated by the manufacturer.

C. RTDs: Bearing RTDs and/or winding RTDs (2 per phase) shall be provided for the project 400HP motors. RTDs shall be 100 ohm platinum, dial element design.

2.5 MOTOR BEARINGS

A. General: Bearings shall conform to Section 410000 - Equipment General Provisions, 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.

2.6 MANUFACTURERS, OR EQUAL

A. U.S. Motors

B. General Electric

C. WEG

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Motor installation shall be performed in accordance with the motor manufacturer's written recommendations and the written requirements of the manufacturer of the driven equipment.

B. Related electrical WORK involving connections, controls, switches, and disconnects shall be performed in accordance with the applicable sections of Division 26.

3.2 FACTORY TESTING

A. Motors rated 100 HP and larger 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.

3.3 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.
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-
PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide induction motors, accessories, and appurtenances, complete and operable, in accordance with the requirements of the Contract Documents.

B. The provisions of this Section apply to medium voltage electric motors 400 HP and larger.

C. Manufacturer

1. The large induction motors shall be produced at a facility owned and operated by the manufacturer.

2. The manufacturer shall be experienced in the manufacturer of large induction motors for at least 10 years.

3. At least 10 of the manufacturer’s large induction motors of comparable capacity and complexity shall have been successfully operating in similar condition as the indicated units, for at least 5 years in the United States.

4. Furnish proof of the manufacturer’s experience within 30 days of the Notice to Proceed.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

ANSI/NEMA MG 1 Motor and Generator

IEEE 112 Standard Test Procedure for Polyphase Induction Motors and Generators

API 670, 4th Edition Machinery Protection Systems

IEEE 43 Recommended Practice for Testing Resistance of Rotating Machinery

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Contractor Submittals.

B. Submit complete, dimensioned Shop Drawings.

C. Submit complete motor data with the driven machinery Shop Drawings, including:

1. machine name and specification number of driven machine

2. motor manufacturer

3. motor type or model, dimension drawing, and motor weight
4. nominal horsepower
5. NEMA design
6. enclosure, including rodent screens and filters
7. frame size
8. winding insulation class and temperature rise class
9. voltage, phase and frequency ratings
10. service factor
11. full-load current at rated horsepower for application voltage
12. full-load speed
13. Efficiencies
   a. guaranteed minimum full-load efficiency
   b. nominal efficiencies at 1/2- and 3/4-load
14. type of thermal protection or overtemperature protection for both stator and rotor
15. type of motor vibration sensors and transducers
16. wiring diagrams for applicable devices such as motor winding, temperature detection, zero speed switches, space heaters, and vibration sensors
17. Bearings
   a. The motor manufacturer shall identify the type of anti-friction bearing to be installed.
   b. Indicate the recommended lubricants for lubricated bearings.
   c. Provide bearing protection with vibration probes and temperature sensors.
18. Certify that the motor is of an inverter duty type.
19. minimum speed at which the motor may be operated for the driven machinery
20. power factor at 1/2-, 3/4-, and full-load
21. torque
22. load $W_k^2$
23. allowable number of starts per hour using a variable frequency drive
24. locked rotor code letter
25. Submit the anticipated maximum maintenance weights for rotors, couplings, and removable casing or housings elements.

26. Assembly Clearances
   a. Submit assembly clearances and tolerances.
   b. Furnish, as a minimum, the diametrical bearing clearances, air gap, and coupling interference fit to shaft.

27. Runout Tolerances
   a. Submit assembly radial and axial runout tolerances.
   b. Furnish the shaft runout at various lateral locations, plus rotor face runout if applicable.

28. If water or oil cooling is required for motor thrust bearings, the Shop Drawing submittals shall indicate this requirement.

1.4 WARRANTY
   A. The CONTRACTOR shall obtain and furnish a manufacturer’s warranty that extends not less than 5 years after the Date of Substantial Completion.
   B. The warranty shall include repair or replacement, at the manufacturer’s option.

PART 2 -- PRODUCTS

2.1 GENERAL REQUIREMENTS

   A. Identification

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<tr>
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<tr>
<td>Pump Elevation, ft (MSL)</td>
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<tr>
<td>Nominal Motor Speed, rpm</td>
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   B. Electric motors that are driving identical machines shall be identical.
   C. The maximum motor loading shall in every case be equal to the nameplate horsepower rating or less, exclusive of service factor and as verified with the approved submittal data of the driven machinery.
D. Motor HP

1. Motors shall be sized to carry continuous loads for the vertical pump in SS432115.
2. The loads may be imposed through their full range of operation.
3. The motor horsepower shall be not less than the estimated value as indicated for each driven machine.
4. If the estimated horsepower as indicated is not adequate to satisfy the foregoing restrictions or any other indicated requirement, the motor with the required horsepower shall be provided at no additional cost to the OWNER.
5. Changes caused by the increase in motor horsepower shall be made by the CONTRACTOR at no additional cost to the OWNER, including such changes as the variable speed drives, circuit breakers, magnetic starters, motor feeder conductors, conduit sizes, and the like.

E. Lateral and Torsional Analysis

1. The Contractor shall arrange for torsional and vibration analyses as required on specification section 410000.

2.2 DESIGN REQUIREMENTS

A. General

1. Electric motors shall comply with the requirements of ANSI/NEMA MG 1 - Motor and Generator.
2. Motors located in non-hazardous areas 400 hp and larger shall be open drip-proof, guarded (ODPG).
3. The motor manufacturer shall examine pump station layout before fabrication of motor enclosures.
4. Spaces, dimensions and arrangement of motor-pump shall be checked to ensure that heat exhaust of one motor is not fed as air intake to the adjacent motor.
5. Any special design of motor enclosures for proper air intake and venting that may be required shall be included in the Bid.
6. The motor shall be air-cooled, self-ventilated with plenums located as indicated.

B. NEMA Design

1. Electric motors shall be constant-speed squirrel-cage induction motors having normal starting torque with low starting current.
2. In no case shall starting torque or breakdown torque be less than the value indicated in ANSI/NEMA MG 1.
3. Motors shall be suitable for the indicated starting method.
C. Voltage Ratings

1. Motors 400-hp and larger shall be rated 4,000 volts, 3 phase, 60 Hz, for use on 4160 V/3 phase/60 Hz system as indicated.

2. Motors less than 400-hp shall be per specification 260510.

D. Insulation

1. As a minimum, motors shall have a service factor of 1.15 and shall be furnished 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 ANSI/NEMA MG 1-12.42 at rated full-load.

2. It shall be the responsibility of the CONTRACTOR to upgrade this insulation to avoid overheating due to inverter drive.

3. Provide slot liners as a part of the winding insulation system.

E. Leads

1. Leads shall be brought out for single- or multi-winding motors.

2. Bring out 6 leads for differential protection where indicated.

F. Terminations

1. Motor leads shall be NEMA 2 hole, compression type, and configured for the machine voltage.

2. Provide 2 stainless steel grounding pads, and locate on each side of the motor frame and diagonally apart.

3. Terminators shall be provided.

4. The terminal box shall be oversized in order to accommodate cables, field cables with NEMA 2 hole lugs, terminations, accessories, and in compliance with NEC requirements.

G. Rotor

1. The rotor shall be balanced and coated per manufacturer standard and comply with ANSI/NEMA MG-1 requirements.

2. Rotor bars and slots shall be sized to assure tight bar construction in order to eliminate motor vibration.

H. Stator

1. The stator iron laminations shall be coated with a high grade silicon material capable of withstanding 1,200 degrees F without deterioration.

2. The stator shall be braced and supported in order to eliminate any detrimental winding movement.
I. Shafts
   1. Shaft dimensions shall be the manufacturer’s standard.
   2. Extended shafts, tapered shafts, double shafts or short shafts shall be provided as required for the driven equipment in specification section 432115.

J. Radial Shaft Vibration Transducers
   1. For motors 400 HP but less than 1000 HP with sleeve bearings, provide vibration switches such as **PMC/BETA Model 440 D-R**, with one limit for alarm, one limit for shutdown and a 4-20ma output for remote readout.
   2. The switches shall be provided and installed by the motor manufacturer.
   3. The vibration switch wiring shall be terminated at a separate terminal box to interface with the field wiring. The motor Manufacturer shall install and wire the vibration switch(es) and the terminal box for this accessory on the motor.

K. Vibration transducers and timing transducer shall be prewired to a terminal junction box mounted on the motor base. These devices shall be provided for motors 1000 HP and larger.

L. Space Heaters
   1. Space heaters shall be provided as required to keep the motor windings 5 to 10 degrees C above the dew point during de-energized conditions.
   2. The space heaters shall be 240 V devices, and shall be operated at 120 VAC.

M. Torque
   1. The manufacturer shall review the pump startup load curve to determine the torques needed for locked-rotor, pullup, and breakdown.
   2. The motor speed torque curve must exceed the pump speed torque by a minimum margin of 10 percent at any point from zero speed to pullup speed.

N. Motors shall be capable of accelerating driven equipment with load $W_k^2$ without excessive temperature rises.

O. Number of Starts
   1. Each motor shall be capable of 3 successive cold starts or 2 successive hot starts in a one-hour period.
   2. The maximum number of starts per day shall not exceed 8.

P. The power factor shall be not less than 0.90 lagging at full-load operating condition.

Q. Adjustable Frequency Drive Application
   1. The motor shall be designed and certified for operation with an adjustable frequency drive.
2. The range of operating speeds shall be as indicated in specification section 432115.

3. The motor shall be designed to operate at a maximum speed of 1,200 rpm without mechanical breakdown or overheating.

R. Premium High Efficiency Motors

1. Motors shall be "premium high efficiency" units, and shall be stamped with the efficiency on the nameplate.

2. Motors shall have efficiencies determined by the test as set forth in ANSI/IEEE 112 - Standard Test Procedures for Polyphase Induction Motors and Generators, Method B.

3. Efficiency index, nominal efficiency, and minimum efficiency shall be defined in accordance with ANSI/NEMA MG 1, and these values shall be stated in the Shop Drawing submittal.

4. Premium high-efficiency motors shall conform to the following nominal minimum efficiency requirements which are full-load values:

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<th>HP</th>
<th>Minimum Efficiency (percent)</th>
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<tr>
<td>1,500</td>
<td>95.0</td>
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</table>

2.3 ACCESSORY REQUIREMENTS

A. General

1. Horizontal motors 250-hp and larger shall have cast boxes or fabricated or pressed steel boxes.

2. Motors other than of the open drip-proof design shall be gasketed.

B. Motors weighing 265 pounds or greater shall have suitable lifting eyes for installation and removal.
C. Provide a motor grounding lug suitable to terminate the ground wire of the indicated size.

D. Motors shall be fitted with a permanent, stainless steel nameplate indelibly stamped or engraved with NEMA Standard motor data, in conformance with NEMA MG 1 10.40.

E. Radial and Axial Vibration Accelerometers
   1. Where indicated, the pump manufacturer shall provide integrated vibration transmitters on the pump bearings and associated motor bearings.
   2. The vibration transmitters for both the pump and motor shall be provided as part of the pump manufacturer’s equipment.
   3. The pump manufacturer shall coordinate with the motor manufacture to ensure that proper provisions are made on the motor bearings for the accelerometers.
   4. Orthogonal X-Y accelerometers shall be installed at each radial bearing housing, and shall be Bentley Nevada Corporation, Metrix Technologies, or equal.
   5. Mounting
      a. Accelerometers on the outboard bearing shall be mounted in the horizontal X-plane, and those on the inboard bearing shall be mounted in the vertical Y-plane.
      b. Accelerometer orientation requirements shall be as indicated.
   6. Accelerometers shall be fully protected in a sealed weatherproof NEMA 4X stainless steel enclosure, and shall have a hazardous area rating suitable for the pump and motor environment.

2.4 MOTOR THERMAL PROTECTION
A. RTDs
   1. Bearing RTDs and winding RTDs shall be provided on motors greater than 100-HP.
   2. Bearing RTDs shall be of the dual-element design.
   3. Provide 2 sets of RTDs per phase, for a total of 6 RTDs per motor.
   4. RTDs shall be 100-ohm and constructed of platinum.

2.5 MOTOR BEARINGS
A. Bearings shall conform to the provisions of Section 41 00 00 – Equipment General Provisions, except as otherwise indicated
B. Motors greater than 100 Hp shall have anti-friction bearings designed for a minimum of 10 years or 40,000 hours, whichever comes first.
C. Vibration Sensors
   1. Vibration sensors shall be provided as indicated.
2. The CONTRACTOR shall coordinate with the sensor supplier to ensure that provisions are made for mounting the sensor devices.

2.6 MOTOR MANUFACTURERS

A. Selection

1. The equipment supplier shall be responsible for the selection and supply of electric motors suitable for the equipment.

2. The equipment supplier’s choice of motor manufacturer shall be subject to acceptance by the ENGINEER, who will consider future availability of replacement parts and compatibility with the driven equipment.

B. The motor manufacturer shall be:

1. TECO Westinghouse Motor Company;

2. Ideal Electric Company;

3. Reliance Electric;

4. General Electric;

5. US Motors; or

6. equal

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Motor installation shall be performed in accordance with the motor manufacturer’s written recommendations and the written requirements of the manufacturer of the driven equipment.

B. Electrical WORK involving connections, controls, switches, disconnects, and the like, shall be in accordance with the indicated requirements.

3.2 FACTORY TESTING

A. Motors rated 100 HP and larger 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.

B. Acceptance

1. In the event that a motor fails to meet any of the indicated requirements or efficiencies, the CONTRACTOR shall make necessary modifications, repairs, or replacements in order to conform to the indicated requirements.
2. The defective motor shall be re-tested at no additional cost to OWNER, and such re-testing shall continue until the motor performs satisfactorily.

C. Perform the following routine tests in accordance with the requirements of NEMA MG-1:

1. resistance of the induction machine windings (IEEE STD 112)

2. High-Potential
   a. A high-potential test shall be taken after other tests have been completed in order to assure that no damage occurred to the insulation during setup and testing.
   b. Apply 1,000 volts plus twice the rated machine voltage across the stator insulation, and 2,500 volts across the rotor insulation for one minute.

3. The air gap shall be measured during assembly.

4. Check the no-load field current at normal voltage and frequency, if the motor is supplied with dual bearings and is factory-assembled.

5. Surge test the stator coils individually, before and after insertion into the stator core, to ensure that there are no turn-to-turn shorts.

6. After the high potential test has been completed, take an insulation resistance reading of the armature insulation with a Megger for one minute.

7. Check the bearing and bearing insulation.

D. Perform efficiency and loss testing in accordance with the requirements of IEEE 112 - Method B -, including the following losses when determining the efficiency:

1. stator $I^2R$
2. rotor $I^2R$
3. core loss
4. stray load loss
5. friction and windage loss
6. power required for auxiliary items

E. Perform starting characteristics testing in accordance with the requirements of IEEE 112, and the following:

1. The motor shall be started on reduced voltage, with data being recorded on an oscillograph.
2. If an oscillograph is not available, time shall be allowed to read the meters at several points during the start.
3. During the start, readings shall include voltage, current, kilowatts, and speed.
4. Subtract the losses determined from voltage and current readings from the kilowatt input.

5. Convert the remaining kilowatts to torque and adjust to rated voltage.

6. Adjust the current reading to rated voltage in order to give starting current value.

F. Perform noise testing in accordance with the requirements of NEMA MG-1, Part 9, and the following.

1. The motor shall be operating at no-load with the rated frequency and voltage applied.

2. Octave band sound pressure levels shall be measured one meter from major machine surfaces, and then the mean sound pressure level of 20 microPascals shall be calculated.

3. The mean weighted sound pressure level measured at one meter from the major machine surfaces shall not exceed 85 dB(A).

G. Perform dynamic balance testing in accordance with the requirements of NEMA MG-1.

H. Perform mechanical balance testing in accordance with the requirements of NEMA MG-1.

I. Frequency Components

1. The machinery shall not exhibit unusual or abnormal frequency components on either the shaft or the casing vibration measurements.

2. Normal frequency components are defined as excitations such as rotational speed or blade passing frequency that are inherent with the mechanical construction of the machinery.

3. Unusual or abnormal frequency components are excitations that are non-synchronous or not related to the known geometry of the machinery.

3.3 FIELD TESTING

A. The CONTRACTOR shall perform the following field tests in accordance with the indicated procedures:

1. Inspect each motor installation for any deviation from rated voltage, phase, or frequency, or improper installation.

2. Visually check for proper phase and ground connections.

3. Verify that multi-voltage motors are connected for proper voltage.

4. Check winding and bearing temperature detectors and space heaters for functional operation.

5. Test for proper rotation prior to connecting to the driven equipment.
6. Insulation
   a. Test the insulation (Megger-test) of new as well as re-used motors in accordance with NEMA MG-1.
   b. Test voltage shall be 1,000 VAC plus twice the rated voltage of the motor.

7. Check the motor for proper temperatures and vibratory behavior, for no less than 4 hours at full operating load and speed.

8. Noise, Vibration, and Overheating
   a. The motor shall be field-tested to demonstrate satisfactory operation without excessive noise, vibration, or overheating of bearings.
   b. The vibration limits used for shop testing with a temporary machinery support shall also be applicable to the field testing condition with a proper rigid support structure below the machinery.

- END OF SECTION -
PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide complete local control stations as indicated herein or in other Sections of the Specifications. The stations shall be designed to provide the sequence of operation in Section 409100 – Process Control and Instrumentation Systems and the P&ID Drawings.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Local control panels shall comply with the requirements of NEC (including Article 409), NEMA, and UL.

1.3 CONTRACTOR SUBMITTALS

A. Furnish Shop Drawings in accordance with Sections 013300 – Contractor Submittals and 260000 – Electrical Work, General.

1. Ladder diagrams and written descriptions explaining ladder diagram operation and system operation.

2. Include catalog cuts of control equipment including enclosures, overcurrent devices, relays, pilot devices, terminations, and wire troughs.

PART 2 – PRODUCTS

2.1 GENERAL

A. The CONTRACTOR shall provide the stations to satisfy the functional requirements in the relevant mechanical equipment and Instrumentation & Control specifications and the Electrical Elementary Schematics. Each station shall be fabricated with UL labeled components. Stations not specifically indicated as being WORK of other Sections shall be provided under this Section. All stations shall be wired under this Section.

B. The controls shall be 120 V maximum. Where the electrical power supply is 240 V, single phase or 480 V, 3 phase, the station shall be provided with a fused control power transformer. Control conductors shall be provided in accordance with Section 260000 – Electrical Work, General.

C. Each station shall be provided with identified terminal strips for the connection of external conductors. The CONTRACTOR shall provide sufficient terminal blocks to connect 25 percent additional conductors for future use. Termination points shall be identified in accordance with Shop Drawings. The stations shall be the source of power for all 120 VAC solenoid valves interconnected with the stations. Equipment associated with the stations shall be ready for service after connection of conductors to equipment, controls, and stations.

D. Wiring to door-mounted devices shall be extra flexible and anchored to doors using wire anchors cemented in place. Exposed terminals of door-mounted devices shall be guarded to prevent accidental personnel contact with energized terminals.
E. Enclosures

1. In finished rooms, enclosures shall be NEMA 12 steel enclosures painted with ANSI 61 exterior and white interior.

2. In all other non-hazardous areas, enclosures shall be NEMA 4X stainless steel (prior to modifications) with brushed finish. Where possible, penetrations shall be made in such a manner to maintain the NEMA 4X rating. If this is not possible, the penetrations shall be made in such a manner to minimize entry of foreign materials into the enclosure.

3. In hazardous areas, enclosures shall be cast aluminum NEMA 7 and shall be UL listed for use in hazardous or classified locations.

4. In chemical areas for alum, sodium hypochlorite, etc, NEMA 4X fiberglass enclosures shall be used.

5. Enclosures shall be freestanding, pedestal-mounted, or equipment skid-mounted, as indicated. Internal control components shall be mounted on a removable mounting pan. Mounting pan shall be finished white.

6. Outdoor mounted enclosures shall be provided with thermostatically-controlled heaters.

7. Provide screened weep holes for draining condensation.

8. Exposed enclosures shall be equipped with sun shields. The front of the enclosure shall face north.

9. As manufactured by Hoffman, or equal.

F. Disconnect Switches

1. Heavy duty, non-fusible, single throw.

2. Horsepower rated.

3. UL listed.

4. Padlockable in "Off" position and door interlock.

5. Enclosure per area classification in Section 260000 – Electrical Work, General.

6. 480 V, 3-phase, 3-pole (6-pole when used with 2-speed motor).

7. Auxiliary control contact as applicable and as indicated.

8. As manufactured by Eaton Electrical, Square D or G.E.

G. Identification of panel-mounted devices, conductors, and electrical components shall be in accordance with Section 260000 – Electrical Work, General.

H. Panel-mounted devices shall be mounted a minimum of 3-feet above finished floor elevation. For enclosures that mount on a separate support, the top of the enclosure shall be six feet above grade maximum.
2.2 STATION COMPONENTS

A. Pushbuttons, selector switches, and pilot lights shall be the heavy-duty, oil-tight type, sized to 30-mm. Miniature style devices are not acceptable. Devices shall be as manufactured by Eaton Electrical, Allen Bradley, Square D, or equal.

1. Lens colors shall be red for "run," "open," or "on"; green for "stopped," "closed," or "off"; and amber for alarm.

2. Pilot lights shall be full voltage LED cluster type.

3. Provide hazardous location type pilot devices in classified locations.

B. Relays shall be 3 PDT with 10 amp contacts, plug-in type with indicating light, rectangular blades and provided with sockets for screw-type termination and hold-down clips. Relays shall be as manufactured by IDEC series, Square D, Potter Brumfield, Eaton Electrical, AB, ABB, or equal.

C. 24 VDC Power Supplies: 24VDC power supplies shall be capable of redundant operation. The power supplies shall be equipped with short circuit protection protective devices on both the input and its output. Power supplies shall be as manufactured by Sola, Phoenix Contact, IDEC or equal.

D. Elapsed time meters shall be non-resettable type, read to a maximum of 99999.9 hours and shall be as manufactured by Yokogawa Switchboard style, Eaton Electrical, or equal.

E. Magnetic starters shall be:

1. NEMA rated. IEC or dual NEMA/IEC rated type are not acceptable.

2. FVNR type unless indicated otherwise.

3. Combination starters with magnetic only instantaneous trip circuit breakers such as Eaton Electrical MCP, General Electric Mag-Break, or equal.

4. Control transformers shall be provided with primary and secondary fuses, 120 V maximum control voltage. VA rating of transformer shall be based on devices on the control schematic.

F. Din rail terminal blocks shall be provided for every panel and shall be the compression type without deformation of the conductor. The terminal block shall accommodate control wiring range from No 16 to No. 12 AWG stranded wire. Terminal blocks shall be equipped to accept jumpers or test probes without encumbering the conductor port. Terminal blocks shall have sufficient surface space to mount block numbering. Multilevel terminal blocks are not acceptable. Provide 25 percent spare terminals in each panel terminal strip. Terminal blocks shall be as manufactured by Weidmüller, Phoenix Contact, AB, ABB, or equal.

G. Grounding Din rail terminal blocks shall be provided for every panel and shall be the compression type without deformation of the conductor. The color shall be green/yellow. Terminal blocks shall be as manufactured by Weidmüller, Phoenix Contact, AB, ABB, or equal.
H. Distribution blocks shall be utilized for larger conductors. The distribution blocks shall include removable clear guards.

I. Time delay relays shall be combination on delay and off delay (selectable) with adjustable timing ranges. Provide socket with screw terminal connections and retaining strap. Time delay relays shall be Square D JCK70 or similar by ATC.

J. Miniature circuit breakers and supplemental circuit breakers shall be din rail mounted, thermal magnetic, snap action mechanism with one lever mechanism. Breakers shall be as manufactured by Eaton Electric, Weidmüller CB9100 series, or equal.

K. Exposed control panel shall incorporate surge protection devices for their power and control wiring interface. SPD shall be as manufactured by Weidmüller, Phoenix Contact, or equal.

2.3 FACTORY TESTING

A. Each LCS shall be factory assembled and tested for sequence of operation prior to delivery.

2.4 SPARE PARTS

A. Provide a minimum of 10 percent spare lamps (minimum 2) and one spare lens for each color LED pilot lamp in each panel.

B. Provide two complete pushbuttons for each panel of the same type used.

C. Provide two boxes of fuses per type utilized in each panel.

D. Provide two spare breakers in place.

E. Provide two relays per panel of the same type used.

F. Provide one elapsed time meters for panels where these are used.

G. Provide two of each kind SPDs per panel where applicable.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Stations shall be installed in accordance with in Section 260000 – Electrical Work, General and in accordance with the manufacturer's recommendations.

B. Stations shall be protected at the Site from loss, damage, and the effects of weather. Stations shall be stored in an indoor, dry location. Heating shall be provided in areas subject to corrosion and humidity.

C. Station interiors and exteriors shall be cleaned, and coatings shall be touched up to match original finish upon completion of the WORK.

D. Conduit, conductors, and terminations shall be installed in accordance with Section 260000 – Electrical Work, General.
3.2 FIELD TESTING

A. Each station shall be tested again for functional operation in the field after the connection of external conductors and prior to equipment startup.

- END OF SECTION -
PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide wire and cable, complete and operable, in accordance with the Contract Documents.

B. In the event that motors provided are larger horsepower than the motors indicated, raceways, conductors, starters, overload elements, and branch circuit protectors shall be revised as necessary to control and protect the increased motor horsepower in accordance with Section 260510 – Electric Motors. Revisions are part of the WORK of this Section.

1.2 CONTRACTOR SUBMITTALS

A. The CONTRACTOR shall submit Shop Drawings in accordance with Sections 013300 – Contractor Submittals and 260000 – Electrical Work, General.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Conductors, include grounding conductors, shall be copper. Aluminum conductor wire and cable will not be permitted. Insulation shall bear 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.

2.2 LOW VOLTAGE WIRE AND CABLE

A. Power and Lighting Wire

1. Wire rated for 600 volts in duct or conduit for power and lighting circuits shall be Class B Type XHHW cross-linked polyethylene conforming to UL-44 - UL Standard for Thermoset-Insulated Wires and Cables. THHN/THWN wire shall not be permitted to be used for any power or control wiring in this project, except as specifically permitted within control panels per Section 409200 – Control Panels.

2. 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.

3. 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.
4. Wiring for 600 volt class power and lighting shall be as manufactured by Okonite, Southwire, or equal.

B. Control Wire

1. Control wire in duct or conduit shall be the same type as power and lighting wire indicated above.
2. Control wiring shall be No.14 AWG.
3. Control wires at panels and cabinets shall be machine tool grade type MTW, UL approved, rated for 90 degrees C at dry locations, and be as manufactured by American, Carol Cable, or equal.

C. Instrumentation Cable

1. Instrumentation cable shall be rated at 600 volts.
2. Individual conductors shall be No. 16 AWG stranded, tinned copper. Insulation shall be color coded polyethylene: black-red for 2 conductor cable and black-red-white for 3 conductor cable.
3. Instrumentation cables shall be composed of the individual conductors, an aluminum polyester foil shield, a No. 18 AWG stranded tinned copper drain wire, and a PVC outer jacket with a thickness of 0.048-inches.
4. Single pair, No. 16 AWG, twisted, shielded cable shall be Belden Part No. 9342, or equal.
5. Single triad, No. 16 AWG, twisted, shielded cable shall be Belden Part No. 1119A, or equal.

D. Tray Cable

1. Multi-conductor tray cable shall be rated 600 volts, listed by UL as Type TC cable per Article 340 of the NEC. The individual conductors shall be UL listed as Type XHHW, with a sunlight-resistant overall jacket.
2. Conductor sizes shall be the same as for power and lighting wire and control wire above.

2.3 MEDIUM VOLTAGE CABLE

A. General: Individual conductors shall be copper, Class B, stranded.

B. 5 KV Cable

1. Cable used in conduit or duct shall be composed of a single conductor, ethylene-propylene rubber (EPR) insulation rated at 105 degrees C, shield, and black polyvinyl chloride (PVC) jacket. Insulation level shall be 133 percent, 115 mil. Shield shall be copper tape type, or corrugated drain wire type. Cable shall be UL Type MV-105 in accordance with UL 1072 and ICEA-S-93-639/NEMA-WC74 - Medium Voltage Power Cables, as manufactured by Okonite, Southwire, or equal.
2. Tray cable shall be composed of one or 3 conductors, a copper grounding conductor, ethylene-propylene rubber (EPR) insulation rated at 90 degrees C, interlocked aluminum armor, and yellow PVC outer jacket. Insulation level shall be 133 percent, 115 mil. Tray cable shall be UL Type MV-90 in accordance with UL 1072 and ICEA-S-96-639/NEMA-WC74 as manufactured by Okonite, Southwire, or equal.

C. 15 KV Cable: Cable used in conduit or duct shall be composed of a single conductor, ethylene-propylene rubber (EPR) insulation rated at 105 degrees C, shield and black polyvinyl chloride (PVC) outer jacket. Insulation level shall be 133 percent. Shield shall be copper tape type, corrugated drain wire type. Cable shall be UL Type MV-105 in accordance with UL 1072 and ICEA-S-93-639/NEMA-WC74 as manufactured by Okonite, Southwire, or equal.

2.4 CABLE TERMINATIONS

A. Compression connectors shall be Burndy Hi Lug, Thomas & Betts Sta-Kon, or equal. Threaded connectors shall be split bolt type of high strength copper alloy. Pressure type, twist-on connectors will not be acceptable.

B. Pre-insulated fork tongue lugs shall be Thomas & Betts, Burndy, or equal.

C. General purpose insulating tape shall be Scotch No. 33, Plymouth Slip-knot, or equal. High temperature tape shall be polyvinyl as manufactured by Plymouth, 3M, or equal.

D. Labels for coding 600 volt wiring shall be computer printable or pre-printed, self-laminating, self-sticking, as manufactured by W.H. Brady, 3M, or equal.

E. Stress cone material for make-up of medium voltage shielded cable shall be as manufactured by Raychem, 3M, or equal.

PART 3 -- EXECUTION

3.1 GENERAL

A. The CONTRACTOR shall provide and terminate power, control, and instrumentation conductors except where indicated.

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.

3.2 INSTALLATION

A. Conductors shall not be pulled into raceway until raceway has been cleared of moisture and debris.

B. Pulling tensions on raceway cables shall be within the limits recommended by the cable manufacturer. Wire pulling lubricant, where needed, shall be UL approved.

C. Instrumentation wire shall not be run in the same raceway with power and control wiring except where specifically indicated.
D. Wire in panels, cabinets, and wireways shall be neatly grouped using nylon tie straps, and shall be 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.

3.3 SPLICES AND TERMINATIONS

A. General

1. Wire taps and splices shall be properly taped and insulated according to their respective classes.

2. In general, there shall be no cable splices in underground manholes or pullboxes. If splices are necessary, the cables shall be brought aboveground and terminated in a NEMA 4X stainless steel terminal or splice cabinet on a concrete pad. Splices in underground manholes and pullboxes may be made only with the approval of the ENGINEER.

3. Stranded conductors shall be terminated directly on equipment box lugs making sure that conductor strands are confined within lug. Use forked-tongue lugs where equipment box lugs have not been provided.

4. Excess control and instrumentation wires shall be long enough to terminate at any terminal block in the enclosure, be properly taped, be identified with origin, and be neatly coiled.

B. Control Wire and Cable

1. Control conductors shall be spliced or terminated only at the locations indicated and only on terminal strips or terminal lugs of vendor furnished equipment.

2. In junction boxes, motor control centers, and control panels, control wire and spare wire shall be terminated to terminal strips.

3. The CONTRACTOR shall provide as a minimum the number of control wires listed in the conduit schedule or as indicated in the Contract Documents. Excess wires shall be treated as spares.

C. Instrumentation Wire and Cable

1. Shielded instrumentation cables shall be grounded at one end only, preferably the receiving end on a 4 - 20 mA system.

2. Two and 3 conductor shielded cables installed in conduit runs which exceed available standard cable lengths may be spliced in pullboxes. Such cable runs shall have only one splice per conductor.

D. Power Wire and Cable

1. 120/208-volt, 120/240-volt, and 480/277-volt branch circuit conductors may be spliced in suitable fittings at locations determined by the CONTRACTOR. Cables rated above 2,000 volts shall be spliced or terminated only at equipment terminals indicated.
2. Splices to motor leads in motor terminal boxes shall be wrapped with mastic material to form a mold and then shall be taped with a minimum of 2 layers of varnished cambric tape overlapped with a minimum of 2 layers of high temperature tape.

3. Shielded power cable shall be terminated with pre-assembled stress cones in a manner approved by the cable and terminal manufacturer. The CONTRACTOR shall submit the proposed termination procedure as a Shop Drawing.

3.4 CABLE IDENTIFICATION

A. General: Wire and cable shall be identified for proper control of circuits and equipment and to reduce maintenance effort.

B. Identification Numbers: The CONTRACTOR shall assign to each control and instrumentation wire and cable a unique identification number. Numbers shall be assigned to conductors having common terminals and shall be shown on "as built" drawings. Identification numbers shall appear within 3-inches of conductor terminals. "Control Conductor" shall be defined as any conductor used for alarm, annunciator, or signal purposes.

1. Multiconductor cable shall be assigned a number which shall be attached to the cable at intermediate pull boxes and at stub-up locations beneath free-standing equipment. It is expected that the cable number shall form a part of the individual wire number. Individual control conductors and instrumentation cable shall be identified at pull points as described above. The instrumentation cable numbers shall incorporate the loop numbers assigned in the Contract Documents.

2. 120/208-volt system feeder cables and branch circuit conductors shall be color coded as follows: Phase A - black, Phase B - red, Phase C - blue, and Neutral - white. The 480/277-volt system conductors shall be color coded as follows: Phase A - Brown, Phase B - Orange, Phase C - Yellow, and Neutral - Gray. Color coding tape shall be used where colored insulation is not available. Branch circuit switch shall be yellow. Insulated ground wire shall be green, and neutral shall be gray. Color coding and phasing shall be consistent throughout the Site, but bars at panelboards, switchboards, and motor control centers shall be connected Phase A-B-C, top to bottom, or left to right, facing connecting lugs. Any phase changes necessary for proper rotation shall be made at the driven equipment and not in the local disconnect.

3. General purpose AC control cable shall be red. General purpose DC control cable shall be blue.

4. Spare cable shall be terminated on terminal screws and shall be identified with a unique number as well as with destination.

5. Terminal strips shall be identified by computer printable, cloth, self-sticking marker strips attached under the terminal strip.

3.5 TESTING

A. Cable Assembly and Testing: Cable assembly and testing shall comply with applicable requirements of ICEA Publication No. S-95-658/NEMA WC70 - Ethylene-Propylene-Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy. Factory test results shall be submitted in accordance with Section
013300 – Contractor Submittals, prior to shipment of cable. The following field tests shall be the minimum requirements:

1. Insulation resistance testing, using a DC megohmeter, shall be performed on cables operating at more than 2,000 volts to ground. Time-resistance readings shall be taken and recorded at intervals of 30 seconds and one minute. Time-resistance voltage levels shall be per the cable manufacturer’s recommendations.

2. Power cable rated at 600 volts shall be tested for insulation resistance between phases and from each phase to a ground using a megohmeter.

3. Field testing shall be done after cable is installed in the raceways.

4. Field tests shall be performed by a certified test organization acceptable to the cable manufacturer. Test results shall be submitted to the ENGINEER for review and acceptance.

5. Cables failing the tests shall be replaced with a new cable or be repaired. Repair methods shall be as recommended by the cable manufacturer and shall be performed by persons certified by the industry.

B. **Continuity Test:** Control and instrumentation cable shall be tested for continuity, polarity, undesirable ground, and origination. Such tests shall be performed after installation and prior to placing cable in service.

- END OF SECTION -
SECTION 260526 - GROUNDING

PART 1 – GENERAL

1.1 THE REQUIREMENT

A. Provide the electrical grounding system, complete and operable, as indicated in accordance with the Contract Documents.

B. The requirements of Section 260000 – Electrical Work, General apply to this Section.

C. Single Manufacturer: Like products shall be the end product of one manufacturer in order to achieve standardization of appearance, operation, maintenance, spare parts, and manufacturer’s services.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 013300 – Contractor Submittals and Section 260000 – Electrical Work, General.

B. Shop Drawings: Submit manufacturer’s product information for connections, clamps, and grounding system components, showing compliance with the requirements of this Section.

PART 2 – PRODUCTS

2.1 GENERAL

A. Components of the grounding electrode system shall be manufactured in accordance with UL 467 - Standard for Safety Grounding and Bonding Equipment, and shall conform to the applicable requirements of National Electrical Code Article 250 and local codes.

2.2 GROUNDING SYSTEM

A. Grounding loop conductors shall be bare annealed copper conductors.

B. Conductors shall be No. 4/0 unless indicated otherwise.

C. Ground Rods

1. Unless indicated otherwise, provide ground rods minimum of 3/4 inch in diameter, 10 feet long, and with a uniform covering of electrolytic copper metallically bonded to a rigid steel core.

2. Provide corrosion-resistant copper-to-steel bond.

3. The rods shall conform to UL 467.

4. The rods shall be of the sectional type, joined by threaded copper alloy couplings.

D. Make buried and concrete-encased cable-to-cable and cable-to-ground rod connections using exothermic welds by Cadweld, Thermoweld, or equal. Compression type irreversible grounding connections are an acceptable alternate as manufactured by FCI-Burndy or approved equal.
E. Exposed Connectors

1. Exposed grounding connectors shall be of the compression type (connector-to-cable), constructed of high-copper alloy, and manufactured specifically for the particular grounding application.

2. The connectors shall be **FCI-Burndy, O.Z. Gedney**, or equal.

F. Use grounding clamps to bond each separately-derived system to the grounding electrode conductors.

G. Equipment Grounding Circuit Conductors

1. The conductors shall be the same type and insulation as the load circuit conductors.

2. The minimum size shall be as outlined in Table 250.122 of the National Electrical Code, unless indicated otherwise.

3. Metallic conduit systems shall have an equipment grounding wires as well as being equipment grounding conductors themselves.

H. Grounding Materials Manufacturer, or Equal

1. Copperweld

2. Thermoweld

3. FCI-Burndy

**PART 3 – EXECUTION**

3.1 GROUNDING

A. Provide a separate grounding conductor, securely grounded in each raceway independent of raceway material.

B. Provide a separate grounding conductor for each motor and connect at motor box.

C. Do not use bolts for securing the motor box to the frame or the cover for grounding connectors.

D. Sizes shall be as indicated on the Conduit Schedule and in accordance with NEC Article 250.

E. Route the conductors inside the raceway.

F. Provide a grounding-type bushing for secondary feeder conduits that originate from the secondary section of each MCC section, switchboard, or panelboard.

G. Individually bond the raceway to the ground bus in the secondary section.

H. Provide a green insulated wire as grounding jumper from the ground screw to a box grounding screw, and, for grounding type devices, to the equipment grounding conductor.
I. Provide a separate grounding conductor in each individual raceway for parallel feeders.

J. Interconnect the secondary switchgear MCC or panelboard neutral bus to the ground bus in the secondary switchgear compartment only at the service entrance point or after a transformer.

K. Provide the duct bank ground system as indicated, including trenching, splices, ground rods, and connections to equipment and structures.

L. Measure ground impedance in accordance with IEEE STD 81 after installation but before connecting the electrode to the remaining grounding system.

M. Low Voltage Grounded System (600V or less)
   1. A low-voltage grounded system is defined as a system where the local power supply is a transformer, with the transformer secondary grounded.
   2. Grounding system connections for a premises-wired system supplied by a grounded AC service shall be provided with a grounding electrode connector connected to the grounded service conductor at each service, in accordance with the NEC.
   3. The grounded circuit conductor shall not be used for grounding non-current-carrying parts of equipment, raceways, and other enclosures except where specifically listed and permitted by the NEC.

N. Embedded Ground Connections
   1. Underground and grounding connections embedded in concrete shall be UL-listed ground grid connectors.
   2. The connection shall be made in accordance with the manufacturer's instructions.
   3. Do not conceal or cover ground connections until the ENGINEER or an authorized representative has established that every grounding connection conforms to the requirements of the Contract Documents and has given the CONTRACTOR written confirmation.

O. Ground Ring
   1. Furnish trenching and materials as necessary to install the ground ring as indicated.
   2. The bonding conductor shall be in direct contact with the earth and of the indicated size.
   3. Provide a minimum burial depth of 36 inches or as indicated on the Drawings, whichever is greater.
   4. Re-compact disturbed soils to their original density in 6-inch lifts.

P. **Duct Bank Ground:** Embed a grounding conductor in every duct bank as indicated.

Q. Ground Rods
   1. Provide ground rods at the indicated locations.
2. A single electrode that does not have resistance-to-ground of 5 ohms or less shall be augmented by additional electrodes to obtain this value.

3. Take the resistance-to-ground measurement during dry weather, a minimum of 48 hours after a rainfall.

4. Rods forming an individual ground array shall be equal in length.

R. Shield Grounding

1. Shielded instrumentation cable shall have its shield grounded at one end only unless the Shop Drawings indicate that the shield will be grounded at both ends.

2. The grounding point shall be at the control panel or at the receiving end of the signal carried by the cable.

3. The termination of the shield drain wire shall be on its own terminal screw.

4. Jumper together the terminal screws, using manufactured terminal block jumpers or a No. 14 green insulated conductor.

5. Connect the ground bus via a green No. 12 conductor to the main ground bus for the panel.

- END OF SECTION -
PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. Provide electrical raceway systems, complete and in place, as indicated in accordance with the Contract Documents.

B. 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.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 013300 – Contractor Submittals, and Section 260000 – Electrical Work, General.

B. Shop Drawings

1. Submit complete catalog cuts of raceways, fittings, boxes, supports, and mounting hardware, marked where applicable to show proposed materials and finishes.

2. Submit dimensioned layout drawings of cable tray routings, including elevations.

3. As-Built Drawings

   a. Prepare as-built drawings of encased concealed and exposed raceways, ducts, raceways, junction boxes, pull boxes, and electrical and instrumentation equipment.

   b. Furnish the drawings to the ENGINEER in accordance with the requirements of Section 013300 – Contractor Submittals.

C. All raceway shall comply with the seismic requirements of the project. The Contractor shall have qualified individuals and tooling to install PVC coated RMC. The Contractor shall submit certification of such individuals.

PART 2 -- PRODUCTS

2.1 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.

2.2 CONDUIT

A. Rigid Galvanized Steel Conduit (RMC)

   1. Provide rigid steel conduit manufactured from mild steel, hot-dip galvanized inside and out.

   2. Provide rigid steel conduit manufactured in accordance with NEMA C80.1 – Electrical Rigid Steel Conduit, and UL-6 – Electrical Rigid Metal Conduit - Steel.
3. Manufacturer, or Equal
   a. **Allied Tube & Conduit**
   b. **Triangle**
   c. **Wheatland Tube**

B. Rigid Non-Metallic Conduit

1. Provide rigid non-metallic conduit manufactured from Schedule 40 PVC, as indicated, and sunlight-resistant.


3. Manufacturer, or Equal
   a. **Carlon**
   b. **Cantex**

C. Rigid PVC-Coated Galvanized Steel Conduit

1. The conduit shall meet the requirements for RMC conduit as indicated above.

2. Bond a PVC coating to the outer surface of the galvanized conduit.

3. Ensure that the bond between the coating and the conduit surface is greater than the tensile strength of the coating.

4. Provide the inside surfaces and threads of the conduit with a 2-mil urethane coating.

5. Provide a PVC coating thickness not less than 40 mils.

6. The PVC-coated RGS shall be manufactured in accordance with the following standards:
   a. **UL-6**
   b. **ANSI C80.1**
   c. **NEMA RN1 - PVC Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit**

7. Manufacturer, or Equal
   a. **Robroy Industries, Perma-Cote**
   b. **Robroy Industries, Plasti-Bond RedH2OT**
   c. **Robroy Industries, Korkap**
   d. **Thomas & Betts, Ocal Blue**
D. Polyolefin Polymer-Coated Rigid Galvanized Steel Conduit

1. All conduit shall be hot dipped galvanized inside and out with hot dipped galvanized factory-cut threads. The Zinc coating shall be intact, uncoated, and shall not impede electrical ground conductivity.

2. Provide all necessary manufacturer material as may be needed to ensure a fully complete, continuously sealed, undamaged conduit system.

3. Provide additional polymer and repair any abrasions to polymer coating.

4. Polymer-coated RMC conduit shall be resistant to UV damage and deterioration when exposed outdoors.

5. All PP-coated conduit, fittings, and accessories shall be supplied by the same manufacturer.

6. All couplings and fittings shall be provided with PP-coated sleeves and seals, unless otherwise approved by the ENGINEER.

7. Material
   a. Conduit: Meet requirements of ANSI C80.1 and UL 6.
   b. Polyolefin Polymer Coating
      1) Minimum 20 mils nominal thickness, exterior coating bonded to metal.
      2) Minimum 2 mils nominal thickness, interior coating bonded to metal.

8. Manufacturer, or Equal
   a. Gafco Green
   b. Cor-Shield

E. Liquid-Tight Flexible Conduit

1. Provide liquid-tight flexible conduit constructed of a flexible galvanized metal core with a sunlight-resistant thermoplastic outer jacket.

2. Provide liquid-tight flexible conduit manufactured in accordance with the requirements of UL-360 - Steel Conduits, Liquid-Tight Flexible.

3. Manufacturer, or Equal
   a. Anaconda, Sealtite
   b. Electriflex, Liquatite

F. Electrical Metallic Tubing (EMT) or Intermediate conduit (IMC) will not be accepted.
2.3 FITTINGS AND BOXES

A. General

1. For use with metallic conduit, provide cast and malleable iron fittings of the threaded type with 5 full threads.

2. Fittings and Boxes

   a. Provide fittings and boxes with neoprene gaskets and non-magnetic stainless steel screws.

   b. Attach covers by means of holes tapped into the body of the fitting.

   c. Covers for fittings attached by means of clips or clamps will not be accepted.

3. Provide boxes larger than standard cast or malleable types manufactured of Type 304 or Type 316 stainless steel, NEMA 4X.

4. Terminations

   a. In outdoor areas, terminate conduit in rain-tight hubs as manufactured by Myers, O.Z. Gedney, Appleton, or equal.

   b. In other than outdoor areas, provide sealed locknuts and bushings.

5. Hazardous Locations

   a. In hazardous locations, provide conduit, fittings, and boxes suitable for the indicated Class and Division.

   b. Provide conduits terminated in NEMA 7 boxes with a male bushing, Adalet Type PEM, or equal, inside the box.

B. Cast Aluminum Fittings and Boxes

1. Provide cast aluminum boxes and fittings with less than 0.40 percent copper content, and use with aluminum conduit.

2. Manufacturer, or Equal

   a. O.Z. Gedney

   b. Appleton

   c. Crouse-Hinds

C. Malleable Iron Fittings and Boxes

1. For use with galvanized steel conduit, provide fittings and boxes constructed of malleable iron or gray-iron alloy with zinc plating.

2. Manufacturer, or Equal

   a. O.Z. Gedney
b. Crouse-Hinds

c. Appleton

D. PVC Fittings and Boxes

1. For use with rigid non-metallic conduit, provide fittings manufactured of solvent-welded PVC.

2. Provide boxes manufactured of PVC or fiberglass reinforced polyester (FRP).

3. Manufacturer, or Equal
   
a. Carlon

b. Crouse-Hinds

   c. Hoffman

4. Provide welding solvent as required for the installation of non-metallic conduit and fittings.

E. PVC-Coated Fittings

1. For use with PVC-coated RGS, provide PVC-coated coated that are the products of the same manufacturer as the conduit.

2. Provide male and female threads and internal surfaces with a 2-mil urethane coating.

F. Stainless Steel Boxes

1. Provide stainless steel boxes with PVC-coated RGS conduit and where indicated.

2. Provide NEMA 4X stainless steel boxes, constructed of Type 304 stainless steel.

3. Provide stainless steel of a minimum of 14-gauge thickness, with a brushed finish.

4. Door Hinges

   a. Provide doors with full-length stainless steel piano hinges.

   b. Non-hinged boxes will not be accepted.

5. Manufacturer, or Equal

   a. Hoffman

   b. Rohn

   c. Hammond
G. Sheet Steel Boxes
   1. Sheet steel boxes shall be galvanized steel outlet and switch boxes. Boxes shall be suitable for installation embedded in concrete, masonry, or stud walls.
   2. Manufacturer, or Equal
      a. Raco
      b. Steel City
      c. Appleton Electric

2.4 CABLE TRAYS
   A. Provide cable tray systems composed of straight sections, fittings, and accessories as defined in the latest NEMA Standards publication VE-1 - Ventilated Cable Tray.
      1. Provide cable trays and fittings shall constructed of aluminum.
      2. Provide cable trays of the ventilated trough type.
      3. Provide tray sizes with a 6-inch minimum usable load depth, as indicated.
      4. Provide loading capacities that meet the NEMA weight classification with a safety factor of 1.5.
      5. In corrosive locations, provide cable trays manufactured of stainless steel.
      6. Manufacturer, or Equal
         a. Husky
         b. B-Line
         c. T.J. Cope

2.5 WIREWAY
   A. General
      1. Provide wireway of the lay-in type and NEMA-rated for the area in which it is to be installed in accordance with the requirements of Section 260000 – Electrical Work, General.
      2. Separate power, control, signal and communications cables by grounded metallic dividers in wireways or run in separate wireways.
   B. Fittings and Covers
      1. Provide fittings and sections with non-magnetic stainless steel screws.
      2. Attach covers by hinges and clamps to the bodies.
      3. Covers attached by means of clips or screws will not be accepted.
4. Provide covers and bodies constructed of aluminum or minimum 14-gauge steel.

C. Grounding

1. Ground the steel and aluminum wireway bodies.

2. Provide steel dividers with steel wireways or aluminum dividers with aluminum wireways, and ground by means of an individual grounding conductor.

3. Non-metallic dividers will not be accepted.

4. Terminations: In indoor and outdoor areas, terminate conduit in rain-tight hubs as manufactured by Myers, O.Z. Gedney, or equal.

PART 3 -- EXECUTION

3.1 GENERAL

A. Run wiring in raceway unless indicated otherwise.

B. Install raceways between equipment as indicated.

C. Provide raceway systems that are electrically and mechanically complete before conductors are installed.

D. Bends and Offsets

1. Provide bends and offsets that are smooth and symmetrical, and accomplished with tools designed for this purpose.

2. Provide factory elbows wherever possible.

E. Combined Raceways

1. Raceways other than those containing power conductors may be combined in strict accordance with the NEC and with prior written permission from the ENGINEER.

2. In general, combine only raceways containing the same type (control, signal, and the like) and voltage of conductors/cables, or dedicated conduits from one source to one device/equipment, in accordance with the NEC.

3. Permission from the ENGINEER shall not relieve the CONTRACTOR of responsibility to meet national, state and local requirements.

4. Do not combine wiring for redundant systems into single raceways.

F. Routing

1. Where raceway routings are indicated, follow those routings to the extent possible.

2. Where raceways are indicated but routing is not indicated, such as home runs or on conduit developments and schedules, raceway routing shall be the CONTRACTOR’s choice and provided in strict accordance with the NEC as well as customary installation practice.
3. Provide the raceway encased, exposed, concealed, or under-floor as indicated, except conceal conduit in finished areas unless specifically indicated otherwise.

4. Adjust routings in order to avoid obstructions.

G. Coordination

1. Coordinate between trades prior to installing the raceways.

2. The lack of such coordination shall not be justification for extra compensation, and any costs for removal and re-installation to resolve conflicts shall be part of the Contract Price.

H. Support rod attachment for ceiling-hung trapeze and cable tray installations shall meet the seismic requirements in the area where the Project is located.

I. Support wireways in accordance with the manufacturer's recommendations for the seismic requirements indicated in Section 260000 – Electrical Work, General.

J. Provide cable tray anchoring that meets or exceeds the manufacturer's recommendations for the seismic zone indicated in Section 260000 – Electrical Work, General.

K. Install exposed raceways parallel or perpendicular to structural beams.

L. Expansion Fittings

1. Install expansion fittings with external bonding jumpers wherever exposed raceways cross building expansion joints.

2. Install expansion/deflection fittings where conduit movement is expected in more than one dimension, and where conduits transition out of structures in locations where differential settlement may occur.

3. Encased Expansion Fittings

   a. Install encased expansion fittings wherever encased conduits cross building expansion joints.

   b. Deflection type fittings shall not be required for encased conduits crossing an expansion joint within a single structure.

4. Provide expansion and expansion/deflection fittings constructed of the same material as the raceway to which they are installed.

M. Install expansion fittings with bonding jumpers wherever raceways cross building expansion joints.

N. Install exposed raceways at least 1/2 inch from walls or ceilings except that at locations above finished grade where damp conditions do not prevail, install exposed raceways at least 1/4 inch from the face of walls or ceilings by the use of clamp backs or struts.

O. Wherever contact with concrete or dissimilar metals can produce galvanic corrosion of equipment, provide a means of suitable insulation in order to prevent such corrosion.
3.2 CONDUIT

A. Provide exposed conduit manufactured of rigid galvanized steel (RMC), except as follows and unless indicated otherwise:

1. In areas with chlorine or hydrofluoric acid, provide Schedule 80 PVC conduit.
2. In areas containing lime or ferric chloride, provide PVC-coated RGS conduit.
3. In Class I, Div I or Div II hazardous locations, provide rigid aluminum conduit.
4. For conduit containing only grounding system bonding conductors, provide Schedule 80 PVC conduit.

B. Power conduit encased in concrete shall be constructed of Schedule 40 PVC with RMC transition for stub ups that continue in the structure.

C. Analog control or instrumentation conduit shall be RMC.

D. Concrete Encasement

1. Where PVC or RMC conduit is stubbed up from a concrete encasement, provide a PVC-coated RMC elbow.
2. The conduit shall emerge from the concrete in a direction perpendicular to the surface whenever possible.
3. Do not encase conduit in the bottom floor slab below grade.

E. Size

1. Provide exposed conduit of 3/4-inch minimum trade size.
2. Provide encased conduit of one-inch minimum trade size.

F. Install supports at distances required by the NEC.

G. Concrete cover for conduit and fittings shall not be less than 1-1/2 inches for concrete exposed to earth or weather, or less than 3/4 inch for concrete not exposed to weather or in contact with the ground.

H. Penetrations

1. Provide conduit passing through walls or floors with plastic sleeves.
2. Perform core drilling in accordance with the requirements of Section 260000 – Electrical Work, General.
3. Conduits passing through a slab, wall, or beam shall not significantly impair the strength of the construction.

I. Conduits embedded within a slab, wall, or beam (other than those merely passing through) shall meet the following requirements:
1. Conduits with their fittings embedded within a column shall not displace greater than 4 percent of the gross area of cross section;

2. Conduits shall not be larger in outside dimension than 1/3 the overall thickness of the slab, wall, or beam in which it is embedded; and,

3. Conduits shall not be spaced closer than 3 outside diameters on centers.

J. Place the conduit such that cutting, bending, or displacing reinforcement from its proper location will not be required.

K. Coat threads with a conductive lubricant before assembly.

L. Joints
   1. Provide joints that are tight, thoroughly grounded, secure, and free of obstructions in the pipe.
   2. Adequately ream the conduit in order to prevent damage to the wires and cables inside.
   3. Use strap-wrenches and vises to install the conduit, in order to prevent wrench marks on the conduit.
   4. Replace conduit with wrench marks.

M. Slope
   1. Wherever possible, slope the conduit runs to drain at one or both ends of the run.
   2. Wherever conduit enters a substructure below grade, slope the conduit in order to drain water away from the structure.
   3. Take extreme care in order to avoid pockets or depressions in the conduit.

N. Installation of rigid steel conduit through a core-drilled hole in an exterior wall below-grade shall utilize a sealing device as manufactured by Link Seal, or equal.

O. Connections
   1. Make connections to lay-in-type grid lighting fixtures by using flexible metal conduit not exceeding 4 feet in length.
   2. Make connections to motors and other equipment subject to vibration by using liquid-tight flexible conduit not exceeding 3 feet in length.
   3. Provide equipment subject to vibration that is normally provided with wiring leads with a cast junction box for the make-up of connections.

P. Provide conduit seal fittings at the following locations:
   1. in hazardous classified locations, in strict accordance with the NEC; and,
   2. in chlorine, ammonia, sulfur dioxide, and hydrofluosilicic acid areas in order to prevent passage of gases to other areas.
Q. Provide conduit, fittings, and boxes required in hazardous classified areas that are suitably rated for the area, and provide in strict accordance with NEC requirements.

R. Empty Conduits
   
1. Tag empty conduits at both ends to indicate the final destination.

2. Where it is not possible to tag the conduit, identify the destination by means of a durable marking on an adjacent surface.

3. Install a pull-cord in each empty conduit in floors, panels, manholes, equipment, and the like.

4. Install a removable plug on empty conduits that terminate below grade, in vaults, manholes, handholes, and junction or pullboxes.

S. Identification of Conduits
   
1. Identify conduits at ends and at pulling points.

2. Identification shall be the unique conduit number assigned in the Contract Documents.

3. Other than 120 VAC panelboard circuits, if a conduit has not been assigned a unique number in the Contract Documents, assign a unique number following the numbering scheme used in the Contract Documents.

4. Assign a unique number to 120 VAC panelboard circuits, similar to the cable numbering scheme used in the Contract Documents.

5. Provide conduit identification by a stamped or engraved non-corroding metal tag attached to the conduit bushing.

6. Provide an engraved phenolic nameplate in accordance with the requirements of Section 260000 – Electrical Work, General, or a computer printed self-adhesive label attached to the equipment or enclosure inside which the conduit terminates.

7. Markings with a pen or paint will not be accepted.

T. Identification of Pullboxes and Junction Boxes
   
1. Identify pullboxes and junction boxes.

2. Identification shall be the unique conduit number assigned in the Contract Documents, or if not assigned a unique number the CONTRACTOR shall assign one following the numbering scheme used in the Contract Documents.

3. Provide box identification by a stamped or engraved non-corroding metal tag or an engraved phenolic nameplate, in accordance with the requirements of Section 260000 – Electrical Work, General, and attached to the box or enclosure.

4. Markings with a pen or paint will not be accepted.
U. Provide conduit for data cables in accordance with the equipment manufacturer's recommendations, especially regarding separation from low- and medium-voltage power raceways.

3.3 CABLE TRAYS

A. Provide cable trays in strict accordance with the manufacturer's printed instructions.

B. Allowable cable fill areas shall meet NEC Article 392 - Cable Trays requirements.

C. Verify cable tray fills prior to installation based on cables and trays actually provided.

D. Maintain continuous grounding of cable trays including bonding jumpers in accordance with the requirements of NEC Article 392.

E. Install cable trays to walls as the primary method of support.

F. If support from the ceiling is the only alternative, use hangers and supports on 6-foot centers, maximum.

- END OF SECTION -
SECTION 260536 - WIRING DEVICES

PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide wiring devices, complete and operable, as indicated in accordance with the Contract Documents.

B. The requirements of Section 260000 – Electrical Work, General apply to this Section.

C. Single Manufacturer: Like products shall be the end product of one manufacturer in order to achieve standardization of appearance, operation, maintenance, spare parts, and manufacturer’s services.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 013300 – Contractor Submittals.

B. Shop Drawings

1. Submit complete catalog cuts of switches, receptacles, enclosures, covers and appurtenances, marked to clearly identify the proposed materials.

2. Submit documentation showing that the proposed materials comply with the requirements of NEC and U.L.

3. Submit documentation of the manufacturer’s qualifications.

PART 2 – PRODUCTS

2.1 GENERAL

A. Devices shall carry the U.L. label.

B. Color

1. General purpose duplex receptacles face and toggle switch handles shall be gray everywhere except in finished rooms where they shall be ivory.

2. Special purpose receptacles shall have a body and face color as indicated.

C. Receptacles and switches shall be of specification grade and shall conform to NEMA WD-1, Federal Specifications W-C-596E and W-S-896E, respectively.

2.2 LIGHTING SWITCHES

A. Local branch switches shall be of the toggle type, rated at 20 amperes, 120-277 VAC, and shall be General Electric Cat. No. GE-5951-1 for single pole, GE-5953-1 for 3 way and GE-5954-1 for 4 way, similar types as manufactured by Hubbell, Leviton, Pass & Seymour, or equal.

B. Switches for hazardous locations shall be factory-sealed, rated at 20 amperes, 120-277 VAC, and shall be as manufactured by Crouse-Hinds, Appleton, or Killark, or equal.
2.3 GENERAL PURPOSE RECEPTACLES

A. Duplex receptacles that are rated at 125V, 20 amperes, shall be of the polarized 3-wire type for use with a 3-wire cord with grounded lead, and one designated stud shall be permanently grounded to the conduit system in accordance with NEMA 5-20R.

B. Dry Areas
   1. Duplex 120V receptacles for dry areas shall be G.E. 5362, Hubbell 5362, or equal.
   2. Single receptacles for dry areas shall be G.E. 4102, Hubbell 6361, or equal.

C. Damp/Wet Areas
   1. Receptacles for damp/wet locations shall be weather-resistant-listed in accordance with NEC-2008, Article 406.8.
   2. Duplex 120V receptacles for damp/wet areas shall be Hubbell HBL5362IWR, or equal.

D. GFCIs
   1. Ground-fault circuit-interrupting receptacles (GFCIs) shall be installed at the indicated locations and as required by the NEC.
   2. GFCIs shall be duplex receptacles, of specification grade, and tripping at 5 mA.
   3. GFCI ratings shall be 125V, 20 amperes, NEMA WD-1, Configuration 5-20R, and capable of interrupting 5,000 amperes without damage.
   4. GFCIs shall be weather resistant-listed in accordance with NEC-2008, Article 406.8.
   5. Feed-through-type GFCIs serving standard receptacles will not be permitted.
   6. GFCIs shall be Hubbell GFR5362SGI or similar as manufactured by Bryant, Leviton, or equal.

E. Hazardous Locations
   1. Receptacles for hazardous locations shall be of the single-gang type with a spring door.
   2. The receptacles shall be provided with a factory-sealed chamber.
   3. The receptacles shall be provided with a delayed action feature requiring the plug to be inserted into the receptacle and rotated before the electrical connection is made.
   4. The receptacle shall not work with non-hazardous rated plugs.
   5. One plug shall be furnished with each receptacle.
   6. The receptacles shall be rated for 20 amps at 125 VAC.
   7. Hazardous location receptacles shall be Appleton EFSB, Crouse-Hinds ENR, or equal.
8. Ground-Fault Protection
   a. Where indicated, hazardous location receptacles shall be provided with ground fault protection.
   b. Ground fault protection shall be Appleton EFSR-GFI, Crouse-Hinds GFS-1, or equal.

2.4 FLOOR RECEPTACLE BOXES
   A. Floor receptacles and jacks shall be installed in rectangular floor boxes.
   B. The floor boxes shall be 1-, 2- or 3-gang as required for each installation.
   C. The floor boxes shall be constructed of cast iron and sized for the depth of the floor slab.
   D. Carpet flanges shall be provided.
   E. Covers shall be constructed of brass, with openings for duplex receptacle voice and data jacks.
   F. Floor boxes shall be as manufactured by Hubbell, or equal.

2.5 ENCLOSURES AND COVERS
   A. Surface-mounted switches and receptacles shall be housed in FS- or FD-type weatherproof conduit fittings.
   B. Switch and receptacle covers on surface-mounted boxes shall be constructed of die-cast copper-free aluminum.
   C. In finished areas, switch and receptacle boxes shall be provided with "super stainless steel covers" as manufactured by Harvey Hubbell, Arrow Hart, Bryant, or equal.
   D. In areas where cast boxes are used, switch and receptacle covers shall be Crouse-Hinds Catalogue No. DS185 and WLRD-1, or Adalet No. WSL and WRD, or equal.
   E. Wet Locations
      1. Receptacles in wet locations shall be provided with a hinged non-metallic cover/enclosure marked “Suitable for Wet Locations when in use” and “UL Listed.”
      2. Provide a gasket between the enclosure and the mounting surface, and between the hinged cover and mounting plate/base.
      3. The cover shall be TayMac Specification Grade, or equal.

2.6 POWER RECEPTACLES
   A. Power receptacles shall be rated 60 amperes, 600 VAC, 3-wire, 4-pole, heavy-duty circuit-breaking-type, complete with an outlet box and connected for 480-volt service.
   B. Furnish a matching plug for every 3 receptacles.
   C. The outlets shall be Crouse Hinds Arktite ARE-6424, with plug APJ-6485.
2.7 RECEPTACLE – TRANSIENT VOLTAGE SURGE SUPPRESSOR (TVSS)
A. Transient voltage surge suppressors shall be of the duplex style, rated for 80 joules (minimum) of energy absorption in each of 3 modes.
B. The units shall be rated 125 volts AC, sized for installation in 2-inch by 4-inch outlet boxes.
C. The units shall be as manufactured by Arrow Hart, Pass & Seymour, or Hubbell.

2.8 RECEPTACLE – SPECIAL PURPOSE
A. Special purpose receptacles shall be provided with the ratings and number of poles as indicated or required for the proposed purpose.
B. Provide a matching plug with cord-grip features with each special purpose receptacle.

2.9 NAMEPLATES
A. Provide nameplates or equivalent markings on the switch enclosures to indicate the ON and OFF positions of each switch.
B. ON and OFF for 3-way or 4-way switches will not be accepted.
C. Provide receptacles for special purposes with nameplates indicating their use.
D. Nameplates shall meet the requirements of Section 260000 – Electrical Work, General.

PART 3 – EXECUTION

3.1 GENERAL
A. Perform WORK in accordance with the requirements of the NEC.

3.2 CONNECTION
A. Rigidly attach wiring devices in accordance with the NEC and as indicated, avoiding interference with other equipment.
B. Securely fasten nameplates using screws, bolts, or rivets centered under or on the device, unless otherwise indicated.
C. Receptacles indicated to be powered by uninterruptible power supplies (UPS) shall have a nameplate installed directly above the receptacle that reads:
   1. (first line) “UPS-POWERED”
   2. (second line) “NO TOOLS”
D. Nameplates shall meet the requirements of Section 260000 – Electrical Work, General, and shall consist of a red plate with white letters a minimum of 1/4 inch tall.
3.3 GROUNDING

A. Devices, including switches and receptacles, shall be grounded in accordance with NEC, Article 250, and Section 260526 – Grounding.

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.

3.4 FIELD TESTING

A. Provide checkout, field, and functional testing of wiring devices in accordance with Section 260000 – Electrical Work, General.

B. Test each receptacle for polarity and ground integrity, using a standard receptacle tester.

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SECTION 260543 - UNDERGROUND RACEWAY SYSTEMS

PART 1 – GENERAL

1.1 THE REQUIREMENT

A. Provide underground raceway systems, complete and in place, as indicated in accordance with the Contract Documents.

B. Manholes, pullboxes, and fittings that are dedicated to the underground raceway system shall comply with the requirements of this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 013300 – Contractor Submittals, and Section 260000 – Electrical Work, General.

   1. Shop Drawings: Submit complete catalog cuts of all raceways, fittings, pullboxes, and manholes, marked where applicable in order to show proposed materials and finishes.

B. As-Built Drawings

   1. Prepare as-built drawings of encased concealed and exposed raceways, ducts, raceways, junction boxes, pull boxes, and electrical and instrumentation equipment.

   2. Show routings, burial depths, manhole and handhole locations and sizes, and where applicable, connections to drainage systems.

   3. Furnish the drawings to the ENGINEER in accordance with the requirements of Section 013300 – Contractor Submittals.

PART 2 – PRODUCTS

2.1 MANHOLES AND PULLBOXES

A. Frames and Covers

   1. Provide traffic-type covers with an H-20 loading, except as otherwise indicated.

   2. Identify manhole and pullbox covers as "ELECTRIC" by providing raised letters cast into the covers.

   3. Provide frost-proof and water-tight grey iron frames and covers with solid lids and inner lids, and with 28-inch clear openings.

   4. Bolt the covers and lids to cast-in-place steel frames using corrosion-resistant hardware.

   5. Factory-prime the frames.

   6. Provide covers constructed of cast-iron, and provide pick holes.
7. Provide frames with a 1/2-inch drilled and tapped hole and lug in order to accommodate a No. 4/0 AWG bare stranded copper conductor connected to a ground rod and the ground conductor of power cables passing through the manhole.

8. Manhole frames and covers shall be Neenah Foundry No. NF-1755GT18 or equal.

B. Equip manholes and pullboxes with pulling-in irons, opposite and below each ductway entrance.

C. Provide manholes and pullboxes with closed bottoms; open-bottom manholes and pullboxes will not be accepted.

D. Provide PVC ductbank conduits with end bells.

E. Brackets
   1. Provide heavy duty nonmetallic cable racks in manholes as required for racking wiring through the manholes
   2. Brackets: Underground Devices Inc. Cat. No. RA14 minimum or equal
   3. Concrete Inserts: 60-inch length minimum; Underground Devices Inc. Cat. No.CR36-B or equal

F. Precast Manholes and Pullboxes Manufacturer, or Equal
   1. Jensen Precast
   2. Oldcastle Precast
   3. Mack

2.2 DUCTBANKS
A. Provide underground ducts constructed of Schedule 40 PVC.

B. Encase ducts in red-dyed concrete with steel reinforcing bars.

C. Provide concrete with a 3,000-psi compressive strength conforming to the requirements of Section 033100 – Cast-in-Place Concrete.

D. Colorant
   1. The concrete shall be dyed red throughout the ducts; surface treatment will not be accepted.
   2. Provide colorant consisting of an integral red-oxide coloring pigment in the proportion of 8 pounds per cubic yard of concrete.
   3. The costs, if any, of cleaning coloring pigment from the concrete delivery equipment and other related cleanings shall be considered as part of the WORK.
E. Ductbanks

1. Ductbanks shall contain a No. 4/0 bare stranded copper ground wire.

2. The ground wire shall be continuous through the ductbank and terminate at power distribution equipment and the grounding grid.

3. Ductbanks shall utilize standard spacers depending on the duct diameter. Duct spacers shall be as manufactured by *Underground Devices, Carlon Snap-Loc®* or equal.

F. Identification Tape

1. Provide continuous lengths of underground warning tapes located 12 inches above and parallel to the ductbanks.

2. Provide tape consisting of 6-inch wide polyethylene film, imprinted with "CAUTION - ELECTRIC UTILITIES BELOW."

3. Provide tape that contains a non-ferrous metal foil conductor sandwiched in the tape for detection purposes.

4. Tape Manufacturer, or Equal: *Brady*.

**PART 3 -- EXECUTION**

3.1 GENERAL

A. Install underground raceways between manholes and pullboxes as indicated.

B. Raceway systems shall be electrically and mechanically complete before conductors are installed.

C. Provide bends and offsets that are smooth and symmetrical, and fabricated with tools designed for this purpose.

D. Use factory elbows wherever possible.

E. To the extent possible, follow the raceway routings as indicated on the Drawings.

F. Adjust the indicated routings as necessary in order to avoid obstructions.

G. Coordination with Other Trades

1. Coordinate with other trades prior to installation of raceways.

2. The lack of coordination shall not be justification for extra compensation.

3. Perform removal and re-installation to resolve conflicts as part of the WORK.
3.2 DUCTBANKS

A. Install ductbanks in accordance with the following criteria:

1. Assemble the duct using high-impact, non-metallic spacers and saddles in order to provide conduits with vertical and horizontal separation.

2. Set the plastic spacers every 5 feet.

3. Anchor the duct array every 5 feet in order to prevent movement during the placement of concrete.

4. Lay the duct on a grade line of at least 3 inches per 100 feet, sloping towards pullboxes or manholes.

5. Install the duct and adjust the pullbox and manhole depths such that the top of the concrete envelope is a minimum of 18 inches below grade and a minimum of 24 inches below roadways.

6. Accomplish changes in direction of the duct envelope by more than 10 degrees horizontally or vertically by using bends with a minimum radius 24 times the duct diameter.

7. Stagger duct couplings a minimum of 6 inches.

8. Provide select backfill or sand for the bottom of the trench.

9. Cleaning
   a. Clean each bore of the completed ductbank by drawing through it a standard flexible mandrel, one foot long and 1/4 inch smaller than the nominal size of the duct.
   b. After passing the mandrel, draw through a stiff plastic brush and swab.

10. For spare raceways that are not indicated to contain conductors, provide mule tape installed in each duct and a plug or cap with eye to fasten the mule tape.

B. Grout duct entrances smooth, and terminate ducts with flush end bells.

C. Assemble sections of pre-fabricated manholes and pullboxes using waterproof mastic, and set on a 12-inch bed of gravel as recommended by the manufacturer or as required by field conditions.

D. Provide watertight ductbank penetrations through walls of manholes, pullboxes, and building walls below grade.

E. Terminate concrete-encased ductbanks at building foundations.

F. When duct enters the building on a concrete slab on grade, do not encase the duct but transition to rigid steel PVC-coated conduits on stub-ups.
G. Sealing

1. Where an underground conduit enters a structure through a concrete roof or a membrane-waterproofed wall or floor, provide a Link-Seal, or equal sealing device.

2. Use the sealing device with rigid steel conduit.

3. Transition from PVC to rigid steel conduit prior to building entry.

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PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall perform the indicated short circuit and protective device studies for the electrical power system in accordance with the Contract Documents.

B. The WORK of this Section shall include protection studies for motors with solid state overload and overcurrent protection devices.

C. It is the responsibility of the CONTRACTOR to obtain the information required from the electric utility and appropriate vendors.

1.2 QUALIFICATIONS

A. Short circuit studies, protective device evaluation studies, arc-flash hazard analysis studies, and protective device coordination studies shall be performed by a manufacturer who has been regularly engaged in short circuit and protective device coordination services for a period of at least 15 years.

B. The indicated studies shall be signed by the professional electrical engineer, registered in the State of California, responsible for the studies.

C. The studies shall utilize computer programs with proven reliability and accuracy for performing 3-phase fault-duty calculations.

1.3 CONTRACTOR SUBMITTALS

A. The indicated studies shall be submitted and approved by the ENGINEER prior to final approval of the distribution equipment Shop Drawings and release of equipment for manufacture.

B. An initial short circuit study shall be submitted and reviewed before the ENGINEER will approve the Shop Drawings for medium-voltage switchgear, transformers, or 480-volt distribution equipment.

C. Submit an initial protective device coordination study shall be submitted with 90 days after the approval of the initial short circuit study.

D. The short circuit, arc-flash hazard analysis, and protective device coordination studies shall be updated prior to Project Substantial Completion; utilize characteristics of as-installed equipment and materials.

E. The adequacy of the equipment "withstand" and interruption ratings shall be approved by the ENGINEER.

1.4 MANUFACTURERS’ SERVICES

A. The low-voltage switchgear manufacturer shall furnish the services of a qualified field engineer and necessary tools and equipment in order to test, calibrate, and adjust the protective relays and circuit breaker trip devices as recommended in the power system coordination study.
B. The motor control center manufacturer shall furnish the services of a qualified field engineer to calibrate the MCPs as recommended in the power system study.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION

3.1 GENERAL

A. The studies shall include development of single-line and impedance diagrams of the power system.

B. The diagrams shall identify components considered in the study and the ratings of power devices, including transformers, circuit breakers, relays, fuses, busses, and cables.

C. The resistances and reactances of cables shall be identified in the impedance diagram.

D. The studies shall contain written data from the electric utility company regarding maximum available short circuit current, voltage, and X/R ratio of the utility power system.

E. The studies shall include every protective device and feeder included within the WORK.

F. The first upstream overcurrent device outside the WORK shall be used as a fixed reference.

G. The studies shall include all portions of the electrical distribution system for normal and standby power sources down to and including the 480-volt distribution system.

3.2 SHORT CIRCUIT STUDY

A. The short circuit study shall be performed with the aid of a digital computer program, and shall be in accordance with the following Standards:

   ANSI/IEEE 141    Recommended Practice for Electrical Power Distribution for Industrial Plants

   ANSI/IEEE 242    Recommended Practice for Protection, and Coordination of Industrial, and Commercial Power Systems

   ANSI/IEEE C 37.010 Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis

   ANSI/IEEE C 37.13 Low-Voltage AC Power Circuit Breakers Used in Enclosures

3.3 PROTECTIVE DEVICE EVALUATION STUDY

A. A protective device evaluation study shall be performed in order to determine the adequacy of circuit breakers, molded case switches, and fuses.

B. Any problem areas or inadequacies in the equipment due to prospective short-circuit currents shall be promptly brought to the attention of the ENGINEER.
C. Do not utilize series-rated circuit breakers to meet short circuit requirements for this project.

D. Devices shall be fully rated to withstand available fault currents.

3.4 PROTECTIVE DEVICE EVALUATION STUDY

A. A protective device coordination study shall be performed in order to develop the necessary calculations to select power fuse ratings, protective relay characteristics and settings, ratios and characteristics of associated current transformers, and low-voltage breaker trip characteristics and settings.

B. Any problem areas or inadequacies in the equipment due to prospective short-circuit currents shall be promptly brought to the ENGINEER's attention.

3.5 TIME/CURRENT COORDINATION CURVES

A. As a minimum, the time/current coordination curves for the power distribution system shall include the following items plotted on 5-cycle log-log graph paper:

1. time/current curves for each protective relay, circuit breaker, or fuse demonstrating graphically that the settings will provide protection and selectivity within industry standards

2. Each curve shall be identified, and tap and time dial settings shall be specified.

3. Provide individual curves for each feeder unless identical to others.

4. Selectivity
   a. Time/current curves for each device shall be positioned to provide the maximum selectivity to minimize system disturbances during fault clearing.
   b. Where selectivity cannot be achieved, the ENGINEER shall be notified as to the cause.
   c. Recommendations shall be included for alternate methods that would improve selectivity.

5. Time/current curves and points for cable and equipment damage.

6. Circuit interrupting device operating and interrupting times

7. Indicate maximum fault values on the graph.

8. Sketch of bus and breaker arrangement.

9. Magnetizing inrush points of transformers.

10. Thermal limits of dry-type and liquid-insulated transformers (ANSI damage curve).

11. Every restriction of the ANSI and National Electrical Code shall be followed, and proper coordination intervals and separation of characteristics curves shall be maintained.
3.6 ARC FLASH STUDY

A. An arc flash study shall be performed with the aid of a digital computer program in order to determine the “Arc Flash Protection Boundary” and “Personal Protective Equipment” (PPE) levels for applicable electrical distribution equipment, stand-alone disconnects, starters, and VFDs in the power distribution system.

B. The arc flash study shall be performed in conjunction with short circuit calculations and protective device coordination.

C. The arc flash study shall be in accordance with the latest version of the following Standards:

- NFPA 70E: Standard for Electrical Safety Requirements for Employee Workplaces
- IEEE 1584: IEEE guide for performing Arc Flash Hazard Calculations
- OSHA (29 CFR PART 1910): Occupational Safety and Health Standards for General Industry
- ANSI Z535.4: Product Safety Signs and Labels

D. The recommended values for the “Arc Flash Protection Boundary” and PPE levels, based on the arc flash study results, shall be tabulated in the study.

E. Labeling

1. The digital computer program shall provide the “Arc Flash Protection Boundary” and PPE values in a format that can be directly printed on to labels.

2. The CONTRACTOR shall provide these labels in accordance with Section 260000 – Electrical Work, General.

3.7 FINAL SUMMARY REPORT

A. Summarize the results of the indicated power system studies in a final report.

B. The report shall include the following items:

1. single-line diagram

2. impedance diagram

3. tabulation of all protective devices identified on the single line diagram

4. time/current coordination curves

5. specific recommendations, if any

6. test instrumentation, condition, and connections, as applicable, for each study

7. computerized fault current calculations
8. any suggested changes to the protection scheme or equipment selection that will result in improved system reliability and safety

9. recommendations to minimize the arc flash energy

C. The report shall include information concerning the computer program used for the study, as well as a general discussion of the procedure, items, and data considered in the preparation of the study.

D. Submit 8 bound copies of the report to the ENGINEER.

3.8 PROTECTIVE DEVICE TESTING, CALIBRATION, AND ADJUSTMENT

A. Test, calibrate, and adjust the protective relays and circuit breaker trip devices in accordance with the recommendations in the power system coordination study.

B. Calibrate the MCPs as in accordance with the recommendations in the power system study.

C. Adjustments shall be made prior to energizing any electrical equipment.

- END OF SECTION -
PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide the 480 V main switchgears, complete and operable, as indicated and in accordance with the Contract Documents.

B. The requirements of Section 260000 – Electrical Work, General, apply to the WORK of this Section.

C. UL Label

1. The switchgear assembly shall bear a UL label.

2. Furnish certified copies of design test reports demonstrating compliance with UL standards.

3. The switchgear shall be suitable for use as service entrance equipment and shall be labeled as such in accordance with UL requirements.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Codes

1. The indicated WORK shall conform to or exceed the applicable requirements of the National Electrical Code (NEC), provided that where a local code or ordinance is in conflict with the NEC, the provisions of the local code or ordinance shall take precedence.

2. Additional requirements are indicated in Section 260000 – Electrical Work, General.

B. Commercial Standards

- ANSI/NFPA 70 National Electrical Code
- UL 1558 Low Voltage Switchgear
- ANSI/IEEE C37.20.1 Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
- ANSI Z55.1 Gray Finishes for Industrial Apparatus and Equipment

1.3 CONTRACTOR SUBMITTALS

A. Submittals shall conform to the requirements of Section 260000 – Electrical Work, General, Section 013300 – Contractor Submittals.

B. In addition, submit the following:

1. A complete list of special tools as may required for the operation and maintenance of the unit.

2. Engineering data, including voltage, current, and short-circuit ratings.
3. Certified outline drawings complete with dimensions, available space for conduits, cable terminations, bus terminations, weights, and cable supports.

4. A complete one-line diagram showing protective and control devices, metering, and terminal numbers.

5. Interconnection diagrams.

6. Design certification of the anchoring systems for seismic requirements in conformance with the requirements of Section 260000 – Electrical Work, General, for the indicated equipment.

7. Spare parts data, listing source and prices of recommended replacement parts and supplies.

8. Recommended maintenance procedures and intervals.

9. Written descriptions, explaining ladder diagrams, control operation, and system operation.

10. A certified factory design test report.

11. A material lists and catalog data.

1.4 QUALITY ASSURANCE

A. General: Materials shall be tested and inspected in accordance with Section 260000 – Electrical Work, General, and the requirements indicated in this Section.

B. Storage

1. Switchgear shall be stored in a clean, dry space.

2. Factory wrapping shall be maintained or a heavy plastic cover shall be provided in order to protect units from dirt, water, construction debris, and traffic.

3. The storage space shall be heated or space heaters shall be provided and energized.

C. Factory Tests

1. Submit a certification of design tests previously conducted on one air-break circuit breaker and switchgear assembly of each rating similar to that indicated.

2. The design testing program shall conform to the requirements of ANSI/IEEE C37.20.1, and shall include the following tests:
   a. dielectric
   b. continuous current
   c. withstand
   d. endurance
3. The low-voltage switchgear section, including the transition section, shall be completely assembled, wired, adjusted, and tested at the factory.

4. After assembly, the complete switchboard shall be tested for operation under simulated service conditions in order to assure the accuracy of the wiring and the functionality of the equipment.

5. Production Testing
   a. Production tests shall be conducted on each low-voltage switchgear assembly, and a certification of each test shall be submitted.
   b. The production testing program shall conform to the requirements of ANSI/IEEE C37.20.1 and other related ANSI standards, as well as the applicable standards of IEEE and of NEMA SG-5.
   c. Production testing shall include the following tests:
      1) contact resistance measurement of all 3 phases
      2) operation of each electrically-operated breaker with the control power supply voltage adjusted to the limits indicated
      3) check of safety interlocks and interchangeability of circuit breakers of the same ratings in various cubicles

D. **Environmental Conditions:** The 480 V switchgear shall be designed for continuous duty service in the environmental conditions indicated in Section 260000 – Electrical Work, General.

1.5 **MAINTENANCE AND GUARANTEE**
   A. The CONTRACTOR shall guarantee that the furnished equipment shall meet the indicated requirements.

1.6 **COORDINATION STUDIES**
   A. The requirements for coordination studies for electrical distribution system protection are indicated in Section 260573 – Protective Device Studies.

**PART 2 – PRODUCTS**

2.1 **REQUIREMENTS**
   A. The main switchgear shall be suitable for indoor service.
   B. The switchgear shall be **front-accessible only**, and shall be provided with a NEMA 1 enclosure.
   C. The main switchgear shall be a product of the manufacturer of the indicated power air circuit breaker.
   D. The switchgear shall be manufactured by **Eaton Electrical, Square D, General Electric**, or equal.
2.2 SWITCHGEAR CONSTRUCTION FEATURES

A. The switchgear shall consist of free-standing vertical sections with the complement of circuit breakers and accessories as indicated.

B. The construction shall facilitate the addition of future sections where indicated.

C. The vertical sections shall be fabricated, rigidly braced, structural steel framework with interior barriers and breaker module side sheets of not less than 12-gauge sheet steel and external panels and covers of not less than 14-gauge sheet steel, with the side and top sheets removable.

D. The compartment doors shall be hinged, flanged, and dead-front panels.

E. Hinged and flanged doors shall be provided on the rear of sections having external power connections and on sections in which the rear cover plates exceed 60 pounds in weight.

F. Panels shall be reinforced with stiffening members in order to minimize vibration.

G. Steel shall be of select quality, free of dents, and true to level after forming.

H. The metering equipment and drawout circuit breakers shall be housed in separate sections or compartments within vertical sections, and shall be isolated from adjacent elements by the use of steel or appropriately insulated barriers.

I. Bus compartments shall be provided in order to fully enclose the incoming line and main bus from the cable termination area.

J. The incoming and main bus shall be of welded or bolted copper.

K. Bolted or pressure joints for buses, interconnections, disconnecting devices, and external connections to the equipment shall be of copper with silver-to-silver torqued contacts.

L. Insulated bus supports shall be of flame-retardant polyester glass, designed and tested to withstand the mechanical stress produced by fault currents as required.

M. Each low-voltage circuit breaker compartment shall have a drawout mechanism consisting of an integral racking device to lock the removable element in the connected position and to overcome the mechanical resistance of making and breaking the contacts of the disconnecting devices.

N. Positive mechanical interlocks of rugged design shall prevent the breaker from being racked in or out unless the breaker is tripped, and shall prevent the breaker from being closed while it is being racked in or out.

O. The breaker drawout mechanism shall be of a design that permits the breaker to be racked from the connected to the test and disconnected positions and then have the door closed.

P. Provide a manual release to hold the breaker in test and disconnected positions.

Q. Provide a limit stop in the fully withdrawn position, in which position there shall be provisions for easy maintenance and inspection or removal.
**R. Control Wiring**

1. Provide control wiring to auxiliary relays and devices indicated to be furnished with the equipment.

2. The control buses and wiring for each vertical section shall be enclosed in panduit or in compartments isolated from the primary circuits.

3. **Terminal Blocks**
   a. Every cubicle containing control wiring which extends to other cubicles shall have terminal blocks.
   b. The control wiring shall be brought to the identified terminal blocks.
   c. Connections made on terminal blocks and on internal devices shall be by means of locking spade-type pre-insulated terminals.

4. Control and secondary wiring shall be 600 V and of the flame-retardant switchboard-type, with a minimum size of No. 14 AWG, stranded tinned copper.

5. Hinge wiring shall be of the extra-flexible stranding type.

6. The wire shall be SIS, with both ends of the wire identified with labels approved by the ENGINEER.

**S. Equipment Enclosure**

1. Enclosure shall be of the indoor type as indicated.

2. Indoor-type enclosures shall be NEMA 1 gasketed.

3. Weather-proof-type enclosures shall have the low-voltage switchgear housed within a walk-in weather-proof enclosure.

4. The enclosure shall include a maintenance aisle wide enough to permit interchanging removable equipment between compartments, with a hinged gasketed door at each end of the aisle.

5. The enclosure doors shall have provisions for locking on the outside and shall be provided with a panic egress from the inside, even if locked outside.

6. Provide rear-gasketed doors for each cubicle, with provisions for padlocking.

7. Ventilation openings shall be provided with screens and replaceable filters.

8. Lights, switches, and convenience receptacles shall be provided in the aisle.

9. The bottom of the entire housing shall be undercoated for rust prevention.

**T. Circuit Breakers and Circuit Breaker Compartments:**

1. Main and feeder circuit breakers shall be air power-type, 100-percent rated, and of the drawout, 3-pole, 2-position type conforming to those ANSI and NEMA standards which apply.
2. Power circuit breakers shall be Eaton Electrical Magnum DS, GE AKR, Square D, or equal.

3. Circuit breaker trip settings shall be as indicated in Section 260573 – Protective Device Studies.

4. The trip units shall be RMS-sensing, microprocessor-based, self-powered, and programmable.

5. The main circuit breakers shall be provided with adjustable pick-up settings for long-time, short-time, and ground fault trips and adjustable time delay settings for short-time, long-time, and ground fault settings.

6. Short-time and ground fault trip functions shall include $I^2t$ slopes as part of the trip unit programming functions.

7. The feeder circuit breaker trip units shall be as indicated for main circuit breakers, except that they shall also be provided with an adjustable instantaneous pick-up, except where deletion is recommended by the Coordination Study.

8. The circuit breakers shall have trip targets.

9. Circuit breakers shall have mechanically trip-free operating mechanisms of the stored energy type and shall be provided with self-aligning primary and secondary disconnecting devices, trip button, position indicator lamps, mechanically-operated devices as listed hereinafter, and other indicated accessories.

10. Electrically-operated circuit breakers shall also be equipped with electrically trip-free operating mechanisms.

11. Manually operated breakers shall be charged from the handle.

12. Power circuit breakers shall have bell alarms and form "C" auxiliary contacts wired to an identified terminal strip.

13. Provide 6 N.O. (Normally Open) and 6 N.C. (Normally Closed) dry contacts for the main and feeder circuit breakers for remote indication.

14. Main circuit breaker shall be electrically and manually operated, and feeder circuit breakers shall be electrically and manually operated.

15. Charging or energy storage springs shall be manually charged from an operating handle.

16. The short circuit interrupting rating of the breakers shall be not less than 85,000 amperes symmetrical, but no less than required by Section 260573 – Protective Device Studies.

17. Provide current limiters, integrally mounted or on a drawout truck, where necessary in order to meet the short circuit rating.

18. Limiters shall be coordinated with the breaker trips in order to avoid unnecessary blowing of the limiters.
19. Provide anti-single-phase protection and blown fuse indication interlocked with the breakers.

20. Mechanical interlocks shall be provided as to prevent the removable element from being moved to or from the operating position with the circuit breaker closed and to prevent the circuit breaker from being closed unless primary disconnecting devices are fully engaged or separated a safe distance.

21. It shall not be possible to withdraw the breaker with the breaker in the closed position.

22. Circuit breaker elements of the same frame size shall be interchangeable.

23. Each low-voltage power circuit breaker shall be mounted in an individually grounded metal barriered compartment, and an insulating flame retardant barrier shall be provided at the rear of each compartment.

24. Each cubicle shall be provided with protection shutters to automatically cover primary line and secondary load studs when the circuit breaker is withdrawn from the cubicle.

25. The breakers shall have high endurance characteristics being capable of no-load and full-load interruptions at rated current equal to or exceeding the UL endurance ratings for power circuit breakers without maintenance.

26. Test Unit
   a. Furnish one 120 VAC static trip calibration and portable test unit shall be furnished per switchgear assembly.
   b. The test unit shall be as designed and built specifically for the type of circuit breakers being furnished and shall contain necessary cables, plugs and instruction manuals required for operation.
   c. Test sets will not be necessary when the circuit breakers trip units include internal test capabilities by an operator.

U. **Utility Metering**: Not applicable.

V. Control Power Transformers
   1. Control power transformers shall be provided in each main circuit breaker section in order to supply power for circuit breaker control and space heaters.
   2. The transformer shall be protected by current limiting fuses in a dead front holder on both the primary and secondary.
   3. Distribution of control power shall be through use of panel mounted fusible switches, or circuit breakers, properly coordinated.

W. Switchgear Bus
   1. Buses shall be of high-conductivity copper, sized for the rated continuous and momentary currents within allowable temperature rise, and shall not be tapered.
2. Buses shall be braced to withstand a short circuit current of 85,000 amperes symmetrical, minimum.

3. Bus Joints
   a. Bus joints shall be welded, brazed, or bolted.
   b. Bolted joints shall be silver-surfaced.
   c. Bolts and associated hardware shall be corrosion-resistant and shall be rear-accessible.

4. Insulating Barriers
   a. Insulating barriers shall be provided where primary buses pass from one compartment to another.
   b. The main and riser bus shall be fully isolated from the circuit breaker and instrument and auxiliary compartments.
   c. The bus bar shall be bolted where horizontal and vertical buses are joined.
   d. Bolted connections shall be silver-plated.
   e. Solid vertical insulating barriers shall be provided in the section between the cable and bus compartments.
   f. A barrier system shall be provided that isolates the bus from the cable compartment.

5. Ground Bus
   a. Provide a copper ground bus extending the entire length of the switchgear assembly and incoming line compartment.
   b. The ground bus shall be provided with clamp type terminal lugs, adjustable between 4/0 AWG and 500 MCM at each end for external cable connections.
   c. All metal parts of the structure shall be effectively connected to the ground bus.
   d. The ground bus shall be of rectangular cross section, not less than 1/4-inch by 1-1/2 inches.

6. Provide a full-capacity neutral bus in the wiring section and main device. Furnish main bonding jumper to ground bus.

X. Terminal Blocks
   1. Terminal blocks for external control connections shall be if the 600 V, barrier type, having a minimum rating of 20 amperes with marker strips identifying internal and external wiring.
   2. Terminal blocks shall be sized to have at least 20 percent unused spare connections after completion of wiring.
3. Terminal blocks for current transformer secondary connections shall be of the short-circuiting type.

4. One 4-pole block shall be used for each current transformer set.

**Y. Meters and Instruments**

1. Meters and instruments shall be provided as indicated.

2. Meters and instruments shall be installed and wired on hinged front panels.

3. The arrangement of the meters and instruments is subject to approval by the ENGINEER.

4. Instruments and meters shall be of the semi-flush switchboard type, with rectangular dustproof enclosing cases and antiglare glass.

5. Indicating instruments shall be provided with white dials with black marking, scales approximately 250 degrees and 7 inches long, accuracy within plus one percent of full-scale, and external zero adjustment.

6. Instruments and meters shall be suitable for operating from instrument transformers with nominal 5-ampere and 120 V secondaries.

7. Scale ranges and dial constants shall be provided to match the primary current and voltage ratings.

8. Multi-function microprocessor based electronic metering panels are acceptable in lieu of analog type instruments. Meter as manufactured by EIGT, Nexus 1500 or equal.

9. **Transducers**

   a. The CONTRACTOR shall provide transducers which produce a 4 - 20 mA analog signal proportional to the electrical parameters required.

   b. Transducers shall be Kratos, Square D, Esterline-Angus, or equal.

   c. Transducers shall be provided for:

      1) voltage at Bus A and Bus B main circuit breaker, 3-phase
      2) voltage at Bus A and Bus B main circuit breaker, 3-phase
      3) kilowatts, 3-phase, instantaneous, through Bus A and Bus B main circuit breaker.

**Z. Instrument Transformers**

1. **Potential Transformers**

   a. The quantity, ratio, and connection of potential transformers shall be provided as indicated.
b. Potential transformers shall be provided with current-limiting high-interrupting-capacity primary fuses in dead front-holders, and shall be mounted in the auxiliary section.

2. Current Transformers
   a. The quantity and ratio of current transformers shall be as indicated.
   b. Current transformers shall have thermal and mechanical ratings and insulation class not less than those of the associated circuit breakers.
   c. Current transformers shall be mounted in such a way as to provide easy access for inspection and maintenance.

3. Provide test blocks and plugs for current and potential circuits for the main breaker(s).

AA. Spare and Space Cubicles
   1. Circuit breaker compartments, where indicated, shall be completely equipped with drawout rails for the future addition of circuit breakers, including all electrical connections.
   2. Insulating sleeves shall be provided over the main stationary disconnect studs.
   3. Circuit breaker compartments indicated as spares shall be provided with spare circuit breakers of the rating shown, installed and wired.

BB. Lifting Device: Provide a top-of-switchgear rail-mounted overhead lighting device and transport dolly for removing the circuit breaker.

CC. Nameplates
   1. Nameplates shall be provided for the front and rear face of each cubicle and for major devices thereon, such as meters, instruments, control switches, and relays.
   2. Nameplates shall also be provided for major internal devices such as relays, instrument and control power transformers, fuse blocks, switches, and transformers.
   3. Cubicle nameplates shall be constructed of 3-layer laminated phenolic plastic, with a black front and back, a white case, and engraved to show white lettering.
   4. The lettering shall be upper case as follows:
      a. one-inch high for switchgear identification
      b. 7/16-inch high for compartment identification
      c. 1/8-inch high for component nameplate
   5. Nameplates that are 1-1/2 inches tall and smaller shall be 1/16-inch thick.
   6. Nameplates larger than 1-1/2 inches tall shall be 1/8-inch thick.
   7. The edges of the nameplates shall be beveled.
8. Nameplates shall be fastened with black anodized screws.

DD. Surface Preparation, Painting, and Cleanliness

1. Metal surfaces shall be smooth and free of all foreign matter such as scale, sand, blisters, weld splatter, metal chips and shavings, oil, grease, organic matter, and rust, and shall be chemically cleaned and treated with a process which provides a phosphate coating.

2. Immediately after the treatment process, the surfaces shall be sprayed with a coating each of primer and finish paint, and both coatings shall be baked.

3. Electrostatically deposited powder coated epoxy finishes, oven baked and 1-mil minimum thickness indoor and 2-mils minimum thickness outdoor, will be acceptable.

4. Each surface shall be finish painted light gray No. 61.

5. The manufacturer's standard practice of double-tone finish on the low-voltage switchgear section will be acceptable.

6. Furnish 2 spray cans of air-drying paint of each color tone.

PART 3 – EXECUTION

3.1 INSTALLATION

A. The CONTRACTOR shall install the switchgear in accordance with the manufacturer's instructions.

B. The CONTRACTOR shall provide floor channels and shall secure the switchgear to the channels by bolting or track welding at the front and the rest.

C. Prior to energizing, the equipment shall be cleaned, inspected for loose connections, checked out for electrical and mechanical operations, phase-sequenced, and all circuits shall be made free of any shorts of ground connections following field testing.

D. The CONTRACTOR shall anchor the substation in conformance with "Anchoring" criteria indicated in Section 260000 – Electrical General Provisions.

3.2 MANUFACTURER'S REPRESENTATIVE

A. The CONTRACTOR shall arrange for a technical service representative of the manufacturer for pre-commissioning checkout of the equipment and to instruct the operating personnel in the operation, shutdown, startup, and maintenance of the equipment.

3.3 FIELD TESTING

A. The CONTRACTOR shall perform all testing required by Section 260126 – Electrical Tests.

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PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide panelboards and general purpose dry-type transformers, complete and operable, in accordance with the Contract Documents.

B. **Single Manufacturer:** Like products shall be the end product of one manufacturer in order to achieve standardization of appearance, operation, maintenance, spare parts, and manufacturer’s services.

1.2 CONTRACTOR SUBMITTALS

A. **General:** Submittals shall be in accordance with Section 013300 - Contractor Submittals and Section 260000 - Electrical Work, General.

B. Shop Drawings

1. Transformers
   a. Dimension drawings
   b. Technical certification sheets
   c. Drawing of conduit entry/exit locations
   d. Transformer ratings, including:
      1) Voltage
      2) Continuous current
      3) Basic impulse level for equipment over 600 volts
      4) KVA
   e. Descriptive bulletins
   f. Product sheets

2. Panelboards
   a. Breaker layout drawings with dimensions and nameplate designations
   b. Component list
   c. Drawings of conduit entry/exit locations
   d. Assembly ratings including:
      1) Short circuit rating
2) Voltage

3) Continuous current

e. Cable terminal sizes

f. Descriptive bulletins

g. Product sheets

h. Installation information

i. Seismic certification and equipment anchorage details

PART 2 -- PRODUCTS

2.1 GENERAL

A. Transformers

1. The transformers shall be dry-type, designed, manufactured, and tested in accordance with the latest applicable standards of ANSI and NEMA.

2. Transformers shall be UL-listed and bear the UL label.

B. Panelboards

1. Panelboards shall be dead front factory assembled. Panelboards shall comply with NEMA PB-1-Panelboards, as well as the provisions of UL 50 - Safety Enclosures for Electrical Equipment and UL 67 - Safety Panelboards. Panelboards used for service equipment shall be UL labeled for such use. Lighting panelboards shall be rated for 120/208 volt, 3 phase operation or 120/240 volt for single phase operation as indicated. Power panelboards shall be rated for 480 volts, 3 phase, 3 wire operation.

2. The manufacturer of the panelboard shall be the manufacturer of the major components within the assembly, including circuit breakers.

2.2 TRANSFORMERS

A. **Energy Efficiency**: Standard dry-type transformers shall meet the energy efficiency requirements of NEMA TP-1 and the Department of Energy Code of Federal Regulations (10 CFR PART 431). The product requirements are in the appliance regulations, Title 20, and the usage requirements are in Title 24.

B. Ratings

1. KVA and voltage ratings shall be as indicated.

2. Transformers shall be designed for continuous operation at rated kVA, for 24 hours a day, 365 days a year operation, with normal life expectancy as defined in ANSI C57.96 - Guide for Loading Dry Type Distribution and Power Transformers.
3. Transformer sound levels shall not exceed the following ANSI and NEMA levels for self-cooled ratings:

<table>
<thead>
<tr>
<th>Rating</th>
<th>Sound Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 9 kVA</td>
<td>40 db</td>
</tr>
<tr>
<td>10 to 50 kVA</td>
<td>45 db</td>
</tr>
<tr>
<td>51 to 150 kVA</td>
<td>50 db</td>
</tr>
</tbody>
</table>

C. Construction

1. Insulation Systems
   a. Transformers shall be insulated as follows:
      1) 2 kVA and smaller: 150 deg C insulation system based upon 80 deg C rise.
      2) 3 to 15 kVA: 185 deg C insulation system based upon 115 deg C rise.
      3) 15 kVA and larger: 220 deg C insulation system based upon 115 deg C rise.
   b. Required performance shall be obtained without exceeding the above indicated temperature rise in a 40 deg C maximum ambient.
   c. Insulation materials shall be flame-retardant and shall not support combustion as defined in ASTM D 635 - Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position.

2. Transformer windings shall be copper.

3. Transformers shall have four 2-1/2 percent taps, 2 above and 2 below 480 volts.

D. Manufacturers: Transformers shall be floor or wall-mounted type by General Electric, Eaton Electrical, Square D, or equal.

2.3 PANELBOARDS

A. Ratings

1. Panelboards rated 240 VAC or less shall have short circuit ratings not less than 10,000 amperes RMS symmetrical or as indicated by the Short Circuit Study, whichever is greater.

2. Panelboards rated 480 VAC shall have short circuit ratings not less than 25,000 amperes RMS symmetrical or as indicated by the Short Circuit Study, whichever is greater.

3. Panelboards shall be labeled with a UL short circuit rating. Series ratings are not acceptable.
B. Construction

1. Lighting and power distribution panels shall have copper busbars.

2. Breakers shall be one, 2, or 3 pole as indicated, with ampere trip ratings as required by the equipment. Breakers shall be quick-make and quick-break, inverse time trip characteristics, to trip free on overload or short circuit, and to indicate trip condition by the handle position.

3. The panels shall have hinged doors with combination catch and latch. The front panels shall be so arranged that when the plates are removed, the gutters, terminals and wiring will be exposed and accessible. The doors shall have inner doors within the plates to have only the breaker operating mechanism exposed when they are opened. Live conductors and terminals shall be concealed behind the plates.

4. Panelboards shall be rated for the intended voltage.

5. Circuit breakers shall be interchangeable and capable of being operated in any position as well as being removable from the front of the panelboard without disturbing adjacent units. No plug-in circuit breakers will be acceptable.

6. Lighting and power distribution panels which are not part of a motor control center shall be constructed in accordance with Section 260000. Panels shall have the necessary barriers, supports, and liberal wiring gutters. Trim screws shall be stainless steel. Panelboard parts of metal other than copper, aluminum, or stainless steel shall be cadmium plated. Panelboards shall be as manufactured by Eaton Electrical or General Electric.

7. Panelboards shall be UL listed except for special enclosures which are not available with UL listing.

8. Panelboards shall be suitable for use as service entrance where indicated.

C. Surge Protective Devices

1. Surge Protective Devices (SPD) shall be designed to provide transient voltage protection for a service entrance panelboard.

2. SPD units shall comply with UL 1449 3rd Edition, and shall be listed for such use.

3. Lighting and power distribution panels shall have SPD units installed as part of the panelboard or close-coupled to the panelboard.

4. SPD units shall be rated for the voltage and phase service of the panel at 120 kA per phase.

5. SPD units shall have a built-in diagnostic package with flashing trouble indicator, a display for the status of each phase, and a counter and display to indicate the number of surges that have caused the device to operate.

6. SPD units shall be Eaton Clipper Power System, Visor Series, or Equal.
PART 3 -- EXECUTION

3.1 GENERAL

   A. WORK of this Section shall be installed as indicated in Section 260000.

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PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide the pad mounted transformer, complete and operable, in accordance with the Contract Documents. Equipment purchased under these Specifications shall be new.

B. The manufacturer of the medium voltage pad-mounted transformer shall furnish and coordinate all major components of the transformer including switches and fuses.

C. Pad-mounted transformers shall be manufactured by Cooper Industries, Eaton Electrical, ABB, or approved equal.

D. The pad-mounted transformer shall be designed, assembled, and tested in accordance with the latest applicable standards of NEMA, IEEE and ANSI.

1.2 RELATED SECTIONS

A. Section 26000 – Electrical Work, General

B. Section 260126 – Electrical Tests

1.3 REFERENCED CODES AND SPECIFICATIONS

A. Reference Codes: All WORK specified herein shall conform to or exceed the applicable requirements of the National Electrical Code (NEC); provided, that where a local code or ordinance is in conflict with the NEC, the provisions of said local code or ordinance shall take precedence. For additional requirements, see Section 26000 - Electrical Work, General.

B. Commercial Standards

1. NFPA 70 – National Electrical Code (NEC)

2. ANSI C57.12.00 – General Requirements for Liquid-Immersed Distribution and Power Transformers

3. ANSI C57.12.22 – Requirements for Pad-Mounted Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers


1.4 SUBMITTALS

A. Furnish submittals in accordance with Part E and Section 260000 and shall include the following additional items:
1. Certified outline drawings complete with dimensions and weights, nameplate, meters, CT’s, and control equipment.

2. Engineering data to include impedance, resistance, reactance, X/R ratio, voltage, continuous current, and temperature rise.

3. Material list and catalog data.

4. Submit spare parts data listing source of replacement parts and supplies; recommended maintenance procedures and intervals.

5. Certified factory design test reports.

6. Complete list of tools required for the operation and maintenance of the unit.

7. Provide schematic diagrams showing all components and their interconnections.

**B. Shop Drawings:** Shop Drawings shall include the following information:

1. Equipment information:
   a. Name of transformer manufacturer.
   b. Type, model and all options provided.
   c. Assembly drawing and nomenclature.
   d. Front view elevation or outline drawing.
   e. Floor plan with recommended pad dimensions.
   f. Schematic diagrams.
   g. Nameplate diagram.
   h. Component list.
   i. Conduit entry/exit locations.
   j. Ratings including:
      1) kVA.
      2) Voltage.
      3) Continuous current (FLA).
      4) Basic Impulse level.
      5) Impedance.
   k. Cable terminal sizes or dead-front elbow information.
   l. Descriptive bulletins.
m. Product sheets.

2. Factory test data certifying compliance with requirements of this Section.

3. Final as-built drawings and information for items listed in item 1.
   a. Wiring diagrams.
   b. Certified production test reports.
   c. Installation information.

4. Operation and maintenance manuals shall include the following information:
   a. Instruction books and/or leaflets.
   b. Drawings and information required by item 1.

C. **Technical Manual:** The OWNER's Manual shall contain the following additional documentation:
   1. Manufacturer's two (2) year warranty.
   2. Field test report.

1.5 DESIGN REQUIREMENTS AND OPERATING CONDITIONS

A. As Specified herein and as indicated in the Contract Documents.

1.6 QUALIFICATIONS / RESPONSIBILITIES / SAFETY

A. The CONTRACTOR shall furnish and install the pad mounted transformer as specified herein and as shown on the Contract Documents.

B. **Qualifications:** The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the ENGINEER, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

C. **General:** All materials shall be tested and inspected in accordance with Section 260000 – Electrical Work, General and the following requirements.

D. Transformer shall be stored in a clean, dry space. Factory wrapping shall be maintained, or a heavy plastic cover shall be provided to protect units from dirt, water, construction debris, and traffic. Storage space shall be heated or space heaters shall be energized.

E. Factory Tests

   1. **Step-Down Transformer:** A certificate of design tests previously conducted on one (1) step-down transformer of similar rating to that specified herein shall be submitted.
2. Production tests on the rated voltage shall be conducted on each step-down transformer supplied herein. Certificates for each test shall be submitted. The production testing program shall conform to ANSI Test Code C57.12.00, and shall include, but not be limited to, the following tests:

   a. Resistance measurements of all windings.
   b. Ratio tests on all tap connections.
   c. Polarity, and phase relation tests.
   d. No-load loss.
   e. Exciting current measurement.
   f. Impedance, and load loss measurements.
   g. Applied potential test.
   h. Induced potential test.
   i. Temperature tests at OA ratings.
   j. Basic impulse test on all windings.

3. Temperature tests shall be made only on one (1) unit of each rating. Temperature tests previously performed on a duplicate unit will be acceptable in lieu of the temperature test on the units to be supplied.

4. The manufacturer shall provide three (3) certified copies of factory test reports.

F. Environmental Conditions: The transformer shall be designed for continuous duty in the environmental conditions specified in Section 260000 - Electrical Work, General.

PART 2 -- PRODUCTS

2.1 DESIGN REQUIREMENTS

   A. The pad-mounted transformer and all components shall be designed, manufactured and tested in accordance with the latest applicable standards of NEMA and ANSI.

   B. The pad-mounted transformer shall be of dead front type, suitable for outdoor service.

   C. The phase-sequence of the assembled 3-phase buses and primary conductors shall be A, B, C starting from front-to-back, top-to-bottom or left-to-right as viewed from the front of the unit.

2.2 RATINGS

   A. The ratings of the transformers shall be as follows or as shown on the Contract Drawings:
### Transformer 40-T-1

**kVA Rating:** As shown on the Contract Drawings

**Type:** ONAN

**Phase:** 3

**Insulating fluid:** Envirotemp FR3 fluid

**Frequency:** 60 Hz

**Impedance:** 5.75 +/- 7 1/2 percent

**HV:** 12.0 kV Delta

**HV BIL:** 95 kV

**HV Taps:** ± 2 - 2 1/2 percent; full capacity

**LV:** 277/480 Wye Volts solidly grounded

**Sound Level:** 62 dBA

**Altitude:** 3,300 ft

**Temperature Rise:** 65 degree C, 30 average/40 degree C maximum ambient

### Transformer 40-T-4

**kVA Rating:** As shown on the Contract Drawings

**Type:** ONAN

**Phase:** 3

**Insulating fluid:** Envirotemp FR3 fluid

**Frequency:** 60 Hz

**Impedance:** 5.75 +/- 7 1/2 percent

**HV:** 12.0 kV Delta

**HV BIL:** 95 kV

**HV Taps:** ± 2 - 2 1/2 percent; full capacity

**LV:** 4.16 Wye/ kV resistance grounded

**Sound Level:** 62 dBA

**Altitude:** 3,300 ft

**Neutral Resistor:** 400A, 10 seconds, 2.4kV

**Temperature Rise:** 55/65 degree C, 30 average/40 degree C maximum ambient

### Construction Features

**Coils**

Copper

**High Voltage**

High Voltage 12 kV, 95 kV BIL with Distribution Class Surge Arresters in NEMA 3R air terminal cabinet

**Low Voltage**

Low Voltage as noted above

**Tank**

Formed Base with Jacking Provisions Cork Neoprene - All Gauge Gaskets Stainless Steel NEMA 2 Ground pads Standard Oil Preservation System, Standard Welded on Flat Tubular Radiators 8-PSI Tank Design

**Fittings**

1" Drain Valve with 3/8" Sampler Valve

1" Upper Filter Press Valve

**Instruments**

Dial Type Thermometer

Liquid Level Gauge

Pressure Relief Device

Pressure Vacuum Gauge
C. Accessories and Components

1. Transformer features and accessories shall include:
   a. One (1) inch drain valve with sample valve.
   b. Non-PCB label.
   c. One (1) inch upper fill/filter press connection.
   d. Three (3) distribution class, metal oxide elbow surge arresters mounted in the high voltage compartment.
   e. Combination Bay-O-Net with expulsion fuse and backup current limiting fuse. Oil immersed load-break bay-o-net overload sensing fuses in series with under oil partial range current limiting fuses. Draw out for fuse replacement, hook stick operable. Size as shown on the Drawings.

D. Neutral Grounding Resistor

1. The CONTRACTOR shall provide one (1) **GE Type DS300B**, or equal, stainless steel neutral grounding resistor, 10-second rating, 2.4 kV, 400 ampere sized according to manufacturer’s recommendations. The resistor elements shall be mechanically braced to withstand the short circuit forces without damage to itself or surrounding objects. The resistor shall be installed in close proximity to the transformer 40-T-4.

2. Primary cable compartment shall include connector and cable supports. Ground sensing current transformer shall be mounted in the respective CT compartment. Cable compartments shall be large enough to accommodate stress cones or potheads and shall have termination points for drainage shield wires.

3. The neutral grounding resistor shall be free-standing NEMA 4X stainless steel enclosure. It shall have a grounded safety-screened enclosure. The neutral grounding resistor shall be mounted on a concrete pad by the CONTRACTOR.

2.3 CONSTRUCTION

A. The unit shall be in accordance with the latest edition of applicable standards and installation according to the current National Electrical Code.

B. The transformer shall carry its continuous rating with average winding temperature rise by resistance that shall not exceed 65 degrees C, based on average ambient of 30 degrees C over 24 hours with a maximum of 40 degrees C.

C. The transformer shall be designed to meet the sound level standards for liquid transformers as defined in NEMA and ANSI.

D. Provide two (2) 2½ percent above and two (2) 2½ percent below primary taps and no-load tap changer.
E. The main transformer tank and attached components shall be designed to withstand pressures 25 percent greater than the required operating design value without permanent deformation. All seams and joints shall be continuously welded.

F. Each radiator assembly shall be individually welded and receive a quality control pressurized check for leaks. The entire tank assembly shall receive a similar leak test before tanking. A final 6-hour leak test shall be performed.

G. The transformer shall be compartmental-type, self-cooled, and tamper resistant for mounting on a pad. The unit shall restrict the entry of water (other than flood water) into the compartments so as not to impair its operation. There shall be no exposed screws, bolts, or other fastening devices which are externally removable.

H. The transformer shall consist of a transformer tank and full-height, bolt-on high- and low-voltage cable terminating compartments located side-by-side separated by a rigid metal barrier. Each compartment shall have separate doors, designed to provide access to the high-voltage compartment only after the low-voltage has been opened. There shall be at least one additional fastening device accessible only after the low-voltage door has been opened, which must be removed to open the high-voltage door. Doors shall be mounted flush with the cabinet frame. The low-voltage door shall have a handle-operated, 3-point latching mechanism designed to be secured with a single padlock. A hex-head bolt shall be incorporated into the low voltage door latching mechanism. Both high- and low-voltage doors shall be incorporated into the low voltage door latching mechanism. Both high- and low-voltage doors shall be equipped with lift-off type stainless steel hinges and door stops to secure them in the open position.

I. Compartment sills, doors and covers shall be removable to facilitate cable pulling and installation. The high-voltage door shall be on the left with the low-voltage door on the right. Compartments shall be designed for cable entry from below and shall be sized to the minimum dimensions of ANSI C57.12.26.

J. Transformer shall be supplied with a welded main tank cover and be of a sealed-tank construction designed to withstand a pressure of 8 psig without permanent distortion. The tank cover shall be domed to shed water and be supplied with a tamper-resistant access handhole sized to allow access to internal bushing and switch connections. The transformer shall remain effectively sealed for a top-oil temperature of -5 degree C to 105 degree C. When necessary to meet the temperature rise rating specified above, flat cooling panels of the common header type shall be provided.

K. The transformer manufacturer shall certify that the transformer is Non-PCB containing no detectable PCBs. Do not provide nonflammable transformer liquids including askarel and insulating liquids containing tetrachloroethylene, perchloroethylene, chlorine compounds, or halogenated compounds.

L. Full-capacity taps shall be provided with a tap changing mechanism designed for de-energized operation. The tap changer operator shall be located within one of the compartments.

M. The coil windings shall be of the 2 winding type designed to reduce losses and manufactured with the copper conductors. The windings shall incorporate a secondary sheet conductor to maximize short-circuit strength. All insulating materials shall be rated 65 degree C rise, 80 degree C hot-spot operation.
N. The core material shall be high-grade, grain-oriented, non-aging silicon core steel with high magnetic permeability, low hysteresis and eddy current losses. Magnetic flux densities are to be kept well below saturation to allow for a minimum of 10 percent overvoltage excitation. The cores shall be properly annealed to reduce stresses induced during the manufacturing processes and minimize core losses.

O. The core frame shall be designed to provide maximum support of the core and coil assembly. The core frame shall be welded or bolted to ensure maximum short-circuit strength.

P. The core and coil assembly shall be designed and manufactured to meet the short-circuit requirements of ANSI C57.12.90. The core and coil assembly shall be baked in an oven prior to tanking to "set" the epoxy coating on the Kraft paper and remove moisture from the insulation prior to vacuum filling.

Q. Transformer shall be vacuum-filled with FR3 fluid. The process shall be of sufficient vacuum and duration to insure that the core and coil assembly is free of moisture prior to filling the tank.

R. Primary Connections: Transformer primary connections shall be dead-front wells inserts and elbows for cable sizes shown on the drawings.

2.4 FINISH

A. Each transformer shall be painted utilizing an initial phosphatizing cleaning treatment, followed by Manufacturer's standard paint process baked on to a total of 3 to 5 mils average thickness. Outdoor liquid transformer units shall include suitable outdoor paint finish. Unit shall be painted Munsell green color.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. The CONTRACTOR shall install the pad mounted transformers in accordance with manufacturer's installation instruction, and as shown. Transformers shall be energized under the guidance of the transformer manufacturer's field engineer.

B. Prior to energizing, all equipment shall be cleaned, inspected for loose connections, checked out for electrical and mechanical operations and phase-sequence, and all circuits made free of any shorts, or ground connectors following field testing.

C. CONTRACTOR shall sample transformer insulating liquid and submit a test report on the sample water content to the OWNER prior to energization.

D. CONTRACTOR shall anchor transformers in conformance with “Anchoring” Criteria stated in Section 260000 – Electrical Work, General.

3.2 FIELD QUALITY CONTROL

A. Provide the services of a qualified factory-trained manufacturer's representative to assist the CONTRACTOR in installation and start-up of the equipment specified under this section for a period of one (1) working day. The manufacturer's representative
shall provide technical direction and assistance to the CONTRACTOR in general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained herein. The manufacturer’s representative shall also instruct the operating personnel in the operation, shutdown, startup, and maintenance of the equipment.

3.3 FIELD TESTS

A. Visual and mechanical inspection after installation:
   1. Inspect for physical damage, proper anchorage and grounding.
   2. Check tightness of bolted connections.

B. Electrical Tests
   1. Insulation tests: Measure insulation resistance of each transformer side phase to phase and phase to ground for one minute. Test voltage and minimum acceptable resistance shall be in accordance with manufacturer's recommendations.
   2. Turns ratio test on all tap connections.

C. The CONTRACTOR shall perform all testing required by Section 260126 - Electrical Tests.

3.4 MANUFACTURER’S CERTIFICATION

A. A qualified factory-trained manufacturer's representative shall certify in writing that the equipment has been installed, adjusted, and tested in accordance with the manufacturer's recommendations.

B. The CONTRACTOR shall provide three (3) copies of the manufacturer's representative's certification before final payment is made.

-END OF SECTION-
PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide the switching center, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 260000 - Electrical Work, General, apply to the WORK of this Section.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Codes

- ANSI/NFPA 70 National Electric Code
- NEMA 210 Unit Substation

B. Commercial Standards

- NEMA SG5 Power Switchgear Assemblies
- NEMA SG6 Power Switching Equipment
- ANSI/IEEE C37.20 (R82) Switchgear Assemblies Including Metal Enclosed Bus

1.3 CONTRACTOR SUBMITTALS

A. Submittals shall conform to the requirements of Section 260000 and the following additional requirements:

1. Engineering data to include voltage, current, and short-circuit ratings.

2. Outline dimensions to include available space for conduits, stress cone type cable terminations, and cable supports.

1.4 QUALITY ASSURANCE

A. General: All materials shall be tested and inspected in accordance with Section 260000 and the following requirements.

B. Factory Tests

1. Design test reports conducted on one medium voltage load break switch assembly having essentially duplicate ratings as indicated herein shall be submitted. The design testing program shall conform to ANSI/IEEE C37.20 and shall include at least the following tests:

   a. Basic impulse level.

   b. Momentary withstand.
c. Short time withstand.

d. Fault closing.

e. Load interruption at various loads and power factors including magnetizing current of the transformer.

2. A Certificate of Qualification shall be submitted to verify that the submitted Design Test Reports are completely applicable to all equipment furnished hereunder. Production Tests shall be conducted on each medium voltage load break switch assembly, and test reports shall be submitted. The production tests program shall conform to ANSI/IEEE C37.20 and NEMA SG-6, and shall include but not be limited to the following tests:

a. Visual and Mechanical Inspection

b. Dielectric test at power frequency for one minute

c. Contact resistance measurement for all the three phases.

d. A check of safety interlocks.

C. The switching center shall be designed for continuous duty service in the environmental conditions in Section 260000.

1.5 MAINTENANCE AND GUARANTEE

A. The CONTRACTOR shall submit recommended spare part lists.

B. Special tools and equipment for system and equipment maintenance shall be furnished.

C. The CONTRACTOR shall guarantee that the furnished equipment shall meet the requirements of the Contract Documents.

D. The 15 kV switchgear center shall carry a manufacturer's label stating switchgear ratings and catalog or shipping number as well as the name of the manufacturer. The manufacturer shall be responsible for activation and acceptance of switchgear center and shall be fabricator of either the main vacuum switch or the load break feeder switches, or both.

PART 2 – PRODUCT

2.1 GENERAL

A. The switching center shall be an integrated assembly of circuit breakers which are coordinated electrically and mechanically for high voltage circuit switching and protection. The switching center shall be provided in compliance with this Specification and with all applicable NEMA and ANSI standards. All major components shall be provided by Eaton Electrical, S & C, or equal, establishing one source of responsibility for the equipment performance and assuring high standards in quality, coordination, reliability, and service.

B. The construction shall be of the universal frame type using die-formed welded and bolted members; enclosing panels shall be 11-gauge steel and shall be bolted in place.
C. The bus bar shall be copper and fully insulated; copper shall be silver-plated at joints. The bus bar shall be braced for short circuits of 50,000 amperes minimum. A full-length ground bus bar shall be provided at the bottom of the switchgear enclosure. The ground bus shall be extended toward the access panel or door and equipped with a rated grounding stud to facilitate placement of safety grounds. The stud shall be as manufactured by Hubbell Power Systems catalog # C6002102 with cover C4060416 or equal.

D. The multi-section switching center shall be constructed on a self-supporting, continuous beam.

E. The revenue metering section shall comply with service requirements of the power utility company and shall include the equipment and accessories which the utility requires the OWNER to furnish.

F. The surge protection shall be furnished at the incoming bus. The compartments where medium voltage cables are terminated shall be equipped with metal oxide intermediate class surge arrestors.

2.2 SERVICE

A. The switching center shall be suitable for operation at 12 nominal kV, 3 phase, 60 Hz as supplied by the utility system and the whole switching center line up shall have the minimum interrupting capacity of 25,000 amp RMS symmetrical at nominal system voltage or as shown.

2.3 ENCLOSURE

A. The switching center enclosure shall be an outdoor, weather-proof NEMA 3R non-walk-in type enclosure.

B. The switching center shall have ventilating louvers top and bottom with dust filters and sloping top. Exhaust fans, if used, shall be heavy duty type with galvanized steel propeller. Housing shall be water tight if it is mounted outside the metal enclosure. Where full-length doors are required, they shall have continuous hinges with lockable handles; all doors at the same switchgear lineup shall be hinged on the same side. The doors shall have welded corners ground smooth. Each door shall have provision for padlocking.

C. The switching center shall be rodent-and bird-proof. Each section shall be equipped with a switched overhead LED luminaire (with minimum illumination level of 30 FC at one foot from the bottom of the section) and one convenience receptacle.

D. The enclosure shall be phosphatized and painted with one coat of primer and one or more coats of ANSI 61 enamel. All covers shall be bolted in place except the front opening doors. Channel bases and lifting arrangements shall be provided. Space heaters in each section and a thermostat shall be provided to prevent moisture condensation. An undercoating compound shall be applied to outdoor switchgear.

E. The floor-standing switching center shall be shipped fully assembled and tested; if shipping breaks are imperative, the units shall be assembled and tested then broken down for shipping.
2.4 DESIGN AND CONSTRUCTION FEATURES

A. The switching center configuration shall be as indicated. It shall have an incoming main circuit breaker and three feeder breakers.

B. Incoming and outgoing sections shall have adequate space to accommodate the 15 kV, 133% shielded jacketed single conductor with stress-cone terminations, and lightning arresters. Terminals and lugs shall be the compression type NEMA 2 suitable for copper cables of size indicated.

C. The circuit breakers shall be of the metal-clad vacuum circuit breaker type and shall be rated 15 kV, 600 amp continuous current and 750 MVA interrupting capacity at nominal system voltage; they shall be complete with all necessary devices and hardware to result in a complete, operable unit. The following devices and provisions shall be included:

1. A wheel-mounted, drawout type vacuum circuit breaker with operating, test, and isolation positions. Each switchgear cubicle or compartment equipped with a circuit breaker shall be provided with a mechanical means for moving the circuit breaker to and from its operating position. Suitable guide rails and positive stops shall be provided for centering the circuit breaker in the proper position when inserting or removing it. All necessary accessories required for removing and transferring the circuit breaker shall be furnished. Each cubicle shall be provided with a positive stop to prevent overtravel of the circuit breaker when moving it into the "Operating" and "Test" positions. An indicator or equivalent indicating means shall be provided to clearly show when the circuit breaker is in the "Test" or "Operating" position.

2. A complete mechanical interlock system to prevent moving the vacuum breaker from and into operating position when the vacuum breaker is closed. Removal of the circuit breaker shall be possible only by operating a mechanical device.

3. Power Terminal Disconnection
   a. A power terminal disconnecting system with automatic shutter, covering all high-voltage parts when the vacuum breaker is moved out of operating position. All disconnecting devices shall be accurately jig aligned and securely mounted to maintain alignment.
   b. The main contacts and their supports shall be guaranteed not to distort or fail under any or all of the following conditions, individually or concurrently:
      1) Mechanical stresses resulting from the momentary current specified.
      2) Misalignment of disconnects of plus or minus 1/8-inch.
   c. All contact surfaces shall be silver-to-silver pressure contacts. In general, these contacts, whether stationary or movable, shall be of rugged silver-plated copper one-piece construction, with spring(s) on fingers to provide uniform contact with the male part of all operating and environmental conditions.
   d. The circuit breaker control voltage shall be 120 VAC. A 120VAC UPS shall be used to provide power to each circuit breaker shunt trip and each WL-2 lockout relay to insure that energy will be available for tripping during faulty conditions. The UPS batteries shall be flooded lead acid or Nickel-Cadmium. Furnish the battery information and test report to the electrical Utility. The minimum UPS run time at rated full load shall be 30 minutes. A control power transformer...
and panelboard shall be provided on the source side of the incoming line breaker. This source will provide power to all the lineup accessories including the UPS. Closing bus tie or bus sectionalizing breakers shall be provided with automatic transfer capability of control power. The wires shall be carried in a wire trough, gutter, or equivalent method within the switchgear assembly. All wiring shall be protected from sharp edges and corners. Terminal blocks shall be provided on one side of a shipping split for termination of the interconnecting wires, with adequate lengths and identification furnished to permit reconnecting the circuits. Wiring provided for the external connection to other locations shall be wired to terminal blocks.

e. To protect the switchgear control power bus, each breaker control circuit shall have a main fuse between the control bus and the breaker control (tripping) circuit. The fuse shall provide power for the tripping circuit and, in addition, a set of separate (secondary) fuses (in series with the main fuse) shall be furnished for the breaker closing and indication circuit. These fuses shall be sized by the manufacturer so that a short circuit in the closing circuit shall not blow or damage the main control circuit tripping fuses.

f. The vacuum circuit breaker shall be operated by an electrically charged, mechanically and electrically trip-free, stored energy operating mechanism. Provision shall be included for manual charging of the mechanism and for slow closing of the main contacts for inspection or adjustments. A manual charging lever shall be furnished with each switchgear line-up. The stored energy mechanism shall discharge when the breaker is withdrawn from the cubicle.

g. Facilities shall be provided for padlocking the trip mechanism to block the closing of the circuit breaker.

h. The withdrawable vacuum circuit breaker assembly shall be equipped with self-coupling primary, secondary, and grounding contacts.

i. In addition to the "Operating" and "Isolated" positions, an intermediate "Test" position shall be provided to facilitate the operation of the vacuum circuit breaker with the primary circuit disconnected. Transfer of the vacuum circuit breaker between the service, test, and isolated positions, shall be mechanically prohibited with the circuit breaker closed.

j. Auxiliary switches shall be directly coupled to the circuit breaker mechanism to positively indicate the open and closed positions of the circuit breaker.

k. Mechanical indication of the circuit breaker position - open, closed, operating, test, isolated - shall be positively indicated at the operating face of the equipment. Electrical indication of the circuit breaker status: open-closed-spring charged, shall also be provided at the operating face of the equipment.

l. A circuit breaker lifting device, which is capable of lifting the rollout circuit breakers from the switchgear assembly, shall be provided. The lifting device shall have 4-inch diameter locking wheels, a steel platform base, and a hoist mechanism to lift the circuit breaker from the assembly and lower it to the platform base. The entire assembly shall be suitably designed to prevent capsizing during movement with the circuit breaker in place on the platform.
m. Close and trip circuits for each breaker shall be separately fused with cascaded connection for the closing circuit. Fuse blocks shall be dead front, pullout type to provide the control disconnecting means.

n. Protective Relays

1) The types of relays and their locations in the switchgear shall be as indicated.

2) All protective-type relays shall be suitable for operation at a frequency of 60 Hz with current transformers having 5 ampere secondary circuits and with potential transformers having 120 V secondary circuits. The relays shall not be damaged by the stresses resulting from the momentary and short-circuit currents indicated. The Supplier shall guarantee the compatibility of ground sensor current transformers and the associated instantaneous overcurrent relays.

3) All protective-type relays shall have drawout type cases of a uniform dull black finish, shall be semi-flush-mounted on the front door operating face of the equipment, and shall be of the rectangular dust-tight type. The relay cases shall be provided with glass covers and gaskets to render them dust tight. Auxiliary relays shall be surface-mounted at easily accessible locations in each cubicle. All protective relays shall be equipped with built-in targets or indicating LED lights indicating a trip condition. The protective relay control power shall be 120VAC.

4) Resistors and other auxiliary components associated with the relays shall be furnished to provide a complete and functional system.

5) Protective and auxiliary relays shall be the following make and type. In order to assure the high degree of reliability and service continuity required, substitutes for any of these relays listed below shall not be acceptable except as noted on the drawing:

<table>
<thead>
<tr>
<th>Device Number</th>
<th>Description</th>
<th>Westinghouse</th>
<th>General Electric (GE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50/51</td>
<td>Phase Overcurrent</td>
<td>CO</td>
<td>IFC, SFC</td>
</tr>
<tr>
<td>50G</td>
<td>Ground Overcurrent</td>
<td>ITH</td>
<td>PJC</td>
</tr>
<tr>
<td>86</td>
<td>Lockout Relay with Overcurrent Manual Reset</td>
<td>WL</td>
<td>HEA</td>
</tr>
</tbody>
</table>

6) It shall be the responsibility of the switchgear manufacturer or supplier to complete the detail design of the complete protective relaying system in accordance with the functional requirements shown in the one-line diagram and to properly apply relay selection and types from the listings above. Solid state-type relays with a minimum of 2 years good and proven records are preferred.
7) The protective device for the main circuit breaker shall be SEL-751, no equal. The protective device shall be coordinated with the electric supply Utility. The main circuit breaker shall be protected by two SEL-751 relays.

4. Requirements for Instrument Current Transformers

a. Current transformers shall be multi-ratio, rated to withstand the indicated operational, short circuit, and voltage impulse conditions, and shall conform to ANSI C57.13.

b. The ratings of the current transformers and locations in the switchgear shall be as indicated. The voltage class shall be not less than that of the enclosing switchgear. The current transformers shall be either the wound, window, or bar type and shall have 5 ampere secondaries. The terminal and mechanical rating of the wound or bar type current transformers shall be equal to that of the assembled switchgear. Window-type current transformers used in the switchgear having insulated buses shall be insulated for not less than 600 V. The transformers shall have been permanently installed in the switchgear at the time the impulse withstand voltage test is made. Window current transformers for ground sensors shall have adequate opening for power cables of the size indicated.

D. The feeder breakers shall be vacuum breaker type.

1. The switchgear shall be an assembly of breaker housings, auxiliary housings, and vacuum circuit breakers. It shall be of aisle-less construction and shall be rated 15 kV. It shall be for use on a 12,000 V, 3 phase 3 wire ungrounded, 60 Hz system. The switchgear shall be designed, manufactured, and tested in accordance with the latest ANSI and NEMA standards.

2. The switchgear assembly shall consist of individual vertical sections housing combinations of circuit breakers and auxiliaries, bolted together to form a rigid metal-clad switchgear assembly. Metal side sheets between adjacent structures and solid removable metal barriers shall isolate the primary major sections of each circuit.

3. Bus supports between units shall be flame-retardant, track-resistant glass polyester. Bus joints shall be provided in each unit. All bus joints shall be silver-plated, bolted, and insulated. The bus shall be braced to withstand fault currents equal to the close and latch rating of the breakers. The temperature rise of the bus and connections shall be in accordance with ANSI standards and documented by design tests. A copper ground bus 1/4-inch by 2-inches shall extend the entire length of the switchgear.

4. The circuit breaker compartment shall be equipped to house the removable breaker element. The mechanism for levering the breaker shall be cell-mounted and include all of the necessary interlocks to render the breaker mechanism mechanically and electrically trip-free during the levering procedure. A ground contact shall ground the breaker between and including the operating and test positions. The stationary primary contacts shall be silver-plated and recessed within insulating tubes. A grounded steel shutter shall automatically cover the stationary primary disconnecting contacts when the breaker is in the disconnect position or out of the cell. Rails shall be provided for withdrawal of the circuit breaker for inspection and maintenance without the use of separate lifting devices.
5. Circuit Breakers

a. The circuit breakers shall be the horizontal drawout type capable of being withdrawn on rails. The breakers shall be operated by a motor-charged spring-stored energy mechanism. The stored energy mechanism shall be front accessible and shall be charged normally by a universal electric motor and in an emergency by a manual handle. The primary disconnecting contacts will be silver-plated copper.

b. Each circuit breaker shall contain 3 vacuum interrupters separately mounted. An integral contact wear gap indicator for each vacuum interrupter shall be easily visible. The breaker front panel shall be removable when the breaker is withdrawn for ease of inspection and maintenance.

c. The secondary contacts shall be silver-plated and shall automatically engage in the breaker operating position. They can be manually engaged in the breaker test position.

d. A mechanical means shall be provided to prevent overtightening a breaker when levered into the compartment.

e. Interlocks shall be provided to prevent closing of a breaker between operating and test positions, to trip breakers upon insertion, or removal from housing and to discharge stored energy mechanisms upon insertion or removal from the housing. The breaker shall be secured positively in the housing between and during the operating and test positions.

6. Transformers

a. Ring-type current transformers shall be provided. The thermal and mechanical ratings of the current transformers shall be coordinated with the circuit breakers. Their accuracy rating shall be equal or higher than ANSI standard requirements. The standard location for current transformers on the bus side and line side of the breaker units shall be front accessible to permit adding or changing current transformers without removing high voltage insulation and connections.

b. Voltage and control power transformers of the quantity and ratings indicated shall be provided. Voltage transformers or control power transformers up to 15 kVA single phase shall be mounted in drawout drawers contained in an enclosed auxiliary compartment. Rails shall be provided for each drawer to permit easy inspection, testing, and fuse replacement.

c. A mechanical interlock shall be provided for control power transformers to require the secondary breaker to open before the drawer can be withdrawn.

d. A shutter assembly shall be provided to prevent contact with live primary parts when an instrument transformer drawer is withdrawn.

e. The switchgear manufacturer shall provide the metal-clad switchgear, for the quantity, type, and rating of protection relays as indicated. A machine engraved plastic nameplate indicating ANSI device function shall be provided for each device. Nameplates shall have black characters on white background. The relays shall be as required above.
7. Termination
   a. The switchgear manufacturer shall provide suitable terminal blocks for secondary wire terminations plus a minimum of 10 percent spare terminal connections. One control circuit cutout device shall be provided in each circuit breaker housing. Switchgear secondary wire shall be No. 14 AWG, type SIS rated 600 V, 90 degrees Centigrade.

   b. Incoming line and feeder cable lugs of the type and size required shall be provided.

   c. All current transformer leads shall be wired to shorting terminal blades. They shall be isolated from the primary compartment by metal barriers.

2.5 METERING AND INSTRUMENT SECTION

   A. The metering section shall be provided with all instruments, equipment, and accessories as required by the power utility.

   B. **Current Transformer:** The current transformer shall be especially designed for installation in metal-clad switchgear. The rating of the current transformers and location in the line-up shall be as indicated. The voltage class shall be not less than that of the line-up in which they are installed. The current transformer shall be either of the wound, window, or bar type and shall have 5 ampere secondary burden and accuracy class shall be suitable for the connected load.

   C. **Potential Transformer:** The potential transformer shall be dry type, and shall be mounted on a draw-out or “trunion” type frame. The rating of the potential transformer and its location in the line-up shall be as indicated. The voltage class shall be not less than that of the line-up in which it is installed; volt-ampere rating and accuracy shall be suitable for the connected load. The potential transformer shall be protected with current limiting fuses on primary and secondary.

   D. Instruments and Meters

      1. Meters and instruments shall be isolated from high voltage by grounded metal barriers and all instruments and meters shall be semi-flush switchboard type.

      2. **Main Incoming Breaker**

         | One | Utility grade three phase revenue meter, equipped with revenue grade CTs and VTs. The line current will range between 72A and 120A, size CTs accordingly. **EI/GT, Nexus 1500 (1500-D2-60Hz-V3-485P-NTRJ-X-X) or equal.** |

      3. **Distribution Feeder Breaker**

         | One | AC indicating ammeter, 5 amperes full scale, single-phase, 0 – 50 amperes dial, one percent accuracy, **Eaton Electrical Type KA-241, GE Type AB-40, or equal** |
4. Where shown on the single line diagram, the following shall be provided:

| One | Utility grade three phase revenue meter, equipped with revenue grade CTs and VTs. The line current will range between 72A and 120A, size CTs accordingly. EI/GT, Nexus 1500 (1500-D2-60Hz-V3-485P-NTRJ-X-X) or equal. |

2.6 NAMEPLATES

A. Nameplates shall be black and white 1/8-inch thick laminoid, with lettering engraved through the black surface exposing the white lamination beneath. Letter height shall be 1/8-inch minimum unless otherwise indicated. Nameplate shall be fastened using 2 matching screws: adhesive tape is not acceptable.

2.7 SURFACE PREPARATION, PAINTING AND CLEANLINESS

A. Cleanliness of the equipment shall be such that it is smooth and free of all foreign matter such as scales, sand, blisters, weld splatters, metal chips and shavings, oil, grease, organic matter, and rust.

B. All metal enclosures shall be chemically cleaned and treated in a process which provides a phosphate coating, then be primed and finished with a corrosion resistant enamel paint.

1. Exterior surfaces shall be painted with dark gray ANSI 24 finish coat, in accordance with the manufacturer's standard practice for the environmental conditions. In addition, the undersurfaces shall be covered with a corrosion resistant protective coating.

2. The CONTRACTOR shall furnish 2 one-pint aerosol spray cans of paint, matching each color used, for field "touch-up" after installation of the equipment.

2.8 ACCESSORIES

A. The switchgear manufacturer shall furnish one set of accessories for test, inspection, maintenance and operation, including:

<table>
<thead>
<tr>
<th>One</th>
<th>Maintenance tool for manually charging the breaker closing spring and manually opening the shutter</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>Levering crank for moving the breaker between the test and connected positions</td>
</tr>
<tr>
<td>Quantity</td>
<td>Description</td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
</tr>
<tr>
<td>One</td>
<td>Test jumper for electrically operating the breaker while out of its compartment</td>
</tr>
<tr>
<td>One</td>
<td>Breaker lifting yoke used for attachment to breaker for lifting breaker on or off compartment rails</td>
</tr>
<tr>
<td>One</td>
<td>Rail clamps for clamping breaker on extended rails for maintenance</td>
</tr>
<tr>
<td>Two</td>
<td>Sets of rail extensions</td>
</tr>
<tr>
<td>One</td>
<td>Mobile lift for lifting the breaker on or off the rails</td>
</tr>
<tr>
<td>Two</td>
<td>Special tools for removal of tamper resistant hardware</td>
</tr>
</tbody>
</table>

**PART 3 -- EXECUTION**

3.1 INSTALLATION

A. The CONTRACTOR shall install the switching center in accordance with the manufacturer's installation instructions and as indicated. The CONTRACTOR shall provide the floor channels in the housekeeping pad and shall secure the switching center to the channels by bolting or tack welding at the front and the rear. Prior to energizing, all equipment shall be cleaned, inspected for loose connections, checked out for electrical and mechanical operations and phase-sequence, and all circuits made free of any shorts or ground connections following field testing.

3.2 MANUFACTURER'S REPRESENTATIVE

A. The CONTRACTOR shall arrange for a technical representative of the manufacturer for pre-commissioning checkout of the equipment and to instruct the operating personnel in the operation, shutdown, startup, and maintenance of the equipment.

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SECTION 261323 - MEDIUM VOLTAGE METAL ENCLOSED SWITCHGEAR

PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide medium voltage metal enclosed switchgear, complete and operable, in accordance with the Contract Documents. The switchgear shall be front accessible such that it can be installed against the wall and shall not require rear access for its maintenance, inspection, or operation.

B. The requirements of Section 26 00 00 - Electrical Work, General, apply to the WORK of this Section.

C. The CONTRACTOR shall include in the work coordination and test support with the WDCWA Ancillary Intake Facility contractor that encompasses the electrical interconnection of the 1250 kW diesel generator set in that contract. The testing shall include activities necessary to both parties to ensure a fully functional standby generator system.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

1. IEEE C37.04, Standard Rating Structure for AC High-Voltage Circuit Breakers (includes supplements C37.04A, C37.04B)

2. IEEE C37.06, Standard for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis – Preferred Ratings and Related Capabilities for Voltages Above 1000 V

3. IEEE C37.09, Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis

4. IEEE C37.20.2, Standard for Metal-Clad Switchgear

5. IEEE C37.20.3, Standard for Metal Enclosed Interrupter Switchgear

6. IEEE C57.13, Standard Requirements for Instrument Transformers

7. IEEE C37.90, Standard for Relays and Relay Systems Associated with Electric Power Apparatus

8. The assembly shall be UL Listed

B. Codes

1. ANSI/NFPA 70 National Electrical Code

1.3 SYSTEM DESCRIPTION

A. Indoor metal enclosed switchgear front accessible only intended for use on 4.16 KV, 3-phase, 3 wire, low impedance grounded, 60-Hz system. Switchgear shall be rated as indicated on the drawings and have removable-element vacuum circuit breakers.
Enclosures and circuit breaker(s), as a unit, shall have a basic impulse rating of 60 KV. Switchgear, including circuit breakers, meters, and relays, shall be factory tested.

B. Equipment shall be completely factory-built, assembled, wired, and tested. All equipment and components shall be of new construction.

C. The switchgear shall be front accessible only and shall not require rear access for its maintenance, inspection, or operation. Mains will have their auxiliaries below the breaker compartment with a separate wiring compartment. Feeder sections shall be capable of housing two breakers adjacent to a wiring cabinet designed for top and bottom cable access. The length of the complete unit shall not exceed the allocated space in the structure as shown on the drawings.

D. The switchgear shall be supplied with a station battery and redundant battery charger that will support the switchgear lineup control power requirements. The battery shall be sized and furnished as part of the switchgear scope of supply.

1.4 CONTRACTOR SUBMITTALS

A. Submittals shall conform to the requirements of Section 260000.

1. Engineering data to include voltage, current, and short-circuit ratings.

2. Outline dimensions to include available space for conduits, stress cone type cable terminations, and cable supports. Furnish front view elevation, floor plan, top view, single line, schematic diagram, conduit entry/exit locations, and component list.

3. Include schematic diagrams showing the switchgear components and interconnections. The diagrams shall show all connections to instruments, relays, controllers, etc. Provide the written description of the automatic transfer to generator system. Schematic diagrams shall be included depicting the circuit breakers control wiring and external control interface with a standby generator.

4. Complete electrical three line and one line diagrams. All protective relays, current transformers, voltage transformers, circuit breakers, and control accessories shall be shown.

5. Complete set of drawings showing the mechanical layout of all the devices in the switchgear.

6. Furnish all documentation for the protective relays utilized and time currents for all the MV circuit breakers.

7. Furnish technical data, instruction manuals, catalog cuts, and bill of materials.

8. Nameplate schedule

9. Certified copies of all Type (Design) and Verification Test Reports on a specified product.

10. Copies of installation, operation and maintenance procedures.

11. Operation and maintenance data based on factory and field testing, operation and maintenance of specified product.
12. Certified factory test reports

13. Final factory drawings shall be provided in an electronic format as well as hardcopy format. Provide electronic files in DXF CAD format.

1.5 QUALITY ASSURANCE

A. **General:** All materials shall be tested and inspected in accordance with Section 260000 and the following requirements.

B. Manufacturer shall have specialized in the manufacture and assembly of medium voltage metal enclosed switchgear for a minimum of 20 years. Major components in the assembly shall be by the same manufacturer of the switchgear.

C. Manufacturer’s Certificate of ISO 9002 Compliance.

D. Switchgear shall be qualified for use in seismic areas as follows:
   1. High seismic loading as defined in IEEE Std 693-1997, with 1.4 amplification factor.
   2. IBC-2003, $S_d = 1.10g$, $S_s = 165\%$, $I_p = 1.5$, for all $z/h$ greater than 0 and $S_d = 1.75g$, $S_s = 262\%$, $I_p = 1.5$, for $z/h$ equal to 0 in accordance with ICC-ES-AC156.
   3. Seismic compliance shall be qualified only through shake table testing. Compliance by calculation is not acceptable.

1.6 PROJECT CONDITIONS (SITE ENVIRONMENTAL CONDITIONS)

A. The switchgear shall be designed for continuous duty service in the environmental conditions in Section 260000.

B. Follow (standards) service conditions before, during and after switchgear installation.

C. Switchgear shall be located in the ventilated pump building, and away from hazardous materials. Ambient temperature of area will range between 10 to 40 degrees C indoors.

1.7 MAINTENANCE AND GUARANTEE

A. The CONTRACTOR shall submit recommended spare part lists.

B. Special tools and equipment for system and equipment maintenance shall be furnished.

C. Manufacturer warrants equipment to be free from defects in materials and workmanship for 2 years from date of commissioning.

D. The CONTRACTOR shall guarantee that the furnished equipment shall meet the requirements specified herein and specified elsewhere in the Contract Documents.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Switchgear shall consist of breaker and auxiliary units, as indicated on drawings, assembled to form a rigid, self-supporting, metal-enclosed structure. Mains will have their auxiliaries below the breaker compartment with a separate wiring compartment.
Feeder sections shall be capable of housing two breakers adjacent to a wiring cabinet designed for top and bottom cable access. The switchgear assembly shall be metal-enclosed, dead front vertical sections requiring only front access for connection, maintenance and operation of the switchgear and containing various combinations of circuit breakers and auxiliaries of rating and type noted on the drawings. The switchgear shall be provided in compliance with this Specification and with all applicable NEMA and ANSI standards. All major components shall be provided by Eaton Electrical, or equal, establishing one source of responsibility for the equipment performance and assuring high standards in quality, coordination, reliability, and service.

B. Switchgear shall be Eaton’s Cutler - Hammer MEF Front-Access Metal Enclosed Switchgear, no equal.

C. Switchgear assembly shall be UL listed and be labeled where possible.

D. The bus bar shall be copper and fully insulated; copper shall be tin plated at joints. All accessible bolted joints shall be covered with insulating boots of the same insulation rating of the bus insulation. A full-length, tin plated, ground bus bar shall be provided at the bottom of the switchgear enclosure.

E. For rigidity during fault conditions all connections to roll-out potential transformer trays and control power transformer trays shall be rigid bus bars insulated to full voltage rating of switchgear assembly.

F. Circuit breaker compartments shall be designed to house 5.0 KV removable-element circuit breakers. Stationary primary disconnect contacts shall be silver-plated copper. Grounded metal safety shutters shall isolate all primary connections in compartment when breaker is withdrawn from connected position. This shall be in compliance with C37.20.2 for use with removable switching and interrupting devices.

G. Metal-enclosed design per C37.20.3, but with removable barriers between primary circuits in cable pull-sections, or bus-transition sections.

2.2 SERVICE

A. The switchgear shall be suitable for operation at 4.16 nominal kV, 3 phase, 60 Hz low resistance grounded system. The switchgear shall have an interrupting rating as indicated on the drawings.

2.3 ENCLOSURE

A. The switchgear enclosure shall be an indoor, NEMA Type I enclosure.

B. The switchgear shall be rodent-and bird-proof.

C. The floor-standing switchgear shall be shipped fully assembled and tested; if shipping breaks are imperative, the units shall be assembled and tested then broken down for shipping.

D. Energized bare parts mounted on doors shall be guarded where the door must be opened for maintenance of equipment or removal of drawout equipment.

E. The switchgear shall be front accessible such that it can be installed against the wall, and shall not require rear access for its maintenance, inspection, or operation. Primary bus joints and supports that are not accessible from the front are to be designed such
that no maintenance is necessary for those joints or supports. All necessary access for owner’s primary cable terminations, joining of main and ground bus joints at shipping splits, and termination of control wires shall be provided from the front or top of the switchgear. Access to primary cable terminals shall not require the removal of any primary or secondary devices. All doors shall be hinged on the same side and shall have no sharp corners.

F. Cable compartment doors shall be equipped with **IRISS 4” infrared inspection windows** with cover catalog number **VPFR-100** or equal. Windows shall be placed in line with the cable terminations to facilitate IR inspection without opening the cable compartment door.

G. Access to any medium-voltage cable or bus connection shall be through removable panels requiring the use of tools and shall be marked with caution signs to indicate the presence of energized conductors behind them.

H. The switchgear design shall allow safe installation and removal of all drawout elements into and from their compartments. No high voltage circuits shall be exposed to maintenance personnel when drawout element compartment doors are opened or drawout elements are removed from the compartment. A metal safety shutter shall automatically cover those stationary high voltage contacts when the breaker is in the test or disconnected position or out of the cell. No high voltage circuits shall be exposed when control compartment doors are opened. Clearly visible caution signs and warnings shall be placed on all removable covers or bolted panels provided for access to primary circuits and cables.

I. All low voltage devices and their associated control wiring shall be isolated by grounded metal barriers from primary circuits with the exception of short lengths of wires such as at instrument transformer and space heater terminals. Thermostatically controlled space heaters shall be supplied rated at 240V and powered at 120VAC. The lineup shall include a CPT to power the space heaters independent of the facility power distribution.

J. Each circuit breaker shall have three positions within its compartment, with compartment door closed: Disconnected, Test, and Connected.

   1. In the **DISCONNECTED** position, no primary high voltage or secondary control wiring connections shall be made and the safety shutters automatically close over the stationary high voltage contacts in the compartment.

   2. The **TEST** position shall be same as the **DISCONNECTED** position, except secondary control wiring shall be connected so that the breaker can be opened or closed electrically or manually.

   3. In the **CONNECTED** position, the circuit breaker shall be in the normal operating position inside the compartment, with safety shutters fully opened, and primary and secondary connections fully made. Provide a label or other marking on the compartment floor, visible when compartment door is opened, to indicate that the circuit breaker is fully connected.

K. Provide the following interlocks for each drawout circuit breaker to insure safe and proper operation:

   1. It shall not be possible to engage levering crank and withdraw the breaker when the breaker is in the connected position and closed.
2. It shall not be possible to close the circuit breaker manually or electrically while it is being levered or while the breaker is in any position between the connected and the test/disconnected.

3. It shall not be possible to insert the circuit breaker into the connected position if the circuit breaker control wiring connector is not properly engaged with its compartment control wiring connector. Interlocking shall also be provided to prevent disconnection of circuit breaker control wiring connector (manually or automatically) while the circuit breaker is in the connected position or in any position between the connected and the test/disconnected.

L. Vertical section construction shall be of the universal frame type using die-formed bolted and welded parts. All enclosing covers and doors shall be fabricated from steel whose thickness shall be equal to or greater than those specified in ANSI/IEEE C37.20.3.

M. Provide a mimic bus on front of the enclosure. Mimic bus shall be adhesively backed plastic.

1. The housing color shall be ANSI 61 gray.

2.4 DESIGN AND CONSTRUCTION FEATURES

A. The switchgear configuration shall be as indicated on drawings.

B. Incoming and outgoing sections shall have ample space for stress-cone terminations, lightning arresters where noted. All terminals and lugs shall be of the solderless type suitable for copper cables of size indicated and with NEMA 2-hole configuration.

C. Main Bus

1. The main bus shall be tin plated copper and rated as indicated on drawings. Bus bars shall have a continuous current rating based on temperature rise and documented by design tests. All joints will be tin plated with at least 2 bolts per joint. Bus bars will be braced to withstand magnetic stresses developed by currents equal to main power circuit breaker close, carry, and interrupt ratings. Access to bus bars shall be through removable top panels. The entire bus, except for terminations, shall be isolated with metal barriers in the breaker sections, and insulated as required by ANSI Standards. Optional removable barriers shall be of the same metal gauge or polyester glass with the same rating of the switchgear shown on the drawings.

D. Ground Bus

1. A ground bus (1/4 by 2 inch tin plated copper) shall extend throughout assembly with connections to each breaker grounding contact and cable compartment ground terminal. Joints shall be made up as indicated in drawings. Station ground connection points shall be located in each end section. Each cable compartment ground bus location shall be equipped with a Hubbell ball ground stud 5/8" diameter with an orange cover or equal.

E. Circuit Breakers

1. Circuit breakers shall be rated as indicated on drawings. Circuit breakers of equal rating shall be interchangeable. Circuit breakers shall be operated by an electrically charged, mechanically and electrically trip-free, stored-energy spring. A handle shall
be used to manually charge the spring for slow closing of contacts for inspection or adjustment. All breakers in the metal enclosed front access only switchgear shall be electrically operated with a breaker interface HMI located on a remote control enclosure in the electrical room.

2. Circuit breakers shall be equipped with secondary disconnecting contacts which shall automatically engage in the connected position.

3. The circuit breakers shall be horizontal drawout type, capable of being withdrawn on rails. The breakers shall be operated by a motor-charged stored energy spring mechanism, charged normally by a universal electric motor and in an standby by a manual handle. The primary disconnecting contacts shall be silver-plated copper.

4. Each circuit breaker shall contain three vacuum interrupters separately mounted in a self-contained, self-aligning pole unit, which can be removed easily. A contact wear gap indicator for each vacuum interrupter, which requires no tools to indicate available contact life, shall be easily visible when the breaker is removed from its compartment.

5. Each breaker compartment shall have a breaker rackout device. Using rackout device, a breaker will be self-aligning and will be held rigidly in the operating position. In the disconnect position, breaker shall be easily removable from compartment. Breaker racking shall be accomplished with door closed and latched. Insert handle through a hole in front door to operate rackout device.

6. An indicating tape shall show breaker position when racking breakers in or out of their connected positions

7. Interlocks shall prevent moving breaker to or from operating position unless main contacts are open. Operating springs shall be discharged automatically when breaker is rolled fully into connected or disconnected position. Rackout device shall have provisions to padlock in connected or disconnected position. When locked in disconnected position, breaker shall be removable from compartment using portable lifting device. Padlock shall not interfere with breaker operation.

8. Automatic shutters shall cover primary disconnect stabs when breaker is withdrawn to test/disconnect position. Shutters shall be positively driven by linkages connected to racking mechanism. A stationary barrier shall be located in front of the shutters for additional safety.

9. Each circuit breaker shall be supplied with Manual “ON” and “OFF” push buttons located on the front of the circuit breaker for opening and closing the breaker manually, without a need for external control power.

10. Breaker control voltage shall be 125 VDC.

11. Circuit breakers shall have a maximum rated interrupting time of 5 cycles.

12. Each circuit breaker shall be equipped with mechanical operations counter on the front of the breaker to provide record of the number of circuit breaker operations

13. One control circuit cutout device shall be provided and installed in the control compartment of each circuit breaker for control circuit isolation and short circuit protection.
14. For EO circuit breakers, provide pad lockable hinged plastic cover to limit access to Manual “OFF” pushbutton and completely prevent access to Manual “ON” pushbutton.

15. Each circuit breaker shall be provided with an auxiliary switch containing five “a” (NO) and five “b” (NC). All spare contacts shall be wired to terminal blocks for Owner’s use.

16. Each circuit breaker shall be provided with a position switch indicating whether the circuit breaker is in the “Connect” or Disconnect” position. All spare contacts shall be wired to terminal boards.

17. Main and Generator breaker closing circuits shall be wired to prevent parallel connection of the utility source through the tie breaker.

2.5 PROTECTIVE RELAYS

A. The switchgear manufacturer shall furnish and install, in the metal-enclosed switchgear, the quantity, type and rating of protection relays as indicated on the drawings and described hereafter in this specification. The protective relays shall be Eaton EDR relays or approved equals.

B. The Main and Generator breakers shall be Eaton Type EDR-5000, microprocessor based multifunction protection and metering unit or equal. ANSI device functions: 51/50, 51N/50N, 50BF, 25, 32, 46, 67, 27, 59, 47, 81-O, 81-U, and 86. The relay shall be powered from an external 125 VDC control power source.

C. The switchgear feeders shall be protected by Eaton Type EDR-4000, microprocessor based multifunction overcurrent protection relay or equal. ANSI device functions: 51/50, 51N/50N, 50BF, 46, 67, 27, 59, 47, 81-O, 81-U, and 86. The relay shall be powered from an external 125 VDC control power source.

D. All protective-type relays shall be suitable for operation at a frequency of 60 Hz with current transformers (CTs) having 5 ampere secondary circuits and with potential transformers (VTs) having 120 V secondary circuits. Zero sequence CTs shall be included when shown on the drawings. CT ratios are noted on the contract drawings. The relaying class CTs shall be C100 minimum.

E. Furnish the compatible software package that allows remote monitoring of all the relays above. Owner will install the software on Owner supplied workstation. The Manufacturer shall furnish required hardware to allow remote monitoring.

2.6 INTERFACE/CONTROL DEVICES

A. Provide automatic open transition transfer control (ATC) scheme. The ATC shall be programmed to respond to a utility outage and is shall call for the local standby generator to start. Once the generator power is available, it shall close the generator circuit breaker and power the dead bus. The controller shall be a solid state, programmable PLC that can carry the all the required functions for a fully functional system and generator handshake.

1. When the voltage on any phase of the normal source drops below 80% or increases to 120%, or frequency drops below 90%, or increase to 110%, or 20% voltage differential between phases occurs, after a programmable time delay period of 0-
9999 seconds factory set at 5 seconds to allow for momentary dips, the engine starting contacts shall close to start the generator.

2. The transfer switch shall transfer to standby when the generator has reached specified voltage and frequency on all phases and 30 seconds (user adjustable) minimum delay.

3. After restoration of normal power on all phases to a preset value of at least 95% to 105% of rated voltage, and at least 97% to 102% of rated frequency, and voltage differential is below 10%, an adjustable time delay period of 0-9999 seconds (factory set at 300 second) shall delay retransfer to allow stabilization of normal power. Generator breaker (52-G) shall open first and then after 30 seconds delay Utility breaker (52-U) shall close. If the standby power source should fail during this time delay period, the switch shall automatically return to the normal source.

4. After opening of generator breaker (52-G), the engine generator shall be allowed to operate at no load for a programmable period of 0-9999 seconds, factory set at 300 seconds.

5. The ATC controller shall post an alarm to the station PLC that the utility power source is out.

6. The ATC shall post “ATC FAIL” alarm when the system is nonfunctional or has been tampered with. The ATC controller shall poll the status of all the breakers in the lineup.

7. The ATC shall be equipped with an Ethernet port for external communications. The manufacturer shall map the communications stack for external polling by the station PLC. The communications protocol shall be coordinated with the PLC programmer. The polled communications matrix shall be provided to the PLC programmer.

B. Automatic Transfer Switch Controls

1. The transfer switch shall be equipped with a microprocessor based control system, to provide all the operational functions of the automatic transfer switch. The controller shall have two asynchronous serial ports and one Ethernet port. The controller shall have a real time clock with NiCad battery backup and flash memory.

2. The CPU shall be equipped with self-diagnostics which perform periodic checks of the memory I/O and communication circuits, with a watchdog/power fail circuit.

3. The controller shall be provided with 2 NO and 2 NC contacts for customer outputs for remote indication of ATC system status.

4. The controller shall have password protection required limiting access to qualified and authorized personnel.

5. The controller shall include a LED HMI interface, with a touch keypad, that allows access to the system.

6. The controller shall include three-phase over/under voltage, over/under frequency, phase sequence detection and phase differential monitoring on both normal and standby sources.
7. The controller shall have facilities to exercise an external diesel generator. Manufacturer to coordinate with Owner’s Engineer for required interface to the external generator.

8. The controller shall be capable of storing the following records in memory for access either locally or remotely:
   a. Number of hours the system is in the standby position (total since record reset).
   b. Number of hours standby power is available (total since record reset).
   c. Total breaker transfer operations in either direction (total since record reset).
   d. Date, time, and description of the last four source failures.
   e. Date of the last exercise period.
   f. Date of record reset

C. Automatic Transfer Scheme Accessories

1. Programmable three phase sensing of the normal source set to pickup at 90% and dropout at 80% of rated voltage and overvoltage to pickup at 120% and dropout out at 110% of rated voltage. Programmable frequency pickup at 95% and dropout at 90% and over frequency to pickup at 110% and dropout at 105% of rated frequency. Programmable voltage differential between phases, set at 20% and phase sequence monitoring.

2. Programmable three phase sensing of the standby source set to pickup at 90% and dropout at 80% of rated voltage and overvoltage to pickup at 120% and dropout out at 110% of rated voltage programmable frequency pickup at 95% and dropout at 90% and over frequency to pickup at 110% and dropout at 105% of rated frequency. Programmable voltage differential between phases set at 20%, and phase sequence monitoring.

3. Time delay for override of momentary normal source power outages (delays engine start signal and transfer switch operation). Programmable 0-9999 seconds. Factory set at 3 seconds, if not otherwise specified.

4. Time delay to control breaker transition time on open transition transfer to either source. Programmable 0-9999 seconds, factory set at 30 seconds.

5. Time delay on retransfer to normal, programmable 0-9999 seconds, factory set at 300 seconds if not otherwise specified, with overrun to provide programmable 0-9999 second time delay, factory set at 300 seconds, unloaded engine operation after retransfer to normal.

6. Time delay on transfer to standby, programmable 0-9999 seconds, factory set at 3 minutes.

7. A maintained type load test switch shall be included to simulate a normal power failure, keypad initiated.

8. A push-button to reset fail to transfer.
9. Contact, rated 10 Amps 30 volts DC, to close on failure of normal source to initiate engine starting.

10. Contact, rated 10 Amps 30 volts DC, to open on failure of normal source for customer functions.

11. LED pilots shall be mounted on the controller door to indicate:
   a. White pilot for system in normal state (Utility supply)
   b. Red pilot for system in standby state (Standby generator active)
   c. Amber pilot for system failure to transfer (System trouble)

12. A three phase digital LCD voltage readout, with 1% accuracy shall display all three separate phase to phase voltages simultaneously, for both the normal and standby source. Voltage parameters shall be available on the HMI interface and remotely.

13. A digital LCD frequency readout with 1% accuracy shall display frequency for both normal and standby source. This parameter shall be made available on the HMI interface and remotely.

14. A color LED HMI touch screen shall display the system status, normal source, standby source, generator status, fuel status, alarm banners, etc., to facilitate operation of the system as a whole.

15. A normal control breaker trip relay with contact wired to terminal strip. Contact to trip normal circuit breaker if closed transition position has exceeds time setting.

16. An standby control breaker trip relay with contact wired to terminal strip. Contact to trip standby circuit breaker if closed transition position has exceeds time setting.

17. One (1) set of control wiring, fuses, fuse blocks, terminals, nameplates, etc. All wiring to be labeled at both ends. Wiring shall match manufacturer drawings.

18. The system shall have facilities, hardwired and software, for a closed transition hand-off to the utility. The facilities will be disabled initially and activated by the manufacturer representative when the Owner requests it.

2.7 CONTROL POWER AND WIRING

A. Provide control power transformers where indicated on drawings. Transformers shall be rated as indicated. Transformers rated 15kVA single phase and less shall be mounted on roll-out trays. Control power shall be utilized for switchgear thermostatically controlled heaters.

B. Furnish all necessary components for a station battery that shall provide 125VDC control power. The 125VDC control power system shall include redundant battery chargers and the station battery as described below.

1. Breaker control voltage for closing and tripping power shall be 125 volts DC. The control power for each circuit breaker shall be obtained from a complete system of 125 V DC batteries with redundant battery chargers (two separate chargers minimum) and a DC distribution panel.
2. The redundant battery chargers shall operate concurrently. Automatic transfer controls shall be provided such that upon a failure of one of the chargers, the nonfunctional charger is isolated from the charging circuit, and the charging circuit is automatically transferred to the redundant charger. The chargers shall be equipped with a load sharing module to force the output voltage at the same level on both units.

3. The 125 V DC batteries, each of the redundant battery chargers, and the DC distribution panel shall be sized to provide adequate control power to all devices in the switchgear that operate on 125 V DC control power.

4. The 125 V DC batteries shall be nickel-cadmium pocket plate type constructed cells. Ampere-hour rating shall be calculated as an all-inclusive system including the estimated ampere-hour rating required for two complete trip, close, spring charge and simultaneous operation of 8 medium voltage circuit breakers supplied with a 5A standing load and the automatic transfer control system. Design margin shall be 15 percent with an aging factor of 25 percent.

5. The battery rack shall be designed in accordance with the seismic requirements on subsection 1.5.D above in this document. Battery rack shall be two-step, acid-resistant, and shall include brackets, inter-rack, and inter-row connectors. Provide a means to cover the battery terminals to prevent accidental shorting of the battery by a metal object. The battery rack shall incorporate spill containment resistant to the electrolytic used in the battery.

6. The batteries shall have a full 5 year warranty that will cover complete replacement if they fail. After 5 years and up to 20 years battery replacement shall be prorated.

7. The 125VDC redundant battery chargers shall be microprocessor controlled. They shall be sized to recharge the batteries from their discharged state within 12 hours. Parallel operation of the two chargers shall be a standard feature of the filtered charger with random load sharing. The battery chargers shall include the following features:
   a. AC input and DC output circuit breakers and 125VDC rated panelboard. See Drawings.
   b. Output ripple of 30mV rms or less.
   c. Digital ammeter and voltmeter.
   d. Combined alarm status monitor.
   e. Upon a failure of a battery charger, the failure status shall be displayed through an alarm light on the front of the switchgear and a dry contact output for the charger failure shall be wired to a terminal strip for monitoring by the plant PLC system.
   f. The battery chargers shall be mounted vertically to minimize space footprint. The installation shall comply with the seismic requirements on section 1.5.D above.
   g. Manufacturer of the battery charger and system shall be Alcad Model AT10, or equal.
C. Secondary control wiring shall be No. 14, extra flexible, stranded, tinned-copper control wire, Type SIS cross-linked polyethylene, rated 600 volts, except for specific circuits requiring larger wire.

D. Crimp-type, insulated ring terminals shall be furnished on all wire ends, except where non-insulated ring terminals are used to connect to fuse blocks, instrument studs, or terminal block points with two or more wire connections.

E. Secondary control wires shall be armored where they pass through primary compartments.

F. Short circuit style terminal blocks shall be installed in current transformer secondary wiring between the current transformer and all connected devices.

G. Provide marking sleeves on all switchgear control wiring, heat stamped with wire origin and / or destination information.

2.8 SURFACE PREPARATION, PAINTING AND CLEANLINESS

A. Cleanliness of the equipment furnished shall be such that it is smooth and free of all foreign matter such as scales, sand, blisters, weld splatters, metal chips and shavings, oil, grease, organic matter, and rust.

B. All metal enclosures shall be chemically cleaned and treated in a process which provides a phosphate coating, then be primed and finished with corrosion resistant enamel paint.

1. The switchgear shall be painted with an electrostatically applied polyester powder with final baked on average thickness between 1.5 and 2.0 mils and meet ANSI requirements for indoor equipment.

2. All exterior surfaces of the switchgear assembly shall be given final finish coats of ANSI 61 gray as standard.

3. Finish shall have a minimum pencil hardness of 2H as tested per ASTM D3363 and shall pass the SATM B117 Salt spray test for a minimum of 1000 hours.

C. The CONTRACTOR shall supply paint, matching each color used, for field "touch-up" after installation of the equipment. Two one-pint aerosol spray cans of each color shall be supplied per assembly.

2.9 ACCESSORIES

A. Provide two indicating lights (red and green) for each breaker and one indicating light (white) for each lockout relay, when provided. The indicating lights shall be GE type ET-16 or equal.

B. Provide a hand-resetable lockout relay (device 86) where indicated on the drawings. The lockout relay shall disable closing of the corresponding circuit breaker until the relay has been reset. The lockout relay shall be a GE type HEA or equal.

C. Provide station class arresters where indicated on drawings. Arresters shall be gapless metal-oxide type with a nominal rating of 6 kV and an MCOV of 5.10 kV. The arrester shall be enclosed in a polymer housing. Arresters shall be designed and manufactured
in accordance with the latest revision of ANSI/IEEE C62.11. Arresters shall be GE type Tranquell or approved equal.

D. Non-drawout style protective relays shall be furnished with test switches to permit trip blocking, relay isolation and testing. Test switch shall be GE Multilin type 515 or approved equal.

E. The switchgear manufacturer shall furnish one set of accessories for each line-up for test, inspection, maintenance and operation, including:

1. 1 Ground and test device
2. 1 Levering crank for manually moving the breaker between the test and connected positions
3. 1 Breaker extension pan
4. 1 VT/CPT drawer extension rails
5. 1 Mobile lift for lifting the breaker on or off the rails
6. 1 Test jumper
7. 1 Breaker lifting yoke
8. 1 High potential test kit
9. 1 Remote racking device including push-button, motor operator, and 25 feet of cable

2.10 NAMEPLATES

A. Furnish nameplates for each device as indicated in drawings. Nameplates shall be black and white 1/8-inch thick lamicoid, with lettering engraved through the black surface exposing the white lamination beneath. Letter height shall be 1/8-inch minimum unless otherwise indicated. Nameplate shall be fastened using 2 matching screws; adhesive tape is not acceptable.

B. The switchgear shall carry a manufacturer’s label stating switchgear ratings and catalog or shipping number as well as the name of the manufacturer.

2.11 FACTORY TESTS

A. The switchgear equipment and circuit breakers shall receive factory production test as listed below:

1. Equipment
   a. Low frequency dielectric test
   b. Grounding of instrument cases
   c. Control wiring and device functional test
   d. Polarity verification
e. Sequence test
f. Low frequency withstand voltage test on major insulation components
g. Low frequency withstand test on secondary control wiring

2. Breakers
   a. Coil check test
   b. Clearance and mechanical adjustment
c. 300 Electrical and mechanical operation test
d. Timing test
e. Conductivity of current path test
   f. Hi-potential testing of breaker
g. Vacuum bottle integrity test

B. Manufacturer shall provide to the Engineer documents verifying completion of factory production tests.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. The CONTRACTOR shall install the switchgear in accordance with the manufacturer's installation instructions and as indicated. The CONTRACTOR shall provide the housekeeping pad, approved seismic calculations and the recommended hardware to install the switchgear as required by the manufacturer.

B. Floor standing equipment shall be leveled with shims as required to maintain horizontal surfaces within 1/32-inch per horizontal foot. After leveling, equipment shall be anchored, and then grouted so that no space exists between its housekeeping concrete pad and the equipment structural elements.

C. Prior to energizing, all equipment shall be cleaned, inspected for loose connections, checked out for electrical and mechanical operations and phase-sequence, and all circuits made free of any shorts or ground connections following field testing.

D. Omissions or conflicts on Drawings or between Drawings and Specifications shall be brought to the attention of the ENGINEER for clarification before proceeding with the WORK.

3.2 MANUFACTURER'S REPRESENTATIVE

A. The CONTRACTOR shall arrange for a technical representative of the manufacturer for pre-commissioning checkout of the equipment and to instruct the operating personnel in the operation, shutdown, startup and maintenance of the equipment.

B. The manufacturer shall be responsible for activation and acceptance of switchgear
3.3 COORDINATION WITH WDCWA ANCILLARY INTAKE FACILITY

A. The CONTRACTOR shall coordinate the testing of the diesel generator electrical (by others) electrical interface with the controls in the medium voltage Switchgear on this section.

B. The CONTRACTOR shall include generator breaker settings for a 1,250kW, 4.16kV, 3-phase, diesel generator set. The settings prepared per Section 260573 shall incorporate the genset.

C. The CONTRACTOR shall provide access to the WDCWA Ancillary Intake Facility diesel genset installer to allow the installation of the the power and control cables. The CONTRACTOR personnel shall be present during the cable pulling and termination of the power and control conductors originating at the Ancillary Intake Facility.

D. The CONTRACTOR shall conduct the switchgear testing with the diesel generator set once the remote generator by others is made ready for testing. The CONTRACTOR shall verify that all the I/O points required from the diesel generator set are verified at the local Automatic Transfer Controller with the help of the switchgear manufacturer field representative.

E. The CONTRACTOR shall obtain a copy of the signed test documentation generated by the WDCWA Ancillary Intake Facility diesel genset installer once the testing is completed. The noted test documents shall be incorporated in the test submittal for the switchgear in this section.

- END OF SECTION -
PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. Provide wood poles, crossarms and timbers, crossarm braces, hardware, pins, racks, hot-line clamps, insulators, guys, guy hooks, guy strain plates, guy wires, guy protectors, anchors, and appurtenant WORK, complete and operable, as indicated in accordance with the Contract Documents.

B. The requirements of Section 260000 – Electrical Work, General, apply to the WORK of this Section.

1.2 REFERENCE CODES AND STANDARDS

A. Without limiting the generality of other requirements of these specifications, the WORK herein shall conform to or exceed the applicable requirements of the National Electrical Code (NEC), provided that where a local code or ordinance is in conflict with the NEC the provisions of said local code or ordinance shall take precedence.

B. Codes

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<tr>
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<th>Description</th>
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<tr>
<td>NEC</td>
<td>National Electrical Code</td>
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C. Commercial Standards

<table>
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<th>Code</th>
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<td>ANSI/IEEE C135.6</td>
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<tr>
<td>AWPA P5</td>
<td>Standards for Waterborne Preservatives</td>
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1.3 CONTRACTOR SUBMITTALS

A. Submit Shop Drawings of the poles and hardware in accordance with the requirements of Section 013300 – Contractor Submittals.

B. Coordination with Utility Company
   1. Furnish such submittals to the utility company having jurisdiction as the utility company may require.
   2. Submittal approvals shall be obtained from the utility company prior to fabrication.

C. Submit manufacturer’s product data for the following items:
   1. wood poles
   2. crossarms and timbers
   3. crossarm braces
   4. hardware, pins and racks
   5. insulator guys
   6. accessories

D. Submit certificates for the following items showing conformance with the referenced Standards indicated in this Section:
   1. wood poles
   2. crossarms and timbers
   3. crossarm braces
   4. hardware, pins and racks
   5. insulator guys
   6. accessories
1.4 QUALITY ASSURANCE

A. General: Inspect materials for compliance with the requirements of Section 260000 – Electrical Work, General and tested in accordance with the requirements of Section 260126 – Electrical Tests.

1.5 WARRANTY

A. The system warranty shall be for not less than one year after initial startup and shall include all costs for repair, parts, travel and living expenses, and labor.

1.6 TECHNICAL MANUAL

A. Submit complete information as indicated in Section 260000 – Electrical Work, General.

B. Supplement the data sheets by written texts, including the following:
   1. maintenance procedures
   2. manufacturer's parts list, illustrations, assemblies and diagrams

PART 2 – PRODUCTS

2.1 GENERAL

A. Materials
   1. Equipment and materials provided under this Section:
      a. shall be new;
      b. shall be in accordance with the Institute of Electrical and Electronic Engineers, the National Electrical Manufacturer's Association, the National Fire Protection Association, and the National Electrical Code; and,
      c. shall bear the Underwriters' Laboratories label where such service is regularly available.

B. Equipment: Similar items in the WORK shall be products of the same manufacturer.

C. Standard Products
   1. Materials and equipment submitted for approval:
      a. shall be the catalogued products of companies regularly engaged in the manufacture of such items;
      b. shall be the latest standard design that conforms to the specification requirements; and,
      c. shall essentially duplicate material and equipment that has been in satisfactory use for several years.
2.2 WOOD POLES

A. Provide wood poles consisting of treated Southern Pine in accordance with ANSI O5.1.

B. Carefully select the poles for straightness and ensure that they have no sweeps or short crooks exceeding the maximum sweeps and short crooks permitted in ANSI O5.1.

C. Preservatives
   1. Preservatives used for protection in a humid, harsh environment shall consist of Chromated Copper Arsenate, Type (A), conforming to AWPA C4 and ASTM D 1625.
   2. Treat wood poles with waterborne preservatives conforming to AWPA P5.
   3. Apply the preservative treatment using a pressure process conforming to AWPA C1 and AWPA C4 for Southern Pine.
   4. The penetration of the preservatives shall be determined as specified in AWPA A3, and complete sapwood penetration shall be obtained.
   5. Roofing, Gaining and Boring
      a. Poles that are to be given a full-length preservative treatment shall be roofed, gained and bored before treatment.
      b. Plug unused holes in poles with treated wood-dowel pins.
      c. Treat field-cut gains or field-bored holes in poles with an approved preservative compound.

D. Storage
   1. Poles stored for more than 2 weeks shall be stacked on pressure-treated or decay-resistant skids of such dimensions and arranged as to support the poles without producing noticeable distortion.
   2. Stack the poles in a manner that will permit the free circulation of air.
   3. Locate the poles at the bottom of the stacks at least one foot above ground level or any vegetation growing thereon.
   4. No decayed or decaying wood will be permitted to remain beneath stored poles.

E. Handling
   1. Do not drag treated poles along the ground.
   2. Pole tongs, cant hooks, and other pointed tools capable of producing indentations more than one inch in depth shall not be used in handling the poles.
   3. No tools shall be applied to the groundline section of a pole; the groundline section is defined as that portion between one foot above and 2 feet below the groundline.
2.3 CROSSARMS AND TIMBERS

A. Before pressure treatment, crossarms shall be machined, chamfered, trimmed, and bored for required pins and bolts.

B. Provide crossarms and timbers from straight and close-grained southern pine, pressure-treated to 8 pounds minimum retention with complete sapwood penetration.

C. The treatment of crossarms and timbers shall meet the requirements of AWPA C25.

D. Crossarms shall be 4-1/4 by 5-1/4 inches by 9 feet, unless otherwise indicated, and shall be straight and free of twists to within 1/10 inch per foot of length.

E. Bends or twists shall be in one direction only.

F. Vertical and longitudinal strength of crossarms shall conform to the requirements of IEEE C2. 2.4

2.4 CROSSARM BRACES

A. Construct crossarm braces of zinc-coated structural steel conforming to ASTM A 675/A 675M.

B. Crossarm braces shall meet the requirements of ANSI C135.6.

C. Angle Braces
   1. Angle brace dimensions shall be 60 inches span by 18 inches.
   2. Drop-form angle braces in one piece from a 1-3/4 by 1-3/4-inch angle.

D. Flat Braces
   1. Flat brace cross-sectional dimensions shall be 1/4 inch by 1-1/4 inches.
   2. Flat braces shall be not less than 20 inches in length for arms 4 feet or less in length, and not less than 28 inches in length for arms exceeding 4 feet in length.

2.5 HARDWARE, PINS, AND RACKS

A. Miscellaneous Hardware
   1. Pole-line hardware shall be hot-dip galvanized after fabrication.
   2. Washers
      a. Install suitable washers under bolt heads and nuts on wood surfaces.
      b. Size the washers used on through-bolts and double-arming bolts approximately 2-1/4 inches square and 3/16-inch thick.
      c. The diameter of holes in washers shall be the correct standard size for the bolts with which the washers are used.
d. Washers for use under the heads of carriage bolts shall be the proper size to fit over the square shank of the bolt.

3. Pole-line hardware shall meet the requirements of IEEE C135.1 for steel bolts and nuts.

B. Pins

1. Construct pins of zinc-coated forged steel, with lead-thread height to suit the insulator to be installed but not less than 4-1/2 inches high by 5/8-inch diameter.

2. The pin's shoulder shall be not less than 2-inch diameter and shall be designed to distribute the load uniformly to the crossarm.

3. Shank
   a. The pin's shank shall be not less than 5/8-inch diameter by 5-3/4 inch in length.
   b. Equip the shank with a 2-inch square washer, nut, and locknut.
   c. The shank shall project not less than 1/8 inch nor more than 2 inches beyond the locknut.

4. The broad-base corner pins of drop-forged welded steel or malleable iron shall be used for turning small angles, as indicated.

C. Hot-Line Clamps

1. Make connections to overhead primary conductors using hot-line clamps of the screw-type with concealed threads.

2. Fill the thread chamber with a corrosion-resistant compound.

3. The hot-line clamp tap conductor shall be composed of bare soft-drawn 7-strand No. 4 copper.

4. The hot-line clamp tap conductor for lateral lines No. 2 and larger shall be composed of bare soft-drawn copper of the same size and stranded as the lateral line.

5. Stirrups
   a. Provide stirrups for hot-line clamp connections.
   b. The stirrups shall be 4 by 4 inches in size.
   c. Construct the stirrups of bare hard-drawn copper of the same size as the tap line but not less than No. 4.

D. Secondary Racks

1. Provide secondary racks of the 2-, 3-, or 4-wire type as required, complete with spool insulators.
2. The racks shall meet industry requirements for the strength and deflection of heavy-duty steel racks, and shall be of either galvanized steel or aluminum alloy construction.

3. Insulators
   a. The top of insulator points shall be rounded and smooth.
   b. Hold the insulators in place with a 5/8-inch buttonhead bolt equipped with a nonferrous cotter pin, or equal retainer, at the bottom.

### 2.6 INSULATORS

A. Insulators for use on primary open-wire construction shall conform to ANSI C29.2, ANSI C29.3, ANSI C29.4, ANSI C29.6, and ANSI C29.7.

B. Insulators shall have a minimum wet flashover rating of 80 kV.

C. Use suspension insulators on the primary system at corners, angles greater than 5 degrees, suspended buses, dead ends, and wherever pin insulators do not provide adequate strength.

D. The mechanical strength of suspension and strain insulators shall exceed the ultimate tensile strength of the conductor or guy attached thereto.

E. Pin insulators used on voltages in excess of 5,000 volts phase-to-phase shall be radio-noise free.

F. Insulators for various uses shall have ratings not less than those indicated in the following table:

<table>
<thead>
<tr>
<th>SERVICE</th>
<th>PIN</th>
<th>LINE POST</th>
<th>SUSPENSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,001- to 15,000-volt</td>
<td>56-3</td>
<td>27-21 or 2s</td>
<td>3 x 52-2*</td>
</tr>
</tbody>
</table>

* Provide a 12-inch extension link in the center phase.

G. Spool Insulators
   1. Spool insulators used on secondaries shall be not smaller than Class 52-2.
   2. Use Class 52-4 spool insulators for conductors sized No. 4/0 and larger.

H. Insulator testing shall be in accordance with ANSI C29.2.

### 2.7 OVERHEAD CONDUCTORS, CONNECTORS AND SPLICES

A. Materials
   1. Conductors shall be composed of bare aluminum alloy (AAAC), and shall be of the indicated sizes and types.
   2. Where aluminum conductors are connected to dissimilar metal, use fittings conforming to the requirements of UL 486A-486B.
3. Aluminum Alloy (AAAC)
   a. ASTM B 398/B 398M or ASTM B 399/B 399M

B. Connectors and Splices
   1. Connectors and splices shall be composed of copper alloys for copper conductors,
   2. Provide aluminum alloys for aluminum-composition conductors, and a type designed to minimize galvanic corrosion for copper to aluminum-composition conductors.
   3. Aluminum-composition, aluminum-composition to copper, and copper-to-copper connectors and splices shall comply with the requirements of UL 486A-486B.

2.8 GUYS
   A. Provide guys of the wrap-type, except where storm guys are indicated.
   B. Guy Hooks and Guy Strain Plates
      1. Guy hooks and guy strain plates shall meet the requirements of IEEE C135.1.
      2. Steel and malleable-iron guy clamps shall meet industry requirements.
   C. **Guy Wires**: Guy wires shall be composed of galvanized steel, with a breaking strength of not less than 10,000 pounds.
   D. Guy Protectors
      1. Polyvinylchloride (PVC) guy protectors shall have a 2-1/4-inch outside width and a minimum thickness of 100 mils.
      2. Use guy protectors in order to visually mark the guy wire at each location that is accessible.
   E. Anchors
      1. Provide anchors of the screw-type.
      2. A 15-inch screw anchor with an 8-foot long by 1-1/2-inch diameter rod will be accepted as a 10,000-pound anchor.

2.9 FACTORY TESTING AND INSPECTION
   A. The inspection of poles, crossarms, and timbers shall be accomplished by a recognized and approved independent timber inspection company.
   B. Treatment
      1. Poles, crossarms, and timbers shall be inspected both prior to and subsequent to treatment.
      2. For the material to be acceptable, the inspection company shall certify that the wood, treating material, and treatment are all in accordance with the requirements of this Section.
PART 3 -- EXECUTION

3.1 INSTALLATION

A. Submit installation drawings for overhead pole line assemblies.

B. Installation shall be in accordance with IEEE C2 for medium loading conditions, Grade B construction.

3.2 POLES

A. Gains

1. Cut gains on the face concave side, or on the side of greatest curvature in poles having reverse or double sweeps between the ground line and the top of the pole.

2. The gained surfaces shall be in approximately parallel planes.

3. Frame the poles as required for the application.

B. Setting of Poles

1. Poles in straight runs shall be set in a straight line.

2. Place curved poles with the curvature in line with the lead pole.

3. Set the poles to maintain as even a grade as practicable.

4. Ground Variance

   a. Where the average ground run is level, consecutive poles shall not vary more than 5 feet in height.

   b. Where the ground is uneven, keep poles of different installed heights to a minimum by locating the poles to avoid the highest and lowest ground points.

5. Shortening

   a. When it becomes necessary to shorten a pole, saw off a piece from the top end.

   b. When poles are shortened after treatment, hot-pressure-treat the shortened end of the pole.

6. Excavation

   a. Mounting holes shall be large enough to permit the proper use of tampers to the full depth of the hole.

   b. Provide fill in 6-inch maximum lifts, then thoroughly compact before the next lift is added.

   c. Place surplus fill around the pole in a conical shape and pack tightly in order to drain water away from the pole.
7. Install poles located at corners, angles, and dead ends with a sufficient degree of rake to ensure sound pole-setting practices.

8. Where poles are to be set along the edge of cuts or embankments or where the soil may be washed out, take special precautions in order to ensure durable foundations.

9. Measure the setting depth from the lower side of the pole.

10. In normal firm ground, provide minimum pole-setting depths as indicated in the following table:

<table>
<thead>
<tr>
<th>Overall Pole Length</th>
<th>Poles in Straight-Line Configuration</th>
<th>Poles at Curves, Corners and Points of Extra Strain</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 ft</td>
<td>5 ft, 6 in</td>
<td>5 ft, 6 in</td>
</tr>
<tr>
<td>35 ft</td>
<td>6 ft, 0 in</td>
<td>6 ft, 0 in</td>
</tr>
<tr>
<td>40 ft</td>
<td>6 ft, 6 in</td>
<td>7 ft, 0 in</td>
</tr>
<tr>
<td>45 ft</td>
<td>7 ft, 0 in</td>
<td>7 ft, 6 in</td>
</tr>
<tr>
<td>50 ft</td>
<td>7 ft, 6 in</td>
<td>8 ft, 0 in</td>
</tr>
<tr>
<td>55 ft</td>
<td>8 ft, 0 in</td>
<td>8 ft, 6 in</td>
</tr>
<tr>
<td>60 ft</td>
<td>8 ft, 0 in</td>
<td>8 ft, 6 in</td>
</tr>
<tr>
<td>65</td>
<td>9 ft, 0 in</td>
<td>9 ft, 6 in</td>
</tr>
<tr>
<td>70</td>
<td>9 ft, 6 in</td>
<td>10 ft, 0 in</td>
</tr>
<tr>
<td>75</td>
<td>10 ft, 0 in</td>
<td>10 ft, 6 in</td>
</tr>
<tr>
<td>80</td>
<td>10 ft, 6 in</td>
<td>11 ft, 6 in</td>
</tr>
<tr>
<td>85</td>
<td>11 ft, 0 in</td>
<td>12 ft, 6 in</td>
</tr>
<tr>
<td>90</td>
<td>12 ft, 6 in</td>
<td>13 ft, 6 in</td>
</tr>
<tr>
<td>95</td>
<td>13 ft, 6 in</td>
<td>14 ft, 6 in</td>
</tr>
<tr>
<td>100</td>
<td>14 ft, 6 in</td>
<td>16 ft, 0 in</td>
</tr>
</tbody>
</table>

C. Marking

1. Mark each pole in accordance with the requirements of ANSI O5.1.

2. Locate the marking on the face of the pole approximately 10 feet from the butt of the pole.

3. Where approved by the ENGINEER, the marking on the face of the pole may be at other pole manufacturer's standard locations.
4. Numbers
   a. Number the poles as indicated.
   b. Number poles without indicated numbers as directed by the ENGINEER.
   c. Pole numbers shall consist of aluminum numerals and characters not less than 2-1/2 inches high, fastened to the pole with aluminum nails.
   d. Locate numerals in order to provide maximum visibility from the road or other access way.

3.3 CROSSARMS AND TIMBERS
   A. Set the crossarms at right angles to the line for straight runs, and bisect the angle of turns.
   B. Bolting
      1. Secure hold the double crossarms in position by means of 5/8-inch double-arming bolts, and provide each double-arming bolt with 4 nuts and 4 square washers.
      2. Bolt the crossarms to the poles with 5/8-inch through-bolts and square washers at each end.
      3. Do not extend bolts less than 1/8 inch nor more than 2 inches beyond the nut.

3.4 CROSSARM BRACES
   A. Provide crossarm braces on the crossarms.
   B. Flat Braces
      1. Bolt flat braces to the crossarms using 3/8-inch carriage bolts, with a round washer between the bolt head and the crossarm.
      2. Secure the braces to the poles with 1/2-inch by 4-inch lag screws after the crossarms have been leveled and aligned.
   C. Angle Braces
      1. Bolt angle braces to the crossarms using 1/2-inch bolts, with a round washer between the bolt head and the crossarm.
      2. Secure the braces shall be secured to the poles using 5/8-inch through-bolts.

3.5 HARDWARE, PINS, AND RACKS
   A. Use eyebolts, bolt eyes, eyenuts, strain load plates, lag screws, guy clamps, fasteners, hooks, shims, and clevises wherever required in order to adequately support and protect the poles, crossarms, guy wires, and insulators.
   B. Provide hardware of the correct size to fit the pole and crossarms on which they are being installed.
C. Attach racks for dead-ending four No. 4/0 or larger conductors to the poles, using 3 through-bolts of 5/8-inch diameter each.

D. Attach other secondary racks to the poles using at least 2 through-bolts of 5/8-inch diameter each.

E. The minimum vertical spacing between conductors shall be as follows:

<table>
<thead>
<tr>
<th>SPAN LENGTH (feet)</th>
<th>VERTICAL SPAN BETWEEN CONDUCTORS (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>200 or less</td>
<td>6</td>
</tr>
<tr>
<td>201 to 250</td>
<td>8</td>
</tr>
<tr>
<td>251 to 300</td>
<td>12</td>
</tr>
</tbody>
</table>

3.6 CONDUCTOR INSTALLATION

A. Line Conductors

1. Unless otherwise indicated, install conductors in accordance with the manufacturer's approved tables of sags and tensions.

2. Handle conductors with necessary care in order to prevent nicking, kinking, gouging, abrasions, sharp bends, cuts, flattening, or otherwise deforming or weakening the conductor or causing any damage to its insulation or impairing its conductivity.

3. Remove damaged sections of the conductor and the splice conductor.

4. Pay out conductors with the free end of conductors fixed and cable reels portable, except where terrain or obstructions make this method unfeasible.

5. The bend radius for any insulated conductor shall not be less than the applicable NEMA specification recommendation.

6. Do not draw conductors over rough or rocky ground, nor around sharp bends.

7. When installed by machine power, draw conductors from a mounted reel through stringing sheaves in straight lines clear of obstructions.

8. Check initial sag and tension in accordance with the manufacturer's approved sag and tension charts, within an elapsed time after installation as recommended by the manufacturer.

B. Connectors and Splices

1. Conductor splices, as installed, shall exceed the ultimate rated strength of the conductor, and shall be of the type recommended by conductor manufacturer.

2. No splices will be accepted within 10 feet of a support.

3. Connectors and splices shall be mechanically and electrically secure under tension, and shall be of the nonbolted compression type.
4. The tensile strength of any splice shall be not less than the rated breaking strength of the conductor.

5. Splice materials, sleeves, fittings, and connectors shall be noncorrosive and shall not adversely affect the conductors.

6. Wire-brush aluminum-composition conductors and apply an oxide inhibitor before making a compression connection.

7. Connectors which are factory-filled with an inhibitor will be accepted.

8. Use inhibitors and compression tools of types recommended by the connector manufacturer.

9. Provide primary line apparatus taps by means of hot line clamps attached to compression-type bail clamps (stirrups).

10. Provide low-voltage connectors for copper conductors of the solderless pressure type.

11. Smoothly tape non-insulated connectors in order to provide a waterproof insulation equivalent to the original insulation, when installed on insulated conductors.

12. On overhead connections of aluminum and copper, install the aluminum above the copper.

C. Conductor-to-Insulator Attachments

1. General

   a. Attach conductors to insulators by means of clamps, shoes or tie wires, in accordance with the type of insulator.

   b. For insulators requiring conductor tie-wire attachments, tie-wire sizes shall be as indicated in the following table:

<table>
<thead>
<tr>
<th>TIE-WIRE REQUIREMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONDUCTOR</td>
</tr>
<tr>
<td>Copper (AWG)</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>4 and 2</td>
</tr>
<tr>
<td>1 through 3/0</td>
</tr>
<tr>
<td>4/0 and larger</td>
</tr>
<tr>
<td>AAC, AAAC or ACSR (AWG)</td>
</tr>
<tr>
<td>any size</td>
</tr>
</tbody>
</table>
D. Armor Rods

1. Provide armor rods for AAC, AAAC, and ACSR conductors.

2. Install armor rods at supports, except armor rods are not required at primary dead-end assemblies if aluminum or aluminum-lined zinc-coated steel clamps are used.

3. Lengths and methods of fastening armor rods shall be in accordance with the manufacturer’s recommendations.

4. Flat Rods
   a. For span lengths of less than 200 feet, flat aluminum armor rods may be used.
   b. Use flat armor rods, not less than 0.03-inch by 0.25-inch, on No. 1 AWG AAC and AAAC and smaller conductors, and on No. 5 AWG ACSR and smaller conductors.
   c. On larger sizes, flat armor rods shall be not less than 0.05-inch by 0.30-inch.

5. For span lengths of 200 feet or more, use preformed round armor rods.

E. Ties

1. Provide ties on pin insulators, installed tight against conductor and insulator.

2. Ends shall be turned down flat against the conductor such that no wire ends project.

F. Low-Voltage Insulated Cables

1. Support low-voltage cables on clevis fittings, using spool insulators.

2. Provide dead-end clevis fittings and suspensions insulators where required for adequate strength.

3. Dead-end construction shall provide a strength exceeding the rated breaking strength of the neutral messenger.

4. Provide clevis attachments, using not less than 5/8-inch through-bolts.

5. Secondary racks may be used when installed on wood poles and where the span length does not exceed 200 feet.

6. Secondary racks shall be 2-, 3-, or 4-wire, and shall be provided complete with spool insulators.

7. Racks shall meet strength and deflection requirements for heavy-duty steel racks, and shall be rounded and smooth in order to avoid damage to conductor insulation.

8. Hold each insulator in place with a 5/8-inch button-head bolt, equipped with a nonferrous cotter pin, or equal retainer, at the bottom.

9. Attach racks for dead-ending four No. 4/0 or larger conductors to the poles, using 3 through-bolts of 5/8-inch diameter each.
10. Attach other secondary racks to the poles using at least 2 through-bolts of 5/8-inch diameter each.

11. The minimum vertical spacing between conductors shall be not less than 8 inches.

G. **Reinstalling Conductors:** Existing conductors to be reinstalled or resagged shall be strung to "final" sag table values indicated for the particular conductor type and size involved.

H. **New Conductor Installation:** String new conductors to "initial" sag table values as recommended by the manufacturer for the indicated conductor type and the indicated size of the conductor and ruling span.

I. **Fittings:** Dead end fittings, clamp-type, shall conform to the written recommendations of the conductor manufacturer and shall develop the full ultimate strength of the conductor.

J. **Aluminum Connections**

1. Make aluminum connections to copper or other material using only splices, connectors, lugs, or fittings designed for that specific purpose.

2. Keep a copy of manufacturer’s instructions for applying these fittings at the Project Site for use by the RESIDENT PROJECT REPRESENTATIVE.

3.7 **GUYS**

A. Provide guys:

1. at the indicated locations;

2. where conductor tensions are not balanced, as at angles and dead ends; and,

3. elsewhere as necessary or as required by IEEE C2.

B. Where points of strain on a pole are separated by more than 3 feet, install separate down-guys at each point of strain.

C. Where a single guy cannot provide the required strength, provide 2 or more guys.

D. Provide a minimum of 2 guy hooks and 2 pole shims for wrap guys.

E. Provide offset or 3-bolt guy clamps or approved guy grips at each guy terminal.

F. Where the total unbalanced load on a pole exceeds 10,000 pounds, provide multiple guys and anchors.

G. Guy strength shall be determined from the minimum holding power of any component.

H. **Protection**

1. **Thimbles**

   a. Provide thimbles or thimble eyes on anchor-rod and eye-bolt guy attachments in order to protect the guy strand.
b. Take care in order to prevent damage to the copper coating.

c. Nicks or similar damage will be cause for rejection.

2. Ground Anchor

a. Equip the ground end of each guy attached to a ground anchor with a half-round galvanized steel or gray PVC guy protector at least 7 feet long.

b. Securely clamp or bolt the protector to the anchor rod or guy wire near the bottom and to the guy wire near the top.

I. Lead-to-Height Ratio

1. Wherever possible, provide guys with a lead-to-height ratio of one-to-one and a minimum lead-to-height ratio of 0.5-to-one.

2. Where field conditions prevent the lead-to-height ratio of one to one, place the anchors in a location approved by the ENGINEER.

3. Guy strength shall be increased by the ratio of the sine of the indicated lead angle to the sine of the provided lead angle.

J. Storm Guys

1. Storm guys and other guys where road clearance is essential shall be installed with a minimum lead.

2. Storm guys shall be tensioned sufficiently in order to remove slack and to present a neat appearance.

K. Strain Insulators

1. Where indicated, equip guy wires with epoxy-bonded fiberglass strain insulators.

2. The length of fiberglass shall be as indicated and shall be of sufficient additional length to provide a minimum 12-inch clearance between the nearest energized surface and the strain insulator fitting farthest from the pole.

3. When loaded to the tension indicated, load the fiberglass strain insulators to not more than 2/3 of the manufacturer's catalog rating.

L. Grounding

1. Guys shall be solidly bonded to the system ground.

2. Span guys shall be solidly grounded at each point of attachment to a pole.

3. Guy wires shall be electrically bonded to the anchor rods by means of suitable guy-bond clamps.

M. Guy anchors and attachments shall provide a strength exceeding the required guy strength.
N. Anchors

1. Install the anchors such that the guy will be in a straight-line pull.
2. The minimum strength of the guy and anchor assembly shall be 5,000 pounds.

3.8 FIELD TESTING

A. Field-test at least one anchor of each capacity installed, in order to ensure that the anchor develops rated holding power as indicated and without noticeable creepage.

B. Failures

1. In the event of failure of a test anchor, test each anchor of the size that failed.
2. Replace those anchors that failed.
3. Test the replacements in the same manner as the original anchor.

C. Materials, labor, and equipment required to perform the above test and for replacing anchors that fail shall be part of the WORK.

D. Test the anchors prior to hanging guys.

E. Anchors to be used as test anchors will be picked at random by the ENGINEER after all of the anchors have been installed.

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PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide motor control centers (MCCs), complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 260000 – Electrical Work, General, apply to the WORK of this Section.

C. In the event that provided motors are of greater horsepower than the indicated motors, revise the raceways, conductors, starters, overload elements, and branch circuit protectors as necessary in order to control and protect the increased motor horsepower in accordance with Section 260510 – Electric Motors.

D. Single Manufacturer

1. The MCCs shall be the end product of one manufacturer in order to standardize appearance, operation, maintenance, spare parts, and manufacturer's services.

2. This requirement, however, does not relieve the CONTRACTOR of overall responsibility for the WORK.

E. Coordination

1. The equipment provided under this Section shall operate the electric motor driver with the driven equipment as indicated under other equipment Sections.

2. The MCC manufacturer shall be provided with the following information, at a minimum:

   b. relevant Division 41 and Division 23 Sections for each piece of equipment driven by the MCC
   c. Section 260000 – Electrical Work, General
   d. Section 260510 – Electric Motors
   e. Section 260515 – Local Control Panels And Miscellaneous Electrical Devices
   f. Section 260126 – Electrical Tests
   g. the Electrical Contract Drawings

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 260000 – Electrical Work, General.

B. Furnish the following equipment information in the Shop Drawings:

   1. NEMA rating and color of enclosure
2. horizontal and vertical bus ampacities, voltage rating, interrupting capacity, and materials of construction

3. ground bus size and material of construction

4. conduit entrance provisions

5. main incoming line entry provision (top or bottom)

6. control unit nameplate schedule

7. circuit breaker types, frames, and settings

8. starter NEMA sizes, auxiliary contact provisions, and coil voltage

9. relays, timers, pilot devices, control transformer VA and fuse sizes

10. MCC Ladder Diagrams
    a. Furnish custom elementary schematic ladder diagrams for each compartment.
    b. The ladder diagrams shall include remote devices.
    c. Submittals not meeting these requirements will not be reviewed further and will be returned to the CONTRACTOR.

11. short circuit rating of the complete assembly

12. replacement parts lists and operation and maintenance procedures

13. seismic design certification of the anchoring system in accordance with Section 260000 – Electrical Work, General

14. time-current curves for protective devices

15. RVSS and VFD Equipment Information
    a. name of starter and drive manufacturer
    b. type and complete model number
    c. assembly drawing and nomenclature, including enclosure dimensions, mounting and anchoring details, and internal layout
    d. detailed schematics, including external wiring connections
    e. maximum heat dissipation capacity in kW
    f. altitude de-rating information

16. factory test data certifying compliance with requirements of similar equipment from the same manufacturer
C. Furnish an Owner’s Manual, including:
   1. manufacturer’s two-year warranty  
   2. field test report

D. Furnish the Manufacturer’s Service Representative’s resume, including the following documentation:
   1. copy of the proposed representative’s Factory Training Certificate
   2. number of years experience servicing the manufacturer’s MCCs and VFDs
   3. a statement that the individual is authorized to inspect, test and perform field service and repairs

E. **Spare Parts List:** Furnish spare parts information for parts required by this Section as well any other spare parts recommended by the MCC manufacturer.

F. Startup and Testing Report
   1. Within 15 days after completion of startup and testing, the CONTRACTOR shall submit a report for the MCC.
   2. The report shall contain the following documentation:
      a. the device name, serial number, rating, and complete model number of each MCC
      b. a complete listing of all tests performed and the results of each test
      c. a complete listing of all circuit breaker and overload settings, fuse ratings, settings, setpoints and configuration information for VFDs and equipment or devices with adjustable settings
      d. documentation for training that was provided to the OWNER’s personnel, including topics covered, instructor’s name and contact information, and a list of attendees

 **PART 2 -- PRODUCTS**

2.1 **GENERAL**

A. The manufacturer of the low-voltage motor control center shall also manufacture at least the following:
   1. Molded case circuit breakers, up to and including 225 ampere frame size.
   2. Disconnect switches.
   4. Control and timing relays rated at 600 volts AC.
5. Pushbuttons, lights and selector switches, including remote mounted control stations.

6. Meters, including ammeter, voltmeter, and solid-state metering devices.

B. Single Manufacturer

1. Devices of the same type shall be products of the same manufacturer.

2. This requirement applies to control devices, custom-fabricated equipment, and insofar as practical to equipment manufactured on a production basis.

C. Lighting transformers and panelboards shall be in accordance with the requirements of Section 261216 – Panelboards and General Purpose Dry-Type Transformers.

D. Motor control centers shall conform to the standards for NEMA Class IIS, Type B diagrams and wiring.

E. MCC Schedule

<table>
<thead>
<tr>
<th>MCC DESIGNATION</th>
<th>LOCATION</th>
</tr>
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<tr>
<td>40-MCC-1</td>
<td>PUMP STATION</td>
</tr>
<tr>
<td>40-MCC-2</td>
<td>PUMP STATION</td>
</tr>
<tr>
<td>40-MCC-3</td>
<td>PUMP STATION</td>
</tr>
<tr>
<td>40-MCC-4</td>
<td>PUMP STATION</td>
</tr>
<tr>
<td>40-MCC-5</td>
<td>ELECTRICAL ROOM 01-102</td>
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</tbody>
</table>

2.2 DESIGN, CONSTRUCTION, AND MATERIAL REQUIREMENTS

A. The motor control centers shall be 600-volt class and suitable for operation on a 3-phase, 60-Hz system.

B. The system operating voltage and number of wires shall be as indicated.

C. Power

1. The motor control center shall receive power from a 3-phase switchgear.

2. Power distribution from the MCC shall be 480-volt, 3-phase 3-wire.

D. Enclosure

1. The enclosure shall be of NEMA Type 1, gasketed.

2. The variable frequency drive (VFD) and solid-state soft starter (RVSS) compartments may be of NEMA Type 1, gasketed, provided that ventilation inlet openings are covered by externally replaceable dust filters.
3. Compartment doors shall be interlocked with compartment circuit breakers, fitted with a maintenance override.

4. Latches for panelboard compartments shall have butterfly heads or another hand operable method that does not require tools to operate.

E. Size and Arrangement

1. Motor control centers shall be configured as mechanical groupings of control center units, assembled into a lineup of control center sections.

2. Each control section shall be nominally 90 inches tall by a typical 20 inches deep.

3. MCCs shall be designed to not exceed the indicated spatial requirements, including spaces, spares, and future compartments.

4. MCCs shall be subject to rejection if they exceed the indicated lengths, where allotted space is critical.

5. Equipment within the MCC may be rearranged at the discretion of the manufacturer, providing that the MCC includes the spares, space, and future provisions as indicated.

6. Switches and circuit breakers used as switches shall be located such that the center of the grip of the operating handle of the switch or circuit breaker, when in its highest position, will not be more than 6 feet, 4 inches above the floor, including the height of the housekeeping concrete pad.

F. Components

1. Busses
   a. Provide a continuous copper ground bus, full width of the motor control center line-up.
   
   b. Horizontal Busses
      1) The main horizontal bus shall be of or silver-plated copper, and located within an isolated compartment.
      
      2) The bus shall be rated for 600 amperes minimum, but in no case less than the main lug or main breaker frame size.
   
   c. Vertical Busses
      1) The vertical bus in each section shall consist of a single tin-plated copper conductor per phase, with a current capacity of not less than 300 amps.
      
      2) The vertical bus shall be completely isolated and insulated, and shall extend the full height of the section wherever possible.
   
   d. Power buses shall be braced to withstand 65,000 amperes, minimum.
2. Wireways
   a. Provide a separate vertical wireway adjacent to each vertical unit, covered by a hinged door.
   b. Each individual unit compartment shall be provided with a side barrier to permit pulling wire in the vertical wireway without disturbing adjacent unit components.
   c. Full height (72-inch) compartments or sections are not required to have a separate wireway.

G. Cabinets
   1. Structural members shall be fabricated of not less than 12-gauge steel, and side and top panels and doors shall be fabricated of not less than 14-gauge steel.
   2. Spaces designated as SPACE or BLANK shall include blank hinged doors and vertical bus bars.
   3. Control units inside compartments shall be clearly identified with tags or stencil markings.
   4. Identification
      a. Each control unit, including spares, spaces and blanks, lights, and devices shall be identified by an engraved nameplate.
      b. Identification shall include the indicated circuit number.
      c. Each motor control center shall be fitted with the manufacturer’s nameplate which shall include the NEMA Standard electric rating and other pertinent data, including manufacturer, sales order number, date of manufacture, and place of manufacture.
   5. Where "L" or "U" shaped MCC layouts are indicated, corner compartments shall have similar current and short circuit ratings as functional compartments.
   6. Fans, heat exchangers, transformers, capacitors, junction boxes, and other devices shall not be mounted on the outside of the motor control center enclosure.
   7. Protective Coating
      a. The finish for motor control center shall be light grey: ANSI 61 or 49.
      b. The panels shall be coated with 2 coats of primer inside and out, and 2 coats of enamel finish.
      c. Furnish two spray paint containers of the specified finish. These shall be shipped with each unit for field touchup.
      d. External colors other than ANSI 61 or 49 will not be accepted.
H. Buss Surge Suppressors

1. Surge suppressors shall be designed to provide transient voltage protection for the MCC main power service compartment.

2. Surge suppressors shall comply with UL 845, UL 1449 3rd Edition and UL 1283, and shall be UL-labeled for such use.

3. Surge suppressors shall be installed with 12 inches or less of connecting cable from the bus to the surge suppressor electronics.

4. Surge suppressors shall be rated for 480-volt, 3-phase service at 250kA per phase.

5. Surge suppressors shall have a built-in diagnostic package with flashing trouble light, a display for the status of each phase, and a counter and display to indicate the number of surges that have caused the device to operate.

6. Surge suppressors shall be resettable.

7. Surge suppressors with sacrificial element shall be not be accepted.

8. Surge suppressors shall be Cutler-Hammer Clipper CPS-250-480Y-S-C, or equal.

2.3 MAIN AND FEEDER CIRCUIT BREAKERS (480 V)

A. Circuit breakers having a frame size of 150 amperes or less shall be molded-case type with thermal magnetic non-interchangeable, trip-free, sealed trip units.

B. Circuit breakers with a frame size of 225 amperes to 1,200 amperes shall be molded case with RMS sensing electronic trip elements with the following adjustments:

1. long-time setting (by changing the unit)

2. long-time delay

3. short-time setting

4. short-time delay

5. instantaneous setting

6. ground-fault setting

7. ground-fault delay

C. The interrupting capacity of the main and feeder branch circuit breakers shall be a minimum of 65,000 RMS symmetrical amperes.

D. Service disconnects rated 1000 amps or greater shall provide for ground fault protection of the equipment.

E. Circuit breaker disconnect operators shall be capable of accommodating 3 padlocks for locking in the OPEN position.

F. Circuit breaker auxiliary contacts shall be furnished where indicated.
2.4 MOTOR STARTERS

A. Motor starters shall be mounted in standard motor control center assemblies, arranged as indicated.

B. Components

1. Each motor starter unit shall consist of a combination magnetic contactor and short circuit protective device, mounted in a completely enclosed cubicle.

2. The short circuit protective device shall be an instantaneous, magnetic only circuit breaker: **Cutler-Hammer Type HMCP, G.E. Mag-Break Motor Circuit Protector**, or equal.

3. Circuit breakers provided as part of a motor starter unit shall be capable of being padlocked in the OPEN position.

4. Resetting of thermal overload elements shall be possible with the unit door closed.

5. Provide 3-phase overload trip units to suit the full load current of the equipment installed, and the trip unit shall be adjusted as required for power factor correction capacitors.

C. Magnetic Starters

1. Magnetic starters shall have auxiliary contacts as indicated, including N-O and N-C contacts as indicated, plus two each spare N-O and N-C contact wired to the bucket terminal block.

2. The combination motor starters shall be drawout-type for Size 5 and below.

3. The fixed-type unit assembly shall be constructed such that it can be easily removed from its panel after disconnecting the wires to the terminal block and withdrawing from the primary bus.

4. Removal of a unit assembly shall be possible without rear access and without disturbing any other unit in the motor control center.

D. Control Power Transformer

1. Each starter unit shall have its own control power transformer, with a 115-volt grounded secondary.

2. The control power transformer primary shall be fused on both poles and the secondary winding will be protected with one fuse.

3. Control power transformers shall be sized to accommodate the indicated control devices.

4. Local control devices shall be mounted independently of the cover door.

5. Starters shall have a local red RUN indicator, and a green STOPPED indicator to indicate the presence of control power when the motor is not running. The indicator pilots shall be full voltage LED type.
6. Starters shall be provided with elapsed time meters, HAND-OFF-AUTO selector switches, and other devices as indicated on the schematic diagrams.

7. Cubicle control wires shall be terminated at a pull-apart disconnecting terminal block located at the cubicle.

E. Identification

1. The motor control center manufacturer shall be responsible for identifying each control wire within each motor starter unit with wrap-around permanent plastic markers.

2. Each control wire shall be identified at both ends.

F. Full-Voltage Starters

1. Full-voltage motor starter units shall be NEMA Size 1 or larger.

2. Each combination starter shall be rated for a minimum 65,000 RMS symmetrical amperes.

G. NEMA Ratings

1. Motor starters shall be designed to NEMA ratings.

2. Starters designed to IEC ratings or with dual IEC/NEMA ratings will not be accepted, either as part of an MCC, as remote starters, or as part of an equipment package.

H. Solid-State Reduced-Voltage Starters

1. Solid-state reduced-voltage starters shall be in accordance with the requirements of Section 262913 – Solid-State Reduced Voltage Starters.

2. Full-voltage bypass contactors, input contactors, output contactors and other components shall be provided where indicated.

I. Unless otherwise indicated, 2-speed starters shall be of the 2-winding type.

J. 40-MCC-1 and 40-MCC-2 shall be equipped with motor protection relays protecting the 400HP electric motors.

1. Furnish the solid state reduced voltage starter (SSRVS) equipped cubicles with a GE Multilin motor protection and management relay, model 469-P5-HI-T-H or equal. The Contractor shall be responsible for all setup paramater programming and connections for the relay but may assign this to the equipment supplier. The motor protection and management relay shall be furnished with a draw-out case. The relay communications protocol shall be initially set at Modbus TCP/IP, but it shall be field adjustable to any of the available protocols the end user deems appropriate. Relays without integral metering, oscillography, event recording, draw out case, and integral RTDs inputs shall be rejected. Metering shall include, but not limited to phase current; L-L and L-N voltages; frequency; real, apparent, and reactive power; totalized watt-hours and var-hours; power factor. The relays on the drives shall be by the same manufacturer. The relay sensing shall be capable of accurately sensing and calculation of the analog values for VFD application. A spare relay is not required. The Ethernet port shall be utilized in the future.
K. Variable Frequency Drives

1. Variable frequency drives (VFDs) shall be in accordance with the requirements of Section 262923 – Variable Frequency Drives.

2. An externally mounted line reactor, cooling fan, and bypass contactor will not be accepted.

3. Full-voltage bypass contactors, input contactors, output contactors and other components shall be provided where indicated.

2.5 CONTROL DEVICES

A. Control devices shall be in accordance with the requirements of Section 260515 – Local Control Stations and Miscellaneous Electrical Devices.

B. Metering

1. Provide solid-state with readout metering where indicated.

2. Include CTs and PTs of ratios as indicated or as recommended by the MCC manufacturer.

3. The CT leads shall terminate on shorting type terminal blocks, and the shorting bar shall be grounded to the MCC ground bus.


2.6 FACTORY TESTS

A. Provide the manufacturer's standard electrical and mechanical production tests and inspections for motor control centers and their components.

B. The tests shall include electrical continuity check, dielectric tests for each circuit, and inspection for proper functioning of components including controls, protective devices, metering, and alarm devices.

2.7 SPARE PARTS

A. The CONTRACTOR shall furnish the following for each MCC:

1. Unit Control Transformer: one of each size furnished in magnetic starters installed

2. Bezels: 3 of each color installed for pilot indicators

3. Panel Lamps: one dozen of each type (form, voltage and current rating) installed

4. Control Fuses: one dozen of each type (form, voltage and current rating) installed

5. Relays: one of each type and size installed

B. Spare parts shall be identified by MCC number, type, size, and manufacturer.
2.8 MCC MANUFACTURER, OR EQUAL

A. Cutler-Hammer "Freedom 2100" Series

B. General Electric "8000 Line"

C. Square D, Model 6

PART 3 – EXECUTION

3.1 GENERAL

A. The CONTRACTOR shall install motor control centers in accordance with the manufacturer's published instructions.

B. Conduit installation shall be coordinated with the manufacturer's as-fabricated drawings such that conduit stub-ups are within the area allotted for conduit.

C. Conduit shall be stubbed up in the section that contains the devices to which conductors are terminated.

3.2 STORAGE AND HANDLING

A. If stored at the Site, motor control centers shall be stored in a clean, dry space.

B. Factory wrapping shall be maintained or an additional heavy plastic cover shall be provided to protect units from dirt, water, construction debris, and traffic.

C. The storage space shall be heated or the MCC space heaters shall be energized.

D. Motor control centers shall be handled carefully to avoid damage to motor control center components, enclosure, and finish.

E. Damage shall be repaired before installation.

3.3 MANUFACTURER'S SERVICES

A. General

1. An authorized Service Representative of the manufacturer shall be present at the Site for 3 Work Days in order to provide the services listed below.

2. For the purpose of this paragraph, a Work Day is defined as an 8-hour period, excluding travel time.

3. The service representative's resume shall be approved by the ENGINEER before training is scheduled.

B. Inspection, Startup, Field Adjustment

1. The Service Representative shall supervise the following items, and shall certify that the equipment and controls have been properly installed, aligned, and readied for operation:

   a. installation of the equipment
b. inspection, checking, and adjusting of the equipment

c. startup and field testing for proper operation

d. performance of repairs to correct any discrepancies or problems revealed during startup and testing

e. performance of field adjustments to ensure that the equipment installation and operation comply with the indicated requirements

f. Preparation and submittal of a report covering startup and testing, including a listing of equipment settings and parameters at the end of startup and testing.

3.4 INSTALLATION

A. Motor control centers shall be installed on 3-1/2-inch concrete housekeeping pads and in accordance with the requirements of Section 260000 – Electrical Work, General.

B. After leveling and shimming, the CONTRACTOR shall anchor motor control centers to the concrete pads, and shall grout such that no space exists between the pad and support beams.

C. The CONTRACTOR shall:

1. torque bus bar bolts to manufacturer’s recommendations, and tighten sheet metal and structure assembly bolts;

2. adjust motor circuit protector (MCP) devices to the instantaneous trip setting position recommended for the actual horsepower and full load amps of the motor;

3. verify that overload devices are proper for equipment installed;

4. make necessary changes in overload devices as required for motors having power factor correcting capacitors;

5. touch up scratches after the equipment has been installed;

6. verify that nameplate, and other identification is accurate; and

7. provide high-voltage switchboard matting in front of the MCC, in accordance with the requirements of Section 260000 – Electrical Work, General.

3.5 FIELD TESTS

A. Provide a visual and mechanical inspection after installation, as follows:

1. Inspect for physical damage, proper anchorage, and grounding.

2. Verify that the ratings of the thermal overload heaters match the motor full-load current nameplate data.

3. Check tightness of bolted connections.
B. Electrical Tests

1. Insulation Tests

   a. Measure the insulation resistance of each bus section phase-to-phase and
      phase-to-ground for one minute.

   b. The test voltage and minimum acceptable resistance shall be in accordance
      with manufacturer's recommendations.

   c. Measure the insulation resistance of each starter section phase-to-phase and
      phase-to-ground with the starter contacts closed and the protective device
      open.

   d. The test voltage and minimum acceptable resistance shall be in accordance
      with the manufacturer's recommendations.

   e. Measure the insulation resistance of each control circuit with respect to ground.

2. Verify the proper operation of control logic in each mode of control.

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PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. **General:** The CONTRACTOR shall provide solid-state reduced voltage motor starters, complete and operable, in accordance with the Contract Documents.

B. **Single Manufacturer:** Like products shall be the end product of one manufacturer in order to standardize appearance, operation, maintenance, spare parts, and manufacturer's services. However, the CONTRACTOR shall remain responsible to the OWNER for the WORK of the Contract.

C. **Coordination:** Equipment provided under this Section shall operate the electric motor and the driven equipment indicated under other equipment specifications. The CONTRACTOR’s attention is specifically directed to the need for proper coordination of the WORK under this Section with the WORK under the equipment section and with the WORK under Section 260510 - Electric Motors.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 013300 - Contractor Submittals, except that Shop Drawing information for the drives shall be submitted as part of the information for the driven equipment.

B. Shop Drawings

1. Equipment information
   a. Name of drive manufacturer
   b. Type and model
   c. Assembly drawing and nomenclature
   d. Maximum heat dissipation capacity (KW)

2. Written description of ladder diagram operation. Custom schematics shall be furnished. Diagrams shall include remote devices.

3. System block diagram and interconnection diagrams.

4. Replacement parts list and operation and maintenance instructions.

PART 2 -- PRODUCTS

2.1 GENERAL

A. The CONTRACTOR shall provide a total of 5 solid-state starters. Equipment to be operated through the starters includes the following:
<table>
<thead>
<tr>
<th>Qty.</th>
<th>Equipment</th>
<th>Tag. No.</th>
<th>HP</th>
<th>Volt</th>
<th>RPM</th>
<th>Enclosure</th>
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</thead>
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<tr>
<td>1</td>
<td>Diversion</td>
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<td>400</td>
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<td>40-P-120</td>
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<tr>
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<td>400</td>
<td>460</td>
<td>600</td>
<td>40-MCC-2</td>
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<tr>
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<td>pump</td>
<td>40-P-150</td>
<td>400</td>
<td>460</td>
<td>600</td>
<td>40-MCC-2</td>
</tr>
</tbody>
</table>

B. Solid-state reduced voltage starters (SSRV) shall be UL-listed and consist of a SCR-based power section, logic board, and internal paralleling bypass contactor.

C. Starters shall conform to the following:

1. The SCR-based power section shall consist of 6 back-to-back SCRs, 2 SCRs per phase, and shall be rated for a minimum peak inverse voltage rating of 2.5 times line voltage, 1200 PIV for 480 volts. Units using triacs or SCR/diode combinations shall not be acceptable. Resistor/capacitor snubber networks shall be used to prevent false firing of SCRs due to dv/dt characteristics of the electrical system.

2. Starters shall include the following logic and control functions:
   a. Adjustable maximum starting current from 200 percent to 500 percent.
   b. Ramp time adjustment from 1 to 40 seconds. Ramp shall apply for pump start and stop application to mitigate hydraulic surges.
   c. Adjustable linear voltage deceleration.
   d. Kick start.
   e. Phase loss protection.
   f. Undervoltage protection.
   g. Current unbalance protection.
   h. Phase rotation protection (prevents starting).
   i. Class 20 electronic overload protection. Heat sink overtemperature protection shall be provided.
   j. Dry contacts for remote indication of RUN and TRIP status.

3. The paralleling bypass contactor shall energize when the motor reaches full speed. The contactor shall be an integral part of the reduced voltage starter and be connected directly across the power SCRs.
4. The starter shall be housed in a NEMA 1 with gaskets, MCC section as noted on the table above in 2.1.A. Heaters and cooling fans shall be provided if required to maintain the equipment within the manufacturer’s environmental guidelines.

5. The starter shall be provided with a control power transformer sized to accommodate controls indicated on the Contract Drawings. An input power circuit breaker shall be provided. Lug termination of the incoming power conductors shall not be permitted. The starter and circuit breaker shall be rated for 65 KAIC RMS at 480 V.

6. The starter shall have door-mounted indication pilots for run, phase rotation, phase loss, undervoltage, current unbalance, and current trip.

7. The starter shall be provided with the operator controls indicated. Operator interface controls shall be heavy duty, oil-tight, 30.5-mm.

8. The front door of the MCC shall have the SSRVS HMI and pilot lights indicating running (red), green (stopped), fault (amber), bypass contactor in service (white). A reset button shall be mounted on the door as well.

2.2 MANUFACTURERS, OR EQUAL

A. Solid-state reduced voltage starters shall be Cutler-Hammer Model S811 (with pump control function & remote keypad), Baldor medium duty MD7-600-CB with remote keypad, Allen Bradley SMC Flex Smart Controller with pump control, or equal.

PART 3 -- EXECUTION

3.1 GENERAL

A. The CONTRACTOR shall have the MCC manufacturer install the solid-state reduced voltage starters (SSRVS) in accordance with the manufacturer's published instructions.

B. The CONTRACTOR shall

1. Verify that the overload devices are properly adjusted for the equipment installed.

2. After the equipment is installed, touch up scratches and verify that nameplate and other identification is accurate.

C. Inspection, Startup, Field Adjustment: An authorized service representative of the manufacturer shall supervise the following and certify the equipment and controls have been properly installed, aligned, and readied for operation.

1. Installation of the equipment.

2. Inspection, checking, and adjusting the equipment.

3. Startup and field testing for proper operation.

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PART 1 – GENERAL

1.1 THE REQUIREMENT

A. General

1. The CONTRACTOR shall provide variable frequency drive (VFD) units, complete and operable, as indicated in accordance with the Contract Documents.

2. It is the intent of this Section to require complete, reliable, and fully tested variable frequency drive systems suitable for attended or unattended operation.

B. The requirements of Section 260000 – Electrical Work, General, apply to the WORK of this Section.

C. Single Manufacturer

1. Like products shall be the end product of one manufacturer in order to standardize appearance, operation, maintenance, spare parts, and manufacturer’s services.

2. This requirement, however, does not relieve the CONTRACTOR of overall responsibility for the WORK.

D. Coordination

1. Equipment provided under this Section shall operate the electric motor driver and the driven equipment as indicated under other equipment specification Sections.

2. The CONTRACTOR’S attention is specifically directed to the need for proper coordination of the WORK under this Section and the WORK under the equipment Section with the WORK under Section 262900 – Electric Motors.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 013300 – Contractor Submittals, except that Shop Drawing information for the drives shall be submitted as part of the information for the driven equipment.

B. Shop Drawings: Include the following information:

1. Equipment Information
   a. Name of drive manufacturer.
   b. Type and model.
   c. Assembly drawing and nomenclature.
   d. Maximum heat dissipation capacity in Kw.

2. Conduit entrance provisions.

3. Circuit breaker type, frames, and settings.
4. Information related to relays, timers, pilot devices, control transformer VA, and fuse sizes, including catalog cuts.

5. Ladder Diagram
   a. Submit the system schematic ladder diagram and interconnection diagrams.
   b. The schematic ladder diagram shall include remote devices.
   c. The ladder diagram shall incorporate the control logic on the corresponding elementary schematic as indicated.
   d. Submittals with drawings not meeting this requirement will not be reviewed further and will be returned to the CONTRACTOR stamped "REJECTED."

6. Factory test data certifying compliance of similar equipment from the same manufacturer with requirements of this Section

C. The Technical Manual shall include the following documentation:
   1. Manufacturer’s 2-year warranty.
   2. Harmonic analysis report.
   3. Field test report.
   4. Programming procedure and program settings.

D. **Spare Parts List:** Submit information for parts required by this Section plus any other spare parts recommended by the controller manufacturer.

**PART 2 – PRODUCTS**

2.1 GENERAL

A. The CONTRACTOR shall provide a total of one variable frequency drive.

B. Equipment to be operated through variable frequency drives shall include the following:

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Equipment</th>
<th>HP</th>
<th>Constant or Variable Torque (C/V)</th>
<th>RPM</th>
<th>Bypass (Y/N)</th>
<th>Enclosure Type</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Traveling jib crane with hoist</td>
<td>4000 lbs capacity assembly</td>
<td>varies</td>
<td>N</td>
<td>NEMA 4X</td>
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<tr>
<td>1</td>
<td>Screen cleaner</td>
<td>5</td>
<td>Constant torque unit</td>
<td>Varies</td>
<td>N</td>
<td>MCC bucket</td>
</tr>
</tbody>
</table>
2.2 EQUIPMENT

A. General

1. The power supply shall be an adjustable frequency inverter designed to convert incoming 3-phase, 480-volt, 60-Hertz power to a DC voltage and then to adjustable frequency AC by use of a 3-phase inverter.

2. Current-source inverters will not be accepted.

3. Inverters shall be sized to match the KVA and inrush characteristics of the motors actually provided.

4. The CONTRACTOR shall be responsible for matching the controller to the load (variable torque or constant torque) as well as the speed and current of the actual motor being controlled.

5. The CONTRACTOR shall provide "clean power” 18-pulse VFD’s for VFDs that are operating motors greater than 60 HP.

B. Inverter

1. The inverter shall be of a voltage-source design, producing a pulse-width-modulated type output.

2. Six-step and current-source inverters will not be accepted.

3. Motors
   a. Inverters shall be provided with 460-volt, 3-phase, 60-Hertz, squirrel-cage high-efficiency inverter duty induction motors.
   b. Motors shall be capable of operating over the range of 50-100 percent of base speed without derating or requiring any motor modifications.
   c. Motors enclosures shall be NEMA B, open drip-proof (1.15 SF) or TEFC (1.15 SF).

4. Inverters shall be capable of delivering the nameplate horsepower exclusive of service factor without the need for mandatory thermostats or feedback tachometers.

5. The VFD shall vary both the AC voltage and frequency simultaneously in order to operate the motor at required speeds.

C. The minimum VFD inverter efficiency shall be 95 percent at 100 percent speed and load, and 85 percent efficiency at 50 percent speed and load.

D. Power Outage

1. The VFD shall shut down in an orderly manner when a power outage occurs on one or more phases.

2. Upon restoration of power and a START signal, the motor shall restart and run at the speed corresponding to the current process input signal.
E. The VFD shall be provided with the following features:

1. Inrush current adjustment between 50 and 110 percent of motor full load current (factory set at 100 percent).
2. Overload capability at 110 percent for 60 seconds for variable torque loads and 150 percent for constant torque loads.
3. Adjustable acceleration and deceleration.
4. Input signal of 4 - 20 mA from process.
5. Output speed signal of 4 - 20 mA; signals other than 4 - 20 mA will not be accepted.
6. Upon loss of input signal, the VFD shall operate at a preset speed.
7. A minimum of 2 selectable frequency jump points in order to avoid critical resonance frequency of the driven system.
8. Additional devices and functions as indicated.

F. The VFD shall be provided with, as a minimum, the following protection features:

1. Input line protection with metal oxide varistor (MOV) and RC network.
2. Protection against single phasing.
3. Instantaneous overcurrent protection.
4. Electronic overcurrent protection.
5. Ground fault protection.
6. Overttemperature protection for electronics.
7. Protection against internal faults.
8. Ability to start into rotating motor (forward or reverse rotation).
9. Additional protection and control as indicated and as required by the motor and driven equipment.

G. The VFD shall be designed and constructed to satisfactorily operate within the following service conditions.

1. Elevation
   a. Elevation to 3300 feet.
   b. For elevation greater than 3300 feet, the VFD shall be derated in accordance with the manufacturer’s recommendation.
2. Ambient Temperature: 0 to 50 degrees C. The unit will be located outside close to the Sacramento River.
3. Humidity: 0 to 95 percent, condensing and non-condensing

4. AC Line-Voltage Variation: plus 10 percent to minus 10 percent

5. AC Line-Frequency Variation: plus and minus 2 Hertz

H. Electrical equipment provided in addition to the adjustable frequency inverter for each drive shall include:

1. 2-1/2-percent (minimum) line reactor integral to the drive enclosure.

2. Fused 480-to-120-volt control transformer to provide system control power for the logic and pilot lamps.

3. Bypass Starters
   a. Bypass starters and circuit breakers shall be provided for VFDs where indicated.
   b. The starters shall be NEMA-rated, Size 1 minimum.
   c. The bypass starter shall include an instantaneous, magnetic-only, MCP circuit breaker, a fused 120 V control transformer, and overload protection, in accordance with NEC requirements.
   d. Output Contactor
      1) A NEMA-rated output contactor shall be provided with the VFD to allow disconnection of the inverter output while operating on the bypass starter.
      2) IEC-rated devices will not be accepted.
   e. The bypass starter and related circuitry shall be mounted in a segregated compartment of the VFD enclosure or MCC, enabling total isolation of the VFD for purposes of servicing while operating the drive through the bypass starter.

4. Provide an input circuit breaker.

5. Heaters
   a. Provide overload heaters with auxiliary contacts in order to protect the motors in both VFD and bypass modes.
   b. Refer to the Elementary Schematics indicated on the Drawings.
   c. The heaters shall be sized for the motor actually being provided.

I. Inverter Signal Circuits

1. The inverter signal circuits shall be isolated from the power circuits and shall be designed to accept an isolated 4-20 mA signal in the automatic mode of operation.

2. The inverter shall follow the setting of a remote or local potentiometer control while in the manual mode.
3. Refer to the Elementary Schematic indicated on the Drawings for speed control and START/STOP methods.

4. Access to set-up and protective adjustments shall be protected by key-lockout.

5. The following operator monitoring and control devices for the inverter shall be provided on the face of the VFD enclosure, either as discrete devices or as part of a multi-function microprocessor-based keypad access device:
   a. AUTO/HAND selection from a remote logic relay or switch
   b. While in AUTO, the inverter shall operate from the remote 4-20 mA input, where applicable, and while in HAND control shall operate from a local or remote manually operated speed potentiometer; speed pot ratings shall be coordinated with the supplier of the Local Control Station.
   c. speed indicator calibrated in percent speed
   d. inverter fault trip pilot light and output alarm contacts
   e. trip reset pushbutton
   f. RUN and OFF indicating lights
   g. Provide other controls and readouts normally furnished as standard equipment, or as otherwise indicated on the Elementary Schematics indicated on the Drawings.

J. Properly identified screw type terminal boards shall be provided for interconnection to remote controls and instrumentation

K. Pilot devices, control relays, time delay relays, elapsed time meters, and indicators provided as a part of the VFD equipment package shall meet the applicable requirements of Section 260515 – Local Control Stations and Miscellaneous Electrical Devices.

2.3 HARMONIC ANALYSIS FOR DRIVES

A. The CONTRACTOR shall perform a harmonic study of the facilities included in this Project.

B. The following assumptions shall be utilized for the harmonic analysis:
   1. The distribution system is a "general" system as classified by IEEE 519 under low voltage systems.
   2. Assume 90 percent of total plant operating load is motor load and 10 percent is resistive.
   3. Assume a 70 percent plant diversity factor (i.e., 70 percent of the total plant load is operating), with motors other than VFDs operating at 90 percent of their nameplate horsepower.
   4. Assume all VFDs are operating
5. Report  
   a. Results of the harmonic analysis shall be submitted prior to VFD shipment.  
   b. Excessive harmonic distortion shall be specifically denoted.  
   c. Corrective measures shall be submitted for action by the ENGINEER.  

2.4 SPARE PARTS  
A. The CONTRACTOR shall furnish the spare parts listed below, suitably packaged and labeled with the corresponding equipment number.  

B. Modified Parts  
   1. At any time prior to Substantial Completion, the CONTRACTOR shall notify the ENGINEER in writing about any manufacturer’s modification of spare part numbers, interchangeabilities, or model changes.  
   2. If the ENGINEER determines that the modified parts no longer apply to the equipment provided, the CONTRACTOR shall furnish other applicable parts as part of the WORK.  

C. The following spare parts shall be furnished:  
   1. Provide one set of spare power fuses of each form, voltage, and current rating.  
   2. Provide 2 boxes of spare control and power fuses of each type and rating. For large fuses, six of each shall be furnished.  
   3. Provide 10 panel lamps of each type (form, voltage, and current rating).  
   4. Provide one of each type of circuit board, as applicable:  
      a. Control board.  
      b. Power board.  
      c. Diode bridge.  
      d. Transistor module.  
   5. Provide one of each size and type power diode and transistor.  
   6. Provide one set of any special tools required for maintenance of the VFD units  

2.5 MANUFACTURERS, OR EQUAL  
A. Eaton Electrical  
B. Allen-Bradley  
C. GE
PART 3 – EXECUTION

3.1 MANUFACTURER’S SERVICES

A. General
   1. An authorized service representative of the manufacturer shall be present at the Site for 3 Days to furnish the services listed below.
   2. For the purpose of this Paragraph, a Day is defined as an 8-hour period excluding travel time.

B. The authorized service representative shall supervise the following and shall certify that the equipment and controls have been properly installed, aligned, and readied for operation:
   1. Installation of the equipment.
   2. Inspection, checking, and adjusting the equipment.
   3. Startup and field testing for proper operation.
   4. Performing field adjustments such that the equipment installation and operation comply with requirements.

C. Instruction of OWNER’s Personnel
   1. The authorized representative shall instruct the OWNER’s personnel in the operation and maintenance of the equipment, including step-by-step troubleshooting with test equipment.
   2. The instruction shall be specific to the VFD models provided.
   3. Training shall be scheduled a minimum of 3 weeks in advance of the first session.
   4. Training shall include individual sessions for 4 shifts of plant personnel.
   5. Proposed training materials shall be submitted for review, and comments shall be incorporated.
   6. Training materials shall remain with the trainees.
   7. The OWNER may videotape the training for later use with the OWNER’s personnel.

3.2 INSTALLATION

A. Conduit stub-ups for interconnected cables and remote cables shall be located and terminated in accordance with the drive manufacturer’s recommendations.

B. Programming
   1. The CONTRACTOR shall perform programming of drive parameters required for proper operation of the VFDs included in this project.
2. Submit records of programming data in the equipment Technical Manual, including setup and protective settings.

3.3 FIELD TESTING

A. Testing, checkout, and startup of the VFD equipment in the field shall be performed under the technical direction of the manufacturer’s service engineer.

B. Under no circumstances shall any portion of the drive system be energized without authorization from the manufacturer’s representative.

C. Verify proper operation of control logic in every mode of control.

D. Harmonic Analysis

1. The CONTRACTOR shall test the completed installation for actual harmonic distortion at the point of common coupling.

2. Harmonic analysis shall be performed in accordance with IEEE 519 - Harmonic Control and Reactive Compensation of Static Power Converters at unit full load using a harmonic analyzer by Hewlett Packard, or equal

3. Tests shall demonstrate that the harmonic voltage distortion at the 480-volt distribution bus of the panelboard, motor control center, or switchgear serving the VFD is limited to a magnitude of 5 percent of the fundamental, with the isolation transformer in the circuit as indicated and with the maximum number of drives, as permitted by the process, in operation and in conformance with the applicable requirements of IEEE-519.

4. Provide a report that shall include the following:
   a. Expected harmonic voltage (THD) through the 35th harmonic, calculated with isolation transformers.
   b. Actual RMS value and measured percentage of the THD in the field.

- END OF SECTION -
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PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide the single phase uninterruptible power system (UPS) and all accessories required, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 260000 - Electrical Work, General, apply to the WORK of this Section.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

   ANSI/IEEE 241 Electric Power Systems in Commercial Buildings, Recommended Practice for
   ANSI/NEMA 250 Enclosures for Electrical Equipment
   EIA Electronic Industries Association Standards
   IEEE-587 Standards for Surge Withstandability
   NEC National Electrical Code; Article 700 Emergency Systems
   NEMA PB2 Panelboard
   UL 1012 Underwriter's Laboratory Listing

1.3 CONTRACTOR SUBMITTALS

A. Furnish Shop Drawings and catalog data in accordance with Section 013300 - Contractor Submittals. Submit sufficient information to indicate the scope and quality of the UPS system installation.

   1. Block diagram showing system relationships of major components and quantities and interconnecting cable requirements.
   2. Control console and panel arrangements, equipment outlet devices, and special mounting details.
   3. Wiring diagrams showing terminal identification for field-installed wiring.
   4. Catalog literature.

B. Instead of the Technical Manuals in Section 013300, furnish 6 copies of the operating and service manuals for the system. The manuals shall be bound in flexible binders and all data contained therein shall be printed or typewritten. Each manual shall include all instruction necessary for proper operation and receiving of the system, and shall include a complete block diagram of the system, a complete circuit diagnosis of the system, and a wiring designation schedule for each amplifier as well as other major components, and
a replacement parts list. The documentation shall include detailed installation instructions for all the components that comprise the complete UPS system.

1.4 QUALITY ASSURANCE

A. Uninterruptible power system components shall be manufactured by firms that are regularly engaged in the production of UPS systems including auxiliary equipment similar to that required by this Contract and that have been in satisfactory service for at least 10 years.

B. Operation of the uninterruptible power system shall be demonstrated to the ENGINEER to prove that under normal conditions, UPS will provide power to the designated load without interruptions of functions and loss of stored information.

1.5 SERVICE DURING CORRECTION OF DEFECTS PERIOD

A. The CONTRACTOR shall respond to trouble calls with a competent repair person at the Site within 24 hours of notice. The CONTRACTOR shall also maintain a full inventory of replacement parts so that all routine repairs can be completed within 24 hours after the initial response.

PART 2 – PRODUCTS

2.1 THE SYSTEM

A. The UPS shall be a continuous duty, on-line, solid-state system, utilizing line-interactive UPS topology and operating in conjunction with the plant electrical system to provide power conditioning, back-up, and distribution for critical equipment loads. The system shall consist of a solid-state inverter/charger, microprocessor controlled logic, a ferro-resonant transformer, a sealed maintenance-free battery, electromechanical bypass switch, and accessories as indicated.

B. In the line-interactive or single conversion UPS, utility power shall be fed directly to the critical load through an inductor transformer. Regulation and continuous power to the critical load shall be achieved through the use of inverter switching elements in combination with inverter magnetic components, such as inductors, linear transformers, or ferro-resonant transformers. The inverter shall interact with the transformer to provide plus or minus 3 percent load regulation under variations of line and load condition within the ratings of the UPS.

2.2 SYSTEM DESCRIPTION

A. The UPS system shall consist of the following major equipment:

1. Inverter/charger.

2. Electromechanical bypass switch.

3. Enclosed, sealed, maintenance-free battery. Battery cabinets for longer protection times.

4. Input, battery, and output breakers.

5. Microprocessor controlled logic and control panel.
6. Magnetics (ferro-resonant regulating transformer).

7. Control panel.

8. External bypass switch to allow the complete physical removal of the UPS unit without interruption to the critical load.

2.3 MODES OF OPERATION

A. The UPS shall operate as an on-line fully automatic system in the following modes:

1. Normal: For incoming utility voltage as low as 62 percent of nominal, based on the size of the load, the ferro-resonant regulating transformer shall provide regulated output voltage without drawing power from the batteries while supplying filtered ac power to the critical loads. In addition, simultaneous float-charging of the battery shall occur.

2. Emergency: Upon failure of the commercial ac power, the inverter shall continue to supply the critical load without any switching by obtaining its power from the storage battery. There shall be no interruption to the critical load upon failure or restoration of the commercial ac source.

3. Recharge: Upon restoration of the commercial ac source, the inverter/charger shall recharge the battery. This shall be an automatic function and cause no interruption to the critical load.

4. Bypass Mode: If the UPS must be taken out of service for overload, load fault, or internal failures, the bypass switch shall automatically transfer the load to the commercial ac power. Return from bypass mode to normal mode of operation shall be automatic, except for overload trip which requires manual reset. Transfer to bypass mode shall also be initiated manually by operating a key-controlled On/Off switch on the control panel.

2.4 PERFORMANCE CHARACTERISTICS

A. **Power Ratings:** 5.3 kVA/3.7 kW

B. Input

1. Nominal input voltage and frequency: 60 Hz models: 120/208 vac.

2. Operating input voltage range: plus 15 percent to minus 20 percent of nominal without battery discharge.

3. Input power factor: 0.98 minimum at full load and nominal input voltage.

4. Output voltage THD: 5 percent maximum at rated kW load.


C. **Runtime (minutes):** 5.3 kVA/3.7 kW for 20 min. under full load; 50 min. half load.
D. Output

1. Nominal output voltage: Same as input voltage.

2. Output voltage regulation: plus and minus 3 percent for input voltages of plus 15 percent to minus 20 percent.

3. Transient voltage response: Within plus and minus 8 percent from nominal peak voltage for a 100 percent load step.

4. Transient voltage recovery: 100 msec to within plus and minus 2 percent of nominal.

5. Frequency regulation: plus and minus 0.1 Hz.

6. Output voltage harmonic distortion: 5 percent or less TDH at rated kW load.

7. Output fully isolated from input and battery.

E. Environmental

1. Efficiency at full, unity power factor load and nominal input voltage: 90 percent.

2. Elevation: The maximum operating ambient temperature drops 1 degree C per 300 meters (2 degrees F per 1000 feet) above sea level, with the maximum elevation being 3000 meters (10,000 feet).

3. Acoustical noise: 51 dBA at one meter (typical at 5.3 kVA but varies with UPS rating) (Measured at 25 degrees C)

4. EMI suppression: Electromagnetic effects shall be minimized to ensure that computer systems or other similar electronic systems are neither adversely affecting to, nor are adversely affected by the UPS. The UPS shall be certified to meet the requirements of Class A, Subpart J of Part 15 of the FCC Rules and Regulations.

F. Battery Pack

1. The battery shall consist of battery tray fully enclosed within the UPS.

2. Batteries shall be sized to provide run times as indicated.

3. Battery Overcurrent Protection: A molded case breaker or fuse shall be provided for battery short circuit protection.

2.5 FUNCTIONAL DESCRIPTION

A. Inverter/Charger: The inverter shall be capable of providing the indicated quality output power while operating from the ac utility or dc source within the required operating range. In addition, the inverter shall simultaneously float charge the battery.

B. Electrical Protection

1. DC Input: DC fuse and battery charger fuse.
2. Output Protection: The ferro-resonant transformer shall inherently limit current and provide overload protection. The UPS shall have high ac and low ac output voltage alarms, as well as an overload alarm. If the ac output voltage falls below the low ac output voltage alarm setpoint, the unit shall alarm after 5 seconds. If the ac output voltage falls below the low ac output shutdown setpoint, the unit shall alarm and shut down.

C. Electromechanical Bypass

1. An electromechanical bypass switch shall include transfer control logic which automatically transfers the load to bypass upon the following conditions:
   a. Output overvoltage or undervoltage.
   b. Overload condition of a duration longer than 10 minutes.
   c. Overtemperature.
   d. Inverter failure.

2. Return to UPS mode of operation upon restoration of normal operating conditions shall be automatic except for overload or inverter failure which requires a manual restart. Electromechanical transfers shall be break before make.

D. Microprocessor Controlled Logic: Fully automatic operation of the UPS shall be provided through the use of microprocessor controlled logic. All operating and protection parameters shall be firmware controlled to eliminate the need for manual adjustment compensation for component tolerances. The logic shall include system and battery test capability to facilitate maintenance and troubleshooting. Start-up, transfers, and battery recharge shall be all automatic functions.

E. Control Panel

1. The UPS shall be equipped with a control panel that provides the monitoring and control functions

2. Four Operating Modes: Auto, Inverter On (Battery Power), Line Condition, and Off. Under normal conditions, selection of the appropriate operating mode shall be automatic, however the operating mode shall be manually selectable from the control panel.

3. Front Panel Lights
   a. AC LINE – Green – Normal AC Input Power
   b. READY – Green – Battery backup power available
   c. CHARGING – Green – Battery is charging
   d. BATTERY POWER – Yellow – UPS is in the inverter mode with power provided from the batteries.
   e. ALARM – Red – Alarm condition
4. **Alarm Monitoring:** The control panel shall display an error message identifying the alarm condition:

<table>
<thead>
<tr>
<th>ALARM MESSAGE</th>
<th>ALARM CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Battery</td>
<td>The battery charge is low because the system was running on battery power or the DC Switch was not on.</td>
</tr>
<tr>
<td>Near Low Battery</td>
<td>The battery voltage has reached the Near Low Battery setpoint.</td>
</tr>
<tr>
<td>High Battery</td>
<td>There may be a problem with the charging circuit or parameter settings.</td>
</tr>
<tr>
<td>Low Runtime</td>
<td>The unit is running on battery power, and the battery runtime remaining is low.</td>
</tr>
<tr>
<td>Low AC Output</td>
<td>The output voltage is below a pre-programmed setpoint.</td>
</tr>
<tr>
<td>High AC Output</td>
<td>The output voltage is higher than the alarm setting.</td>
</tr>
<tr>
<td>Output Overload</td>
<td>Equipment is drawing more power than the UPS can provide. The unit shall continue to run with overloads as high as 125 percent for 10 minutes and then shut down.</td>
</tr>
<tr>
<td>Hi Ambient Temp</td>
<td>The temperature inside the unit is too high. If the temperature reaches a preset point, the unit shall shut down.</td>
</tr>
<tr>
<td>Hi Heatsink Temp</td>
<td>The inverter temperature is too high. If the temperature reaches a preset point, the UPS shall shut down.</td>
</tr>
<tr>
<td>User Test Alarm</td>
<td>The user is testing the alarm feature.</td>
</tr>
<tr>
<td>Hi Transformer Temp</td>
<td>The transformer temperature is too high. If the temperature reaches a preset point, the UPS shall shut down.</td>
</tr>
<tr>
<td>Check Charger</td>
<td>The UPS has detected a charger problem.</td>
</tr>
<tr>
<td>Check Battery</td>
<td>The batteries have failed the automatic system test.</td>
</tr>
<tr>
<td>Check Inverter</td>
<td>The inverter has failed the automatic system test.</td>
</tr>
<tr>
<td>Memory Check</td>
<td>Possible microprocessor problem.</td>
</tr>
<tr>
<td>Emergency Power Off</td>
<td>The Remote Shutdown feature has been activated at the RS232 port.</td>
</tr>
<tr>
<td>---------------------</td>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>Hi PFM Res Temp</td>
<td>The Power Factor Module’s temperature is too high. If the temperature reaches a preset point, the UPS shall shut down.</td>
</tr>
<tr>
<td>Probe Missing</td>
<td>A temperature probe is missing or damaged.</td>
</tr>
<tr>
<td>High AC Input</td>
<td>The input voltage is higher than the alarm setting.</td>
</tr>
<tr>
<td>Call Service</td>
<td>The UPS has detected a problem that requires service.</td>
</tr>
<tr>
<td>Fan Alarm</td>
<td>The fan has stopped.</td>
</tr>
</tbody>
</table>

**F. Alarm Contact:** A dry type summary alarm contact shall be provided for remote indication of alarm conditions.

### 2.6 ENCLOSURES

**A.** The UPS shall be housed in a free standing double dead front (safety shields behind front door) enclosure equipped with casters and leveling feet. Enclosures shall be designed for office or computer room applications. If system consists of more than one cabinet, the cabinets shall be shipped with joining hardware to be bolted together at time of installation.

**B.** **Ventilation:** Electronics cabinets shall be designed for natural convection cooling aided by a thermostatically controlled fan. Air inlets shall be in the lower front and rear; air outlets shall be in the upper rear. Battery cabinets shall be convection cooled.

**C.** **Cable Entry:** Units equipped with input cord and plug and output receptacles shall not require any installation. Hard-wired systems shall provide for conduit entry through knockouts located in the rear of the unit. Connection between UPS and battery cabinets shall consist of cables and power plugs.

**D.** **Front Access:** Major subassemblies shall be modular and shall be replaceable from the front of the unit.

### 2.7 MANUFACTURERS, OR EQUAL

**A.** The UPS shall be **Ferrups FE Series**, as manufactured by **Powerware**.

**PART 3 – EXECUTION**

### 3.1 GENERAL

**A.** The uninterruptible power system shall be installed as indicated and shall conform to Section 260000 - Electrical Work, General and the equipment manufacturer's installation instructions.
1. The CONTRACTOR shall receive, store, and assemble all sections of the UPS to form complete units. The CONTRACTOR shall make all internal wiring interconnections as required for complete assembly of each UPS. Where wiring connectors are not supplied by the manufacturer, the CONTRACTOR shall furnish the connectors required to complete internal wiring terminations.

2. The CONTRACTOR shall take all necessary precautions to eliminate moisture and foreign material from the equipment at all times during storage and installation. Special care shall be taken to prevent corrosion of and damage to the UPS.

3. Each UPS shall be set level and plumb on its floor channels and be grouted in as indicated. The CONTRACTOR shall provide all shims necessary to accomplish these requirements.

- END OF SECTION -
SECTION 263623 - AUTOMATIC TRANSFER SWITCH

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide an automatic transfer switch (ATS) matching the motor control center enclosure (MCC) dimensions and color, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 260000 – Electrical Work, General, apply to the WORK of this Section.

C. Single Manufacturer

   1. The ATS shall be the end product of one manufacturer in order to standardize appearance, operation, maintenance, spare parts, and manufacturer’s services.

   2. This requirement, however, does not relieve the CONTRACTOR of overall responsibility for the WORK.

B. Coordination

   1. The equipment provided under this Section shall provide the means to interface with a normal and standby source.

   2. The ATS manufacturer shall be provided with the following information, at a minimum:

      a. Section 260000 – Electrical Work, General

      b. Section 260126 – Electrical Tests

      c. Section 260515 – Industrial Control Panels

      d. Section 260519 – Wire and Cable

      e. Section 261110 – 480V Main Switchgear

      f. Section 262900 – Low Voltage Motor Control Centers

      g. Electrical Contract Drawings

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 260000 – Electrical Work, General.

B. Furnish the following equipment information in the Shop Drawings:

   1. NEMA rating and color of enclosure.

   2. Rated current, voltage, frequency, and interrupting capacity.

   3. Number of poles.
5. Ground bus size and enclosure dimensions.
7. Main incoming line entry provision.
8. Controller information.
9. List of accessories.
10. Control elementary diagram.
11. Wiring diagram and identification of the field wiring.
12. Short circuit rating of the complete assembly.
13. Replacement parts lists and operation and maintenance procedures.
14. Seismic design certification of the anchoring system in accordance with Section 260000 – Electrical Work, General.
15. Time-current curves for protective devices where applicable.
16. Factory test data certifying compliance with requirements of similar equipment from the same manufacturer.
17. Warranty information and extended warranty information.
18. All other information required on Section 260000.

C. Furnish an Owner's Manual, including:
   1. Manufacturer's two-year warranty.
   2. Field test report.

D. Furnish the Manufacturer's Service Representative's resume, including the following documentation:
   1. Copy of the proposed representative's Factory Training Certificate.
   2. Number of years experience servicing the manufacturer's ATS.
   3. A statement that the individual is authorized to inspect, test and perform field service and repairs.

E. **Spare Parts List:** Furnish spare parts information for parts required by this Section as well any other spare parts recommended by the ATS manufacturer.
F. Startup and Testing Report

1. Within 15 days after completion of startup and testing, the CONTRACTOR shall submit a report for the ATS.

2. The report shall contain the following documentation:
   
a. The device name, serial number, rating, and complete model number of each ATS.

b. A complete listing of all tests performed and the results of each test.

c. Documentation for training that was provided to the OWNER's personnel, including topics covered, instructor's name and contact information, and a list of attendees.

PART 2 -- PRODUCTS

2.1 GENERAL

A. The manufacturer of the low-voltage ATS shall also manufacture at least the following:

1. Molded case circuit breakers, up to and including 225 ampere frame size.

2. Disconnect switches.

3. Control and timing relays rated at 600 volts AC.

4. Pushbuttons, lights and selector switches, including remote mounted control stations.

5. Meters, including ammeter, voltmeter, and solid-state metering devices.

6. ATS controllers and repair parts.

B. Single Manufacturer

1. Devices of the same type shall be products of the same manufacturer.

2. This requirement applies to control devices, custom-fabricated equipment, and insofar as practical to equipment manufactured on a production basis.

C. ATS units shall conform to the standards for NEMA Class IIS, Type B diagrams and wiring.

D. ATS Schedule

<table>
<thead>
<tr>
<th>EQUIPMENT DESIGNATION</th>
<th>LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 - ATS - 1</td>
<td>PUMP ROOM 1 ELECTRICAL AREA</td>
</tr>
</tbody>
</table>

2.2 DESIGN, CONSTRUCTION, AND MATERIAL REQUIREMENTS

A. The ATS shall be 600-volt class and suitable for operation on a 3-phase, 60-Hz system.
B. The system operating voltage and number of wires shall be as indicated on the Contract Documents.

C. Power
   1. The ATS shall receive normal power from a 3-phase, 3-wire, motor control center and standby power from a 3-phase, 3-wire switchboard.
   2. The power output from the ATS shall be 480-volt, 3-phase, 3-wire.
   3. The ATS shall include a ground bus for termination of the incoming equipment grounding conductors in conformance to NEC requirements.

D. Enclosure
   1. The enclosure shall be of NEMA Type 1, gasketed.
   2. Ventilation inlet openings shall be equipped with replaceable dust filters.
   3. The control door shall be independent from the power compartment. The control section door shall be accessible from the front without opening the power section.

E. Size and Construction
   1. The transfer switch unit shall be electrically operated and mechanically held.
   2. The electrical operator shall either be a single or dual motor design with over-center type linkage solenoid mechanism, momentarily energized to minimize power consumption and heat generation.
   3. The switch shall be positively locked and unaffected by voltage variations or momentary outages so that contact pressure is maintained at a constant value and temperature rise at the contacts is minimized for maximum reliability and operating life.
   4. The switch shall be mechanically interlocked to ensure only one of two possible positions - normal or standby for single solenoid design and three possible positions - normal off, standby for dual motor design.
   5. All main contacts shall be silver-plated copper composition. All switches shall have segmented blow-on construction for high withstand current capability and be protected by separate arcing contacts.
   6. ATS utilizing components of molded-case circuit breakers, contactors or parts thereof which have not been intended for continuous duty, repetitive switching or transfer between two active power sources are not acceptable.
   7. Inspection of all contacts (movable and stationary) shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. An insulated manual operating handle shall be provided for maintenance purposes.
   8. Utilize quick-make quick-break contacts mounted so that contact position may be verified by observation.
9. The ATS shall be fully rated including the cable terminations.

10. All terminal lugs shall be compression, AL/CU Type.

11. The ATS size was based on a typical MCC enclosure with 36” width. The CONTRACTOR shall be responsible for any and all required changes and costs to fit larger equipment built with “or equal” hardware. The ATS may be rejected on size alone.

F. Components

1. Busses
   a. Provide a copper ground bus rated the same as the main contacts. The ground bus shall be of adequate length to accommodate all equipment ground conductors and the ground grid riser conductor.
   b. Power Busses
      1) The connection from 40-ATS-1 to 40-MCC-4 shall be bused if both the ATS and the MMC are furnished by the same vendor.
      2) The ATS bus shall be rated for 600 amperes minimum, but in no case less than the rating shown on the Contract Documents.
      3) The normal and standby source shall interface with the ATS at the top of the enclosure.
   c. The ATS assembly shall be braced to withstand 65,000 amperes, minimum.

2. Wireways: Provide a separate control wireway to interface with the station SCADA equipment.

3. Control wires shall be color coded in accordance with Section 260519 – Wires and Cables.

G. Cabinets

1. Structural members shall be fabricated of not less than 12-gauge steel, and side and top panels and doors shall be fabricated of not less than 14-gauge steel.

2. Control devices inside compartments shall be clearly identified with lamicoid tags or machine printed labels for the purpose. The machine printed labels shall be of a durable material impervious to decay due to heat and oxidation by ozone or gases generated by electrical arcs.

3. Identification
   a. Devices and control switches shall be identified by an engraved nameplate.
   b. Identification shall include the indicated circuit number and foreign power sources.
   c. Each motor control center shall be fitted with the manufacturer’s nameplate which shall include the NEMA Standard electric rating and other pertinent data,
including manufacturer, sales order number, date of manufacture, and place of manufacture.

4. Fans, heat exchangers, transformers, capacitors, junction boxes, and other devices shall not be mounted on the outside of the ATS enclosure.

5. Protective Coating

a. The finish for motor control center shall be light grey: ANSI 61 or 49.

b. The panels shall be coated with 2 coats of primer inside and out, and 2 coats of enamel finish.

c. External colors other than ANSI 61 or 49 will not be accepted.

2.3 OPERATION

A. The voltage of each phase of the normal source shall be monitored, with pickup adjustable from 85 to 100 percent and dropout adjustable from 75 to 98 percent of pickup setting, both in increments of 1 percent, and shall be fully field-adjustable. Repetitive accuracy of settings shall be ±2 percent or better over an operating temperature range of -20 degrees C to 70 degrees C. Factory set to pick up at 90 percent and drop out at 85 percent.

B. Single-phase voltage sensing of the standby source shall be provided, with a pickup adjustable from 85 to 100 percent (and dropout fixed at 84 to 86 percent of pickup), and frequency sensing with pickup adjustable from 90 to 100 percent (and dropout fixed at 87 to 89 percent of pickup). Both pickup settings shall be fully field adjustable. Repetitive accuracy of settings shall be ±2 percent or better over an operating temperature range of -20 degrees C to 70 degrees C. Factory set to pick up at 90 percent voltage and 95 percent frequency:

C. The control module shall include four (4) time delays that are fully field adjustable in increments of at least 13 steps over the entire range as follows:

1. Time delay to override momentary normal source outages to delay all transfer switch and engine starting signals. Adjustable from 0 to 6 seconds. Factory set at 1 second.

2. Transfer to standby source time delay. Adjustable from 0 to 5 minutes. Factory set at .5 minutes, unless indicated otherwise on the Drawings.

3. Retransfer to normal source time delay. Time delay is automatically bypassed if the standby source fails and normal source is acceptable. Adjustable from 0 to 30 minutes. Factory set at 5 minutes.

4. Unloaded running time delay for emergency engine generator cool-down. Adjustable from 0 to 60 minutes. Factory set at 5 minutes.

D. A set of DPDT silver composition contacts rated 10 amps, 32 VDC shall be provided for a low-voltage engine start signal when the normal source fails. The start signal shall prevent dry cranking of the generator by requiring the generator to reach proper output, and to run for the duration of the cool-down setting, regardless of whether the normal source restores before the load is transferred. This feature shall be programmable to allow the standby source to be a different feeder.
E. Provide a pushbutton to bypass time delay on retransfer to the normal source.

F. A momentary-type keyed test switch shall be provided to simulate a normal source failure. The key will remain captive unit the switch is locked out be the Operator.

G. The ATS enclosure shall be equipped with thermostatically controlled heaters if deemed necessary to control condensation.

H. Output terminals to signal the actual availability of the normal and emergency sources, as determined by the voltage-sensing pickup and dropout settings for each source, shall be provided.

I. Provide the following sets of dry auxiliary contacts rated 10 amps 480 VAC wired to an accessible terminal strip. SCADA Provider shall connect these contacts to the station controller for remote monitoring:
   1. One (2) contact closed when the ATS is connected to the normal source
   2. One (2) contact closed when the ATS is connected to the standby source
   3. One (2) contact closed when the normal source is available; and
   4. One (2) contact closed when standby source is available.
      a. It is unacceptable to have one (1) form C contact to account for more than one of the specified auxiliary contacts.

J. Provide four (4) sets of signal lights to indicate the following:
   1. When the ATS is connected to normal source;
   2. When the ATS is connected to emergency source;
   3. When normal power is available; and
   4. When emergency power is available
      a. Form C contacts are unacceptable. Contacts shall be wired to an accessible terminal strip

K. In place of discrete lights, the equipment can have a HMI and graphically represent the same function as the lights.

L. Each switch shall be furnished with an operator's manual providing installation and operating instructions.

M. On all switches not part of a bypass isolation switch assembly, provide an external manual operator, UL listed for transferring the switch to either source under load.

N. Provide LED type indicating lights; one to indicate normal source (white), one to indicate standby (amber). Provide indicating lights for both normal and standby source availability.
O. Bypass/Isolation Operation

1. Provide a bypass/isolation switch to electrically bypass and isolate the automatic transfer switch. The switch must be capable of bypassing to whichever source the ATS is connected to.

2. The bypass/isolation switch also permits continuous service in case the transfer switch is inoperable, damaged, or removed.

3. All auxiliary circuits to the automatic transfer switch remain in service during operation of the bypass/isolation switch. Interlocking shall be provided to prohibit personnel from controlling the sequence of operations and to prevent operation to the isolation position until the bypass function has been completed.

P. In-phase Monitor

1. If the ATS is of a single solenoid design, an in-phase monitor shall be built-in to the ATS and shall control transfer so that motor load inrush currents do not exceed normal starting currents, to avoid nuisance tripping of circuit breakers and possible mechanical damage to motor couplings.

2. The in-phase monitor shall operate without external control of electrical loads and without any external control of the power sources.

3. The monitor shall compare the phase relationship and frequency difference between the normal and emergency sources and permit transfer the first time the sources are within 15 electrical degrees and only if transfer can be accomplished within 60 electrical degrees as determined by monitoring the frequency difference.

4. In-phase transfer shall be accomplished if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage. This is not required for dual motor design.

Q. Center Off Position: If the ATS is of the dual motor design, a time delay relay shall be provided to vary the center off delay from 0 to 60 seconds.

2.4 MAIN CONTACT PROTECTION AND WITHSTAND CURRENT RATINGS

A. Protect main contacts by providing arc barriers on each contact, and on switches rated above 300 amperes by providing separate arcing contacts.

B. The ATS shall be UL 1008 listed for a 3-cycle close and withstand current rating as indicated on the Drawings. Series rating of switches with particular circuit breakers or fuses is not acceptable.

2.5 NEUTRAL BAR

A. Provide a 100 percent rated neutral bar with the same capacity as the ampere rating of the switch, unless otherwise noted on the Drawings.

2.6 ENCLOSURE

A. Provide NEMA 1 switch enclosure suitable for floor mounting.
B. Mount the bypass/isolation switch in a common enclosure with the associated transfer switch. Separate the bypass/isolation switch from the associated transfer switch by a metal divider panel.

C. Make the switch operable from a dead-front location. Design switch so that it can be padlocked in the bypass/isolation position.

D. Permanently attach wiring diagrams and maintenance instructions on the inside of enclosure door in a mounting designed to hold the data. Instructions shall be laminated.

2.7 FACTORY TESTS

A. Provide the manufacturer's standard electrical and mechanical production tests and inspections for motor control centers and their components.

B. The tests shall include electrical continuity check, dielectric tests for each circuit, and inspection for proper functioning of components including controls, protective devices, metering, and alarm devices.

2.8 SPARE PARTS

A. The CONTRACTOR shall furnish the following for each ATS:
   1. Unit Control Transformer: one of each size furnished in magnetic starters installed.
   2. Bezels: 3 of each color installed for pilot indicators.
   3. Panel Lamps: one dozen of each type (form, voltage and current rating) installed.
   4. Control Fuses: one dozen of each type (form, voltage and current rating) installed.
   5. Relays: one of each type and size installed.
   6. ATS contacts and consumable parts.
   7. ATS components recommended by the manufacturer.

2.9 ATS MANUFACTURER, OR EQUAL

A. ATS shall as manufactured by:
   1. Eaton Electric
   2. ASCO
   3. GE Zenith
   4. Or approved equal

PART 3 -- EXECUTION

3.1 GENERAL

A. The CONTRACTOR shall install ATS switches in accordance with the manufacturer's published instructions.
B. Conduit installation shall be coordinated with the manufacturer's as-fabricated drawings such that conduit stub-ups are within the area allotted for conduit.

C. Conduit shall be stubbed up in the section that contains the devices to which conductors are terminated. Alternately, the conduits shall be arranged in a workmanlike manner and supported from the structure for top entry.

3.2 STORAGE AND HANDLING

A. If stored at the Site, ATS units shall be stored in a clean, dry space.

B. Factory wrapping shall be maintained or an additional heavy plastic cover shall be provided to protect units from dirt, water, construction debris, and traffic.

C. The storage space shall be heated or the ATS space heaters shall be energized. Otherwise the Contractor shall use temporary means to accomplish the same.

D. ATS units shall be handled carefully to avoid damage the unit, its components, enclosure, and finish.

E. Damage shall be repaired before installation.

3.3 MANUFACTURER'S SERVICES

A. General

1. An authorized Service Representative of the manufacturer shall be present at the Site as required and a minimum of 5 trips in order to provide the services listed below.

2. For the purpose of this paragraph, a Work Day is defined as an 8-hour period, excluding travel time.

3. The service representative's resume shall be approved by the ENGINEER before training is scheduled.

B. Inspection, Startup, Field Adjustment

1. The Service Representative shall supervise the following items, and shall certify that the equipment and controls have been properly installed, aligned, and readied for operation:

   a. installation of the equipment
   
   b. inspection, checking, and adjusting of the equipment
   
   c. startup and field testing for proper operation
   
   d. performance of repairs to correct any discrepancies or problems revealed during startup and testing
   
   e. performance of field adjustments to ensure that the equipment installation and operation comply with the indicated requirements
f. Preparation and submittal of a report covering startup and testing, including a listing of equipment settings and parameters at the end of startup and testing.

g. Adjust the ATS timers and programmable settings. Verify that the mechanism functions as intended and in accordance with the manufacturer’s literature.

3.4 INSTALLATION

A. The CONTRACTOR shall:

1. Torque all bus bar or cable lug bolts to manufacturer’s recommendations. Tighten all sheet metal and structure assembly bolts.

2. After equipment is installed, touch up scratches and verify that nameplates and other identification are accurate.

3. Provide high voltage switchboard matting in front of each ATS unit.

B. ATS units shall be installed on 3-1/2-inch concrete pads and in accordance with the requirements of Section 260000 – Electrical Work, General.

C. After leveling and shimming, the CONTRACTOR shall anchor ATS units to the concrete housekeeping pads, and shall grout such that no space exists between the pad and support beams.

3.5 FIELD TESTS

A. Provide a visual and mechanical inspection after installation, as follows:

1. Inspect for physical damage, proper anchorage, and grounding.

2. Verify that the unit ratings match the motor design and documentation nameplate data.

3. Check tightness of bolted connections.

4. Electrical tests.

5. Insulation tests.

B. Measure the insulation resistance phase-to-phase and phase-to-ground for one minute.

C. The test voltage and minimum acceptable resistance shall be in accordance with manufacturer's recommendations.

D. Measure the insulation resistance of each control circuit with respect to ground.

E. Demonstrate to the Owner that the automatic transfer switches and bypass isolation switches perform all required functions.

3.6 TRAINING

A. Formal training for the operation and maintenance of all equipment and systems specified herein shall be given by factory trained and certified personnel.
B. Training shall consist of a minimum of five, complete 4-hour training sessions. The training shall cover operation, routine maintenance, complete overhaul, recommissioning, troubleshooting, programming, and interface with an external maintenance PC.

C. Timing of the training should coincide with the schedule for the manufacturer's representatives to be on Site for testing and Start-up of the systems.

D. The specified training shall be given at a location designated and provided by the Owner for a minimum of five (5) personnel selected by the Owner, in addition to any necessary on-Site orientation and training.

E. A training program shall be submitted with material, instructors' qualifications, and proposed schedule, a minimum of 60 days prior to the proposed training.

F. The Owner reserves the right of approval of any training course, material, instructor and schedule.

G. The Contractor will engage a firm that records instruction videos in behalf of the Owner and the recordings will be part of the deliverables.

- END OF SECTION -
PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide air cooled 18 step (minimum) or Active Front End (AFE), pulse width modulated (PWM) variable frequency drive (VFD) units, designed to operate with the indicated induction motors, complete and operable, in accordance with the Contract Documents and as follows:

<table>
<thead>
<tr>
<th>Pump Tag</th>
<th>Pump Motor Size and RPM</th>
<th>Type of Cooling</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-510</td>
<td>400HP -1200</td>
<td>FORCED AIR</td>
</tr>
<tr>
<td>P-520</td>
<td>400HP -1200</td>
<td>FORCED AIR</td>
</tr>
<tr>
<td>P-530</td>
<td>400HP -1200</td>
<td>FORCED AIR</td>
</tr>
<tr>
<td>P-540</td>
<td>400HP -1200</td>
<td>FORCED AIR</td>
</tr>
</tbody>
</table>

B. Drive ratings shall be coordinated with the nameplate ratings of the pump motor in Section 432000 - Pumps General.

C. Each variable frequency drive shall be produced and assembled by the manufacturer at a facility owned or operated by the manufacturer and under the direct supervision and control of the manufacturer.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

- UL 347B High Voltage Industrial Control Equipment
- NEMA AC ICS 3-2 Medium Voltage Controllers
- NFPA 70 National Electrical Code (NEC)
- IEEE Standard 519 Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems

1.3 SHOP DRAWINGS AND SAMPLES

A. The CONTRACTOR shall submit the listing of the VFD manufacturer's qualifications within 30 Days after receiving Notice of Proceed.

B. Submit the following in accordance with Section 013300 - Contractor Submittals:

1. Calculation of VFD efficiencies at 50, 75, and 100 percent speed. The system efficiency shall include power losses from the cooling system, controls, contactors, isolation transformers, line reactors, and filters.
2. Continuous and fault ratings of drive and disconnecting means.

3. Description of proposed factory test procedure and sketch of test setup.

4. Harmonic analysis results.

5. VFD output pulse maximum peak voltage, pulse rise time, and pulse rate of rise. Include motor manufacturer’s certification that motor insulation will withstand long-term over voltages caused at motor terminals due to output pulse data.

6. Complete system rating, including all nameplate data and continuous operation load capability throughout speed range of 0 to 110 percent rated speed.

7. Controller dimensional drawings, weight, and information on size and location of space for incoming and outgoing conduit.

8. Maximum heat dissipation from enclosure.

9. Should separate enclosures and equipment be necessary for filter element, isolation transformer, PLC, motor monitor, or vibration monitoring panel, furnish complete dimensional information including location of space for incoming and outgoing conduit, weight, maximum heat loss, and minimum current carrying capacity and recommended wire size of required interconnecting circuits.

10. Layout of controller face showing pushbuttons, switches, instruments, indicating lights, LCD display unit, etc.

11. Complete system operating description.

12. Complete system elementary schematic wiring diagrams.

13. Complete system interconnection diagrams between controller, drive motor, and all related components or controls external to system, including wire numbers and terminal board point identification.

14. One-line diagram of system, including component ratings.

15. Description of diagnostic features being provided.

16. Descriptive literature of all control devices such as relays, timers, etc.

17. Itemized bill-of-materials listing all system components.

18. Description of PLC, vibration monitoring panel, and motor protection relay.

19. Annotated and cross referenced PLC and LCD unit program printout.

20. The names and recent VFD experience of the manufacturer's qualified and experienced representatives who will be responsible for:
   a. Office engineering.
   b. Project management.
   c. Field testing, calibration, and startup.
d. Operator training.

21. A letter certifying that manufacturer’s representatives have read and studied the Contract Documents and agree to the requirements of this Section.

1.4 MANUFACTURER’S QUALIFICATIONS

A. The variable frequency drive manufacturer shall have been actively involved in the manufacture of VFD systems under the same corporate name for a minimum of 10 years.

B. The VFD manufacturer shall furnish a listing of at least ten, 18-step (or greater, or AFE) pulse width modulated medium voltage variable frequency drive installations of this type, size, and voltage for systems operating for at least 3 years on which the VFD manufacturer performed systems engineering, including harmonic filter and power factor correction calculations, system fabrication and installation, documentation (including schematic, wiring, and panel assembly drawings), field testing, calibration and startup, operator instruction, and maintenance training. At least 5 such installations shall be within the continental United States of America. The list shall include the following information for each installation:

1. Name of facility, owner of facility, contact name, address, and telephone number.

2. Name and type of driven equipment, including horsepower, voltage, speed range, and application.

3. Drive type furnished (18-pulse, etc.)

C. The VFD manufacturer shall furnish the services of qualified and experienced representatives.

D. The VFD manufacturer shall agree in writing to the requirements of this Section.

1.5 SERVICES OF MANUFACTURER

A. Inspection, Startup and Field Adjustment: An authorized service representative of the manufacturer shall visit the Site for not less than 4 Days per drive system to perform the following services:

1. Verify proper installation of the equipment.

2. Inspection, checking and adjusting the equipment.

3. Startup and field testing of the VFD controllers.

B. Instruction of OWNER’s Personnel

1. An authorized service representative or training instructor shall instruct the OWNER’s personnel in all aspects of drive operation and maintenance, including step-by-step troubleshooting procedures with necessary test equipment. Instructions shall be given after all VFDs are in place and in full service condition. Instruct a maximum of 6 personnel for a total of 3 Days.

2. The representative shall have at least 2 year's experience in training. A resume for the representative shall be submitted.
3. Training shall be scheduled a minimum of 3 weeks in advance of the first session.

4. Proposed training material and a detailed outline of each lesson shall be submitted for review at least 4 weeks before training is conducted. Comments shall be incorporated into the material.

5. The training materials shall remain with the trainees.

6. The OWNER may videotape the training for later use with its personnel.

PART 2 -- PRODUCTS

2.1 DRIVE

A. General

<table>
<thead>
<tr>
<th>Number of drive units</th>
<th>4 (four)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driven equipment</td>
<td>Vertical Turbine Pump</td>
</tr>
<tr>
<td>Driven equipment specification</td>
<td>432115</td>
</tr>
<tr>
<td>VFD tags</td>
<td>VFD-510/-520/-530/-540</td>
</tr>
<tr>
<td>Drive voltage</td>
<td>4160 Volt</td>
</tr>
</tbody>
</table>

B. Service Conditions: The VFD shall be designed and constructed to operate within the following service conditions:

<table>
<thead>
<tr>
<th>Elevation</th>
<th>to 3,300 feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient Temperature Range</td>
<td>0 degrees C to 50 degrees C</td>
</tr>
<tr>
<td>Atmosphere</td>
<td>Noncondensing relative humidity to 95 percent</td>
</tr>
<tr>
<td>AC Line Voltage Variation</td>
<td>minus 5 percent to plus 10 percent</td>
</tr>
<tr>
<td>AC Line Frequency Variation</td>
<td>plus or minus 3 Hz</td>
</tr>
</tbody>
</table>

C. Operating Conditions

1. Minimum VFD efficiency shall be 96 percent at 100 percent speed and 100 percent torque and 87 percent at 60 percent speed based on nominal 1200 RPM motor with load horsepower to vary as cube of speed.

2. Distribution voltage shall be 4.16 kV, three phase, three wire, wye connected, grounded neutral, 60 Hz as indicated.

3. Total harmonic distortion with input and output filters shall be not more than 3 percent at the unit terminals.
4. Notching area, as defined by IEEE 519, shall be not more than 22,800 voltmicroseconds. Notch depth shall not exceed 10 percent of normal peak voltage for line-to-neutral observations.

2.2 GENERAL

A. Basic Description: The VFD shall be modularized to simplify the troubleshooting of the unit. Semiconductors in the converter and inverter sections shall be standard rectifier grade devices bearing the manufacturer's standard catalog numbers such that they can be readily cross-referenced and interchanged with other semiconductor manufacturer's devices. Semiconductor catalog numbers shall be submitted as part of the submittal package.

1. Converter: The converter shall be a full wave, phase-controlled, 3 phase converter to change the input AC power to DC power. The output of the converter shall feed an inductor and the converter/inverter combination shall form a current source whose output is regulated and limited. The current limit feature of the converter shall be sufficiently fast and effective so as to protect against a sudden or random application of a short circuit to the output terminals of the current source. The unit shall include a MV contactor to isolate its input MV power when the drive is not running. The unit shall be equipped with a control power transformer to produce its own control power from its feed and a UPS in the chassis in order to keep the controls functional during an outage. The input section shall be equipped with an input harmonic filter to minimize harmonics injection to its source bus.

2. Inverter: The inverter shall convert the DC power of the current source to adjustable frequency power to the motor. The VFD shall not induce excessive power losses in the motor. The worst case RMS motor line current measured at rated speed, torque, and voltage shall not exceed 1.05 times the rated RMS motor current for pure sine wave operation. The inverter section with its output to the motor shall be equipped with a filter to minimize harmful harmonic injection to the motor.

3. Inductor: The drive shall contain an input AC reactor to allow the VFD to operate properly without an isolation transformer. The reactor shall attenuate the commutation notches generated by the VFD. The line reactor shall be mounted and wired within the drive enclosure.

4. Power Bridges: The power bridge of the converter shall utilize a semiconductor configuration to provide an 24 pulse or greater waveform to minimize harmonics on the main AC power line. The input section shall be equipped with an input harmonic filter to minimize harmonics injection to its source bus.

B. Motor Compatibility

1. VFD system shall provide an output waveform that will allow utilization of standard motors, without need of any special insulation or derating. Motor life expectancy should not be compromised in any way by operation with the VFD system. The system must comply with all elements of the Output Harmonics section of this specification. The VFD must provide motor overload protection in any operating condition.

2. VFD output waveform shall be suitable for operating a squirrel cage induction motor without derating or requiring additional service factor. To ensure that there are no problems with motor heating, VFD output current waveform shall be inherently
sinusoidal at all speeds, with a total harmonic current distortion not exceeding 3% at 100% speed and load. VFD’s utilizing output isolation transformers are not acceptable.

3. The system design shall not have any inherent output harmonic resonances in the converter operating speed range.

4. The VFD output shall produce no electrically induced pulsating torques to the output shaft of the mechanical system eliminating the possibility of exciting a resonance caused by VFD induced torque pulsations.

5. VFD shall inherently protect motor from high voltage $\delta v/\delta t$ stress, independent of cable length to motor. VFD shall not require nonstandard insulation systems or insulation ratings above the VFD output voltage rating. The VFD system shall be designed to produce no standing waves or overvoltage conditions based on a cable length of 1000 ft (a typical length which will cover most application requirements and allow for potential future cable run changes) from VFD to motor. If the VFD requires an output filter to meet this requirement, it shall be an integral part of the VFD system and included within the VFD enclosure.

6. An input filter shall be included to provide harmonics mitigation, common mode voltage protection and allow the use of a standard motor. Special high voltage motor insulation is not an acceptable method for protection against common mode voltages.

C. The motor shall be squirrel-cage induction design in accordance with Section 260512 - MV Induction Motors, suitable for variable speed operation with the following additional features:

1. Copper windings.
2. 6 RTDs in stator windings.
3. 1 RTD per sleeve bearing (or vibration switch for ball bearings).
4. Class F insulation (Class B rise).
5. 120-volt space heaters.
6. Premium efficiency.

D. Performance Requirements

1. Efficiency: Minimum guaranteed overall VFD efficiency shall be not less than 96 percent at 100 percent speed and 90 percent at 60 percent speed based on actual motor provided. VFD overall efficiency determination shall include all VFD losses including:
   a. Harmonic filters and capacitors.
   b. VFD power conversion sections.
   c. Input contactor.
   d. Control and auxiliary power.
e. Cooling system, including fans, motors and other components.

2. Efficiency Measurement and Verification: Perform efficiency measurements and verification as part of acceptance testing at VFD manufacturer’s facility. For at least one of each identical VFD system provided, perform actual efficiency measurements for input transformer or line reactor, VFD power conversion sections, and harmonic filters. Overall VFD efficiency may then be calculated using certified efficiency data for other components, subject to approval. The Owner reserves the right to perform additional overall efficiency testing at the job site using the power monitors specified on the input and output of the drives.

3. Power Factor: Input power factor, measured at the input to the VFD shall not be less than 98 percent throughout its loading range conditions.

4. Output Capacity: Each VFD shall be rated for continuous operation at full output current and voltage at a 40 degrees C ambient temperature. Drive output current rating shall be not less than 110 percent of the motor nameplate full load current, at 100 percent synchronous speed, based on the actual motors being provided.

5. Overload Capacity: Each VFD shall be capable of producing not less than 110 percent of its continuous full load current output rating for a minimum of one minute.

6. Drive Output Torque: VFD output shall produce no electro-magnetically induced pulsating or harmonic torques to the motor output shaft and shall produce no mechanical resonances due to harmonic torques. Pump manufacturer shall prepare and submit complete torsional analysis for the complete system, including all effects of VFD harmonic output, and shall certify that the system will operate satisfactorily over the entire specified speed range.

E. Harmonic Distortion

1. Total harmonic distortion with filtration shall be not more than 5 percent for voltage and as listed in table below for current as measured on the medium voltage bus at the point of common coupling in accordance with IEEE Standard 519-1992. Harmonic distortion shall be measured when all VFD’s are operating at full load.

<table>
<thead>
<tr>
<th>Individual Harmonic Order (Odd Harmonics)</th>
<th>Harmonic Current Distortion Percent of Max. Demand Load Current I_L</th>
</tr>
</thead>
<tbody>
<tr>
<td>H &lt; 11</td>
<td>3.0</td>
</tr>
<tr>
<td>11 &lt; h &lt; 17</td>
<td>2.0</td>
</tr>
<tr>
<td>17 &lt; h &lt; 23</td>
<td>1.5</td>
</tr>
<tr>
<td>23 &lt; h &lt; 35</td>
<td>0.6</td>
</tr>
<tr>
<td>35 &lt; h</td>
<td>0.3</td>
</tr>
<tr>
<td>Total Demand Distortion (TDD)</td>
<td>3.0</td>
</tr>
</tbody>
</table>
2. Notching area, as defined by IEEE 519-1992, shall be not more than 22,800 volt-microseconds. Notch depth shall not exceed 20 percent of normal peak voltage for line-to-line observations.

3. The point of common coupling for all harmonic calculations and field measurements for both voltage and current distortion shall be defined as the line side of the VFD where the medium voltage switchgear feeds the VFD.

4. The VFD manufacturer must provide any required harmonic filters, and is responsible for the design and manufacturing of the filter.

5. A preliminary harmonic analysis must be submitted by the VFD manufacturer with preliminary submittal data that includes all voltage and current harmonics up to the 49th.

6. Compliance shall be verified with onsite field measurements of both the voltage and current harmonic distortion at the defined point of common coupling with and without the VFD's operating.

F. Basic Features: The controllers shall be compatible for use with the medium voltage pump drive motor designated for operation from the VFD and shall be capable of operating the motor at full rated horsepower.

1. The door of each power unit shall include:
   a. Input disconnect switch handle integrally interlocked with power unit door. Handle shall be down for open and up for closed.
   b. One manual speed control potentiometer.
   c. One 3 position mode selector switch marked "LOCAL - OFF - REMOTE".
   e. A speed indicating meter with a range of 0 to 110 percent of full speed.
   f. One elapsed time meter with five digits, without reset.
   g. One VFD fault reset pushbutton.
   h. One ammeter with a range of 0 to 125 percent of drive current rating.
   i. One output voltmeter with a range of 0 - 5 kV that functions throughout the frequency range of the VFD output.
   j. VFD fault diagnostics.
   k. Indicating lights to show running and ready status.
   l. One power factor meter.
2. Switches in the door shall control the drive as follows:
   a. With the "LOCAL - OFF - REMOTE" switch in the "LOCAL" position, the drive output speed shall be controlled by the manual potentiometer.
   b. With the "LOCAL - OFF - REMOTE" switch in the "REMOTE" position, the drive shall start when an external isolated contact closes and its speed shall be controlled by a 4 - 20 ma external reference signal.

3. The VFD shall be selectable to provide automatic restart after a trip condition resulting from overcurrent, overvoltage, undervoltage, or over - temperature. For safety, the drive shall shut down and require manual reset and restart if the automatic reset/restart function is not successful within a maximum of 3 attempts within a short time period.

4. Digital Communication / Protocols / Modem or Cable
   a. VFD shall be capable of direct communication to a laptop computer for serial link setup of parameters, fault diagnostics, trending and diagnostic log downloading. An RS-485 port shall be door-mounted for computer or printer interface. VFD parameters, fault log and diagnostic log shall be downloadable for hard copy printout via the RS-485 port and a standard serial printer. A USB port shall be provided with the same functionality and recognized by the drive PC link software.
   b. The VFD shall be furnished with an Ethernet port. The port shall facilitate the communication of the VFD with the station PLC, SCADA, or other control system for status interrogation and direct control.

5. Speed Profile: Individual adjustable settings for start, stop entry, slope, and minimum and maximum speed points. Speed reference shall be from an external 4 - 20 mA DC signal. Drives shall include "Critical Frequency Avoidance" logic. Initial acceleration setting shall be from 0 to minimum speed in 15 seconds and from minimum to maximum speed in 15 seconds. The time from minimum to maximum speed shall be adjustable from 5 seconds to 10 minutes.

6. Control Circuit: Fused 120 VAC control transformer and control relays for system logic functions. For system logic, see Electrical Drawings.

7. Provision for an external 4 - 20 mA DC speed reference input signal. VFD manufacturer shall provide a signal current isolator to ensure signal and galvanic isolation of the grounded or ungrounded input speed reference signal. Where indicated, a frequency proportional 4 - 20 mA powered output signal shall be provided for external use and wired out to terminals.

8. Status and alarm outputs, each consisting of SPDT electrically isolated auxiliary contacts rated 5 amp at 120 VAC.
   a. Alarm output shall consist of 2 separate outputs; VFD fault and motor fault. VFD fault is either:
      1) Output or input under - voltage.
      2) Semiconductor over - temperature.
3) Instantaneous overcurrent.
4) Commutation failure.
5) Convertor saturation.
6) Current limit timeout.
7) Incorrect phase sequence or control power failure.

b. VFD and motor failure shall latch in the trip mode and shall require operator intervention to reset the drive.

c. Status outputs shall consist of three separate unpowered outputs; 2 run status outputs, and a VFD enable output. VFD enable status contacts shall monitor the emergency (coast to a stop) circuit. Wiring shall be as required by the electrical control diagrams.

9. Automatic and safety inputs, each consisting of a remote contact closure rated 5 amp at 120 VAC maximum. Opening of the automatic input remote contact shall cause the motor speed to ramp down to zero speed by controlled deceleration. Opening of the safety input remote contact shall cause the VFD output to go to zero and motor speed to coast to a complete stop. Wiring shall be as required by the electrical control diagrams.

10. Adjustable minimum to maximum frequency limits of 30 to 66 hertz.

11. Independent timed linear acceleration and deceleration functions, adjustable from 4 to 300 seconds.

12. Terminal blocks for wires entering and leaving the VFD unit. Terminals shall be identified with alpha-numeric characters identical to the terminal identifiers indicated on the schematic and connection diagrams.

13. Frequency regulator to operate within the following tolerances:
   a. Frequency regulator span shall be 4 mA at minimum speed and 20 mA at maximum speed.
   b. Frequency regulator accuracy shall be within 1.0 percent of span.
   c. Frequency regulator deadband shall be within 0.5 percent of span.
   d. Frequency regulator repeatability shall be within 0.5 percent of span.

14. Frequency reference signal input resistance shall be 0 to 550 ohms.

2.3 ENCLOSURE

A. The enclosure shall be a dead-front, freestanding assembly with cabinet base and maximum dimensions as indicated. Doors shall be 11-gauge sheet steel with full length piano hinges. Removable lifting angles shall be provided.

B. Unless otherwise indicated, the enclosure shall be NEMA 1 with gasketed doors and door openings. Enclosure shall be front access only, as indicated. No rear access shall
be provided. Rear panel cover shall not be used for mounting of internals. Enclosure shall be suitable for either top or bottom cable entry as indicated.

C. Mechanical key interlocks shall be provided on all doors. Interlocking shall be fully coordinated to prevent access to all high voltage compartments, including filters or any switchgear that is part of the supply, when line power is applied to the VFD system. Interlocks must be mechanical to provide positive lock-out prevention and safety. Electrical interlock switches alone are not acceptable, due to the possibility of inadvertent shutdown and the ease with which such switches could be bypassed.

D. Low voltage, 3 phase auxiliary power will be provided by an onboard control power transformer to convert input medium-voltage power to 460 Volt to provide power for control logic and auxiliary cooling motors. All VFD control circuits shall be 120 Vac single phase. Manufacturer shall provide an internal control power transformer suitably rated to provide all VFD required control power.

E. The VFD system must fit in the space indicated on the contract drawings.

F. Enclosure shall be painted ANSI 61. Inside shall be white.

2.4 PROTECTIVE FEATURES AND CIRCUITS

A. VFD system shall include distribution class surge arrestors to protect input filter if required and VFD or MOVs on the VFD input to protect the VFD against voltage surges.

B. The VFD system shall include power fuses on the onboard input contactor to the drive system or converter rectifier devices to protect the unit from potentially harmful fault currents. Alternative arrangements that involve coordinated protection with an input circuit breaker shall include all coordinating elements including the circuit breaker itself and must provide a detailed description of the protection scheme with the proposal.

C. The controller shall include the following protective features:

1. Static instantaneous overcurrent and overvoltage trip.
2. Phase sequence detector, undervoltage and power loss protection.
3. Power unit over-temperature protection.
4. Electronic motor inverse time overload protection.
5. Furnish the drive with a GE Multilin motor protection and management relay, model 469-P5-HI-T-H or equal. The Contractor shall be responsible for all setup parameter programming and connections for the relay but may assign this to the drive supplier. The motor protection and management relay shall be furnished with a draw-out case. The relay communications protocol shall be initially set at Modbus TCP/IP, but it shall be field adjustable to any of the available protocols the end user deems appropriate. Relays without integral metering, oscillography, event recording, draw out case, and integral RTDs inputs shall be rejected. Metering shall include, but not limited to phase current; L-L and L-N voltages; frequency; real, apparent, and reactive power; totalized watt-hours and var-hours; power factor. The relays on the drives shall be by the same manufacturer. The relay sensing shall be capable of accurately sensing and calculation of the analog values for VFD application. A spare relay is not required. The Ethernet port shall be utilized in the future.
6. Responsive action to motor winding and bearing temperature detectors and any bearing vibration switches indicated. All analog temperature signals shall be converted to contacts by the use of RTD relays or similar devices. Contacts shall open on fault condition or loss of relay power. RTD relays or similar devices shall be selected and provided by VFD manufacturer in coordination with the motor manufacturer. RTD relays or similar devices shall be mounted within the VFD cabinet. A dry contact (NC) input to the VFD is required.

7. The VFD shall be capable of transient operation with a line voltage dip of 15 percent of normal operating voltage on a variable torque load. During line dip, the VFD shall automatically provide a speed droop limiting maximum capable speed for the duration of the input voltage dip.

8. When power is restored after a complete power outage, the VFD shall be capable of catching the motor while it is still spinning in the forward direction and restoring it to proper operating speed.

D. The power circuit design shall be such that the following fault conditions can occur without damage to the power circuit components:

1. Single phase fault or three-phase short circuit on VFD output terminals.
2. Failure to commutate inverter due to severe overload or other conditions.
3. Opening of VFD output contactor or motor disconnect switch during VFD operation.
4. Loss of input power due to opening of VFD input disconnect device or utility power failure during VFD operation.
5. Loss of one phase of input power.

E. Drive shall be provided with a lockable main circuit breaker or input fused disconnect switch, mechanically interlocked with the drive cabinet door. Interlock shall be provided with defeater. Unless otherwise indicated, circuit breaker or fuse shall have a minimum short circuit interrupting capacity of 30,000 RMS symmetrical amps.

2.5 CONTROL DEVICES

A. Pilot devices and instruments shall be flush mounted on a VFD unit door. Pilot devices shall be heavy duty with contacts rated 10 amp minimum at 600 VAC. Indicating lights shall be "push - to - test" type. Lens colors shall be in accordance with details on Drawings. Door - mounted indicating lights shall be removable without removing related wiring. The control units of a given type and size shall be made interchangeable. Relays shall be hermetically sealed.

B. Control devices shall conform to the requirements of Section 26 05 15 - Local Control Stations and Miscellaneous Electrical Devices. Provide solid state type metering, including power quality functions. Include CT's and PT's of ratios required. Solid state metering shall be Allen Bradley Power Monitor 3000, or equal.

2.6 DATA DISPLAYS

A. A door-mounted LCD display shall be furnished, capable of displaying the VFD operational status and drive parameters. The digital display must present all diagnostic
message and parameter values in English Engineering units when accessed, without the use of codes.

B. As a minimum, the following door mounted digital indications shall be supplied:

1. Speed demand in percent
2. Output current in amperes
3. Output Frequency in hertz
4. Input voltage
5. Output voltage
6. Total 3-phase KW output
7. Elapsed time running meter

2.7 DIAGNOSTICS AND FAULT RECORDING

A. The control logic section shall be fully digital and not require analog adjustment pots or fixed selector resistors. The microprocessor shall be a 16-bit arithmetic logic unit, 8K-bytes of supplementary on-board static RAM shall be furnished. The program memory shall be stored in a 2-megabyte electrically programmable ROM.

B. Fault log data storage memory shall be stored in non-volatile memory or be supported by a UPS sized to provide a minimum of 48 hour data retention.

C. The VFD shall include a comprehensive microprocessor based digital diagnostic system which monitors its own control functions and displays faults and operating conditions. Microprocessor systems must be products of the same manufacturer as the VFD (to assure single source responsibility, availability of service and access to spare parts). The VFD shall be provided with the following diagnostics:

1. Lights to indicate a failure of converter or inverter.
2. Lights to indicate presence of gate pulses on converter and inverter.
3. Indication of the following fault conditions:
   a. No fault
   b. Incorrect phase sequence
   c. Blown power fuse
   d. Control power failure
   e. Under - voltage
   f. Instantaneous overcurrent
   g. Sustained overload
h. Semiconductor over-temperature
i. Output over-voltage

4. Meter with switch to test the following control signals:
   a. Frequency command
   b. Voltage command
   c. Motor voltage feedback
   d. Inverter bus voltage
   e. Current command
   f. Current feedback
   g. Converter command
   h. Filtered inverter bus voltage

5. Test lead and jack for monitoring logic cards

6. Circuitry for the following test modes
   a. Manual operation of the inverter through each firing sequence to test power circuit and logic.
   b. Operation of the drive open circuit.

2.8 POWER FACTOR CORRECTION

A. The collective power factor of the VFD and the motor, when running at full load amps, shall not be less than 0.95.

2.9 ACCESSORIES

A. Motor RTD Monitor: A motor RTD monitor shall be supplied with a minimum of eight channels (for two winding RTDs per phase, plus one RTD for each bearing) to monitor motor temperatures and alarm or trip on user-selectable set points. RTD's shall be 100 ohms and of the platinum type.

B. Analog Communication: Output 4-20 mA signals shall be provided. If direct wired analog communication is needed for process control, these shall be optically isolated 4-20 mA DC signals that can be sent to a remote location. Where significant amounts of data are required for monitoring purposes or process control, digital communication is recommended.

2.10 SPARE PARTS

A. Spare Parts: Furnish the following spare parts for each VFD:
   1. Three (3) of each type of power and control fuse.
2. Ten percent (10%) of each type of power module (SCR, GTO, IGBT, IGCT, power diode, etc.) used in the converter/rectifier or inverter.

3. Two (2) of each type of DC link capacitors.

4. Two (2) of each type of input and output filter capacitor.

5. Two (2) of each control printed circuit board, two (2) of each type gate firing boards, include all diagnostic system printed circuit boards.

6. Five (5) spare indicating lights of each type used

7. One (1) replacement cooling fan

8. Two (2) spare relays of each type used

9. Two (2) cans of aerosol spray touchup paint

B. Provide One (1) complete spare cell for each type and size of VFD unit being supplied.

2.11 FACTORY TESTING

A. Component Tests

1. Components shall be 100 percent tested per the manufacturers approved testing procedures. Every semiconductor shall have the following critical parameters tested at rated current: gating, turn-on, turn-off, high temperature, forward blocking, reverse blocking, and waveform characteristics. All assembled phase cells shall be tested for cell balance at rated voltage, maximum current, maximum dV/dT and maximum dI/dT.

2. Control power shall be applied to microprocessors, printed circuit boards, diagnostic boards and similar devices including software to test for proper operation, sequencing, logic, and diagnostics.

3. All wiring shall be checked for continuity and for compliance with the wiring diagrams.

B. VFD Tests

1. Submit a sketch of the proposed test setup, along with a description of the proposed testing procedure to Engineer for acceptance at least 10 weeks in advance of the proposed testing date. No tests shall be performed until the test procedure meets with the Engineer's approval.

2. In addition, furnish Engineer with at least 2 weeks advance written notice of the date and location of the tests, 4 weeks if the tests are to be performed outside of the United States of America.

3. Testing shall be performed at the manufacturing facility of the VFD supplier, with a motor load.

4. City and Engineer (at the option of either or both) reserve the right to witness the tests. Travel, living, and incidental expenses (including any passport or visa costs) shall be paid by the OWNER.
2.12 MANUFACTURERS, OR EQUAL

A. Toshiba Corporation
B. Rockwell Allen Bradley
C. Eaton Ampgard

PART 3 -- EXECUTION

3.1 FIELD TESTING

A. An authorized service representative of the MANUFACTURER shall be present at the Site for a minimum of 2 days for each drive, to furnish the services listed below. For the purpose of this paragraph, a day is defined as an 8-hour period excluding travel time.

B. Coordinate the schedule of MANUFACTURER’s services (assistance with installation, testing, start-up, and training) with the CONTRACTOR to avoid conflicting with other onsite construction, testing, or other manufacturer’s onsite services.

C. Installation, Inspection, Startup, Field Adjustment

1. The MANUFACTURER’s service representative shall supervise the following and certify the equipment and controls have been properly installed, aligned, and readied for operation.
   a. Installation of the equipment.
   b. Inspection, checking, and adjusting the equipment.
   c. Startup and field testing for proper operation.
   d. Performing field adjustments such that the equipment installation and operation comply with requirements.

D. Field testing shall be performed in accordance with Section 260126 - Electrical Tests.

1. Testing, checkout, and startup of the VFD equipment in the field shall be performed under the technical direction of the MANUFACTURER’s service engineer. No portion of the drive system shall be energized without authorization from the MANUFACTURER’s representative during commissioning.

2. Measure and record actual RMS value and measured percentage of the THVD and THID.

E. All equipment shall be installed in accordance with the Contract Documents and with the equipment MANUFACTURER’s printed installation instructions.

F. Following delivery of equipment to the job site, and until final acceptance of the completed work, the CONTRACTOR shall protect and maintain the equipment in a condition that will prevent damage in accordance with the MANUFACTURER’s instruction approved by the ENGINEER. The CONTRACTOR shall pay for the replacement of parts of the equipment items that became corroded, damaged, or deteriorated prior to the final acceptance of the work.
G. The CONTRACTOR shall replace or repair, as directed by the ENGINEER, any equipment or parts broken or damaged during handling and installation.

H. The CONTRACTOR shall repair any damage to the drive enclosure finish during handling and installation following the manufacturer’s recommendations.

I. The CONTRACTOR shall protect and maintain the MV variable frequency drives. The drives shall be protected from damage and stored per manufacturer’s recommendations.

J. The CONTRACTOR shall clean the drives housing from contaminants before facility acceptance. The CONTRACTOR shall request the ENGINEER inspect the equipment to confirm these were properly cleaned.

- END OF SECTION -
SECTION 264210 - CORROSION MONITORING

PART 1 -- GENERAL

1.1 WORK OF THIS SECTION

A. The WORK of this Section includes providing a complete corrosion monitoring system for the Sacramento River Joint Intake buried piping, fittings and appurtenances, as shown on the Contract Drawings and as specified herein. The WORK includes testing of the system during installation, and final system check out.

B. If the products installed as part of this Section are found to be defective or damaged or if the WORK of this Section is not in conformance with these Specifications, then the products and WORK shall be corrected at the CONTRACTOR's expense.

C. Any retesting required due to inadequate installation or defective materials shall be paid for by the CONTRACTOR.

D. The WORK also requires that one Supplier or Subcontractor accept responsibility for the WORK as indicated, but without altering or modifying the CONTRACTOR's responsibilities under the Contract Documents.

E. The WORK also requires coordination of assembly, installation and testing of the pipelines with the material supplier or subcontractor for the corrosion monitoring system.

1.2 REFERENCED SPECIFICATIONS, CODES AND STANDARDS

A. The WORK of this Section shall comply with the current editions of the following codes and standards:

1. ASTM: ASTM International
   a. D1248: Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
   b. D1785: Standard Specification for Polyvinyl Chloride (PVC) Plastic Pipe, Schedules 40, 80, and 120.
   c. C94: Standard Specification for Ready-Mixed Concrete
   d. B3: Standard Specification for Soft or Annealed Copper Wire
   e. B8: Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
   f. D2220: Standard Specification for Polyvinyl Chloride (PVC) Insulation for Cable and Wire

2. NACE International, the Corrosion Society
   a. SP0286: Electrical Insulation of Cathodically Protected Pipelines
   b. RP0375: Wax Coating Systems for Underground Piping Systems
c. TM0497: Measurement Techniques Related to Criteria for Cathodic Protection on Underground or Submerged Metallic Piping Systems

3. NFPA: National Fire Protection Association
   a. NFPA 70: National Electric Code (NEC)

4. NEMA: National Electrical Manufacturers Association
   a. TC2: Electrical Polyvinyl Chloride (PVC) Tubing and Conduit
   b. TC3: PVC Fittings for Use with Rigid PVC Conduit and Tubing

5. UL: Underwriters Laboratories
   a. 514B: Fittings for Cable and Conduit

B. Whenever the Contract Drawings or these Specifications require a higher degree of workmanship or better quality of material than indicated in the above codes and standards, these Contract Drawings and Specifications shall prevail.

1.3 QUALITY ASSURANCE

A. Installation of the corrosion monitoring equipment shall be performed by individuals having at least 5 years of experience in the installation of the equipment described herein.

B. All testing required to be performed by a “qualified corrosion technician” shall be performed by a Certified NACE Cathodic Protection Technician under the supervision of a Corrosion Engineer. A Corrosion Engineer is a Registered Professional Corrosion Engineer or a Certified NACE Cathodic Protection Specialist.

1.4 SUBMITTALS

A. The following shall be submitted to the ENGINEER prior to any equipment installation:
   1. Catalog cuts, bulletins, brochures, or data sheets for all materials specified herein.
   2. Certification that the equipment and materials proposed meet the Specifications and the intent of the Specifications.
   3. Written certification of experience required.

B. The following shall be submitted to the ENGINEER after completion of the WORK.
   1. Wire connection testing.
   2. Insulating joint testing, before and after backfill.
   3. Joint bond testing, before and after backfill.
   5. Record Drawings shall be submitted to and approved by the ENGINEER before the WORK is considered complete.
1.5 INTERFERENCE AND EXACT LOCATIONS

A. The locations of corrosion monitoring equipment, test stations, devices, outlets, and appurtenances as indicated are approximate only. Exact locations shall be determined by the CONTRACTOR in the field subject to the approval of the ENGINEER.

B. The CONTRACTOR shall field verify all data and final locations of work done under other Sections of the Specifications required for placing of the WORK.

C. In case of interference with other work or erroneous locations with respect to equipment or structures, the CONTRACTOR shall furnish all labor and materials necessary to complete the WORK in an acceptable manner.

PART 2 -- PRODUCTS

2.1 GENERAL

A. All materials installed must be new. All equipment and materials supplied shall be similar to that which has been in satisfactory service for at least 5 years.

2.2 CONDUIT AND FITTINGS

A. The minimum conduit size shall be 1 inch unless otherwise indicated. Refer to NFPA 70 (NEC) for additional conduit size requirements.

B. Conduit and fittings shall be PVC, Schedule 80.

2.3 CONCRETE TRAFFIC VALVE BOXES

A. The traffic valve boxes shall be G5 Utility Boxes as manufactured by Christy Concrete Products, Inc., No. 3RT Utility Box as manufactured by Brooks Products, or equal. Traffic box covers for test stations shall be cast iron and labeled “CP TEST”.

B. Traffic valve boxes shall be rated to withstand AASHTO H20 traffic loading.

2.4 READY-MIXED CONCRETE

A. Ready-mixed concrete shall be in accordance with ASTM C94.

2.5 PANEL BOARDS

A. Panel boards shall be made of ¼-inch thick fabric reinforced phenolic sized as indicated on the Contract Drawings.

B. Connection hardware shall be nickel plated brass. All connections shall be double nutted bolts with lock washers.

C. Copper bus bar shall be 1/8-inch thick and sized to fit.

2.6 SOLDERLESS LUG CONNECTORS

A. Solderless lug connectors shall be made of brass or copper with a brass screw. The lug shall be designed for direct burial and shall be appropriately sized for the connection wire. The lug shall be ILSCO Type XT-6DB, or equal.
2.7 WIRE

A. Conductors shall consist of stranded copper of the gauge indicated. Wire sizes shall be based on American Wire Gauge (AWG). Copper wire shall be in conformance with ASTM Designations B3 and B8.

B. All wires terminating in a junction box or test station shall have a wire identifier attached within 4 inches from the end of wire at the terminal board, prior to backfill, as specified under "Wire Identification".

C. High molecular weight polyethylene (HMWPE) insulating jackets shall conform to ASTM D-1248.

2.8 WIRE IDENTIFIERS

A. Wire identifiers shall be the wrap-around type with a high resistance to oils, solvents and mild acids. Wrap-around markers shall fully encircle the wire with imprinted alpha-numeric characters for pipe identification. The letters and numbers shall be printed, minimum 3/16-inch in size.

2.9 EXOTHERMIC WELDS

A. Exothermic welds shall be in accordance with the manufacturer’s recommendations. Exothermic welds shall be Cadweld, as manufactured by Erico Products, Inc. or Thermoweld as manufactured by Continental Industries, Inc., or equal. Duxseal packing as manufactured by Johns-Manville, or equal, shall be used where necessary to prevent leakage of molten weld metal.

B. The shape and charge of the exothermic weld shall be chosen based on the following parameters:

1. Pipe material
2. Pipe size
3. Wire material/size and requirement for sleeves
4. Number of strands to be welded
5. Orientation of weld (vertical or horizontal)

2.10 EPOXY RESIN

A. Epoxy used for sealing the cable-to-pipe connections shall be Durcon-164, manufactured by the Duriron Company; Scotchcast Resin No. 4, manufactured by the 3M Company; or CC-1 Potting Compound, manufactured by PSI Products.

2.11 PETROLATUM TAPE

A. Petrolatum tape system shall be Trenton Primer and #1 Wax-tape, as manufactured by Trenton Corp., Denso Paste and Densyl Tape by Denso North America, Inc., or equal.
2.12 DIELECTRIC INSULATING FLANGE KITS

A. Insulating flange kits shall include full faced gaskets, insulating sleeves and washers and steel bolts, nuts and washers. The complete assembly shall have a pressure rating equal to or greater than the flanges between which it is installed. Insulating gasket shall be neoprene faced phenolic, 1/8-inch thick. Insulating sleeves shall be Mylar, 1/32-inch thick. Insulating washers shall be 2 sets of 1/8-inch thick phenolic. Sleeves, gaskets and insulating washers shall have a dielectric constant of 300 Volts per mil, minimum. Steel washers shall fit well within the bolt facing on the flange. Insulating washers shall fit within the bolt facing on the flange and over the outside diameter of the sleeve.

2.13 DIELECTRIC UNIONS

A. The dielectric unions shall be rated for 250 psi (ANSI B 16.39). The body and nut shall be galvanized steel. The insulator and gasket shall be nylon or EPDM. Both sides of the union shall be threaded to accept threaded steel and stainless steel pipe.

PART 3 -- EXECUTION

3.1 EXCAVATION AND BACKFILL

A. Buried wires shall have a minimum cover of 24 inches.

B. Red caution tape (3 inches wide) shall be installed above buried wire and conduits shall be installed at a maximum depth of 18 inches below grade over the wire and conduit location.

C. Anode wire identification tags shall be placed on the wires prior to placing wire in conduit or backfilling.

3.2 TEST STATIONS

A. Test stations shall be installed at the approximate locations shown on the Contract Drawings. Flush mounted test stations shall be located in the sidewalk, behind the curb, or other areas not subject to vehicular traffic. The CONTRACTOR shall field verify final location of the test stations. Wire identifiers shall be placed on all wire prior to backfill and installation of test stations.

3.3 WIRES

A. Buried wires shall be laid straight without kinks. Each wire run shall be continuous in length and free of joints or splices, unless otherwise indicated. Care shall be taken during installation to avoid punctures, cuts or other damage to the wire insulation. Damage to insulation shall require replacement of the entire length of wire at the CONTRACTOR's expense.

B. At least 18 inches of slack (coiled) shall be left for each wire at each test station. Wire slack shall be sufficient to allow removal of wire extension for testing. Wire shall not be bent into a radius of less than 6 inches.

C. The wire conduits must be of sufficient diameter to accommodate the wires. This shall be determined by the number and size of wires in accordance with the applicable codes and standards.
3.4 WIRE IDENTIFIERS

A. All wires shall be coded with wire identifiers.

B. Wire identifiers shall be placed on the wires prior to backfill.

3.5 EXOTHERMIC WELD CONNECTIONS

A. Exothermic weld connections shall be installed in the manner and at the locations indicated. Coating materials shall be removed from the surface over an area of sufficient size to make the connection. The surface shall be cleaned to bare metal by grinding or filing prior to welding the conductor. The use of resin impregnated grinding wheels will not be allowed. A copper sleeve shall be fitted over conductors smaller than AWG #8. Only enough insulation shall be removed such that the copper conductor can be placed in the welding mold.

B. A test station consists of two wire connections to the pipeline, as shown on the Contract Drawings. Each exothermic weld shall connect only one wire to the pipeline. Adjacent welds shall be separated by 6 inches, minimum.

C. The CONTRACTOR shall be responsible for testing all test lead and bond wire welds. The ENGINEER may witness these tests.

D. After the weld has cooled, all slag shall be removed and the metallurgical bond shall be tested for adherence by the CONTRACTOR. A 22-ounce hammer shall be used for adherence testing by striking a blow to the weld. Care shall be taken to avoid hitting the wires. All defective welds shall be removed and replaced.

E. All exposed surfaces of copper and steel shall be covered with a minimum thickness of 1/4-inch of epoxy resin as shown on the Contract Drawings.

F. After backfilling pipe, all test lead pairs shall be tested for broken welds using a standard ohmmeter. The resistance shall not exceed 150% of the theoretical wire resistance as determined from published wire data.

3.6 JOINT BONDS

A. Bond wires shall be provided across restrained couplings and all non-welded joints, as necessary to ensure electrical continuity, except where insulating joints have been installed to provide electrical isolation. Joint bonds shall be of the size and number shown on the Contract Drawings and installed as indicated. The bond wires shall be at least 12 inches long and shall be installed so as to allow for movement of at least 2 inches in the pipe joint. Use at least 2 bond cables across all discontinuous joints.

3.7 PETROLATUM TAPE SYSTEM APPLICATION

A. Petrolatum tape system shall be applied on insulating joints and as indicated in the Contract Drawings. Petrolatum tape system shall be applied in accordance with NACE RP0375, Manufacturer’s recommendations and these Specifications.

B. All loose scale shall be removed from the surface to be coated with hand tools (wire brush, scraper, rags). Debris and moisture shall be wiped from surface with clean rag. Petrolatum tape shall be applied immediately after applying the primer, using a 1-inch overlap. A spiral wrap shall be used and a slight tension shall be applied to ensure that there are no air pockets or voids. After applying the tape the applicator shall firmly press
and smooth out all lap seams and crevice areas. The tape shall be in tight intimate contact with all surfaces.

3.8 INSULATING JOINTS/DIELECTRIC UNIONS

A. Insulating joints shall be installed to effectively isolate metallic piping from foreign metallic structures. The CONTRACTOR shall test the performance of these insulating joints before and after backfill.

B. Before backfill, the CONTRACTOR shall test the insulating joint using a Gas Electronics Model No. 601 Insulation Checker, or equal. If the testing results indicate less than 100% insulation, the insulating joints shall be repaired and retested at the CONTRACTOR’s expense.

C. After backfill, testing shall be performed by measurement of native pipe-to-soil potentials at both sides of the insulating joint. If the difference in native pipe-to-soil potentials on both sides of the insulating joint is within ±50 mV, then additional testing shall be performed as follows. Temporary cathodic protection current shall be circulated on one side of the insulating joint. “On” and “Instant Off” pipe-to-soil potentials shall be measured on the other side of the insulating joint. If the “Instant Off” potential is more negative than the native potential, the insulating joint shall be considered deficient and shall be repaired and retested at the CONTRACTOR’s expense.

3.9 ELECTRICAL CONTINUITY TESTING

A. Electrical continuity testing of buried pipeline to verify proper installation of the joint bonds shall be performed by the CONTRACTOR’s qualified corrosion technician after backfill. The electrical continuity test may additionally be performed before backfill at the CONTRACTOR’s option.

B. Continuity shall be verified using the linear resistance method. The pipe shall be tested in spans that are no less than 250 feet unless the pipe is shorter than 250 feet and no more than 1,000 feet. Each test span shall have two test leads connected to the pipe at each end. Existing test stations can be used. A direct current shall be applied through the pipe using two of four test leads. The potential across the test span shall be measured using the other two test leads. The current applied and voltage drop shall be recorded for a minimum of three different current levels.

C. The theoretical resistance of the pipe shall be calculated. It shall take into account the pipe wall thickness, material, number, length and gauge of joint bond wires used.

D. Acceptance of the test span; the average measured resistance shall be compared to the theoretical resistance of the pipe and bond wires. If the measured resistance is greater than 125% of the theoretical resistance, then the joint bonds shall be considered deficient and shall be repaired and retested at the CONTRACTOR’s expense. If the measured resistance is less than 100% of the theoretical resistance then the test and/or calculated theoretical resistance shall be considered deficient and the test span shall be retested and/or recalculated at the CONTRACTOR’s expense. If the piping forms a loop which allows current to flow both in and out of the test span, then consideration shall be made for current circulating through both the loop and the test span.

3.10 SYSTEM CHECK-OUT

A. Upon completion of the installation, the CONTRACTOR shall provide testing of the completed system by a qualified corrosion technician and the data shall be reviewed by
a Corrosion Engineer to ensure conformance with the Contract Documents, and NACE RP0286.

B. The testing described herein shall be in addition to, and not substitution for, any required testing of individual items at the manufacturer's plant and during installation.

C. Testing shall be performed at all test leads of all test stations and at the locations of exposed pipe as soon as possible after installation of the corrosion monitoring system.

D. Testing shall include the following and shall be conducted in accordance with NACE TM0497:

1. Verify electrical isolation at all insulating joints, insulating unions, and casing insulators per NACE SP0286.

2. Confirm electrical continuity of the pipeline in accordance with this Section.

3. Measure and record native structure-to-soil potentials at each location.

E. The CONTRACTOR shall provide a written report, prepared by the Corrosion Engineer documenting the results of the testing and recommending corrective work, as required to comply with the Contract Documents. Any deficiencies of systems tested shall be repaired and re-tested by the CONTRACTOR at no additional cost to the OWNER.

- END OF SECTION -
SECTION 265000 - LIGHTING

PART 1 – GENERAL

1.1 THE REQUIREMENT

A. Provide luminaires and accessories, complete and operable, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Codes

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NFPA 70</td>
<td>National Electric Code</td>
</tr>
<tr>
<td>NEMA 250</td>
<td>Enclosures for Electrical Equipment (1,000 Volts Maximum)</td>
</tr>
<tr>
<td>IBC</td>
<td>Earthquake Requirements</td>
</tr>
<tr>
<td>UL-595</td>
<td>Standard for Safety Marine-Type Electric Lighting Fixtures</td>
</tr>
<tr>
<td>UL-844</td>
<td>Standard for Safety Electric Lighting Fixtures for Use in Hazardous (Classified Locations)</td>
</tr>
<tr>
<td>UL-924</td>
<td>Standard for Safety Emergency Lighting and Power Equipment</td>
</tr>
<tr>
<td>ANSI C82.1</td>
<td>Specifications for Fluorescent Lamp Ballasts</td>
</tr>
<tr>
<td>ANSI C84.4</td>
<td>Specifications for High-Intensity-Discharge Lamp Ballasts (Multiple Supply Type)</td>
</tr>
</tbody>
</table>

Standards of the Certified Ballast Manufacturer’s Association

1.3 CONTRACTOR SUBMITTALS

A. Furnish the following product information in accordance with the requirements of Section 013300 – Contractor Submittals.

B. Furnish the following information:

1. Interior Luminaires
   a. Catalog data sheets and photos.
   b. Luminaire finish and metal gauge.
   c. Lens material, pattern, and thickness.
   d. Candlepower distribution curves in 2 or more planes.
   e. Candlepower chart, 0 to 90 degrees.
f. Lumen output chart.
g. Average maximum brightness data in foot-lamberts.
h. Coefficients of utilization for zonal cavity calculations.
i. Mounting or suspension details.
j. Heat exchange and air handling data.

2. Exterior Luminaires
   a. Catalog data sheets and photos.
   b. Luminaire finish and metal gauge.
   c. Lens material, pattern, and thickness.
   d. IES lighting classification and isolux diagram.
   e. Fastening details to wall or pole.
   f. Ballast type, location, and method of fastening.
   g. For light poles: wind loading; complete dimensions; and finish.

3. Lamps
   a. Voltages.
   b. Colors.
   c. Approximate life (in hours).
   d. Approximate initial lumens.
   e. Lumen maintenance curve.
   f. Lamp type and base.

4. Ballasts
   a. Type.
   b. Wiring diagram.
   c. Nominal watts and input watts.
   d. Input voltage and power factor.
   e. Starting current, line current, and restrike current values.
   f. Sound rating.
   g. Temperature rating.
h. Efficiency ratings.

i. Low-temperature characteristics.

j. Emergency ballasts rating and capacity data.

5. Photocells

a. Voltage and power consumption.

b. Capacity.

c. Contacts and time delay.

d. Operating levels.

e. Enclosure type and dimensions.

f. Temperature range.

PART 2 -- PRODUCTS

2.1 LUMINAIRES

A. General

1. Additional WORK requirements are indicated in the Luminaire Schedule on the Drawings.

2. Fluorescent luminaires that utilize double-ended lamps and contain ballast(s) that can be serviced in place shall be provided with a disconnecting means either internal or external to each luminaire, in accordance with the requirements of Article 410.130 (G) (1) of the 2008 NEC.

B. Provide a feed-through type or separate junction box.

C. Provide 2-lamp ballasts when possible.

D. Tandem-wire luminaires for 3-lamp fluorescent luminaires.

E. Provide minimum 18 AWG wire leads.

F. Provide components that are accessible and replaceable without removing the luminaire from the ceiling.

G. Soffit Installations

1. Installations shall be UL-labeled as "Suitable for Damp Locations."

2. Provide removable and prewired ballasts.

H. Exterior Installations

1. Installations shall be UL-labeled as "Suitable for Wet Locations."
2. Provide removable and prewired ballasts.

3. When factory-installed photocells are provided, the entire assembly shall be UL-labeled.

I. Marine Environments

1. Installations shall be UL-labeled as "Marine, Outside Type."

2. Provide a copper-free aluminum housing in accordance with the requirements of UL-595.

J. Emergency Lighting

1. Power Pack
   a. Self-contained.
   b. 120V
   c. 6 V sealed nickel-cadmium battery.
   d. Indicator switch in accordance with the requirements of UL 924.

2. Lighted, push-to-test pushbutton and indicator.

3. Capability of providing full illumination for 1-1/2 hours in emergency mode.

4. Capability of full recharge in 24 hours, automatically initiated upon resumption of normal line voltage.

5. Capability of protecting against excess charging and discharging.

6. Twin halogen or LED, sealed lighting heads.

7. Solid state charger.

8. Normal and emergency LED indicating lights.

9. Provide a 3-wire power cord and plug set.

10. Mounting stand.

11. Time delay relays in order to maintain emergency lighting in areas illuminated by HID luminaires for 5 minutes after normal power has been restored.

12. Provide NEMA-rated enclosures in accordance with the area classifications in which they are installed.

K. Exit Signs

1. Internally illuminated.

2. Universal mounting type.
3. Internal 6 V nickel-cadmium battery.
4. Battery charger.
5. LED-type emergency and normal indicating lights.
6. Press-to-test button.
7. Directional arrows.
8. Green letters on a white panel.

L. Hazardous Classified Areas
1. UL-labeling shall be CLASS II, DIVISION 1, GROUPS F AND G.
2. Provide copper-free cast aluminum luminaire enclosures and fittings, in accordance with the requirements of UL-844.

2.2 LAMPS

A. Fluorescent
1. Type: T-8, energy-efficient
2. Color: K-4100
3. Lengths: 48 inches
4. Rated Burning Life: 20,000 hours
5. Compact Fluorescent
   a. Type: double biax
   b. Color: K-4100
   c. Rated Burning Life: 10,000 hours.
6. Electronic Biax Lamps
   a. Type: double biax, with screw shell for replacement of incandescent lamps
   b. Color: K-2700 or higher
   c. Rated Burning Life: 10,000 hours

B. High Intensity Discharge
1. Type: high-pressure sodium and metal halide
2. Color: color-corrected
C. Tungsten Halogen
   1. Efficiency Type: energy
   2. Color: clear

D. LED
   1. Sealed high efficiency LED arrays with glass optics
   2. Color: K-4000
   3. Rated burning life: 51,000 hours at 40 °C ambient

E. Manufacturer, or Equal
   1. Holophane
   2. General Electric
   3. Sylvania
   4. North American Philips

2.3 BALLASTS

A. General
   1. UL-Listed, ETL-certified.
   2. High power factor, energy-efficient type.
   3. Ballasts shall meet luminaire requirements.
   4. Provide exterior ballasts that produce reliable starting and produce the full output of the lamps when the ballasts and lamps are operating within an ambient temperature of 10 degrees F at 90 percent of normal line voltage.

B. Fluorescent
   1. Type: electronic, high-frequency; full-output rapid start; for use with 265 mA T-8 lamps
   2. Sound Rating: minimum 'A'; maximum allowable noise level of 30 decibels measured 2 feet from the luminaire.
   3. Class: 'P'
   4. Current Crest Factor: 1.7
   5. Where indicated, diming ballasts will have 0-10VDC dimming control voltage
   6. Manufacturer, or Equal
      a. Advance Mark V
b. Valmont
c. Osram/Sylvania

C. Metal Halide
   1. High power factor, normal ambient, 180 degrees C insulation class.
   2. Types.
      a. Auto transformer, with capacitor and ignitor for lamps 150 watts and less.
      b. Constant-wattage auto transformer, with capacitor for lamps greater than 150 watts.
   3. Manufacturer, or Equal
      a. MagneTec Jefferson
      b. Advance Transformer
      c. Universal

D. High-Pressure Sodium
   1. High power factor, normal ambient, 180 degrees C insulation class, with capacitor and ignitor.
   2. Type
      a. Auto transformer for 50-watt lamps.
      b. Constant-wattage auto transformer for 70-watt lamps and greater.

E. LED Driver
   1. LED dual driver system for extended operation.
   2. Surge arrester
   3. Manufacturer, or Equal
      a. Holophane

2.4 LIGHTING CONTROL

A. Time Switch
   1. Hand operated, mechanical timer, dial where indicated.
   2. Mechanical time switch shall fit in single gang box.
   3. Manufacturer, or Equal
      a. Leviton
b. **Wattstopper**

B. **Photocell**

1. Photo Control: automatic ON-OFF switch.
2. Housing: self-contained; die-cast aluminum; unaffected by moisture, vibration, or temperature changes.
3. Settings: ON at dusk; OFF at dawn.
4. Provide a time delay feature in order to prevent false switching.
5. Field-adjustable to control operating levels.
6. Manufacturer, or Equal
   a. **Tork**
   b. **Paragon**
   c. **Holophane**

2.5 **POLES**

A. Rating (with luminaire): 100-mph steady winds without incurred damage.
B. Material: steel.
C. One-piece stationary type.

**PART 3 – EXECUTION**

3.1 **LUMINAIRES**

A. General

1. Install in accordance with the manufacturer’s recommendations.
2. Provide necessary hangers, pendants, canopies, and other accessories.
3. Provide additional ceiling bracing, hanger supports, and other structural reinforcements to the building and to concrete pole bases as required to safely mount the luminaire.
4. Install the luminaire plumb and level.
5. The mounting heights indicated for wall-mounted or pendant-mounted luminaires are from the bottom of the luminaire to finished floor or finished grade, whichever is applicable.
6. Install each luminaire outlet box with a galvanized stud.
B. Pendant Mounting

1. Provide swivel-type hangers and canopies to match the luminaires, unless otherwise indicated.

2. Space single-stem hangers on continuous-row fluorescent luminaires 48 inches apart.

3. Provide twin-stem hangers on single luminaires.

C. Pole Mounting

1. Provide a cast-in-place concrete base.

2. Install the pole base flush with the finished grade where located in grassy areas not subject to vehicular traffic, and 30 inches above the finished grade when the pole is located in areas subject to damage from vehicular traffic.

3. Set the luminaire poles on anchor bolts and secure with double nuts on each bolt.

4. After the luminaire has been leveled and plumbed, dry-pack the luminaire base with grout.

D. Finished Areas

1. Install the luminaires symmetrically with tile pattern.

2. Locate with the centerline of tile or with centerline of the joint between adjacent tile runs.

3. Install recessed luminaires tight to the finished surface such that no spill light will show between the ceilings and the sealing rings.

4. When installing on combustible low-density cellulose fiberboard, provide spacers and mount luminaires 1-1/2 inches from ceiling surface, or use luminaires suitable for mounting on low-density ceilings.

5. Junction Boxes
   a. Flush and Recessed Luminaires: Locate a minimum of one foot from the luminaire.
   b. In concealed locations, install junction boxes to be accessible by the removal of the luminaire.

6. Wiring and Conduit
   a. Provide wiring of a suitable temperature rating as required by the luminaire.
   b. Provide flexible steel conduit.

7. Provide plaster frames when required by ceiling construction.

8. Independent Supports
a. Provide each recessed fluorescent luminaire with 2 safety chains or 2 No. 12 soft-annealed galvanized steel wires of length needed to secure the luminaire to the building structure, independent of the ceiling structure.

b. Ensure that the tensile strength of chain or wire, and the method of fastening to the structure, is adequate to support the weight of the luminaire.

c. Fasten the chain or wire to each end of the luminaire.

E. Unfinished Areas

1. Locate the luminaires to avoid conflicts with other building systems and blockage of the luminaire light output.

2. Luminaire Suspension
   
   
b. Scissor-type hangers will not be accepted.

3. For attachments to steel beams, provide flanged beam clips and straight or angled hangers.

3.2 LAMPS

A. Within each luminaire, provide the number and type for which the luminaire is designed, unless otherwise indicated.

3.3 BALLASTS

A. Install in accordance with the manufacturer’s recommendations.

B. Use ballast mounting holes to fasten the ballast securely within the luminaire.

C. Replace noisy or defective ballasts.

3.4 LIGHTING CONTROL

A. **Outdoor Luminaires**: The photocells shall switch the time clock ON at dusk and the time clock shall switch lights OFF at a preset time.

B. Dimming Systems
   
   1. Install in accordance with the manufacturer’s recommendations.
   
   2. Do not connect ballasts or equipment to the dimming system unless such connections are acceptable to the dimming system manufacturer.

3.5 CLEAN-UP

A. Remove labels and other markings, except the UL listing mark.

B. Wipe the luminaires inside and out in order to remove construction dust.

C. Clean the luminaire plastic lenses with an antistatic cleaner only.
D. Touch up painted surfaces of the luminaires and the poles with matching paint provided by the manufacturer.

E. Replace defective lamps at the Date of Substantial Completion.

- END OF SECTION -
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PART 1 – GENERAL

1.1 THE REQUIREMENT

A. In its initial move onto the Site, the CONTRACTOR shall protect existing fences, houses and associated improvements, streets, and utilities downslope of construction areas from damage due to boulders, trees, or other objects dislodged during the construction process and clear, grub, strip; and regrade certain areas, in accordance with the Contract Documents.

1.2 SITE INSPECTION

A. Prior to moving onto the Site, the CONTRACTOR shall inspect the Site conditions and review maps of the Site and off-Site pipeline routes and facilities delineating the OWNER's property and right-of-way lines.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION

3.1 PRIMARY SITE ACCESS

A. The CONTRACTOR shall develop any necessary access to the Site, including access barriers to prohibit entry of unauthorized persons.

B. Utility Interference: Where existing utilities interfere with the WORK, notify the utility owner and the ENGINEER before proceeding in accordance with the General Conditions.

3.2 CLEARING AND GRUBBING

A. Construction areas shall be cleared of grass and weeds to at least a depth of 6-inches and cleared of structures, pavement, sidewalks, concrete or masonry debris, trees, logs, upturned stumps, loose boulders, and any other objectionable material of any kind which would interfere with the performance or completion of the WORK, create a hazard to safety, or impair the subsequent usefulness of the WORK, or obstruct its operation. Loose boulders within 10-feet of the top of cut lines shall be incorporated in landscaping or removed from the Site. Trees and other natural vegetation outside the actual lines of construction shall be protected from damage during construction.

B. Within the limits of clearing, the areas below the natural ground surface shall be grubbed to a depth necessary to remove stumps, roots, buried logs, and other objectionable material. Septic tanks, drain fields, and connection lines and any other underground structures, debris or waste shall be removed if found on the Site. Objectionable material from the clearing and grubbing process shall be removed from the Site and wasted in approved safe locations.

C. Unless otherwise indicated, native trees larger than 3-inches in diameter at the base shall not be removed without the ENGINEER's approval. The removal of any trees, shrubs, fences, or other improvements outside of rights-of-way, if necessary for the
CONTRACTOR's choice of means and methods, shall be arranged with the owner of the property, and shall be removed and replaced, as part of the WORK.

- END OF SECTION -
SECTION 312319 - DEWATERING

PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall dewater trench and structure excavations, in accordance with the Contract Documents. The CONTRACTOR shall secure all necessary permits to complete the requirements of this Section of the Specifications.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 013300 – Contractor Submittals.

B. Prior to commencement of excavation, the CONTRACTOR shall submit a detailed plan and operation schedule for dewatering of excavations. The detailed plan shall include mitigation measures to prevent settlement of nearby structures and a contingency plan for restoring nearby structures if settlement is observed as a result of the CONTRACTOR's dewatering operations. The CONTRACTOR may be required to demonstrate the system proposed and to verify that adequate equipment, personnel, and materials are provided to dewater the excavations at all locations and times. The CONTRACTOR's dewatering plan is subject to review by the ENGINEER.

1.3 QUALITY CONTROL

A. It shall be the sole responsibility of the CONTRACTOR to control the rate and effect of the dewatering in such a manner as to avoid all objectionable settlement and subsidence.

B. All dewatering operations shall be adequate to assure the integrity of the finished project and shall be the responsibility of the CONTRACTOR.

C. All structures or facilities that are located within the radius of influence of the CONTRACTOR's dewatering operation shall have reference points established and observed at frequent intervals to detect any settlement which may develop. The responsibility for conducting the dewatering operation in a manner which will protect adjacent structures and facilities rests solely with the CONTRACTOR. The CONTRACTOR shall survey, record and report the reference points on a daily basis, and submit the written log to the ENGINEER at the completion of construction. The ENGINEER shall be immediately notified should any sign of settlement is observed. The cost of repairing any damage to adjacent structures and restoration of facilities shall be the responsibility of the CONTRACTOR.

PART 2 – PRODUCTS

2.1 EQUIPMENT

A. Dewatering, where required, may include the use of well points, sump pumps, temporary pipelines for water disposal, rock or gravel placement, and other means. Standby pumping equipment shall be maintained on the Site.
PART 3 – EXECUTION

3.1 GENERAL REQUIREMENTS

A. The CONTRACTOR shall provide all equipment necessary for dewatering. It shall have on hand, at all times, sufficient pumping equipment and machinery in good working condition and shall have available, at all times, competent workmen for the operation of the pumping equipment. Adequate standby equipment shall be kept available at all times to insure efficient dewatering and maintenance of dewatering operation during power failure.

B. Dewatering for structures and pipelines shall commence when groundwater is first encountered, and shall be continuous until such times as water can be allowed to rise in accordance with the provisions of this Section or other requirements.

C. At all times, site grading shall promote drainage. Surface runoff shall be diverted from excavations. Water entering the excavation from surface runoff shall be collected in shallow ditches around the perimeter of the excavation, drained to sumps, and be pumped or drained by gravity from the excavation to maintain a bottom free from standing water.

D. Dewatering shall at all times be conducted in such a manner as to preserve the undisturbed bearing capacity of the subgrade soils at proposed bottom of excavation.

E. If foundation soils are disturbed or loosened by the upward seepage of water or an uncontrolled flow of water, the affected areas shall be excavated and replaced with drain rock.

F. The CONTRACTOR shall maintain the water level below the bottom of excavation in all work areas where groundwater occurs during excavation construction, backfilling, and up to acceptance.

G. Flotation shall be prevented by the CONTRACTOR by maintaining a positive and continuous removal of water. The CONTRACTOR shall be fully responsible and liable for all damages which may result from failure to adequately keep excavations dewatered.

H. If well points or wells are used, they shall be adequately spaced to provide the necessary dewatering and shall be sandpacked and/or other means used to prevent pumping of fine sands or silts from the subsurface. A continual check by the CONTRACTOR shall be maintained to ensure that the subsurface soil is not being removed by the dewatering operation.

I. The CONTRACTOR shall dispose of water from the WORK in a suitable manner without damage to adjacent property. CONTRACTOR shall be responsible for obtaining any permits that may be necessary to dispose of water. No water shall be drained into work built or under construction without prior consent of the ENGINEER. Water shall be filtered using an approved method to remove sand and fine-sized soil particles before disposal into any drainage system.

J. The release of groundwater to its static level shall be performed in such a manner as to maintain the undisturbed state of the natural foundation soils, prevent disturbance of compacted backfill and prevent flotation or movement of structures, pipelines, and sewers.
K. Dewatering of trenches and other excavations shall be considered as incidental to the
construction of the WORK and all costs thereof shall be included in the various contract
prices in the Bid Forms, unless a separate bid item has been established for dewatering.

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PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall perform earthwork as indicated and required for construction of the WORK, complete and in place, in accordance with the Contract Documents.

1.2 REFERENCE MATERIALS

A. RD2035 Sacramento River Pump Station Geotechnical Investigation by Taber Consultants

1.3 CONTRACTOR SUBMITTALS

A. The CONTRACTOR's attention is directed to the provisions for "Shoring and Bracing Drawings" in Section 6705 of the California Labor Code.

B. The shoring plan for intake structure excavations is expected to be a "Critical Path" item on the Contractor's schedule. Within 45 days after the date of commencement as stated in the Notice to Proceed the CONTRACTOR shall have the shoring plan for intake structure excavations submitted and approved by the ENGINEER.

C. CONTRACTOR's Detailed Plan

1. The CONTRACTOR, prior to beginning any trench or structure excavation 5 feet deep or deeper, shall submit to the OWNER and shall be in receipt of the OWNER's written acceptance of the CONTRACTOR's detailed plan showing the design of shoring, bracing, sloping of the sides of excavation, or other provisions for worker protection against the hazard of caving ground during the excavation of such trenches or structure excavation.

2. The CONTRACTOR's plan shall be prepared and signed and sealed by a Professional Engineer experienced in the field of geotechnical engineering and licensed in the State where the WORK is being performed.

3. The OWNER's acceptance of said plan will be for verification of submittal of the plan with this requirement.

4. If such plan varies from the shoring system standards established in the Construction Safety Orders of the State of California, such alternative systems plans shall be prepared by a civil or structural engineer licensed in the State of California.

D. The CONTRACTOR shall submit a copy of the excavation permit issued by the California Department of Industrial Safety.

E. Samples

1. The CONTRACTOR shall submit samples of materials proposed for the WORK in conformance with the requirements of Section 013300 – Contractor Submittals.

2. Sample sizes shall be as determined by the testing laboratory.
PART 2 -- PRODUCTS

2.1 FILL AND BACKFILL MATERIAL REQUIREMENTS

A. General

1. Fill, backfill, and embankment materials shall be selected or shall be processed and clean fine earth, rock, gravel, or sand, free from grass, roots, brush, other vegetation and organic matter.

2. Fill and backfill materials that are to be placed within 6 inches of any structure or pipe shall be free of rocks or unbroken masses of earth materials having a maximum dimension larger than 3 inches.

B. Suitable Materials

1. Materials not defined below as unsuitable will be considered as suitable materials and may be used in fills, backfilling, and embankment construction, subject to the indicated requirements.

2. If acceptable to the ENGINEER, some of the material listed as unsuitable may be used when thoroughly mixed with suitable material to form a stable composite.

3. Mixing or blending of materials to obtain a suitable composite is the CONTRACTOR's option but is subject to the approval of the ENGINEER.

4. The CONTRACTOR shall submit certification to the ENGINEER that the chloride concentration in imported materials within the pipe zone does not exceed 100 ppm, when tested in accordance with the requirements of AASHTO T291-94 – Standard Method of Test for determining Water-Soluble Chloride Ion Content in Soil.

5. Suitable materials may be obtained from on-Site excavations, may be processed on-Site materials, or may be imported.

6. If imported materials are required by this Section or are required in order to meet the quantity requirements of the WORK, the CONTRACTOR shall provide the imported materials as part of the WORK, unless a unit price item is included for imported materials in the Bidding Schedule.

C. The following types of materials are defined:

1. Type A (three-quarters inch minus granular backfill): Crushed rock or gravel, and sand with the gradation requirements below. The material shall have a minimum sand equivalent value of 28 and a minimum R-value of 78. If the sand equivalent value exceeds 35 the R-value requirement is waived.

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percentage Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4-inch</td>
<td>100</td>
</tr>
<tr>
<td>No. 4</td>
<td>30 - 50</td>
</tr>
<tr>
<td>No. 200</td>
<td>0 - 12</td>
</tr>
</tbody>
</table>
2. Type B (Class I crushed stone): Manufactured angular, crushed stone, crushed rock, or crushed slag with the following gradation requirements. The material shall have a minimum sand equivalent value of 75.

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percentage Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4-inch</td>
<td>100</td>
</tr>
<tr>
<td>No. 4</td>
<td>30 - 50</td>
</tr>
<tr>
<td>No. 200</td>
<td>0 - 5</td>
</tr>
</tbody>
</table>

3. Type C (sand backfill): Sand with 100 percent passing a 3/8-inch sieve, at least 90 percent passing a Number 4 sieve, and a sand equivalent value not less than 30.

4. Type D (structure backfill): A mixture of crushed rock, gravel, sand, and fines with the gradation requirements below. The material shall have a minimum sand equivalent value of 20.

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percentage Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-inch</td>
<td>100</td>
</tr>
<tr>
<td>No. 4</td>
<td>35 - 100</td>
</tr>
<tr>
<td>No. 30</td>
<td>20 - 100</td>
</tr>
</tbody>
</table>

5. Type E (pea gravel backfill): Crushed rock or gravel with 100 percent passing a 1/2-inch sieve and not more than 10 percent passing a Number 4 sieve.

6. Type F (coarse drainrock): Crushed rock or gravel meeting the following gradation requirements:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percentage Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-inch</td>
<td>100</td>
</tr>
<tr>
<td>1-1/2 inch</td>
<td>90 - 100</td>
</tr>
<tr>
<td>1-inch</td>
<td>20 - 55</td>
</tr>
<tr>
<td>3/4-inch</td>
<td>1 - 15</td>
</tr>
<tr>
<td>No. 200</td>
<td>0 - 3</td>
</tr>
</tbody>
</table>

7. Type G (Class 2 aggregate base): Crushed rock aggregate base material of such nature that it can be compacted readily by watering and rolling to form a firm, stable base for pavements. At the option of the CONTRACTOR, the grading for either the 1-1/2 inch maximum size or 3/4-inch maximum size gradation shall be used. The sand equivalent value shall be not less than 22, and the material shall meet the following gradation requirements:
8. Type H (graded drainrock): Drainrock shall be crushed rock or gravel, durable and free from slaking or decomposition under the action of alternate wetting or drying. The material shall be uniformly graded and shall meet the following gradation requirements:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>1-1/2 inch Max Gradation</th>
<th>3/4-inch Max Gradation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-inch</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>1-1/2-inch</td>
<td>90 - 100</td>
<td>-</td>
</tr>
<tr>
<td>1-inch</td>
<td>-</td>
<td>100</td>
</tr>
<tr>
<td>3/4-inch</td>
<td>50 - 85</td>
<td>90 – 100</td>
</tr>
<tr>
<td>No. 4</td>
<td>25 - 45</td>
<td>35 – 60</td>
</tr>
<tr>
<td>No. 30</td>
<td>10 - 25</td>
<td>10 – 30</td>
</tr>
<tr>
<td>No. 200</td>
<td>2 - 9</td>
<td>2 – 9</td>
</tr>
</tbody>
</table>

The drainrock shall have a sand equivalent value not less than 75. The finish graded surface of the drainrock immediately beneath hydraulic structures shall be stabilized to provide a firm, smooth surface upon which to construct reinforced concrete floor slabs. The CONTRACTOR shall use, at its option, one of the asphalt types listed below:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percentage Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-inch</td>
<td>100</td>
</tr>
<tr>
<td>3/4-inch</td>
<td>90 – 100</td>
</tr>
<tr>
<td>3/8-inch</td>
<td>40 – 100</td>
</tr>
<tr>
<td>No. 4</td>
<td>25 – 40</td>
</tr>
<tr>
<td>No. 8</td>
<td>18 – 33</td>
</tr>
<tr>
<td>No. 30</td>
<td>5 – 15</td>
</tr>
<tr>
<td>No. 50</td>
<td>0 – 7</td>
</tr>
<tr>
<td>No. 200</td>
<td>0 – 3</td>
</tr>
</tbody>
</table>

The drainrock shall have a sand equivalent value not less than 75. The finish graded surface of the drainrock immediately beneath hydraulic structures shall be stabilized to provide a firm, smooth surface upon which to construct reinforced concrete floor slabs. The CONTRACTOR shall use, at its option, one of the asphalt types listed below:

<table>
<thead>
<tr>
<th>Type</th>
<th>Designation</th>
<th>Spray Temperature, deg F</th>
<th>Coverage, gal/sq yd</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SC-800</td>
<td>175-255</td>
<td>0.50</td>
</tr>
<tr>
<td>2</td>
<td>SC-250</td>
<td>165-200</td>
<td>0.50</td>
</tr>
<tr>
<td>3</td>
<td>RS-1</td>
<td>70-120</td>
<td>0.50</td>
</tr>
</tbody>
</table>

If the surface remains tacky, sufficient sand shall be applied to absorb the excess asphalt.

9. Type I: Any other suitable material as defined herein.
10. Type J (cement-treated backfill): Material which consists of Type H material, or any mixture of Types B, C, G, and H materials which has been cement-treated so that the cement content of the material is not less than 5 percent by weight when tested in accordance with ASTM D 2901 - Standard Test Method for Cement Content of Freshly Mixed Soil Cement. The ultimate compressive strength at 28 days shall be not less than 400 psi when tested in accordance with ASTM D 1633 - Standard Test Method for Compressive Strength of Molded Soil - Cement Cylinders.

11. Type K (topsoil): Stockpiled topsoil material which has been obtained at the Site by removing soil to a depth not exceeding 2 feet. Removal of the topsoil shall be done after the area has been stripped of vegetation and debris.

12. Type L (controlled low strength material): Controlled low strength material shall be in accordance with Section 033400 - Controlled Low Strength Material.

13. Type M (aggregate subbase): Crushed rock aggregate subbase material that can be compacted readily by watering and rolling to form a firm stable base. The sand equivalent value shall be not less than 18 and the material shall meet the following gradation requirements:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percentage Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-inch</td>
<td>100</td>
</tr>
<tr>
<td>2-1/2 inch</td>
<td>87 - 100</td>
</tr>
<tr>
<td>No. 4</td>
<td>35 - 95</td>
</tr>
<tr>
<td>No. 200</td>
<td>0 - 29</td>
</tr>
</tbody>
</table>

14. Type N (trench plug): Low permeable fill material, a non-dispersible clay material having a minimum plasticity index of 10.

15. Type O (Levee Backfill): The levee material shall have a minimum plasticity index of 8 and a maximum plasticity index of 40. The maximum liquid limit shall be 45. The material shall meet the following gradation requirements:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percentage Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-inch</td>
<td>100</td>
</tr>
<tr>
<td>No. 200</td>
<td>30 - 100</td>
</tr>
</tbody>
</table>

16. Type P (MSE Wall Backfill): Provide MSE granular backfill material meeting the following requirements. The material shall have a maximum plasticity index of 6. The MSE walls will be subject to water inundation during higher river levels. Provide the following permeable, free draining backfill material within the entire soil reinforced zone:
<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percentage Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-inch</td>
<td>100</td>
</tr>
<tr>
<td>3/4-inch</td>
<td>50-90</td>
</tr>
<tr>
<td>No. 4</td>
<td>20 - 50</td>
</tr>
<tr>
<td>No. 200</td>
<td>0 - 2</td>
</tr>
</tbody>
</table>

Electrochemical Properties: The electrochemical properties of the material shall meet the following requirements:

<table>
<thead>
<tr>
<th>Property</th>
<th>Limits</th>
<th>Test Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>5.0 - 10.0</td>
<td>ASTM D 4972</td>
</tr>
<tr>
<td>Resistivity</td>
<td>5,000 Ω-cm (min.)</td>
<td>CTM 643</td>
</tr>
</tbody>
</table>

MSE granular backfill material with resistivities of less than 5,000 Ω-cm but greater than 3,000 Ω-cm and meeting all other requirements may be accepted if they meet the following additional requirements:

<table>
<thead>
<tr>
<th>Property</th>
<th>Limits</th>
<th>Test Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorides</td>
<td>100 PPM (max.)</td>
<td>CTM 422</td>
</tr>
<tr>
<td>Sulfates</td>
<td>200 PPM (max.)</td>
<td>ASTM C 1580</td>
</tr>
</tbody>
</table>

17. Soils which, when classified under ASTM D 2487 - Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System), fall in the classifications of Pt, OH, CH, MH, or OL shall be classified as unsuitable.

18. **Schedule:** Materials shall be used as indicated below:

<table>
<thead>
<tr>
<th>Pipe foundation zone backfill</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe Zone for Mortar coated pipe</td>
<td>A, B</td>
</tr>
<tr>
<td>Pipe Zone for PVC pipe</td>
<td>B</td>
</tr>
<tr>
<td>Pipe trench zone backfill except as identified below</td>
<td>I, A through H or mixture thereof.</td>
</tr>
<tr>
<td>Pipe trench final backfill under paved areas</td>
<td>I, A through H or mixture thereof.</td>
</tr>
<tr>
<td>Pipe trench final backfill unpaved areas</td>
<td>K</td>
</tr>
<tr>
<td>Pipe trench zone and final backfill under structures</td>
<td>Same as pipe zone except where concrete encasement is required</td>
</tr>
<tr>
<td>Replace pipeline trench over excavation</td>
<td>F with 6-inch top layer of E, or non-woven filter fabric, or same as pipe zone backfill if trench is above water table.</td>
</tr>
<tr>
<td>Aggregate base materials</td>
<td>G</td>
</tr>
<tr>
<td>Aggregate subbase</td>
<td>M</td>
</tr>
<tr>
<td>Backfill up to 6-inches below structures and around all structures</td>
<td>D</td>
</tr>
<tr>
<td>Top 6-inches of backfill below outlet structure or slabs on grade</td>
<td>G</td>
</tr>
<tr>
<td>Levee Backfill</td>
<td>O</td>
</tr>
<tr>
<td>Mechanically Stabilized Earth (MSE) Retaining Wall Backfill</td>
<td>P</td>
</tr>
<tr>
<td>Under structures where ground water is removed to allow placement of concrete, underlain by non-woven filter fabric</td>
<td>F</td>
</tr>
<tr>
<td>All other Embankment Fills or mixture of I and A through H</td>
<td>I</td>
</tr>
<tr>
<td>Top 6-inches of embankment fills, or backfills around structures</td>
<td>K</td>
</tr>
</tbody>
</table>

D. In addition to the materials identified as unsuitable in Section 2.1.C, a material shall be classified as unsuitable if one of the following conditions is present:

1. Soils which cannot be compacted sufficiently to achieve the density specified for the intended use.

2. Materials that contain hazardous or designated waste materials including petroleum hydrocarbons, pesticides, heavy metals, and any material which may be classified as hazardous or toxic according to applicable regulations.

2.2 MATERIALS TESTING

A. Samples

1. Soils testing of samples submitted by the CONTRACTOR will be performed by a testing laboratory of the OWNER’s choice and at the OWNER’s expense.

2. The ENGINEER may direct the CONTRACTOR to supply samples for testing of any material used in the WORK.

B. Particle size analysis of soils and aggregates will be performed using ASTM D 422 - Standard Test Method for Particle-Size Analysis of Soils.

C. Determination of sand equivalent value will be performed using ASTM D 2419 - Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate.

D. Unified Soil Classification System

1. References in this Section to soil classification types and standards shall have the meanings and definitions indicated in ASTM D 2487.

2. The CONTRACTOR shall be bound by applicable provisions of ASTM D 2487 in the interpretation of soil classifications.

E. Testing for sulfate, resistivity, and pH shall be performed in accordance with California Test Methods 417 and 643 of the California Department of Transportation.

F. Testing for chloride shall be performed in accordance with California Test Methods 422 of the California Department of Transportation for determining Water-Soluble Chloride Ion Content in Soil.
2.3 IDENTIFICATION TAPE

A. Unless otherwise indicated, identification tape shall be placed above buried pipelines that are not comprised of magnetic components at least in part.

B. Identification tape shall be 6-inches wide, yellow in color, composed of polyethylene, and provided with an integral metallic wire.

C. Tape shall be labeled with CAUTION – BURIED UTILITIES.

2.4 SOIL STERILANT

A. Soil sterilant or chemical weed control agent shall be a commercial product manufactured specifically to sterilize the subgrade soil against the growth of weeds, plants, or any type of vegetation.

PART 3 -- EXECUTION

3.1 EXCAVATION AND BACKFILLING - GENERAL

A. General

1. Except when specifically provided to the contrary, excavation shall include the removal of materials, including obstructions, that would interfere with the proper execution and completion of the WORK.

2. The removal of such materials shall conform to the lines and grades indicated or ordered.

3. Unless otherwise indicated, the entire Site shall be stripped of vegetation and debris and shall be grubbed, and such material shall be removed from the Site prior to performing any excavation or placing any fill.

4. The CONTRACTOR shall furnish, place, and maintain supports and shoring that may be required for the sides of excavations.

5. Excavations shall be sloped or otherwise supported in a safe manner in accordance with applicable state safety requirements and the requirements of OSHA Safety and Health Standards for Construction (29CFR1926).

6. The CONTRACTOR shall provide quantity surveys where so required to verify quantities for Unit Price Contracts.

7. Surveys shall be performed prior to beginning WORK and upon completion by a surveyor licensed in the state where the Site is located.

B. Removal and Exclusion of Water

1. The CONTRACTOR shall remove and exclude water, including stormwater, groundwater, irrigation water, and wastewater, from excavations.

2. Dewatering wells, wellpoints, sump pumps, or other means shall be used to remove water and continuously maintain groundwater at a level at least 2 feet below the bottom of excavations before the excavation WORK begins at each location.
3. Water shall be removed and excluded until backfilling is complete and field soils testing has been completed.

3.2 OVER-EXCAVATION

A. **Indicated:** Where areas are indicated to be over-excavated, excavation shall be to the depth indicated, and backfill shall be installed to the grade indicated.

B. **Not Indicated:** When ordered to over-excavate areas deeper and/or wider than required by the Contract Documents, the CONTRACTOR shall over-excavate to the dimensions ordered and backfill to the indicated grade.

C. **Neither Indicated nor Ordered:** Any over-excavation carried below the grade that is neither ordered or nor indicated shall be backfilled and compacted to the required grade with the indicated material as part of the WORK

3.3 EXCAVATION IN VICINITY OF TREES

A. Except where trees are indicated to be removed, trees shall be protected from injury during construction operations.

B. No tree roots larger than 2 inches in diameter shall be cut without the express permission of the ENGINEER.

C. Trees shall be supported during excavation by any means previously reviewed and accepted by the ENGINEER.

3.4 ROCK EXCAVATION

A. Rock excavation shall include removal and disposal of the following items:

1. Boulders measuring 1/3 of a cubic yard or more in volume;

2. Rock material in ledges, bedding deposits, and un-stratified masses that cannot be removed using conventional equipment as defined herein and which require systematic drilling for removal;

3. Concrete or masonry structures that have been abandoned; and,

4. Conglomerate deposits that are so firmly cemented that they possess the characteristics of solid rock and cannot be removed using conventional equipment as herein defined and require systematic drilling and blasting for removal.

B. **Scope and Payment**

1. Rock excavation shall be performed by the CONTRACTOR, provided that if the quantity of rock excavation is affected by any change in the scope of the WORK an appropriate adjustment of the Contract Price will be made under a separate Bid Item if such Bid Item has been established.

2. Otherwise, payment will be made in accordance with a negotiated price.

C. Explosives and Blasting: Blasting will not be permitted.
3.5 DISPOSAL OF EXCESS EXCAVATED MATERIAL

A. Unless otherwise indicated, excess excavated material shall be the property of the CONTRACTOR. The CONTRACTOR shall remove and dispose of excess excavated material at an off-Site location selected and arranged for by the CONTRACTOR.

B. The CONTRACTOR shall obtain required permits and landowner approvals for disposal of excess excavated material off-Site and shall submit copies of related documents to the ENGINEER for information prior to disposal. CONTRACTOR shall pay costs associated with the removal and disposal.

3.6 BACKFILL

A. General

1. Backfill shall not be dropped directly upon any structure or pipe.

2. Backfill shall not be placed around or upon any structure until the concrete has attained sufficient strength to withstand the loads imposed.

3. Backfill around water-retaining structures shall not be placed until the structures have been tested, and the structures shall be full of water while backfill is being placed.

B. Except for drainrock materials being placed in over-excavated areas or trenches, backfill shall be placed after water is removed from the excavation and the trench sidewalls and bottom have been dried to a moisture content suitable for compaction.

C. Pre-Placement Conditions

1. Immediately prior to placement of backfill materials, the bottoms and sidewalls of trenches and structure excavations shall have any loose, sloughing, or caving soil and rock materials removed.

2. Trench sidewalls shall consist of excavated surfaces that are in a relatively undisturbed condition before placement of backfill materials.

D. Soil Sterilant: Apply soil sterilant or a chemical weed control agent under roads and as indicated, in strict compliance with the manufacturer's dosage and application instructions and with applicable laws, ordinances, and regulations governing the use of such chemicals.

E. Layering

1. Backfill materials shall be placed and spread evenly in layers.

2. Backfill layers shall be evenly spread in horizontal layers of 8 inches uncompacted thickness, maximum.

F. Using flooding and jetting methods for compaction is not permitted.

G. During spreading, each layer shall be thoroughly mixed as necessary in order to promote uniformity of material in each layer.
H. Moisture Content

1. Where the backfill material moisture content is below the optimum moisture content, water shall be added before or during spreading until the proper moisture content is achieved.

2. Where the backfill material moisture content is too high to permit the indicated degree of compaction, the material shall be dried until the moisture content is satisfactory.

3.7 SETTLEMENT MONITORING AND CONTINGENCY PLANNING

A. The CONTRACTOR shall comply with all requirements of Section 022213 – Settlement Monitoring.

3.8 STRUCTURE, ROADWAY, AND EMBANKMENT EXCAVATION AND BACKFILL

A. Excavation Beneath Structures and Embankments

1. Excavation below the Outlet Structure (Area 20) shall be carried to elevation 0.0 and at least 15 feet horizontally beyond the limits of the foundation slab and brought back to grade with compact materials acceptable for placement beneath structures.

2. Except where indicated otherwise for a particular structure or where ordered by the ENGINEER, excavation shall be carried to an elevation 24 inches below the bottom of the footing or slab and at least 5 feet horizontally beyond the limits of the footing or slab and brought back to grade with compacted materials acceptable for placement beneath structures.

3. The area where a fill or embankment is to be constructed shall be cleared of vegetation, roots, and foreign material.

4. Where indicated or ordered, areas beneath structures or fills shall be over-excavated.

5. After the fill areas have been cleared, grubbed, and excavated, the subgrade areas beneath embankments shall be excavated to remove not less than the top 6 inches of native material and where such subgrade is sloped, the native material shall be benched for keying the fill and removing severe or abrupt changes in the topography of the Site.

6. When such over-excavation is indicated, both the over-excavation and the subsequent backfill to the required grade shall be performed by the CONTRACTOR.

7. After the required excavation or over-excavation for fills and embankments has been completed, the exposed surface shall be scarified to a depth of 12 inches, brought to optimum moisture content, and rolled with heavy compaction equipment to obtain 95 percent of maximum density.

B. Excavation Beneath Paved and Graveled (AB) Areas

1. Excavation under areas to be paved or finished with aggregate base shall extend to the bottom of the aggregate base.
2. After the required excavation has been completed, the top 12 inches of exposed surface shall be scarified, brought to optimum moisture content, and rolled with heavy compaction equipment to obtain 95 percent of maximum density.

3. The finished subgrade shall be even, self-draining, and in conformance with the slope of the finished pavement or aggregate base.

4. Areas that could accumulate standing water shall be regraded to provide a self-draining subgrade.

C. Excavation Beneath Concrete Pipe Encasement On Levee Prism

1. Excavation under the concrete pipe encasement, through the top of the levee prism, shall extend to the bottom of the encasement to elevation 35.80.

2. After the required excavation has been completed, the top 12 inches of exposed surface shall be scarified, brought to optimum moisture content, and rolled with heavy compaction equipment to obtain 95 percent of maximum density.

D. Notification of ENGINEER: The CONTRACTOR shall notify the ENGINEER at least 3 Days in advance of completion of any structure or roadway excavation and shall allow the ENGINEER a review period of at least one day before the exposed foundation is scarified and compacted or is covered with backfill or with any construction materials.

E. Compaction of Fill, Backfill, and Embankment Materials

1. Each layer of backfill materials as defined herein, where the material is graded such that 10 percent or more passes a No. 4 sieve, shall be mechanically compacted to the indicated percentage of density.

2. Equipment that is consistently capable of achieving the required degree of compaction shall be used, and each layer shall be compacted over its entire area while the material is at the required moisture content.

3. Each layer of coarse granular backfill materials with less than 10 percent passing the No. 4 sieve shall be compacted by means of at least 2 passes from a vibratory compactor that is capable of obtaining the required density in 2 passes.

4. The Yolo County Road 117 subgrade shall have a minimum R-Value of 20. R-Value testing shall be performed for the Yolo County Road 117 subgrade. R-Value testing will be performed using California Test Method (CTM) 301 - Method of Test for Determining the Resistance "R" Value of Treated and Untreated Bases, Subbases and Basement Soils by the Stabilometer.

F. Roofs

1. Fill on structure roofs shall be deposited not sooner than 30 Days after the concrete roof slab has been placed.

2. Equipment weighing more than 10,000 pounds when loaded shall not be used on a roof.

3. A roller weighing not more than 8,000 pounds shall be used to compact fill on a roof.

G. Flooding, ponding, and jetting shall not be used.
H. Heavy Equipment

1. Equipment weighing more than 10,000 pounds shall not be used closer to walls than a horizontal distance equal to the vertical depth of the fill above undisturbed soil at that time.

2. Hand-operated power compaction equipment shall be used where the use of heavier equipment is impractical or restricted due to weight limitations.

I. Layering

1. Embankment and fill material shall be placed and spread evenly in approximately horizontal layers.

2. Each layer shall be moistened and aerated as necessary.

3. Unless otherwise approved by the ENGINEER, no layer shall exceed 8 inches of uncompacted thickness.

4. The embankment and fill shall be compacted in conformance with Paragraph K, below.

J. Embankments and Fills

1. When an embankment or fill is to be constructed and compacted against hillsides or fill slopes steeper than 5:1, the slopes of the hillsides or fills shall be horizontally benched in order to key the embankment or fill to the underlying ground.

2. A minimum of 12 inches perpendicular to the slope of the hillside or fill shall be removed and re-compacted as the embankment or fill is brought up in layers.

3. Material thus cut shall be re-compacted along with the new material.

4. Hillside or fill slopes 4:1 or flatter shall be prepared in accordance with Paragraph A, above.

K. Compaction Requirements: The following compaction requirements shall be in accordance with ASTM D 1557 - Test Method for Laboratory Compaction Characteristics of Soils Using Modified Effort (56,000 ft-lbf/ft³ (2,700 kN-m/m³)) where the material is graded such that 10 percent or more passes a No. 4 sieve and in accordance with ASTM D 4253 - Test Method for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table, and D 4254 - Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density, where the material is coarse granular backfill materials with less than 10 percent passing the No. 4 sieve. All levee embankment compaction requirements shall be in accordance with ASTM D 698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft³ (600 kN-m/m³)): 
<table>
<thead>
<tr>
<th>Location or Use of Fill or Backfill</th>
<th>Percentage of Maximum Dry Density</th>
<th>Percentage of Relative Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Embankments and fills not identified otherwise</td>
<td>90</td>
<td>55</td>
</tr>
<tr>
<td>Levee Embankments (ASTM D698)</td>
<td>95</td>
<td>75</td>
</tr>
<tr>
<td>Embankments and backfill beneath paved or graveled areas and structures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All other embankments and backfill above Elevation 0.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Topsoil</td>
<td>80</td>
<td>NA</td>
</tr>
<tr>
<td>Aggregate base or subbase</td>
<td>95</td>
<td>NA</td>
</tr>
</tbody>
</table>

3.9 **PIPELINE AND UTILITY TRENCH EXCAVATION AND BACKFILL**

A. **General**: Unless otherwise indicated or ordered, excavation for pipelines and utilities shall be open-cut trenches with minimum widths as indicated.

B. **Trench Bottom**

1. Trench excavations for all concrete encased piping through the top of the levee prism shall not go below elevation 35.80.

2. Except where pipe bedding is required, the bottom of the trench for all pipelines outside of the levee prism shall be excavated uniformly to an elevation 30 inches below the bottom of the pipe.

3. Excavations for pipe bells and welding shall be made as required.

4. Where pipe bedding is required, the bottom of the trench for all pipelines outside of the levee prism shall be excavated uniformly to an elevation 20 inches below the bottom of the pipe bedding.

C. **Open Trenches**

1. The maximum amount of open trench permitted in any one location shall be 500 feet or the length necessary to accommodate the amount of pipe installed in a single Day, whichever is greater.

2. Trenches shall be fully backfilled at the end of each Day or, in lieu thereof, shall be covered by heavy steel plates adequately braced and capable of supporting vehicular traffic in those locations where it is impractical to backfill at the end of each Day.

3. These requirements for backfilling or use of steel plate will be waived in cases where the trench is located further than 100 feet from any traveled roadway or occupied structure; in such cases, however, barricades and warning lights meeting appropriate safety requirements shall be provided and maintained.
D. Embankments, Fills and Structural Backfills

1. Where pipelines are to be installed in embankments, fills, or structure backfills, the fill shall be constructed to a level at least one foot above the top of the pipe before the trench is excavated.

2. Upon completion of the embankment or structural backfill, a trench conforming to the appropriate detail may be excavated and the pipe may be installed.

E. Trench Shield

1. If a moveable trench shield is used during excavation operations, the trench width shall be wider than the shield such that the shield is free to be lifted and then moved horizontally without binding against the trench sidewalls and causing sloughing or caving of the trench walls.

2. If the trench walls cave or slough, the trench shall be excavated as an open excavation with sloped sidewalls or with trench shoring, as indicated and as required by the pipe structural design.

3. If a moveable trench shield is used during excavation, pipe installation, and backfill operations, the shield shall be moved by lifting the shield free of the trench bottom or backfill and then moving the shield horizontally.

4. The CONTRACTOR shall not drag trench shields along the trench causing damage or displacement to the trench sidewalls, the pipe, or the bedding and backfill.

F. Placing and Spreading Of Backfill Materials

1. Each layer of coarse granular backfill materials with less than 10 percent passing the No. 4 sieve shall be compacted by means of at least 2 passes from a vibratory compactor that is capable of achieving the required density in 2 passes and that is acceptable to the ENGINEER.

2. Where such materials are used for pipe zone backfill, vibratory compaction shall be used at vertical intervals of the lesser of:

   a. one-half the diameter of the pipe; or

   b. 24 inches, measured in the uncompacted state.

3. In addition, these materials shall be subjected to vibratory compaction at the springline of the pipe and the top of the pipe zone backfill, regardless of whether that dimension is less than 24 inches or not.

4. Each layer of backfill material with greater than 10 percent passing the No. 4 sieve shall be compacted using mechanical compactors suitable for the WORK.

5. The material shall be placed and compacted under the haunch of the pipe and up each side evenly so as not to move the pipe during the placement of the backfill.

6. The material shall be placed in lifts that will not exceed 8 inches when uncompacted.

G. Using flooding and jetting method for compaction is not permitted.
H. Mechanical Compaction

1. Backfill around and over pipelines that is mechanically compacted shall be compacted using light, hand-operated vibratory compactors and rollers that do not damage the pipe.

2. After completion of at least 2 feet of compacted backfill over the top of pipeline, compaction equipment weighing no more than 8,000 pounds may be used to complete the trench backfill.

I. Pipe And Utility Trench Backfill

1. Foundation Zone Backfill
   a. The foundation zone backfill is defined as that portion of the vertical trench cross-section lying as indicated between the trench bottom and a plane 20 inches above the trench bottom.
   b. The foundation zone shall be backfilled with the indicated backfill material and to the indicated compaction requirements.

2. Pipe Zone Backfill
   a. Definitions
      1) The pipe zone is defined as that portion of the vertical trench cross-section lying between a plane below the bottom surface of the pipe and a plane at a point above the top surface of the pipe as indicated.
      2) The bedding is defined as that portion of pipe zone backfill material between the top of the foundation zone backfill and the bottom of the pipe.
      3) The embedment is defined as that portion of the pipe zone backfill material between the bedding and a level line as indicated.
   b. Final Trim
      1) After compacting the bedding, the CONTRACTOR shall perform a final trim using a stringline for establishing grade, such that each pipe section when first laid will be continually in contact with the bedding along the extreme bottom of the pipe.
      2) Excavation for pipe bells and welding shall be made as required.
   c. The pipe zone shall be backfilled with the indicated backfill material.
   d. Pipe zone backfill materials shall be manually spread evenly around the pipe, maintaining the same height on both sides of the pipe such that when compacted the pipe zone backfill will provide uniform bearing and side support.
   e. The CONTRACTOR shall exercise care in order to prevent damage to the pipeline coating, cathodic bonds, and the pipe itself during the installation and backfill operations.
3. Trench Zone Backfill
   a. After the pipe zone backfill has been placed, backfilling of the trench zone may proceed.
   b. The trench zone is defined as that portion of the vertical trench cross-section lying as indicated between a plane above the top surface of the pipe and a plane at a point 18 inches below the finished surface grade, or if the trench is under pavement, 18 inches below the roadway subgrade.

4. Final Backfill: Final backfill is defined as backfill in the trench cross-sectional area within 18 inches of finished grade, or if the trench is under pavement, backfill within 18 inches of the roadway subgrade.

J. Identification Tape
   1. Install identification tape as indicated.
   2. Terminate the tape in a precast concrete box either adjacent to or part of the valve box, manhole, vault, or other structure into which the non-metallic pipe enters or at the end of the non-metallic pipeline.
   3. The termination box shall be covered with a cast iron lid.
   4. The box shall be located at grade in paved areas or 6 inches above grade in unpaved areas.

K. Trench Shield
   1. If a moveable trench shield is used during backfill operations, the shield shall be lifted to a location above each layer of backfill material prior to compaction of the layer.
   2. The CONTRACTOR shall not displace the pipe or backfill while the shield is being moved.

L. Compaction Requirements: The following compaction test requirements shall be in accordance with ASTM D 1557 - Test Method for Laboratory Compaction Characteristics of Soils Using Modified Effort (56,000 ft - lbl/ft³) (2,700 kN-m/m³) where the material is graded such that 10 percent or more passes a No. 4 sieve, and in accordance with ASTM D 4253 - Standard Test Method for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table, and D 4254 - Standard Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density where the material is coarse granular backfill materials with less than 10 percent passing the No. 4 sieve.
<table>
<thead>
<tr>
<th>Location or Use of Fill or Backfill</th>
<th>Percentage of Maximum Dry Density</th>
<th>Percentage of Relative Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Pipe foundation zone backfill</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Over-excavated zones under pipe foundation zone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Pipe bedding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Pipe embedment backfill</td>
<td>95</td>
<td>70</td>
</tr>
<tr>
<td>• Pipe zone backfill portion above embedment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Trench zone backfill and final backfill, beneath paved areas, structures, and levees</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trench zone backfill and final backfill, not beneath paved areas, structures, or levees</td>
<td>90</td>
<td>55</td>
</tr>
</tbody>
</table>

3.10 FIELD TESTING

A. **General**: Field soils testing will be performed by a testing laboratory of the OWNER's choice at the OWNER's expense, except as indicated below.

B. **Density**

1. Where soil material is required to be compacted to a percentage of maximum density, the maximum density at optimum moisture content will be determined in accordance with Method C of ASTM D 1557.

2. Where cohesionless, free draining soil material is required to be compacted to a percentage of relative density, the calculation of relative density will be determined in accordance with ASTM D 4253 and D 4254.

3. Field density in-place tests will be performed in accordance with ASTM D 1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method, ASTM D 6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth), or by such other means acceptable to the ENGINEER.

C. **Remediation**

1. In case the test of the fill or backfill shows non-compliance with the required density, the CONTRACTOR shall accomplish such remedy as may be required to ensure compliance.

2. Subsequent testing to show compliance shall be by a testing laboratory selected by the OWNER and paid by the CONTRACTOR.
D. CONTRACTOR's Responsibilities

1. The CONTRACTOR shall provide test trenches and excavations, including excavation, trench support and groundwater removal for the OWNER's field soils testing operations.

2. The trenches and excavations shall be provided at the locations and to the depths as required by the OWNER.

3. Lawn areas destroyed by test trenching and excavation shall be regraded and relandscaped with hydroseeding.

- END OF SECTION -
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SECTION 313419 - GEOTEXTILES

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide geotextiles, complete and in place, in accordance with the Contract Documents.

B. Definitions: The following definitions apply to the WORK of this Section:

1. Fabric: Geotextile, a permeable geosynthetic comprised solely of textiles.

2. Minimum Average Roll Value (MinARV): Minimum of series of average roll values representative of geotextile provided.

3. Maximum Average Roll Value (MaxARV): Maximum of series of average roll values representative of geotextile provided.


5. Overlap: Distance measured perpendicular from overlapping edge of one sheet to underlying edge of adjacent sheet.

6. Seam Efficiency: Ratio of tensile strength across seam to strength of intact geotextile, when tested according to ASTM D 4884.

7. Woven geotextile: A geotextile fabric composed of polymeric yarn interlaced to form a planar structure with uniform weave pattern.

8. Nonwoven geotextile: A geotextile fabric composed of a pervious sheet of polymeric fibers interlaced to form a planar structure with uniform random fiber pattern.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. The following standards are referenced in this Section:

ASTM D 4355 Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture, and Heat in a Xenon-Arc Type Apparatus

ASTM D 4491 Standard Test Methods for Water Permeability of Geotextiles by Permittivity

ASTM D 4533 Standard Test Method for Trapezoid Tearing Strength of Geotextiles


ASTM D 4751 Standard Test Method for Determining Apparent Opening Size of a Geotextile
1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 013300 - Contractor Submittals.

B. Shop Drawings
   
   1. Manufacturer material specifications and product literature.
   
   2. Installation drawings showing geotextile sheet layout, location of seams, direction of overlap, and sewn seams.
   
   3. Description of proposed method of geotextile deployment, sewing equipment, sewing methods, and provisions for holding geotextile temporarily in place until permanently secured.

C. Samples
   
   1. Geotextile: One-piece, minimum 18-inches long, taken across full width of roll of each type and weight of geotextile. Label each with brand name and furnish documentation of lot and roll number from which each sample was obtained.
   
   2. Field Sewn Seam: 5-foot length of seam, 12-inches wide with seam along center, for each type and weight of geotextile.
   
   3. Securing Pin and Washer: 1 each.

D. Certifications
   
   1. Certification from geotextile manufacturer that products satisfy the indicated requirements.
   
   2. Field seam efficiency test results.

PART 2 -- PRODUCTS

2.1 WOVEN GEOTEXTILE

A. Woven geotextile shall be composed of polymeric yarn interlaced to form a planar structure with uniform weave pattern. Products shall be calendared or finished so that yarns will retain their relative position with respect to each other.

B. Polymeric yarn shall be long-chain synthetic polymers (polyester or polypropylene) with stabilizers or inhibitors added to make filaments resistant to deterioration due to heat and ultraviolet light exposure.
C. **Sheet Edges:** Selvaged or finished to prevent outer material from separating from sheet.

D. **Unseamed Sheet Width:** Minimum 6 feet.

E. **Nominal Weight per Square Yard:** 6.

F. **Physical Properties:** Conform to requirements below.

### PHYSICAL PROPERTY REQUIREMENTS FOR WOVEN GEOTEXTILE

<table>
<thead>
<tr>
<th>Property</th>
<th>Requirement</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apparent Opening Size (AOS)</td>
<td>No. 10 to No. 100 U.S. Standard Sieve Size</td>
<td>ASTM D 4751</td>
</tr>
<tr>
<td>Water Permittivity</td>
<td>0.02 to 3.34 sec.(^{-1}), MinARV</td>
<td>ASTM D 4491</td>
</tr>
<tr>
<td>Vertical Waterflow Rate</td>
<td>10 to 150 gpm/sq ft, MinARV</td>
<td>(Falling Head)</td>
</tr>
<tr>
<td>Wide Width Strip Tensile Strength</td>
<td>60 to 1,500 lb/in.-width, MinARV</td>
<td>ASTM D 4595</td>
</tr>
<tr>
<td>Wide Width Strip Elongation</td>
<td>14 to 60 percent, MaxARV</td>
<td></td>
</tr>
<tr>
<td>Trapezoidal Tear Strength</td>
<td>30 to 200 lb, MinARV</td>
<td>ASTM D 4533</td>
</tr>
<tr>
<td>Puncture Strength</td>
<td>50 to 250 lb, MinARV</td>
<td>ASTM D 4833</td>
</tr>
<tr>
<td>Abrasion Resistance</td>
<td>5 to 25 percent loss, 250 cycles, MaxARV</td>
<td>ASTM D 4886</td>
</tr>
<tr>
<td>Ultraviolet Radiation Resistance</td>
<td>70 to 90 percent strength retention, MinARV after 500 hours</td>
<td>ASTM D 4355</td>
</tr>
</tbody>
</table>

2.2 **NONWOVEN GEOTEXTILE**

A. Nonwoven geotextile shall be composed of a pervious sheet of polymeric fibers interlaced to form a planar structure with uniform random fiber pattern. Products shall be calendared or finished so that yarns will retain their relative position with respect to each other.

B. Polymeric yarn shall be long-chain synthetic polymers (polyester, polypropylene, or polyethylene) with stabilizers or inhibitors added to make filaments resistant to deterioration due to heat and ultraviolet light exposure.

C. **Geotextile Edges:** Selvaged or finished to prevent outer material from separating from sheet.
D. **Unseamed Sheet Width**: Minimum 6-feet.

E. **Nominal Weight per Square Yard**: 12 ounces.

F. **Physical Properties**: Conform to requirements below.

### PHYSICAL PROPERTY REQUIREMENTS FOR NONWOVEN GEOTEXTILE

<table>
<thead>
<tr>
<th>Property</th>
<th>Requirement</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apparent Opening Size (AOS)</td>
<td>No. 100 to No. 140 U.S. Standard Sieve Size</td>
<td>ASTM D 4751</td>
</tr>
<tr>
<td>Water Permittivity</td>
<td>1.2 sec.(^{-1}), MinARV</td>
<td>ASTM D 4491 (Falling Head)</td>
</tr>
<tr>
<td>Vertical Waterflow Rate</td>
<td>90 gpm/sq ft, MinARV</td>
<td></td>
</tr>
<tr>
<td>Wide Width Strip Tensile Strength</td>
<td>300 MinARV</td>
<td>ASTM D 4595</td>
</tr>
<tr>
<td>Wide Width Strip Elongation</td>
<td>70 percent, MaxARV</td>
<td>ASTM D 4595</td>
</tr>
<tr>
<td>Trapezoidal Tear Strength</td>
<td>120 lb, MinARV</td>
<td>ASTM D 4533</td>
</tr>
<tr>
<td>Puncture Strength</td>
<td>130 lb, MinARV</td>
<td>ASTM D 4833</td>
</tr>
<tr>
<td>Ultraviolet Radiation Resistance</td>
<td>90 percent strength retention, MinARV after 500 hours</td>
<td>ASTM D 4355</td>
</tr>
</tbody>
</table>

2.3 **SEWING THREAD**

A. Sewing thread shall be polypropylene, polyester, or Kevlar thread with durability equal to or greater than durability of geotextile sewn.

2.4 **SECURING PINS**

A. Securing pins shall be steel rods or bars conforming to the following:

1. 3/16-inch diameter.
2. Pointed at one end; head on other end, sufficiently large to retain washer.

B. Steel washers for securing pins shall be:

1. Outside Diameter: Not less than 1-1/2 inches.
2. Inside Diameter: 1/4-inch.

C. Steel Wire Staples
   1. U-shaped.
   2. 10-gauge.
   3. Minimum 6-inches long.

PART 3 -- EXECUTION

3.1 PRODUCT DELIVERY, STORAGE, AND HANDLING
   A. Deliver each roll with sufficient information attached to identify manufacturer and product name or number.
   B. Handle products in manner that maintains undamaged condition.
   C. Do not store products directly on ground. Ship and store geotextile with suitable wrapping for protection against moisture and ultraviolet exposure. Store geotextile in a way that protects it from elements. If stored outdoors, elevate and protect geotextile with waterproof cover.

3.2 LAYING GEOTEXTILE
   A. Notify the ENGINEER whenever geotextiles are to be placed. Do not place geotextile prior to obtaining ENGINEER's approval of underlying materials.
   B. Lay and maintain geotextile smooth and free of tension, folds, wrinkles, or creases.

3.3 ORIENTATION ON SLOPES
   A. Orient geotextile with long dimension of each sheet parallel to direction of slope.
   B. Geotextile may be oriented with long dimension of sheet transverse to direction of slope only if sheet width, without unsewn seams, is sufficient to cover entire slope and anchor trench and extend at least 18-inches beyond toe of slope.

3.4 JOINTS
   A. Unseamed Joints
      1. Unseamed joints shall be overlapped to the following dimensions unless otherwise indicated:
         b. Riprap: Minimum 18-inches.
         c. Drain Trenches: Minimum 18-inches, except overlap shall equal trench width if trench width is less than 18-inches.
         d. Other Applications: Minimum 12-inches.
B. Sewn seams shall be used wherever stress transfer from one geotextile sheet to another is necessary. Sewn seams, as approved by ENGINEER, also may be used instead of overlap at joints for applications that do not require stress transfer.

1. Seam efficiency shall be minimum 70 percent, verified by preparing and testing minimum of one set of nondestructive samples per acre of each type and weight of geotextile provided. Test according to ASTM D 4884.

2. Type: "J" type seams are preferred, but flat or butterfly seams are acceptable.

3. Stitch Count: Minimum 3 to maximum 7 stitches per inch.


5. Stitch Location: 2-inches from geotextile sheet edges, or more if necessary to develop required seam strength.


3.5 SECURING GEOTEXTILE

A. Secure geotextile during installation as necessary with sand bags or other means approved by ENGINEER.

B. Securing Pins

1. Insert securing pins with washers through geotextile, midway between edges of overlaps and 6-inches from free edges.

2. Spacing

<table>
<thead>
<tr>
<th>Slope</th>
<th>Maximum Pin Spacing, feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steeper than 3:1</td>
<td>2</td>
</tr>
<tr>
<td>3:1 to 4:1</td>
<td>3</td>
</tr>
<tr>
<td>Flatter than 4:1</td>
<td>5</td>
</tr>
</tbody>
</table>

3. Install additional pins across each geotextile sheet as necessary to prevent slippage of geotextile or to prevent wind from blowing geotextile out of position.

4. Push each securing pin through geotextile until washer bears against geotextile and secures it firmly to subgrade.

3.6 PLACING PRODUCTS OVER GEOTEXTILE

A. Notify ENGINEER before placing material over geotextile. Do not cover installed geotextile prior to receiving authorization from the ENGINEER to proceed.
B. If tears, punctures, or other geotextile damage occurs during placement of overlying products, remove overlying products as necessary to expose damaged geotextile. Repair damage as indicated below.

3.7 INSTALLING GEOTEXTILE IN TRENCHES

A. Place geotextile in a way that will completely envelope granular drain material to be placed in trench and with indicated overlap at joints. Overlap geotextile in direction of flow. Place geotextile in a way and with sufficient slack for geotextile to contact trench bottom and sides fully when trench is backfilled.

B. After granular drain material is placed to grade, fold geotextile over top of granular drain material, unless otherwise indicated. Maintain overlap until overlying fill or backfill is placed.

3.8 RIPRAPH APPLICATIONS

A. Overlap geotextile at each joint with upstream sheet of geotextile overlapping downstream sheet.

B. Sew joints where wave runup may occur.

3.9 GEOTEXTILE-REINFORCED EARTH WALL APPLICATIONS

A. Sew exposed joints; extend sewn seams minimum 3-feet behind face of wall.

B. Protect exposed geotextile from damage and deterioration until permanent facing is applied.

3.10 SILT FENCE APPLICATIONS

A. Install geotextile in one piece or continuously sewn to make one piece, for full length and height of fence, including portion of geotextile buried in toe trench.

B. Install bottom edge of sheet in toe trench and backfill in a way that securely anchors geotextile in trench.

C. Securely fasten geotextile to a wire mesh backing and each support post in a way that will not result in tearing of geotextile when fence is subjected to service loads.

D. Promptly repair or replace silt fence that becomes damaged.

3.11 REPAIRING GEOTEXTILE

A. Repair or replace torn, punctured, flawed, deteriorated, or otherwise damaged geotextile. Repair damaged geotextile by placing patch of undamaged geotextile over damaged area plus at least 18-inches in all directions beyond damaged area. Remove interfering material as necessary to expose damaged geotextile for repair. Sew patches or secure them with pins and washers, as indicated above for securing geotextile, or by other means approved by ENGINEER.
3.12 REPLACING CONTAMINATED GEOTEXTILE

A. Protect geotextile from contamination that would interfere, in ENGINEER's opinion, with its intended function. Remove and replace contaminated geotextile with clean geotextile.

- END OF SECTION -
PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide riprap, including associated earthwork, complete and in place, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

ASTM C 88 Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate


AASHTO T 85 Standard Method of Test for Specific Gravity and Absorption of Coarse Aggregate

AASHTO T 210 Method of Test for Aggregate Durability Index.

1.3 CONTRACTOR SUBMITTAL

A. Furnish submittals in accordance with Section 013300 – Contractor Submittals.

B. Testing certificates from a qualified testing agency shall be submitted prior to acceptance of the rock source to verify the conformity to the requirements of the Contract Documents.

PART 2 – PRODUCT

2.1 STONES FOR RIPRAP

A. Stones shall be graded in size to produce a reasonably dense mass. Riprap shall consist of dense, natural rock fragments. Stones shall be resistant to weathering and to water action; free from overburden, spoil, shale, and organic material; and shall meet the gradation requirements below. Shale and stones with shale seams are not acceptable.

B. Riprap shall conform to the size types as follows:

1. Type I (6-inch Average Size):

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Percentage Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-inch</td>
<td>95 - 100</td>
</tr>
<tr>
<td>6-inch</td>
<td>25 - 75</td>
</tr>
<tr>
<td>3-inch</td>
<td>0 - 10</td>
</tr>
</tbody>
</table>
2. Type II (12-inch Average Size):

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Percentage Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-inch</td>
<td>95 - 100</td>
</tr>
<tr>
<td>12-inch</td>
<td>25 - 75</td>
</tr>
<tr>
<td>6-inch</td>
<td>0 - 5</td>
</tr>
</tbody>
</table>

3. Type III (18-inch Average Size):

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Percentage Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>24-inch</td>
<td>95 - 100</td>
</tr>
<tr>
<td>18-inch</td>
<td>25 - 75</td>
</tr>
<tr>
<td>13-inch</td>
<td>0 - 5</td>
</tr>
</tbody>
</table>

4. Type IV (24-inch Average Size):

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Percentage Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-inch</td>
<td>95 - 100</td>
</tr>
<tr>
<td>24-inch</td>
<td>25 - 75</td>
</tr>
<tr>
<td>18-inch</td>
<td>15 - 25</td>
</tr>
<tr>
<td>12-inch</td>
<td>0 - 5</td>
</tr>
</tbody>
</table>

C. The greatest dimension of 50 percent of the stones shall be at least two-thirds but not more than 1-1/2 times the diameter of the average size. Neither the breadth nor thickness of any piece of riprap shall be less than one-third its length. Material shall be of shapes which will form a stable protection structure of required depth. Rounded boulders or cobbles shall not be used.
D. Stones shall consist of durable, sound, hard, angular rock meeting the following requirements for durability absorption ratio, soundness test, and abrasion test:

<table>
<thead>
<tr>
<th>Durability Absorption Ratio</th>
<th>Acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater than 23</td>
<td>Passes</td>
</tr>
<tr>
<td>10 to 23</td>
<td>Passes only if Durability Index is 52 or greater</td>
</tr>
<tr>
<td>Less than 10</td>
<td>Fails</td>
</tr>
</tbody>
</table>

D.1. The durability index and percent absorption shall be determined by AASHTO T 210 and AASHTO T 85, respectively. The minimum apparent specific gravity of the stones shall be 2.5 as determined by AASHTO T 85.

F. Stones shall have less than 10 percent loss of weight after five cycles, when tested per ASTM C 88.

G. Stones shall have a wear not greater than 40 percent, when tested per ASTM C 535.

H. Control of gradation shall be by visual inspection. The CONTRACTOR shall furnish a sample of the proposed gradation of at least 5 tons or 10 percent of the total riprap weight, whichever is less. If approved, the sample may be incorporated into the finished riprap at a location where it can be used as a frequent reference for judging the gradation of the remainder of riprap.

I. The acceptability of the stones will be determined by the ENGINEER prior to placement. Any difference of opinion between the ENGINEER and the CONTRACTOR shall be resolved by dumping and checking the gradation of two random truckloads of stones. Arranging for and the costs of mechanical equipment, a sorting site, and labor needed in checking gradation shall be the CONTRACTOR’s responsibility.

2.2 GEOTEXTILE FABRIC

A. Geotextile fabric shall be nonwoven and conform to the requirements of Section 313419 - Geotextiles.

2.3 FILTER MATERIAL

A. Filter material shall be clean and free from organic matter. It shall be crushed rock or gravel, durable and free from slaking or decomposition under the action of alternate wetting or drying. The material shall be uniformity graded and shall conform to the following gradation:
1. Type 1

<table>
<thead>
<tr>
<th>Size</th>
<th>Percentage Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-inch</td>
<td>85 – 100</td>
</tr>
<tr>
<td>1-1/2 inch</td>
<td>45 – 75</td>
</tr>
<tr>
<td>3/4-inch</td>
<td>10 – 25</td>
</tr>
</tbody>
</table>

2. Type 2: CLASS 2, 1-1/2 inch aggregate base material, as described in Specification Section 26 of the Caltrans Standard Specifications is acceptable as Type 2 filter material.

PART 3 -- EXECUTION

3.1 SURFACE PREPARATION

A. Surfaces to receive riprap shall be smooth and firm, free of brush, trees, stumps, and other objectionable material, and shall be brought to the line and grade indicated.

B. If a boulder is encountered during excavation of areas where large riprap is to be placed, the CONTRACTOR shall excavate around the boulder. If the boulder is larger than the largest allowable stone size for that area, the CONTRACTOR shall break up the boulder to an acceptable size or remove it entirely.

C. Prior to placement of the geotextile, the surface shall be prepared to a smooth condition free of debris, depressions, or obstructions which may damage the geotextile. The geotextile shall be overlapped a minimum of 2-feet at longitudinal and transverse joints. Upstream sheets shall overlap downstream sheets. For slope placement, each strip shall overlap the next downhill strip. The geotextile shall be anchored using key trenches or aprons at the crest and toe of the slope. Pins may be used in securing the geotextile during installation. In no instance shall the geotextile be left exposed to sunlight longer than 7 Days. Overexposed geotextile shall be removed and replaced.

3.2 PLACEMENT OF FILTER BLANKET

A. Area of riprap placement shall be excavated to the bottom of the filter blanket as indicated and in accordance with Section 313000 – Earthwork. After the excavation has been completed, the top 12-inches of exposed surface shall be scarified, brought to optimum moisture content, and compacted to 95 percent of maximum density. The finished grade shall be even, self-draining, and in conformance with the slope of the finished grade.

B. Placement of filter material shall be in accordance with Section 313000. Filter material shall be placed, spread, and compacted in lifts not to exceed 12-inches.

C. The CONTRACTOR shall remove any portion of the filter blanket that has been disturbed to the degree that the layers become mixed. Replace the removed portion with the required sizes.

D. Filter material shall be placed as follows, unless otherwise indicated.
1. For Type II, III and IV riprap, use 12-inches of Type 1 filter material.

2. For Type I riprap, use 6-inches of Type 2 filter material.

3.3 PLACEMENT OF RIPRAP

A. Placement of riprap shall begin at the toe of the slope and proceed up the slope. The stones may be placed by dumping and may be spread by bulldozers or other suitable equipment as long as the underlying material is not displaced. Stones shall be placed so as to provide a minimum of voids. Smaller stones shall be uniformly distributed throughout the mass. Sufficient hand work shall be done to produce a neat and uniform surface, true to the lines, grades, and sections indicated.

B. Where riprap is placed over a geotextile fabric, the riprap shall be placed so as to avoid damage to the geotextile. Stones shall not be dropped from a height greater than 3-feet, nor shall large stones be allowed to roll downslope.

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PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide structural steel piles, all in accordance with the requirements of the Contract Documents.

1.2 SUBSURFACE CONDITIONS

A. Geotechnical investigations have been performed at the Project site as described in Section 007313 – Supplementary General Conditions, SGC-4.2. The CONTRACTOR shall review the technical data associated with pile foundations given in these geotechnical investigations.

B. The CONTRACTOR shall visit the site and shall satisfy itself as to all existing surface and subsurface conditions affecting its work. Prior to bidding, bidding contractors may make their own subsurface investigations to satisfy themselves as to site and subsurface conditions, but such subsurface investigations shall be performed only under time schedules and arrangements approved in advance by the OWNER.

1.3 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

ASTM A 252 Specification for Welded and Seamless Steel Pipe Piles

ASTM D 4595 Standard Test Method for High Strain Dynamic Testing of Piles

1.4 CONTRACTOR SUBMITTALS

A. All CONTRACTOR submittals shall be in accordance with the requirements of Section 013300 - Contractor Submittals.

B. The delivery of the structural steel piling shop drawing is expected to be a "Critical Path" item on the Contractor's schedule. Suppliers are advised that the schedule for the completion of the construction of the Joint Intake and Fish Screen Project is time sensitive and suppliers shall review the Contractor's schedule to ensure the Contractor's required delivery dates can be met. Suppliers shall not be relieved of liability under the contract for any loss sustained by the Contractor as a result of any delay. All required submittals made by the suppliers must be accurate, timely, and complete. Suppliers shall review Section 011400 - Construction Constraints paragraph 1.8 for approved submittal schedule.

C. The CONTRACTOR shall provide written notification to the ENGINEER of its scheduled date for commencing of pile driving at the site at least one week in advance of that date. With this notification the CONTRACTOR shall provide information including make, model and rated driving energy for the pile driving hammer it proposes to use, and details of collars, shoes, splices, cushion blocks and related items. The CONTRACTOR shall also describe the method it proposes to use to test load the piles, if test loading is required.
D. Pile Installation Sequence and Layout

1. Submit layout drawings showing the proposed sequence for installing all piles, including indicator piles and test piles (if required).

2. On the layout drawings, show each pile by identification and its installation sequence number, length, and pile tip elevation as planned.

3. Submit a pile numbering plan which clearly identifies and numbers each pile for reference.

E. Indicator Pile Driving Report: The CONTRACTOR shall submit an Indicator Pile Driving Report containing the Indicator Pile Driving data described in Section 3.2 – Indicator Piles. The Indicator Pile Driving Report shall be reviewed by the ENGINEER. The CONTRACTOR shall not order production piles until the Indicator Pile Driving Report has been reviewed by the ENGINEER. Revisions to specified tip elevations may be made based on the results contained in the Indicator Pile Driving Report.

F. Production Pile Driving Records: The CONTRACTOR shall submit within 2 working days, on a form approved by the ENGINEER, a driving record of each pile driven. The record shall include date and time of driving, pile location and number, pile dimensions, elevation of point, elevation of butt before and after cutoff, ground elevation, number of blows required for each foot of penetration, pile deviation, description of driving equipment used, and any unusual occurrences during pile driving.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Steel pipe piles shall be welded or seamless steel pipe sections of the size, thickness, and length shown, and shall conform to the requirements of ASTM A 252. The material shall meet the requirements of ASTM A 252 for Grade 2 material, uncoated.

B. Splices in steel piles shall be made by a complete joint penetration butt weld of the entire cross section. Care shall be taken to properly align adjacent sections so that the axis of the pile will be straight. Splices in the top 10-feet of the piles will not be permitted. All welding shall be performed by qualified welding operators.

PART 3 -- EXECUTION

3.1 GENERAL

A. The CONTRACTOR shall furnish all tools, equipment, and incidentals necessary for satisfactory driving of piles as required by the Contract Documents, and test loading of piles if required.

B. Piles shall be accurately located and driven either vertically or to the prescribed batter as shown. No variation greater than 1/4-inch per foot will be permitted. Piles with greater variation and those seriously damaged in driving shall be removed or cut off, and replaced with new piles. Any pile heaved by the subsequent driving of adjacent piles shall be redriven. Piles, after driving, shall not be out of position by more than 6-inches. All correction costs shall be paid by the CONTRACTOR.
C. If the CONTRACTOR elects to drive piles from a temporary Trestle System, the CONTRACTOR shall submit a complete work plan that is to include but not be limited to:

1. Complete calculations for the Trestle System that is stamped and signed by a Register Engineer in the State of California.

2. A complete set of drawings outlining all members, connections and erection sequence for the Trestle System.

3. If the CONTRACTOR intends to use piles from the Trestle system as permanent piles in the final structure, the CONTRACTOR is to submit this as a request to the ENGINEER and receive written permission from the ENGINEER prior to proceeding with this concept.

3.2 INDICATOR (EXPLORATORY) PILES

A. Indicator piles shall be driven at the locations indicated in the Contract Documents. Indicator piles shall be driven to the lengths specified in Paragraph 3.7 – Determination of Length. Piles shall be driven with impact hammers unless otherwise indicated.

B. Driving equipment used for driving indicator piles shall be the same as that which the CONTRACTOR will use for the driving of production piles.

C. The CONTRACTOR shall excavate the ground at each indicator pile to the elevation of the bottom of the pile-cap footing before the pile is driven, or the CONTRACTOR may employ “followers” to compensate for the extra depth.

D. Indicator piles at production pile locations shall be driven to the length specified in Paragraph 3.7 – Determination of Length. Indicator piles which do not attain the hammer blow count specified at a depth of 1 foot above the estimated tip elevation indicated shall be allowed to “set up” for 12 to 24 hours before being redriven. A cold hammer shall not be used for redrive. The hammer shall be warmed up before driving begins by applying at least 20 blows to another pile.

E. If the specified hammer blow count is not attained on redriving, the ENGINEER may direct the CONTRACTOR to drive a portion or all the remaining pile length and repeat the “set up” – redrive procedure. Piles shall be driven to the estimated tip elevation indicated and, when not having the hammer blow count required, shall be spliced and driven until the required bearing is obtained.

F. Indicator Pile Driving Data: A record of driving for indicator, reaction, and test piles shall be prepared by the CONTRACTOR which will include the number of hammer blows per foot for the entire driven length, the as-driven length of the pile, cutoff elevation, tip elevation, penetration in ground, and any other pertinent information. If redrive is necessary, the CONTRACTOR shall record the number of hammer blows per inch of pile movement for the first foot of redrive. The CONTRACTOR shall not order production piles until indicator pile data has been reviewed by the ENGINEER.

G. From the pile driving behavior and indicator pile data, the ENGINEER shall review the required length of production piles determined by the CONTRACTOR. The ENGINEER may also determine the required penetration based upon settlement criteria or any other factors which in the opinion of the ENGINEER are applicable to the WORK.
3.3 DYNAMIC LOAD TESTING

A. The CONTRACTOR shall secure the services of a Dynamic Testing Consultant to perform dynamic pile testing on the indicator piles. The dynamic pile testing shall be performed to monitor hammer and drive system performance (additional tests required following any hammer or driving system modifications or if another hammer is to be used on the site), assess pile installation stresses and integrity, as well as to evaluate pile capacity. The number of indicator piles is as shown on the contract drawings. The pile depths to which dynamic testing will be performed, and restrike interval shall be determined by the ENGINEER prior to pile installation.

B. Testing procedures and equipment should conform to the requirements of ASTM D4595-00 Standard Test Method for High Strain Dynamic Testing of Piles, unless otherwise directed by the ENGINEER. The dynamic monitoring shall be performed using a Pile Driving Analyzer Model PAK or PAL. The Dynamic Testing Consultant shall furnish all equipment necessary for the dynamic monitoring.

C. Prior to lifting the pile to be dynamically tested, the CONTRACTOR shall provide a minimum of 3 ft (1 m) of clear access to 180 degree opposite faces of the pile for pile preparation. The Dynamic Testing Consultant or the CONTRACTOR’S personnel shall then drill and prepare holes for gage attachment.

D. The CONTRACTOR’S personnel shall attach the gages to the pile after the pile has been driven to the penetration depths identified by the ENGINEER. Driving shall then continue using routine pile installation procedures. When the level of the gages is within 1 ft (0.3 m) of any obstruction endangering the survival of sensors or cables, driving shall be halted to remove the gages from the pile. If additional driving is required, the obstruction shall be removed or the pile shall be spliced and the gages shall be reattached to the head of the next pile segment prior to the resumption of driving.

E. Ten days prior to driving the indicator piles, the CONTRACTOR shall submit the pile and complete driving equipment data form to the ENGINEER. The ENGINEER shall use the submitted information to perform wave equation analyses and shall prepare a summary report of the wave equation results. The wave equation analyses shall be used to assess the ability of the proposed driving system to install the pile to the required capacity and desired penetration depth within the allowable driving stresses.

F. Approval of the proposed driving system by the ENGINEER shall be based upon the wave equation analyses indicating that the proposed driving system can develop a pile capacity and driving resistance determined by the ENGINEER. The hammer should also be sized such that the penetration per blow at the required ultimate capacity does not exceed 0.5 inches (12 mm).

G. Indicator piles shall be driven to an ultimate capacity specified by the ENGINEER and based upon the preliminary driving resistance indicated by wave equation results. Adjustments to the preliminary driving criteria may be made by the ENGINEER based upon the dynamic testing results.

H. All indicator piles shall be re-driven with dynamic testing. The waiting period and restrike driving sequence shall be determined by the ENGINEER prior to the indicator pile program.

I. The Dynamic Testing Consultant shall prepare a written report of the indicator pile program. This report shall include the results of static load test(s) (if performed) and shall contain a discussion of the pile capacity obtained from the dynamic and static testing. The
report shall also discuss hammer and driving system performance, driving stress levels, and pile integrity.

J. For a blow count based driving criterion, the ENGINEER shall perform a refined wave equation analysis or analyses based upon the variations in the subsurface conditions and/or drive system performance observed in the indicator pile program results.

3.4 DRIVING EQUIPMENT

A. Pile hammers shall be approved types that develop sufficient energy to drive the pile at a penetration rate of not less than 1/8-inch per blow at the required bearing value, and shall develop energy per blow at each full stroke of the piston of not less than 1 foot-pound for each pound of weight driven. Diesel and vibratory pile hammers may be used only when approved by the ENGINEER.

B. Steam or air hammers shall be furnished with boiler or air capacity at least equal to that specified by the manufacturers of the hammers being used. The boiler or compressor shall be equipped at all times with an accurate pressure gauge. The valve mechanism and other parts of steam or air hammers shall be maintained in first-class condition so that the length of stroke and number of blows per minute for which the hammer is designed can be obtained at all times.

C. When necessary to obtain the specified penetration, and with the approval of the ENGINEER, the CONTRACTOR may be required to supply and operate one or more water jets and pumps. The use of jets at locations where the stability of embankments or other improvements would be endangered will not be permitted. Jetting will not normally be permitted in cohesive soils. All jetting shall be suspended and the pile driven for the last 3-feet to specified bearing.

3.5 DRILLED HOLES

A. Predrilling shall not be permitted.

3.6 DRIVING

A. During driving operations the pile heads shall be protected and held in position by the use of steel combination driving heads and pilots. The driving head shall closely fit the top of the steel pile and shall extend down the side of the pile at least 4-inches.

3.7 DETERMINATION OF LENGTH

A. Piles shall be driven to the tip elevations shown on the Contract Documents or to practical refusal. The ENGINEER reserves the right to revise the specified tip elevations based on the results of the pile load tests and indicator pile driving.

3.8 CUTOFF

A. All piles shall be cut off at the elevation shown. If a cutting torch is used, the cut surface shall be made as smooth as possible. Any irregularity due to cutting or burning shall be leveled off with deposits of weld metal prior to placing bearing caps. All cut off lengths of piling shall become the property of the CONTRACTOR and shall be disposed of outside the project area.
3.9 PILE TIPS

A. Where foundation material is so dense that the pile cannot be driven to the required penetration and firmly seated without danger of crumpling the tip, the ENGINEER may order the tips to be reinforced by the welding-on of steel plates.

- END OF SECTION -
PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall design, furnish, install, maintain, leave in place, and remove as indicated and required the Intake Structure Upstream Sheet Piling, Intake Structure Downstream Sheet Piling, and Intake Structure Cofferdam, all in accordance with the requirements of the Contract Documents.

B. The CONTRACTOR shall comply with the Project constraints specified in Section 011400 - Construction Constraints.

C. Temporary sheet piling installed by the CONTRACTOR to facilitate the installation or construction of other features of the work is not covered by this section.

D. **Intake Structure Upstream Sheet Piling and Intake Structure Downstream Sheet Piling:** The construction methods for the Intake Structure Upstream Sheet Piling and Intake Structure Downstream Sheet Piling, as shown on Drawing C-20, shall be determined by the CONTRACTOR. Construction methods shall consider coordination with the construction of the concrete deadmen and soil retained behind the sheet piles, as well as the Intake Structure. All risks associated with the sheet pile construction such as flood damage, schedule impacts, and coordination with the construction of other facilities shall be the sole responsibility of the CONTRACTOR.

E. **Intake Structure Cofferdam:** The Intake Structure Cofferdam top elevation and construction methods shall be determined by the CONTRACTOR. Design shall consider the soil retained on the levee side of the cofferdam and coordination with the construction Intake Structure, including the Pump Station support corbels. All risks associated with the cofferdam design such as flood damage, schedule impacts, buoyancy, tremie seal thickness and coordination with the construction of other facilities shall be the sole responsibility of the CONTRACTOR.

F. As part of the Intake Structure Cofferdam design, the CONTRACTOR may elect to engage the capacity of the structural steel piles. The allowable capacities of the piles shall be as indicated on the Contract Documents. The design of the connection between the structural steel piles and the tremie seal shall be the responsibility of the CONTRACTOR and shall not be detrimental to the capacity of the structural steel piles.

1.2 SUBSURFACE CONDITIONS

A. A geotechnical engineering study has been performed for the site, see Specification Section 007313 – Supplementary General Conditions for additional information.

B. The CONTRACTOR shall visit the site and shall satisfy itself as to all existing surface and subsurface conditions affecting its work. The information provided in the reports referenced above is available to the CONTRACTOR to assist it, at its own risk, in its assessment of subsurface conditions at the site. Prior to bidding, prospective contractors may make their own subsurface investigations to satisfy themselves as to site and subsurface conditions, but such subsurface investigations shall be performed only under time schedules and arrangements approved in advance by the OWNER.
1.3 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

ASTM A 36 Specification for Structural Steel
ASTM A 328 Specification for Steel Sheet Piling
ASTM A 572 Specification for High-Strength Low-Alloy Columbium-Vanadium Steels of Structural Quality
ASTM A 690 Specification for High-Strength Low-Alloy Steel H-Piles and Sheet Piling for Use in Marine Environments

1.4 CONTRACTOR SUBMITTALS

A. All submittals shall be in accordance with the requirements of Section 013300 - Contractor Submittals.

B. The delivery of the intake structure cofferdam shop drawing is expected to be a "Critical Path" item on the Contractor's schedule. Suppliers are advised that the schedule for the completion of the construction of the Joint Intake and Fish Screen Project is time sensitive and suppliers shall review the Contractor's schedule to ensure the Contractor's required delivery dates can be met. Suppliers shall not be relieved of liability under the contract for any loss sustained by the Contractor as a result of any delay. All required submittals made by the suppliers must be accurate, timely, and complete. Suppliers shall review Section 011400 - Construction Constraints paragraph 1.8 for approved submittal schedule.

C. Schedule Submittals: Pile driving sequence schedule.

D. Intake Structure Upstream Sheet Piling and Intake Structure Downstream Sheet Piling Plans

1. As a minimum the plans shall include:
   a. Description of proposed sheet piling construction including, but not limited to, equipment, material, construction methods and sequencing, bracing, dam closure piece, scheduling, methods to control seepage and construction details.
   b. Shop drawings showing locations, dimensions, relationships and details of the elements of each system.

E. Intake Structure Cofferdam Plan

1. As a minimum the plan shall include:
   a. Description of proposed cofferdam construction including, but not limited to, equipment, material, construction methods and sequencing, bracing, dam closure piece, scheduling, methods to control seepage and construction details.
   b. Detailed design drawings showing locations, dimensions, relationships and details of the elements of each system. Drawings shall be signed and stamped by a civil or structural engineer registered in the State of California.
   c. Complete design calculations as specified herein.
F. **Wind Load**: The wind load shall be calculated in accordance with ASCE 7-05, Chapter 6, using the following design parameters:

1. Wind Speed: 85 mph
2. Exposure: D
3. Importance Factor: $I_w = 1.15$

G. **Seismic Loads**: The seismic lateral and vertical forces shall be calculated in accordance with the ASCE 7-05, Chapters 11 and 13, using the following design parameters:

1. Site Class: D
2. Seismic Use Group: IV
3. Seismic Design Category (SDC): D
4. Seismic Importance Factor: $I_e = 1.5$
5. Short Period Spectral Acceleration: $S_s = 0.67 \text{ g}$
6. 1 Second Period Spectral Acceleration: $S_1 = 0.27 \text{ g}$

H. **Design Calculations**: Submit design calculations demonstrating adequacy of Intake Structure Cofferdam components including all assumptions and design criteria. Calculations shall specifically address buoyancy and the determination of the tremie seal thickness, and connection of the tremie seal to the structural steel piles. Design calculations shall be signed by a Civil or Structural Engineer registered in the State of California.

I. **Quality Control Submittals**

1. Description of barges, cranes, and support equipment.
2. Manufacturer’s product data prior to ordering piles.
3. Written sequence of setting and driving operation.
4. Installer qualifications.
5. Daily Log and Record: At end of each working day, submit two copies of each record for every pile installed that day.

1.5 **QUALIFICATIONS**

A. **Piling Installer**: The onsite principal superintendent shall have at least 10 years of responsible experience in the construction of cofferdams. The qualifications shall be submitted for review and approval and shall include as a minimum the specific projects, number of years of actual field experience, and a description of the duties and responsibilities for cofferdam construction.
PART 2 – PRODUCTS

2.1 SHEET PILES

A. Sheet piles shall meet the following requirements:

1. Sheet pile sections shall be hot rolled. Cold rolled sections shall not be used.

2. Sections: Continuously interlocking type. Section designation, based on Trade Arbed, Inc., Luxembourg, and minimum structural characteristics shall be as follows:

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<td>AZ18</td>
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3. CONTRACTOR may provide equivalent sheet piles from other manufacturers.

4. Section Modulus: Base on individual whole piece, not dependent on the interlock friction between pile sections to secure the required section modulus.

5. Corners
   a. Provide sheet piles with all of the corner pieces necessary for a fully interlocked system.
   b. All corners shall have a continuously welded or interlocking connection. The use of standard or fabricated pieces is at the supplier’s option.

6. Tolerances: Weight per square foot may not vary by more than 2-1/2 percent over or under that specified.

2.2 ACCESSORIES

A. Walers, Struts, Bracing, and Accessories: Adjust spacing, size, plate dimensions, and length of tie rods if piling sections are of different proportions. Conform to CONTRACTOR’s approved Shop Drawings.

PART 3 – EXECUTION

3.1 INTAKE STRUCTURE COFFERDAM

A. Excavation and construction work on the Intake Structure shall be completed within a watertight sheet pile cofferdam. The cofferdam shall be constructed as required to allow the WORK to be completed. Minimum dimensions of cofferdam shall be determined by the CONTRACTOR. Cofferdam shall be designed, constructed, and dewatered to meet all regulatory constraints as shown on the Construction Documents and listed in the permit conditions.

B. CONTRACTOR shall review hydrologic and hydraulic information described in Section 011400 - Construction Constraints and included in Volume 1C of the Contract Documents to design the cofferdam. During construction, coordinate with ENGINEER on expected conditions.
river flows controlled by USBR. If cofferdam is overtopped or otherwise flooded, CONTRACTOR shall remove all water, soil, and debris prior to obtaining ENGINEER’s approval to continue the WORK.

C. The CONTRACTOR shall coordinate with the OWNER’s fisheries biologist and California Department of Fish and Game to provide for fish rescues in accordance with the requirements of Section 007313, SGC-6.7 - Permits.

3.2 DRIVING EQUIPMENT

A. All driving and support equipment shall be equipped with diapers or collection devices capable of preventing petroleum products from entering water courses and water bodies both on land and over water.

3.3 SHEET PILE DEPTH

A. Sheet piles shall be driven to the minimum tip elevations shown on the Contract Documents

3.4 DRIVING GUIDES

A. Position sheet piles using temporary guide wales support and anchor guide wales to form rigid structures during the sheet pile setting and driving operation.

B. Guide Wales: Stationary (not moveable) with fluctuating water stage.

3.5 HANDLING AND SETTING

A. Sheet Piles: Lift and handle so that maximum bending stresses shall not exceed 22,500 pounds per square inch.

B. Clean pile, inspect for defects and proper interlock dimensions.

C. Allow pile sufficient clearance in the interlocks to slide, under its own weight, in the interlock of the sheet pile previously placed until the top of existing ground is reached by the tip of the sliding pile. Do not use vibratory or drive hammer to force the interlocking of piles.

3.6 DRIVING

A. The CONTRACTOR shall use vibrational pile driving to the greatest extent feasible.

B. Allowable hours for pile driving operations shall be in accordance with the Mitigation Monitoring and Reporting Plan included in Section 007313 – Supplementary General Conditions.

C. Before driving is started, check sheet piles for position and alignment.

D. Construct sheet pile walls and cofferdams from the upstream end to the downstream end.

E. Drive sheet piles in rotating stages such that the tip of any sheet pile is not more than 5 feet below the tip of any adjacent sheet pile nor more than 8 feet below the tip of any other sheet pile in the bulkhead, except as required by regulatory agency dictates or by the final tip elevations shown. Drive sheet piles to the tip elevations shown. Drive down piles which are raised during the process of driving adjacent piles.
F. If refusal is reached before driving to the specified tip elevation, an impact hammer or controlled jetting may be used. Perform jetting on both sides of sheet pile simultaneously with driving.

G. Remove and replace any sheet pile driven out of interlock.

H. Face of pile at cutoff elevation shall not vary from design position shown by more than 3 inches after driving.

I. Prior to completion of the downstream end of the cofferdam, fish shall be removed in accordance with the requirements of Section 007313, SGC-6.7 - Permits.

3.7 SPLICING PILES

A. **Pile Splicing**: Butt weld, making full penetration of the web. Piles adjoining spliced piles shall be full length piles.

3.8 CUTOFFS

A. Tops of sheet piling shall be cut off or driven down to a straight line at the elevation shown, or as directed. If a cutting torch is used on steel sheet piling, the cut surface shall be made as smooth as practicable by grinding or other approved methods.

B. If heads of sheet piles are appreciably distorted or otherwise damaged below cut-off level, damaged portions shall be removed and replaced, or repaired to the satisfaction of the ENGINEER.

C. Sheet piles damaged during driving, or driven out of proper position or below cut-off elevation, shall be withdrawn and replaced with new piles.

3.9 EXCAVATION WITH INTAKE STRUCTURE COFFERDAM

A. CONTRACTOR shall excavate material within cofferdam only after cofferdam is closed and fish are removed from within in accordance with the requirements of Section 007313, SGC-6.7 - Permits.

B. The CONTRACTOR shall remove and dispose of all excavated material from within the cofferdam at a site selected by the CONTRACTOR and reviewed by the ENGINEER.

C. The CONTRACTOR shall obtain all required permits, landowner, and agency approvals for disposal of excess excavated material and shall pay all costs associated with the removal and disposal.

3.10 PLACEMENT OF STRUCTURAL STEEL PILES

A. Structural steel piles shall be furnished and installed in accordance with the requirements of Specification Section 316219 - Structural Steel Piling.

3.11 PLACEMENT OF TREMIE SEAL PLACEMENT

A. Tremie seal concrete shall be placed in accordance with the requirements of Specification Section 033726 - Concrete Placed Under Water.
3.12 FINAL CUT-OFF AND REMOVAL OF INTAKE STRUCTURE COFFERDAM SHEET PILES

A. After completion of work within the sheet pile cofferdam, the sheet piles shall be cut off at the elevations shown or removed as indicated on the Contract Documents. The CONTRACTOR shall be responsible for the methods used to cut-off and remove the sheet piles.

3.13 DEWATERING

A. Use low flow pumps with screened intakes for dewatering.

B. When the Intake Structure Cofferdam is being dewatered, fish shall be removed in accordance with the requirements of Section 007313, SGC-6.7 - Permits.

3.14 FIELD QUALITY CONTROL

A. **Daily Log and Record**: Document for each sheet pile driven, showing as a minimum:

   1. Pile identification/location.
   2. Weather/groundwater conditions.
   3. Date and time start and complete driving.
   4. Respective depths of penetration.
   5. Cutoff elevations.
   6. Driving resistance for each foot of driving over entire pile length.
   7. Equipment used.
   8. Installation method.
   9. Final pile head position (x, y, z coordinates) after cut off indicating if pile is installed within the specified tolerances
   11. Other pertinent pile driving behavior.

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PART 1 – GENERAL

1.1 THE REQUIREMENT

A. This section specifies the requirements for designing and testing grout mixes, furnishing and injecting contact grout outside the jacked steel casing between, the casing and the ground, to completely fill the void and sealing the grout holes.

1.2 REFERENCES

A. The publication listed below forms a part of this specification to the extent referenced. Where no date is given for reference standards, the latest edition available on the date of the Notice Inviting Bids shall be used.

B. American Society for Testing and Materials (ASTM)


1.3 SUBMITTALS

A. Furnish submittals in accordance with Section 013300 - Contractor Submittals.

B. Product Data

   1. Manufacturer’s product data sheets indicating:

      a. Mixing, handling, storage, and waste disposal requirements.

      b. Personal safety equipment and first aid measures.

   2. Source of supply for each grout ingredient.

   3. For each type and source of material:

      a. Cement: Standard physical and chemical analysis. For information, shipping receipts showing source and the cement manufacturer’s quality control reports certifying compliance with requirements herein.

      b. Sand: Test reports showing that aggregates meet specifications.

      c. Admixtures: Documentation showing that the proposed admixtures have a history of demonstrable satisfactory performance. Approval of admixture is required before the Engineer can review mix designs containing the admixture.

   4. Calibration procedures for gauges and meters to be used in grouting operations.

C. Working Drawings and Methods Statements

   1. Grout patterns and details for sequencing and performing grouting, including means and methods for cleaning up grout spills and disposing of wasted or excess grout.
2. Methods for sealing and welding grout holes within the casing pipe.

3. Layout and description of grouting equipment and facilities including:
   a. Supply equipment.
   b. Drilling equipment.
   c. Agitators or holding tanks.
   d. Mixers.
   e. Pumps.
   f. Grout delivery piping and manifolds.
   g. Hookup details including valves, packers, and gauges.

4. Means and methods for:
   a. Proportioning and mixing grout.
   b. Measuring grout pressure and injection rate.
   c. Maintaining grout pressure below specified limits.
   d. Sequencing grouting and establishing basis and threshold values for modifying mixes.

D. Mix design data shall be provided for each mix comprising type, brand, and proportions of each ingredient. Compressive strengths in accordance with ASTM C-495-83 at 72 hours, 28 days and as required by the Engineer.

E. Quality Control

1. Qualifications of testing personnel/company performing calibration and testing accuracy of master gages and meters.

2. Certifications
   a. Certificates of compliance for all materials incorporated into the Work, including: Certification from the supplier that the source for proposed aggregates to be used (if any) is the same as the source for the aggregates tested.
   b. Calibration certificates for gauges and meters to be used in grouting operations.

3. Quality Control Plans
   a. Methods for assuring uninterrupted grouting at the pressures that do not exceed the maximum specified.
   b. Methods for demonstrating that grout mixes meet design criteria.
4. Daily Records
   
a. Records of strength tests on grout samples as soon as practicable after performing tests.

   b. Shift report for each grout crew and for each shift, regardless of actual progress, and submitted no later than the beginning of the following working day. Include:

   1) Crew size, employee classification and employee work assignment.
   
   2) Number and type of equipment used.
   
   3) List of idle or inoperative equipment and reason for downtime.
   
   4) Grout injection records for each hole:
      
      a) Location and orientation.
      
      b) Any drilling required.
      
      c) Mix type and batch number.
      
      d) Grouting time spent on each hole broken down by quantity injected, injection pressure and pumping rate.
      
      e) Communication to other holes.

5. Notifications

   a. Within 1 workday of any proposed addition, deletion, or change to the scheduling of shift work.

   b. Within 1 workday of performing gage and meter tests.

1.4 QUALITY ASSURANCE

   A. Preconstruction Meeting: Hold meeting at least 5 days but not more than 15 days prior to commencing grouting.

PART 2 -- PRODUCTS

2.1 MATERIALS

   A. General

      1. Conform to the requirements of Section 033100 for all materials, except as modified herein.

      2. Furnish grout mix components that are nontoxic after 30 days.

   B. Cement: Conforming to ASTM C150, Type II cement.
C. **Water:** Water shall be potable, clear and free of injurious oil, acid, salts, organic matter, and other substances that may be deleterious.

D. **Sand:** ASTM C-144. Aggregate shall be free of injurious alkali, salts, organic matter, and other substances that may be deleterious. Sand shall be used only with the approval of the Engineer.

2.2 **EQUIPMENT**

A. **Grouting Equipment**

1. **Mixer**
   a. High-speed colloidal-type capable of providing a homogenized mix with a tangential return flow from the mixer pump.
   b. Size to ensure an uninterrupted supply of grout to the pump.
   c. Provide with a means of accurately measuring and metering grout ingredients, including modifying the water/cement ratio.

2. **Agitator**
   a. Provide a separate agitator serving as a holding tank between the mixer and the pump.
   b. Equip with:
      1) Baffles to induce turbulence.
      2) Rotating paddles to assure thorough mixing of the grout prior to and during injection.

3. **Pump**
   a. Helical screw rotor-type producing uniform flow without pulsation.
   b. Equip with a water connection to facilitate flushing the system.
   c. Equip with a pressure gage as specified herein.

4. **Appurtenances**
   a. **Piping**
      1) Provide a manifold comprising a system of valves and pressure gauge in the line at the collar of the hole to permit accurate control and monitoring of grouting pressure, bleeding, and regulation of flow.
      2) Size to fit the grout holes indicated.
      3) Pre-installed grout pipe: Schedule 40, threaded at one end.
   b. Pressure gages: Accurate to ± 1 psi over allowable grouting pressure range.
PART 3 -- EXECUTION

3.1 GENERAL

A. Perform contact grouting within 3 days after completion of installation of casing.

B. All grouting operations, including drilling, hole flushing, grout mixing, and injection operations, shall be performed in the presence of the sand.

C. Cement

1. Furnish in sacks as packaged by the manufacturer.

2. Use cement as close as possible to the chronological order of delivery to the job site.

3. Furnish cement free from foreign matter and lumps. If cement is found to contain lumps or foreign matter of a nature and in amounts deleterious to the grouting operations, do not use and dispose of in a manner satisfactory to the Engineer.

D. Perform grouting in a progressive, methodical manner:

1. From hole to hole, starting at one end of the tunnel and working to the other end.

2. From lower to higher holes.

E. Waste grout shall not be used. Waste grout shall be considered any grout issuing forth from a grout hole, or grout not placed within 2 hours of the time of initial mixing unless a retarder specially formulated to suspend hydration was used in the grout mix.

F. Replace any grout hole lost due to interruptions in the grout supply, failure or breakdown of the Contractor’s equipment, or any other cause related to the Contractor’s operations, at no cost to Metropolitan.

G. Contractor shall maintain a clean working area at the drilling and grouting locations, free of wastewater and grout, and shall be prepared to remedy overflows and accidental spills.

3.2 SYSTEM DESCRIPTION

A. Design Criteria: Maximum contact grouting injection pressure at point of injection, measured in pounds per square inch (psi), shall be equal to 0.75 times the depth of ground cover in feet, or 30 psi, whichever is less.

B. Mix Designs: Mix designs used for contact and skin grouting shall have a minimum 7-day compressive strength of 1,500 psi. The mix designs for contact and skin grouting shall remain fluid long enough to be injected through the lining, to fill all voids, and to set in the presence of water.

3.3 CONTACT GROUTING

A. General

1. For the tunnel, perform contact grouting systematically.
2. Contact grout holes shall be provided or drilled through the steel pipe casing shall be on 8' centers, longitudinally and offset 22 degrees from vertical, and staggered to the left and right of the top longitudinal axis of the pipe.

3. Contact grout holes shall be shown on the approved working drawings.

4. The spacing of the holes shall be adequate to ensure that all voids are filled.

5. The diameter of each hole shall not be less than 1-1/2 inches and shall be compatible with piping specified in Part 2 - Products.

B. Grouting

1. Leave adjacent grout holes open during grouting operations to facilitate the escape of air, water, and lubricant from void in the space surrounding the tunnel jacked casing. Where grout is found to flow from adjacent grout connections in sufficient quantity to seriously interfere with the grouting operations or to cause appreciable loss of grout, such connections may be temporarily capped, or valved for bleeding and subsequent grout connections.

2. Once grouting is started, do not interrupt grouting of a hole without specific approval of the Engineer.

C. Completion of Grouting

1. Grouting will be considered complete only when refusal is reached. Refusal for contact grouting shall occur when the grout hole accepts less than 0.5 cubic feet of grout at the maximum injection pressure.

2. Upon completion of grouting at each connection, close the connection valve and leave it in place until the grout has set.

3. Following completion of grouting, install a threaded plug in the casing pipe and seal weld the steel plug as shown in the approved Working Drawings.

3.4 CLEAN-UP

A. Perform the following concurrently with grouting operations

1. Cleaning the surface of the steel casing.

2. Maintaining the work area free of debris.

3. Welding of grout plugs in the tunneled steel casing in accordance with the approved Working Drawings.

B. Immediately remove and dispose of any leakage or wastage of drill cuttings, grout, or other objectionable materials.
3.5 FIELD QUALITY CONTROL

A. Strength Tests

1. Manufacture and store six compressive strength specimens in accordance with ASTM C109 from a single sample taken from each 50 cubic feet, or portion thereof, of each type of grout mixed each day.

2. Test the specimens for compressive strength in accordance with ASTM C109. Each test shall consist of the average strength of three specimens tested at 7 days and three specimens tested at 28 days, except that if any specimen shows evidence of improper handling, molding, or testing, it shall be discarded and the strength test shall consist of the average strength of the remaining two specimens.

B. Master Gages and Meters

1. Perform testing of all field gages and meters no less often than weekly using master gages and meters.

2. Perform field tests in the presence of the Engineer.

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PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall perform all work associated with A.C. Pavement and Base as shown and as specified herein including all labor, materials, equipment supplies, and facilities associated with providing a finished product satisfying all the requirements of the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Codes: All codes, as referenced herein.

B. References: These specifications refer to “CalTrans Standard Specifications,” and “County of Yolo County Standard Specifications and Plans.”

1.3 CONTRACTOR SUBMITTALS

A. The CONTRACTOR shall submit, in writing, materials testing reports, mix designs, and other pertinent information satisfactory to the ENGINEER demonstrating that materials and methods it proposes to utilize will comply with the referenced provisions of “Standard Specifications,” in accordance with CONTRACTOR submittal requirements.

PART 2 -- PRODUCTS

2.1 MATERIALS REQUIREMENTS

A. Aggregate Base: Materials for aggregate base shall be ¾-inch maximum Class 2 Aggregate Base as specified in Section 26-1.02A of CalTrans Standard Specifications and Specification Section 313000.

B. Prime Coat: Prime coat material shall be SC-250 or MC-250 conforming to CalTrans Specifications Section 93.

C. Tack Coat: Tack coat material shall be SS-1h or CSS-1h type emulsion conforming to CalTrans Specifications Section 94.

D. Asphalt Concrete

1. Asphalt concrete shall be Type A. Asphalt concrete shall conform to the provisions of Section 39 of CalTrans Standard Specifications.

2. Asphalt concrete shall have a viscosity grade of AR-4000 as specified in CalTrans Standard Specifications Section 92, and be a minimum of 5.3% (by weight) bituminous material. Aggregate shall be ¾ inch maximum (medium grading).

3. Asphalt content as a percentage of the dry aggregate weight shall be approved by the ENGINEER. All surface courses of Asphalt Concrete shall have ½ inch minimum aggregate.

E. Pavement Marking Paint: Pavement marking paint shall be as specified in Section 321723 – Pavement Marking.
PART 3 -- EXECUTION

3.1 CONSTRUCTION REQUIREMENTS FOR FULL ROADWAY REPLACEMENT

A. **Subgrade Preparation:** The subgrade shall be prepared as specified in Section 313000 – Earthwork as applicable to roadways and embankments. Two-inch by 4-inch wood headers shall be firmly staked in the proper positions along all edges other than those where the pavement is to be placed against existing concrete or paved surfaces.

B. **Aggregate Base:** Aggregate base shall be provided where shown and to the thickness shown. Construction of the aggregate base course shall be as specified in Section 26 of CalTrans Standard Specifications.

C. **Prime Coat:** Prior to placing of pavement a prime coat of liquid asphalt shall be applied to the compacted base or subgrade at a rate of 0.2 gal/sq yd and in conformance with CalTrans Standard Specification Section 39.

D. **Tack Coat:** A tack coat shall be applied in accordance with the requirements of Section 39-4.02 of CalTrans Standard Specifications before placement of the surface course. Tacking between base courses shall be applied to a clean surface at the rate of 0.01 to 0.03 gallon per square yard.

E. **Asphalt Concrete**

1. Asphalt concrete paving shall be constructed as specified in Section 39 of CalTrans Standard Specifications.

2. Alternate compacting equipment or substitution of a vibratory roller for a pneumatic-tired roller will not be permitted.

3. All mixtures shall be spread at a temperature of not less than 250 degrees F. Base material compaction shall be completed before the mix reaches 200 degrees F.

F. **Fog Seal**

1. A fog seal shall be applied to match the surfaces to adjacent existing pavement and to cover the joint between the pavement patch and the existing pavement. Before placing fog seal the pavement shall be cleaned by sweeping, flushing or other means necessary to remove all loose particles of paving, dirt and other extraneous material.

2. The cleaned surface shall be fog sealed with SS-1h emulsified asphalt in accordance with the requirements of Section 37 of the CalTrans Standard Specifications. The fog seal coat shall not be applied sooner than 24 hours after pavement is placed.

G. **Traffic Marking:** Application of the paint shall be in accordance with the paint manufacturer’s instructions. Traffic markings obliterated by the WORK shall be repainted, unless otherwise directed by the ENGINEER.

3.2 CONSTRUCTION REQUIREMENTS FOR PAVEMENT REPAIR

A. Preparation of the site for pavement repair shall be accordance with the County of Yolo Standard Specifications and Plans and Contract Drawings.
B. New pavement shall be placed according to the provisions of this section and shall be of similar materials and pavement thickness as existing adjacent pavement except that the new pavement section surface shall be 1/8 inch higher than adjacent pavement.

C. The CONTRACTOR shall diamond saw cut joining pavement edges and tack coat edges.

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SECTION 321723 - PAVEMENT MARKING

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide pavement marking and striping, complete and in place, in accordance with the Contract Documents.

1.2 QUALITY ASSURANCE

A. Perform WORK in accordance with the requirements of local agencies.

PART 2 -- PRODUCTS

2.1 MATERIALS

A. Paint traffic stripes shall consist of one coat of paint and two applications of retroreflective glass elements and beads of two gradations. Paint shall be a high-build, ready-mixed, one-component, waterborne acrylic traffic paint conforming to the requirements in State Specification No. PTWB-01R2, with an acrylic polymer emulsion such as Dow Fastrack HD-21A, or approved equivalent selected from the “Qualified Products List of Two-Component Traffic Striping Paints and Large Gradation Retroreflective Glass Beads” list which is available from the Caltrans Transportation Laboratory. The paint shall be free of lead, chromium, barium and heavy metals. The large gradation glass elements shall be white or yellow 3M Microcrystalline Ceramic Elements, or an equivalent product selected from the list titled "Qualified Products List of Two Component Traffic Striping Paints and Large Gradation Retroreflective Glass Beads". The small gradation glass beads shall conform to the requirements in AASHTO Designation: M247, Type 1. Both gradations of retroreflective glass shall be coated with an adhesion promoting and water repellant coating as recommended by the paint manufacturer.

B. Retroreflectivity of the paint traffic stripes and pavement markings shall conform to the requirements in ASTM Designation: D 6359-99. The white paint traffic stripes and pavement markings shall have a minimum initial level of retroreflectivity of 250 mcd m⁻²lx⁻¹. The yellow paint traffic stripes and pavement markings shall have a minimum initial level of retroreflectivity of 175 mcd m⁻²lx⁻¹. Daytime and nighttime color of the paint traffic stripes and pavement markings shall conform to the requirements in ASTM Designation: D 6628-01.

C. The Contractor shall furnish to the County Inspector a Certificate of Compliance in conformance with the provisions in Section 6 1.07, "Certificates of Compliance“ of the Caltrans Standard Specifications for the paint and retroreflective glass elements and beads furnished. The certificate shall specify the name, batch number, and manufactured date of the products. The Contractor shall provide the County Inspector a Material Safety Data Sheet (MSDS) for the paint, elements, and beads upon the County Inspector’s request.
PART 3 -- EXECUTION

3.1 TRAFFIC AND LANE MARKINGS

A. New pavement surfaces to receive paint shall be prepared in conformance with the provisions in Section 84-2.04, "Application," of the Caltrans Standard Specifications. Paint traffic stripes and pavement markings shall be applied only to clean and completely dry surfaces and when pavement surface temperature is above 50 degrees F and the atmospheric temperature is above 50 degrees F. During application, the temperature of the paint shall be as recommended by the paint manufacturer.

B. Paint traffic stripes shall be applied at a minimum thickness of 25 mils and a minimum application rate of 1 gallon per 65 square feet. The application rate is based on the actual area of the paint and marking. During application of the paint and retroreflective glass elements and beads, the striping machine shall not travel faster than 10 mph.

C. Paint traffic stripes shall be applied in one pass. The paint shall be applied first, followed by the large gradation glass elements and then the small gradation glass beads. Glass elements and beads shall be applied using two separate applicator guns.

D. Glass shall be uniformly distributed in the traffic stripes. The large glass elements shall be applied at a minimum rate of 11.7 pounds per gallon of paint. The smaller glass beads shall be applied at a minimum rate of 8.3 pounds per gallon of paint. The combined weight of the two gradations of glass beads shall be greater than 20 pounds per gallon of paint.

E. Prior to beginning application, in the presence of the County Inspector, the Contractor shall apply a test section of the paint stripe on roofing felt or other suitable material to demonstrate the Contractor's abilities to properly apply the paint traffic stripes. The test section shall be at least 50 feet in length.

- END OF SECTION -
PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall furnish perimeter security fencing and gates and appurtenant WORK, complete and in place, in accordance with the Contract Documents.

1.2 REFERENCES

A. Codes: All codes, as referenced herein, are specified in Section 014219 - Reference Standards.

B. American Society for Testing and Materials (ASTM) Publications

1. ASTM A653/A653M – Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) by the Hot Dip Process

2. ASTM B117 – Practice for Operating Salt Spray (Fog) Apparatus

3. ASTM D523 – Test Method for Specular Gloss


5. ASTM D1654 – Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments

6. ASTM D2244 – Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates


8. ASTM D3359 – Test Method for Adhesion by Tape Test

9. ASTM F2408 – Ornamental Fences Employing Galvanized Steel Tubular Pickets

10. ASTM F1184 – Industrial and Commercial Horizontal Slide Gates

C. Reference Specifications, Codes, and Standards for Controller

1. UL – Underwriters Laboratories

2. NEC – National Electrical Code

3. EIA – Electronic Industries Association Standards
1.3 CONTRACTOR SUBMITTALS

A. **General:** Submittals shall be in accordance with Section 013300 – Contractor Submittals.

B. **Product Data:** Fence, gate, and motorized gate operator manufacturer’s product specifications, installation, maintenance, and operations instructions shall be submitted.

C. **Shop Drawings:** Fence and gate shop drawings showing layout, dimensions, spacing of components, interface with electric gate operator, and anchorage and installation details shall be submitted.

D. **Automatic Operator:** Operator block diagram, electrical and control interfaces, installation plan including conduit and wiring, make and model of components, mounting details, power and control wiring diagrams, and catalog cuts.

E. **Operations and Maintenance Manuals:** The Contractor shall submit Operations and Maintenance Manuals for the Automatic Gate Operator in accordance with the requirements of Section 013300 – Contractor Submittals.

F. The **CONTRACTOR** shall furnish and install a fully functional gate control system to the satisfaction of the **OWNER**. Contractor shall provide all conduits, conductors, cables and fittings, and all equipment as specified in these specifications and shown in the Plans. All work shall be coordinated with the equipment manufacturer all in accordance with the requirements of the Contract Documents.

G. The **CONTRACTOR** shall complete and submit calculations for the gate and fence systems per the requirements stated in 1.4 below.

1.4 SUPPORTS AND FOUNDATIONS

A. **Supports:** Unless otherwise indicated, supports, anchors, and restrainers shall be adequately designed for static, dynamic, wind, and seismic loads as stated in the 2009 International Building Code (IBC), Chapter 16 and ASCE 7-05. Submitted design calculations for supports and anchorage shall bear the signature and seal of a Registered Professional Engineer licensed in the State of California, unless otherwise indicated. Calculations shall account for forces and distribution of forces on supporting structures resulting from normal operation, normal operation plus seismic loadings, normal operation plus wind loadings, as well as the other load combinations stated the 2009 IBC.

B. **Wind Load:** The wind load shall be calculated in accordance with ASCE 7-05, Chapter 6, using the following design parameters:

1. Wind Speed: 85 mph
2. Exposure: D
3. Importance Factor: \( \text{Iw} = 1.15 \)

C. **Seismic Loads:** The seismic lateral and vertical forces shall be calculated in accordance with the ASCE 7-05, Chapters 11 and 13, using the following design parameters:

1. Site Class: D
2. Seismic Use Group  IV
3. Seismic Design Category (SDC)  D
4. Seismic Importance Factor:  Ie = 1.5
5. Short Period Spectral Acceleration  Ss = 0.67 g
6. 1 Second Period Spectral Acceleration  S1 = 0.27 g

D. Anchors: Anchor bolts shall be in accordance with Section 05 5 0 00 - Miscellaneous Metalwork, and shall be designed to resist the above loads. Anchor bolt calculations shall clearly show that the capacity of the anchor and the capacity of the concrete that the anchor is embedded in are adequate to resist all loads stated in the 2009 IBC and ASCE 7-05, including lateral wind and lateral and vertical seismic loads. Reduction factors associated with edge distance, embed length, and bolt spacing shall all be considered and based on the actual dimensions of the concrete that resists the anchorage forces. Anchor bolt details shall include required bolt diameter, embed, and edge distances. Further, the design of Anchors shall consider the ductility requirements stated in ASCE 7-05, Chapter 13, Section 13.4.2 and Chapter 15, Section 15.7.3. Anchor bolt calculations and details shall be submitted and shall bear the signature and seal of a Registered Professional Engineer licensed in the State of California.

E. Foundations: Foundations are to sized considering the requirements above.

PART 2 -- PRODUCTS

2.1 MANUFACTURER

A. Ameristar Fence, P.O. Box 581000, Tulsa, OK 74258. Telephone: (800) 321-8724, FAX (877) 926-3747, or equal.

2.2 MATERIALS

A. Steel Material for fence framework (pickets, rails, and posts) shall be manufactured from tubing meeting the following requirements:

1. Pickets: Minimum 2.75-inch by 0.75-inch 14 gauge steel tube with 3.5 inch maximum clear space between pickets. Each picket is spear-topped and extends a minimum of one foot above the top rail, curving outward.

2. Rails: Three rail system with minimum 2-inch by 2-inch 11 gauge steel tube.

3. Posts: Minimum 3-inch by 2.75-inch 12 gauge. Spacing of posts shall be as indicated by the manufacturer.

4. Steel materials for fence framework (pickets, rails, and posts), when galvanized after forming, shall conform to the requirements of ASTM A10011/1011M, with a minimum yield strength of 45,000 psi. The exterior shall be hot-dip galvanized meeting the requirements of ASTM A653/A653M with a 0.90 oz/ft² minimum zinc weight. The interior surface shall be coated with a minimum 81% nominal zinc pigmented coating, 0.3 mils minimum thickness.
5. Steel materials for fence framework (pickets, rails, and posts), when galvanized prior to forming, shall conform to the requirements of ASTM A924/924M, with a minimum yield strength of 45,000 psi. The steel shall be hot-dip galvanized to meet the requirements of ASTM A653/A653M with a minimum zinc coating weight of 0.90 oz/ft², Coating Designation G-90.

6. Height of fences shall be as indicated on the Drawings.

7. Fence shall be “Impasse II High Security Steel Fence (Gauntlet Panel Type – 3 Rail)” as manufactured by Ameristar Fence, or equal.

8. Gates shall be cantilever sliding gates “Fortress” as manufactured by Tymetal Corporation, “Transport IS (Gauntlet)” as manufactured by Ameristar Fence, or equal.

   B. Pickets for gates shall be of the same material and similar size, and style as those in the fence panels. Frames for gates shall be of sufficient size and thickness to provide adequate support without sag. Adjustable trussing shall be provided as required by the manufacturer. Gate hardware shall be supplied by the gate manufacturer and shall be of sufficient size and capacity to support the gate specified.

1. Cantilever Slide Gates: The gate frame and track shall be fabricated from 6063-T aluminum alloy extrusions. The top member shall be a 3-inch by 5-inch (76 mm by 127 mm) aluminum structural channel/tube extrusion weighing not less than 3.0 lb/lf (4.4 kg/m) for Internal Picket designs or 2.6 lb/lf (3.8 kg/m) for External Picket designs. If fabricated as a single horizontal piece, the bottom member shall be 2-inch by 5-inch (51 mm by 127 mm) aluminum structural tube weighing not less than 2.0 lb/lf (2.9 kg/m). If fabricated in two horizontal pieces, the bottom member shall be a 5-inch (127 mm) aluminum structural channel weighing not less than 2.6 lb/lf (3.8 kg/m). When the gate frame is manufactured in two horizontal pieces or sections, they shall be spliced in the field. Material for diagonal bracing and vertical members of the frame shall be 2-inch by 2-inch (51 mm by 51 mm) in the cross section weighting not less than 1.1 lb/lf (1.6 kg/m).

2.3 FABRICATION

   A. Steel used in the manufacturing of panels, gates, and posts shall conform to the ASTM standards specified.

   B. Completed panels shall be capable of supporting a 600 lb. load (applied at mid-span) without permanent deformation. Panels without rings shall be bias able to a 25% change in grade; panels with rings shall be bias able to a 12.5 % change in grade.

   C. After fabrication panels, gates and posts shall be power washed in a zinc phosphate solution, rinsed and dried.

2.4 FINISH

   A. After fabrication, materials shall be coated with a zinc rich thermosetting epoxy powder coating with a minimum thickness of 2 mils, and finished with a topcoat of “no-mar” TGIC polyester powder coat finish with a minimum thickness of 2 mils. The finish color shall be black.

   B. Finish shall be “PermaCoat” as manufactured by Ameristar Fence, or equal.
2.5 MOTORS AND CONTROLS

A. Automatic opening gates shall be complete with equipment mounting concrete pads, motorized operators, hardware, controls, and interface pedestal. The interface pedestal shall be configured as shown on detail E-901. This interface pedestal shall be equipped with a card reader that interfaces with the gate motorized operator, a Knox box with a switch to open the gate by emergency personnel, and adequate space for future equipment. Vehicular traffic encompasses light duty pick-up trucks, automobiles, to tractor-trailer trucks.

B. The automatic operator motor shall be no less than 1/2 hp, 460 Volt, three-phase and of adequate power to operate the gate under all weather conditions. The unit shall be equipped with a control power transformer to derive service power when the unit is serviced. The automatic gate operator shall be as manufactured by Door King 9150 or equal.

1. Each automatic operator shall be housed in a NEMA 3R enclosure, containing relays, motor starters, control power transformers, power supplies, controller and all necessary devices that compose a fully equipped operator. The unit shall be UL 325 and UL 991 compliant.

2. The automatic limit switch shall be self-adjusting and unaffected by gearbox variances. The automatic limit switch shall have an independent set of contacts to indicate the gate position (fully open and fully closed) for the User. These contacts shall be landed on separate terminals and clearly labeled.

3. Each automatic operator shall be equipped to accept hardwired open and close gate commands remotely. The input shall be landed on separate terminals and labeled for the User.

4. Each automatic operator shall include a main disconnect inside its housing for isolation from its power source. It shall have a barrier between the low voltage control section and the 460 volts supply.

5. Each automatic operator shall be equipped with a selector switch with "OFF- AUTO-MANUAL" control steps. The automatic operator shall be inoperative if the selector switch is in the "OFF" position. When the selector switch is in the "AUTO" position, the unit shall be fully functional and accept all the field inputs as equipped.

C. The automatic gate operator shall be supplied with vehicle loop detectors and performed or field formed loops for installation on the roadway surface.

1. The loop detectors shall comply with the California DOT standards. The detectors shall have on board means for tuning and adjustment. The detector shall be capable to be used to work with either safety/reverse loops or the exit loop. The loop detector shall be as manufactured by Daiblo Controls Inc. cat # DSP-10-177 or equal.

2. The automatic gate operator shall be equipped with inside and outside safety/reverse loops, and free exit loops. The loops shall be of the of copper, and a road rated box shall be provided to route all the loop wiring to the automatic gate operator housing in conduit.

3. The roadway surface shall be repaired after the loops are installed. The Contractor shall utilize a backing rod and rated sealant to ensure long service.
4. The gate shall be equipped with a safety sensing edge. **Miller Edge** or equal.

5. The automatic operator shall be equipped with a stainless steel chain.

6. The automatic operator shall be equipped with all necessary accessories for a fully functional system.

D. The automatic gate operator shall be equipped with a controller capable of communications and interface with the card reader at the interface pedestal. The card readers shall scan compatible security cards and open any of the automatic gates on the site.

1. The interface pedestal hardware shall be tamper resistant.

2. The interface pedestal enclosure shall be custom fabricated, equipped with a rain hood, and attached to a “gooseneck” stand of 2” tubing minimum. The assembly will be set in concrete at the locations shown on the Contract Drawings.

3. The interface pedestal shall be equipped with a card reader as manufactured by **Lenel** or equal. Units with keypad shall be rejected.

4. The interface pedestal shall be equipped with a KNOX Box Series 3200. The KNOX box shall house a key to allow emergency personnel entry to the secured area. The KNOX™ box shall be coordinated by the Contractor with the Authority Having Jurisdiction (AHJ).

**PART 3 -- EXECUTION**

3.1 PREPARATION

A. The CONTRACTOR shall layout the new fence and gates in accordance with the fence construction plans, shop drawings, and all applicable requirements and codes.

B. The CONTRACTOR shall verify any grade changes or surface irregularities.

C. Discrepancies between the approved shop drawings and field conditions must be approved by the ENGINEER prior to proceeding with the installation.

3.2 INSTALLATION

A. Fence posts shall be set plumb and level at spaces shown on the approved Shop Drawings. Footings shall be of the sizes indicated on the approved Shop Drawings. Post caps shall be as indicated on the Drawings.

B. Fence panels shall be bolted or welded to the posts according to manufacturer’s recommendations. Field welding of rail to the post shall be a complete 360 degree (all four sides) and shall be the size indicated on the approved Shop Drawings. Welds shall be cleaned and coated with a primer the same day the welding is performed.

C. Gates shall be installed plumb and level and shall be the sizes and style indicated on the approved Shop Drawings. The CONTRACTOR shall install any gate stops that may be required. Any padlock provisions or strikes shall be field attached to assure alignment. The CONTRACTOR shall lubricate the hinges, rollers and other gate hardware after installation.
D. All field welds and any abrasions to factory coatings shall be thoroughly cleaned, reprimed and touched up by the CONTRACTOR with coating material of the same quality, color and gloss of that supplied from the manufacturer.

E. Work shall be performed in a workmanlike manner, by craftsmen skilled in the particular trade. All work shall present a neat and finished appearance.

F. Install equipment in accordance with shop drawings and manufacturer's recommendations. Retighten to manufacturer's standards all current-carrying bolted connections and all support framing and panels. After the equipment is installed, touch up any scratches, marks, etc., incurred during shipment or installation of equipment. If required by the ENGINEER because of undue amount of scratches, repaint the entire assembly.

G. Prior to facility startup, all equipment shall be inspected for proper connection, proper operation of controls and all corresponding accessories, and satisfactory starting and operation of all gates. Correct all defects.

H. The following is a description of the operational requirements of the automatic gate operator system:

1. Open Gate Signal
   a. Manually through the control station inside the operator housing.
   b. Manually through a key switch (KNOX box) at the gate.
   c. Manually by placing a jumper on the remote open gate command terminal blocks.
   d. Automatically if vehicle is within shadow loop.
   e. Automatically if the gate in closing hits an obstruction.

2. Close Gate Signal
   a. Automatically if the gate is fully open and all vehicle detectors are clear.
   b. Manually through the control station inside the operator housing.
   c. Manually by placing a jumper on the remote close gate command terminal blocks.

I. A solid state timer in the gate controller shall be activated by a gate fully open status from the gate operator. Timer shall be adjustable 0 - 60 seconds to permit a vehicle to clear the entrance detector loop and the shadow detector loop.

J. The CONTRACTOR shall prepare and submit for review a complete and detailed final inspection check-off list for system functional tests for all equipment, circuits, and functions. The list shall be a complete representation of all specified functions including contingency, and priority features and abnormal modes of operation. The arrangement of the list shall be such as to provide an orderly method of tabulating checks of system features, response, and operation. The tests shall be structured so that all sensors are stimulated directly in their installed and finally adjusted positions and all audible and visual displays, alarms, and other response are observed and recorded. The tests shall
be scheduled with the concurrence of the ENGINEER when the system is complete in all respects and the test check-off list has been accepted. The tests shall be conducted by the CONTRACTOR who shall furnish all required personnel for test operations. The tests will be witnessed by the ENGINEER. Pretesting by the CONTRACTOR shall assure that final witnessed tests are conducted efficiently and without delays.

3.3 CLEANING

A. The CONTRACTOR shall clean job site of excess materials.

B. Post hole excavations shall be scattered uniformly away from the posts or removed as directed by the ENGINEER.

C. Concrete splatter shall be cleaned from exposed posts.

- END OF SECTION -
PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide chain link fencing and gates and appurtenant WORK, complete and operable, in accordance with the Contract Documents.

B. Single Manufacturer: Chain link fencing, gates, accessories, fittings, and fastenings shall be products of a single manufacturer.

1.2 CONTRACTOR SUBMITTALS

A. General: Furnish submittals in accordance with Section 013300 - Contractor Submittals.

B. Shop Drawings

1. Manufacturer’s technical data, product specifications, standard details, certified product test results, installation instructions and general recommendations.

2. Scale layout of fencing, gates, and accessories. Drawings shall show fence height, post layout, including sizes and sections; post setting and bracing configuration, details of gates and corner construction, barbed wire support arms; and other accessories which may be necessary.

3. Color charts accurately illustrating the full range of standard colors available from the manufacturer.

C. Samples: Samples of proposed fence components, at least 12-inches long, to illustrate the selected color and finish.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Dimensions indicated herein for roll-formed pipe and H-sections are outside dimensions, excluding coatings.

B. Fence fabric height shall be 8-feet unless otherwise indicated.

C. Fencing materials shall be hot-dip galvanized after fabrication.

D. Fencing shall be topped with 3 lines of barbed wire on single, 45 degree supporting arms, sloped outward.

2.2 STEEL FABRIC

A. Fence fabric shall be No. 9 gauge steel wire, 2-inch mesh, with top selvages knuckled and bottom selvages twisted and barbed.

B. Fabric Finish: Fabric shall be galvanized in conformance with ASTM A 392 - Zinc-Coated Steel Chain Link Fence Fabric, Class II, with not less than 2.0 ounces zinc per square foot of coated surface.
2.3 FRAMING AND ACCESSORIES

A. **Steel Framework, General:** Unless otherwise indicated, framework components shall be fabricated of galvanized steel conforming to ASTM A 53 - Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless, or ASTM A 123 - Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products, with not less than 1.8 ounces zinc per square feet of coated surface.

1. Fittings and accessories shall be galvanized in accordance with ASTM A 153 - Zinc Coating (Hot-Dip) on Iron and Steel Hardware, with zinc weights per Table I of that standard, except that no coating shall be less than 1.8-ounce zinc per square foot of coated surface.

B. **End, Corner and Pull Posts:** Posts shall be one-piece without circumferential welds, 3-inch schedule 40 pipe, 5.79 pounds per linear foot.

C. **Line Posts:** Line posts shall be spaced no more than 10-feet on center and shall be 2-1/4 inch “H” column section, 4.1-pounds per linear foot, or schedule 40, 2-1/2 inch pipe, 3.65-pounds per linear foot.

D. **Gate Posts:** Gate posts shall be 4-inch schedule 40 pipe, 9.1-pounds per linear foot.

E. **Top Rail:** Top railing shall be provided in manufacturer’s longest lengths, with expansion type couplings, approximately 6-inches long, for each joint. Fence design shall provide positive, secure attachment of top rail to each gate post, corner post, pull post and end post. Top rail and braces shall be 1-5/8 inch schedule 40 pipe, 2.27-pounds per linear foot, or 1-1/2 inch “H” column section, 2.00-pounds per linear foot.

F. **Tension Wire:** Tension wire shall be located at the bottom of the fabric and shall consist of No. 7 gauge coated coil spring wire of metal and finish to match fabric. Tension wire shall be interlaced with the fabric or attached to the fabric along the extreme bottom of the fence. Tension wire attachment shall be with fabric tie wires at a spacing of no more than 24-inches apart.

G. **Fabric Tie Wires:** Fabric tie wires shall be No. 9 gauge galvanized steel wire of the same finish as the fabric. Aluminum ties shall not be used. Ties shall be spaced 14-inches apart on posts and 24-inches apart on rails.

H. **Post Brace Assembly:** Post brace assembly shall be manufacturer’s standard adjustable brace assembly provided at each end post, gate post and at both sides of each corner post and intermediate brace post. Material used for brace shall be same as top rail. Truss bracing between line posts shall be achieved with 0.375-inch diameter rod and adjustable tensioner.

I. **Post Tops:** Post tops shall be weather-tight closure caps, designed for containment of top rail and positive permanent attachment to post. One cap shall be provided for each post.

J. **Stretcher Bars:** Stretcher bars shall be one-piece lengths equal to the full height of the fabric, with minimum cross-section of 3/16-inch by 3-1/2 inch. One stretcher bar shall be provided for each gate and end post, and 2 for each corner and intermediate brace post.

K. **Stretcher Bar Bands:** Stretcher bar bands shall be one-piece fabrications designed to secure stretcher bars to end, corner, intermediate brace, and gate posts. Bands shall
have a minimum cross-section of 1/8-inch by 3/4-inch. Stretcher bar bands shall be spaced no more than 15-inches on center.

L. **Barbed Wire Supporting Arms:** Supporting arms shall be manufacturer’s standard fabrication, of metal and finish to match fence framework, with provision for anchorage to each post and attachment of three rows of barbed wire to each arm. Supporting arms may be either attached to posts or integral with post top weather cap. Supporting arm shall be single 45-degree arm type and shall be capable of withstanding 250 pounds of downward pull at outermost end.

M. **Barbed Wire:** Barbed wire shall be 2-strand, No. 12-1/2 gauge zinc-coated steel or iron wire with four-point, 14-gauge barbs spaced no more than 5-inches apart.

**2.4 GATES**

A. **Fabrication:** Perimeter frames of gates shall be fabricated from same metal and finish as fence framework. Gate frames shall be assembled by welding or with fittings and rivets for rigid, secure connections. Welds shall be ground smooth. Gate frames and any ungalvanized hardware, shall be hot-dip galvanized after fabrication. Horizontal and vertical members shall be provided to ensure proper gate operation and attachment of fabric, hardware and shall be hot-dip galvanized after fabrication.

1. Fabric for gates shall match fence fabric, unless otherwise indicated. Fabric shall be installed with stretcher bars at all perimeter edges. Stretcher bars shall be attached to gate frame with stretcher bar bands spaced no more than 15-inches on center.

2. Each gate shall be diagonally cross-braced with a 3/8-inch diameter adjustable length truss rod to ensure frame rigidity without sag or twist.

3. Where barbed wire is indicated above gates, vertical members shall be extended and fabricated as required to receive barbed wire supporting arms.

B. **Swing Gates:** Perimeter frames of swing gates shall be constructed of the same pipe or “H” column members as the top rails and shall be fabricated by welding. Welds shall be ground smooth prior to hot-dip galvanizing.

1. Hardware and accessories shall be provided for each gate, galvanized in conformance with ASTM A 153, and in accordance with the following:

   a. **Hinges:** Hinges shall be of size and material to suit gate size, non-lift-off type, offset to permit 180-degree gate opening. Three hinges shall be provided for each leaf 6-feet or more in height.

   b. **Latch:** Latch shall be forked type or plunger-bar type, permitting operation from either side of the gate, with padlock eye as an integral part of the latch.

   c. **Double Gates:** Gate stops shall be provided for double gates, consisting of mushroom type flush plate with anchors, set in concrete, and designed to engage center drop rod or plunger bar. Locking device and padlock eyes shall be provided as an integral part of the latch, permitting both gate leaves to be locked with a single padlock.
2.5 RELATED ITEMS

A. **Concrete:** Concrete shall be provided according to Section 033100 - Cast-In-Place Concrete.

B. Nuts, bolts and screws shall be steel, minimum size 3/8-inch diameter, hot-dip galvanized after fabrication.

2.6 MANUFACTURERS

A. **Manufacturer’s Qualifications:** Chain link fencing and gates shall be products of a single manufacturer which has been successfully engaged in the production of such items for a period of at least 5 years.

B. **Installer’s Qualifications:** Installation of the chain link fence shall be by the manufacturer or by a firm accepted and licensed by the manufacturer.

C. Manufacturers, or Equal

1. American Fence Corp.

2. Anchor Fence, Inc.

3. United States Steel

PART 3 -- EXECUTION

3.1 INSPECTION

A. Prior to commencing installation, require Installer to inspect all areas and conditions within which WORK of this Section will be performed. Dimensions and clearances shall be verified. Final grading shall be completed and all earth, brush, or other obstructions which interfere with the proper alignment and construction of fencing shall be removed.

3.2 INSTALLATION

A. **General:** Unless otherwise indicated, all posts shall be set in concrete. Gate and related posts, corner posts, and other critical elements shall be provided with concrete foundations which are designed by an engineer to safely accommodate the loads to which they will be subjected.

B. **Excavation:** Holes for posts shall be drilled or hand excavated to the diameters and spacings indicated, in firm, undisturbed or compacted soil. Post foundations which are not designed by an engineer shall comply with the following:

   1. Holes shall be excavated to a diameter not less than 12-inches or not less than 5 times the largest dimension of the item being anchored, whichever is larger.

   2. Depth for holes shall be not less than 40-inches; excavated approximately 4-inches lower than the post bottom, with bottom of posts set not less than 36-inches below finish grade surface.

C. **Setting Posts:** Line posts shall be spaced at not more than 10-foot intervals, measured from center to center of the posts, parallel to the ground slope. Posts shall be set plumb
and shall be centered in holes, 4-inches above the bottom of the excavation, with posts extending not less than 36-inches below finish grade surface.

1. Corner posts shall be installed where changes in the fence lines equal or exceed 15 degrees, measured horizontally.

2. Each post shall be properly aligned vertically and its top aligned parallel to the ground slope. Posts shall be maintained in proper position during placement and finishing operations.

D. Concrete

1. Concrete for footings may be placed without forms, providing the ground is firm enough to permit excavation to neat line dimensions. Prior to placing concrete, the earth around the hole shall be thoroughly moistened.

2. Encasement concrete for footings shall be placed immediately after mixing in a manner such that there will be no concentration of the large aggregates. The concrete shall be consolidated by tamping or vibrating.

3. Concrete footings shall have a neat appearance and shall be extended 2-inches above grade and troweled to a crown to shed water.

4. A minimum of 7 days shall elapse after placing the concrete footings before the fence fabric or barbed wire is fastened to the posts.

E. Bracing: Bracing shall be provided at all ends, corners, gates, and intermediate brace posts. Corner posts and intermediate brace posts shall be braced in both directions. Horizontal brace rails shall be set midway between the top rail and the ground, running from the corner, end, intermediate brace or gate post to the first line post. Diagonal tension members shall connect tautly between posts below horizontal braces.

1. Braces shall be so installed that posts remain plumb when diagonal rod is under proper tension.

F. Intermediate Brace Posts: Where straight runs of fencing exceed 500-feet, intermediate brace posts shall be installed, spaced equally between ends or corners; with additional posts provided as required, such that the spacing between intermediate brace posts does not exceed 500-feet. Intermediate brace posts shall be equivalent in size to corner posts and shall be braced with horizontal brace rails and diagonal tension members in both directions.

G. Top Rails: Top rails shall be run continuously through post caps, bending to radius for curved runs. Expansion couplings shall be provided as recommended by the fencing manufacturer.

H. Tension Wire: Continuous bottom tension wire shall be stretched tight with turnbuckles at end, gate, intermediate, and corner posts. Tension wire shall be installed on a straight grade between posts, with approximately 2-inches of space between finish grade and bottom selvage, unless otherwise indicated. Tension wire shall be tied to each post with not less than 6 gauge galvanized wire.

I. Fabric

1. Chain-link fabric shall be fastened on the secured side of the posts.
2. Fabric shall be stretched and securely fastened to posts. Between posts, top and bottom edges of the fabric shall be fastened to the top rail and bottom tension wire, respectively.

3. Fabric shall be stretched and anchored in such a manner that it remains in tension after the pulling force is released.

J. **Tie Wires:** Tie wire shall be bent to conform to the diameter of the pipe to which it is attached, clasping pipe and fabric firmly with ends twisted at least two full turns. Ends of wire shall be bent back to minimize hazard to persons or clothing.

   1. Fabric shall be tied to line posts with tie wires spaced at 12-inches on center.
   2. Fabric shall be tied to rails and braces with tie wires spaced at 24-inches on center.
   3. Fabric shall be tied to tension wires, with hog rings spaced 24-inches on center.

K. **Stretcher Bars:** Fabric shall be fastened to end, corner, intermediate brace, and gate posts with stretcher bars. Bars shall be threaded through or clamped to fabric at 4-inches on center and secured to posts with stretcher bar bands spaced no more than 14-inches on center.

L. **Fasteners:** Nuts for tension bands and hardware bolts shall be installed on the side of fence opposite the fabric side. Ends of bolts shall be peened or the threads scored to prevent removal of nuts.

M. Galvanized coating damaged during construction of the fencing shall be repaired by application of **Galvo-Weld; Galvinox;** or equal.

3.3 GROUNDING

A. Fences crossed by powerlines of 600 volts or more shall be grounded at or near the point of crossing and at distances not exceeding 150-feet on each side of the crossing.

B. Fences, gates and appurtenances enclosing electrical equipment areas, gas yards, or other hazardous areas shall be electrically continuous and grounded.

C. Ground conductor shall consist of No. 8 AWG solid copper wire. Grounding electrodes shall be 3/4-inch by 10-foot long copper-clad steel rod. Electrodes shall be driven into the earth so that the top of the electrode is at least 6-inches below grade.

   1. Where driving is impracticable, electrodes shall be buried a minimum of 12-inches deep and radically from the fence. Top of electrode shall be not less than 2-feet or more than 8-feet from the fence.

D. Ground conductor shall be clamped to the fence and electrodes with bronze grounding clamps so as to create electrical continuity between fence posts, fence fabric, and ground rods. After installation, the total resistance of fence to ground shall not be greater than 25 ohms.

- END OF SECTION -
PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The Contractor shall provide mechanically stabilized earth retaining walls with hot dipped galvanized steel reinforcing grids positively connected to precast concrete panels, complete and in place, in accordance with the Contract Documents. The MSE wall system shall include:

1. Excavation and backfill for the MSE retaining wall system in accordance with Section 313000 – Earthwork and the requirements specified herein;

2. Design, supply, and installation of all precast concrete facing panels, soil reinforcing and connections, leveling pads, and concrete copings or caps.

1.2 REFERENCE SPECIFICATIONS

A. ASTM A 82 - Standard Specification of Steel Wire, Plain, for Concrete Reinforcement


C. ASTM A 185 - Standard Specification of Steel Welded Wire, Plain, for Concrete Reinforcement


E. ASTM D 4972 - Standard Test Method for pH of Soils

F. CTM 643 - Method for Determining Field and Laboratory Resistivity and pH Measurements for Soil and Water

G. CTM 422 - Method of Testing Soils and Waters for Chloride Content

H. ASTM C 1580 - Standard Test Method for Water-Soluble Sulfate in Soil


J. ASTM D 6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

1.3 CONTRACTOR SUBMITTALS

A. Submit under provisions of Section 013300 – Contractor Submittals.

B. **Product Data:** Manufacturer’s data sheets on each product to be used, including:

   1. Preparation instructions and recommendations.

   2. Storage and handling requirements and recommendations.
3. Installation methods.

C. **Shop Drawings:** Engineering drawings, elevations, and large-scale details of elevations, typical sections, details, and connections.

1. Include design calculations sealed by a Registered Professional Engineer licensed in the State of California.

2. Submit stamped working drawings and design calculations, and field construction manuals and product brochures prepared by the manufacturer of the proprietary retaining wall selected. Submit this information at least 30 calendar days before beginning retaining wall fabrication or construction. Obtain the Engineer’s approval before fabricating retaining walls.

3. Manufacturer’s certifications that the ultimate tensile strength and junction strength of the welded wire reinforcing mesh are equal to or greater than those specified.

4. General
   a. General Notes: Necessary information on design and construction of the retaining wall.
   b. Materials and Quantity Summary List: Show all items of each wall.
   c. Plan View: Show the construction centerline, the offset from the construction centerline to the face of the wall at all changes in horizontal alignment, soil reinforcement and backfill limits, and the centerline of any utility or drainage structure or pipe that is behind or passes under or through the wall.
   d. Elevation View: Show the elevation at the top of the wall at all horizontal and vertical break points, at least every 20 feet along the wall, and at all pipe penetrations; the location of the original and final ground line at both the heel and face of the wall; elevations at the base of the wall (for example, top of cast-in-place footings and/or leveling pads); the distance along the face of the wall to all steps in the wall base; and the applied bearing pressures; the type and size of facing components; the length, size and number of soil reinforcements; and the distance along the face of the wall to where changes in the length of the soil reinforcement occur.
   e. Typical Sections: Show wall construction, soil reinforcement limits, and limits of backfill.
   f. Facing Components: Show all dimensions, including thickness; all details necessary to construct the facing components; all reinforcing steel in the component; and the location of tensile soil reinforcement attachment devices embedded in the facing. Show the type of concrete finish.
   g. Soil Reinforcements: Show all dimensions and details necessary to construct the soil reinforcements.
   h. Other Structural and Geometric Details: The following minimum structural and geometric details.
      1) Loading conditions.
2) Footing or leveling pad details.
3) Concrete wall cap or coping details.
4) Concrete barrier wall details.
5) Final front face architectural finish details.
6) Reinforcing bar bend details.
7) Wall details at horizontal bend in alignment.
8) Wall joint details for interface at the intake structure and outlet structure.
9) Details for appurtenances not detailed in the plans.
10) Construction around all pipe penetrations and drainage facilities.
11) Joint details for walls at structures.

D. **Wind Load:** The wind load shall be calculated in accordance with ASCE 7-05, Chapter 6, using the following design parameters:

1. Wind Speed: 85 mph
2. Exposure: D
3. Importance Factor: \( I_w = 1.15 \)

E. **Seismic Loads:** The seismic lateral and vertical forces shall be calculated in accordance with the ASCE 7-05, Chapters 11 and 13, using the following design parameters:

1. Site Class: D
2. Seismic Use Group: IV
3. Seismic Design Category (SDC): D
4. Seismic Importance Factor: \( I_e = 1.5 \)
5. Short Period Spectral Acceleration: \( S_s = 0.67 \, g \)
6. 1 Second Period Spectral Acceleration: \( S_1 = 0.27 \, g \)

F. **Design Calculations:** The design calculations shall include but not be limited to:

1. General
   a. Calculations are to be stamped and signed by an Engineer registered in the State of California.
   b. Calculations are to consider the Wind and Seismic Parameters stated above.
   c. Calculations are to comply with Building Category IV requirements.
d. All lateral loading, including seismic soils lateral loads, as given in the geotech report titled “RD2035 Final Geotech Report 9-28-2010” and related addendums by Taber Consultants.

e. Design Input: Show wall geometry; soil parameters; and both permanent and temporary design loads, including applied loads from concrete barriers, fencing, and luminaire supports.

f. Indicate factors of safety against sliding and overturning.

g. Foundation Bearing Pressure Calculations: Indicate the factor of safety against foundation bearing failure.

h. Internal Stability: Indicate reduction factors and factors of safety against soil reinforcement rupture, pullout, and facing connection strength.

i. Local Stability: Indicate factors of safety against sliding and bulging of segmental retaining wall facing units.

G. Field Construction Manual: Provide a field construction manual, prepared by the manufacturer of the proprietary retaining wall selected, including step-by-step directions for constructing the retaining wall.

H. Samples: Two samples of each wall system component including:


2. Concrete Facing Unit: A minimum 12 inch wide section of precast wall panel showing the selected architectural finish.


I. Manufacturer’s Certificate: Certify Products meet or exceed specified requirements.

1.4 QUALITY CONTROL

A. Design Requirements: Design retaining wall system in accordance with the local codes and regulations and the design guidelines of AASHTO and the Manufacturer’s Design shall be by a professional engineer registered in the state of California and a firm that has designed at least five projects of similar construction and scope within the last five years. Walls and slopes constructed with granular fill can be designed using the geotechnical parameters listed in the following table.

<table>
<thead>
<tr>
<th>Soil Parameter</th>
<th>Structural Fill - Granular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Weight</td>
<td>130 pcf</td>
</tr>
<tr>
<td>Inter Friction Angle</td>
<td>38 degrees</td>
</tr>
<tr>
<td>Cohesion</td>
<td>0</td>
</tr>
<tr>
<td>Horizontal Seismic Coefficient</td>
<td>0.23g PGA</td>
</tr>
</tbody>
</table>

B. Manufacturers: MSE wall system components as manufactured by SSL LLC, Hilfiker Retaining Walls, or equal. Only one type of proprietary wall system will be acceptable.
Do not substitute for any component normally supplied by the supplier of the wall system.

C. Installer Qualifications: Firm with documented experience of 10 years and at least five projects of similar construction and scope within the last five years. Include brief description of each project and name and phone number of Owner's Representative knowledgeable in each listed project.

D. Pre-Construction Meeting: Prior to construction of retaining walls, conduct a meeting at the site with the retaining wall materials supplier, the retaining wall installer, and the Contractor to review the retaining wall requirements. Notify the Owner and the Engineer at least 3 days in advance of the time of the meeting.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store products in manufacturer's unopened packaging until ready for installation.

B. Prevent excessive mud, fluid concrete, epoxy, or other deleterious materials from coming in contact with and affixing to retaining wall materials.

1.6 PROJECT CONDITIONS

A. Do not place backfill when subgrade is wet or frozen.

B. Do not place backfill during wet or freezing weather that prevents conformance with specified compaction requirements.

PART 2 -- PRODUCTS

2.1 MATERIALS

A. Retaining Wall Facing System: The MSE wall system shall include precast concrete facing panels with a smoothed formed face.

   1. Precast concrete facing panels shall be in accordance with 034113-Structural Precast Concrete.

B. Leveling Pads: Leveling pads for facing elements shall be to the specifications of the supplier's wall system.

C. Wall Caps: Concrete wall caps shall be provided to the specifications of the suppliers wall system in accordance with the Contract Documents.

D. Steel Wire Mesh Reinforcement: Welded wire fabric reinforcing element shall be shop fabricated from cold drawn steel rod conforming to the minimum requirements of ASTM A 82 and shall be welded at the junctions between longitudinal and transverse wires in accordance with ASTM A 185. Mesh shall be hot dipped galvanized after mesh fabrication and shall conform to the minimum requirements of ASTM A 123.

   1. The allowable tensile stress in the longitudinal wires of the mesh shall not exceed 55 percent of the nominal yield stress of the steel, provided that the yield stress does not exceed 65,000 psi.
2. The maximum tension in any reinforcing element shall not exceed the product of the maximum allowable tensile stress and the area of steel remaining at the end of the nominal service life.

E. **Reinforcement Connections to Panels:** Connectors for the facing panels to soil reinforcing elements shall be to the specifications of the wall system supplier. Steel connectors shall be hot dip galvanized as specified herein.

F. **Backfill:** Backfill material shall be Type P material as specified in Section 313000.
   1. All backfill material in the reinforced zone shall be free from organic content and other deleterious materials.

G. **Joints:** Filter fabric shall be used on the backfill side of the facing elements at all wall joints and interface points with structures to prevent backfill from seeping through the joints while allowing hydrostatic relief. Adhesive shall be used to hold the filter fabric in place until the backfill is placed.

**PART 3 -- EXECUTION**

3.1 **PREPARATION**

A. Do not begin installation until excavation to foundation elevation has been completed and the foundation for the reinforced fill and leveling pad has been properly prepared.

B. Do not begin work until unsatisfactory conditions have been rectified.

C. Excavation
   1. Excavate subgrade vertically to suppliers detailed plan elevations and horizontally to designed wire mesh reinforcement lengths.
   2. Geotechnical engineer will inspect foundation area to ensure proper bearing strength.
   3. Remove soils not meeting required strength and replace with Geotechnical Engineer-approved materials.

D. Prepare subgrade for leveling pad and wall backfill in accordance with Section 313000. Scarify and compact subgrade to a minimum of 95 percent Standard Proctor Dry Density in accordance with ASTM D 698.

3.2 **CONSTRUCTION**

A. Provide for a field representative from the selected proprietary retaining wall company to be present at the start of retaining wall construction. Supervisory personnel of the Contractor, the company field representative, and any subcontractors who are to be involved in the construction of the proprietary retaining wall shall meet with the Engineer for a retaining wall preconstruction conference. At this conference, discuss methods of accomplishing all phases of the work required to construct the proprietary retaining wall. If all representatives are not in attendance, the retaining wall preconstruction conference and start of retaining wall construction shall be rescheduled.
In addition to the retaining wall preconstruction conference, the company field representative shall be available as needed during the erection of the proprietary retaining wall to provide instructions and recommendations, and to assist the Contractor or Engineer. Follow instructions and recommendations of the representative if approved by the Engineer.

B. Retaining walls, regardless of design, shall conform to the applicable top of wall elevations shown. Verify existing ground elevations and bottom of wall elevations for proprietary retaining walls prior to final design.

C. Construct MSE wall system in accordance with approved shop drawings and manufacturer’s instructions.

D. Any wall materials which become damaged or disturbed during placement shall either be removed and replaced at the Contractor’s expense or corrected, as directed by the Owner's Representative.

E. **Facing Panel Installation:** Erect facing panels and coping in accordance with instructions of supplier of the wall system. Provide temporary clamps, hardwood edges or other means to properly align and level facing panels, and to allow for rotation of panels as backfilling operations proceed.

F. **Wire Mesh Reinforcement Placement:** Install reinforcing elements as indicated and to the requirements of the wall system supplier. Place reinforcing elements perpendicular to facing panels, except where indicated otherwise. Lay reinforcing elements horizontally, on compacted backfill. Connect to facing panels as instructed by the wall system supplier.

G. **Backfill Placement:** Backfill shall be placed behind facing panels in accordance with Section 313000 and the wall system supplier requirements. Backfill shall closely follow erection of each course of reinforcement mats. Backfill shall be placed in such a manner as to avoid any damage or disturbance to the wall materials or misalignment of the facing panels. The backfill shall be in contact with the reinforcing elements for the full length of each element and that the backfill occupies all openspaces between solid components of wire mesh.

3.3 FIELD QUALITY CONTROL

A. Testing and Inspection shall be provided by the Contractor’s Quality Control Manager as specified in Section 014500 – Quality Control. Notify the Owner’s Representative 72 hours in advance of testing.

3.4 PROTECTION

A. Protect installed products until completion of project.

B. Touch-up, repair or replace damaged products before Substantial Completion.

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PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide landscaping and appurtenant work, complete and in place, in accordance with the Contract Documents.

1.2 DEFINITIONS

A. The terms "plant material" or "plants" refer to all vegetation, whether trees, shrubs, ground cover, or herbaceous vegetation.

B. "Quality" refers to structure and form, as evidenced by density and number of canes and branches, compactness, symmetry, and general development without consideration of size or condition. "Standard quality" indicates the least acceptable quality. "Standard quality" plants shall be typical of the species and variety of good average uniform growth, shall be well formed and uniformly branched, and shall have the minimum number of canes indicated, free from irregularities, or shall conform to minimum quality index. Where the number of canes is not specifically stated in describing this grade, the "Horticultural Standards" as adopted by the American Association of Nurserymen shall apply. In such a case, the number of canes and other factors for the appropriate classification under "quality definition" in the Horticultural Standards shall be the Quality Index. Plant material below this standard will be considered "culs" and are not acceptable. Plants shall be nursery grown.

C. "Specimen" means an exceptionally heavy, symmetrical, tightly-knit plant, so trained or favored in its development and appearance as to be outstanding, superior in form, number of branches, compactness, and symmetry.

D. "Size" is the factor controlled by dimensions representing height or spread, or both, without consideration of quality or conditions. For standard quality, a dimension is given for height or container size, or a dimension is given for height as well as container size.

E. "Height" is usually indicated with a tolerance. The smaller dimension is the minimum acceptable. The larger dimension represents the maximum permissible. The average dimension of all plants shall equal the average of the tolerance figures for each item.

F. "Condition" is the factor controlled by vitality and ability to survive and thrive and be comparable with normal plants of the same species and variety in the vicinity at the same season of the year. Plants shall be free from physical damage or adverse conditions that would prevent thriving. "Condition" also sometimes refers to state of growth, i.e., whether "dormant condition" or "growing condition" and this state shall be comparable to plants of similar species in the vicinity for leaves, formation of buds, and the like.

G. "Cane" means a primary stem which starts from the ground, or close to the ground, at a point not higher than 1/4 the height of the plant.

H. "Caliper" shall be measured 12-inches above the finish grade or ground, as a guide, or where the trunk appears to form the head of the tree.
I. “Foliage line” is maximum dimension in case of specimen plants. It measures from ground to lowest part of body of plant.

1.3 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

ASTM D 422 Method for Particle-Size Analysis of Soils

ANSI Z60.1 Nursery Stock


1.4 CONTRACTOR SUBMITTALS

A. General: Submittals shall be furnished in accordance with Section 013300 - Contractor Submittals.

B. Product Information

1. Manufacturer’s product information on fertilizer, peat moss, mulch, and seed mixtures.

2. Topsoil Analysis Report: A report certified by an analytical laboratory which shows results of analyzing representative samples of topsoil proposed for use. Approval of the report does not constitute final acceptance of the topsoil.

C. Certificate

1. Certificates shall accompany each delivery stating source, quantity, and type of material. All certificates shall be submitted at the time of delivery.

2. Certificates of inspection of plant material, as may be required by Federal, State, or other authorities having jurisdiction, which accompany the shipment, shall be submitted at delivery.

3. Landscaping Subcontractor guarantee to perform planting maintenance services during the 90-day correction of defects period.

D. Samples

1. Three samples of typical plants from each variety and size indicated shall be submitted. If approved, samples shall be planted and maintained as standards for comparison with plants provided.

2. Samples of grass seed: 5lb samples of each type of grass seed required with the dealer’s guaranteed germination rate. Grass seed shall not be delivered to the Site prior to written approval of the samples. Approval of the samples, however, shall not affect the right of the ENGINEER to reject the seed upon or after delivery.

1.5 QUALITY ASSURANCE

A. General: All plants shall be true to type or name as indicated in the Contract Documents and shall be tagged in accordance with the standard practice recommended
by the Agricultural Code of the State of California; however, determination of plant species or variety will be made by the ENGINEER.

B. All plants shall comply with Federal and State laws requiring inspection for plant diseases and infestations.

C. The CONTRACTOR shall obtain clearance from the County Agricultural Commissioner, as required by law, before planting plants delivered from outside the County in which they are to be planted. Evidence that such clearance has been obtained shall be filed with the ENGINEER.

D. Inspections will be made by the ENGINEER or its representative. The CONTRACTOR shall request inspection at least 24 hours in advance of the time inspection is required. Inspection is required on the following stages of the WORK:

1. During preliminary grading, soil preparation, and initial weeding.

2. When live stakes are spotted for planting, but before planting holes have been excavated.

3. When finish grading has been completed.

4. When all WORK except the maintenance period has been completed.

5. Final inspection at the completion of the maintenance period.

E. Plants shall be subject to inspection and approval or rejection by the ENGINEER at place of growth and upon delivery to the Site at any time before or during progress of the WORK based on:

1. Quantity, quality, size, and variety;

2. Ball and root condition; and

3. Latent defects and injuries resulting from handling, disease, and insects.

F. Plants approved at pre-planting inspection are subject to rejection during planting if found to be defective.

G. Rejected plants shall be identified as such in an obvious manner, shall be removed from the Site, and be replaced with acceptable plants.

H. Plants shall have been grown in nurseries that have been inspected by the governing authorities. Inspection of plant materials required by City, County, State, or Federal authorities shall be the responsibility of the CONTRACTOR, who shall have secured permits or certificates prior to delivery of plants to Site.

1.6 CLEANUP

A. Upon completion of all planting operations, the portion of the Site used for a work or storage area by the CONTRACTOR shall be cleaned of all debris, superfluous materials, and equipment. All such materials and equipment shall be entirely removed from the Site in accordance with Section 017700 - Project Closeout.
B. All walks or pavement shall be swept or washed clean upon completion of the WORK of this Section.

C. During the entire Contract period, plant containers that have been cut or removed from plant materials shall be removed from the Site daily.

1.7 MAINTENANCE OF LANDSCAPING PLANTING PRIOR TO ACCEPTANCE OF PROJECT

A. General: The CONTRACTOR shall be responsible for protecting, watering, and maintaining all planting and irrigation systems until final acceptance of all WORK under the Contract.

B. At time of acceptance of the complete project, the hydroseeded areas shall be totally established with no bare spots.

C. Watering: Shrubs shall be thoroughly soaked after planting and provided with additional water at intervals as necessary to provide for good health and growth of the planting.

D. Protection: The CONTRACTOR shall provide adequate protection to all newly seeded areas including the installation of approved temporary fences to prevent trespassing and damage, as well as erosion control, until the end of the correction of defects period.

E. The CONTRACTOR shall replace any materials or equipment or which its employees or Subcontractors have damaged.

F. Partial utilization of the project shall not relieve the CONTRACTOR of any of the requirements contained in the Contract Documents.

G. Plants shall be maintained in a vigorous, thriving condition by watering, cultivating, weeding, pruning, spraying, and other operations necessary. No shrubs will be accepted unless they are healthy and show satisfactory foliage conditions.

H. All planted areas shall be cultivated at least every 2 weeks and be raked smooth to present a neat appearance, and additional mulch shall be added where necessary.

I. Maintenance shall include, in addition to the foregoing, cleaning, edging, repairs to stakes, wire, and wrappings, the repair of erosion, and all other necessary work of maintenance. Sidewalks and other paved areas shall be kept clean while planting and maintenance are in progress.

J. Any existing sprinkler lines broken or disrupted shall be replaced to proper working order prior to work under this Contract and shall be acceptable to the OWNER.

1.8 FINAL INSPECTION AND GUARANTEE

A. Inspection of hydroseeded areas and planting will be part of final inspection under the Contract.

B. Written notice requesting inspection shall be submitted to the ENGINEER at least 10 days prior to the anticipated inspection date.

C. Final acceptance prior to start of the guarantee period of the Contract will be on written approval by the ENGINEER, on the satisfactory completion of all WORK, including maintenance, but exclusive of the replacement of plant material.
D. Any delay in the completion of any item of work in the planting operation which extends the planting into more than one season shall extend the correction period in accordance with the date of completion given above.

E. The CONTRACTOR shall replace, as soon as weather conditions permit, all dead plants and all plants not in a vigorous, thriving condition which are noted at the end of the one-year correction period.

F. Plants used for replacement shall be of the same size and variety on the Plant List. Replacement plants shall be furnished, planted, and mulched as indicated for new plants.

G. All WORK under this Section shall be left in good order to the satisfaction of the OWNER and the ENGINEER, and the CONTRACTOR shall, without additional expense to the OWNER, replace any trees, shrubs, etc., which develop defects or die during the one-year correction period.

1.9 MAINTENANCE AND GUARANTEE FOLLOWING ACCEPTANCE OF PROJECT

A. General: The CONTRACTOR shall be responsible for a period of 90-days after date of acceptance of the WORK of this Section, for maintaining all plantings, including all necessary plant replacements, weeding, cultivating, fertilizing, pruning, controlling insects and diseases, and performing all other operations incident thereto, as well as maintenance of the irrigation system in Section 338300 - Landscape Irrigation System. The CONTRACTOR shall obtain a written guarantee from the landscaping Subcontractor embodying the provisions of this paragraph.

B. The WORK covered by the maintenance and guarantee portions of this paragraph includes providing all replacements of plants, labor, materials, equipment, and supplies and in performing all operations in connection with maintenance and guarantees.

C. All plant materials shall be in a condition acceptable to the OWNER or its representative at the end of the maintenance guarantee period.

D. The OWNER will furnish all water required during the maintenance and correction period.

E. The CONTRACTOR shall make any changes or adjustments necessary to the automatic sprinkler system during the maintenance and correction period.

F. The CONTRACTOR shall replace any dead or diseased plants during the maintenance and correction period.

G. All planting areas shall be fertilized during the maintenance and correction period with 16-6-4 chemical fertilizer. Amount of fertilizer applied shall be per fertilizer’s written instructions on bag. Fertilizers applied to planting areas shall be cultivated into the top 2-inches of topsoil.

H. The CONTRACTOR shall clean-up and remove unused or waste materials from the Site and leave the area in a neat condition satisfactory to the OWNER whenever it performs work during the maintenance period.

I. Final Inspection: The OWNER and CONTRACTOR shall make a final inspection at the end of the 90-day correction period. Any plants and materials found defective at time of final inspection shall be replaced within a time agreed upon by both parties. If it is too
late in the planting season for replanting, the replacements shall be made during the next planting season even though such planting may run beyond the maintenance and correction period.

PART 2 -- PRODUCTS

2.1 GENERAL

A. All landscaping materials for soil conditioning, weed abatement, or planting shall be first-grade, commercial quality and shall have certificates indicating the source of material, analysis, quantity, or weight attached to each sack or container or furnished with each delivery. Delivery certificates shall be given to the ENGINEER as each shipment of material is delivered. A list of the materials used, together with typical certificates of each material, shall be submitted to the ENGINEER prior to final acceptance.

2.2 TOPSOIL

A. Topsoil shall be obtained from naturally drained areas and shall be fertile, friable loam suitable for plant growth. Topsoil shall be subject to inspection and approval at the source of supply and upon delivery.

B. The topsoil shall be of uniform quality, free from subsoil, stiff or lumpy clay, hard clods, hardpan, rocks, disintegrated debris, plants, roots, seeds, and any other materials that would be toxic or harmful to plant growth. Topsoil shall contain no noxious weeds or noxious weed seeds.

C. The topsoil shall contain at least 6 percent organic matter as determined by loss of weight after ignition of moisture-free samples in accordance with current methods of the Association of Official Agricultural Chemists.

D. The acidity of the topsoil shall result in soil pH between 5.5 and 7.5. The salinity level shall be less than 3 millimhos/cm.

E. Clay, as determined by the Bouyoucous hydrometer or by the decantation method, shall not exceed 60 percent of the topsoil material.

F. Mechanical analysis shall be performed and shall conform to ASTM D 422.

2.3 FERTILIZER AND ADDITIVES

A. Fertilizer shall be furnished in bags or other standard containers with name, weight, and guaranteed analysis of contents clearly marked thereon.

B. Chemical fertilizers shall be Gro-Power Plus (5-3-1).

C. Tablets shall be Gro-Power Transplant Fertilizer 7 Gram tablets, or equal.

D. Lime shall be dolomite limestone containing not less than 85 percent of total carbonates. Limestone shall be ground to such fineness that 100 percent will pass a No. 200 sieve.

E. Agricultural gypsum shall be standard brand agricultural calcium sulfate intended for soil application and shall contain 19 percent combined sulfur.
2.4 MULCH

A. Mulching material shall be well-rotted sawdust minimum 2 years old, pine bark or tan bark, all free of sticks, stones, clay, or other foreign materials. Bark mulch shall be medium chunk size, fortified with 1 percent nitrogen.

B. "Silva-fiber" mulch material shall be Silva-fiber as manufactured by the Weyerhauser Company, Silva Products Department, Tacoma, Washington, or equal.

C. Wood chip mulch in planting beds shall be clean, inexpensive, pulverized shavings, 2-inch minimum to 4-inch maximum length as produced by chipping tree branches or similar means, placed to a depth of 2-inches.

D. Straw mulch or native hay for a soil/seed stabilizer shall be clean hay or straw applied at a rate of 3 tons per acre. Mulch is to be crimped into soil with a mulch crimper. Spacing on the blades of the mulch crimper shall be 6-inches minimum and 9-inches maximum. Blades shall be sufficiently weighted to penetrate the ground 3-inches.

2.5 PLANT MATERIALS

A. Plants shall meet requirements of the Contract Documents and shall be in accordance with the botanical names and applicable standards of quality, size, condition, and type. Plants shall be true to name, genera, species, and variety in accordance with reference publications.

B. Plant names are defined in "Standardized Plant Names" and "Bailey's Encyclopedia of Horticulture." When a name is not found in either reference, the accepted name used in the nursery trade shall apply.

C. Plants shall be marked for identification. Each bundle of plants and at least 25 percent of each species and variety of separate plants in any one shipment shall have legible labels securely attached before delivery to the Site.

D. Shrubs shall be measured while their branches are in their normal position. Height and spread dimensions refer to the main body of the plant and not from branch or root tip to tip. No trees will be accepted with leaders cut or so damaged that cutting is necessary.

E. All plants shall be symmetrical and shall conform to the size, age, and condition on the Plant List. Exceptions are as follows:

1. Plants larger than indicated on the plant list may be used if approved by the ENGINEER, but approval of such plants shall not increase the Contract Price. If the use of larger plants is approved, the spread of roots or ball earth shall be increased in proportion to the size of the plant. Bare root plants furnished in size greater than indicated shall be balled and burlapped when required by the ENGINEER.

2. Where caliper or other dimensions of any plant materials are omitted from the Plant List, it shall be understood that such plant materials shall be normal stock for type listed.

F. Plants shall be of sound health, vigorous, and free from plant disease and shall be well branched, shall have full foliage when in leaf, and shall have a healthy well-developed normal root system. Cold storage plants will not be accepted. Plants that are sensitive to shock from elevation change shall be grown for at least 2 years at elevations close enough to the Site to alleviate any plant damage due to such change.
G. Roots or balls of all plants shall be adequately protected at all times from sun and drying winds.

H. Plants indicated to be in marked cans, pots, or other containers on the Plant List shall have been grown in the containers for a minimum of 6 months and a maximum of 2 years. Roots shall fill the containers but show no evidence of being or having been root bound.

I. Plants shall have been transplanted or root-pruned at least once in the 2 years prior to delivery, but plants shall not be pruned immediately prior to delivery except as authorized by the ENGINEER.

2.6 SEED MIXTURES

A. Seed shall conform to applicable City, County, State, and Federal regulations. Seed shall be mixed by dealer. The CONTRACTOR shall furnish dealer's guaranteed germination figure for each variety. Hydroseed shall not be delivered until samples have been approved in writing by the ENGINEER or its authorized landscape representative. Approval of samples, however, shall not affect the right of the ENGINEER or the authorized landscape representative to reject seed upon or after delivery. Seed that has become wet, moldy, or otherwise damaged prior to use will not be accepted.

B. Hydroseed shall be fresh, clean, new-crop seed, composed of the following varieties mixed in the proportions by weight. Purity and germination percentage shall be the results of testing.

<table>
<thead>
<tr>
<th>Common Names</th>
<th>Proportion by Weight (percent)</th>
<th>Purity (percent)</th>
<th>Germination (percent)</th>
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<tr>
<td><strong>Area #1</strong></td>
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</tr>
<tr>
<td>Spanish Clover</td>
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<tr>
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<tr>
<td>Annual Semaphoregrass</td>
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</table>

Seed Mixes available from Pacific Coast Seed, Inc. (925) 373-4417

PART 3 -- EXECUTION

3.1 GENERAL

A. The landscape work shall not be performed at any time when it may be subject to damage by climatic conditions.

B. The CONTRACTOR shall carefully scale or otherwise verify all dimensions in the Contract Documents. Dimensions and plant locations shall be coordinated with ENGINEER and final location shall be Site-oriented by the planter and ENGINEER. Any discrepancies or inconsistencies shall be brought to the attention of the ENGINEER.

C. In case of conflict between the Plant List totals and total plant count of the Contract Documents, the CONTRACTOR shall provide the higher number of plants.

D. Delivery of materials may begin only after samples and tests have been approved by the ENGINEER. Materials provided shall be not less quality than the approved sample.

E. Substitutions for the indicated plant materials may be considered pursuant to the Contract Documents.

F. The CONTRACTOR shall provide temporary fencing, barricades, covering, or other protections to preserve existing landscaping items indicated to remain and to protect the adjacent properties and other structures when they may be damaged by the landscape work.

G. The CONTRACTOR shall retain the services of a tree surgeon approved by the ENGINEER to repair damage to existing trees. Existing trees which are to be saved and which cannot be restored to full growth, as determined by tree surgeon, shall be removed and replaced with a new similar tree of 24-inch box size unless otherwise approved by the ENGINEER.
H. The CONTRACTOR shall remove and/or relocate landscape items such as trees, shrubs, grass, other vegetation, improvements, and obstructions as indicated.

I. Waste materials shall be removed and disposed of off the Site, unless otherwise indicated.

J. It shall be the responsibility of the CONTRACTOR to obtain information regarding utilities in the area of work and to prevent damage to the same. The CONTRACTOR shall protect the utilities as necessary.

K. Burning of combustible materials on the Site shall not be permitted.

L. The CONTRACTOR shall protect structures, sidewalks, pavements, and other facilities that are subject to damage during landscape work. Open excavations shall be provided with barricades and warning lights which conform to the requirements of governing authorities and the State's OSHA safety requirements from dusk to dawn each day and when needed for safety.

M. Planting areas include all areas to be landscaped unless indicated otherwise.

3.2 SOIL PREPARATION

A. The landscape work shall not begin until all other trades have repaired all areas of settlement, erosion, rutting, etc., and the soils have been re-established, recompacted, and refinished to finish grades. The ENGINEER shall be notified of all areas that prevent the landscape work from being executed.

B. Areas requiring grading by the landscaper including adjacent transition areas shall be uniformly level or sloping between finish elevations to within 0.10-ft above or below required finish elevations.

C. The landscape work shall not proceed until after walks, curbs, pavings, edging, and irrigation systems are in place. WORK under the Contract shall be completed to a point where the landscape areas will not be disturbed. The subgrade shall be free of waste materials of all kinds.

D. During grading, waste materials in the planting areas such as weeds, rocks 2-inches and larger, building materials, rubble, wires, cans, glass, lumber, sticks, etc., shall be removed from the Site. Weeds shall be dug out by the roots.

E. Fertilizers, additives, seed, peat, etc. subject to moisture damage shall be kept dry in a weatherproof storage place.

F. After removal of waste materials, the planting area subgrade shall be scarified and pulverized to a depth of not less than 6-inches, and all surface irregularities below the cover of topsoil shall be removed.

G. Finish grading shall consist of:
   1. Final contouring of the planting areas.
   2. Placing 4-inches of topsoil over all shrub and ground cover areas to be planted unless indicated otherwise.
   3. Placing all soil additives and fertilizers.
4. Tilling of planting areas.

5. After tilling, bringing areas to uniform grades by floating and/or hand raking.

6. Making minor adjustment of finish grades as directed by the ENGINEER.

7. Removing waste materials such as stones, roots, or other undesirable foreign material and raking, diskimg, dragging, and smoothing soil ready for planting.

H. Any unusual subsoil condition that will require special treatment shall be reported to the ENGINEER.

I. Topsoil shall be uniformly distributed over all areas where required. Subgrade and topsoil shall be damp and free from frost.

J. Surface drainage shall be provided as indicated by shaping the surfaces to facilitate the natural run-off of water. Low spots and pockets shall be filled with topsoil and graded to drain properly.

K. Finish grade of all planting areas shall be 1-1/2 inches below finish grade of adjacent pavement of any kind.

3.3 DELIVERY, STORAGE, AND HANDLING OF PLANT MATERIALS

A. No plants other than the required samples shall be dug or delivered to the Site until the required inspections have been made and the plant samples are approved.

B. Plants shall not be pruned prior to delivery except upon approval by the ENGINEER.

C. Plant material shall be planted on the day of delivery if possible. The CONTRACTOR shall protect the stock in a temporary nursery at the Site where it shall be protected from sun and drying winds and shall be shaded, kept moist, and protected with damp soil, moss, or other acceptable material. Plants shall be planted within 2 days after delivery.

D. During planting operations, bare roots shall be covered with canvas, wet straw, or other suitable materials. No plants shall be bound with wire or rope at any time so as to damage the bark or break branches.

E. Plants shall not be picked up or moved by stem or branches, but shall be lifted and handled from the sides of the containers.

F. Plants shall be lifted and handled from the bottom of the ball or container. Plants with balls cracked or broken before or during planting operations will not be accepted and shall be immediately removed from the Site.

3.4 PLANT LOCATIONS

A. The CONTRACTOR shall locate and stake all shrub locations and have the locations approved by the ENGINEER before starting excavation for same. The plant locations shall be observed, and their locations shall be adjusted as directed by ENGINEER before final approval.

B. Ground covers and shrubs may be planted up to structures or curbs.
3.5 PLANT PITS

A. Plant pits, centered on location stakes, shall be excavated circular pits with vertical sides and flat or saucer shape bottom in accordance with the details on plans.

3.6 PREPARED BACKFILL

A. Typical shrub - 3 parts native soil, 2 parts soil conditioner. Provide watering basins for all plant material. Remove basins from all trees in turf areas. Materials shall be thoroughly rotary-mixed on the Site before placement. Mixing of materials in pits, bins, trenches or beds will not be permitted.

B. Shrub pits shall be provided with fertilizer tablets as follows:

- 2 per one-gallon can plant
- 7 per 5-gallon can plant
- 13 per 15-gallon can plant

3.7 ROCKS OR UNDERGROUND OBSTRUCTIONS

A. In the event that rock or underground obstructions are encountered in the excavation of plant pits, alternative locations will be selected by the ENGINEER. Moving of plants to alternative locations shall not entail additional costs to the OWNER.

3.8 SETTING PLANT MATERIALS

A. The soil shall not be worked when the moisture content is so great that excessive compaction will occur, nor when it is so dry that a dust will form in the air or that clods will not break readily. Water shall be applied if necessary to provide ideal moisture for filling and for planting.

B. Plants shall be set plumb and straight in center of pits, and at such a level that after settlement that the crown of the plant will be 2-inches above the finished grade.

C. Vines shall be removed from stakes, untied, and securely fastened in an approved manner to wall or fence next to which they are planted.

D. Ground cover plants shall be evenly spaced, staggered in rows, and set at intervals indicated, so as to produce a uniform effect. Plants shall be watered immediately after planting operations have been completed.

E. Shrubs and vines shall be pruned to remove damaged branches.

F. Planting soil around roots or balls shall be thoroughly compacted and watered. After planting, the soil in the shrub beds shall be cultivated between shrubs, raked smooth, and neatly outlined. Muddy soil shall not be used for backfilling. All broken or frayed roots shall be properly cut off.

G. Shrubs on slopes steeper than 6 to 1 shall be provided with watering dams or berms at least 6-inches high and 8-inches wider than planting pit unless indicated otherwise.

H. Shrubs shall be thoroughly watered immediately after planting.

I. Remove all tags and labels when directed by ENGINEER.
3.9 PRUNING AND MULCHING

A. Each shrub shall be pruned in accordance with standard horticultural practice to preserve the natural character of the plant in the manner fitting its use in the landscape design, as approved by the ENGINEER.

B. All dead wood or suckers and all broken or badly bruised branches shall be removed by thinning out and shortening branches. Deciduous bare-rooted plants shall have not less than 1/3 of their respective leaf surfaces removed. All cuts shall be made just above a healthy bud. Pruning shall be done with clean, sharp tools.

C. Plants shall be mulched after planting and cultivating have been completed. A layer of mulch materials shall be spread on finished landscaping grade within all planting areas to a depth of 2-inches. The mulch around isolated plants shall be 6 inches greater in diameter than the planting hole. All shrub and ground cover beds shall be completely covered with the mulch.

3.10 HYDRO-SEEDING

A. One-step hydro seeding may be utilized between May 1 and September 15. This method consists of preparing the seed bed; combining seed mixture at the rate as shown in the Plant Legend; fertilizer at the rate of 15 lb per 1000 sq ft; Silva-fiber or equal at the rate of 1400 lb per acre of area and water in tanks; agitating these compounds into a well-mixed slurry suspension; and spraying the mixture under pressure onto the prepared areas to be seeded.

B. Two-step hydro-seeding may be utilized between March 1 and September 15. This method consists of preparing the seed bed; sowing seed mixture at the rate as shown in the Plant Legend in 2 directions with an approved mechanical seeder; incorporating fertilizers; and spraying under pressure a mixture of water and Silva-fiber or equal at the rate of 1400 lb per acre onto prepared, seeded, and fertilized areas. Fertilizer can be applied with the water and Silva-fiber or equal mixture if desired.

3.11 MISCELLANEOUS ITEMS

A. Wood chip mulch shall be placed in all shrub areas where indicated, spread carefully and evenly to a minimum depth of 2-inches over planted areas.

B. Cobble shall be hand placed where indicated. Care shall be taken to fill all spaces, placing small cobble in the voids between the large cobble. When complete, CONTRACTOR shall fill all voids with sand and water thoroughly to ensure solid settlement of sand into all cracks and voids. Repeat as necessary to secure cobble from shifting.

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PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide and install steel casing, carrier pipe, and conduits by tunneling/pipe jacking including pipe, specials, and fittings, complete and in place, in accordance with the Contract Documents. The casing shall be contact grouted, in accordance with Section 317316, following installation of the casing the carrier pipe and conduits supported by casing spacers shall be installed, and the annulus between casing and carrier pipe shall be filled with grout.

B. All materials for the work shall be furnished by the Contractor. Material shall include the carrier pipe to be inserted into the steel casing.

C. The work shall be performed by qualified supervisory personnel experienced in tunneling/jacked casing construction.

D. The Contractor shall also follow the Union Pacific Railroad Pipeline Installation Engineering Specifications.

E. The Contractor shall comply with all applicable OSHA and CalOSHA requirements.

1.2 QUALIFICATION OF TUNNELING CONTRACTOR/SUBCONTRACTOR

A. The contractor/subcontractor performing tunneling shall hold the following minimum qualifications:

1. Contractor/subcontractor shall have constructed and shall submit references for at least 2 successful tunneling construction projects crossing railroads or freeways in the past ten (10) years performing trenchless crossing with a minimum diameter of 36 inches.

2. Contractor/subcontractor performing this work shall have successfully completed two thousand (2,000) linear feet of tunneling/jack casing construction during the last five (5) years.

3. The tunneling superintendent(s) shall have a minimum of two (2) years tunneling/jack casing experience during the last five (5) years and must demonstrate at least one (1) project where he/she successfully performed a tunneling work as described in Item 1 above.

1.3 SUBMITTALS

A. Furnish submittals in accordance with Section 013300 - Contractor Submittals.

B. Within thirty (30) days prior to start of micro-tunneling/jack casing construction, submit names and experience resumes of all supervisory micro-tunneling/jack casing construction personnel. Resumes shall include references and successfully completed project.

C. Submit full details of Contractor’s proposed work at least thirty (30) days prior to the start of the work activities for installing the steel casing. This submittal shall be prepared by a
State of California registered Civil Engineer and will include, but will not limited to, the following:

1. Site layout of all major equipment; access/egress routes; fencing; baracades, etc.
2. Jacking operations, thrust jacks and blocks details including methods to monitor and control the jacking force.
3. Detailed description of the tunneling equipment and procedures to be employed including the manufacturer, make, model and detail drawings of the tunneling equipment.
4. Method of maintaining annular space between casing and ground including bentonite/polymer mix design, material data sheets, injection locations, and methods verify annular fluids are maintained.
5. Design calculations demonstrating the adequacy of the casing to adequately support the ground in accordance with the specifications.
6. Procedures for turning under.
7. Settlement monitoring programs.
8. Breasting procedures.
10. Method of control casing line and grade.
11. Contingency plan including obstructions, settlement grouting, frac-out contingency plan for any tunneling activities that use pressurized drilling fluids, etc.
12. Power, ventilation system details, lighting, communication and air monitoring procedures.
13. Bulkhead details for casing end bulkheads.
14. Details of the carrier pipe installation, including casing spacers, and conduits.

D. Submit work schedule describing construction activities, including staging and coordination.

E. Submit traffic control plans for the tunneling/jacked steel casing areas where work will impact local traffic.

F. Submit Tunnel Pre-job Safety Conference Check List, air monitoring equipment and personnel certifications.

G. Submit all other pertinent information required to understand the proposed approach to the work.

H. Daily Records including shift report for each shift worked; location of the face of the tunnel at the start and end of each shift; crew size, employee classification, and assignment; number and types of equipment used; idle equipment on site; gas testing and air quality measurements; line and grade at 4 foot intervals; ground conditions and
any groundwater inflows; cutting tool changes; delays; jacking pressures; position of laser on target relative to design line and grade.

1.4 QUALITY ASSURANCE

A. Qualifications

1. The project superintendent shall have no less than 10 years of recent on-the-job supervision experience on projects involving tunnels of similar size constructed by similar methods as those proposed.

2. Shift supervisors shall have at least 3 years of recent experience in responsible charge of a tunneling shift performing similar tunnel excavation methods as those proposed in similar ground conditions.

3. The safety representative shall have no less than 5 years of recent experience in tunnel construction and be certified by Cal/OSHA.

4. Personnel responsible for testing underground gases and monitoring air quality shall be certified by Cal/OSHA as a gas tester.

5. Licensed surveyors shall be State of California registered Land Surveyors.

B. Preconstruction Meeting: Hold meeting at least 5 days but no more than 30 days prior to commencing tunneling.

PART 2 -- PRODUCTS

2.1 MATERIALS

A. The steel casing shall be a plain straight cylinder steel pipe having a minimum inside diameter of 54 inches. The casing thickness shall be 0.625-inch (minimum). The steel plates shall conform to the requirements for such materials herein set forth. Field joints in the steel pipe casing shall be full penetration butt welds. Steel casing pipe shall have minimum yield strength of 35,000 psi, and a minimum tensile strength of 60,000 psi. Field joints shall be made as part of the tunneling operations prior to the incorporation of each length of casing into the crossing.

B. A sufficient number of steel stiffener rings shall be tack welded to the steel pipe casing to strengthen the end during jacking operations.

C. Casing Spacers. Carrier pipe and conduits shall be supported and secured within the casing and restrained against floatation by use of casing spacers specifically designed for the application. Non-metallic, non-conductive casing spacers compatible with the corrosion control design shall be used. Casing spacers shall have low friction bearing surfaces to facilitate carrier pipe installation, the spacers shall protect the carrier pipe and conduit from damage during installation and grouting. The spacers shall hold the carrier pipe and conduits firmly in place. The distance between the spacers shall be a maximum of 8 feet.
PART 3 -- EXECUTION

3.1 SAFETY

A. Contractor to conduct Cal/OSHA required on-site safety conference prior to beginning any boring work and to perform gas monitoring during construction. Underground classification request has been submitted to the Division of Occupational Safety and Health Mining and Tunneling unit. It is expected that the tunnels will be classified as “Potentially Gassy with Special Condition”. A copy of the classification will be included in an Appendix of the Contract Documents. Contractor will have to schedule the mandated pre job conference with the Division prior to commencing any activity associated with the construction of the tunnels.

B. Methods of tunnel construction shall be such as to ensure the safety and health of the Work, the Contractor's employees, the Engineer, the Owner, and representatives of the Engineer and Owner, and adjacent property and facilities. All work shall conform to the requirements of Cal/OSHA.

C. The Safety Representative shall prepare a Code of Safe Practices and an emergency plan. Safety and health meetings shall be conducted and safety and health instructions provided for new employees as required.

D. A temporary ventilation system and air quality monitoring system which conforms to the requirements of all federal, state and local laws and regulations shall be provided, operated, and maintained for the duration of the construction operations.

E. The air quality shall be monitored in accordance with applicable underground classification requirements of Cal/OSHA and, as a minimum, monitor for the presence of methane.

F. The Contractor shall complete and submit the Tunnel Pre-job Safety Conference Check List from California Code of Regulations, Title 8, Tunnel Safety Orders, at least 30 days prior to commencing tunneling.

3.2 TUNNEL EXCAVATION

A. Contractor shall exercise extreme care so as not to cause damage to the railroad, pavement, and related facilities. Any facilities, which are locally cracked, broken, damaged or removed because of work performed by the Contractor, shall be fully repaired and restored and cleaned up to the Engineer’s satisfaction, at the Contractor’s expense. Tunnel excavation shall not commence before all geotechnical instrumentation is installed.

B. The application of jacking pressure and excavation of material ahead of the casing as it advances shall be carefully controlled to prevent the casing from becoming earthbound. The Contractor shall restrict the excavation of the materials to the least clearance necessary to prevent binding in order to avoid loss of ground and consequent settlement or possible damage to overlying structures. Maximum allowable overcut shall be no greater than 1” larger than the outside diameter of the steel casing. The Contractor shall maintain the annulus outside the casing completely filled with a bentonite or polymer fluid to keep the annulus stable such that no ground loss occurs. The annulus, excess excavation or over-break, outside the required line of excavation, shall be satisfactorily refilled by grouting through holes provided for that purpose. The Contractor shall be responsible for preventing settlement of the structures or pavement above the opening and for other damage due to tunneling operations.
C. The Contractor shall be responsible for maintaining the required straight alignment and grade. Tunnel alignment and grade shall be monitored with a laser guidance system. The tolerances for deviation from the line and grade for the jacking operation shall be within 3-inches shown on plans.

D. Maximum allowable surface settlement shall not exceed ½ inch. The Contractor shall establish a Survey Grid Line prior to tunneling and implement a monitoring program. If the surface monitoring measurements indicate surface settlement is at 80% of the maximum allowable surface settlement (0.4 inch), contractor shall evaluate the tunneling operation to determine the cause and make necessary adjustment to limit the amount of settlement. If maximum allowable is exceeded, contractor shall cease all construction and construction related activities. Immediately inform the Engineer whenever any maximum value is exceeded. Contingency measures submitted under Section 1.3 C.10 shall be put into operation with the approval of the Engineer. Contingency measures may include, but not be limited to changing or modifying control of the water system or changing tunnel excavation sequence.

E. The annular space and any voids resulting from caving or excavating outside the limits of pipe jacking shall be immediately contact grouted upon completion of the jacking with a neat cement or sand-cement slurry to fill the voids.

F. The ends of the casing are to be suitably sealed against the entrance of foreign material, but are not to be tightly sealed.

G. All surplus excavated materials from the jacking operations shall be hauled away and disposed by the Contractor at his/her own expense.

H. The Contractor shall schedule the Work so that the jacking and receiving pits are completed within not more than twenty working days prior to the start of the jacking operation. After the pipe casing and the carrier pipe is installed and grouted, the pits shall be backfilled and pavements restored. Within the periods of no activities, the pits shall be covered with steel plate or other approved means.

I. In preparation for installing carrier pipe, clean casing pipe of loose soil, and grind smooth any rough welds at steel casing joints. Survey the casing invert elevation for deviations from true grade. Furnish casing spacer runners accordingly to ensure carrier pipe is installed within final grade tolerances. Mount casing spacers to carrier pipe in conformance with the spacer manufacturer’s recommendations, and minimum requirements specified herein. Install carrier pipe by sliding into position, and in a manner to prevent damage to the carrier or the casing pipes.

3.3 FIELD QUALITY CONTROL

A. Coordinate the work to be performed with the Engineer allowing access to the face for observations and geologic mapping for up to 15 minutes per 4 feet of advance. Allow safe access in to the tunnel at other times as deemed necessary by the Engineer under circumstances that do not require any work stoppages.

B. Surveying

1. Unless specified otherwise, surveys may be performed by the tunnel foreman.

2. The initial establishment of tunnel line and grade, and the setup and any subsequent adjustment of the laser used to control and monitor tunnel alignment shall be performed by a licensed surveyor.
3. Survey the advancing tunnel face prior to beginning excavation of each.

4. A licensed surveyor shall perform surveys for alignment and grade, and install survey points, as a minimum, at no greater than 30-foot intervals.

5. At the completion of tunnel excavation perform a detailed profile survey of the tunnel excavation to allow planning of the final lining placement to ensure that final lining tolerances and minimum clearances have been achieved.

   - END OF SECTION -
PART 1 – GENERAL

1.1 THE REQUIREMENT

A. General: The CONTRACTOR shall hire the services of a well drilling and maintenance contractor to assess the condition of the existing well, rehabilitate if required, determine the flow capacity well and provide new equipment and appurtenances necessary to meet the domestic well system flow and pressure requirements specified herein. The location of the existing well is depicted in the Contract Drawings. Well modification shall include all appurtenant work, including pump, motor, hydropneumatic tank, piping, valves, inline strainer and electrical, instrumentation, and controls, enlargement of the well concrete base slab, and construction of a wooden shed enclosure, all in accordance with the requirements of these Contract Documents and state and local regulations. The CONTRACTOR shall be responsible for a complete and operable potable water supply system.

B. The requirements of Section 410000 – Equipment General Provisions and Section 432000 – Pumps, General, shall apply to this Section.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

AWWA A100-97 Standard for Water Wells

CDWR Bulletin 74-81 and 74-90 California Well Standards

ANSI/AWWA C654 Disinfection of Wells

1.3 PERMITS

A. The CONTRACTOR is responsible for compliance with all requirements of the Owner’s existing Yolo County Well Permit, Permit No. 07-123, issued on 7/12/07 and associated Yolo County Health Department well disinfection requirements. Water well permit information is available at the Yolo County website at www.yolocounty.org. The CONTRACTOR must also comply with the Project’s Central Valley Regional Water Quality Control Board NPDES permit conditions.

1.4 EXISTING WELL INFORMATION

A. The well is located near the north property line of the site as shown on the Contract Drawings.

B. The existing well is 205 feet deep from surface, with well casing of 6-inch diameter Class 200 ASTM F-480 PVC pipe. Well screen with 0.35 inch slot size extends from 180 to 200 feet deep from surface.

C. A copy of the original Yolo County Well Permit is attached to this specification as Attachment A.
1.5 CONTRACTOR SUBMITTALS

A. Submittals shall be made in accordance with 013300 - Contractor Submittals and the specifications referenced in paragraph 1.1 B.

B. Submit well inspection, cleaning and testing procedure

C. Submit certification that the well has been rehabilitated, equipped and tested to meet all the requirement of applicable to drinking water by the State of California.

PART 2 – PRODUCTS

2.1 WELL PUMP AND HYDROPNEUMATIC TANK SYSTEM

A. Furnish and install a pre-charged bladder type steel expansion/hydropneumatic tank with replaceable heavy duty bladder. The tank shall be constructed in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code, and stamped at 150 psi working pressure. The tank shall be sized by the contractor to meet the specified flow and pressure conditions with a maximum of six pumping cycles per hour. For bidding purposes the CONTRACTOR shall assume a minimum 255 gallon capacity tank.

B. The tank shall be designed to accept water from the well to cycle the pump to start/stop between two set point pressures, controlled by a well pump system switch. Pump shall start at 115 psi and stop at 135 psi to assure downstream pressure at the tank is maintained at greater than 110 psi. The well/tank shall be equipped with a system monitor with visual LED warning. The tank monitor shall activate a local LED low pressure alarm and shall transmit a signal the SCADA system, specified elsewhere, to notify maintenance staff of a potential system issue. The tank shall be furnished with isolation, drain and pressure relief valve. Pressure relief valve to be set at 140 psi.

C. The hydropneumatic tank shall be securely mounted on a reinforced concrete pad at the well. The concrete pad shall be 12” thick and shall extend 12” all the way around beyond the legs of the tank. The concrete pad shall also be designed to accommodate anchorage of the wooden shed enclosure specified in paragraph 2.3 below. The existing concrete pad may be modified to achieve these space requirements or the existing concrete slab may be demolished and replaced with a complete new slab, all in accordance with Section 033100 – Cast-In-Place Concrete and the Structural Code requirements of these Contract Documents.

D. Hydropneumatic Tank Manufacturer: Wessels series FXA-WG or Approved Equal.

E. Pump Features

1. Pump shall be able to operate continuously without damage to the motor.

2. Pump shall be designed to pump sand particles and include sand handling design,

3. Stainless Steel Metal Parts shall be corrosion resistant, non-toxic and non-leaching.

4. FDA Compliant Non-Metallic Parts Impellers, diffusers and bearing spiders shall be constructed of glass filled engineered composites. They shall be corrosion resistant and non-toxic.
5. Discharge elbow shall be stainless steel. It shall feature built-in safety loops and an upthrust limiting stud which is factory set to prevent the rotating assembly from upthrusting. A field install external check valve shall be installed to prevent backflow.

6. Strainer, bowl and impeller shall be stainless steel for strength and abrasive resistance.

7. Column: stainless steel

8. Hex Shaft Design shall be six sided shafts for positive impeller drive.

9. Shaft Coupling shall be exposed for ease of field alignment to motor shaft and to check pump rotation.

10. Bearings shall be polymer bearing material with abrasion and heat resistant design.

F. **Pump Operating Conditions:** The WORK of this Section shall be suitable for long term operation under the following conditions.

1. Duty Intermittant
2. Drive Constant Speed
3. Fluid Service Untreated Groundwater
4. Fluid Specific Gravity 1
5. Project Site Elevation (NGVD29) 37 – 42 ft.
6. Power Supply 480 Volt, three phase

G. Pump Performance Requirements

1. Maximum shut-off head (ft) TBD by CONTRACTOR
2. System Design Flow Capacity and Head Condition. These two system demands occur continuously and concurrently: (1) 40 gpm at 95 psi at 3” PW WDCWA termination point (See Contract Drawings, Sheet C-12), and (2) 25 gpm at 95 psi at intake structure (See Contract Drawings, Sheet C-11).
3. Design flow pump head (TDH) TBD by CONTRACTOR
4. Pump Speed (rpm) TBD by CONTRACTOR
5. Motor Speed (rpm) TBD by CONTRACTOR
6. Minimum Motor Size (hp) TBD by CONTRACTOR. CONTRACTOR shall assume 10 hp for bidding purposes.

H. **Controls:** The pump manufacturer shall provide a complete control system housed in a NEMA 4X fiberglass enclosure with hinged, gasketed door and mounting bracket or pedestal and all necessary components to provide the following functions:
1. 480 volt, 20-amp circuit breaker disconnect switch for entire panel.
3. 480/120VAC transformer sized for the panel load.
4. 120 volt distribution circuit breaker.
7. Common pump fail/tank fail alarm to shall be wired from the local control panel to the facility SCADA system.
8. The pump shall be controlled by the pressure in the hydropneumatic tank to maintain tank pressure between specified set points.

I. Pump Dimensions

1. Inside diameter of well casing (in.)  6
2. Maximum diameter of bowl (in.)  4
3. Overall depth of well below grade (ft.)  220

J. Pump Manufacturer: Gould series GS Xtreme, Grunfos or approved equal.

2.2 WOODEN SHED ENCLOSURE

A. The CONTRACTOR shall provide a wooden shed enclosure with lockable access door to cover and enclose the well pump, hydropneumatic tank, and appurtenances. The wooden shed enclosure shall be of similar materials, features, and color to match the existing wooden shed enclosure. The shed shall include interior and exterior wall-mounted lights to facilitate operation and maintenance. The shed shall be founded and anchored to the specified 12” thick concrete slab and shall be in accordance with Section 033100 – Cast-In-Place Concrete and the Structural Code requirements of these Contract Documents.

B. The CONTRACTOR is to submit a complete set of calculations for the shed and foundation stamped and signed by a Registered Engineer in the state of California. The Calculations are to comply with the 2010 California Building Code (CBC) and are to include the following Wind and Seismic parameters.

C. **Wind Load**: The wind load shall be calculated in accordance with ASCE 7-05, Chapter 6, using the following design parameters:

1. Wind Speed: 85 mph
2. Exposure: D
3. Importance Factor: \( I_w = 1.15 \)
D. **Seismic Loads:** The seismic lateral and vertical forces shall be calculated in accordance with the ASCE 7-05, Chapters 11 and 12, using the following design parameters:

1. Site Class: D
2. Seismic Use Group IV
3. Seismic Design Category (SDC) D
4. Seismic Importance Factor: \( I_e = 1.5 \)
5. Short Period Spectral Acceleration \( S_s = 0.67 \, g \)
6. 1 Second Period Spectral Acceleration \( S_1 = 0.27 \, g \)

**PART 3 – EXECUTION**

3.1 **CAPACITY TESTING**

A. **General:** Prior to generating the submittal for the hydropneumatic tank and the submersible well pump required under this specification, the CONTRACTOR shall test the existing well to confirm the well’s capacity is a minimum of 65 gallons per minute and to determine the static water surface elevation. Capacity testing shall be in accordance with the procedures described in CDWR Bulletin 74-81 for performance testing of small capacity wells. The CONTRACTOR shall immediately notify the ENGINEER if the well’s capacity is less than 65 gallons per minute, prior to generating the hydropneumatic tank and the submersible well pump submittal. If the well’s capacity is less than 65 gallons per minute, the ENGINEER may modify the system flow requirements or make other adjustments to the domestic well system requirements. The static water surface elevation will be used by the CONTRACTOR in its calculation of required pump head.

3.2 **DISINFECTION**

A. **General:** The CONTRACTOR shall provide for disinfection of the wells immediately after modification of the well has been completed. The CONTRACTOR shall carry out adequate cleaning procedures immediately preceding disinfection where evidence indicates that normal well construction and development work have not adequately cleaned the well.

B. **Disinfection:** The well shall be disinfected in accordance with the requirements of ANSI/AWWA C654, except as modified herein. The method of chlorination to be used shall consist of treating the water in the well casing to provide a chlorine residual of approximately 50 mg/L; circulating the chlorinated water within the well casing and pump column; and pumping the well to waste to remove chlorinated water. The quantity of chlorine compounds required to produce a chlorine residual of 50 mg/L may be calculated by multiplying the appropriate quantity shown in ANSI/AWWA C654, Appendix A, Table A.1 by the appropriate factor.

3.3 **DISPOSAL OF DEVELOPMENT AND TEST WATER**

A. **General:** The CONTRACTOR shall provide all pipeline and facilities for discharging water from the well site to the nearest permitted discharge point as per the NPDES permit, dechlorinating the discharge as required. The CONTRACTOR shall design the
system so that no erosion results from the discharge. All actions necessary to conform to discharge requirements shall be performed by the CONTRACTOR as a part of this contract.

3.4 WATER QUALITY SAMPLING

A. General: CONTRACTOR shall retain the services of a water quality laboratory to analyze water quality samples to comply with the NPDES permit. The CONTRACTOR will collect the water quality samples. The water quality laboratory shall be certified by the State of California to perform all required analyses and shall be acceptable to the OWNER and ENGINEER. Three copies of the laboratory analysis reports shall be provided to the OWNER and ENGINEER.

1. NPDES Protocols sampling: The CONTRACTOR shall perform water quality analysis of samples to comply with the monitoring requirements of the NPDES permit for this project.

3.5 WELL ACCEPTANCE

A. General: It is the responsibility of the CONTRACTOR to properly construct the well modifications according to the requirements of this specification so that the well is a suitable potable water supply. If the CONTRACTOR, due to his negligence, completes the modifications such that the well is not functional or not in accordance with specifications, the ENGINEER will disapprove the well and direct the CONTRACTOR to repair it. This work shall be done at no additional cost to the OWNER.

B. Pump: Prior to OWNER acceptance and formal pump station start-up, all equipment shall be inspected for proper alignment, quiet operation, proper connection, and satisfactory performance by means of a function test. A start-up report showing function testing, motor voltages, running amperages and well water levels shall be provided to the ENGINEER after well start-up.

C. Certification: The well contractor shall issue a certification that the well has been rehabilitated, equipped and tested to meet all the requirements applicable to drinking water by the State of California.

- END OF SECTION -
**YOLO COUNTY HEALTH DEPARTMENT**  
**WELL AND/OR SEWAGE DISPOSAL PERMIT**

**Application** is hereby made to the Yolo County Department of Health for a permit to construct and install the work herein described. This application is made in compliance with Yolo County Code, Chapter 8, Title 5. Plot plan must be placed on attached form.

**JOB ADDRESS/LOCATION**: 1801 N CIR 117 West Sacramento  
**PARCEL NO.**: 057-210-16

**Owner's Name**: Conaway Ranch  
**Phone**: 530-662-2200

**Address**: 45332 CIR 25  
**City**: Woodland  
**ZIP**: 95776

**Contractor's Name**: Eaton Drilling Co Inc.  
**License No.**: 133782 C57A  
**Phone**: 530-662-7495

**Installation will serve**: Residence [x]  
**Number of separate living units**:  
**Number of bedrooms per unit**:  
**Number of person per unit**:  
**Type of Well**: a) INDUSTRIAL [x] PRIVATE DOMESTIC [x] PUBLIC [x] IRRIGATION [x] OTHER [ ]

**Distance to Nearest**: SEPTIC TANK 100'  
**Other**: Leach Lines 100' SEWER 100' OTHER

**Construction Specs**: DIA. EXCAVATION 12"  
**Dia. casing 12" GAUGED CASING**

**Surface Seal**: MATERIAL & PROCEDURE  
**Type**: Class A  
**Depth**: 10 ft. cement

**Pump Installation**: CONTRACTOR  
**Pump Type**: H.P.

**Abandonment of Well**: WELL TYPE:  
**Method**:  
**SEWAGE DISPOSAL**:  
**SOIL TO 5 FEET**:  SAND [x] SILT [ ] CLAY [ ] PEAT [ ] SANDY LOAM [ ] CLAY LOAM [ ] WATERTABLE [ ] HARDPAN [ ] ADOBE [ ] FILL MATERIAL [ ] TYPE [ ]

**Septic Tank**: TANK MATERIAL: GAS. [ ] NO. COMPARTMENTS: DEPTH:  
**Distance to Nearest**: WELL FOUNDATION: PROPERTY LINE:  
**Leach Lines**: DISTANCE TO NEAREST: PROPERTY LINE:  
**Other**: NO. OF LINES: LENGTH: WIDTH: DEPTH: TOTAL LIN. FT.

**Special Design**: DESCRIPTION:  
**Repair/Addition**: PREVIOUS SANITATION PERMIT NO.: DATE:  
**Septic Tank (Specify requirements)**:  
**Disposal Field (Specify requirements)**:  

I hereby certify that I have prepared this application and that the work will be done in accordance with Yolo County Ordinances, State Laws, and Rules and Regulations of the Yolo County Department of Health.

**Signed**: Paul Damian  
**Date**: 7/12/07

**Application Accepted By**: G. W. Jennings  
**Fees Paid**: $563.00  
**Well Inspection: Seal: Surface:  
**Sanitary: Final**

**Sewage Disposal Inspection: Tank: Leach Field: Final**

Em 14/15: 120' to ground level sealed 7/17/07.
STATE OF CALIFORNIA
WELL COMPLETION REPORT
No. E058182

GEOLOGIC LOG

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<td>220 BROWN TAN CLAY</td>
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ENVIRONMENTAL HEALTH

WELL LOCATION

Address: 2 MI NW L5 & E5 OF ROAD 117
City: CA
County: YOLO
APN: 65322 COUNTY ROAD 25
Township: 10 N
Range: 3 E
Section: 28
Latitude: 35° 15′ 45″ N
Longitude: 121° 30′ 00″ W

WATER LEVEL & YIELD OF COMPLETED WELL

Depth to First Water: 205 ft
Depth of Static Water Level: 205 ft
Estimated Yield: 0.1 GPM

ANNULAR MATERIAL

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CERTIFICATION STATEMENT

NAME: JASON D. HALL
ADDRESS: 20 WEST KENTUCKY AVE
WOODLAND CA 95695

07/19/2007

WELL DRILLER AUTHORIZED REPRESENTATIVE
DATE SIGNED
CST LICENSE NUMBER: 075 A & HC - 133783
PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall furnish a 50 foot Antenna Tower, fixed at its base and laterally supported by a custom bracket attached to the CMU-constructed Intake Pump Station in accordance with the Contract Documents. CONTRACTOR shall design and install Antenna Tower as specified herein.

B. The requirements of Section 260000 – Electrical Work, General and Section 409620 – Radio Communications Network and Appurtenances Construction Document Development shall apply to this Section.

C. The CONTRACTOR shall attach antennas required in Section 409620 for communication from RTU-100 and 40-PLC-1 to the Antenna Tower as specified. The Antenna Tower design shall provide for attachment of two additional antennas of the same type, within five feet of the installed antenna.

D. The Antenna Tower shall be a complete system furnished by the CONTRACTOR including tower design, tower fabrication, foundation and lateral support design, footings, grounding system design, grounding system, and access appurtenances for antenna installation and maintenance, including all required OSHA-compliant safety features. Tower to be designed in accordance with the design parameters in section 2.2 below.

E. The Antenna Tower shall comply with all Federal Aviation Administration (FAA) requirements relative to the Sacramento International Airport, located approximately 2 miles from the Project site. A report prepared by Concepts in Controls, Inc, in August 2010 stated that a 50-foot tall tower at the Project site would meet FAA height requirements.

F. The Antenna Tower shall be offset 18-inches from the face of the Intake Pump Station. The CONTRACTOR shall assure that its design for the Antenna Tower lateral support bracket does not conflict with the architectural and structural elements of the Intake Pump Station shown and specified in the Contract Documents.

1. The Antenna Tower shall be attached to the CMU pump station building by a single custom designed lateral support bracket. The lateral support that is attached to the CMU pump station building must only be attached at the same elevation as the metal roof deck. No bracket is to be attached to the CMU wall at any other height.

2. The ENGINEER will consider minor modifications to the architectural elements to facilitate support bracket attachment. The CONTRACTOR shall submit any such proposed modifications to the ENGINEER in accordance with Section 013300 - Contractor Submittals.

G. Structural calculations shall be stamped by California registered Structural Engineer and submitted for approval.
1.2 PROJECT CONDITIONS

A. Design shall account for following site conditions:

1. Annual Temperature Range: 28 degree F to 114 degree F
2. Relative Humidity: 0-95 percent
3. Elevation at Antenna Tower base: 37.8 feet (NGVD 29).
4. Design Wind Speed: 90 MPH
5. The Design Parameters stated in section 2.2 below.

1.3 CONTRACTOR SUBMITTALS

A. General: Submittals shall be furnished in accordance with Section 013300 - Contractor Submittals.

1. A complete index shall appear in the front of the bound volume.

2. Provide data sheets for all products. Data sheets shall be included for each component together with a technical product brochure or bulletin. These data sheets shall show: the component name as used within the CONTRACTOR’S drawings, the manufacturer’s model number or other identifying product designation, the requirements for electric power, the specifications for ambient operating conditions, and details on materials of construction.

3. Complete and detailed bills of materials: A bill of material list, including quantity, description, manufacturer, and part number, shall be submitted for each component.

4. Scale construction drawings showing physical arrangement of Antenna Tower and grounding. Scale shall be 1/4” = 1’ for site layout, or as approved by ENGINEER to show sufficient detail on 11” x 17” drawing.

B. Antenna Tower

1. Catalog Data: Submit catalog literature and data sheets for the complete tower assembly. Include complete manufacturer’s part and model numbers.

2. Tower Design: Provide drawings on 11” x 17” hardcopy and electronic version using AutoCAD, for detailed tower design. Provide structural calculations justifying tower design. Design and calculations of tower shall be stamped by registered Professional Structural Engineer with a valid registration in the State of California. Design shall meet or exceed requirements of ANSI/EIA/TIA-222. Design shall include but not limited to: anchoring, materials, calculations, plans, sections, cable grounding, tower grounding safety equipment, cable strain relief, signage, orientation, fabrication and erection sequence.

3. Tower Foundation/Base and Support Design: Provide drawings on 11” x 17” hardcopy and electronic version using AutoCAD for detailed foundation/base design and support of the tower along the tower height. Provide calculations of foundation/base design and design of structural tower support, including design and detailing of the anchorage of the tower and the tower base to the supporting structure. Design and calculations of foundation/base and support shall be stamped
by registered Professional Structural Engineer with a valid registration in the State of California. Design shall meet or exceed requirements of ANSI/EIA/TIA-222. Design shall include but not be limited to anchoring, support, calculations, reinforcements, grounding system, plans, sections, and fabrication. The design shall include all loading conditions, such as wind, seismic and thermal (temperature) loading.

4. Foundation and support plans with structural calculations for 50 foot tower, considering both wind and seismic loads.

5. Installation instructions: Submit complete assembly drawings including identification, description, location and orientation of every piece and subassembly. Provide sequence of erecting the structure. Provide limits on plumbness of the structure and how to test for such.

6. Submit as-built drawings of tower on 11” x 17” hardcopy and electronic version using AutoCAD.

7. Submit maintenance schedule of tower.

8. Submit warranty lasting 5 years from date of acceptance by OWNER.

C. Submit overall Grounding Plan showing grounding system for Antenna Tower. Provide drawings on 11” x 17” hardcopy and electronic version using AutoCAD.

1.4 STORAGE AND HANDLING

A. All equipment and materials delivered to the jobsite shall be stored in a clean, temperature controlled environment. Building interior shall be dust free prior to any energizing and testing. Storage and handling shall be performed in manners which shall afford maximum protection to the equipment and materials. It is the CONTRACTOR’S responsibility to assure proper handling and on-site storage.

PART 2 – PRODUCTS

2.1 GENERAL

A. Materials: Provide only new, undamaged, and in original condition.

B. Nameplates: All equipment shall be labeled with a nameplate and inscribed as called out on CONTRACTOR design drawings. All wires and coaxial cables shall be identified with phenolic tag, inscribed with identifier as noted on CONTRACTOR’S drawing.

C. Field Wiring: All control and power wiring shall be labeled at both ends and at intermediate pull boxes.

D. Physical Arrangement: CONTRACTOR is responsible for actual layout, dimensions, footprint, conduit coordination, and seismic anchoring.

E. Standards: Antenna Tower construction and interior wiring shall be done in accordance with the National Electrical Code, state and local codes, and applicable sections of NEMA, ANSI, and UL.

F. Labor and Workmanship: Antenna Tower shall be fabricated and wired by fully qualified workmen who are properly trained and experienced.
   1. Electrical work shall meet Specification Section 260000 requirements.
   2. Conduits and raceway systems per Specification 260533.
   3. Communication Cables per Specification 409620.

H. Labor and Workmanship: Panels shall be fabricated and wired by fully qualified workmen who are properly trained, experienced, and supervised.

2.2 ANTENNA TOWER

A. Design Criteria: Provide calculations for the Site Conditions listed above with loading and twist and sway requirements listed below. Tower and anchoring shall meet or exceed latest version of ANSI/EIA/TIA-222.

B. Tower and Equipment Supports: Unless otherwise indicated, equipment supports, anchors, and restrainers shall be adequately designed for static, dynamic, wind, and seismic loads as stated in the 2010 California Building Code (2010 CBC), Chapter 16 and ASCE 7-05. Submitted design calculations for equipment supports and anchorage shall bear the signature and seal of an Registered Professional Structural Engineer licensed in the State of California, unless otherwise indicated. Calculations shall account for forces and distribution of forces on supporting structures resulting from normal operation, normal operation plus seismic loadings, normal operation plus wind loadings, as well as the other load combinations stated the 2010 CBC.

   1. Wall-mounted equipment weighing more than 250 pounds or which is within 18-inches above the floor shall be provided with fabricated steel supports. Pedestals shall be of welded steel. If the supported equipment is a panel or cabinet or is enclosed with removable sides, the pedestal shall match the supported equipment in appearance and dimensions.

C. Wind Load: The wind load shall be calculated in accordance with ASCE 7-05, Chapter 6, using the following design parameters:

   1. Wind Speed: 90 mph
   2. Exposure: D
   3. Importance Factor: \( I_w = 1.15 \)

D. Seismic Loads: The seismic lateral and vertical forces shall be calculated in accordance with the ASCE 7-05, Chapters 11 and 13, using the following design parameters:

   1. Site Class: D
   2. Seismic Use Group IV
   3. Seismic Design Category (SDC) D
   4. Seismic Importance Factor: \( I_e = 1.5 \)
5. Short Period Spectral Acceleration \( S_s = 0.67 \text{ g} \)

6. 1 Second Period Spectral Acceleration \( S_1 = 0.27 \text{ g} \)

E. **Anchors:** Anchor bolts shall be in accordance with Section 055000 - Miscellaneous Metalwork, and shall be designed to resist the above loads. Anchor bolt calculations shall clearly show that the capacity of the anchor and the capacity of the concrete that the anchor is embedded in are adequate to resist all loads stated in the 2010 CBC and ASCE 7-05, including lateral wind and lateral and vertical seismic loads. Reduction factors associated with edge distance, embed length, and bolt spacing shall all be considered and based on the actual dimensions of the concrete that resists the anchorage forces. Anchor bolt details shall include required bolt diameter, embed, and edge distances. Further, the design of Anchors shall consider the ductility requirements stated in ASCE 7-05, Chapter 13, Section 13.4.2 and Chapter 15, Section 15.7.3. Anchor bolt calculations and details shall be submitted and shall bear the signature and seal of a Registered Professional Engineer licensed in the State of California.

F. Tower shall be triangular steel lattice tower construction, 50 feet.

G. **Twist and Sway:** Design Antenna Tower support structures to hold directional antennas on path to the following tolerances:
   1. Limit of antenna movement with respect to structure 0.2 degrees maximum.
   2. Limit of structure movement, twist and sway, at antenna attachment point 2.3 degrees maximum.

H. **Fabrication:** Conform fabrication, erection and identification of structural steel to AISC specifications. Insure that no dissimilar metals are used in contact with one another. Insure that no coating on a metal member or fastener is cathodic relative to the base material. Hot-dip galvanize steel members per ASTM A 123. Galvanize tubular members inside and out. Use welding processes and installers qualified in accordance with AWS “Standard Qualification and Procedure”. Properly mark and match-mark materials for field assembly. Fabricate materials for a delivery sequence which will expedite erection and minimize field handling of materials.

I. **High Strength Connections:** Provide galvanized ASTM A 325, tensions set bolts of US manufacture for field connections. Provide the correct size and length of anchor bolts necessary to carry the anticipated loads. Insure the threaded fasteners extend not less than 1-1/2 threads beyond nuts and locking devices.

J. **Cable Ladder:** Provide manufacturer’s recommended cable ladder sized to accommodate coaxial cable from antenna.

K. **Person Climbing Ladder:** Provide climbing ladder per ANSI/EIA/TIA-222. Provide anti-climb guard installed at 15 feet. Provide anti-fall devices in accordance with ANSI A 14.3. Provide one large and one extra large sized leather double D-ring climbing belt with safety attachments and adjustable webbed lanyards, complete.

L. **Grounding:** Provide per Specification 260526.

M. **Antenna Mounts:** Provide tower manufacturer’s recommended side-mount support for required antennas.
N. **Finish:** Hot dipped galvanized, internal and external, all tower components, after fabrication.

O. **Radio Frequency Alerting Identification:** Provide tower signage per Identification section below.

2.3 **RADIOfREQUENCY ALERTING IDENTIFICATION**

A. Provide and install the following signs per FCC rules on radio frequency emissions 47 CFR 1.1307(b) in English:

   1. RadioFrequency “Notice” Sign: shall be 8” x 12” made of aluminum panel with rounded corners and UV resistant coating. Color shall be blue. Mounting shall be predrilled at each corner. Manufactured by Richard Tell Associates, Inc. SKU #8X12RFN, or equal. Sign shall be mounted on tower 6’ above grade, adjacent to personal climbing ladder per manufacturer’s recommendation.

   2. RadioFrequency “Caution” Sign: shall be 8” x 12” made of aluminum panel with rounded corners and UV resistant coating. Color shall be yellow. Mounting shall be predrilled at each corner. Manufactured by Richard Tell Associates, Inc. SKU #8X12RFC, or equal.

   3. RadioFrequency “Site Guidelines” Sign: shall be 8.5” x 11.5” made of laminated heavy placard. Color shall be yellow. Mounting shall be self adhesive strips. Manufactured by Richard Tell Associates, Inc. SKU #8.5X11RFSGPL, or equal.

**PART 3 – EXECUTION**

3.1 **ANTENNA TOWER INSTALLATION**

A. Verify location of Antenna Tower with ENGINEER prior to commencing of work.

B. **Antenna Tower Erection:** Align and adjust the members forming each tower section before permanently fastening. Maintain a check of structure plumbness throughout erection work. Make field connections with tension set bolts. Field welding is not permitted. Filed modifications including welding or burning of holes in members is not acceptable. Touch up damaged galvanizing using zinc rich (95% in dried film) paint that meets Federal Specifications: TT-P-6416 Galvanized Repair. Touch up may be done by either a spray or brush application.

C. **Cable Ladder:** Install and support ladder per manufacturer’s recommendation.

D. **Personnel Climbing Ladder:** Install and support personnel climbing ladder per manufacturer’s recommendation.

E. **Grounding:** Install grounding in accordance with Section 260526 – Grounding. All grounds shall be routed in most direct fashion to ground, eliminate bends.

F. **Acceptance Testing:** ENGINEER will visibly inspect the bolts used to erect the Antenna Tower to insure proper tension. Tension shall be tested and set at no extra cost to the OWNER.
3.2 RADIOFREQUENCY ALERTING IDENTIFICATION

A. RadioFrequency “Notice” sign shall be mounted on tower 6’ above grade, adjacent to personal climbing ladder per manufacturer’s recommendation.

3.3 FIELD TESTING

A. Testing shall be in accordance with Section 409620.

- END OF SECTION -
SECTION 338300 - LANDSCAPE IRRIGATION

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide an automatic irrigation system, complete and operable, in accordance with the Contract Documents.

B. Minor items necessary for proper construction and functional operation of the system, even if not specifically described in the Contract Documents, shall be included as a part of the WORK of this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 013300 - Contractor Submittals.

B. Shop Drawings

1. Complete list of irrigation materials and equipment, including manufacturer's name/address, specific trade names, catalog numbers, complete with illustrations and/or necessary descriptive literature. The proposed items shall be clearly marked or underlined.

2. Controller literature, specifications, installation wiring diagram, and circuit breaker information shall be submitted for review prior to ordering.

C. Record Drawings: Record drawings showing locations of all valves, pipe, heads, dimensions, controllers, control cables, and electrical wiring shall be submitted to the ENGINEER prior to final inspection.

1.3 QUALITY ASSURANCE

A. The CONTRACTOR shall give at least 72 hours notice to the ENGINEER for scheduling the following special inspections:

1. Layout of the system

2. Inspection of trenches, backfilling, and equipment.

3. Pressure tests

4. Coverage adjustment

5. Automatic operation

B. Pressure Testing: Tests shall be performed in the presence of the ENGINEER.

1. After assembly and installation, water pipes, fittings, automatic equipment, and appurtenances shall be tested at a hydrostatic pressure of 150 psi at the lowest point of the system for not less than 60 minutes.

2. The first test shall be made in such a manner that all valves in the new water pipe sprinkler lines will be tested for watertight closure. Valves may be tested in groups
or singly while subjected to 150 psi water pressure for a period of not less than 60 minutes.

3. The second test shall be made by forcing air from the pipes with water and capping or plugging pipe risers. After the pipe risers have been plugged or capped, line valves shall be fully opened and the pipelines subjected to the full static water pressure for a period of not less than 120 minutes. (Pressure pipelines 150 psi).

4. The third test requires that lateral lines be tested at 100 psi for 120 minutes.

5. The fourth test requires that all pressure lines be tested at 120 psi for 24 hours.

6. Water lines and valves which show evidence of leakage or fail to be watertight shall be repaired or replaced. After all repairs or replacements have been made, the above tests shall be performed again.

C. **Coverage Adjustment:** When the sprinkler system is completed, the CONTRACTOR, in the presence of the ENGINEER, shall demonstrate coverage of water onto the hydroseed and planting areas. The CONTRACTOR shall furnish all material and perform all WORK required to correct any inadequacies of coverage disclosed. The CONTRACTOR shall inform the ENGINEER of any deviation from the Drawings required due to wind, planting, soil, or Site conditions that bear on proper coverage.

1. Upon completion of each phase of the WORK, the CONTRACTOR shall check and adjust each sprinkler head to meet the Site requirements of the Contract Documents.

1.4 **SCHEDULING AND COORDINATION**

A. The CONTRACTOR shall be responsible for making arrangements for the coordination of its construction operations with those of all others on the Site. The CONTRACTOR shall permit others engaged in work on the Site to accomplish their work without undue interference or delay.

B. The CONTRACTOR shall be responsible for the scheduling and coordination of the electrical and water connections and the installation of the piping and equipment in a manner that will effect the earliest completion of the WORK in conformance with the construction progress schedules.

1.5 **SPECIAL CORRECTION OF DEFECTS REQUIREMENTS**

A. The CONTRACTOR shall repair any settling of backfilled trenches occurring during a one year period after final acceptance without expense to the OWNER including complete restoration of all damaged planting, paving, or other improvements of any kind.

B. The CONTRACTOR shall provide winterization of the irrigation system during the one year period if necessary.

C. When defective material or workmanship is discovered which will require repair or replacement, such repair or replacement shall be completed by the CONTRACTOR within 3 Days after written notification of such required repair is given by the OWNER. However, if the CONTRACTOR fails to comply after notification is given, the OWNER will proceed to have the repairs made by others at the CONTRACTOR's expense.
PART 2 -- PRODUCTS

2.1 GENERAL

A. **Equipment Compatibility:** Controller and automatic control valves shall be products of the same manufacturer and have similar operational and adjustment features.

2.2 PLASTIC PIPE AND FITTINGS

A. Pipe shall be continuously and permanently marked with the manufacturer's name, nominal pipe size, PVC type, pressure rating, and extrusion date. Pipe shall be as recommended for the intended application.

B. Lateral lines shall be PVC SDR 21, Class 200, NSF approved.

C. Piping upstream from remote control valves and quick coupling lines shall be PVC SDR 21, Schedule 40, NSF approved, or galvanized steel pipe in accordance with Section 431053. Galvanized steel pipe shall have joints of standard size and length. Joints on PVC piping larger than 3-inches diameter shall be O-ring type flexible couplings and on size 3-inches and smaller shall be solvent welded.

D. Fittings shall be PVC Schedule 40, Type II, NSF, or Schedule 80 as indicated.

E. Swing joint ells shall be Schedule 80 PVC.

F. Teflon thread tape sealant shall be **Rectorseal No. 5** or equal., 3/4-inch wide.

G. Emitter lines shall be **PEPCO, Rainbird**, or equal.

2.3 VALVES

A. Main shut-off valves shall be bronze gate valves with union bonnet, renewable seats, and non-rising stem, Class 150, or better. Gate valves shall be provided with 2-inch square operating nuts.

B. Isolation valves for main lines shall be bronze gate valves with wedge disc, Class 125, screwed ends, and operating nut, as manufactured by **Rainbird, Buckner, Toro**, or equal.

C. **Remote Control Valves:** Remote control valves for the irrigation system shall conform to the following requirements:

   1. Molded-plastic body, normally closed, diaphragm type with manual-flow adjustment, bleed fitting, and operated by 24-V ac solenoid for Commercial/institutional applications. Valves shall be operable electrically and manually.

   2. Each remote control valve shall be housed in a valve box marked “RCV.” The box shall be of adequate size and be set in clean gravel.

   3. Control valves shall be by the same manufacturer as the controller.

D. Quick-coupling valves shall be products of the same manufacturer as the sprinklers.
2.4 AUTOMATIC CONTROLLER

A. Controllers shall be electrically-timed devices for automatically opening and closing remote control valves. Controllers and remote control valves shall be of the same manufacturer and have similar operational and adjustment features.

B. Controller(s) shall be single-phase, 115 volt AC operated and shall be provided with an On-Off switch and fuse assembly. Controller(s) shall be equipped with a transformer to reduce voltage to 24 volt control valves.

C. Controllers shall be adjustable so that each control valve in the circuit will remain open for an adjustable period of 5 or less minutes to 60 minutes. Readily made field adjustments shall include a provision whereby any number of days in a week can be skipped and whereby one or more positions on the controller may be skipped. When any or all of the above adjustments have been made, the controller shall continue to operate automatically until further adjustments are made. Provision shall be made for conveniently resetting the start of the irrigation cycle at any time and also for advancing from one position to any other position; at will.

D. The controller shall be enclosed in a weatherproof metal housing having locking cover or covers to protect all adjustment and breakable equipment from vandalism. Exterior controllers shall be provided with locking covers. One key shall fit all lock mechanisms. The controller shall be pedestal mounted.

E. Automatic controller shall be Hunter, Rainbird, Toro with pedestal mount; or equal.

2.5 SPRINKLER HEADS

A. Sprinkler heads shall conform to the standards indicated.

B. Rotor pop-up sprinklers shall be gear driven rotary heads. Rotation shall be accomplished by a sealed, oil packed gear assembly isolated from the water supply. The sprinkler housing shall be of high impact molded plastic with a 3/4-inch NPT connection. The sprinkler shall be capable of installation at grade level. Heads shall have adjustable arc increments. Provide Rainbird, Toro, Hunter, or equal.

C. Shrubbery spray heads shall be pop-up type, full or part circle sprinklers with gear driven rotary. Part circle heads shall be adjustable from 15 to 360 degrees. Rotation shall be accomplished by a sealed, oil packed gear assembly isolated from water supply. The sprinkler shall be capable of installation above grade. The sprinkler housing shall be of high impact molded plastic with a 1/2-inch NPT connection. Provide Rainbird, Toro, Hunter, or equal.

D. Spray heads shall be pop-up design, full or part circle, fixed spray sprinklers designed for inground installation. The sprinkler shall have a riser screen filter to prevent entry of foreign material to the nozzle. All parts shall be removeable through the top of the sprinkler case. Sprinkler shall have a stainless steel retraction spring. Provide Rainbird, Toro, Hunter, or equal.

E. Emitters for drip irrigation shall be equipped with multi-port outlet. All emitters shall be provided with outlet caps. Provide Rainbird, Toro, Hunter, or equal.
2.6 CONTROL WIRING
A. Control wiring shall be Standard UF Direct Burial Copper Wire, Type UF Bearing, UL approved for direct underground burial in National Electrical Code Class II circuits, AWG sizes.
B. Conductors shall be grade copper meeting ASTM B 3 - Soft or Annealed Copper Wire.
C. Splices shall be made with DBY Seal Pack wire connectors, such as manufactured by 3M, or equal.

2.7 PVC SOLVENT CEMENT AND PRIMERS
A. Solvent cement shall be NSF approved and shall meet requirements of ASTM D 2564 - Solvent Cements for Poly Vinyl Chloride (PVC) Plastic Pipe and Fittings.
B. Primer shall be NSF approved and shall be Weld-On, P-70 Industrial Polychemical Service, or equal.

2.8 WORM GEAR CLAMPS
A. Worm-gear clamps shall be stainless steel.

2.9 VALVE AND CONTROLLER BOXES
A. Boxes for valves and controllers shall be PVC or concrete and shall be complete with lid. Boxes shall be sized for equipment within box, depth of installation, and operation and maintenance space required. Lid shall identify equipment inside box, such as RCV for remote control valve, etc.

2.10 SPARE PARTS
A. Furnish the following:
   1. Four control valve operating keys.
   2. Four keys for locking automatic controller door.
   3. Two gate valve keys.

PART 3 -- EXECUTION
3.1 EXISTING CONDITIONS
A. Prior to trenching, the CONTRACTOR shall locate all cables, conduits, sewers, septic tanks, and other such underground utilities, and shall take proper precautions not to damage or disturb such improvements. If a conflict exists between such obstacles and the proposed WORK, the CONTRACTOR shall promptly notify the ENGINEER.
B. The CONTRACTOR shall be responsible for coordinating its work with the operation of existing utilities and new utilities on the Project. The CONTRACTOR shall notify the ENGINEER or its representative when operating utilities require shut-off.
C. Due to the scale of Drawings, it is not possible to indicate all offset fittings, etc., which may be required. The CONTRACTOR shall carefully investigate the structural and
finished conditions affecting all its WORK, and plan accordingly, providing such fittings, etc., as may be required to meet such conditions. The Contract Documents are generally diagrammatic and indicative of the WORK to be installed. The WORK shall be installed in the most direct and workmanlike manner, so that conflicts between sprinkler systems, planting, structures, and piping, will be avoided.

D. The CONTRACTOR shall verify the water pressure available at the Site before installation of the system to make sure there is adequate pressure (design pressure 60 psi) to properly operate sprinkler heads and valves, and shall also provide pressure reducing valves if required. If the pressure at Site or any other job condition will create problems that will prevent proper operation of the irrigation system, the ENGINEER shall be notified before commencement of any WORK. Minor additions and adjustments of heads, piping, and circuits shall be made at no additional cost to OWNER where it is necessary to make the irrigation system operate properly.

3.2 EXECUTION - GENERAL

A. Installation of the irrigation system shall be performed after the finish grading, but prior to landscaping.

B. Valves, fittings, heads, and piping shall be installed as indicated and all connections made to permit the irrigation system to function properly through its entire length.

C. Materials and equipment shall be installed in strict accordance with manufacturer's written instructions and recommendations and all local and state codes, laws, ordinances, and regulations.

D. Before proceeding with the installation of any section or unit of the irrigation system, the CONTRACTOR shall check and verify the correlation between ground measurements and Drawings and shall advise the ENGINEER of any discrepancies.

3.3 EXCAVATION

A. Trenches shall be dug as wide and as deep as necessary to properly install the irrigation lines. Width shall allow for proper tamping of backfill around the pipe.

B. Pipe trenches shall be straight or "snaked" slightly allowing for expansion and contraction of PVC pipe.

C. Subsoil shall be kept separate from topsoil, where possible.

D. Minimum cover depth shall be:

1. Supply pressure lines from water source to control valves: 24-inches unless otherwise indicated.

2. Lateral lines from control valves to sprinkler heads; 12-inches unless otherwise indicated. Lateral lines under paving, roadways, and driveways shall have 24-inches of cover and be located in Schedule 40 PVC sleeves.

3. Trenches for control wire only shall be 18-inches deep unless otherwise indicated. Control wires under concrete walks and slabs, paving, roadways, and driveways shall be installed in Schedule 40 PVC sleeves.

4. Maximum depth for all pipes to be buried on levee slopes is 8".
3.4 PIPING - GENERAL

A. Piping shall be laid out and installed in accordance with manufacturer’s printed recommendations and industry standards. Substantial support shall be provided at all points, and pipes shall be snaked slightly allowing for expansion and contraction.

B. Minimum one-inch vertical clearance shall be between lines crossing at angles greater than 45 degrees.

C. Horizontal and vertical clearances between all lines shall be minimum 3-inches.

D. Swing or swivel joints shall provide a leak-resistant joint with freedom of movement.

E. Teflon thread sealant shall be used at threaded joints.

F. Galvanized steel pipes shall have clean standard threads of standard lengths. Joints shall be made up with pipe compound applied to male threads only and not more than 2 threads shall show at the joints when connected.

G. Pipe sleeves shall be provided under all paving and where necessary for passage under finish surface material, future replacement, and for protection of PVC piping and control wire. Pipe sleeves shall extend at least 12-inches beyond the edge of pavement.

3.5 PLASTIC PIPE

A. The plastic pipe sections shall be placed accurately to line and grade in the prepared trenches. The inside of all pipe shall be clean and free from foreign matter and shall be end-reamed to remove burrs and provide full inside diameter of the pipe end.

B. Pipe shall have a firm, uniform bearing for the entire length of each pipeline to prevent uneven settlement. Adjustments to grade shall be made by scraping away or filling in with clean earth backfill material, well compacted under the body of the pipe. Wedging of pipe will not be permitted. The inside of pipe shall be clean and free from foreign materials before joints are assembled.

C. Open pipe ends where the WORK has been stopped shall be closed at the end of each day’s construction work with a suitable temporary plug to prevent entrance of any foreign materials into the assembled pipeline.

D. Pressure pipe shall be defined as all piping lying “upstream” from remote control valves and quick-coupling lines.

E. O-Ring type flexible coupling pipe shall be used on pressure pipes larger than 2-inches diameter.

F. Three-inch and smaller mainlines and fittings of pressure piping shall be solvent-weld type.

G. Pressure piping 3-inches and larger shall be provided with portland cement concrete thrust blocks. Thrust blocks shall be constructed at the following places:

1. Where pipe changes direction at fittings.

2. Where pipe changes size.
3. Where line terminates.

4. Around gate valves (bottom half of valve in concrete; bolts exposed for change of top half).

H. Thrust blocks shall be constructed of 2000 psi concrete, as follows:

<table>
<thead>
<tr>
<th>THRUST BLOCKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe Size</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>3-inches</td>
</tr>
<tr>
<td>4-inches</td>
</tr>
</tbody>
</table>

I. The areas given in the table shall be measured in a plane perpendicular to the longitudinal axis of the pipe or to the longitudinal axis of the thrust developed. The thrust block bearing area shall be against undisturbed ground.

3.6 VALVES

A. Valves shall be the full size of the line in which they are installed, unless otherwise indicated.

B. Remote control valves shall be enclosed in valve boxes. Valves shall be adjusted so the most remote sprinkler heads operate at the pressure recommended by the head manufacturer and so a uniform distribution of water is applied by the sprinkler heads to the planting areas. A metal union shall be provided on the discharge side of the control valve. They shall be wired to operate in the order indicated.

C. Gate valves shall be properly blocked to a cast-iron water works valve box. One 5-foot wrench for each 3 gate valves shall be furnished.

D. Quick-coupling valves shall be provided, with one-inch swing joint in the same manner as the pop-up sprinklers. Quick-coupler lines shall be installed not less than 18-inches below grade.

3.7 VALVE BOXES

A. Valve boxes shall be set 1/2-inch above the designated finish grade in lawn areas and 2-inches above finish grade in ground cover areas.

3.8 SPRINKLER HEADS

A. Nozzles on sprinklers shall be tightened after installation. Sprinklers having an adjustment stem shall be adjusted on a lateral line for the proper radius diameter and/or flow rate.

B. Sprinkler heads shall be set perpendicular to finished grades and at finish ground level unless otherwise indicated.
C. Emitters shall be coordinated with actual field placement of shrubs as directed by the ENGINEER.

D. The sprinkler system shall be thoroughly flushed as so to remove all possible foreign matter prior to installation of the sprinkler heads.

E. The CONTRACTOR shall protect against re-entry of contaminated water into risers or piping. After flushing, the CONTRACTOR shall immediately install sprinkler heads or cap risers until sprinkler heads are installed.

3.9 CONTROLLERS

A. Controller location on the Drawings is essentially diagrammatic, and the actual installation shall be as specifically located by the ENGINEER.

B. Applicable codes shall be followed in providing a 115 volt electrical service to the controller.

C. Pedestal mounted controllers shall have concrete pads in accordance with the manufacturer's printed recommendations.

D. The CONTRACTOR shall properly ground the control boxes to copper ground rods driven into the ground.

E. The ENGINEER will determine the timing, sequence, and period for the controller. Provide the manufacturer's recommended waterproof circuit breaker disconnect switch.

3.10 WIRING

A. Electrical equipment and wiring shall comply with applicable codes and shall be installed by those skilled and licensed in the trade.

B. 115 volt wire shall be installed in conduit, routed from the power source indicated.

C. The CONTRACTOR shall provide low voltage, 24 volt direct burial wires of not less than No. 14 AWG. Where sizes are not indicated, they shall be sized per wire manufacturer's sizing charts and specifications.

D. The CONTRACTOR shall provide all wiring, conduits, sleeves, and connection for the low voltage electrical system between controller and valves where indicated and necessary for a complete and operable irrigation system.

E. Wires shall be color coded as follows:
   1. Control wires shall be red.
   2. Ground (neutral) wire shall be white.

F. Splices shall be moisture proof using appropriate electrical connectors.

G. Wires shall be bundled together and wrapped with PVC tape at 5-foot intervals. They shall be buried in same trench as the pipe where possible.

H. An expansion curl shall be provided within 3-feet of each wire connection and at least every 100-ft of wire length on runs more than 100-feet in length. Expansion curls shall
be formed by wrapping at least 5 turns of wire around a one-inch pipe or more in diameter, then withdrawing pipe.

I. Conduits and sleeves necessary for running wires under concrete, walks, and paving shall be provided before concrete, walks, and paving work is constructed. Changes in conduit and sleeve direction under paving shall be made with sweep ells.

J. Wire shall be continuous without splices except at control valves, and shall be routed in main line trench whenever possible.

3.11 PIPE TRENCH BACKFILL

A. Bottom of trenches shall be smooth and free of sharp rocks and other objects that may damage pipe.

B. Backfill material shall be free of rocks and other materials that may damage the piping.

C. The initial backfill shall be accomplished by carefully tamping selected material (from material excavated from the trench) under the pipe and between the pipe and the trench walls.

D. The pipes shall be filled with water and pressurized during backfilling operations if necessary, to prevent drainage into piping.

E. The backfill shall be carefully installed around and over the pipe to approximately 10-inches of the ground surface, then water shall be allowed to flow in the trench. After this puddling operation has been completed and allowed to stand for 24 hours, the balance of the materials shall be placed in the trench to the sub-grade line, leaving room for topsoil. The backfill shall be compacted carefully and thoroughly.

F. Couplings and fittings shall be left exposed until leakage tests have been completed, unless the ENGINEER orders otherwise.

G. Topsoil shall be installed prior to planting.

3.12 TESTING AND ADJUSTMENTS

A. The sprinkler heads shall be adjusted and balanced for optimum and uniform coverage without excessive fogging and overthrow on walks, paving, and structures. The height and elevations of risers and sprinkler heads shall be adjusted.

B. Following adjusting and balancing of the sprinkler heads, an operating test of the entire system shall be performed by the CONTRACTOR in the presence of the ENGINEER at normal operating pressures. The test will be considered as acceptable if the system operates in a satisfactory manner providing uniform coverage of irrigated areas for a one week period of automatic operation with no leaks.

3.13 INSTRUCTION

A. The CONTRACTOR shall, upon completion of the maintenance period of the irrigation system, instruct the OWNER and the OWNER's personnel as to the proper operation and maintenance of the system.

-END OF SECTION-
PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide steel pipe, specials, and fittings, complete and in place, in accordance with the Contract Documents.

B. A single pipe manufacturer shall be made responsible for furnishing steel pipe, specials, fittings, and appurtenances such as bolts and gaskets for the WORK.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 – Contractor Submittals.

B. Furnish the following information with Shop Drawings:

1. Certified dimensional drawings of fittings and appurtenances.

2. Joint and pipe/fitting wall construction details which indicate the type and thickness of cylinder; the position, type, size, and area of reinforcement; coating and lining holdbacks, manufacturing tolerances, and other pertinent information required for the manufacture of the product.

3. Details for elbows, wyes, tees, outlets, connections, test bulkheads, and nozzles or other specials that indicate amount and position of reinforcement.

4. Fittings and specials, showing proper reinforcement to withstand the internal pressure, both circumferential and longitudinal, and the external loading conditions as indicated.

5. Material lists and steel reinforcement schedules that describe materials to be utilized, including metallurgical, chemical, and physical test reports from each heat of steel to verify the steel conforms to the indicated requirements.

6. Line layout and marking diagrams which indicate the specific number of each pipe and fitting, the location of each pipe, the direction of each fitting in the completed line, and the following:

   a. The pipe station and invert elevation at every change in grade or horizontal alignment.

   b. The station and invert elevation to which the bell end of each pipe will be laid.

   c. Elements of curves and bends, both in horizontal and vertical alignment.

   d. The limits within each reach of restrained and/or welded joints or of concrete encasement.

   e. Location and dimensional allocations for each indicated valve, fitting, and appurtenance.
7. Welds
   a. Submit full and complete information regarding location, type, size, and extent of welds.
   b. The Shop Drawings shall distinguish between shop and field welds.
   c. Shop Drawings shall indicate by welding symbols or sketches the details of the welded joints and the preparation of parent metal required to make them.
   d. Joints or groups of joints in which welding sequence or technique are especially important shall be carefully controlled to minimize shrinkage stresses and distortion.

8. Rubber gasket joint design and details.

9. Drawings showing the location, design, and details of bulkheads for hydrostatic testing of the pipeline, and details for removal of test bulkheads and repair of the lining.

10. Details and locations of closures for length adjustment and for construction convenience.

11. Detail drawings indicating the type, number, and other pertinent details of the slings, strutting, and other methods proposed for pipe handling during manufacturing, transport, and installation.

12. Manufacturer's Written Quality Assurance/Control Program.

C. Certifications

1. The CONTRACTOR shall furnish a certified affidavit of compliance for pipe and other products or materials in AWWA C200 - Steel Water Pipe 6 in and Larger, AWWA C205 - Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 in and Larger-Shop Applied, AWWA C207 - Steel Pipe Flanges for Waterworks Service - Sizes 4 In Through 144 In, AWWA C208 - Dimensions for Fabricated Steel Water Pipe Fittings, AWWA C210 - Liquid–Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines, AWWA C219 - Bolted, Sleeve-Type Couplings for Plain-End Pipe, and C222 - Polyurethane Coatings for the Interior and Exterior of Steel Water Pipelines and Fittings, and the following supplemental requirements:
   a. Physical and chemical properties of steel.
   b. Hydrostatic test reports.
   c. Results of production weld tests.
   d. Sand, cement, and mortar tests.
   e. Rubber gasket tests.

2. Performance and payment for sampling and testing necessary for certification are the CONTRACTOR's responsibility as part of the WORK.
D. Manufacturer’s Qualifications: Furnish a copy of manufacturer’s certification to ISO 9000, SPFA, or LRQA, and documentation of manufacturer’s experience in fabricating AWWA C200 pipe.

E. Design Calculations of Fittings and Specials: Furnish a copy of the design calculations for fittings and specials including miters, welds, and reinforcement, prior to manufacture of the pipe, fittings, and specials.

1.3 QUALITY ASSURANCE

A. Pipe Manufacturer Qualifications

1. The pipe manufacturer shall be certified to ISO 9000, the Steel Plate Fabricator’s Association (SPFA), or Lloyd’s Register Quality Assurance (LRQA), and shall be experienced in fabrication of AWWA C200 pipe of similar diameters, lengths, and wall thickness to this WORK.

2. Experience shall be in the production facilities and personnel, not the name of the company that owns the production facility or employs the personnel.

B. Inspection

1. Pipe shall be subject to inspection at the place of manufacture in accordance with the provisions of AWWA C200, C205, and C214, as supplemented by the indicated requirements.

2. The CONTRACTOR shall notify the ENGINEER in writing of the manufacturing start date not less than 14 Days prior to the start of any phase of the pipe manufacture.

C. Tests

1. Except as indicated otherwise, materials used in the manufacture of the pipe shall be tested in accordance with the requirements of AWWA C200, C205, and C214 as follows and as applicable:

   a. Joint gaskets shall be tested in accordance with AWWA C200.

   b. Shop Tests

      1) After the joint configuration is completed and prior to lining with cement mortar, each length of pipe of each diameter and pressure class shall be shop-tested and certified to a pressure of at least 75 percent of the yield strength of the steel.

      2) The test pressure shall be held for 2 minutes and the pipe visually inspected to confirm that welds are sound and leak-free.

   c. In addition to the tests required in AWWA C200, weld tests shall be conducted on each 5,000-feet of production welds and at any other times there is a change in the grade of steel, welding procedure, or welding equipment.

   d. Fittings fabricated from straight pipe previously passing a hydrostatic test need not have an additional hydrostatic test, provided that the welds are tested by nondestructive means and are demonstrated to be sound.
D. Shop Testing of Steel Plate Specials

1. If any special has been fabricated from straight pipe not previously tested and is of the type listed below, the special shall be hydrostatically tested with a pressure equal to 1-1/2 times the design working pressure: bends, wyes, crosses, tees with side outlet diameter greater than 30 percent of the main pipe diameter, and manifolds.

2. Specials not required to be hydrostatically tested shall be tested by liquid dye penetrant inspection method in accordance with ASTM E 165 - Standard Test Methods for Liquid Penetrant Examination, Method A, or the magnetic particle method in ASME Section VIII, Division 1, Appendix VI.

3. Reinforcing plates shall be tested by the solution method using approximately 40 psig air pressure introduced between the plates through a threaded test hole; the test hole shall be properly plugged following successful testing.

4. Weld Imperfections
   a. Weld defects, cracks, leaks, distortion, or signs of distress during testing shall require corrective measures.
   b. Weld defects shall be gouged out and re-welded.
   c. After corrections, the special shall be retested.

5. Test Heads
   a. Where welded test heads or bulkheads are used, extra length shall be provided to each opening of the special.
   b. After the removal of each test head, the special shall be trimmed back to the design points with finished plate edges ground smooth, straight, and prepared for the field joint.

6. Testing shall be performed before joints have been coated or lined.

7. Ultrasonic examination shall be performed in accordance with the following:
   a. Steel plate that will be in welded joints or welded stiffener elements shall be examined ultrasonically for laminar discontinuities where both of the following conditions exist:
      1) Any plate in the welded joint has a thickness exceeding 1/2 inch.
      2) any plate in the welded joint is subject to transverse tensile stress through its thickness during the welding or service.
   b. Ultrasonic examination may be waived where joints are designated to minimize potential laminar tearing.
   c. The ultrasonic examination shall be in accordance with ASTM A 578 - Straight Beam Ultrasonic Examination of Plain and Clad Steel Plates for Special Applications, with a Level I acceptance standard.
8. Plates that are not in conformance with the acceptance criteria in ASTM A 578 may be used in the WORK if the areas that contain the discontinuities are a distance at least 4 times the greatest dimension of the discontinuity away from the weld joint.

E. The CONTRACTOR shall be responsible for performing and paying for the indicated material tests.

F. The ENGINEER has the right to witness testing conducted by the CONTRACTOR, provided that the CONTRACTOR's schedule is not delayed for the convenience of the ENGINEER.

G. Additional Testing

1. In addition to those tests specifically required, the ENGINEER may request additional samples of any material including mortar lining and coating for testing by the OWNER.

2. The additional samples shall be furnished as part of the WORK.

H. Field Testing: Field testing shall be in accordance with the requirements of Section 017430 – Pressure Pipe Testing and Disinfection.

I. Welding Requirements

1. Welding procedures used to fabricate and install pipe shall be prequalified under the provisions of ANSI/AWS D1.1 - Structural Welding Code-Steel, or the ASME Boiler and Pressure Vessel Code, Section 9.

2. Welding procedures shall be required for longitudinal and girth or spiral welds for pipe cylinders, spigot and bell ring attachments, reinforcing plates and ring flange welds, and plates for lug connections.

J. Welder Qualifications

1. Welding shall be performed by skilled welders, welding operators, and tackers who have had adequate experience in the methods and materials to be used.

2. Welders shall be qualified under the provisions of ANSI/AWS D1.1 or the ASME Boiler and Pressure Vessel Code, Section 9 by an independent local, approved testing agency not more than 6 months prior to commencing WORK on the pipeline.

3. Machines and electrodes similar to those used in the WORK shall be used in qualification tests.

PART 2 – PRODUCTS

2.1 GENERAL

A. The 42-inch diameter steel pipe furnished shall be polyurethane lined and mortar coated if buried; polyurethane lined and System 4 coated if exposed. The buried 36-inch diameter steel pipe furnished shall be mortar lined and mortar coated. Furnished exposed steel piping 16-inch diameter through 36-inch diameter shall be mortar lined and System 4 coated. Furnished exposed steel piping 14-inch diameter and smaller shall be polyurethane lined and polyurethane coated.
B. Lined and coated steel pipe and specials shall conform to AWWA C200, C205, C210, and C222, subject to the following supplemental requirements:

1. The pipe, specials, and fittings shall be of the diameter and class indicated and shall be provided complete with rubber gaskets or welded joints as indicated.

2. For pipe, specials, and fittings, the nominal inside diameter after lining shall be not less than the indicated diameter, allowing for tolerances according to AWWA C200 and C205, as well as AWWA C222 as modified by Section 099610.

C. Markings

1. The manufacturer shall legibly mark pipe, specials, and fittings in accordance with the laying schedule and marking diagram.

2. Each pipe, special, and fitting shall be numbered in sequence and said number shall appear on the laying schedule and marking diagram in its proper location for installation.

3. Each pipe, fitting, and special shall be marked at each end with top field centerline.

D. Handling and Storage

1. The pipe, specials, and fittings shall be handled by use of wide slings, padded cradles, or other devices designed and constructed to prevent damage to the pipe coating and exterior.

2. The use of chains, hooks, or other equipment that might injure the pipe coating or exterior will not be permitted.

3. Stockpiled pipe, specials, and fittings shall be supported on padded skids, sand or earth berms free of rock exceeding 3 inches in diameter, sand bags, or suitable means so that the pipe including coating and lining coating will not be damaged.

4. Pipe, specials, and fittings shall not be rolled and shall be secured to prevent accidental rolling.

E. The CONTRACTOR shall replace or repair damaged pipe, specials, and fittings.

F. Strutting

1. Adequate strutting shall be provided on specials, fittings, and straight pipe in order to avoid damage to the pipe, specials, and fittings during handling, storage, hauling, and installation.

2. For mortar-lined steel pipe, specials, or fittings the following requirements shall apply:

   a. The strutting shall be placed as soon as practicable after the mortar lining has been applied and shall remain in place while the pipe, special, or fitting is loaded, transported, unloaded, installed, and backfilled at the Site.

   b. The strutting materials, size, and spacing shall be adequate to support the earth backfill plus any greater loads that may be imposed by the backfilling and compaction equipment.
c. Any pipe, special, or fitting damaged during handling, hauling, storage, or installation due to improper strutting shall be repaired or replaced.

G. **Laying Length:** The maximum pipe laying length shall be 48 feet, with shorter lengths to be provided as indicated and required.

H. **Lining:** The pipe, specials, and fittings shall have smooth, dense interior surfaces and shall be free from fractures, excessive interior surface crazing, and roughness.

I. **Closures and Correction Pieces:** Closures and correction pieces shall be provided as required such that closures may be made due to different headings in the pipe laying operation and such that corrections may be made to adjust the pipe laying to conform to the indicated pipe stationing.

2.2 **MATERIALS**

A. **Mortar**

1. Materials for mortar shall conform to the requirements of AWWA C205; provided that cement for mortar coating shall be Type II, and mortar lining shall be Type II.

2. Cement in mortar lining and coating shall not originate from kilns that burn metal-rich hazardous waste fuel, nor shall a fly ash or pozzolan be used as a cement replacement.

3. Admixtures shall contain no calcium chloride.

B. **Steel for Cylinder and Fittings**

1. Pipe, specials, and fittings manufactured under AWWA C200 shall satisfy the following requirements:
   a. minimum yield strength of steel: 42,000 psi
   b. manufactured by a continuous casting process
   c. fully kilned
   d. fine grain practice
   e. maximum carbon content: 0.25 percent
   f. maximum sulfur content: 0.015 percent
   g. minimum elongation: 22 percent in a 2-inch gauge length
   h. in accordance with one of the following Standards:
      1) ASTM A 1011 - Steel Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability
      2) ASTM A 283 - Low and Intermediate Tensile Strength Carbon Steel Plates
2. Testing

a. Steel equal to or greater than 1/2 inch thick used in fabricating pipe shall be tested for notch toughness using the Charpy V-Notch test in accordance with ASTM A 370 - Test Methods and Definitions for Mechanical Testing of Steel Products.

b. The frequency of testing shall be one impact test (set of 3 specimens - transverse, not longitudinal) for each coil used in manufacturing the pipe.

c. The testing frequency for sheets and plates shall be one impact test (set of 3 specimens) for each 30 tons of product.

d. The steel shall withstand a minimum impact of 25 ft-lb at a temperature of 30 degrees F.

C. Polyurethane: The polyurethane coating system for shall be in accordance with AWWA C222, as modified by Section 099610 – Polyurethane Coating on Pipe.

2.3 DESIGN OF PIPE

A. General

1. The pipe shall be suitable to transmit potable water or raw water, as indicated and under the indicated conditions.

2. The steel pipe shall have rubber-gasketed or field-welded joints as indicated.

3. The 42-inch diameter buried pipe shall consist of a steel cylinder, shop-lined with polyurethane in accordance with C222, as modified by Section 096610, and an exterior coating of cement mortar in accordance with C205.

4. The 42-inch diameter exposed pipe shall consist of a steel cylinder, shop-lined with polyurethane in accordance with C222, as modified by Section 096610 and exterior coated using System 4 in accordance with Section 099600.

5. The 36-inch diameter buried pipe shall consist of a steel cylinder, shop-lined with Portland cement mortar and an exterior coating of cement mortar in accordance with C205.

6. The exposed pipe 16-inch diameter through 36-inch diameter shall consist of a steel cylinder, shop-lined with Portland cement mortar in accordance with C205 and exterior coated using System 4 in accordance with Section 099600.

7. The exposed and submerged pipe 14-inch diameter and smaller shall consist of a steel cylinder, shop-lined and exterior coated with polyurethane in accordance with C222, as modified by Section 096610.
B. The pipe shall be designed, manufactured, tested, inspected, and marked according to applicable requirements as indicated and, except as indicated, shall conform to AWWA C200.

C. **Pipe Dimensions:** The pipe shall be of the diameter and minimum wall thickness indicated.

D. **Fitting Dimensions:** Fittings shall be of the diameter and class indicated.

E. **Joint Design**

1. Butt-strap joints shall be used only where required for closures or where indicated.

2. Unless indicated otherwise, the standard field joint for steel pipe shall be as indicated in the following table:

<table>
<thead>
<tr>
<th>Pipe Diameter</th>
<th>Application</th>
<th>Joint Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>42 inches and 36 inches</td>
<td>standard field joint</td>
<td>full penetration welded butt joint</td>
</tr>
<tr>
<td></td>
<td>field joint where indicated</td>
<td>restrained Carnegie gasket joint or restrained sleeve coupling</td>
</tr>
<tr>
<td></td>
<td>closures</td>
<td>butt strap joint</td>
</tr>
<tr>
<td>30 inches and smaller</td>
<td>standard field joint</td>
<td>full penetration welded butt joint</td>
</tr>
<tr>
<td></td>
<td>field joint where indicated</td>
<td>restrained Carnegie gasket joint, restrained sleeve coupling, or mechanical coupling</td>
</tr>
<tr>
<td></td>
<td>closures</td>
<td>butt strap joint</td>
</tr>
</tbody>
</table>

F. **Butt Joints for Field Welding:** Butt joints prepared for field welding shall be in accordance with AWWA C200.

G. **Carnegie Joints**

1. Field joints for steel pipe shall be steel joint rings with rubber gaskets (Carnegie joint) in accordance with AWWA C303.

2. The joints shall have the same or higher pressure rating as the adjoining pipe.

3. The clearance between faying surfaces shall be less than 1/8 inch.

4. The joints shall be fully restrained using a joint harness designed in accordance with AWWA Manual M-11.
H. Shop-applied interior linings and exterior coatings shall be held back from the ends of the pipe as indicated or as otherwise acceptable to the ENGINEER.

I. Restrained Joints

1. Designs shall include stresses created by the greater of:
   a. A temperature differential of 40 degrees F plus Poisson’s effect in combination with hoop stress, or;
   b. Thrust due to bulkheads, bends, reducers, and line valves resulting from working pressure in combination with hoop stress.

2. For field-welded joints, design stresses shall not exceed 50 percent of the specified minimum yield strength of the grade of steel utilized, or 21,000 psi, whichever is less, for the part being examined when longitudinal thrust is assumed to be uniformly distributed around the circumference of the joint.

2.4 SPECIALS AND FITTINGS

A. Design

1. Except as otherwise indicated, materials, fabrication and shop testing of specials and fittings shall conform to the requirements stated above for pipe and shall conform to the dimensions of AWWA C208.

2. The minimum thickness of plate for pipe from which specials are to be fabricated shall be the greatest of those determined by the following 3 criteria:
   a. Working and Transient Pressure Design

   \[
   T = \frac{P_w D}{2} \frac{Y}{S_w} \quad \quad T = \frac{P_t D}{2} \frac{Y}{S_t}
   \]

   Where:
   - \( T \) = Steel cylinder thickness in inches
   - \( D \) = Outside diameter of steel cylinder in inches
   - \( P_w \) = Design working pressure in psi
   - \( P_t \) = Design transient pressure in psi
   - \( Y \) = Specified minimum yield point of steel in psi
   - \( S_w \) = Safety factor of 2.5 at design working pressure
   - \( S_t \) = Safety factor at design transient pressure; for elbows 1.875 and 2.0 for other specials
   
   b. Mainline Pipe Thickness: Plate thickness for specials shall be not less than the adjacent mainline pipe.
c. Thickness Based on Pipe Diameter

<table>
<thead>
<tr>
<th>Nominal Pipe Diameter, inches</th>
<th>Pipe Manifolds Piping Above Ground Piping Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 and under</td>
<td>3/16 inch</td>
</tr>
<tr>
<td>25 to 48</td>
<td>1/4 inch</td>
</tr>
<tr>
<td>over 48</td>
<td>5/16 inch</td>
</tr>
</tbody>
</table>

B. Specials

1. Specials installed on saddle supports shall be designed to limit the longitudinal bending stress to a maximum of 10,000 psi.

2. Design shall be in accordance with the provisions of Chapter 7 of AWWA Manual M11.

C. Deflections and Angles

1. Moderate deflections and long radius curves may be constructed by means of beveled joint rings, by pulling standard joints, by using short lengths or pipe, or a combination of these methods provided that pulled joints shall not be used in combination with bevels.

2. The maximum total allowable angle for beveled joints shall be 5 degrees per pipe joint.

3. Bevels shall be provided on the bell ends.

4. Mitering of the spigot ends will not be accepted.

5. The maximum allowable angle for pulled joints shall be in accordance with the manufacturer's recommendations, or the angle which results from a 3/4-inch pull-out from normal joint closure, whichever is less.

6. Horizontal deflections or fabricated angles shall fall on the alignment.

7. Vertical Deflections
   a. Vertical deflections shall fall on the alignment and shall be at locations adjacent to underground obstructions, points of minimum earth cover, and pipeline outlets and structures.

   b. The pipe angle points shall match the indicated angle points.

D. Outlets, Tees, Wyes, Crosses, and Nozzles

1. Outlets 12 inches and smaller may be fabricated from Schedule 30 or heavier steel pipe in the standard outside diameters, that is, 12-3/4-inch, 10-3/4-inch, 8-5/8-inch, 6-5/8-inch, and 4-1/2-inch.
2. The minimum plate thickness for reinforcements shall be 10-gauge.

3. The outlet reinforcement design shall be in accordance with the procedures given in Chapter 13 of AWWA Manual M11, and the design pressures and factors of safety indicated above.

4. In lieu of saddle or wrapper reinforcement as provided by the design procedure in Manual M11, pipe or specials with outlets may be fabricated entirely of steel plate having a thickness equal to the sum of the pipe wall plus the required reinforcement.

5. Where Manual M11 requires the design procedure for crotch plate reinforcement, such reinforcement shall be provided.

6. Reinforcing Plates
   a. Outlets shall be fabricated such that there is always at least a 12-inch distance between the outer edge of the reinforcing plate and any field-welded joints.
   b. For outlets without reinforcing plates, outlets shall penetrate the steel cylinders so that there is at least a 12-inch clearance between the outlet and any field-welded joints.

7. Tees, wyes, crosses, elbows, and manifolds shall be fabricated such that the outlet clearances and reinforcing plates from any weld joints are a minimum of 5 times cylinder thickness or 2 inches, whichever is greater.

8. Longitudinal weld joints in adjacent cylinder sections shall be oriented such that there is a minimum offset of 5 times cylinder thickness or 2 inches, whichever is greater.

9. Reinforcement
   a. Reinforcement for wyes, tees, outlets, and nozzles shall be designed in accordance with AWWA Manual M11.
   b. Reinforcement shall be designed for the design pressure indicated and shall be as indicated.

10. Specials and fittings shall be equal in pressure design strength and shall have the same lining and coating as the adjoining pipe.

11. Unless otherwise indicated, the minimum radius of elbows shall be 2.5 times the pipe diameter and the maximum miter angle on each section of the elbow shall not exceed 11-1/4 degrees.

E. Steel welding fittings shall conform to ASTM A 234 - Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.

F. Ends for Mechanical-Type Couplings
   1. Except as otherwise indicated, where mechanical-type couplings are indicated the ends of pipe shall be banded with Type C collared ends using double fillet welds.
   2. Where pipe 12-inch and smaller is furnished in standard schedule thickness and where the wall thickness equals or exceeds the coupling manufacturer's minimum wall thickness, the pipe ends may be grooved.
2.5 CEMENT-MORTAR LINING

A. Cement-Mortar Lining for Shop Application

1. Unless indicated otherwise, interior surfaces of 16-inch diameter through 36-inch diameter pipe, specials, and fittings shall be cleaned and lined in the shop with cement mortar lining applied centrifugally in conformity with AWWA C205.

2. During the lining operation and thereafter, the pipe, specials, and fittings shall be maintained in a round condition by suitable bracing or strutting.

3. The lining machines shall be of a type that has been used successfully for similar work.

4. Every precaution shall be taken to prevent damage to the lining.

5. If the lining is damaged or found defective at the Site, the damaged or unsatisfactory portions shall be replaced with lining conforming to the indicated requirements.

B. The minimum lining thickness and tolerance shall be in accordance with AWWA C205.

C. Field Joints

1. The pipe shall be left bare as indicated where field joints occur.

2. Ends of the linings shall be left square and uniform.

3. Feathered or uneven edges will not be accepted.

D. Defective Linings

1. Defective linings, as determined by the ENGINEER, shall be removed from the pipe wall and shall be replaced to the full thickness required.

2. Defective linings shall be cut back to a square shoulder in order to avoid feather-edged joints.

E. The progress of the application of mortar lining shall be regulated in order that handwork, including the repair of defective areas, is cured in accordance with the provisions of AWWA C205.

F. Cement mortar for patching shall be the same materials as the mortar for machine lining, except that a finer grading of sand and mortar richer in cement shall be used when field inspection indicates that such mix will improve the finished lining of the pipe.

G. Hand-Applied Linings

1. Specials and fittings that cannot be mechanically lined and coated shall be lined and coated by hand-application using the same materials as used for the pipe and in accordance with the applicable AWWA or ASTM standards and as indicated.

2. Coating and lining applied in this manner shall provide protection equal to that for the pipe.
3. Fittings may be fabricated from pipe that has been mechanically lined and/or coated.

4. Areas of lining and coating that have been damaged by such fabrication shall be repaired by hand-application.

H. Cement-Mortar Lining for Field Application

1. Unless otherwise indicated, steel pipe shall be mortar-lined.

2. The materials and design of in-place cement mortar lining shall be in accordance with AWWA C602 and the following supplementary requirements:
   a. Pozzolanic material shall not be used in the mortar mix.
   b. Admixtures shall contain no calcium chloride.
   c. The minimum lining thickness shall be as indicated for shop-applied cement mortar lining, and finished inside diameter after lining shall be as indicated.
   d. Temperature and shrinkage cracks in the mortar less than 1/16 inch wide need not be repaired, whereas pipe, specials, or fittings with mortar cracks wider than 1/16 inch shall be rejected.

I. Protection of Pipe Lining/Interior

1. For pipe, specials, and fittings with plant-applied cement-mortar linings, the CONTRACTOR shall provide a 12-mil polyethylene sheet or other suitable bulkhead on the ends of the pipe and on each opening to prevent the lining from drying out.

2. Bulkheads shall be substantial enough to remain intact during shipping and storage until the pipe is installed.

2.6 POLYURETHANE LINING

A. Unless indicated otherwise, interior surfaces of pipe 14-inch diameter and smaller and 42-inch diameter pipe, specials, and fittings shall be lined with polyurethane in conformity with AWWA C222, as modified by Section 099610 – Polyurethane Coating on Pipe.

B. Protection of Pipe Lining/Interior

1. The CONTRACTOR shall provide a 12-mil polyethylene sheet or other suitable bulkhead on the ends of the pipe and on each opening to protect the lining.

2. Bulkheads shall be substantial enough to remain intact during shipping and storage until the pipe is installed.

2.7 EXTERIOR COATING OF PIPE

A. **Exterior Coating of Exposed Piping:** The exterior surfaces of pipe, specials, and fittings that will be exposed to the atmosphere inside structures or above ground shall be thoroughly cleaned and then given a shop coat of primer compatible with the finish coating application by paragraph 2.3 A.
B. Exterior Coating of Buried Piping

1. Pipe for buried service, including bumped heads, shall be coated with a minimum one-inch thickness of reinforced cement-mortar coating.

2. Unless otherwise indicated, exterior surfaces of pipe or fittings passing through structure walls shall be cement-mortar coated from the center of the wall or from the wall flange to the end of the underground portion of pipe or fitting.

3. The coating shall be reinforced with a spiral wire reinforcement or welded wire fabric in accordance with AWWA C205.

4. The welded wire fabric shall be securely fastened to the pipe with welded clips or strips of steel.

5. The wire shall be spaced 2 inches on centers and shall extend circumferentially around the pipe.

6. The ends of reinforcement strips shall be lapped 4 inches, and the free ends shall be tied or looped to assure continuity of the reinforcement.

2.8 PIPE APPURtenANCES

A. Pipe appurtenances shall be in accordance with the requirements as indicated.

B. Access manholes with covers shall be as indicated, installed during fabrication and not in the field.

C. Threaded outlets shall be forged steel suitable for 3000-psi service, and shall be as manufactured by Vogt, or equal.

PART 3 – EXECUTION

3.1 INSTALLATION OF PIPE

A. Handling and Storage

1. Pipe, specials, and fittings shall be carefully handled and protected against damage to lining and coating/interior and exterior surfaces, and impact shocks and free fall.

2. Pipe, specials, and fittings shall not be placed directly on rough ground but shall be supported in a manner that will protect the pipe against injury whenever stored at the Site or elsewhere.

3. Pipe, specials, and fittings shall be handled and stored at the Site in accordance with the requirements indicated in Part 2, above.

4. No pipe shall be installed when the lining or coating, or interior or exterior surfaces show cracks that may be harmful as determined by the ENGINEER.

5. Such damaged lining and coating, and interior and exterior surfaces shall be repaired or a new undamaged pipe, special, or fitting shall be provided.

B. Pipe damaged prior to Substantial Completion shall be repaired or replaced.
C. The CONTRACTOR shall inspect each pipe, special, and fitting for damage.

D. The CONTRACTOR shall remove or smooth out any burrs, gouges, weld splatter, or other small defects prior to laying the pipe, special, or fitting.

E. Cleaning

1. Before the placement of pipe, specials, or fittings in the trench, each shall be thoroughly cleaned of any foreign substance that may have collected thereon and shall be kept clean thereafter.

2. For this purpose, the openings of pipes, specials, and fittings in the trench shall be closed during any interruption to the WORK.

F. Placement

1. Pipe, specials, and fittings shall be laid directly on the imported bedding material.

2. No blocking will be permitted, and the bedding shall be such that it forms a continuous, solid bearing for the full length of the pipe, special, or fitting.

3. Excavations shall be made as needed to facilitate removal of handling devices after the item has been laid.

4. Bell holes shall be formed at the ends of the pipe to prevent point loading at the bells or couplings.

5. Excavation outside the normal trench section shall be made at field joints as needed to permit adequate access to the joints for field connection operations and for application of coating on field joints.

6. Except for short runs that may be permitted by the ENGINEER, pipes shall be laid uphill if on grades exceeding 10 percent.

7. Pipe that is laid on a downhill grade shall be blocked and held in place until sufficient support is furnished by the following pipe to prevent movement.

8. Bends shall be installed as indicated.

G. Installation Tolerances

1. Each section of pipe, special, or fitting shall be laid in the order and position on the laying diagram and in accordance with the following:

   a. Each section of pipe, special, or fitting having a nominal diameter less than 48 inches shall be laid to line and grade, within plus or minus 2 inches horizontal deviation and plus or minus one inch vertical deviation.

   b. Each section of pipe, special, or fitting having nominal diameter 48 inches and larger shall be laid to line and grade, within plus or minus 5 percent of diameter horizontal deviation and plus or minus 2.5 percent of diameter vertical deviation.
c. In addition to the horizontal and vertical tolerances above, the pipe shall be laid so that no high or low points other than those on the laying diagram are introduced.

d. After installation, the pipe, specials, and fittings shall not show deflection greater than:

1) Mortar-lined and mortar-coated pipe, specials, and fittings: 1.5 percent

2) Mortar-lined and flexible-coated pipe, specials, and fittings: 2.25 percent

3) Flexible-lined and flexible-coated or bare pipe, specials, and fittings: 3.0 percent

e. The allowable deflection shall be based on the design inside diameter.

H. Test Section

1. At the beginning of pipe laying operations, the CONTRACTOR shall perform a test section to demonstrate that the methods and materials to be used will satisfy the pipe zone backfill compaction and pipe deflection criteria.

2. The maximum length of the test section shall be 500 feet.

3. The CONTRACTOR shall not proceed with production pipe laying beyond the test section without the ENGINEER's approval.

4. The entire test section length that does not comply with the Contract Documents shall be reworked as necessary to comply.

5. The ENGINEER will observe construction of the test section.

6. The OWNER will take measurements and keep records for quality assurance purposes.

7. Any change in means, methods, and trench conditions, including excavation, bedding, and pipe zone materials, in situ soils, water conditions, and backfill and compaction methods shall require another successful test section before additional production pipe installation.

I. Changes in Alignment and/or Grade

1. Where necessary to raise or lower the pipe, specials, or fittings due to unforeseen obstructions or other causes, the ENGINEER may change the alignment and/or the grade.

2. Such change shall be made by the deflection of joints, by the use of bevel adapters, or by the use of additional fittings, although in no case shall the deflection in a joint exceed 75 percent of the maximum deflection recommended by the pipe manufacturer.

3. No joint shall be misfit any amount that will be detrimental to the strength and water tightness of the finished joint.
4. In each case the joint opening, before finishing with the protective lining inside the pipe, shall be the controlling factor.

J. Struts

1. Struts in pipe 42-inch diameter and larger shall be left in place until backfilling operations have been completed.

2. Struts in pipe smaller than 42-inch may be removed immediately after laying.

3. A laboratory selected and paid by the OWNER may monitor pipe deflection by measuring pipe inside diameter before struts are removed and 24 hours after struts are removed.

4. Pipe deflection shall not exceed 3 percent 24 hours after the struts have been removed.

5. After the backfill has been placed, the struts shall be removed and shall remain the property of the CONTRACTOR.

K. Cold Weather Protection

1. No pipe, special, or fitting shall be installed upon a foundation into which frost has penetrated or at any time that there is a danger of the formation of ice or penetration of frost at the bottom of the excavation.

2. No pipe, special, or fitting shall be laid unless it can be established that the trench will be backfilled before the formation of ice and frost occurs.

L. Pipe, Specials, and Fitting Protection

1. The openings of pipe, specials, and fittings shall be protected with suitable bulkheads to maintain a moist atmosphere and to prevent unauthorized access by persons, animals, water, or any undesirable substance.

2. The bulkheads shall be designed to prevent the drying out of the interior of the pipe, specials, and fittings.

3. The CONTRACTOR shall introduce water into the pipe to keep the mortar moist if moisture has been lost due to damaged bulkheads.

4. Means shall be provided to prevent the pipe from floating due to water in the trench from any source.

5. Pipe that has floated shall be repaired, including restoration to original condition and profile.

M. Pipe Cleanup

1. As pipe laying progresses, the CONTRACTOR shall keep the pipe interior free of debris.

2. The CONTRACTOR shall completely clean the interior of the pipe of sand, dirt, mortar splatter, and any other debris following completion of pipe laying, pointing of
joints, and any necessary interior repairs prior to testing and disinfecting of the completed pipeline.

3.2 RUBBER GASKETED JOINTS

A. Rubber Gasketed Joints

1. Immediately before jointing pipe, the spigot end of the pipe shall be thoroughly cleaned, and a clean rubber gasket lubricated with a non-toxic vegetable-based lubricant shall be placed in the spigot groove.

2. The lubricant shall be a compound listed as in compliance with NSF Standard 61.

3. The volume of the gasket shall be "equalized" by moving a metal rod between the gasket and the spigot ring around the full circumference of the spigot ring.

4. The bell of the pipe already in place shall be carefully cleaned and lubricated with the vegetable-based lubricant.

5. The spigot of the pipe section shall then be inserted into the bell of the previously laid joint and telescoped into its proper position.

6. Tilting of the pipe to insert the spigot into the bell will not be permitted.

7. After the pipe units have been joined, a feeler gauge shall be inserted into the recess and moved around the periphery of the joint to detect any irregularity in the position of the rubber gasket.

8. If the gasket cannot be "felt" all around, the joint shall be disassembled and the joint shall be reassembled with a new gasket.

B. Double Gasket Lap Joints

1. Double gasket lap joints shall be air-tested by shop drilling and tapping for 1/8-inch or 1/4-inch national pipe thread in the lap or bell end of the pipe.

2. Apply 40 psig of air or other satisfactory gas into the connection between the 2 gaskets.

3. Test pressure shall be measured with a minimum 4-inch diameter pressure gauge with a range no greater than 0 to 100 psig.

4. The air test shall consist of holding the test pressure undiminished for 5 minutes.

5. If the test fails, the joint shall be disassembled and reassembled with new gaskets.

6. After the repair is made, the joint shall be checked by repeating the original test procedure.

7. After a successful test, close the threaded opening with a pipe plug or by welding.
3.3 WELDED JOINTS

A. General

1. Prior to beginning the welding procedure, any tack welds used to position the pipe during laying shall be removed.

2. Any annular space between the faying surfaces of the bell and spigot shall be equally distributed around the circumference of the joint by shimming, jacking, or other suitable means.

3. Where more than one pass is required, each pass except the first and final ones shall be peened to relieve shrinkage stresses, and dirt, slag, and flux shall be removed before the succeeding bead is applied.

4. Prior to butt welding, the pipe and joint shall be properly positioned in the trench using line up clamps so that, in the finished joint, the abutting pipe sections shall not be misaligned more than 1/16 inch.

5. Unless double fillet welds are indicated, field welded lap joints may, at the CONTRACTOR's option, be made on either the inside or the outside of the pipe.

6. Field welded joints shall be in accordance with AWWA C206 - Field Welding of Steel Water Pipe.

7. Where exterior welds are performed, adequate space shall be provided for welding and inspection of the joints.

8. Butt straps shall be as indicated.

9. A heat resistant shield shall be draped over at least 24-inches of coating beyond the holdback on both sides of the weld during welding to avoid damage to the coating by hot weld splatter.

10. Welding grounds shall not be attached to the coated part of the pipe.

B. Backfilling

1. After the pipe and joint are properly positioned in the trench, the length of pipe between joints shall be backfilled to at least one foot above the top of the pipe.

2. Care shall be exercised during the initial backfilling to prevent movement of the pipe and to prevent any backfill material from being deposited on the joint.

C. Temperature Stresses

1. To control temperature stresses, the unbackfilled joint areas of the pipe shall be shaded from the direct rays of the sun by the use of properly supported awnings, umbrellas, tarpaulins, or other suitable materials for a minimum period of 2 hours prior to the beginning of the welding operation and until the weld has been completed.

2. Shading materials at the joint area shall not rest directly on the pipe but shall be supported to allow air circulation around the pipe.
3. Shading of the pipe joints need not be performed when the ambient air temperature is below 45 degrees F.

D. Shrinkage Control Joints

1. At intervals not exceeding 250 feet along welded reaches of the pipeline and at the first regular lap-welded field joints outside concrete encasements and structures, the pipe shall be laid with an initial lap of not less than one inch greater than the minimum lap dimension.

2. The welding of each such shrinkage control joint shall be performed when the temperature is approximately the lowest during the 24 hour day, after at least 250 feet of pipe have been laid and the joints have been welded ahead of and in back of the shrinkage control joint, and after backfill has been completed to at least one foot above the top of the pipe ahead of and in back of the shrinkage control joint.

3. Where shrinkage control joints occur in a traveled roadway or other inconvenient location, the location of the shrinkage control joint may be adjusted, as acceptable to the ENGINEER.

E. Inspection of Field-Welded Joints

1. An independent testing laboratory acceptable to the ENGINEER but paid by the CONTRACTOR shall inspect the joints.

2. Inspection shall be as soon as practicable after the welds are completed.

3. Fillet welds shall be tested by the Magnetic Particle Inspection Method in accordance with ASME Section VIII, Division 1, Appendix VI.

4. Double-Welded Lap Joints
   a. Double-welded lap joints shall be air-tested by shop drilling and tapping for 1/8-inch or 1/4-inch national pipe thread in the lap or bell end of the pipe.
   b. Apply 40 psig of air or other satisfactory gas into the connection between the 2 fillet welds.
   c. Test pressure shall be measured with a minimum 4-inch diameter pressure gauge with a range no greater than 0 to 100 psig.
   d. The air test shall consist of holding the test pressure undiminished for 5 minutes.
   e. If the air test fails, paint the welds with a soap solution and mark any leaks indicated by the escaping gas bubbles.
   f. Leaking portions of the welds or defective welds shall be removed and re-welded.
   g. The amount of material removed shall be limited to that required to correct the defect.
   h. After the repair is made, the joint shall be checked by repeating the original test procedure.
5. Butt welds shall be inspected by radiographic methods in accordance with API Standard 1104.

F. Following tests of the joint, the exterior joint spaces shall be coated as indicated, after which backfilling may be completed.

G. Repair of Welds

1. Defective welds shall be repaired by the CONTRACTOR to meet the indicated requirements.

2. Defects in welds or defective welds shall be removed, and that section of the joint shall then be re-welded.

3. Only sufficient removal of defective material that is necessary to correct the defect shall be required.

4. After the repair is made, the joint shall be checked by repeating the original test procedure.

5. Welds deficient in size shall be repaired by adding weld metal.

3.4 JOINT COATING AND LINING

A. General

1. The interior and exterior joint recesses shall be thoroughly wiped clean.

2. Remove water, loose scale, dirt, and other foreign material from the inside surface of the pipe.

B. Testing

1. The ENGINEER will test each joint with an electrical detector, furnished by the CONTRACTOR and capable of at least a 12,000 volt output.

2. The tests will be performed using 6,000 to 7,000 volts.

3. The CONTRACTOR shall repair any holidays.

4. Re-Testing

   a. When a visual inspection indicates that a portion of the coating system has sustained physical damage, the CONTRACTOR shall perform an electrical holiday test of 6,000 to 7,000 volts.

   b. When the test indicates no holiday, a notation shall be applied to the area indicating the test is satisfactory.

C. Coating Repair

1. Mortar-Coated Pipe: Perform coating repairs on mortar-coated pipe in accordance with the requirements of AWWA C205.
2. Polyurethane-Coated Pipe: Perform coating repairs on polyurethane-coated pipe in accordance with the requirements of AWWA C222, as modified by Section 099610 – Polyurethane Coating on Pipe.

3. System 4 – Coated Pipe: Perform coating repairs on System 4 - coated pipe in accordance with the requirements of Section 099600 – Protective Coatings.

D. Coating of Fittings and Specials: Buried fittings and specials shall be coated in accordance with Section 099600 – Protective Coatings.

E. Joint Lining – Mortar Lined Pipe

1. After the backfill has been completed to final grade, the interior joint recess shall be filled with mortar.

2. Materials of construction for mortar shall be in accordance with the requirements of AWWA C602.

3. The mortar shall be tightly packed into the joint recess and troweled flush with the interior surface, and excess shall be removed.

4. At no point shall there be an indentation or projection of the mortar exceeding 1/16 inch.

5. With pipe smaller than 24-inch in diameter, before the spigot is inserted into the bell, the bell shall be daubed with mortar.

6. The joint shall be completed and excess mortar on the inside of the joint shall be swabbed out.

F. Joint Lining – Polyurethane Lined Pipe: Joints of polyurethane lined pipe shall be lined in conformity with AWWA C222, as modified by Section 099610 – Polyurethane Coating on Pipe.

3.5 INSTALLATION OF PIPE APPURTENANCES

A. Installation of Valves

1. Valves shall be handled in a manner to prevent any injury or damage to the valve or any part of it.

2. Joints shall be thoroughly cleaned and prepared prior to installation.

3. The CONTRACTOR shall adjust stem packing and operate each valve prior to installation to verify proper operation.

4. Valves shall be installed so that the valve stems are plumb and in the location indicated.

5. Buried valves and flanges shall be coated and protected in accordance with Section 099600 – Protective Coating.
B. Installation of Flanged Joints

1. Before the joint is assembled, the flange faces shall be thoroughly cleaned of foreign material with a power wire brush.

2. The gasket shall be centered and the connecting flanges drawn up watertight without unnecessarily stressing the flanges.

3. Bolts shall be tightened in a progressive diametrically opposite sequence and torqued with a suitable and calibrated torque wrench.

4. Clamping torque shall be applied to the nuts only.

5. Full-face reinforced rubber gaskets shall be applied to the inside face of blind flanges with adhesive.

C. Insulated Joints

1. Insulated joints and appurtenant features shall be provided as indicated.

2. The CONTRACTOR shall exercise special care when installing these joints in order to prevent electrical conductivity across the joint.

3. After the insulated joint is completed, an electrical resistance test shall be performed by the CONTRACTOR.

4. If the resistance test indicates a short circuit, the CONTRACTOR shall remove the insulating units to inspect for damage, replace all damaged portions, and reassemble the insulating joint.

5. The insulated joint shall then be retested to assure proper insulation.

D. Flexible Coupled Joints

1. When installing flexible couplings, care shall be taken that the connecting pipe ends, couplings, and gaskets are clean and free of dirt and foreign matter, with special attention given to the contact surfaces of the pipe, gaskets, and couplings.

2. The couplings shall be assembled and installed in conformance with the recommendations and instructions of the coupling manufacturer.

E. Bolting

1. Wrenches used in bolting couplings shall be of a type and size recommended by the coupling manufacturer.

2. Coupling bolts shall be tightened in such a manner as to secure a uniform annular space between the follower rings and the body of the pipe.

3. Bolts shall be tightened approximately the same amount.

4. Diametrically opposite bolts shall be tightened progressively and evenly.

5. Final tightening shall be performed with a suitable and calibrated torque wrench set for the torque recommended by the coupling manufacturer.
6. Clamping torque shall be applied to the nut only.

3.6 CORROSION CONTROL

A. Joint Bonding/Electrolysis Test Stations

1. Except where otherwise indicated, joints shall be bonded.

2. The pipe shall be cleaned to bare bright metal at the point where the bond is to be installed.

3. Electrolysis test stations shall be installed where indicated.

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PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide Process Control and Instrumentation Systems (PCIS) complete and operable, in accordance with the Contract Documents.

B. The CONTRACTOR shall provide all training and documentation for the Instrumentation Systems, in accordance with the Contract Documents.

C. The requirements of this Section apply to every component of the PCIS unless indicated otherwise.

D. Responsibilities

1. The CONTRACTOR, through the use of a SYSTEM INTEGRATOR and qualified electrical and mechanical installers, shall be responsible to the OWNER for the implementation of the PCIS and the integration of the PCIS with other required instrumentation and control devices.

2. Due to the complexities associated with the interfacing of numerous control system devices, it is the intent of these specifications that the SYSTEM INTEGRATOR be responsible to the CONTRACTOR for the integration of the PCIS with existing devices and devices provided under other sections with the objective of providing a completely integrated control system free of signal incompatibilities.

   a. All RD-2035 RTU, PLC, OIT, networks, devices, instruments, panels, testing, and all other work shall be provided by PCIS. All programming for the RD-2035 RTU, OIT, Remote SCADA, and radio will be developed and provided by PCIS, except for interlock coordination between RD-2035 and WDCWA which shall be joint effort of WDCWA and PCIS.

   b. All WDCWA PLC and SCADA hardware, panels, testing and all other work shall be provided by PCIS.

      1) All programming for the WDCWA PLC, SCADA Workstation, and radio system will be developed and provided by WDCWA, except for interlock coordination between RD-2035 and WDCWA which shall be joint effort of WDCWA and PCIS.

3. As a minimum, the SYSTEM INTEGRATOR shall perform the following WORK:

   a. Implementation of the PCIS

      1) prepare analog hardware submittals

      2) design, develop, and electronically draft loop drawings and control panel designs

      3) prepare the test plan, the training plan, and the spare parts submittals

      4) procure hardware
5) fabricate panels
6) perform RTU programming and SCADA HMI programming
7) perform factory tests on panels
8) perform bench calibration and verify calibration after installation
9) oversee and certify installation
10) oversee, document, and certify loop testing
11) oversee, document, and certify system commissioning
12) conduct the performance test
13) prepare Technical Manuals
14) conduct training classes
15) prepare record drawings
16) coordination with WDCWA for pump station interlocks (as defined hereinafter)
17) coordination with WDCWA for testing of WDCWA PLC and SCADA Workstation software

b. Integration of the PCIS with instrumentation and control devices provided under other sections;

1) Develop requisite loop drawings and record loop drawings associated with equipment provided under other Divisions of these Specifications and OWNER-furnished and existing equipment.

2) Resolve signal, power, or functional incompatibilities between the PCIS and interfacing devices.

4. Any SYSTEM INTEGRATOR responsibilities in addition to the list above are at the discretion of the CONTRACTOR and the SYSTEM INTEGRATOR. Additional requirements in this Section and throughout Division 40 that are stated to be the CONTRACTOR's responsibility may be performed by the SYSTEM INTEGRATOR if the CONTRACTOR and SYSTEM INTEGRATOR so agree.

E. SYSTEM INTEGRATOR Qualifications

1. Prior to acceptance for the performance of this WORK, the CONTRACTOR shall demonstrate the SYSTEM INTEGRATOR adheres to the following qualifications:

a. SYSTEM INTEGRATOR must provide proof of successful completion of previous projects over the prior three years, at minimum, and shall be subject to one or more audits, at the OWNER's discretion, before, during, or after the project. Successful project completion includes, but is not limited to, delivery in accordance with contract obligations, delivery within the contract schedule, and delivery of prompt positive response to field failures.
b. SYSTEM INTEGRATOR shall supply examples of and references from at least three similar projects that they have successfully completed within the past five years involving the following communications networks.

1) Modbus
2) Ethernet

c. SYSTEM INTEGRATOR shall supply examples and references from at least three similar projects that they have successfully completed within the past five years involving each of the following hardware and software (software versions to be current version at the time work performed).

1) SCADAPack RTUs and Telepace development software by Schneider
2) Magelis Series OITs and Vijeo Designer development software by Schneider
3) LabVIEW HMI software by National Instruments

d. SYSTEM INTEGRATOR shall have an office or location staffed with competent engineers that shall be used for the Work within 200 miles of the job site.

e. The SYSTEM INTEGRATOR shall supply detailed resumes and work experience for the staff that shall be working on the project. This requirement shall apply both to office staff and field staff of the SYSTEM INTEGRATOR. Because of the highly technical and skilled nature of the work, the OWNER shall retain the right of approval and removal of all SYSTEM INTEGRATOR staff.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 013300 - Contractor Submittals and the following:

1. Process Control and Instrumentation Systems (PCIS) WORK shall not commence until the SYSTEM INTEGRATOR Qualifications are submitted and approved.

2. The CONTRACTOR shall coordinate the PCIS WORK so that the complete instrumentation and control system will be provided and will be supported by accurate Shop Drawings and record drawings.

3. Exchange of Technical Information: During the period of preparation of these submittals, the CONTRACTOR shall authorize a direct, informal liaison with the ENGINEER for exchange of technical information. As a result of this liaison, certain minor refinements and revisions in the systems as indicated may be authorized informally by the ENGINEER, but will not alter the scope of WORK or cause increase or decrease in the Contract Price. During this informal exchange, no oral statement by the ENGINEER shall be construed to give approval of any component or method, nor shall any statement be construed to grant exception to or variation from these Contract Documents.

4. Symbology and Nomenclature: In these Contract Documents, systems, meters, instruments, and other elements are represented schematically, and are designated by symbology as derived from Instrument Society of America Standard ISA S5.1 -
Instrumentation Symbols and Identification. The nomenclature and numbers designated herein and on the Drawings shall be employed exclusively throughout Shop Drawings, and similar materials. No other symbols, designations, or nomenclature unique to the manufacturer’s standard methods shall replace those prescribed above, used herein, or on the Drawings.

B. Presubmittal Conference

1. The CONTRACTOR shall arrange and conduct a Presubmittal Conference within 90 Days after award of the Contract. The purpose of the Presubmittal Conference is to review and approve the manner in which the CONTRACTOR intends to carry out its responsibilities for Shop Drawing submittal on the WORK to be provided under this Section. The CONTRACTOR, the SYSTEM INTEGRATOR, and the ENGINEER shall attend. Both the CONTRACTOR and the ENGINEER may invite additional parties at their discretion.

2. The CONTRACTOR shall allot one, 4 hour day for the Conference.

3. The CONTRACTOR shall present the following for discussion at the Conference:
   a. A bar-chart type schedule for system-related activities from the Presubmittal Conference through start-up and training. Dates of submittals, design, fabrication, programming, factory testing, deliveries, installation, field testing, and training shall be shown. The schedule shall be subdivided to show activities relative to each major item or group of items when everything in a given group is on the same schedule. The CONTRACTOR shall demonstrate during this meeting that the SYSTEM INTEGRATOR’S schedule is fully integrated into CONTRACTOR’S project schedule.
   b. A list of equipment and materials required for the PCIS and the manufacturer's name and model number for each proposed item.
   c. A list of proposed clarifications to the Contract Documents along with a brief explanation of each. Resolution shall be subject to a separate formal submittal and review by the ENGINEER.
   d. An exact one-to-one sample of each type of submittal herein.
   e. A flow chart showing the steps to be taken in preparing and coordinating each submittal to the ENGINEER.
   f. An overview of the proposed training plan. The OWNER’s staff and ENGINEER will review the overview and may request changes. Changes to the proposed training shall be resolved at the pre-submittal conference. The overview shall include the following for each proposed course.
      1) Course title and objectives.
      2) Prerequisite training and experience of attendees.
      3) Course content - a topical outline.
      4) Course duration.
      5) Course format - lecture, laboratory demonstration, etc.
4. The CONTRACTOR shall furnish 2 copies of the items above to the ENGINEER.

5. The CONTRACTOR shall take minutes of the Conference, including events, questions, and resolutions.

C. Shop Drawings

1. General

   a. Preparation of Shop Drawings shall not commence until adjournment of the Presubmittal Conference.

   b. Shop Drawings shall include the letter head or title block of the SYSTEM INTEGRATOR. The title block shall include, as a minimum, the SYSTEM INTEGRATOR’s registered business name and address, project name, drawing name, revision level, and personnel responsible for the content of the drawing. The quantity of submittal sets shall be as indicated in Section 013300 - Contractor Submittals.

   c. Organization of the Shop Drawing submittals shall be compatible with eventual submittals for later inclusion in the Technical Manual. Submittals not so organized and incomplete submittals for a given loop will not be accepted.

   d. Shop Drawing information shall be bound in standard size, 3 ring, looseleaf, vinyl plastic, hard cover binders suitable for bookshelf storage. Binder ring size shall not exceed 3-inches.

   e. Interfaces between instruments, motor starters, control valves, variable speed drives, flow meters, chemical feeders and other equipment related to the PCIS shall be included in the Shop Drawing submittal.

2. Hardware Equipment Submittal: The CONTRACTOR shall submit a complete bound package at one time within 120 Days after the commencement date stated in the Notice to Proceed, including:

   a. A complete index which lists each device by tag number, type, and manufacturer. A separate technical brochure or bulletin shall be included with each instrument data sheet. The data sheets shall be indexed in the submittal by systems or loops, as a separate group for each system or loop. If, within a single system or loop, a single instrument is employed more than once, one data sheet with one brochure or bulletin may cover multiple identical uses of that instrument in that system. Each brochure or bulletin shall include a list of tag numbers for which it applies. System groups shall be separated by labeled tags.

   b. Fully executed data sheets according to ISA TR20 - Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves, for each component, together with a technical product brochure or bulletin. The technical product brochures shall be complete enough to verify conformance to Contract Document requirements. The data sheets, as a minimum, shall show:

      1) Component functional description used in the Contract Documents

      2) Manufacturer’s model number or other product designation
3) Project tag number used in the Contract Documents
4) Project system or loop of which the component is a part
5) Project location or assembly at which the component is to be installed
6) Input and output characteristics
7) Scale, range, units, and multiplier (if any)
8) Requirements for electric supply (if any)
9) Requirements for air supply (if any)
10) Materials of component parts to be in contact with or otherwise exposed to process media and corrosive ambient air
11) Special requirements or features

c. Flow meter statement of accuracy. An accuracy statement and supporting calculations shall be submitted on the instrument manufacturer letterhead and shall include the following:
   1) Guaranteed meter accuracy based on the upstream and downstream straight runs associated with the location of each meter

d. Priced list of spare parts for every device.

e. Instrument installation, mounting, and anchoring details shall be submitted in an electronic MICROSTATION and hard copy format. Each instrument shall have a dedicated 8-1/2 inch by 11-inch detail that only pertains to the specific instrument by tag number. Each detail shall be certified by the instrument manufacturer that the proposed installation is in accordance with the instrument manufacturer's recommendations and is fully warrantable. These certifications shall be embedded in the CAD files and also appear as a stamp on the hard copies. As a minimum, each detail shall have the following contents;
   1) Show necessary sections and elevation views required to define instrument location by referencing tank, building or equipment names and numbers, and geographical qualities such as north, south, east, west, basement, first floor.
   2) Ambient temperature and humidity of the environment that the instrument is to be installed in.
   3) Corrosive qualities of the environment that the instrument is to be installed in.
   4) Hazardous rating of the environment that the instrument is to be installed in.
   5) Process line pipe or tank size, service, and material.
   6) Process tap elevation and location.
7) Upstream and downstream straight pipe lengths between instrument installation and pipe fittings and valves.

8) Routing of tubing and identification of supports.

9) Mounting brackets, stands, and anchoring devices.

10) Conduit entry size, number, location, and delineation between power and signal.

11) NEMA ratings of enclosures and components.

12) Clearances required for instrument servicing.

13) List itemizing manufacturer makes, model numbers, quantities, lengths required, and materials of each item required to support the implementation of the detail.

3. Project-Wide Loop Drawing Submittal: The CONTRACTOR shall furnish a Project-wide Loop Drawing Submittal (PLDS) which completely defines and documents the contents of each monitoring, alarming, interlock, and control loop associated with equipment provided under Division 40 sections, equipment provided under sections in other Divisions, existing, and OWNER-furnished equipment which is to be incorporated into the PCIS. The PLDS shall be a singular complete bound package electronically drafted in MICROSTATION, submitted 90 Days prior to beginning field terminations of control and signal wire, and shall include the following:

a. A complete index in the front of each bound volume. The loop drawings shall be indexed by systems or process areas. Loops shall be tagged in a manner consistent with the Contract Documents. Loop drawings shall be submitted for every analog and discrete monitoring and control loop.

b. Drawings showing definitive diagrams for every analog and every discrete instrumentation loop system. These diagrams shall show and identify each component of each loop or system using legend and symbols from ISA S5.4 - Instrument Loop Drawings, extending the format as shown on Drawing GI-1 and as defined by the most recent revision in ISA. Panel drawings showing RTU I/O module wiring may serve as the basis for the internal RTU wiring portion of the loop drawings. Wiring external to the RTU shall be detailed as defined herein. Each system or loop diagram shall be with no more than 8 loops per drawing. Loop drawings shall be developed for loops in equipment vendor-supplied packages, equipment provided under Division 40, and OWNER-furnished equipment. In addition to the expanded ISA S5.4 requirements, the loop diagrams shall also show the following details:

1) Functional name of each loop.

2) Reference name, drawing, and loop diagram numbers for any signal continuing off the loop diagram sheet.

3) Motor Control Center (MCC) panel, lighting panel, RTU, circuit, and breaker numbers for power feeds to the loops and instrumentation.

4) Motor Control Center (MCC), Reduced Voltage Solid State Starter (RVSS), Variable Frequency Drive (VFD), and Vendor Panel
terminations, termination identification wire numbers and colors, power circuits, and ground identifications.

5) Instrument panel and instrument terminations, termination identification wire numbers and colors, power circuits, and ground identifications.

6) RTU panel terminations, termination identification wire numbers and colors, power circuits, and ground identifications.

7) Designation, and if appropriate, terminal assignments associated with every manhole, pullbox, junction box, conduit, and panel through which the loop circuits pass.

8) Terminal boxes, isolation relays and current to current signal isolators serving as provision for wiring to future Woodland Davis equipment.

c. Itemized instrument summary. The summary shall be prepared with Microsoft Access software and shall be submitted as a hardcopy and electronic copy. The instrument summary shall list all of the key attributes of each instrument provided under this Contract. As a minimum, attributes shall include:

1) Tag number
2) Manufacturer
3) Model number
4) Serial number
5) Service / Description
6) Area location
7) Calibrated range
8) Loop drawing number
9) Associated RTU (or PLC)

4. Startup Submittals

a. The CONTRACTOR shall submit the proposed procedures to be followed during startup of the PCIS and its components.

b. Preliminary Submittal: Outlines of the specific procedures and examples of proposed forms and checklists.

c. Detailed Submittal: After approval of the Preliminary Submittal, the CONTRACTOR shall submit the proposed detailed procedures, forms, and checklists. This submittal shall include a statement of objectives with the test procedures.

5. Training Submittals: Subsequent to the receipt of the OWNER's and ENGINEER's inputs made at the Presubmittal Conference, the CONTRACTOR shall submit a training plan which includes:
a. A resubmittal of the training plan overview from the Presubmittal Conference with incorporation of modifications agreed upon at that meeting.

b. Schedule of training courses including dates, durations, and locations of each class.

c. Resumes of the instructors who will actually implement the plan.

D. Technical Manual

1. General: Information in the Technical Manual shall be based upon the approved Shop Drawing submittals as modified for conditions encountered in the field during the WORK.

2. The Technical Manual shall have the following organization for each process:

   a. Section A - Process and Instrumentation Diagrams

   b. Section B - Loop Descriptions

   c. Section C - Loop Drawings

   d. Section D - Instrument Summary

   e. Section E - Instrument ISA TR20 Data Sheets

   f. Section F - Sizing Calculations

   g. Section G - Instrument Installation Details

   h. Section H - Test Results

3. Signed results from Loop Testing, Precommissioning, and Performance Testing shall be included in Section H.

4. Initially, 2 sets of draft Technical Manuals shall be submitted for review after return of favorably reviewed Shop Drawings and data required herein. Following the ENGINEER's review, one set will be returned to the CONTRACTOR with comments. The Manuals shall be revised and amended as required and the final Manuals shall be submitted 15 Days prior to startup of systems.

E. Record Drawings: The CONTRACTOR shall keep current a set of complete loop and schematic diagrams which shall include field and panel wiring, piping and tubing runs, routing, mounting details, point-to-point diagrams with cable, wire, tube and termination numbers. These drawings shall include every instrument and instrument element. One set of drawings electronically formatted in MICROSTATION and 2 hard copies shall be submitted after completion of Precommissioning tasks but prior to Performance Testing. Such drawings shall be submitted for review prior to acceptance of the completed WORK by the OWNER.

1.3 COST LOADING AND CASH FLOW

A. General: The CONTRACTOR shall develop a schedule, schedule of values, and cash flow summary for inclusion in the submittals of Section 012973 - Schedule of Values and Section 013216 – CPM Construction Schedule. Failure to submit the schedule, schedule
of values, or cash flow summary shall be cause for withholding any progress payment due for instrumentation WORK under sections in this Division.

B. **Schedule of Values:** Break down value of instrumentation and control WORK by structure, as follows:

1. Equipment procurement and fabrication
2. Programming
3. Testing and Commissioning
4. Technical manual and record drawings

C. **Cash Flow Summary:** The cash flow summary shall be based on the submitted schedule and equal in total to the CONTRACTOR's instrumentation Bid price plus approved contract modifications. Expected payment requests for each month shall be included, as well as the cumulative payment requests to date for each month of the project. The net payment requests for each month after deducting retainage and the cumulative payment requests to date shall also be shown.

1.4 **SPECIAL CORRECTION OF DEFECTS REQUIREMENTS**

A. **Extended Period for Correction of Defects:** The CONTRACTOR shall correct defects in the PCIS upon notification from the OWNER within 2 years from the date of Substantial Completion. Corrections shall be completed within 5 Days after notification.

1.5 **ALLOWANCES**

A. Allowances under this WORK are contingency allowances. Refer to specification section, 012900 Measurement and Payment. They shall be done only when, and as directed, in writing by the Owner.

B. The amount given in section 012900 Measurement and Payment for WDCWA PCIS SYSTEM ALLOWANCE is the sum of money set aside for the allowance.

C. If the cost of the equipment provided under the PCIS allowance is less than the amount given on the section 012900 Measurement and Payment for WDCWA PCIS SYSTEM ALLOWANCE, the contract sum shall be reduced by the difference between the amount given and actual costs. This reduction shall be done under the final modification of the Contract.

D. Scope of Allowance

1. For all following equipment, Engineer will inform the PCIS and CONTRACTOR of the quantity, specific manufacturer, model number, and accessories.

2. All costs of furnishing, placing, installing of the materials and furnishing such manpower and equipment to accomplish the WORK shall be by PCIS. These costs are not included as part of the WDCWA PCIS Allowance.

   a. WDCWA Workstation

   b. WDCWA Ethernet Radio
c. WDCWA Radio Antenna

d. WDCWA Ethernet Switches
   1) Redundant PLC processor switches
   2) WDCWA Surge Control Panel Remote I/O switch (WDCWA Surge Control Panel and fiber cable by WDCWA, connected to 40-PLC-1 via fiber)

e. All warranties shall be provided in name of WDCWA.

PART 2 – PRODUCTS

2.1 GENERAL

A. **Code and Regulatory Compliance:** PCIS WORK shall conform to or exceed the applicable requirements of the National Electrical Code. Conflicts between the requirements of the Contract Documents and any codes or referenced standards or specifications shall be resolved according to Section 014219 - Reference Standards.

B. **Current Technology:** Meters, instruments, and other components shall be the most recent field-proven models marketed by their manufacturers at the time of submittal of the Shop Drawings unless otherwise required to match existing equipment.

C. **Adverse Environmental Impact:** No component of an instrumentation system shall contain liquid mercury.

D. **Hardware Commonality:** Instruments which utilize a common measurement principle (for example, d/p cells, pressure transmitters, level transmitters that monitor hydrostatic head) shall be furnished by a single manufacturer. Panel mounted instruments shall have matching style and general appearance. Instruments performing similar functions shall be of the same type, model, or class, and shall be from a single manufacturer.

E. **Loop Accuracy:** The accuracy of each instrumentation system or loop shall be determined as a probable maximum error; this shall be the square root of the sum of the squares of certified "accuracies" of the designated components in each system, expressed as a percentage of the actual span or value of the measured variable. Each individual instrument shall have a minimum accuracy of plus and minus 0.5 percent of full scale and a minimum repeatability of plus and minus 0.25 percent of full scale unless otherwise indicated. Instruments that do not conform to or improve upon these criteria are not acceptable.

F. **Instrument and Loop Power:** Power requirements and input/output connections for components shall be verified. Power for transmitted signals shall, in general, originate in and be supplied by the control panel devices. The use of "2 wire" transmitters is preferred, and use of "4 wire" transmitters shall be minimized. Individual loop or redundant power supplies shall be provided as required by the manufacturer's instrument load characteristics to ensure sufficient power to each loop component. Power supplies shall be mounted within control panels or in the field at the point of application.

G. **Instrument Air:** Dry, filtered control air at 30 psig nominal pressure shall be piped to field instruments and instrument panels requiring air. Each field instrument shall be provided with an integral, non-adjustable filter/regulator assembly to provide regulated
air. Each instrument panel requiring air shall be provided with an adjustable filter/regulator assembly with gauge and an air manifold to provide air to pneumatic instruments. Air shall be filtered to 5-micron maximum particle size. Pressure reducers and regulators shall be furnished with additional instrumentation as required.

H. **Loop Isolators and Converters:** Signal isolators shall be provided as required to ensure adjacent component impedance match where feedback paths may be generated, or to maintain loop integrity during the removal of a loop component. Dropping precision wirewound resistors shall be installed at field side terminations in the control panels to ensure loop integrity. Signal conditioners and converters shall be provided where required to resolve any signal level incompatibilities or provide required functions.

I. **Environmental Suitability:** Indoor and outdoor control panels and instrument enclosures shall be suitable for operation in the ambient conditions associated with the locations designated in the Contract Documents. Heating, cooling, and dehumidifying devices shall be provided in order to maintain instrumentation devices 20 percent within the minimums and maximums of their rated environmental operating ranges. The CONTRACTOR shall provide power wiring for these devices. Enclosures suitable for the environment shall be furnished. Instrumentation in hazardous areas shall be suitable for use in the particular hazardous or classified location in which it is to be installed.

J. **Signal Levels:** Analog measurements and control signals shall be as indicated herein, and unless otherwise indicated, shall vary in direct linear proportion to the measured variable. Electrical signals outside control panels shall be 4 to 20 milliamperes dc except as indicated. Signals within enclosures may be 1 to 5 volts dc. Electric signals shall be electrically or optically isolated from other signals. Pneumatic signals shall be 3 to 15 psig with 3 psig equal to 0 percent and 15 psig equal to 100 percent.

K. **Control Panel Power Supplies:** Control panels shall be provided with redundant power supplies which are configured in a fault-tolerant manner to prevent interruption of service upon failure and interruption of service necessitated by the replacement of a power supply. Power supplies shall have an excess rated capacity of 40 percent. The failure of a power supply shall be annunciated at the control panel and repeated to the SCADA System.

L. **Alternative Equipment and Methods:** Equipment or methods requiring redesign of any project details are not acceptable without prior written approval of the ENGINEER through the "or equal" process of the Bid Forms. Any proposal for approval of alternative equipment or methods shall include evidence of improved performance, operational advantage, and maintenance enhancement over the equipment or method indicated, or shall include evidence that an indicated component is not available.

### 2.2 OPERATING CONDITIONS

A. The PCIS shall be designed and constructed for satisfactory operation and long, low maintenance service under the following conditions:

<table>
<thead>
<tr>
<th>Environment</th>
<th>water treatment facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature Range</td>
<td>32 through 104 degrees F</td>
</tr>
<tr>
<td>Thermal Shock</td>
<td>1 degree F per minute, max</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>20 through 90 percent, non-condensing</td>
</tr>
</tbody>
</table>
2.3 SPARE PARTS AND SPECIAL TOOLS

A. The CONTRACTOR shall furnish the following special tools and spare parts:

1. One portable instrument calibrator current simulator with charger and carrying case (RIS 4500, Fluke, or equal).

2. One (1) spare pressure switch of each type.

3. One (1) spare pressure transmitter of each range.

4. Spare fuses, 10 minimum of each type and size.

B. Special tools and spare parts shall be submitted before startup commences, suitably wrapped and identified.

2.4 FACTORY TESTING

A. The CONTRACTOR shall arrange for the manufacturers of the equipment and fabricators of panels and cabinets supplied under this Section to allow the ENGINEER, OWNER, and WDCWA to inspect and witness the testing of the equipment at the site of fabrication. Equipment shall include the cabinets, special control systems, flow measuring devices, and other pertinent systems and devices. A minimum of 10 Days notification shall be furnished to the ENGINEER prior to testing. No shipments shall be made without the ENGINEER's approval.

PART 3 -- EXECUTION

3.1 PRODUCT HANDLING

A. Shipping Precautions: After completion of shop assembly, factory test, and approval, equipment, cabinets, panels, and consoles shall be packed in protective crates and enclosed in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture. Dehumidifiers shall be placed inside the polyethylene coverings. The equipment shall then be skid-mounted for final transport. Lifting rings shall be provided for moving without removing protective covering. Boxed weight shall be shown on shipping tags together with instructions for unloading, transporting, storing, and handling at the Site.

B. Special Instructions: Special instructions for proper field handling, storage, and installation required by the manufacturer shall be securely attached to each piece of equipment prior to packaging and shipment.

C. Tagging: Each component shall be tagged to identify its location, instrument tag number, and function in the system. A permanent stainless steel or other non-corrosive material tag firmly attached and permanently and indelibly marked with the instrument tag number, as given in the tabulation, shall be provided on each piece of equipment in the PCIS. Identification shall be prominently displayed on the outside of the package.

D. Storage: Equipment shall not be stored outdoors. Equipment shall be stored in dry permanent shelters, including in-line equipment, and shall be adequately protected against mechanical injury. If any apparatus has been damaged, such damage shall be repaired by the CONTRACTOR. If any apparatus has been subject to possible injury by water, it shall be thoroughly dried out and put through tests as directed by the ENGINEER. If such tests reveal defects, the equipment shall be replaced.
3.2 MANUFACTURER'S SERVICES

A. The CONTRACTOR shall furnish the following manufacturer's services for the instrumentation listed below:

1. Perform bench calibration.
2. Oversee installation.
3. Verify installation of installed instrument.
5. Oversee loop testing, prepare loop validation sheets, and certify loop testing.
6. Prepare pre-commissioning validation sheets, oversee pre-commissioning, and certify when pre-commissioning is completed.
7. Train the OWNER's personnel

B. Manufacturer’s services shall be furnished for the following equipment:

1. Installation and calibration of all flowmeters.

3.3 INSTALLATION

A. General

1. Instrumentation, including instrumentation furnished under other Divisions, shall be installed under Division 40 and the manufacturers’ instructions.

2. Equipment Locations: The monitoring and control system configurations indicated are diagrammatic. The locations of equipment are approximate. The exact locations and routing of wiring and cables shall be governed by structural conditions and physical interferences and by the location of electrical terminations on equipment. Equipment shall be located and installed so that it will be readily accessible for operation and maintenance. Where job conditions require reasonable changes in approximated locations and arrangements, or when the OWNER exercises the right to require changes in location of equipment which do not impact material quantities or cause material rework, the CONTRACTOR shall make such changes without additional cost to the OWNER.

B. Conduit, Cables, and Field Wiring

1. Conduit shall be provided under Division 26 without delay to the WORK of Division 40.

2. Process equipment control wiring, 4 to 20 mA signal circuits, signal wiring to field instruments, SCADA input and output wiring, and other field wiring and cables shall be provided under Division 26.

3. RTU equipment cables, Modbus communication network cables, and Antenna cables shall be provided under Division 40.
4. Terminations and wire identification at PCIS equipment furnished under this or any other Division shall be provided under Division 40.

C. **Instrumentation Tie-Downs:** Instruments, control panels, and equipment shall be anchored by methods that comply with seismic requirements applicable to the Site.

D. **Existing Instrumentation:** Each existing instrument to be removed and reinstalled shall be cleaned, reconditioned, and recalibrated by an authorized service facility of the instrument manufacturer. The CONTRACTOR shall provide certification of this WORK prior to reinstallation of each instrument.

E. **Ancillary Devices:** The Contract Documents show necessary conduit and instruments required to make a complete instrumentation system. The CONTRACTOR shall be responsible for providing any additional or different type connections as required by the instruments and specific installation requirements. Such additions and such changes, including the proposed method of installation, shall be submitted to the ENGINEER for approval prior to commencing that WORK. Such changes shall not be a basis of claims for extra WORK or delay.

F. **Installation Criteria and Validation:** Field-mounted components and assemblies shall be installed and connected according to the requirements below:

1. Installation personnel have been instructed on installation requirements of the Contract Documents.
2. Technical assistance is available to installation personnel at least by telephone.
3. Installation personnel have at least one copy of the approved Shop Drawings and data.
4. Instrument process sensing lines shall be installed in conduit under Section 260000 - Electrical General Provisions. Individual tubes shall run parallel and near the surfaces from which they are supported. Supports shall be used at intervals of not more than 3-feet of rigid tubing.
5. Bends shall be formed to uniform radii with the proper tool without deforming or thinning the walls of the tubing. Plastic clips shall be used to hold individual plastic tubes parallel. Ends of tubing shall be square cut and cleaned before being inserted in the fittings. Bulkhead fittings shall be provided at panels requiring pipe or tubing entries.
6. Differential pressure elements shall have 3 valve manifolds.
7. Flexible cables and capillary tubing shall be installed in flexible conduits. The lengths shall be sufficient to withdraw the element for periodic maintenance.
8. Power and signal wires shall be terminated with crimped type lugs.
9. Connectors shall be, as a minimum, water tight.
10. Wires shall be mounted clearly with an identification tag that is of a permanent and reusable nature.
11. Wire and cable shall be arranged in a neat manner and securely supported in cable groups and connected from terminal to terminal without splices unless specifically
approved by the ENGINEER. Wiring shall be protected from sharp edges and corners.

12. Mounting stands and bracket materials and workmanship shall comply with requirements of the Contract Documents.

13. Verify the correctness of each installation, including polarity of electric power and signal connections, and make sure process connections are free of leaks. The CONTRACTOR shall certify in writing that discrepancies have been corrected for each loop or system checked out.

14. The OWNER will not be responsible for any additional cost of rework attributable to actions of the CONTRACTOR or the SYSTEM INTEGRATOR.

3.4 CALIBRATION

A. General: Devices provided under Division 40 shall be calibrated according to the manufacturer's recommended procedures to verify operational readiness and ability to meet the indicated functional and tolerance requirements.

B. Calibration Points: Each instrument shall be calibrated at 0, 25, 50, 75, and 100 percent of span using test instruments to simulate inputs. The test instruments shall have accuracies traceable to National Institute of Standards and Testing.

C. Bench Calibration: Instruments that have been bench-calibrated shall be examined in the field to determine whether any of the calibrations are in need of adjustment. Such adjustments, if required, shall be made only after consultation with the ENGINEER.

D. Field Calibration: Instruments which were not bench-calibrated shall be calibrated in the field to insure proper operation in accordance with the instrument loop diagrams or specification data sheets.

E. Analyzer Calibration: Each analyzer system shall be calibrated and tested as a workable system after installation. Testing procedures shall be directed by the manufacturers' technical representatives. Samples and sample gases shall be furnished by the manufacturers.

F. Calibration Sheets: Each instrument calibration sheet shall provide the following information and a space for sign-off on individual items and on the completed unit:

1. Project name
2. Loop number
3. Tag number
4. Manufacturer
5. Model number
6. Serial number
7. Calibration range
8. Calibration data: Input, output, and error at 0 percent, 50 percent, and 100 percent of span

9. Switch setting, contact action, and deadband for discrete elements

10. Space for comments

11. Space for sign-off by SYSTEM INTEGRATOR and date

12. Test equipment used and associated serial numbers

G. **Calibration Tags:** A calibration and testing tag shall be attached to each piece of equipment or system at a location determined by the ENGINEER. The CONTRACTOR shall have the SYSTEM INTEGRATOR sign the tag when calibration is complete. The ENGINEER will sign the tag when the calibration and testing has been accepted.

3.5 LOOP TESTING

A. **General:** Individual instrument loop diagrams per ISA Standard S5.4 - Instrument Loop Diagrams, expanded format, shall be submitted to the ENGINEER for review prior to the loop tests. The CONTRACTOR shall notify the ENGINEER of scheduled tests a minimum of 30 Days prior to the estimated completion date of installation and wiring of the PCIS. After the ENGINEER's review of the submitted loop diagrams for correctness and compliance with the specifications, loop testing shall proceed. The loop check shall be witnessed by the ENGINEER.

B. **Control Valve Tests:** Control valves, cylinders, drives and connecting linkages shall be stroked from the operator interface units as well as local control devices and adjusted to verify proper control action, hand switch action, limit switch settings, torque settings, remote control actions, and remote feedback of valve status and position. Control valve actions and positioner settings shall be checked with the valves in place to insure that no changes have occurred since the bench calibration.

C. **Interlocks:** Hardware and software interlocks between the instrumentation and the motor control circuits, control circuits of variable-speed controllers, and packaged equipment controls shall be checked to the maximum extent possible.

D. **Instrument and Instrument Component Validation:** Each instrument shall be field tested, inspected, and adjusted to its indicated performance requirement in accordance its manufacturer's specifications and instructions. Any instrument which fails to meet any Contract requirement, or, in the absence of a Contract requirement, any published manufacturer performance specification for functional and operational parameters, shall be repaired or replaced, at the discretion of the ENGINEER.

E. **Loop Validation:** Controllers and electronic function modules shall be field tested and exercised to demonstrate correct operation. Control loops shall be checked under simulated operating conditions by impressing input signals at the primary control elements and observing appropriate responses of the respective control and monitoring elements, final control elements, and the graphic displays associated with the SCADA system. Actual signals shall be used wherever available. Following any necessary corrections, the loops shall be retested. Accuracy tolerances for each analog network are defined as the root-mean-square (RMS) summation of individual component accuracy requirements. Individual component accuracy requirements shall be as indicated by Contract requirements or by published manufacturer accuracy specifications, whenever Contract accuracy requirements are not indicated. Each analog
network shall be tested by applying simulated analog or discrete inputs to the first element of an analog network. For networks which incorporate analog elements, simulated sensor inputs corresponding to 0, 25, 50, 75, and 100 percent of span shall be applied, and the resulting element outputs monitored to verify compliance to calculated RMS summation accuracy tolerance requirements. Continuously variable analog inputs shall be applied to verify the proper operation and setting of discrete devices. Provisional settings shall be made on controllers and alarms during analog loop tests. Analog loop test data shall be recorded on test forms attached at the end of this Section which include calculated RMS summation system accuracy tolerance requirements for each output.

F. **Loop Validation Sheets:** The CONTRACTOR shall prepare loop confirmation sheets for each loop covering each active instrumentation and control device except simple hand switches and lights. Loop confirmation sheets shall form the basis for operational tests and documentation. Each loop confirmation sheet shall cite the following information and shall provide spaces for sign-off on individual items and on the complete loop by the SYSTEM INTEGRATOR:

1. Project name
2. Loop number
3. Tag number, description, manufacturer, and model number for each element
4. Installation bulletin number
5. Specification sheet number
6. Loop description number
7. Adjustment check
8. Space for comments
9. Space for loop sign-off by SYSTEM INTEGRATOR and date
10. Space for ENGINEER witness signature and date

G. **Loop Certifications:** When installation tests have been successfully completed for individual instruments and separate analog control networks, a certified copy of each test form signed by the ENGINEER or the ENGINEER’s representative as a witness, with test data entered, shall be submitted to the ENGINEER together with a clear and unequivocal statement that the instrumentation has been successfully calibrated, inspected, and tested.

3.6 PRE-COMMISSIONING

A. **General:** Pre-commissioning shall commence after acceptance of wire test, calibration tests and loop tests, and inspections have demonstrated that the instrumentation and control system complies with Contract requirements. Pre-commissioning shall demonstrate proper operation of every system with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.
B. **Pre-commissioning Procedures and Documentation:** Pre-commissioning and test activities shall follow detailed test procedures and check lists accepted by the ENGINEER. Test data shall be acquired using equipment as required and shall be recorded on test forms accepted by the ENGINEER, which include calculated tolerance limits for each step. Completion of system precommissioning and test activities shall be documented by a certified report, including test forms with test data entered, delivered to the ENGINEER with a clear and unequivocal statement that system pre-commissioning and test requirements have been satisfied.

C. **Operational Validation:** Where feasible, system pre-commissioning activities shall include the use of water to establish service conditions that simulate, to the greatest extent possible, normal final control element operating conditions in terms of applied process loads, operating ranges, and environmental conditions. Final control elements, control panels, and ancillary equipment shall be tested under startup and steady state operating conditions to verify that proper and stable control is achieved using motor control center and local field mounted control circuits. Hardwired and software control circuit interlocks and alarms shall be operational. The control of final control elements and ancillary equipment shall be tested using both manual and automatic (where provided) control circuits. The stable steady state operation of final control elements running under the control of field mounted automatic analog controllers or software based controllers shall be assured by adjusting the controllers as required to eliminate oscillatory final control element operation. The transient stability of final control elements operating under the control of field mounted, and software-based automatic analog controllers shall be verified by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations (if any), and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates.

D. **Loop Tuning:** Electronic control stations incorporating proportional, integral or differential control circuits shall be optimally tuned, experimentally, by applying control signal disturbances and adjusting the gain, reset, or rate settings as required to achieve a proper response. Measured final control element variable position/speed setpoint settings shall be compared to measured final control element position/speed values at 0, 25, 50, 75, and 100 percent of span and the results checked against indicated accuracy tolerances.

E. **Pre-commissioning Validation Sheets:** Pre-commissioning shall be documented on one of 2 types of test forms as follows:

1. For functions which can be demonstrated on a loop-by-loop basis, the form shall include:
   a. Project name
   b. Loop number
   c. Loop description
   d. Tag number, description, manufacturer, and data sheet number for each component.
   e. Space for sign-off and date by both the SYSTEM INTEGRATOR and ENGINEER.
2. For functions that cannot be demonstrated on a loop-by-loop basis, the test form shall be a listing of the specific tests to be conducted. With each test description the following information shall be included:

a. Specification page and paragraph of function demonstrated

b. Description of function

c. Space for sign-off and date by both the SYSTEM INTEGRATOR and ENGINEER

F. **Pre-commissioning Certification:** The CONTRACTOR shall submit an instrumentation and control system pre-commissioning completion report which shall state that Contract requirements have been met and shall include a listing of instrumentation and control system maintenance and repair activities conducted during the pre-commissioning testing. Acceptance of the instrumentation and control system pre-commissioning testing must be provided in writing by the ENGINEER before the performance testing may begin. Final acceptance of the control system shall be based upon plant completion as stated in the General Conditions.

3.7 **ON-SITE SUPERVISION**

A. The CONTRACTOR shall furnish the services of an on-Site resident engineer to supervise and coordinate installation, adjustment, testing, and start-up of the PCIS. The resident engineer shall be present during the total period required to affect a complete operating system. A team of engineering personnel shall be at the Site for 80 hours to check equipment, perform the tests indicated in this Section, and furnish startup services. The 80 hours shall be in addition to time required for the CONTRACTOR to complete system troubleshooting and repairs.

3.8 **COMMISSIONING**

A. The entire WORK shall operate without failure for 30 Days, including the 8 Day demonstration required under Section 017500-Equipment Testing and Facility Startup.

B. In addition to the commissioning requirements of Section 017500, the CONTRACTOR shall furnish support staff as required to operate the system and to satisfy the repair or replacement requirements.

C. If any component fails during the performance test, it shall be repaired or replaced and the performance test shall be restarted at time zero on another 30 Day period.

3.9 **TRAINING**

A. **General:** The CONTRACTOR shall train the OWNER'S personnel on the maintenance, calibration, and repair of instruments provided under this Contract.

B. **Instructions:** The training shall be performed by qualified representatives of the equipment manufacturers and shall be specific to each piece of equipment.

C. **Duration:** Each training class shall be a minimum of 8 hours in duration and shall cover, as a minimum, operational theory, maintenance, troubleshooting/repair, and calibration of the instrument.
D. **Schedule:** Training shall be performed during the pre-commissioning phase of the project. The training sessions shall be scheduled a minimum of 3 weeks in advance of when the courses are to be initiated. The ENGINEER will review the course outline for suitability and provide comments that shall be incorporated.

E. **Agenda:** The training shall include operation and maintenance procedures, trouble shooting with necessary test equipment, and changing set points, and calibration for that specific piece of equipment.

F. **Documentation:** Within 10 Days after the completion of each session the CONTRACTOR shall submit the following:

1. A list of OWNER personnel who attended the session.
2. An evaluation of OWNER personnel via written testing or equivalent evaluation.
3. A copy of the training materials utilized during the lesson with notes, diagrams, and comments.

### 3.10 CRITERIA FOR SUBSTANTIAL COMPLETION

A. For the purpose of this Section and all Division 40, the following conditions shall be fulfilled before the WORK is considered substantially complete:

1. Submittals have been completed and approved.
2. The PCIS has been calibrated, loop tested, and pre-commissioned.
3. The OWNER training has been performed.
4. Spare parts and expendable supplies and test equipment have been delivered to the ENGINEER.
5. Commissioning has been successfully completed.
6. Punch-list items have been corrected.
7. Record drawings in both hard copy and electronic format have been submitted.
8. Revisions to the Technical Manuals that may have resulted from the field tests have been made and reviewed.
9. Debris associated with installation of instrumentation has been removed.
10. Probes, elements, sample lines, transmitters, tubing, and enclosures have been cleaned and are in like-new condition.

- END OF SECTION -
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<table>
<thead>
<tr>
<th>INSTRUMENT TAG</th>
<th>PID NO.</th>
<th>INSTRUMENT DESCRIPTION</th>
<th>SPECIFICATION</th>
<th>INSTALL DETAIL</th>
<th>CALIBRATED RANGE</th>
<th>SETPOINT</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIT-400A</td>
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**Remarks:**
- **Vendor Setpoint**
- **Supplied with Vendor System**

**Specifications:**
- **INSTALL DETAIL**
- **CALIBRATED RANGE**
- **SETPOINT**
- **REMARKS**

**INSTRUMENT LIST**

MWH - DECEMBER 2013
1012294 - JOINT INTAKE AND FISH SCREEN PROJECT

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<td>WDCWA Pump No 4 Bearing RTD</td>
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SECTION 409102 - IN-LINE LIQUID FLOW MEASURING

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. General: The CONTRACTOR shall provide in-line liquid flow measuring systems, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 409100 - Process Control and Instrumentation apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. Shop Drawings shall be submitted in conformance with Section 409100 and Section 013300 - Contractor Submittals.

PART 2 -- PRODUCTS

2.1 ULTRASONIC FIELD MOUNTED LIQUID FLOW MEASURING SYSTEMS (TRANSIT TIME)

A. Type: Meters shall be directional and utilize ultrasonic velocity measurement principles. The electronic unit shall utilize information from the velocity sensing probes to accurately measure flow in the pipe. The meters shall be suitable for measuring raw water.

B. Features

1. Components: Field-mounted ultrasonic flow meters shall consist of transducers mounted in bosses welded directly to metal pipes. The equipment manufacturer shall select the signal and frequency for proper ultrasonic transmission. Wiring within the electronic unit shall be factory pre-wired. A local flow indicator, scaled in the indicated flow range, shall be provided in an accessible location for easy reading.

2. Sensors: Two sensors shall be permanently mounted to a straight pipe provided by the CONTRACTOR, with weldments such that the acoustic pulses pass diagonally upstream and downstream across the centerline of the pipe. The probes shall be wetted and be removable under pressure and flow conditions. The probes shall be fabricated of non-corrosive material and shall be equipped with an armored triaxial cable for electric transmission.

3. Transmitter: The transmitter unit shall produce a 4 to 20 mA DC signal, and a scaled pulse output signal, if totalization is indicated, proportional to the flow rate.

C. Accuracy: The meters shall have an accuracy of plus and minus 1.5 percent of actual flow at velocities greater than one foot per second.

D. Power Consumption: The meter shall be designed to operate on 120 VAC supply with a power consumption of not more than 30 watts indoor locations and 250 watts outdoor locations with heater activated.
E. Manufacturers, or Equal

1. **Badger Eastech, Vantage 4000**
2. **Panametrics, AquaTrans**

F. Refer to Appendix A of Section 409100 for the complete instrument schedule.

### 2.2 ROTAMETER LIQUID FLOW MEASURING SYSTEMS

#### A. General

1. Rotameters in chemical solution lines and where indicated shall have vertical bottom inlets and top outlets with ANSI 150 lb flanged ends for vertical mounting.

2. The meters shall have Hastelloy C floats, 10-inch long scales, and a range of 10:1 with an accuracy of plus or minus 2 percent. Meters shall be rated for a minimum working pressure of 150 psi. Flanged rotameters for chemical solutions and where indicated shall be calibrated in gallons per minute.

3. The bodies shall have union ends for ease of maintenance, polysulphone tubes, aluminum or brass end fittings, Type 316 stainless steel internal parts and scales suitable for the indicated capacity range.

4. The meters shall have an accuracy of not more than plus and minus 5 percent over the capacity range indicated.

#### B. Application Requirements

1. Meters in air and pump seal flushing lines shall be of the modified rotameter design with screwed ends, spring-loaded pistons, and union bodies for mounting in any position.

2. For activated carbon solution, bodies shall be Type 316 stainless steel construction with magnetically actuated float and scale.

3. For other chemicals bodies shall have Type 316 stainless steel ends with heavy borosilicate glass tubes and packing glands or other best suitable material.

4. Rotameters with NPT screwed ends for water, air, and fuel gas service shall be calibrated in gallons per minute or cubic feet per minute. The scales shall be suitable for the capacity ranges indicated.

#### C. Manufacturers, or equal

1. Activated carbon solution: **Brooks No. 3611** or **Pennwalt Varea-Meter**.

2. Other chemicals: **Brooks No. 1144** or **Pennwalt Varea-Meter**.

3. Water service: **Headland In-Line Meters**, or **Universal Flow Monitors, Inc. INSITE Meters**, or **McCrometer SK**.
2.3 MAGNETIC FLOW MEASURING SYSTEMS

A. Magnetic flowmeter systems shall be the low frequency electromagnetic induction type which produces a DC pulsed signal directly proportional to and linear with the liquid flow rate. Complete zero stability shall be an inherent characteristic of the flowmeter system. Each magnetic flow metering system shall include a metering tube, signal cable, transmitter, and flowmeter grounding rings.

1. The metering tube shall have:
   a. Flanged connections shall be constructed of Type 304 or Type 316 stainless steel, with pressure ratings as indicated and in accordance with the requirements of Section 431050 – Piping, General.
   b. Minimum of 2 self-cleaning electrodes
   c. Liner conforming to the manufacturer’s recommendation for the intended service
   d. Electrodes constructed of materials conforming to the manufacturer’s recommendation for the intended service
   e. Meter housing rated for NEMA 6
   f. Epoxy protective coating
   g. Grounding rings that conform to the manufacturer’s bore and material recommendation for the intended service. Grounding rings shall be designed to protect and shield the liner’s edge interface from abrasion at the meter end.

2. The microprocessor-based signal converter/transmitter shall have:
   a. DC pulse technique to drive flux-producing coils
   b. Capability to convert DC pulse signal from the tube to a standardized 4 to 20 mA DC signal into a minimum of 700 ohms.
   c. Six digit LCD displays for flow rate, percent of span, and totalization
   d. An operator interface with keypad which responds to English text entry
   e. Integral zero return to produce a consistent zero output signal in response to an external dry contact closure
   f. Integral low flow cutoff and zero return
   g. Automatic range change
   h. Capable of measuring flow in both directions
   i. Programmable parameters including meter size, full scale Q, magnetic field frequency, primary constant, time constant
   j. Data retention for a minimum of 5 years without auxiliary power from main source or battery
k. Self diagnostics and automatic data checking

l. Protected terminals and fuses in a separate compartment which isolates field connection from electronics

m. Ambient temperature operating limits of -20 to 140 degrees F (-29 to 60 degrees C)

B. **Calibration:** Each flow metering system shall be hydraulically calibrated at a facility that is traceable to the National Institute of Standards and Technologies. The calibration procedure shall conform to the requirements of ANSI/NCSL Z 540-1 Calibration. A real-time computer generated printout of the actual calibration data shall be submitted to the ENGINEER at least 30 Days prior to shipment to the Site.

C. The flow metering system shall conform to the following:

1. Time constant: 0.5 to 1000 seconds; galvanic or optic isolation

2. Accuracy: 0.15 percent of flow rate from 10 to 100 percent full scale for velocities over 3 feet per second.

3. Repeatability: 0.25 percent full scale

4. Power consumption: 30 watts or less

5. Power requirements: 90-250 V AC, 50–60 Hz or 12-42 V DC

D. Manufacturers, or Equal

1. **Rosemount Series 8700**

2. **Endress + Hauser**

2.4 THERMAL FLOW SWITCHES

A. Thermal flow switches shall be thermal dispersion type with no moving parts. Flow shall be detected by measuring the differential temperature between two RTD’s while maintaining a constant current to the heater. The probes, electronic circuits, and relay shall all be part of an integral unit with a non-ferrous cast housing. Wetted parts shall be constructed of 316SS or Hastelloy C depending on chemical compatibility with the process. In horizontal pipe runs the unit shall be side mounted. All switches shall be equipped to function in an environment where the probes are not always immersed. Output relay shall be configurable to energize on increasing or decreasing flow and have (1) DPDT or (2) SPDT contacts rated 2A, 120 VAC minimum. Contact transfer point shall be field adjustable from .003 - 47 gpm in water. Response time shall be adjustable from 0.5 to 150 seconds. The trip flow point shall not be affected by process fluid changes in the range of 32 to 140 degrees F and shall have a repeatability of plus or minus 5 percent. The contact unit shall operate within the indicated repeatability in an ambient temperature range of 25 to 120 degrees F. The unit shall have a pressure rating of 150 psi or greater and shall be suitable for installation in pipe sizes of 0.5-inch diameter and greater. Unit shall include 120V AC power supply in a stainless steel NEMA-4X box.

B. Thermal flow switch with flanged fittings (material to match installation pipe) shall be as manufactured by:
1. Fluid Components, Inc. Model FLT93L Series

2. Approved equal.

C. Thermal Flow Switches shall be provided for all eyewash/shower flow detection applications depicted in the contract drawings, appropriately rated to detect minimum flow associated with eyewash operation only. Refer to Appendix A of Section 409100 - Process Control and Instrumentation Systems for the complete instrument schedule.

PART 3 – EXECUTION

3.1 GENERAL

A. In-line flow measuring systems shall be executed according to Section 409100.

B. The equipment manufacturer shall select mounting sensor mounting alignment.

- END OF SECTION -
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PART 1 – GENERAL

1.1 THE REQUIREMENT

A. **General:** The CONTRACTOR shall provide level measuring systems, complete and operable in accordance with the Contract Documents.

B. “Smart” transmitters shall be furnished when or wherever possible.

C. The requirements of Section 409100 - Process Control and Instrumentation apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 409100.

PART 2 – PRODUCTS

2.1 NON-CONTACT SONIC LEVEL MEASUREMENT, SEPARATE TRANSMITTER

A. Sonic level measuring systems shall consist of an electronic controller-transmitter, a non-contact sonic transducer, and interconnecting cables. The controller-transmitter shall generate the sonic signal to drive the transducer, detect the return echo and convert the elapsed time to a level signal.

B. The controller-transmitter shall be housed in a NEMA 4X watertight enclosure have the following features; solid state design, integral level indicator, infrared handheld programmer, isolated, 4 - 20 mA output signal linearly proportional to level, transducer temperature compensation and a contact output upon transmitter failure (loss of echo). Input power shall be 120 VAC 60 Hz.

C. The sonic transducer shall be rated IP 68, submersible, and shall be constructed of corrosion resistant materials.

D. Sonic level measuring systems shall be Milltronics Hydroranger 200, Ametek Drexelbrook USonic-R, or equal.

E. Refer to Appendix A of Section 409100 for the complete instrument schedule.

2.2 NON-CONTACT SONIC LEVEL MEASUREMENT, INTEGRAL TRANSMITTER

A. Where integral transmitter non-contact sonic level measurement is indicated, sonic level measuring systems shall consist of an electronic transmitter and a non-contact sonic transducer in single assembly. The transmitter shall generate the sonic signal to drive the transducer, detect the return echo and convert the elapsed time to a level signal.

B. The transmitter shall have the following features; solid state design, integral level indicator, keypad for calibration and configuration, isolated, 4-20 Ma output signal linearly proportional to level, Modbus RTU communications via RS-485, transducer temperature compensation and a minimum four user programmable contact outputs (relay). Input power shall be 120 VAC 60 Hz. The sonic transducer shall be housed in a NEMA 4X watertight enclosure and be constructed of corrosion resistant materials.
C. Level transmitters shall be as manufactured by Endress & Hauser Model: Prosonic, Siemens Model: Sitrans L or approved equal. Refer to Appendix A of Section 17100 for the complete instrument schedule.

2.3 SUBMERSIBLE TRANSDUCER TYPE LEVEL MEASUREMENT

A. The level measurement system shall consist of a submersible transducer, electronic transmitter, support cable, and interconnecting cable with cable shield and vent tube for atmospheric reference. The vent tube shall be provided with a replaceable moisture barrier. The submersible transducer shall be the strain gauge type suitable for sensing pressure equivalent to the liquid level range indicated. The transducer shall have 316 stainless steel process wetted parts and shall be provided with a waterproof interconnecting cable. The transducer shall be provided with 316 stainless steel anti-clog guard and be suspended by a corrosion resistant cable as recommended by the manufacturer. The installation shall allow easy removal of the transducer and cable assembly for maintenance purposes. The electronic level transmitter shall be remote mounted and shall produce a 4 - 20 mA DC signal linearly proportional to the level range indicated. The interconnecting cable shall have a pull strength of 200 pounds, be factory attached to the transducer, and shall be terminated in a weather proof enclosure furnished with the unit. The weatherproof enclosure shall house the vent tube moisture barrier, and provisions for zero and span adjustments. The measurement system shall be suitable for the area classification and operation over a temperature range of 32 to 122 degrees Fahrenheit with an accuracy of plus or minus 0.5 percent of span.

B. Submersible level transducers/transmitters shall be Wika Model LS-10 with LevelGuard, or equal

PART 3 -- EXECUTION

3.1 GENERAL

A. Level measuring systems shall be executed according to Section 409100.

- END OF SECTION -
PART 1 – GENERAL

1.1 THE REQUIREMENT

A. **General:** The CONTRACTOR shall provide level detection switches, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 409100 - Process Control and Instrumentation apply to this Section.

1.2 CONTRACTOR SUMITTALS

A. Furnish submittals in accordance with Section 409100.

PART 2 – PRODUCTS

2.1 TIPPING FLOAT LEVEL SWITCHES

A. Tipping float level switches shall consist of a switch, a moving float, and a connecting cable that is anchored at the midpoint of a differential band. As the level rises and falls the float rights itself or inverts causing switching actions. The cable anchoring point shall be protected by strain relief. The hermetically sealed switches shall be SPDT with a minimum rating of 10 Amps at 120 VAC.

B. Manufacturer shall be **MAGNETROL T10, FLYGT ENM-10, Siemens Models 9G & 9G-EF**, or equal.

C. Refer to Appendix A of Section 409100 for the complete instrument schedule.

PART 3 – EXECUTION

3.1 GENERAL

A. Level detection switches shall be executed according to Section 409100.

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SECTION 409108 - PRESSURE MEASURING, GENERAL

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. General: Provide pressure measuring systems, complete and operable, as indicated in accordance with the Contract Documents.

B. The requirements of Section 409100 – Process Control and Instrumentation apply to the WORK of this Section.

1.2 CONTRACTOR SUBMITTALS

A. Submit the Shop Drawings and Technical Manual in accordance with the requirements of Section 409100 – Process Control Instrumentation and Section 013300 – Contractor Submittals.

PART 2 -- PRODUCTS

2.1 PRESSURE GAUGES

A. Construction

1. Diameter: 4-1/2 inches
2. Dampered movement - dry-type
3. Bottom connected
4. White laminated dials and black graduations
5. Windows: shatterproof glass

B. Provide the gauges with a blowout disc, and encase in phenolic, steel, or cast iron.

C. The measuring element shall be a stainless steel bourdon tube with welded, stress-relieved joints.

D. Provide the socket with wrench flats.

E. Provide a rotary-geared movement and construct of stainless steel.

F. Provide the gauges with a pulsation snubber constructed of Type 316 stainless steel, and an isolation valve.

G. Calibrate the gauges to read in applicable units.

H. Provide an accuracy of plus and minus 1/2-percent range to 150 percent of the working pressure or vacuum of the pipe or vessel to which the gauge is connected.

I. Pressure Gauges Manufacturer, or Equal

1. Ashcroft 1279 - Plus
2. **Ametek Solfrunt 1981 - Advantage**

J. Refer to Appendix A of Section 409100 for the complete instrument schedule.

2.2 **ELECTRONIC GAUGE PRESSURE TRANSMITTERS**

A. Provide electronic gauge transmitters consisting of:

1. capsule assembly;
2. bottom works;
3. vent plug;
4. drain plug;
5. cover flange;
6. process connector and connection;
7. amplifier unit;
8. integral indicator;
9. terminal box with cover;
10. block and bleed valves; and,
11. conduit connections.

B. **Operating Principles**

1. Transmit the pressure applied to the unit by a sealed-fill fluid to both sides of a sensing diaphragm.

2. The sensing diaphragm and the sensor body shall function as the moving and fixed electrodes, respectively, of a differential capacitor.

3. As the applied pressure causes the diaphragm to move, the capacitance of the cell shall change.

C. **Performance Requirements**

1. The amplifier unit shall convert the change in capacitance to a 4-to-20 mA DC signal, 2-wire type, with an allowable loop load of not less than 600 ohms.

2. Provide a static pressure rating of at least 500 psig.

3. Prove a maximum overrange pressure limit of at least 150 percent of the range.

4. Provide a span that is adjustable over a minimum 5:1 range.

5. External adjustments shall include zero and span.

6. Provide output signal damping as an internal adjustment.
7. Provide equipment suitable for an ambient operating range of minus 40 degree F to plus 212 degrees F.

8. Calibrate the integral indicator in process units.

9. Provide a power supply of 24 VDC.

10. Provide an accuracy, including linearity and repeatability, of plus or minus 0.2 percent of span.

11. Gauge pressure transmitters used for flow service shall include square root extraction in order to produce an output signal linearly proportional to flow.

12. Construct wetted parts, including block and bleed valve parts, of Type 316 stainless steel.

13. Electronic Gauge Pressure Transmitter Manufacturer, or Equal
   a. Foxboro IGP Series
   b. Rosemount 3051CG
   c. Yokogawa Corporation of America EJA Series

D. Refer to Appendix A of Section 409100 for the complete instrument schedule.

2.3 DIAPHRAGM SEALS FOR PRESSURE MEASURING SYSTEMS

A. Provide diaphragm seals with:
   1. bottom housing;
   2. lower ring;
   3. diaphragm capsule;
   4. fill screw;
   5. flushing connection; and,
   6. top housing.

B. Operating Principles
   1. The diaphragm seal shall attach to the inlet connection of a pressure instrument in order to isolate its measuring element from the process fluid.
   2. Completely fill the space between the diaphragm and the pressure element with a glycerin fill fluid.
   3. Displacement of the liquid fill in the pressure element through the movement of the diaphragm shall transmit process pressure changes directly to a gauge, transmitter, switch, or other pressure instrument.
4. Provide the diaphragm seal with a removable bottom housing in order to permit servicing.

5. Factory-assemble the diaphragm seal to the corresponding pressure instrument and factory-fill.

6. Ship the assembly with a tag reading "Do not disassemble for installation."

7. Construct exposed surfaces housings of Type 316 stainless steel.

C. Materials of Diaphragm Construction

<table>
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<th>Raw water, liquids containing solids, and pulsating flow</th>
<th>Seals of Type 316 stainless steel with stainless steel diaphragm for pressures over 15 psig and elastomer diaphragm for pressures of 15 psi and below. Type 316 stainless steel nuts and bolts, fill connection and valved flush port size 1/4-inch NPT, capable of disassembly without loss of filler fluid</th>
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</table>
|                                                        | **Ashcroft Model 101**  
|                                                        | **U.S. Gauge (Ametek) SG**  
|                                                        | **Marshalltown Series 225-01** |

PART 3 -- EXECUTION

3.1 GENERAL

A. Pressure measuring systems shall be handled, installed, calibrated, loop-tested, pre-commissioned, and performance tested in accordance with the requirements of Section 409100 – Process Control and Instrumentation.

B. The manufacturer shall furnish the manufacturer's service, supervision, and training in accordance with the requirements of Section 409100 – Process Control and Instrumentation.

- END OF SECTION -
PART 1 – GENERAL

1.1 THE REQUIREMENT

A. General The CONTRACTOR shall provide pressure detection switches, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 409100 - Process Control and Instrumentation apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 409100.

PART 2 – PRODUCTS

2.1 ADJUSTABLE PRESSURE SWITCH

A. Adjustable pressure switches shall be diaphragm-actuated, dual adjustment pressure switches with SPDT contacts rated for a minimum of 5 Amps at 120 VAC. The dead band shall be adjustable up to 60 percent of full scale. Set points shall fall between 20 and 80 percent of the adjustable range. The diaphragm shall be Buna-N, and the lower housing shall be brass with a 1/4-inch bottom sensing connection, unless otherwise indicated.

B. Manufacturer shall be United Electric Series 400, Ashcroft Series L/Series B, or equal.

C. Refer to Appendix A of Section 409100 for the complete instrument schedule.

PART 3 – EXECUTION

3.1 GENERAL

A. Pressure-measuring systems shall be handled, installed, calibrated, loop-tested, pre-commissioned, and performance tested according to Section 409100. The CONTRACTOR shall furnish the manufacturer’s service, supervision, and training indicated by Section 409100.

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1.1 THE REQUIREMENT

A. General: The CONTRACTOR shall provide control panels, complete and operable, in accordance with the Contract Documents.

B. Control panels shall comply with NEC Article 409 and this section.

C. The requirements of Section 409100 - Process Control and Instrumentation apply to this Section.

D. The provisions of this Section apply to Section 409220 - Control Panel Instrumentation except where indicated otherwise.

E. The provisions of this Section and 260515 apply to local panels provided in equipment systems specified in other sections unless indicated otherwise in those sections.

1.2 CONTRACTOR SUBMITTALS

A. General: Submittals shall be furnished in accordance with Section 013300 - Contractor Submittals.

B. Control Panel Engineering Submittal: The CONTRACTOR shall submit a control panel engineering submittal (CPES) for each control panel and enclosure provided under Division 40. The CPES shall completely define and document the construction, finish, layout, power circuits, signal and safety grounding circuits, fuses, circuit breakers, signal circuits, internally-mounted instrumentation and SCADA system components, faceplate-mounted instrumentation components, internal panel arrangements, and external panel arrangements. Panel drawings shall, as a minimum, be "B" size with data sheets and manufacturer specification sheets being "A" size. The submittal shall be in conformance with ISA S20 - Standard Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves, shall be submitted as a singular complete bound volume or multi-volume package within 120 Days after Notice to Proceed, and shall have the following contents:

1. A complete index shall appear in the front of each bound volume. Drawings and data sheets associated with a panel shall be grouped together with the panels being indexed by systems or process areas. Panel tagging and nameplate nomenclature shall be consistent with the requirements of the Contract Documents.

2. Scale construction drawings which define and quantify the type and gauge of steel to be used for panel fabrication, the ASTM grade to be used for structural shapes and straps, panel door locks and hinge mechanisms, type of bolts and bolt locations for section joining and anchoring, details and proposed locations for "UNISTRUT" members, stiffener materials and locations, electrical terminal box and outlet locations, electrical access locations, print pocket locations, writing board locations, and lifting lug material and locations.

3. Scaled physical arrangement drawings drawn to scale which define and quantify the physical groupings comprising control panel sections, auxiliary panels, subpanels, and racks. Cutout locations with nameplate identifications shall be shown.
4. Front of panel layouts for control panels.

5. Schematic/elementary diagrams shall depict control devices and circuits and their functions.

6. Wiring/connection diagrams shall locate and identify electrical devices, terminals, and interconnecting wiring. These diagrams shall show interconnecting wiring by lines, designate terminal assignments, and show the physical location of electrical and control devices.

7. Interconnection diagrams shall locate and identify external connections between the control panel/control panel devices and associated equipment. These diagrams shall show interconnecting wiring by lines, designate terminal assignments, and show the physical locations of panel ingress and egress points.

8. Control sequence diagrams to portray the contact positions or connections required to be made for each successive step of the control action. Written descriptions explaining the control sequence diagrams and system operation shall be furnished.

9. Completed ISA S20 data sheets for instrumentation devices associated with each control panel supplemented with manufacturer specification sheets which verify conformance to the requirements of the Contract Documents.

10. A bill of material which enumerates devices associated with the control panel.

11. A priced listing of analog spare parts in conformance with Section 409100.

1.3 EXTENDED PERIOD FOR CORRECTION OF DEFECTS

A. The CONTRACTOR shall correct defects in accordance with Section 409100.

PART 2 – PRODUCTS

2.1 GENERAL

A. **Environmental Suitability:** Indoor and outdoor control panels and instrument enclosures shall be suitable for operation in the ambient conditions associated with the locations designated in the Contract Documents. Heating, cooling, and dehumidifying devices shall be provided in order to maintain instrumentation devices 20 percent within the minimums and maximums of their rated environmental operating ranges. The CONTRACTOR shall provide power wiring for these devices. Enclosures suitable for the environment shall be provided. Instrumentation in hazardous areas shall be suitable for use in the particular hazardous or classified location in which it is to be installed.

B. The control panel controls shall be 120 VAC. Where the electrical power supply to the control panel is 240 VAC single phase or 480 VAC 3 phase, the control panel shall be provided with a control panel transformer. Control conductors shall be provided in accordance with the indicated requirements.

C. The control panel shall be the source of power for any 120 VAC solenoid valves interconnected with the control panel. Equipment associated with the control panel shall be ready for service after connection of conductors to equipment, controls, and control panel.
D. The main feeder disconnect shall have a door-mounted handle unless otherwise indicated.

E. Unless indicated otherwise, control panels shall be housed in NEMA rated enclosures in accordance with Section 260000 – Electrical Work, General. Control panels shall be either freestanding, pedestal-mounted or equipment skid-mounted, as indicated. Internal control components shall be mounted on an internal back-panel or side-panel as required.

F. Each source of foreign voltage shall be isolated by providing disconnecting or pull-apart terminal blocks or a disconnect operable from the control panel front. Each control panel shall be provided with identified terminal strips for the connection of external conductors. The CONTRACTOR shall provide sufficient terminal blocks to connect 25 percent additional conductors for future use.

G. Motor starters, where required, shall be in accordance with Section 262900 - Low Voltage Motor Control Center. Each motor starter shall be provided with contact closures for motor overload, local indication, and remote alarm. Electrical components shall be of standard American manufacture.

H. Discrete outputs from the control panel shall be provided by electrically-isolated contacts rated for 5 amps at 120 VAC. Analog inputs and outputs shall be isolated 4 to 20 mA, 2 wire signals with power supply.

I. Programmable Logic Controllers (PLCs) may be supplied in lieu of relays, provided the programmable logic controllers match the PLCs provided under Section 409605 - PLC-Based Control Systems Hardware.

J. Control panel mounted devices shall be mounted a minimum of 3-feet above finished floor elevation. Provide combination motor starters not furnished in a MCC but specified in Section 410000 - Equipment General Provisions.

K. **Painting:** Steel control panels shall be thoroughly cleaned and sand blasted per Society for Protective Coatings SP6 (Commercial Blast), after which surfaces shall receive manufacturer's standard prime plus finish coats. The finish color shall be ANSI 61 gray for indoor and white for outdoor unless otherwise indicated. Interior of the control panel, back-panel, and side panels shall have a white finish coat. The CONTRACTOR shall furnish 2 one pint containers of the finish coat for future maintenance purposes.

### 2.2 CONTROL PANELS

#### A. Materials

1. Steel panel section faces shall be 10-gauge minimum thickness for free standing panels and 14-gauge minimum thickness for wall-mounted or pedestal-mounted panels. Materials shall be selected for levelness and smoothness.

2. Relay rack high density type panels shall utilize standard relay racks with 14-gauge steel frame and supports.

3. Structural shapes and strap steel shall comply with ASTM A 283 - Low and Intermediate Tensile Strength Carbon Steel Plates, Grade C.

   a. Bolting Material: Commercial quality carbon steel bolts, nuts, and washers shall be 1/2-inch diameter with UNC threads. Carriage bolts shall be used for
attaching end plates. Other bolts shall be hex end machine bolts. Nuts shall be hot pressed hex, American Standard, heavy. Standard wrought washers shall be used for foundation bolts and attachments to building structures. Other bolted joints shall have SAE standard lock washers.

4. Construction: Dimensions shall be in accordance with vendor's requirements. Elevations and horizontal spacing shall be subject to ENGINEER's approval.

B. Fabrication

1. End plates, top plates, and top closure panels (to hung ceiling) shall be provided when required by the material requisition. End plates, top plates, and top closure panels shall be removable with countersunk bolts to match panels. Top closure panels shall be furnished in lengths that match the widths of standard panels, except that one top closure panel may extend across two 4-foot 6-inch wide or five 2-foot wide standard panels. The vertical joints of these panels shall align with the vertical joints of the standard panels.

2. End closure or rear closure doors shall be provided where required. Such doors shall be flush fitting, gasketed, and be of the hinged lift-off type with lockable door handles. A common key shall be provided for the doors on each panel assembly. Removable access panels shall be provided with dished handle fasteners. Screwdriver 1/4 turn or Dzus type fasteners are not acceptable.
   a. The flanged edges of panels shall be straight and smooth. Corners shall be welded and ground smooth.
   b. The face of the panel shall be true and level after flanging.
   c. Panel cutouts and holes may be cut or drilled by any standard method that does not cause deformation. Burrs shall be ground smooth.
   d. Adjacent panels shall assemble with faces flush. Gaps or cracks shall not be visible from the front of the assembled instrument board.
   e. Stiffeners shall be welded to the back of panels as required to prevent panel deformation due to the weight of face-mounted instruments.
   f. Panels shall be self-supporting as defined below.

C. Framework and Supports

1. The rear of each panel section shall have a steel framework for supporting conduit, wireways, switches, piping, and instrument accessory items such as relay or terminal enclosures, transducers, pressure switches, valves, and air relays. The main framework shall be constructed of standard structural shapes. Special shapes such as Unistrut may be used for secondary supports. Framework shall neither interfere with instrument connections nor interfere with access needed for maintenance or adjustments.

2. Steel framework shall extend 2-feet 4-inches back from the panel face or as indicated in the material requisition. Where indicated, individual adjustable leg supports shall be provided at the back of the framework so that the entire panel is self-supporting.
D. Preparation of Panel Surface

1. The following requirements apply to the front and rear face of the panel, both sides and the edges of flanges and the periphery of holes or cutouts.
   a. High spots, burrs, and rough spots shall be ground smooth.
   b. The surfaces shall be sanded or sandblasted to a smooth, clean, bright finish.
   c. Every trace of oil shall be removed with a solvent.
   d. The first coat of primer shall be applied immediately.

E. **Instrument Finishing:** The final coats applied to painted surface of instrument cases, doors, or bezels which are visible from the front of panels shall be manufacturer’s standard unless otherwise indicated. Black japan or "crinkle" finishes on instrument cases are not acceptable.

F. Mounting of Instruments

1. The panel vendor shall provide cutouts and shall mount instrument items indicated to be panel mounted, including any instruments indicated to be furnished by other vendors but installed in the panel.

2. The panel vendor shall also mount behind the panels other instrument accessory items as required for functionality as indicated.

3. Equipment mounted at the rear of panel shall be installed to allow for commissioning adjustments, servicing requirements, and cover removal.

4. Spare space shall be kept clear of wiring, etc., to give maximum space for future additions.

G. Electrical Requirements

1. The CONTRACTOR shall provide conduit, wireways, switches, wire, and electrical fittings for 120 volt circuits to instruments and other electrical devices as required for a complete and operable installation.

2. Conduit, wireways, junction boxes, and fittings shall be provided for signal wire, thermocouple, or resistance thermometer lead wire. Conduit or wireway runs shall include those required between temperature sensors and temperature transmitters and between the thermocouple wireway or junction box and instruments.

3. Each terminal connection shall have a plastic plate with a terminal and instrument tag number. Wiring shall be identified with stamped tubular wire end markers.

4. Freestanding panels shall be provided with switched 100 watt incandescent back-of-panel lights. One light shall be provided for every 4-feet of panel width and shall be mounted inside and in the top of the back-of-panel area.

5. Freestanding panels shall be provided with a 15 amp, 120 volt, service outlet circuit within the back-of-panel area. The circuit shall be provided with 3 wire, 120 volt, 15 ampere, duplex receptacles, one for every 4-feet of panel width (one minimum per panel), spaced evenly along the back-of-panel area.
6. Wall-mounted or pedestal-mounted panels shall be sized to adequately dissipate heat generated by equipment mounted in or on the panel.

7. Wall-mounted or pedestal-mounted panels outside or in unshaded areas shall be provided with thermostatically-controlled heaters that maintain inside temperatures above 40 degrees F.

8. Provide a hand switch-controlled 100 watt incandescent light and a breaker-protected 120 volt, 15 amp duplex receptacle within each wall mounted or pedestal mounted panel larger than 4 cubic feet volume.

9. Wiring Methods: Wiring methods and materials for panels shall be in accordance with the NEC requirements for General Purpose (no open wiring) unless otherwise indicated.

10. Signal and Control Circuit Wiring

   a. Wire type and sizes: Conductor shall be flexible stranded copper machine tool wire, UL listed Type MTW, and shall be rated 600 volts. Wires for instrument signal circuits and alarm input circuits shall be 14 AWG. Other wires, including shielded cables, shall be 16 AWG minimum.

   b. Wire Insulation Colors: Conductors supplying 120 VAC power on the line side of a disconnecting switch shall have a black insulation for the ungrounded conductor. Grounded circuit conductors shall have white insulation. Insulation for ungrounded 120 VAC control circuit conductors shall be red. Wires energized by a voltage source external to the control panel shall have yellow insulation. Insulation for DC conductors shall be blue.

   c. Wire Marking: Wire numbers shall be marked using white numbered wire markers made from plastic-coated cloth, Brady Type B 500 or equal, or shall be heat shrink plastic.

   d. Flexible conduit is not acceptable except when specifically approved by the ENGINEER in writing.

   e. Conduit fittings shall be Crouse Hinds cast fittings or equal.

   f. Splicing of wires will only be allowed in junction boxes. Splices shall be either soldered or pressure crimped type.

   g. For case grounding, panels shall be provided with a 1/4-inch by one-inch copper ground bus complete with solderless connector for one 4 AWG bare stranded copper cable. The copper cable shall be provided by the CONTRACTOR and be connected to a system ground loop.

11. Electrical Locations

   a. When the Contract Documents call for thermocouple-actuated instruments, the thermocouple lead wire shall be installed without junction by the CONTRACTOR. The panel vendor shall provide dedicated empty conduits or wireways running from the instruments to the top or bottom of the panel as called for in the material specifications or as otherwise required. Sizing of the conduit or wireway shall be in accordance with the capacity of the instruments.
b. Single case (no remote logic) annunciator units shall be installed at the top of panel and may be considered as a terminal box when top of panel wire entry is indicated. If bottom of panel entry is indicated, a terminal box shall be provided at the bottom of the panel and be wired to the annunciator unit. Terminals shall be identified with plastic marker strips.

c. Terminal boxes for incoming and outgoing signal leads shall be located at the top or bottom of the panel as indicated in the material specification or as otherwise required.

12. Power Supply Wiring

a. Unless otherwise indicated, instruments, alarm systems, and motor controls shall operate on 120 volt, 60 Hz circuits.

b. At a location near the top of the panel (or bottom), the panel fabricator shall provide terminal box connections for the main power supply entry.

c. Power supply switches for alarm units shall be 3 pole type, arranged to open both power circuits and alarm circuits. Each annunciator unit shall be equipped with a separate switch.

d. Instruments located on the same panel section and serving the same process unit may be connected to a common branch circuit from the power supply. The number of circuits depends on the circuit load as noted herein. A 15 amp, 2 pole circuit breaker shall be provided in each branch circuit. The circuit load shall not exceed 10 amp. Different panel sections or different process units must not use common branch circuits. When instruments do not come equipped with integral fuses, provide fuses as required for the protection of individual instruments against fault currents. Fuses shall be mounted on the back of the panel in a fuse holder, and each fuse shall be identified by a service name tag. Fuses shall be as manufactured by Bussmann Manufacturing Division, Type KAW TRON or equal.

e. Each potentiometer type instrument, electronic transducer, controller, or analyzer shall have an individual disconnect switch. Disconnect switches shall have metal or plastic tags indicating instrument tag numbers. Individual plug and cord set power supply connections may be used without switches when indicated in the material specification.

f. Where alarm units are single unit types, one switch may be used to disconnect not more than 6 alarm units located on the same or adjacent panels.

13. Alarm Wiring: The panel vendor shall install and wire alarms including light cabinets, audible signal units, test and acknowledge switches, and remote logic units as indicated. Interconnecting wiring to panel mounted initiating devices shall also be wired by the panel vendor. The wiring from external initiating devices shall be provided by the CONTRACTOR. Where plug and cord sets are provided for component interconnection, the panel vendor shall harness and support the cables in neat and orderly fashion. Where separate wire is required, panel vendor shall install 16 AWG with THWN or THHN insulation between components.
14. Signal Wiring

a. Signal Wire - Non Computer Use

1) Signal wire shall be twisted pair or triads in conduit or troughs. Cable shall be constructed of 16 AWG copper signal wires with THWN or THHN insulation.

2) Color code for instrument signal wiring shall be as follows:

   Positive (+) – Black
   Negative (-) - White

3) Multiconductor cables where indicated shall consist of 16 AWG copper signal wires twisted in pairs with 90-C, 600 V fault insulation. A copper drain wire shall be provided for the bundle with a wrap of aluminum polyester shield. The overall bundle jacket shall be PVC.

b. Signal Wire - Computer Use

1) Signal wires shall be similar to those for non-computer use but each pair shall be triplexed with a copper drain wire and aluminum polyester tape shall be applied over the triplexed group. Cable shields, including thermocouple extension leads shall be terminated in the central control room at the computer system grounding bus. Continuity of the shield shall be maintained throughout the cable runs.

c. Multi-conductor cables, wireways, and conduit shall be sized to allow for 10 percent spare signal wire.

H. Labor and Workmanship: Panels shall be fabricated, piped, and wired by fully qualified workmen who are properly trained, experienced, and supervised.

2.3 SCADA SYSTEM ENCLOSURES

A. Each SCADA system RTU and remote I/O system and corresponding housing, I/O modules, power supply modules, communication interface devices, and peripheral equipment shall be mounted inside a NEMA enclosure in accordance with Section 260000. I/O wiring from the field to the remote I/O system shall be terminated on terminal blocks in the lower portion of the enclosure. A nameplate shall be mounted on the outside of the door of the enclosure and be engraved with "RTU-X" or "RIO-X" where "X" is the number as shown on the Drawings. Where indicated, RTUs mounted in free-standing enclosures shall be 84-inches tall by 36-inches wide by 18-inches deep, minimum. Where indicated, RTUs mounted in wall or pedestal mounted enclosures shall be 48-inches tall by 36-inches wide by 18-inches deep, minimum. Enclosures shall be as manufactured by Hoffman, or equal.

2.4 OPERATOR VERTICAL CONSOLES

A. Consoles shall house WDCWA operator workstation at the following location:

   1. WDWCA - Electrical Room.
B. General

1. Modular construction comprised of:
   a. Metal vented frame.
   b. Three doors (upper, lower, rear). Upper door shall be 19-inch window for viewing operator workstation monitor.
   c. Keyboard compartment with keyboard shelve that shall be sealed and lockable.
   d. Sealed.
   e. Control compartments for workstation and monitor.
   f. Integral mouse pad holder.
   g. UL 508 Listed.

2. Manufacturer and Product: Hoffman; Proline – PC Type 12.

2.5 SPARE PARTS AND SPECIAL TOOLS

A. Control panel spare parts selected by the ENGINEER and special tools shall be furnished in accordance with Section 409100.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Preparation for Shipment and Shipping

1. Panels shall be crated for shipment using a heavy framework and skids. Panel sections shall be cushioned to protect the finish of the instruments and panel during shipment. Instruments that are shipped with the panel shall have suitable shipping stops and cushioning material installed to protect parts that could be damaged due to mechanical shock. Each separate panel unit shall be provided with removable lifting lugs to facilitate handling.

2. Shipments shall be by air ride van unless otherwise indicated.

3. Control panel testing and inspection shall be performed prior to shipping.

4. Control panels shall be installed in accordance with Section 409100.

3.2 CONTROL PANEL SIGNAL AND CONTROL CIRCUIT WIRING

A. Wiring Installation: Wires shall be run in plastic wireways except (1) field wiring, (2) wiring between mating blocks in adjacent sections, (3) wiring from components on a swing out panel to components on a part of the fixed structure, and (4) wiring to panel-mounted components. Wiring run from components on a swing out panel to other components on a fixed panel shall be made up in tied bundles. These bundles shall be tied with nylon wire ties and shall be secured to panels at both sides of the hinge loop so that conductors are not strained at the terminals.
B. Wiring run to control devices on the front panels shall be tied together at short intervals with nylon wire ties and be secured to the inside face of the panel using adhesive mounts.

C. Wiring to rear terminals on panel-mount instruments shall be in plastic wireways secured to horizontal brackets above or below the instruments in about the same plane as the rear of the instruments.

D. Shop Drawings shall show conformance to the above wiring installation requirements.

E. **Wire Marking:** Each signal, control, alarm, and indicating circuit conductor connected to a given electrical point shall be designated by a single unique number which shall be shown on Shop Drawings. These numbers shall be marked on conductors at every terminal.

3.3 CALIBRATION, TESTING, AND INSTRUCTION

A. **General:** Calibration, testing, and instruction shall be performed in accordance with Section 409100.

B. Inspection and Approval

1. Panel fabricator shall conduct the following tests prior to arrival of the ENGINEER or before shipment, if the ENGINEER chooses not to witness factory testing.
   
   a. Alarm circuits rung out to determine their operability.
   
   b. Electrical circuits checked for continuity and where applicable, operability.
   
   c. Any other test required to place the panel in an operating condition.

2. It shall be the responsibility of the CONTRACTOR to furnish necessary testing devices and sufficient manpower to perform the tests required by the ENGINEER.

3. Field Testing: Each control panel shall be tested again for functional operation in the field after the connection of external conductors and prior to equipment startup.

- END OF SECTION -
PART 1 – GENERAL

1.1 THE REQUIREMENT

A. **General:** The CONTRACTOR shall provide control panel instrumentation, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 409100 - Process Control and Instrumentation apply to the WORK of this Section.

C. The requirements of Section 409200 - Control Panels apply to the WORK of this Section.

1.2 CONTRACTOR SUBMITTALS

A. **General:** Submittals shall be included within the submittals of Section 409200 - Control Panels.

PART 2 – PRODUCTS

2.1 GENERAL

A. **Power Supplies:** Power supplies shall conform with the requirements of Section 409100.

2.2 INDICATORS

A. **Indicators, Digital Process:** Digital process indicators shall be self-contained instruments that display process signals directly in engineering units. The unit shall be suitable for panel mounting and shall utilize a 3-1/2 digit LED display of no less than 0.5-inch height. The input signal to the digital process indicator shall be 4 - 20 mA DC or 1-5 VDC as indicated. The input sample rate of the unit shall be a minimum of 2 per second. The unit shall have an auto-zeroing feature and shall have provisions for field adjustable scaling and offset. Accuracy shall be plus and minus 1 least significant digit. Input power to the digital indicator shall be 120 VAC, 60 Hz. Digital process indicators shall be as manufactured by Digitec Corp., Action Instruments Co., or equal.

2.3 LIMIT SWITCHES

A. **Limit Switches:** The Contractor shall furnish and install limit switches for door or hatch intrusion or for general purposes as shown on the contract drawings. Limit switches shall be provided with operating mechanisms as required for the mounting installation application and shall be provided with one set of SPDT contacts, rated at a minimum of 120 volts and 10 amps. The limit switches shall be NEMA 4X enclosure rated and shall be supplied with all mounting adapters required, custom or standard, and all hardware required for an operable installation. The limit switches shall be **Square D, Allen-Bradley** or approved equal.
2.4 FUNCTION MODULES

A. **Deviation Alarm Trips:** Deviation alarm trips shall accept two voltage or current input signals and produce a dry contact output whenever the amount of deviation of these two signals exceeds the deviation setpoint. The deviation setpoint shall be adjustable over 0-20 percent of span, minimum. Deviation alarm trips shall include a fixed deadband of 1 percent of span, maximum. Alarm trips shall be equipped with 10 A DPDT contacts. Alarm trips shall be **Moore Industries Model DCA, Rochester Instrument Systems Model ET-1224**, or equal.

2.5 CONVERTERS

A. **Pulse Duration to Voltage/Current Signal Converter:** The signal converters shall accept pulse duration signals and produce a voltage or current signal output in linear proportion to the input signal. Output span and zero shall be adjustable and accuracy shall be plus and minus 0.1 percent of span. The unit shall be surface or rack mounted. Power input shall be 120 VAC, 60 Hz. The signal converters shall be **Moore Industries Model PDR, AGM Electronic Model TA-5100-2**, or equal.

B. **Voltage/Current to Pulse Duration Signal Converter:** The signal converters shall accept voltage/current signals and produce a dry contact pulse duration output signal in linear proportion to the input signal. Output span, zero and cycle duration shall be adjustable and accuracy shall be plus and minus 0.1 percent of span. The units shall be surface or rack mounted. Power input shall be 120 VAC, 60 Hz. The signal converters shall be **Moore Industries Model PDT, AGM Electronics Model TA 5000**, or equal.

C. **Signal Inverter:** Signal inverters shall have complete isolation of input, output, and power input. Signal input shall be 4 - 20 mA into 50 ohms maximum. Signal output shall be 20 - 4 mA, linearly inverse to the input signal into 1000 ohms minimum. Power input shall be 120 VAC, 60 Hz. Span and zero shall be adjustable; accuracy shall be plus and minus 0.1 percent of span. Units shall be surface or rack mounted. Signal inverters shall be **Moore Industries Model SCT, Rochester Instrument Systems Model SC-1302 LZ**, or equal.

D. **Pulse Rate to Voltage/Current Signal Converter:** The signal converters shall accept a pulse rate input signal and produce a voltage or current output signal in linear proportion to the input signal. The output span and zero shall be adjustable and accuracy shall be within plus and minus 0.1 percent of span. The unit shall be surface or rack mounted. Power input shall be 120 VAC, 60 Hz. The signal converters shall be **AGM Electronics Model TA-5100, Moore Industries Model FDT**, or equal.

E. **Resistance/Current Signal Converter:** The signal converters shall accept potentiometer signals and produce a voltage or current signal output in linear proportion to the input signal. Output span and zero shall be adjustable and accuracy shall be plus and minus 0.1 percent of span. The unit shall be surface or rack mounted. Power input shall be 120 VAC, 60 Hz. The signal converters shall be **Moore Industries Model PTT, AGM Electronics Model TA-4003**, or equal.

F. **Signal Splitters:** Signal splitters shall be capable of generating two identical 4-20mA isolated outputs from a single 4-20mA input. Each input and output channel shall operate independently and shall employ galvanic isolation to prevent interaction, formation of ground loops and reduce noise. The units shall automatically compensate for load resistance variations from 0 to 1000 ohms. Current output shall be limited to 27mA. Signal splitters shall be as manufactured by **Acromag Model 633T**, or equal.
PART 3 -- EXECUTION

3.1 GENERAL

A. Control panel instrumentation shall be executed in accordance with Section 409100.

- END OF SECTION -
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1.1 THE REQUIREMENT

A. The CONTRACTOR, through the use of the designated Integrator, shall provide all RTU and PLC-based control and monitoring systems programming required to implement the control strategies described in this section, the functions shown on the drawings and I/O schedules complete and operable in accordance with the Contract Documents.

B. The requirements of Section 409100 – Process Instrumentation and Control Systems, Section 409510 – RTU and PLC – Based Control Systems Hardware, and Section 409520 – RTU-Based Control Systems Software apply to this Section.

C. The requirement includes all RTU/PLC, OIT and Workstation (Master SCADA site at the RD 2035 Office) programming. The requirement also includes all other programming of RTU and PLC interface, network and communication devices. The PLC, radio, and Workstation associated with WDCWA will be programmed by WDCWA.

D. The HMI status and control as described herein and as indicated on sheets GI-3, GI-7 and I-1 through I-10 of the Contract drawings shall be provided at the OIT’s in the pump station and at the workstations at the RD 2035 office. Alarms shall be integrated into the RD 2035 remote alarm notification systems.

E. Programming of the RD-2035 OIT in the pump station shall include screens to display the status and control of the entire RD 2035 system. I/O points from other sites shall be relayed through the RD 2035 office for display and control features at the pump station. Additionally, several canal levels, river level, post screen levels, screen cleaner monitoring and control, sediment pump and valve controls and monitoring from the system will be integrated into the pump station controls as described below.

F. Programming of the WDWCA OIT/Workstation in the pump station shall be configured by WDCWA.

G. Programming of the WDCWA Remote SCADA shall include coordination with RD 2035. The river level, post screen levels, screen cleaner monitoring and control, sediment pump and valve controls and monitoring from the system will be integrated into the pump station controls as described below.

H. The I/O Point Lists for each system are attached to Section 409510, Attachments 1 & 2.

1.2 COMMON FUNCTIONS

A. Common functions that are generally applicable to all loops or to many similar loops are described under the heading “General Control Loop Functions.” These functions are not repeated in the descriptions for each individual control strategy.

B. General Control Loop Functions

1. The following terms are used in the descriptions of RTU and PLC functions:
a. Operator Settings: Operator set or entered values shall be constants that are adjustable or set from operator displays. Specific values that are required to be operator set are noted in the process control strategy descriptions.

b. Tunable Values: Tunable values are constants that are adjustable at engineer level displays without requiring any software reconfiguration. These values are not adjustable from operator level displays.

2. The following general control system functions shall be provided:

   a. All analog and discrete inputs to the RTU shall be displayed. Both RUNNING and OFF input states shall be displayed.

   b. All analog inputs shall have instrument failure alarms when the input is below 0 percent or above 100 percent for a tunable time initially set at 10 seconds.

   c. All discrete FAIL inputs shall be alarmed. Other discrete inputs shall be alarmed as noted in the control strategy descriptions.

   d. Where alarms are specified in the control strategy descriptions, alarms shall be initiated from the applicable inputs. If discrete inputs are not available, the specified alarms shall be initiated from the applicable analog input; alarm setpoints shall be operator adjustable.

   e. All analog inputs shall be trended.

   f. All flow inputs and equipment run times shall be totalized and recorded. All totalized values shall be displayed.

   g. Displays shall be grouped functionally for ease of operation. Both analog and discrete functions associated with an item of equipment or a group of equipment shall be provided on the same display.

   h. Unless otherwise stated or shown, all discrete outputs shall be maintained outputs. For START/STOP RTU/PLC functions, the RTU/PLC shall issue a maintained START command until a FAIL state is detected or when a STOP command is issued. When a momentary command is required, the RTU/PLC shall issue the command for two (2) seconds, then remove the signal.

   i. For equipment that is controllable from the RTU/PLC a control mode status signal will be sent to the RTU/PLC to indicate when the RTU/PLC is allowed to control the equipment. The RTU/PLC shall monitor the control mode status (LOCAL/ REMOTE) and control only that equipment which is in the REMOTE mode.

   j. For equipment that the RTU/PLC is to control, the RTU/PLC shall provide a FAIL alarm if the equipment fails to comply with a RTU/PLC command signal (START, STOP, OPEN, CLOSE) that has been present for more than a tunable time period. In this event, the command shall be removed subsequent to the expiration of the tunable time period.

   k. For equipment that is controllable from the RTU/PLC in either a MANUAL or AUTOMATIC mode, the operator shall be provided with a software AUTO/MANUAL selector switch at the operator workstation. Transfer between the MANUAL and AUTOMATIC modes shall be bump less (make before break).
I. All PID control functions (P, PI, and PID) shall be provided with standard analog controller functions and operator interfaces including, but not limited to, the following:

1) AUTO/MANUAL mode selection: In AUTO, the output of controller shall be based on the PID control calculation. In MANUAL, the output of the controller shall be operator adjustable. Transfer between operational modes shall be bumpless.

2) LOCAL/REMOTE set point selection: In LOCAL, the set point shall be operator adjustable from the equipment. In REMOTE, the set point shall be adjustable from a REMOTE set point input.

3) Set point, process variable, and controller output shall be displayed.

4) Provisions shall be included to prevent reset windup.

m. When equipment is tagged OUT OF SERVICE, by the operator, all associated equipment shall have their alarms inhibited until the tagged equipment is re-tagged IN SERVICE.

n. Speed indications and speed control setpoints shall be displayed in RPM for rotational motion and feet/second for linear motion.

o. Wherever two or more pieces of equipment are provided for the same functions, the SCADA system shall alternate the equipment after each use.

C. Networks

1. The new RD-2035 RTU, OIT, and radio shall be interconnected with Modbus.

2. The new WDCWA PLC and OIT shall be interconnected via Ethernet.

3. The new WDCWA PLC Remote I/O panel (provided by others and remotely mounted by WDCWA) shall be connected via fiber optic Ethernet (fiber optic cable provided by others).

4. The new WDCWA PLC shall communicate via a Ethernet radio link to the external WDCWA SCADA systems.

5. The new WDCWA PLC shall communicate via Devicenet to the Motor Operated Valves (MOV's) on the system. (NOTE to Phil/Janet --- I thought this was being removed and hardwired instead)

6. The new RD 2035 valves, gates and canal level transmitters at the Outfall Structure shall be interconnected with Modbus.

7. Power Monitoring - All information, including Phase Voltages, Phase Amps, Kilowatts, Kilovars, Power Factor, and Frequency, shall be made available to the respective SCADA system, except for the common power monitoring for the incoming power which shall go to both SCADA systems.

8. All data available over the networks shall be available on both the Control Systems.
D. The following abbreviations are used throughout this section:

SS: Selector Switch  
LOR: LOCAL/OFF/REMOTE  
VFD: Variable Frequency Drive  
LR: Local/Remote  
HOA: Hand/Off/Auto  
MOV: Motor Operated Valve  
LOS: Lock-Out Stop  
RVSS: Solid State Starter

1.3 SCADA FAILURE MODES

A. Operator Interface Terminals and HMI Workstations

1. RTU/PLC programs shall be capable of functioning normally in the absence of an OIT or and HMI Workstation without any special modifications. Process logic, including monitoring, control, and alarming functions shall be programmed at the RTU/PLC level only.

2. Should any OIT or HMI workstations fail, the SCADA shall continue control functions independent of the workstation status.

B. SCADA

1. Software watchdog timers, incorporating a “heartbeat” routine, shall be included to monitor the condition of the SCADA systems.

2. RTU to RTU component failures shall be indicated on the OIT and SCADA HMI graphic display.

3. Independent watchdog routines shall include, but not be limited to the following:
   a. Power supply failure.
   b. SCADA / RTU network failure.
   c. SCADA / PLC network failure.
   d. RTU to PLC communication failures.
   e. SCADA / RTU component failure.

4. The PLC shall have internal diagnostics that detect and report I/O module failures.

5. In the event of a RTU/PLC component (rack, I/O module, communication card, etc), failure, the affected RTU/PLC outputs shall fail to a de-energized state.

C. SCADA System Monitoring: OIT and HMI graphic screens will be required for monitoring the SCADA / RTU/PLC Network, RTU/PLC panels and I/O Modules. Any system faults shall be indicated on the graphic screen and the appropriate action taken.
D. Equipment Re-Start

1. Equipment furnished with a Local-Remote or Local-Off-Remote selector switch shall re-start after a power outage when in the Remote mode and based on the status of the associated field interlocks, i.e. pump level controls calling for a pump to run. When multiple pumps are required to run, they shall be restarted at 3 minute intervals.

2. When equipment has been stopped (shutdown) due to an alarm condition, it shall automatically be placed Out of Service by the SCADA logic. When a piece of equipment is tagged Out of Service, that equipment shall have the alarms inhibited until the equipment is placed back In Service.

3. When equipment has failed, the fail alarm must be manually acknowledged at the HMI or OIT. Latched alarms must be reset locally at the equipment panels. After the alarm has been acknowledged and reset, the operator shall have the capability of placing the equipment back in service.

1.4 SCOPE OF THIS SECTION

A. These control strategies are intended to address systems that will be installed or modified as part of the project and to describe the general operation of the systems and processes. These control strategies are not intended to be all-inclusive operational procedures for the operation of the complete facility. The CONTRACTOR shall make refinements, modifications and additions to these strategies as needed.

PART 2 -- PRODUCTS (NOT USED)

PART 3 – EXECUTION

3.1 CONTROL STRATEGIES
INTAKE FISH SCREEN CLEANER SYSTEM

Reference Drawings: I-1

Overview:

1. An intake fish screen will prevent fish and debris from the Sacramento River entering the intake of the pumping station. The screen will be equipped with a screen cleaner system that includes a motorized brush mechanism driven by a variable frequency drive (VFD). The speed of the brush mechanism drive motor shall be set to provide for breakaway from its rest position and slow movement to a designated position at the beginning of each operation. At the designated position, control through the drive mechanism VFD shall increase the speed. When the brush mechanism nears the end of travel, control shall slow the speed of the brush mechanism to its stopping position. Return travel to its resting position shall occur in the same manner. The resting position, the end of travel position and the change of speed positions shall be detected by proximity switches. The brush mechanism movement at ends of travel shall have limit switches as back up to the proximity switches. The speed of the brush, thereby the setting of the VFD frequency, shall be adjustable from the Vendor Control Panel (VCP). The VCP shall allow testing of the brush assembly by setting speed and direction of movement.

Local Manual Control:

1. Local control of the screen cleaning system is provided at the VCP. Local control is performed by placing the screen cleaner L/R switch in the LOCAL position and pressing the START button. Forward motion (rest position to extended position) is initiated by the START FORWARD button and reverse motion is initiated by the START REVERSE button. Speed is set by the SPEED potentiometer. Indicating lights show the position of the screen.

2. The VCP is located on the structure deck near the rest position of the screen drive mechanism.

3. Panel VCP shall also include wiring and components to provide complete and separate hardwired interfaces to the RD 2035 and WDCWA control systems.

Remote Automatic Control:

1. The screen cleaner has three remote operating modes, MANUAL, CYCLE AND DURATION and HEADLOSS. When the L/R switch is in the REMOTE position and MANUAL is selected from the OIT or remote HMI, the screen start cycle can be manually initiated from either RD 2035 or WDCWA. The remainder of the automatic controls for the cycle reside in the screen cleaner VCP.

2. When the L/R switch is in the REMOTE position and CYCLE AND DURATION is selected at the VCP, the screen start cycle is initiated by time of day. It shall be possible for the setting of multiple operations in a 24 hour period. Duration of screen cleaner cycle may be adjusted to require multiple cleaning cycles. The time clock setting and the duration setting shall be adjustable at the VCP where all the automatic controls for the cycle reside in the screen cleaner VCP.
3. When the L/R switch is in the REMOTE position and HEADLOSS is selected from the OIT or remote HMI, the screen start cycle is automatically initiated by differential level across the intake screen. The setting of the differential head shall be adjustable from the either the RD 2035 or WDCWA OIT’s. The remainder of the automatic controls for the cycle reside in the screen cleaner VCP.

4. The VCP shall track the predicted location of the brush as it passes from one end to the other by use of the brush speed as derived from the frequency setting of the VFD and the travel distance. The extended, retracted and intermediate positions of the brush as determined by the proximity switches shall be displayed at the OIT. Failure to reach the proximity switch locations in the predicted period of time shall cause an alarm to be made and shall cause the VFD to be de-energized. An adjustable time delay shall be utilized in the alarming. Screen cleaner operating current will be monitored for overload conditions.

Alarms:

1. Excessive Cycle Time.
2. Failure of the brush drive motor to start/stop
3. VCP control power failure
4. Emergency stop
5. VFD Fault
6. Post Screen Water Level Transducer Failure
7. High Differential Water Level
8. River Water Level Transducer Failure
9. Low River Level
10. Post Screen Water Levels
SEDIMENT CONTROL SYSTEM

Reference Drawings: I-1 and I-2

Overview:

1. Sediment Control Systems shall be provided to prevent the accumulation of sediment in front of and within the intake to the Raw Water Pumps. One system will serve the upstream half of the intake structure and one will serve the downstream half of the intake structure. Each system will be equipped with a submersible pump, pump discharge manifold and five valves. The valves shall be cycled individually to provide for the desired cleaning. Desired cleaning is an operator determined operation. The sequence of the valves, time of opening and the time of day cleaning shall be adjustable and provided at the panel 40-LCP-450.

2. Operation of the Sediment Control Pump shall be prevented in case of Low Suction Level. Operation of the SED Pump shall be stopped when Low Suction Level, Low System Pressure or High System Pressure occurs. Adjustable time delays shall be used to override transient conditions.

Local Manual Control:

1. Local control of the sediment control system is provided at each valve motor operator and the pump RVSS. Local control is performed at the pump RVSS by placing the L/R switch in the LOCAL position and using the START and STOP pushbuttons. Local control is performed at a valve by placing the motor operator LOR switch in the LOCAL position and using the OPEN/STOP/CLOSE selector.

2. In local operation, the operator is responsible for coordinating simultaneous operation of the pump and valve(s).

Local Manual Control at System Panel:

1. A system control panel, 40-LCP-450, provides controls to locally operate the upstream and downstream sediment control systems. Local control may be performed at the sediment control panel by placing the equipment L/R switches in the REMOTE position, placing the HOA switch in the HAND position, and using the ON/OFF and OPEN/CLOSE selector switches.

2. In local operation, the operator is responsible for coordinating simultaneous operation of the pump and valve(s).

3. Panel 40-LCP-450 also includes wiring and component to provide a complete and separate hardwired interface to both the RD 2035 and WDCWA control systems.

Remote Automatic Control:

1. Automatic control of the sediment control system shall be provided by the 40-LCP-450 panel. Automatic control is performed by the relay logic within the 40-LCP-450 panel. The sediment control system has a a HAND/OFF/AUTO selector switch at the panel. In the HAND position, each of the pumps and control valves are operated by the Operator as specified above. When the selector switch is in AUTO, the starting and stopping of the sedimentation pumps and the opening and closing of the individual branch valves will be actuated automatically by the relay logic. Also, the
automatic cycle can be remotely manually initiated by either the RD 2035 or WDCWA panels. At either of the OIT’s the initiation of the cycle can be programmed through a software L/R switch. When the L/R switch is in the REMOTE position, the start cycle shall be initiated by time of day. It shall be possible for the setting of multiple operations in a 24 hour period. The operation of the valve OPEN/CLOSE sequence shall be adjustable at the 40-LCP-450 panel. The OPEN duration for each valve shall also be adjustable from the 40-LCP-450 panel.

2. The sediment control sequence, in general, is as follows:

   a. Start Sediment Control Pump

   b. Open one valve at a time, sequencing through all valves to provide for the desired cleaning.

   c. Stop Sediment Control Pump

   d. In the event of a valve failure during the sequence, the control system will continue with the remainder of the sequence and then shut down the pump after the last valve closes.

**Alarms:**

- 1. Failure of the sedimentation pump to start/stop
- 2. Control power failure
- 3. RVSS Fault
- 4. Low System Pressure
- 5. High System Pressure
- 6. Low Suction Level
RD-2035 RAW WATER PUMPING SYSTEM

Reference Drawings: I-3, I-4, I-5, I-6

Overview:

1. Five constant speed vertical turbine pumps, Raw Water Pumps 1,2,3,4,5 (P-1120, P-120, P-130, P-140, P-150), pump water from the Sacramento River to the District's main canal.

2. The Raw Water Pumps can be controlled locally from the face for the Reduced Voltage Solid State Starter (RVSS) or from the SCADA system. A LOCAL / REMOTE selector switch is available at the face of the RVSS. A MANUAL / AUTO selection is provided at the SCADA operator interface screen.

3. For maintenance, local control of the Pump Discharge Valves and Outlet Structure Sluice Gates is performed by placing the motor operator LOR switch in the LOCAL position and using the OPEN/STOP/CLOSE selector.

4. All modes of operation utilize automatic controls through the RTU to sequence a pump start with the operation of siphon assist systems and lubrication systems as well as the discharge valves to regulate flow provided by the pump. The Pump Discharge Valve and Outlet Structure Sluice Gate.

5. The automatic controls for the Pump Start/Stop Sequence and flow regulation is as listed below.

   a. Pumps and Discharge Valves: A pump will normally start with the 36-inch butterfly valve at the discharge outlet structure partially closed. After a preset adjustable time delay to allow the discharge pipe to fill with water and the flowmeter to begin reading flow, the 36 inch butterfly valve will readjust (open or closed as required) to obtain the maximum possible flow output, or the maximum allowable flow limit of flow at pump run-out, whichever is less. The valves will be controlled solely based on the feedback from the flowmeter to maintain the desired operator flow input into the Remote Terminal Unit (RTU) or SCADA system, with a maximum allowable flow limit at pump run-out. If the maximum flow limit is exceeded as detected by the flowmeter, the valve will slowly close until the flowmeter detects a flow below the predetermined maximum amount. A butterfly valve will not remain open when its respective pump is not running or is off-line to prevent siphoning through the 42-inch pipeline in either direction, which may happen under certain combinations of river/canal water levels. The basic operating statement for throttling of the butterfly valve is defined below:

   1) If Flow > 42,250 gpm (maximum flow at pump run-out)
   2) Close Valve until Flow = 42,250 gpm
   3) Else, if Flow < 41,000 gpm
   4) Open Valve until Flow = 41,000 gpm
b. Outlet Structure Sluice Gates: Independent of valve and pump operations, the sluice gates at the discharge outlet structure will fully open or fully close with respect to the difference in river and canal water levels. Operation of the sluice gates will be controlled by the RD 2035 RTU/SCADA system solely based on input from the level sensors in the intake structure and in the canal. The RTU system will be programmed such that if the elevation of the river water surface minus the canal water surface exceeds a determined maximum value of 1.5 feet, the sluice gates will close to increase the water surface over the butterfly valves, and prevent cavitation at the valves. The basic sluice gate operating statement is defined below:

1) If “River Level” – “Canal Level” > 1.5 feet, Close Sluice Gate

2) Else, if “River Level” – “Canal Level” < 1.2 feet, Open Sluice Gate

c. Vacuum Assist / Siphon Break System:

1) The vacuum assist solenoid valves (SV-112, SV-122, SV-132, SV-142 and SV-152) are located on the line between the pump discharge air release valve and the vacuum pump system. The valves are normally closed. When a pump is started, the corresponding vacuum assist solenoid valve will open after a time delay. The valve will remain open continuously while the pump is running.

2) The siphon break solenoid valves (SV-111, SV-121, SV-131, SV-141 and SV-151) are located on the line between the pump discharge line and the pump discharge air release valve and the vacuum pump system. The valves are normally open. When a pump is started, the corresponding siphon assist solenoid valve will close. The valve will remain closed continuously while the pump is running. When a pump is stopped, the corresponding siphon break solenoid valve will open after a time delay.

d. Pump Lubrication System: The oiling solenoid valve will be energized to the open position when the pump is started and will remain open continuously while the pump is running.

Integration of RD2035 and WDCWA Control Systems and Operations:

1. The Joint River Intake will provide pumping capabilities for two organizations, Reclamation District 2035 (RD2035) and Woodland Davis Clean Water Agency (WDCWA). A pump capacity summary for the two organizations is listed below.

<table>
<thead>
<tr>
<th>Owner</th>
<th>No. of Pumps</th>
<th>Capacity per Pump (gpm)</th>
<th>Capacity per Pump (cfs)</th>
<th>(n-1) Pump Capacity (cfs)</th>
<th>Design Capacity (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RD2035</td>
<td>5</td>
<td>39512 - 43350</td>
<td>80 - 94</td>
<td>320-376</td>
<td>400</td>
</tr>
<tr>
<td>WDCWA</td>
<td>4</td>
<td>12200</td>
<td>27</td>
<td>80</td>
<td>100</td>
</tr>
</tbody>
</table>

2. Interlocks will limit operation of the RD2035 and WDCWA pumps to prevent the total Intake Structure flow from exceeding 400 cfs. The status and alarms of the pumps will
be monitored by both organizations, so both can view how many and which pumps are running within the pump station.

3. Given that each RD2035 Pump is rated to deliver 80-95 cfs, four pumps would deliver 320-376 cfs. The fifth pump will not be permitted to start under any mode of operation if the measured discharge flow of the RD2035 pumps exceeds 320 cfs. In general, the controls shall be designed to prevent the start of a pump that will cause the 400 cfs limit to be exceeded.

4. Changing operating conditions or WDCWA pump starts may cause the flow limit to be momentary exceeded. Several cases are listed below that will stop a pump. The control system shall prevent this pump from attempting to restart under this condition.

a. If the total RD2035 flow exceeds 400 cfs under any mode of operation, the pump that was last started will be stopped.

b. If the combined total of RD2035 and WDCWA flows exceeds 400 cfs under any mode of operation, the pump that was last started, either the fourth RD2035 pump or the third WDCWA pump will be stopped.

c. If the combined total of RD2035 and WDCWA flows exceeds 400 cfs under any mode of operation and WDCWA is operating only one or two pumps, the fourth RD2035 pump will be stopped.

5. The three intake isolation gates, G-101, G-102 and G-103 may be manually closed to isolate the upstream and downstream halves of the wet well. It is assumed that if any or all of the gates are closed, water will be pumped from only the upstream or only the downstream half of the intake and not pump from both halves simultaneously. The intake screens for each half are rated for 200 cfs, maximum. If any or all of the isolation gates are closed, the controls shall be designed to prevent the start of a pump (RD2035 or WDCWA) that will cause the 200 cfs flow limit to be exceeded. If the combined total of RD2035 and WDCWA flows exceeds 200 cfs under any mode of operation while any or all of the gates are closed, the pump that was last started will be stopped.

6. From the HMI, the RD2035 operator may select Four-Pump Operation or Three-Pump Operation to assist with operational coordination between the two organizations. Under Four-Pump operation, up to four pumps may run to provide up to 320-376 cfs for canal level control. Under Three-Pump operation, up to three pumps may run to provide up to 240-282 cfs for canal level control.

7. The two organizations will have independent PLC/SCADA and radio communications systems but an interface between the two will be crucial to continued operations. The PLC to PLC interface between RD2035 and WDCWA will be required to establish the necessary interlocks defined in this design for excess flow scenarios. The summated WDCWA and RD2035 flow data will be shared between the two controllers. PLC to PLC I/O points for the pump controls include listed below. Refer to the I/O for a complete listing of shared I/O points.

a. Digital Inputs from WDCWA

   1) WDCWA Raw Water Pump 1 Run Status
   2) WDCWA Raw Water Pump 2 Run Status
   3) WDCWA Raw Water Pump 3 Run Status
   4) WDCWA Raw Water Pump 4 Run Status
b. Digital Outputs to WDCWA
   1) Raw Water Pump 1 Run Status
   2) Raw Water Pump 2 Run Status
   3) Raw Water Pump 3 Run Status
   4) Raw Water Pump 4 Run Status
   5) Raw Water Pump 5 Run Status

c. Analog Inputs from WDCWA
   1) WDCWA Total Flow

d. Analog Outputs to WDCWA
   1) RD2035 Total Flow

Local Operation:

1. While in LOCAL mode, the pump can be started and stopped by pressing START or STOP at the RVSS. This mode of operation would typically be used for maintenance. Standard operating procedures should require an interval of 3 minutes, minimum, between pump starts. Any given pump should not be started more than 4 times an hour or as otherwise recommended by the pump.

2. Hardwired interlocks prevent the pump from running under any mode of operation including local. HIGH DISCHARGE PRESSURE, LOW INTAKE LEVEL, MPR TRIP, RVSS FAIL, and HIGH VIBRATION ALARMS will cause the pump to shut down or prevent it from starting.

3. An Emergency-STOP (E-STOP) pushbutton will also prevent the pump from running under any mode of operation.

4. Pump Starter devices
   a. LOCAL/REMOTE selector switch (REMOTE status is provided to SCADA)
   b. RVSS RESET Pushbutton
   c. Pump RUN indication light
   d. E-STOP pushbutton
   e. HIGH AND LOW DISCHARGE PRESSURE ALARMS, MPR TRIP, RVSS FAIL, and HIGH VIBRATION ALARM indication lights. (A common alarm is provided to SCADA.)
   f. Motor Protection Relay (MPR) device with a TRIP RESET pushbutton.

5. DISCHARGE PRESSURE and DISCHARGE flow is monitored by the SCADA system in all modes of operation.
Remote Manual Operation:

1. While in REMOTE MANUAL mode, each pump can be started and stopped by pressing START or STOP at the SCADA operator interface screen.

2. While in REMOTE MANUAL or REMOTE AUTO control, LOW INTAKE LEVEL alarms (LSL-100, LSL-101) are supplemented by LOW INTAKE LEVEL alarms generated by the RTU from the LIT-400B and LIT-400C level signals. A LOW INTAKE LEVEL alarm will cause the pump to shut down or prevent it from starting.

3. Pumps are operated to control level in the canal as follows:
   a. When not delivering water the canal level is allowed to drop below 11’ to a level of approximately 10’–8”.
   b. The canal level is monitored via several analog level transmitters, as outlined below, that feed into the SCADA system.
      1) Existing Level transmitter LIT-203 provides canal level near the reservoir.
      2) New Level transmitter LIT-204 provides redundant indication of canal level near the reservoir.
      3) Level transmitter LIT-202 provides indication of canal level at the siphon.
   c. The canal level also monitored by sight at the headquarters on an existing level measuring ruler (feet).
   d. If the level in the canal is allowed to rise to 11’ 6”, the canal road is flooded. Canal level is maintained at 11’-2” or less under typical operation.

Remote Automatic Operation:

1. While in REMOTE AUTO mode, the Raw Water Pumps operate together through a combination of canal level controls and operator inputs from the SCADA operator interface screen.

2. The automatic controls for maintaining canal level are as described below.
   a. From the HMI, the operator may select Four-Pump Operation or Three-Pump Operation. Under Four-Pump operation, up to four pumps may run to provide up to 320-376 cfs for canal level control. Under Three-Pump operation, up to three pumps may run to provide up to 240-282 cfs for canal level control. Three-pump control is designed to provide a reduced flow option for RD 2035 coordination with WDCWA flow requirements. Four-Pump Operation is described below.
   b. During periods of water delivery, pumps are run in a Lead - Lag 1 - Lag 2 – Lag 3 level control configuration to maintain a target level of 11’ - 0” (or other operator selected setpoint) in the canal.
c. The operator may adjust the canal setpoint level. Setpoint selection between 10’-8” and 11’-2”, in one inch increments is available at the SCADA screen. This setpoint is initially set at 11’-0”.

d. The canal level is also monitored via several analog level transmitters, as outlined below, that feed into the SCADA system.

e. Primary level control for the pumps is provided by level transmitters LIT-203 and LIT-204 near the reservoir.

f. Level transmitter LIT-202 provides indication of canal level at the County Road 22 siphon. This level indication is interlocked to the pump controls via RTU-CR22 to prevent flooding ahead of the siphon. If at any time during the AUTO sequence, level ahead of the siphon reaches a level of 11’-3”, one pump will be stopped. If the level ahead of the siphon continues to rise and reaches a level of 11’-4”, and all pumps will be stopped. After the level has fallen to a level of 11’-0”, the pump automatic controls will resume as needed to maintain canal level.

g. A START / STOP level control chart for the default setpoint is provided below.

<table>
<thead>
<tr>
<th>ELEVATION (Falling Level)</th>
<th>ELEVATION (Rising Level)</th>
<th>START / STOP / ALARM DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>11’ – 4”</td>
<td></td>
<td>High-High level Alarm</td>
</tr>
<tr>
<td>11” – 3”</td>
<td></td>
<td>High Level Warning</td>
</tr>
<tr>
<td>11” – 0.5”</td>
<td></td>
<td>Stop Lead (All pumps off)</td>
</tr>
<tr>
<td>11” – 0”</td>
<td></td>
<td>Stop all Lag Pumps</td>
</tr>
<tr>
<td>10’ – 11.25”</td>
<td></td>
<td>Start Lead Pump</td>
</tr>
<tr>
<td>10’ – 10.75”</td>
<td></td>
<td>Start Lag 1 Pump</td>
</tr>
<tr>
<td>10’ – 10.25”</td>
<td></td>
<td>Start Lag 2 Pump</td>
</tr>
<tr>
<td>10’ – 9.75”</td>
<td></td>
<td>Start Lag 3 Pump</td>
</tr>
<tr>
<td>10’ – 7”</td>
<td></td>
<td>Low Level Warning</td>
</tr>
</tbody>
</table>

h. When not delivering water, the controls utilize the same automatic sequence. The setpoint, however, is reduced to maintain a minimum canal level of 10’-8”.

i. The controls will require an interval of 3 minutes, minimum, between pump starts.

j. The controls will require that any given pump should not be started more than 4 times an hour or as otherwise recommended by the pump manufacturer.

k. The five Raw Water Pumps will be automatically assigned to the AUTO sequence on a rotating basis to maintain similar run times. After the sequence has been completed, these assignments will be rotated each time all pumps are stopped. If a pump is in local control, it is not available for automatic controls and taken out of the pump start sequence.

3. CANAL HIGH LEVEL WARNING AND HIGH LEVEL ALARM will be provided at 11-3” and 11’-4” respectively at the SCADA system.
4. CANAL LOW LEVEL WARNING will be provided at 10-7” at the SCADA system.

Alarms:

1. Failure of the raw water pump to start/stop
2. Control power failure
3. RVSS Fault
4. Low Discharge Pressure
5. High Discharge Pressure
6. Low Suction Level
7. High Pump Vibration
8. Motor Protection Relay Trip
9. High Motor Bearing Temperature
10. High Motor Winding Temperature
11. Canal High Level Warning
12. Canal High Level Alarm
13. Canal Low Level Warning
VACUUM PUMP AND RECEIVER

Reference Drawings: I-7

Overview:

1. The Vacuum Pump and Receiver provide siphon assist to the Raw Water Pumps. Operation is provided through the vendor control panel only.

Local Manual Control:

1. When the HOA switch is in HAND, the Vacuum Pump runs. The pump will trip on a LOW LOW RECEIVER PRESSURE alarm or other equipment alarm. Vacuum Pump RUN status and LOW OIL and HIGH TEMPERATURE are displayed at the VCP.

2. Hand operation is typically for maintenance. The operator is responsible for monitoring the receiver pressure.

3. The RTU monitors system pressure as well as LOW LOW RECEIVER PRESSURE and HIGH HIGH RECEIVER PRESSURE alarms. The RTU also monitors vacuum pump RUN status and a general FAIL alarm.

Local Automatic Control:

1. When the HOA switch is in AUTOMATIC, the Vacuum Pump cycles on and off to maintain vacuum pressure within the range of the START and STOP pressure switches.

Remote Control:

1. There is no remote control.

Alarms:

1. Low Low Receiver Pressure
2. High High Receiver Pressure
3. Vacuum Pump Fail
INTAKE ISOLATION GATES

Reference Drawings: I-8

Overview:

1. Three hydraulically operated Intake Isolation Gates separate the Upstream Intake Structure from the Downstream Intake Structure. The gates normally remain in the open position.

2. The gates are controlled from the vendor provided hydraulic power unit, HPU. The HPU includes the reservoir, two hydraulic pumps, solenoid control valves, and an integral vendor control panel, VCP.

3. The VCP provides controls for both the HPU and the Isolation Gates.

4. Gate OPEN and CLOSED feedback is provided from submersible proximity sensors mounted in the hydraulic cylinder for each gate.

Local Manual Control:

1. When a Hydraulic Pump HOA switch is in HAND, the Pump cycles on and off to maintain system pressure within the range of the START and STOP pressure switches. Pump RUN and FAIL status will be provided at the VCP. A SYSTEM COMMON FAULT will be indicated at the RTU.

2. Overall system status will be provided through monitoring of reservoir levels and system pressures. LOW LEVEL WARNING, LOW LEVEL ALARM, HIGH LEVEL WARNING, LOW PRESSURE WARNING, LOW PRESSURE ALARM, HIGH PRESSURE WARNING, and HIGH PRESSURE ALARM are displayed at the VCP. The Hydraulic Pumps will trip on any of the alarm conditions, but continue to operate on the warning conditions. A COMMON LEVEL ALARM, LOW PRESSURE ALARM, and HIGH PRESSURE ALARM are displayed at the HMI.

3. Local Isolation Gate control is performed at the Hydraulic Unit VCP by using the OPEN/STOP/CLOSE selector. Gate OPEN and CLOSED status will be provided at the VCP and the HMI.

Local Automatic Control:

1. When both Hydraulic Pump HOA switches are in AUTO, the Pumps alternate starts to maintain system pressure within the range of the START and STOP pressure switches. One pump will run to maintain system pressure. If a pump fails or trips on an alarm condition, the other pump will start.

2. The hydraulic system does not include accumulators. Upon a failure condition, the gates will maintain current position.

Remote Control:

1. There is no remote control.
Alarms:

1. Low Level Warning
2. Low Level Alarm
3. High Level Warning
4. Low Pressure Warning
5. Low Pressure Alarm
6. High Pressure Warning
7. High Pressure Alarm
WDCWA RAW WATER PUMPING SYSTEM

Reference Drawings: I-9, I-10

Overview:

1. Provided hereinafter for reference only, all WDCWA PLC and HMI programming will be developed by WDCWA, except for interlock coordination between RD-2035 and WDCWA which shall be joint effort of WDCWA and PCIS.
2. Four variable speed vertical turbine pumps, Raw Water Pumps P-510, P-520, P-530, P-540), pump water from the Sacramento River into the WDCWA distribution pipeline.
3. The pumps shall normally be in a Duty/Duty/Duty/Standby configuration however all of the pumps can be run continuously.
4. The Raw Water Pumps can be controlled locally from the face for the Variable Speed Drive (VFD) or from the SCADA/OI system. A LOCAL / REMOTE selector switch is available at the face of the VFD. A MANUAL / AUTO selection is provided at the SCADA operator interface screen.
5. For maintenance, local control of the Pump Discharge Valves (Devicenet) is performed by placing the motor operator LOR switch in the LOCAL position and using the OPEN/STOP/CLOSE selector.
6. All modes of operation utilize automatic controls through the PLC to sequence a pump start.
7. The operation of the seal water supply solenoid is directly hardwired from the VFD panel and not through the PLC.

Local Manual Control:

Pumps
1. When a Pump LOR switch is in LOCAL, the Pump can be started and stopped using the START/STOP commands on the local VFD Operator Interface panel.

Valves
2. When a Valve LOR switch is in LOCAL, the Valve can be opened and closed using the OPEN/CLOSE/STOP commands on the local valve Operator Interface panel.

Local Automatic Control:

1. None

Remote Manual Control:

Pumps
1. When a Pump LOR switch is in REMOTE, and the pump is selected to MANUAL on the local Operator Interface or from the remote SCADA, the Pump can be started and stopped using the START/STOP commands on the Operator Interface or the remote SCADA.

Valves
2. When a Valve LOR switch is in REMOTE, and the valve is selected to MANUAL mode on the local Operator Interface or SCADA, the Valve can be opened and
closed using the OPEN/CLOSE/STOP commands on the Operator Interface or the remote SCADA system.

**Note:** That selection of the operating mode shall be reflected on both the local Operator Interface and the remote SCADA systems. The SCADA should be configured such that only one workstation can control a piece of equipment at any one time.

**Remote Automatic Control:**

1. The 24" discharge valve(s) are OPENED and CLOSED dependent on pump operation when selected to AUTO. If a pump is selected to DUTY and AUTO, the valve is OPENED before the pump is called to run and CLOSED when the pump is STOPPED.

2. A pump cannot be started unless the discharge valve is detected as OPENED.

3. Should a pump be running and the discharge valve is detected as NOT OPENED, the pump shall be stopped.

4. It shall be possible to START a DUTY pump even if the discharge valve is in MANUAL providing that the Valve is detected as fully OPENED.

5. When a Pump LOR switch is in REMOTE, and the pump is selected to AUTO on the local Operator Interface or remote SCADA and the pump is selected as one of the DUTY pumps, the Pump shall be started by the PLC and the SPEED shall be modulated to achieve an operator entered FLOW setpoint.

6. A single PI controller in the PLC shall be programmed to modulate the pump speed to achieve a single target flow setpoint.

7. The FLOW feedback signal to the single PI controller is the summation of the two WDCWA flow meters FI-585 and FI-575.

8. The output of the single PI controller shall be passed to the VFD for each of the pumps selected as DUTY. Therefore the DUTY VFD’s shall all run at the same speed.

9. Operationally, the target flow setpoint should be achievable by the number of DUTY pumps available.

10. All of the pumps selected as DUTY shall start automatically when placed into AUTO mode.

11. To remove a pump from the DUTY configuration, the pump should be selected to MANUAL mode.

12. When a DUTY pump is selected to MANUAL mode or that pump FAULTS when in the AUTO mode, it shall be replaced by the designated STANDBY pump.

13. All four pumps would need to be available and in AUTO to allow the designation of a STANDBY pump.

14. Should the pump fail when in AUTO then the valve shall be CLOSED.
15. If the pump is the designated STANDBY then the discharge valve shall be CLOSED.

16. Pump Lubrication System: The seal water solenoid valve will be energized to the open position when the pump is started and will remain open continuously while the pump is running.

Digital Inputs from RD 2035:

1. Raw Water Pump 1 Run Status
2. Raw Water Pump 2 Run Status
3. Raw Water Pump 3 Run Status
4. Raw Water Pump 4 Run Status
5. Raw Water Pump 5 Run Status

Digital Outputs to RD 2035:

1. WDCWA Raw Water Pump 1 Run Status
2. WDCWA Raw Water Pump 2 Run Status
3. WDCWA Raw Water Pump 3 Run Status
4. WDCWA Raw Water Pump 4 Run Status

Analog Inputs from RD2035:

1. RD2035 Total Flow

Analog Outputs to RD2035:

1. WDCWA Total Flow

Alarms:

1. Failure of the raw water pump to start/stop
2. Control power failure
3. VFD Fault
4. Low Discharge Pressure
5. High Discharge Pressure
6. Low Suction Level
7. High Pump Vibration
8. Motor Protection Relay Trip
9. High Motor Bearing Temperature
10. High Motor Winding Temperature
PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR, through the use of the SYSTEM INTEGRATOR and qualified electrical installers, shall provide the RD-2035 RTU-based Supervisory Control and Data Acquisition system (SCADA) complete and operable, in accordance with the Contract Documents.

B. The CONTRACTOR, through the use of the SYSTEM INTEGRATOR and qualified electrical installers, shall provide the WDCWA PLC-based Supervisory Control and Data Acquisition system (SCADA) hardware, panels, testing, and other services complete and operable, in accordance with the Contract Documents.

C. The CONTRACTOR, through the use of the DBO Engineer and qualified electrical installers, shall provide the WDCWA PLC-based Supervisory Control and Data Acquisition system (SCADA) applications software complete and operable, in accordance with the Contract Documents.

D. System Integrator: It is the intent of these specifications to have the SYSTEM INTEGRATOR be singularly responsible for selecting, configuring, and verifying correct operation of compatible hardware and software to provide a functional RD-2035 SCADA System and the WDCWA SCADA system hardware, and to provide future support of all SCADA hardware and software. In order to preserve this focused responsibility, the SYSTEM INTEGRATOR shall be the integrator of all hardware and all databases, data acquisition, and control software. Additionally the SYSTEM INTEGRATOR shall be responsible for the application programming of the SCADA system per the Control Strategies and other Sections of the Specifications. Application programming of the SCADA HMI graphics software shall be performed by the SYSTEM INTEGRATOR.

E. System Integrator Scope: The CONTRACTOR and SYSTEM INTEGRATOR are responsible for all aspects of the supply, programming, configuration, installation, check out, testing, startup and warranty of the SCADA System(s). For the RD-2035 system, the SCADA System includes RTU’s, local panels, field instrumentation, Operator Workstations (PC’s with National Instruments HMI programming), radio communication equipment, alarm notification communication equipment, communication cabling, and software. For the WDCWA system, the SCADA System includes a single PLC, local panels, field instrumentation, Operator Workstation, radio communication equipment, alarm notification communication equipment, communication cabling, and software. The WDCWA system will include a surge control panel and fiber cable supplied by WDCWA that will be connected as remote I/O to WDCWA PLC at 40-PLC-1 via fiber.

F. DBO Engineer: It is the intent of these specifications to have the DBO Engineer be singularly responsible for configuring, and verifying (jointly with CONTRACTOR and SYSTEM INTEGRATOR) correct operation of compatible hardware and software to provide a functional WDCWA SCADA System and to provide future support of all SCADA hardware and software. In order to preserve this focused responsibility, the DBO Engineer shall be the integrator of all hardware and all databases, data acquisition, and control software. Additionally the DBO Engineer shall be responsible for the application programming of the SCADA system per the Control Strategies and other Sections of the Specifications. Application programming of the SCADA HMI graphics software shall be performed by the DBO Engineer.
G. **DBO Engineer Scope:** The CONTRACTOR and DBO Engineer are responsible for all aspects of the programming and configuration of the WDCWA applications software. Check out, testing, startup of the WDCWA SCADA system shall be executed jointly by WDCWA, CONTRACTOR, and SYSTEM INTEGRATOR. For the WDCWA system, the SCADA System includes PLC’s, local panels, field instrumentation, Operator Workstations (PC’s with HMI programming), radio communication equipment, alarm notification communication equipment, communication cabling, and software. For the WDCWA system, the SCADA System includes a single PLC, local panels, field instrumentation, Operator Workstation, radio communication equipment, alarm notification communication equipment, communication cabling, and software.

H. The exact contractual relationship and scope definition shall be established exclusively between the CONTRACTOR and the SYSTEM INTEGRATOR for RD-2035 systems. It is the intent of these specifications that the SYSTEM INTEGRATOR, under the direction of the CONTRACTOR, shall assume full responsibility for the following, as a minimum:

1. Procurement of all hardware and software required to conform to these specifications.
2. Design and submit SCADA hardware, software, and spare parts submittals for the RD-2035 and WDCWA systems.
3. Design and submit SCADA training for factory and on-site training for the RD-2035 and WDCWA systems.
4. Perform all required SCADA tests, adjustments, and calibrations for the RD-2035 and WDCWA systems.
5. Furnish qualified labor to supervise SCADA installation and to perform start-up activities for both RD-2035 and WDCWA systems.
6. Furnish qualified certified instructors to provide SCADA instruction and training for both RD-2035 and WDCWA systems.
7. Furnish all required SCADA tools, test equipment, spare parts, supplies, operations and maintenance manuals, reproducible record drawings, and program listings as specified herein for both RD-2035 and WDCWA systems.
8. RD-2035 - RTU Application programming.
9. WDCWA - PLC Application programming will be supplied by WDCWA DBO Engineer.

I. **SCADA Configuration:** The SCADA shall consist of RTU’s, PLC’s, communication modules, and all required equipment and peripherals as shown on the Contract Drawings and as described in these specifications, and as required to meet the functional intent of the specifications.

J. The SYSTEM INTEGRATOR shall be responsible for the interface to systems furnished by others and for the interface to existing equipment as shown on the Contract Drawings.
1.2 CONTRACTOR SUBMITTALS

A. Shop Drawings: SCADA submittals shall be in accordance with the applicable requirements of Section 409100. SCADA submittals shall, however, be made separately from other process control and instrumentation system submittals.

B. Hardware Submittals: The SCADA hardware submittal shall be a single submittal which includes at least the following:

1. A complete index appearing in the front of each bound submittal volume. System groups shall be separated by labeled tags.

2. Complete grounding requirements for the entire SCADA including any requirements for SCADA communication networks and control room equipment.

3. Requirements for physical separation between SCADA components and 120 volt, 480 volt elements.

4. Electrical and Control Room floor plans drawn to scale. Drawings shall be drawn in a 1/2 inch = 1 foot scale.

5. UPS and battery load calculations to show that the backup capacity and time meet the specified requirements.

6. A complete set of SCADA diagrams which depict:
   a. All RTU's, PLC's, area control stations, printers, communication devices, and communication links.
   b. All cables required to support the communication requirements. A separate diagram shall be submitted for each component fully annotated with conduit size and number associated with the power source.

7. Data sheets shall be included for each SCADA component together with a technical product brochure or bulletin. These data sheets shall show the component name as used within the Contract Documents, the manufacturer's model number or other identifying product designation, the project tag number, the project system of which it is a part, the Site to which it applies, the input and output characteristics, the requirements for electric power, the ambient operating condition requirements, and details on materials of construction.

8. Complete and detailed bills of materials: A bill of material list, including quantity, description, manufacturer, and part number, shall be submitted for each component of the SCADA system. Bills of material shall include all items within an enclosure.

9. Site-specific arrangement and construction drawings for all equipment cabinets, including dimensions identification of all components, preparation and finish data, nameplates, and the like. Drawings shall be scaled and show the position of the equipment on its intended installation location. Drawings must show a scaled representation of the placement of all equipment and its spatial relationship to all other equipment located in the abutting and adjoining areas. All acquired access and clearances associated with the equipment must be shown with a statement of compliance to manufacturer's recommendations, NEC, and other applicable codes.

10. Calibration, adjustment, and test details for all SCADA components.
C. **Owner's Manuals:** General requirements for Owner's Manuals are as described in Section 409100. The following items shall also be included in the SCADA manual:

1. A documented RTU and PLC program listing including the I/O list and housing configuration for each RTU/PLC, a memory usage report for each RTU/PLC, and a register layout list for each RTU/PLC.

2. Operation and maintenance manuals for the RTUs and PLC’s, the network hardware, and all other SCADA hardware.

D. **System Test Procedures**

1. System test procedures shall be developed by the System Integrator in accordance with the requirements for system testing indicated below, and shall be submitted to the ENGINEER for review. An approved submittal shall be required prior to the commencement of system testing.

2. Procedures shall be prepared for each process system. The procedures shall be in narrative form, and shall sequentially describe the operational steps to be followed in verifying the correct operation of each process system, including all features described in the control strategies contained in Specification Section 409300. All equipment, including the SCADA system and its various operator workstations, local panels, and communication systems which function together to form a complete process system shall be tested together, (including interlocks between devices controlled by the SCADA).

3. The loop test shall be point-point from the field device to the SCADA area control stations HMI screen. Testing shall reflect the requirements of Section 409100 – Process Control and Instrumentation.

E. **Factory Test Procedure:** The SYSTEM INTEGRATOR shall prepare and submit a factory test procedure which incorporates test sequences, test forms, samples of database lists, a SCADA testing block diagram, and an estimated test duration which comply with the requirements of the factory test specified herein.

1.3 **SERVICES OF MANUFACTURER'S REPRESENTATIVE**

A. The CONTRACTOR/SYSTEM INTEGRATOR shall arrange for visits by, and services of, technical field representatives of the RTU and PLC software manufacturers for installation certification, system testing, training, and start-up. These services shall be part of the WORK.

1.4 **STORAGE AND HANDLING**

A. All equipment and materials delivered to the Site shall be stored in a location which shall not interfere with the operations of the OWNER's personnel or interfere with construction. Storage and handling shall be performed in a manner which shall afford maximum protection to the equipment and materials. It is the CONTRACTOR's responsibility to assure proper handling and on-site storage.

1.5 **SPECIAL WARRANTY REQUIREMENTS**

A. Special warranty requirements shall be in accordance with the applicable requirements of Section 409100. The following additional warranty requirements apply specifically to the SCADA System.
B. The complete SCADA System (and associated software) included therein shall be guaranteed to meet or exceed the design requirements set forth in the Contract Documents.

C. Equipment, software, and materials which do not achieve design requirements after installation shall be replaced or modified by the SYSTEM INTEGRATOR to attain compliance. The cost for doing so shall be the CONTRACTOR’s responsibility. Following replacement or modification, the CONTRACTOR shall retest the system and perform any additional procedures needed to place the complete SCADA in satisfactory operation and attain design compliance approval from the ENGINEER.

D. The CONTRACTOR warrants the materials and workmanship used for the SCADA equipment and materials and further guarantees the materials and workmanship used for any equipment and materials produced and furnished hereunder as a part of the Work to be as required and agreed upon, free from injurious defects, and in all respects satisfactory for the service required.

E. The CONTRACTOR warrants/guarantees the satisfactory performance of the equipment and materials under operating conditions for a period of two years after the date of final acceptance of the entire SCADA (i.e. completion of all contractual items including a successful full system-wide 30 day performance test as specified in Part 3). In the event that tests and inspections disclose latent defects or failure to meet the specified requirements, the SYSTEM INTEGRATOR upon notification by the OWNER shall proceed at once to correct or repair any such defects or non-conformance or to furnish, at the delivery point named in the Contract Documents, such new equipment or parts as may be necessary for conformity to the requirements, and shall receive no additional compensation therefore. In case of any required repairs or other corrective or remedial work covered under warranty, the warranties on all such corrections, repairs, new equipment, or parts shall be extended for an additional 24 months from the date of final acceptance or 12 months from the date of completion of any such corrections, repairs, new equipment, or parts, whichever date is later. If the OWNER performs repair, the CONTRACTOR shall reimburse the OWNER for all costs incurred in the removal of the defective material and installation of the replacement.

PART 2 -- PRODUCTS

2.1 GENERAL

A. The requirements of Section 409100 apply to this Section.

B. All materials and all SCADA equipment furnished under this Contract shall be new, free from defects, of first quality, and produced by manufacturers regularly engaged in the manufacture of these products.

C. All RTU and PLC hardware, components, circuit boards, and modules shall be furnished with conformal coating where offered by the manufacturer. The conformal coating is required to extend the life of the components and circuitry by protecting against moisture, dust, chemicals, temperature extremes and airborne contaminants.

D. **Hardware Commonality:** Where there is more than one item of similar equipment being furnished all such similar equipment shall be the product of a singular manufacturer.
E. SCADA Growth Provisions

1. The SCADA growth provisions are divided into three sections:
   
a. Future expansion capacity (100%).
   
b. Installed Spare I/O points (20%)
   
c. Panel, cabinet, communication rack Spare Space Allocation (25%).

2. Future expansion capacity: the SCADA firmware and hardware, including RTU/PLC processor memory, operator workstation, device network gear, and communications equipment shall have the capacity to accommodate a future expansion of 100% in the number of I/O points as shown in the Contract Documents and listed in Appendix A – IO Lists. This requirement is in regards to the SCADA System’s capacity to accommodate a growth of 100% future HMI displays, 100% future RTU/PLC I/O, 100% future RTU/PLC logic and 100% future network and communications capabilities.

3. Installed Spare RTU/PLC I/O points: All hardware and resources, including RTU/PLC I/O cards, wiring, terminals, fuses, database and configuration shall be furnished such that at least 20% additional I/O points can be implemented without any additional cost to the OWNER. The Installed Spare I/O shall be 20% of the total I/O installed per RTU or PLC cabinet, e.g. each RTU and PLC enclosure shall have 20% Installed Spare I/O.

4. Panels, cabinets, communication racks Spare Space Allocation: the CONTRACTOR shall provide 25% spare space for hardware including; I/O modules, terminal blocks, fused terminal blocks, circuit breakers, ground provisions, wiring, rack mount shelves, etc.

2.2 SCADA ENCLOSURES

A. Each RTU and PLC and its corresponding I/O modules, power supply module(s), communication interface device(s), and peripheral equipment shall be mounted inside suitable enclosures. All I/O wiring from the field to the I/O modules shall be terminated on terminal blocks in the enclosure.

B. SCADA enclosures shall be provided in accordance with Section 409200 - Control Panels.

2.3 UNINTERUPTABLE POWER SUPPLYS

A. Provide and install line interactive UPS’s where indicated.

B. The CONTRACTOR shall provide and install an uninterruptible power supply (UPS) for each Panel. The SUBCONTRACTOR shall be responsible for calculating the power requirements of the panel and sizing the UPS’s to support each Panel for a minimum of 45 minutes at 120% of calculated full load. The UPS shall be a Powerware model 5125 or approved equal.

C. The UPS calculation should include the load of any associated Radio equipment.

D. The equipment submittal shall include sizing calculations which support the unit selected.
2.4 RTU HARDWARE (RD-2035 System)

A. RTU Controller: The RTU Controller shall have the following features:

1. Processors: CPU: 32-bit ARM7 microcontroller, 32 MHz clock, integrated watchdog timer, Two Microcontroller co-processors, 20 MHz clock

2. Power Requirement: 11V DC to 30V DC input

3. Memory: 16 MB Flash ROM, 4 MB CMOS RAM, 4 kB EEPROM.

4. Memory Type: A lithium battery shall maintain non-volatile battery-backed CMOS RAM memory for a minimum of 2 years with no power applied.

5. I/O Capacity: The controller shall support the I/O expansion of up to twenty (20) I/O modules.

6. Communication Ports: The RTU controller shall be equipped with on-board communications ports for the following:
   a. One (1) RS-232 Serial Port
   b. One (1) RS-485 Serial Port
   c. One (1) RS-232/485 Serial Port
   d. One (1) RJ-45 Ethernet port
   e. One (1) USB-A port
   f. One (1) USB-B port

7. Diagnostics
   a. Standard, self-diagnostic routines shall be provided to determine proper hardware and software operation.

   b. Diagnostic LEDs shall be provided on the processor front panel to indicate the following:
      1) Controller executing program.
      2) Controller fault.
      3) Battery low.
      4) Forced I/O.
      5) Communications active.
      6) Communications error.

8. Instruction Set
   a. The RTU shall be equipped with the following instructions as a minimum:
1) Relay-type logic functions including normally open contacts, normally closed contacts, and output coils.

2) Timers: On delay, off delay, and retentive.

3) Counters: Up, down.

4) Math functions including integer and floating point, add, subtract, multiply, divide, and square root.

5) Data transfer instructions.

6) Logical AND, NOT, OR, XOR instructions.

7) Compare Instructions: Equal to, greater than, less than.

8) Proportional - Integral - Derivative control instruction.

b. The RTU shall support branching functions to allow any combination of series or parallel instructions.

c. The RTU shall support the use of subroutines where appropriate.

9. Manufacturer and Model: **SCADAPack 350 Controller** as manufactured by **Schneider Electric**.

10. Programming software: **Schneider Electric Telepace**. IEC 61131-6 compliant. Available languages:

   a. Ladder logic

   b. Function block diagram (FBD)

   c. Sequential function charts (SFC)

   d. Structured text

11. Online programming including run-time editing.

B. Power Supplies

1. Each RTU processor and I/O chassis shall include a power supply or power supplies as necessary to power all modules, all I/O and meet the expansion capabilities defined elsewhere in this specification section. The power supply shall plug directly into the modules.

2. Input Voltage: 24 VDC, 60 Hz.

3. Output Current: 5 VDC for the modules and 24 VDC for analog loops.

4. Provide all cabling as required.

5. Manufacturer and Model: **SCADAPack 5103** as manufactured by **Schneider Electric**.
C. I/O Modules

1. Provide I/O module-ready cables with a pre-wired Removable Terminal Blocks. The number of conductors (20 or 40) to be established per I/O module type. The I/O module-ready cables consist of pre-wired connections at the I/O module end and provide termination on a standard terminal block for field wire connection.

2. Available Types: The types of I/O modules available for use with the RTU system shall be as required by the Contract Documents. Provide screw-clamp removable terminal blocks for all I/O cards. The following types of manufacturer standard I/O modules shall be available:

   a. Sixteen point individually optically isolated discrete input modules which accept an input of 120 VAC, 60 Hz. **SCADAPack 5404-120** as manufactured by Schneider Electric.

   b. Sixteen point isolated output modules. Each output point shall be independent form A relay contact output. Isolated outputs shall have a current capacity of 6 amps at 120 VAC. **SCADAPack 5404-24** as manufactured by Schneider Electric.

   c. Eight point isolated analog input modules which accept an input of 4-20mA DC. **SCADAPack 5506** as manufactured by Schneider Electric.

   d. Four point isolated analog output modules which provide an input of 4-20mA DC. **SCADAPack 5302** as manufactured by Schneider Electric.

3. Required Features: The I/O modules and system hardware supplied shall incorporate the following design and construction features and comply with the following requirements:

   a. Noise immunity and filtering.

   b. IEEE surge-withstand rating to IEEE 472.

   c. Optical isolation for all inputs and outputs to provide controller logic protection.

   d. All modules shall be replaceable under power.

   e. Software configuration of modules (no jumpers or switches).

   f. 300 volt I/O wiring terminal arms sized to accommodate up to #14 AWG wires. Wiring design shall allow I/O module removal and replacement without disturbing I/O wiring connections.

   g. Front-of-module LED Status indicators for each individual input and output point are to indicate when power is applied at I/O terminals.

   h. Fused output circuits for all output modules with blown fuse indication.

   i. Where required and recommended by the manufacturer, external transient suppressor shall be provided for installation across the output loads.

   j. Provide required connectors with each I/O module.
4. All I/O, including future and spare, shall be wired to terminal blocks and fused terminal blocks prior to interconnection with other devices.

2.5 PROGRAMMABLE LOGIC CONTROLLERS (WDCWA SYSTEMS)

A. The OWNER has standardized on the Rockwell - Allen Bradley Control Logix family of products. The PLC shall have a redundant configuration; therefore both Primary and Secondary PLC chassis shall be identical linked to I/O modules in remote chassis via Controlnet. I/O is only terminated to the remote chassis the I/O is serviced by either the Primary or Secondary PLC, whichever is designated as the Primary processor shall control the I/O.

The following equipment is therefore preferred:

B. Programmable Logic Controllers (CPU) shall be:

1. Allen Bradley - ControlLogix L75 or approved equal.

C. Power Supplies: All Main, Expansion and Remote I/O Chassis shall have their own separate power supplies. For the existing racks that are to be expanded to accommodate the new I/O cards, it should be determined that the existing power supply has sufficient capacity to cope with the new I/O.

1. 1756 Main PLC Chassis Allen Bradley-1756-P72C or approved equal.

D. PLC Chassis: All Main, Expansion and Remote I/O Chassis shall be from the following:

1. Primary and Secondary PLC Chassis Allen Bradley-1756-A7 or approved equal.


E. PLC Redundancy Modules: Primary and Secondary Racks shall each contain redundancy modules.

1. Primary and Secondary PLC Chassis Allen Bradley-1756-RM or approved equal.

F. PLC Controlnet Network and Communication Modules: Primary, Secondary and Remote Racks shall each contain Controlnet modules. Note that addressing the primary controlnet module automatically assigns the next node address to the secondary controlnet module. I.e. if primary node DIP switch is set to address 3, the secondary is automatically assigned address 4 although the DIP switch is set to address 3. Also note that the remote racks should be addressed with lower addresses than the primary and secondary rack addresses due to this auto allocation.

1. Controlnet Modules shall be Allen Bradley-1756-CN2R/B or approved equal.

2. All Controlnet segments shall have a terminating resistor at the end of each segment.

   a. Controlnet terminating resistors shall be 1756-TPS or approved equal.

3. Controlnet Taps shall be 1756-XP or approved equal.
G. **Input/Output (I/O) Modules:** All I/O housings and modules shall be suitable for industrial environments as described in Section 409100 – Process Control and Instrumentation Systems. All I/O modules shall be isolated and conform to IEEE Surge Withstand Standards and NEMA Noise Immunity Standards. The I/O shall be one hundred and twenty (120) VAC for discrete inputs and dry relay contacts for safe discrete outputs. Modules shall be removable without having to disconnect wiring from the module's terminals by means of plug-in wiring connectors.

1. The PLC cabinet(s) shall contain the I/O modules required to provide all of the I/O points (including designated future I/O points) contained in the I/O List that is included in Appendix A at the end of this specification. All spares provided shall be wired and connected to the field terminal strip.

2. For the Main PLC Panel the I/O modules will be as follows.
   a. Discrete Input Modules: The digital input cards shall be Allen Bradley 1756-IA16I (Isolated 79-132 VAC) or approved equal.
   b. Discrete Output Modules: The digital input cards shall be Allen Bradley 1756-OA16I (Isolated 74-265 VAC), or approved equal.
   c. Analog Input Modules: The analog input cards shall be Allen Bradley 1756-IF16 (voltage/current), or approved equal.
   d. Analog Output Modules: The analog output cards shall be Allen Bradley 1756-OF8 (voltage/current), or approved equal.

H. **Modbus TCP/IP Communication Modules**

1. A Prosoft communications module shall be need to establish communications between the Allen Bradley Controllogix PLC and the SCADAPack 350 PLC.
   a. Prosoft MVI56E-MNETR, or approved equal.

I. **Ethernet Communications Module**

1. For the Primary and Secondary PLC Panel the Ethernet modules shall be as follows.
   a. Allen Bradley 1756-EN2TR, or approved equal.

J. **Network Communications**

1. A Copper Ethernet network is to be utilized between the Main PLC Panel Switch and the various vendor package equipment such as the security DVR and Cameras.

2. Please refer to the ‘Allowance List’ in section 1.5 of specification 409100 to identify the required equipment.
2.6 OPERATOR INTERFACE TERMINALS (RD 2035 Systems)

A. Provide an HMI touch screen panel that will be connected to the RTU for local monitoring of all I/O.

B. OITs shall be conform to the following requirements, minimum:

1. Display Screen Size: 15 inches, diagonally measured.
2. Resolution: 1024 x 768.
3. Display type: Color active-matrix TFT display.
4. Operating System: Magelis
5. Memory: 512 MB.
6. Storage Memory: 512 MB of flash memory on a removable compact Flash card to hold all required process application, alarm, help, form and recipe pages.
7. Supply Voltage: 120 VAC.
8. Communications: Ethernet
9. Development Software: Vijeo Designer
10. Mounting: Unit shall be mounted on the front face of panel, as indicated on the Drawings.
11. Manufacturer and Model: Schneider Magelis Series, Model XBT GT 42/43.

2.7 OPERATOR INTERFACE TERMINALS (WDCWA Systems)

A. Please refer to the ‘Allowance List’ in section 1.5 of specification 409100 to identify the required equipment.

2.8 SPARE PARTS

A. Provide one (1) spare RTU Controller.
B. Provide one (1) spare PLC Controller.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. The CONTRACTOR shall utilize personnel to accomplish, or supervise the physical installation of all elements, components, accessories, or assemblies which it provides. The CONTRACTOR shall employ installers who are skilled and experienced in the installation and connection of all elements, components, accessories, and assemblies it provides.

B. All components of the SCADA including all communication cabling shall be the installation responsibility of the CONTRACTOR unless specifically noted otherwise. The installation of the communication network shall be the complete installation responsibility
of the CONTRACTOR including all cables, connectors, transceivers, and any required electrical grounds. Grounding shall be shown on submittal drawings. After installation of the SCADA is completed, the installation shall be inspected jointly by the CONTRACTOR and the Equipment Manufacturer's representatives. Any problems shall be corrected, and when both are satisfied with the installation, a written certification of the installation shall be delivered to the ENGINEER. The certification shall state that all RTU/PLC communication and I/O modules, system grounds, communication network, and all other components of the SCADA system have been inspected and are installed in accordance with the manufacturer's guidelines.

C. The RTU/PLC and associated I/O modules shall be installed such that all LED indicators and switches are readily visible with the panel door open and such that repair and/or replacement of any RTU/PLC component can be accomplished without disconnecting any wiring or removing any other components.

D. All network cabling shall be certified prior to use. UTP cable shall be certified to EIA/TIA category 6A standards using a logging certification type tool or approved equal.

3.2 FACTORY TEST

A. General: Note that RD-2035 systems and WDCWA systems shall be tested separately. Prior to the delivery and installation of the SCADA System at the Site, but after the procurement, assembly, and configuration of all components, the CONTRACTOR shall conduct a factory test. This test shall be witnessed by representatives of the OWNER and the ENGINEER. The factory test is intended to be a complete SCADA system check. The factory test shall demonstrate the functionality and performance of specified features of the RTU or PLC. The tests shall include verification of all RTUs and PLC's. A complete system checklist shall be available during the test for recording results of selected points.

B. Test Setup: The RTUs, RTU programming terminal or PLC and Operator Workstation, and communication devices shall be loaded with their applicable software packages and configuration programming. Note: The WDCWA PLC programming software and Operator Workstation software shall be not be provided by the SYSTEMS INTEGRATOR but by the DBO Engineer. RTU and PLC input and output modules shall be installed in their assigned housings and wired to field termination points in the enclosures. The CONTRACTOR shall have a complete, up to date set of wiring drawings and a RTU and PLC register list for review throughout the test.

C. CONTRACTOR shall schedule individual factory tests after receiving approval of the factory test procedures submittal. The SYSTEM INTEGRATOR and the DBO Engineer shall provide the CONTRACTOR with written notice of the start and expected duration of the factory test for the RD-2035 and WDCWA factory tests at least 30 days prior to the start of the test.

D. Test Procedure: The factory test shall be conducted in accordance with the previously submitted and approved test procedures. The test procedures shall include written descriptions of how individual tests shall be performed and shall incorporate testing the following features as a minimum. All testing shall be completed in one continuous factory test which may extend over several continuous days if necessary.

1. Power Failure: External power to enclosures shall be turned off and back on in order to test the operation of the UPS units.
2. Communications Testing

a. The factory test setup shall include testing of radio communications equipment.

b. Test Equipment: Modbus – The CONTRACTOR shall use simulation software (for example: Modbus PLC Simulator) to evaluate all Modbus Communication Systems. The software shall be used to quantify the quality of the signals on the Modbus Network. During the test this software shall evaluate transmissions to each slave device to ensure the slave is sending and receiving messages as directed by the master. The messages shall be evaluated to verify the physical network is built correctly, as explained by the Modbus Serial Line Planning and Installation Guide (www.schneider-electric.com pub no: 33003925.01), and that the slave node can interact with the master as specified by the manufacturer’s literature without errors. The reports generated by this software shall be included with the report in section 17510.5.7.E.

E. Test Report: The CONTRACTOR shall record the results of all factory testing on preapproved test forms which the OWNER's and ENGINEER's representatives shall sign. A copy of the completed test forms and a report certifying the results shall be provided to the ENGINEER within 10 days of completing the test.

F. Rework and Retest: If the SCADA systems do not operate as required, the CONTRACTOR shall make whatever corrections are necessary, and the failed part of the tests shall be repeated. If, in the opinion of ENGINEER's representative, the changes made by the CONTRACTOR for such a correction are sufficient in kind or scope to effect parts of system operation already tested, then the effected parts shall be retested also. If a reliable determination of the effect of changes made by the CONTRACTOR cannot be made, then the ENGINEER's representative may require that all operations be retested. The CONTRACTOR shall bear all of its own costs for the factory test, including any required retesting.

3.3 TESTING, AND INSTALLATION

A. Testing of this facility will include integration into the existing radio network and remote SCADA system. All testing shall be coordinated with OWNER. The CONTRACTOR shall give sufficient notice to the OWNER prior to the start of any testing.

B. As previously noted. RD-2035 and WDCWA systems shall be tested separately.

C. Testing: After the SCADA installation has been certified, the system shall be tested to verify that all inputs and outputs of both the RTU or PLC systems and the operator workstations HMI graphic displays are correct. All I/O points shall be checked “end to end.” For example, valve operation shall be checked by stroking the valve open/closed, verifying the valve physically went open/close and the open/close limit switch feedback was properly received at the RTU or PLC input and operator area control stations HMI graphic display. Simulated testing shall be allowed only when no practical alternative exists. An I/O checklist shall be used to record test results and a copy provided to the ENGINEER upon completion.

D. System Testing: Note: As with the Factory Test, the system test will occur separately for the RD-2035 and WDCWA systems. When the SCADA installations have been certified and discrete I/O testing has been completed, system testing shall be performed in accordance with the approved test procedures. System testing shall operate the various process systems of the raw water intake to verify compliance with all functional
requirements specified, including the automatic control modes and the SCADA interlocks described in the control strategies contained in Section 409300. Tests which fail to demonstrate the required operation shall be repeated in their entirety or continued after corrective action has been completed at the discretion of the ENGINEER.

E. During system tests, the CONTRACTOR shall have a representative on site continuously, which is capable of trouble-shooting and modifying the SCADA system configuration programming.

F. The CONTRACTOR shall submit to the ENGINEER a system testing completion report when each process system and all aspects of the configuration software have been successfully tested as described herein. The report shall note any problems encountered and what action was required to correct them. It shall include a clear and unequivocal statement that the process systems have been thoroughly tested and are complete and functional in accordance with all specification requirements.

G. **Plant Start-Up Test:** The CONTRACTOR shall provide start-up support to include the SYSTEM INTEGRATOR's personnel, ELECTRICAL CONTRACTOR personnel, OWNER, and the SCADA system manufacturer's representative as required during the testing period to produce a fully operational treatment plant. This support shall be provided as part of the WORK.

H. **Performance Test**

1. Subsequent to the system and plant start-up testing of Conveyance System operation the CONTRACTOR shall conduct a successful 30 day final acceptance test for each of the SCADA systems. In the tests, the entire SCADA shall be continuously operated and maintained (i.e., 7 days per week, 24 hours per day) during the test period with zero downtime resulting from system failures. If a system failure occurs, the 30 day test shall be considered a failure and not acceptable. The CONTRACTOR shall repeat the 30 day test. The SCADA system shall be acceptable only after all equipment and software has satisfied the performance test requirements.

2. Downtime resulting from the following shall be considered system failures:
   a. If a component or software failure cannot be repaired/replaced within 2 hours.
   b. Downtime of any component (exclusive of I/O) whose failure results in the inability of the Operator to monitor and manipulate control loops from the associated area control stations using standard interface procedures.
   c. Downtime in excess of 2 hours resulting from any I/O component failure.
   d. Downtime resulting from concurrent failure of 2 or more I/O components in a single RTU or PLC.
   e. Downtime of any component/peripheral associated with the communication network if the failed component (1) results in a disabling of the historical functions and (2) the failed component is not repaired or replaced within 8 hours.

3. The CONTRACTOR shall submit a final performance test completion report which shall state that all contract requirements have been met and which shall include (1) a listing of all SCADA equipment maintenance/repair activities conducted during
testing and (2) a listing of all components which were unable to operate successfully. Final acceptance, in writing, of the SCADA systems shall be provided by the ENGINEER if the results of all of the performance tests are acceptable.

4. After acceptance of all required performance tests, the CONTRACTOR shall be responsible for furnishing the spare parts/tools on site at an inventory level the CONTRACTOR determines is sufficient. All spare parts/tools stored on-site shall become the property of the OWNER upon completion of the guarantee period. The CONTRACTOR shall guarantee that the completed system shall perform all of the data acquisition, control, and reporting functions as indicated.

3.4 TRAINING

A. **Instruction:** The CONTRACTOR shall provide training for the purpose of familiarizing the OWNER's maintenance and operating with the use, maintenance, calibration, and repair of all components of the SCADA systems.

B. The training shall be scheduled concurrent with the calibration, equipment testing, and process system testing phases of the project.

C. The training shall be performed by qualified representatives of the CONTRACTOR or the Manufacturer as noted in the table below. Training shall be specifically tailored to this project and reflect the SCADA system installation and configuration. The table below summarizes training hours required, which shall be furnished as part of the WORK. All training shall be conducted at the Site unless another location is approved by the ENGINEER and OWNER.

<table>
<thead>
<tr>
<th>Training Classes Required</th>
<th>Maintenance and Operator’s Class (hours)</th>
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<tr>
<td>RD-2035 SCADA System Hardware/Software General Familiarity</td>
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<td>CONTRACTOR</td>
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<tr>
<td>Project Specific RTU programming I/O, ladder logic, registers, etc</td>
<td>8</td>
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<td>Project Specific Modbus Networks and Troubleshooting and Maintenance</td>
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<tr>
<td>WDCWA SCADA System Hardware/Software General Familiarity</td>
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D. Each training class shall be a minimum of 8 hours in duration. Separate classes shall be conducted for the OWNER's maintenance and operating personnel. Maintenance classes shall stress troubleshooting, repair, calibration, and other technical aspects of the RTU. Operator classes shall stress operational theory and use of the SCADA
E. The training classes shall be scheduled a minimum of 3 weeks in advance of when they are to be given. Proposed training material, including a resume for the proposed instructor(s) (indicating previous instructional experience) and a detailed outline of each lesson shall be submitted to the ENGINEER at least 30 days in advance of when the lesson is to be given. The ENGINEER will review the submitted data for suitability and provide comments that shall be incorporated into the course. Final materials will be provided at least two weeks in advance of the training sessions.

F. Within 10 days after the completion of each class the CONTRACTOR shall present to the ENGINEER the following:

1. A list of all OWNER personnel that attended the class.
2. An evaluation of OWNER personnel that attended the class via written testing or equivalent evaluation.
3. A copy of the hard copy text utilized during the class with all notes, diagrams, and comments. This documentation shall be contained in the Training Manual.

G. Directed Training: After completion of all SCADA training specified above, the CONTRACTOR shall provide directed training for persons to be selected by the OWNER. This training shall be conducted by the individual most familiar with the configuration of this project and who was significantly involved in performing this configuration. Training sessions shall be conducted with no more than 3 of the selected personnel at a time.

H. The CONTRACTOR shall provide 40 hours of on-site directed training for each selected group of personnel at no separate additional cost to the OWNER. This training shall be scheduled with OWNER a minimum of 3 weeks in advance. This training shall have the audio and video digitally recorded by the CONTRACTOR.

I. The OWNER reserves the right to digitally record any or all portions of training performed for future usage by the OWNER’s staff.

J. The CONTRACTOR shall provide one day services of a RTU and PLC factory representative to certify the SCADA systems.

K. The CONTRACTOR shall provide 5 days services of a trained RD-2035 RTU programmer to make modifications to the logic up to 180 days after the date of final acceptance.

L. The CONTRACTOR shall provide 5 days services of a trained WDCWA system technician to make modifications to the system up to 180 days after the date of final acceptance.

3.5 LADDER LOGIC DOCUMENTATION

A. The CONTRACTOR shall annotate the RTU and PLC ladder logic by providing a descriptive label for all coils, contacts and function blocks and functional description of each rung, section, routine, sub-routine, etc.

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* "Y" Indicates that provisions will be made to allow this I/O point to be wired to the WDCWA PLC.

In the case of a digital input (DI) an additional contact will be provided for separate input to the WDCWA PLC.
In the case of an analog input (AI) a current to current converter will be provided to repeat the signal to the WDCWA PLC.
Analog outputs (AO) will be wired directly to the WDCWA PLC.
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PART 1 -- GENERAL

1.1 GENERAL

A. The CONTRACTOR shall furnish and install the new Radio Communication Network (RCN) equipment as specified herein. It is the intent of these specifications to have a single CONTRACTOR be responsible for furnishing all equipment, tools, labor, essential communication, transportation, fuel, water, power, hardware, software, radio interfaces, system integration, testing, and startup services to provide a complete turn-key system. It is the responsibility of the CONTRACTOR to provide fully functional Radio Communications that is seamless to the existing RTU network.

B. The requirements of Section 409100 – Radio Telemetry Process Control and Instrumentation Systems apply to this Section.

C. The RCN shall include all work as defined in the CONTRACT DRAWINGS and as specified herein. There are two radio systems on the facility with the RD-2035 system having a satellite location for RTU-202 on the canal. Firstly, the RCN shall provide for the RD-2035 RTU communications radio to communicate from the project site and the canal location to the main RD-2035 SCADA. Secondly, a separate RCN shall communicate between the WDCWA PLC Communications radio and the WDCWA remote SCADA system.

D. The Telemetry CONTRACTOR shall be responsible for coordinating the installation of the RCN with the installation of the PLC’s by others under a separate Contract.

E. Materials used in fabrication of the equipment shall be new and undamaged.

F. The RCN installation shall meet the following standard:

1. FCC Part 15 Radio Frequency Devices

G. The delivered equipment shall include all tools, diagnostic equipment, and documentation to install and maintain all future expansion capabilities. Each radio system shall be completely functional and interchangeable with any other Telemetry CONTRACTOR furnished or modified radio system without hardware modification.

H. The CONTRACTOR shall perform a propagation study report to determine required antenna mounting heights, signal strength, separation between antennae and other requirements for a complete and functioning communication system. This includes communications between the existing RD 2035 office and all new satellite RTU sites including RTU-100, RTU-202, WDCWA Water Treatment Plant, and WDCWA PLC.

I. All radio components shall be rated for operation in hostile industrial environment (i.e. subject to heat, electrical transient, RFI, vibration, etc) without fans, air conditioning, or electrical filtering up to 60 degrees C and 95 percent humidity, non-condensing.

J. The RCN shall furnish temporary electrical power where needed to perform field test as required per this specification.
K. Reference P&ID drawing notes for additional requirements.

L. Reference NFPA 780 for lightning arrestor equipment requirements.

1.2 SUBMITTALS

A. **General**: Prior to release for fabrication, the Vendor shall submit for ENGINEER’S approval, shop drawings and Operation and Maintenance instructions for equipment proposed. Shop drawings shall include the following:

1. Proposed schedule.
2. Equipment technical product brochure / catalog sheets / data sheets.
3. Site specific antenna installation details.
4. Radio enclosure panel drawings including, front panel layout, sub-panel layout, wiring diagrams, and bill of materials.
6. Existing network traffic report.
7. Radio network throughput analysis.

B. Vendor Submittals and Operation and Maintenance Manuals shall adhere to the requirements of Section 409100 of the Contract Documents.

1.3 PRODUCT DELIVERY, STORAGE AND HANDLING

A. All equipment parts shall be properly protected in accordance with manufacturer requirements so that no damage or deterioration will occur.

B. Factory assembled parts and components shall not be dismantled for shipment unless permission is received in writing from the ENGINEER.

C. Each box or package shall be properly marked to show its contents.

D. Delivery, storage and handling shall adhere to the requirements of 409100 of the Contract Documents.

PART 2 -- PRODUCTS

2.1 GENERAL

A. The Radio System shall be an extension of the existing SCADA network. It shall be built so as to behave seamless to any communications sent or received with the system.

B. The Radio System shall be a fully functional system and fully integrated into the existing network. It shall be the responsibility of the Telemetry CONTRACTOR to provide any equipment necessary to integrate the Radio System to the existing network.
2.2 UNLICENSED RADIO SYSTEM

A. The radio system shall be capable of supporting EXISTING communication functions for the RTU and PLC control systems via serial communication interfaces. The radio system shall be 902-928 MHz, unlicensed frequency hopping spread spectrum type.

1. The fixed range of the radio shall be 25 miles typical, 40 km, maximum.
2. The radio shall support 128-bit data encryption and two-way authentication security features.
3. The radio shall transmit/receive at a rate of greater than 100 kbps.
4. Power: 10-30 VDC input
5. Humidity: 95% at 40 deg c
6. Where indicated on the Contract Drawings, RTU or PLC communications shall be via direct serial connection between the radio and the RTU or PLC port. The communication protocol for the radios shall be Modbus.

B. The Telemetry CONTRACTOR shall supply a directional Yagi antenna for remote site. The Telemetry CONTRACTOR shall verify the number of elements and the overall gain required to maintain a -20 dB fade margin.

C. The complete communications subsystem including all interconnecting cables shall contain lightning, surge and transient protection. For new sites, Telemetry CONTRACTOR shall provide line-loss calculations and a propagation study report.

D. Radios shall be manufactured by Microwave Data Systems (MDS) Model TransNET and MDS NETIO T Model as indicated on the contract drawings.

E. WDCWA radio shall be supplied by Allowance.

1. Please refer to the ‘Allowance List’ in section 1.5 of specification 409100 to identify the required equipment.

2.3 ELECTRICAL TRANSIENT PROTECTION

A. All electrical and electronic elements shall be protected against damage due to electrical transient induced in interconnecting lines from lightning discharges and nearby electrical systems. Installation shall meet or exceed NFPA 70 standards.

B. **Manufacturer’s Requirements:** All surge suppressor devices shall be manufactured by a company that has been engaged in the design, development, and manufacture of such devices for at least 5 years. Supplied TVSS units shall meet or exceed UL 1449 requirements for transient voltage surge suppression.

C. **Suppressor Locations:** As a minimum, provide surge suppressors at the following locations:

1. Electrical CONTRACTOR shall furnish and install surge suppressor on the 120 VAC power circuit at the point of entrance
2. Surge Suppressor Assemblies for 120-Volt AC Power Supply Connectors: Surge suppressors for connections to AC power supply circuits shall be assemblies that:

a. Have been provided with two-3-terminal barrier terminal strips capable of accepting No. 12 AWG solid or stranded copper wire. One terminal strip shall be located on each end of the suppressor unit. Units shall be DIN rail mounted.

b. Are epoxy encapsulated within a nonflammable phenolic enclosure with provisions for mounting to interior of equipment racks, cabinets, or to the exterior of freestanding equipment. Epoxy encapsulation shall be flame retardant.

c. Are constructed as multistage devices. The first stage shall be a high-energy metal oxide varistor element. The second stage shall consist of fast-acting high power bipolar silicon avalanche devices. First and second stages shall be interconnected through a series air core inductor of sufficient current-carrying capacity to permit a continuous operating current of 15 amperes. Inductors having ferrous or other high permeability core materials are not acceptable. Suppressor assemblies shall be the automatic recovery type.

d. Meet or exceed the following performance criteria based on a test surge wave shape with an 8-microsecond rise time and a 20-microsecond exponential decay time:

1) Nominal Voltage: 120V AC
2) Arrester Rated Voltage: 150V AC
3) Maximum Operating Current: 6 amps
4) Peak First Stage Surge Current: 20,000 amps
5) Maximum First Stage Clamping Voltage: 350 volts
6) Maximum Second Stage Clamping Voltage: 210 volts
7) Ambient Temperature Range: -200 C to +850 C
8) Auto Recovery

e. The suppressor shall be Phoenix Contact model UAK 2-PE/S or equal.

2.4 ANTENNAS

A. The RTU Antennas shall be a YAGI type designed for use from 900-960MHz and fabricated of solid aluminum elements, 360 degree welds and Txylan protective coating. All antennas shall be Celwave Model PD 10108-2/Celwave Model PD 10212-2 or approved equal.

B. Lightning arrester shall be for 50 Ohm transmission cables, have Type N connectors, and shall limit surge voltage to less than 50Volts within 8 microseconds from current surges up to 5000 amperes. Arrester shall be Polyphasor Model IS-50NX-C2 or approved equal.
C. Surge suppressors shall be manufactured by PERMA POWER Model PXD 609, or ENGINEER’s approved equal.

2.5 COAX CABLE

A. **Coax Cable and Connectors:** The coax cable shall be a 1/2-inch, low loss foam cable with corrugated copper or aluminum shield suitable for use in the 900-960MHz frequency range. Attenuation shall be no greater than 3.9dB/100-ft. The PVC jacket shall be UV rated for outdoor use. The cable shall not be spliced at any point. The cable shall be Andrews LDF4-50A or approved equal. The connectors shall be designed for low loss foam cable and shall be as manufactured by Andrews. Provide weatherproofing kits as manufactured by Andrews.

2.6 UPS

A. The CONTRACTOR shall provide and install uninterruptible power supplies (UPS) for the radio equipment located remote to the facility. The CONTRACTOR shall be responsible for calculating the power requirements of the radio and sizing the RD 2035 and WDWCA UPS to support the radio for a minimum of 30 minutes at 120% of calculated full load in addition to the equipment that those UPS service.

2.7 POWER SUPPLY

A. **Power Supplies:** Power supplies shall convert 120 VAC ±10% to 24 volt DC or other DC voltages as necessary. Output regulation shall be accurate within ±0.05% for a 10% line change or a 50% load change and shall include remote voltage sensing. The power supply shall be rated for temperatures of -10 to 60 degrees C and shall be UL recognized. Power supplies shall have fully isolated primary and secondary coils which shall be surrounded by an insulating enclosure which shall also provide mechanical isolation. Provide primary 120V and secondary (24 VDC) fuses for each power supply. The power supply shall be provided and work in conjunction with a redundant back-up system with automatic transient free switchover to a second identical redundant power supply. Provide relay alarm contact to indicate primary power supply failure. Power Supplies shall be Sola SDN, or equal.

2.8 APPURTENANCES

A. **Wiring Methods:** Wiring methods and materials for all panels shall be in accordance with the N.E.C. requirements including article 409 and Chapter 8.

B. Equipment mounted on the cabinet back-plate shall be installed to allow for commissioning adjustments, servicing requirements, and cover removal.

C. Enclosures shall be furnished with integral grounded RFI shielding.

D. **Wire and Cable Marking:** Each power, signal, control, and communication conductor or cable shall be designated by a single unique tag or number which shall be shown on all shop drawings.

E. **Nameplates:** A nameplate shall be provided for the outside face of each panel and each major component mounted inside the panel(s). Adhesives shall be acceptable for attaching nameplates. Nameplates shall be fabricated from black-face, white-center, laminated engraving plastic. Colors, lettering, styles, abbreviations, and sizes shall be in
conformance with ISA-RP-60.6 with an intended viewing distance of 3 to 6 feet as shown or as selected by ENGINEER.

2.9 CONDUIT SYSTEMS

A. The Telemetry CONTRACTOR, through the submittal process, shall be responsible for confirming conduit sizing and conduit routing for the wire and cable installed as part of this work. Conduit shall be furnished and installed by the Electrical CONTRACTOR. Conduits shall conform to Division 26.

2.10 ANTENNA POLE AND TOWER

A. **RTU-100 & WDCWA Antenna Tower:** The tower shall be as specified in Section 338116 – Antenna Tower. The ENGINEER has assumed that a 50-foot tall antenna with a minimum separation of 10-feet between RTU-100 and WDCWA antenna’s will be required, based on a radio survey report prepared by Concepts in Controls, Inc in August 2010.

B. **RTU-202 Antenna/RTU Pole:** The pole shall be free standing and constructed as to ensure a 90 mph wind-load rating with yagi antenna, solar panel, and RTU mounted. Yagi antenna mounting hardware shall be constructed of 316SS with weatherproof material separators. Final installation or pole, RTU and antenna shall be rated for 90 mph sustained winds (or as required by the permit date Local Building Code). Refer to detail I-942 for general configuration of the installation. Antenna height shall be as required by the propagation study report. Pole diameter and pole base installation requirements shall exceed the requirements of detail I-942 as needed to meet the requirements of this specification.

PART 3 – EXECUTION

3.1 GENERAL

A. The Telemetry CONTRACTOR shall configure and program the radio.

B. The Telemetry CONTRACTOR shall be responsible for furnishing all equipment, tools, labor, essential communication, transportation, fuel, water, power, etc. as needed furnish, install and test the RCN.

C. The CONTRACTOR shall furnish the services of a factory trained Engineer representation of the radio manufacturer to check the complete SCADA system installation and to make all necessary adjustments for satisfactory operation of the RTU’s.

D. Reference 409100-2.3 for required spare parts supply.

E. Wiring shall comply with the requirements latest revision of the NEC and Division 26 of the specifications.

F. Panel components and construction methods shall conform to Division 26 and specification section 409200.

G. The CONTRACTOR shall use a signal strength meter to position/align the RTU antenna for maximum signal strength. Final readings and antenna bearings shall be recorded and...
included in the Owner O&M documents. Installation test equipment shall be the supply responsibility of the CONTRACTOR.

H. The Telemetry CONTRACTOR shall be responsible for furnishing, installing and terminating all antenna coaxial cable and serial communications cable between the antennas, radios, and the RTU.

3.2 TESTING AND INSTALLATION

A. **Start-Up Test:** INTEGRATOR will perform programming for the RTU and HMI programming associated information conveyed over the RCN.

B. The Telemetry CONTRACTOR shall provide start-up support to the SYSTEM INTEGRATOR as required during the testing periods. Note that there shall be two distinct testing periods for both the RD-2035 and WDWCA systems to produce a fully operational facility. Support for theses two testing phases shall be provided at no additional cost to the OWNER.

C. **Performance Test**

1. Subsequent to the system start-up the Telemetry CONTRACTOR shall conduct a successful 30 day final acceptance test for the RCN system furnished under this contract. In the test, the entire RCN shall be continuously operated and maintained (i.e., 7 days per week, 24 hours per day) during the test period with zero downtime resulting from system failures. If a system failure occurs do to hardware or configuration provided under this Contract, the 30 day test shall be considered a failure and not acceptable. The Telemetry CONTRACTOR shall repeat the 30 day test. The RCN system shall be acceptable only after all equipment and software has satisfied the performance test requirements.

2. Downtime resulting from the following shall be considered system failures:

   a. If a failed component cannot be repaired/replaced within 2 hours.

   b. Downtime of any component whose failure results in the inability of the Operator to monitor and manipulate control loops from the associated workstations using standard workstation interface procedures.

   c. **Rework and Retest:** If the RCN does not operate as required, the Telemetry CONTRACTOR shall make whatever corrections are necessary, and the failed portion of the test shall be repeated.

3. The Telemetry CONTRACTOR shall submit a final performance test completion report which shall state that all contract requirements have been met and which shall include (1) a listing of all RCN equipment maintenance/repair activities conducted during testing and (2) a listing of all components which were unable to operate successfully. Final acceptance, in writing, of the RCN system shall be provided by INTEGRATOR if the results of all of the performance tests are acceptable.

3.3 TRAINING

A. **Instruction:** The Telemetry CONTRACTOR shall provide training for the purpose of familiarizing ENGINEER and the Owner’s technical maintenance staff with the use,
maintenance, trouble shootings and repair of all supplied field hardware components of the RCN.

B. The training shall be scheduled concurrent with the system testing phases of the project.

C. The training shall be performed by qualified representatives of the Telemetry CONTRACTOR or the instrument/equipment Manufacturer. Training shall be specifically tailored to this project and shall be conducted at the job site unless another location is approved by ENGINEER and OWNER.

D. The training classes shall be scheduled a minimum of 3 weeks in advance of when they are to be given. Proposed training material, including a resume for the proposed instructor(s) (indicating previous instructional experience) and a detailed outline of each lesson shall be submitted to ENGINEER at least 30 days in advance of when the lesson is to be given. ENGINEER shall review the submitted data for suitability and provide comments that shall be incorporated into the course. Final materials will be provided at least two weeks in advance of the training sessions.

E. Within 10 days after the completion of each class the Telemetry CONTRACTOR shall present to ENGINEER the following:

1. A list of all OWNER personnel that attended the classes.

2. An evaluation of OWNER personnel that attended the class via written testing or equivalent evaluation.

3. A copy of the hard copy text utilized during the class with all notes, diagrams, and comments. This documentation shall be contained in the Training Manual.

F. The OWNER reserves the right to videotape and record any or all portions of training performed for future usage.

- END OF SECTION -
PART 1 -- GENERAL

1.1 CONDITIONS AND REQUIREMENTS

A. The General Conditions, Supplementary Conditions, and Division 01 – General Requirements apply.

1.2 SECTION INCLUDES

A. General description, functional requirements, operational characteristics, and criteria for the Security Management System (SMS).

1.3 RELATED SECTIONS

A. Division 26 - Electrical: Electrical systems and components.
B. Division 32 – Ornamental Fencing & Gates
C. Division 40 - Instrumentation: Specifically sheets GI-7 Security System Block Diagram and GI-3 Network Block Diagram.

1.4 DEFINITIONS

A. API: Application Programming Interface.
C. NTSC: National Television Standards Committee.
D. PAL: Phase Alternating Line. PAL is the color video standard used in Europe and many other countries.

1.5 REFERENCE STANDARDS

A. Where more than one (1) reference standard, code, or regulation applies, the more stringent one shall govern.
B. National Fire Protection Association (NFPA)
   1. NFPA 70 - National Electrical Code.
   2. Underwriters Laboratories Inc. (UL):
      3. UL 294 - Standard for Access Control System Units.
      4. UL 1076 - Standard for Proprietary Burglar Alarm Units and Systems.

1.6 SECURITY MANAGEMENT SYSTEM (SMS) DESCRIPTION

A. The Security Management System (SMS) outlined in this section is the key central software component for managing physical security and the bridge between physical
and logical security for a project. The system shall provide a variety of integral functions including: regulation of access and egress; provision of identification credentials; monitor, track and interface alarms and; view, record and store digital surveillance video linked to SMS events.

B. The SMS shall be a web browser based application with no requirement for a server installation and work with common browsers such as internet explorer, chrome or safari.

C. The SMS shall be fully integrated with the surveillance Digital Video Recorder and associated cameras.

D. The SMS shall monitor all system activity.

E. The SMS shall allow user groups to be easily configured allowing access given certain credentials to differing locations within the facility.

F. The SMS shall have remote door open, lock and lock-out functionality.

G. The SMS shall interface to both standard door entry/exit hardware and also vehicle gate entry/exit systems incorporating interfaces to vehicle exit detection systems and automatic gate operator controllers as defined in the relevant section(s) of specification 323100.

H. The SMS shall provide reports for the following items as a minimum:
   1. Access History Report
   2. Credential Report
   3. Reader Access Report
   4. Roster Report
   5. Roll Call Report
      a. The SMS shall have a data backup capability.
      b. The SMS shall enforce anti-passback capability.
      c. The SMS shall include system diagnostic functionality.
      d. The SMS Video capability shall include viewing of live and recorded data.
      e. The SMS system shall be secure from a remote access perspective.
      f. The SMS shall allow a minimum of 10 cameras to be installed on the system.
      g. The SMS shall allow for a minimum of two DVR’s to be installed on the system.
      h. The SMS shall allow access cards to be enrolled via a USB reader.

1.7 SUBMITTALS

A. Submit under provisions of Section 013300.
B. **Product Data:** For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Reference each product to a location on Drawings.

1. Manufacturer’s technical data for all material and equipment at the system and sub-system level to be provided as part of the SMS.

2. A system description including analysis and calculations used in sizing equipment required by the SMS. The description shall show how the equipment will operate as a system to meet the performance requirements of the SMS. The following information shall be supplied as a minimum:
   a. Description of site equipment and its configuration.
   b. Network bandwidth, latency and reliability requirements.
   c. Backup or archive system size and configuration.
   d. Start up operations.
   e. System expansion capability and method of implementation.
   f. System power requirements and UPS sizing.
   g. Device or component environmental requirements (cooling and or heating parameters).
   h. A description of the operating system and application software.

C. **Shop Drawings:** Submit plans, elevations, sections, details, and attachments to other work.

1. Indicate all system device locations on architectural floor plans. No other system(s) shall be included on these plans.

2. Include full schematic wiring information on these drawings for all devices. Wiring information shall include cable type, conductor routings, quantities, and connection details at device.

3. Include a complete SMS one-line, block diagram.

4. Include a statement of the system sequence of operation.

D. **Operation and Maintenance Data:** For electronic security system to include in emergency, operation, and maintenance manuals. Items specified shall include the following:

1. Provide three sets of electronic format manuals including operating instructions, maintenance recommendations and parts list including wiring and connection diagrams modified to reflect as-built conditions.

2. Manuals: Deliver final copies of the manuals within 30 days after completing the installation test. Each manual’s contents shall be identified on the cover. The manual shall include names, addresses, and telephone numbers of the Contractor responsible for the installation and maintenance of the system and the factory.
representatives for each item of equipment for each system. The manuals shall have a table of contents and labeled sections. The final copies delivered after completion of the installation test shall include all modifications made during installation, checkout, and acceptance testing. The manuals shall consist of the following:

a. Functional Design Manual: Identify the operational requirements for the system and explain the theory of operation, design philosophy, and specific functions. Include a description of hardware and software functions, interfaces, and requirements.

b. Hardware Manual: Describe equipment furnished including:

1) General description and specifications.
2) Installation and check out procedures.
3) Equipment layout and electrical schematics to the component level.
4) System layout drawings and schematics.
5) Alignment and calibration procedures.
6) Manufacturer’s repair parts list indicating sources of supply.

c. Software Manuals: Describe the functions of software and include all other information necessary to enable proper loading, testing, and operation. The manual shall include:

1) Definition of terms and functions.
2) System use and application software.
3) Initialization, startup, and exit.
4) Reports generation.
5) Details on forms customization and field parameters.

3. As-Built Drawings: During system installation, the Contractor shall maintain a separate hard copy set of drawings, elementary diagrams, and wiring diagrams of the SMS to be used for record drawings. This set shall be accurately kept up to date by the Contractor with all changes and additions to the SMS. Copies of the final as-built drawings shall be provided to the end user in DXF format.

1.8 QUALITY ASSURANCE

A. Manufacturer Qualifications

1. SMS manufacturer shall be an established organization with referenced and documented experience delivering and maintaining SMS of equal or higher sophistication and complexity as compared to the system detailed in this specification.
2. SMS manufacturer shall employ at a minimum the following methods for quality assurance of component and assembly devices.

   a. Perform visual inspection of devices to verify assembly according to defined procedures. Perform end of line operational tests to ensure product functionality has been correctly configured.

3. Perform individual functionality and system level regression testing to ensure compliance with product specifications. Perform single and multiple unit system tests to mimic end-user installation configurations. Utilize automated hardware and software testing to evaluate system performance under published operational loads and compare to published system capabilities.

B. Bidder Qualifications

1. At the time of the bid, the bidder shall have satisfactorily completed projects of a similar size, scope and complexity as the system detailed in this specification. The bidder shall furnish written proof of experience from three (3) references and proof of current accreditation or certification by the manufacturer for required training for sales or installation or service of the SMS and associated devices.

2. The bidder shall also be a factory authorized local service organization that shall carry a complete stock of parts and provide maintenance for the SMS and related systems under this contract. Local shall be defined as an area in a 50 mile radius of installed location.

1.9 DELIVERY, STORAGE AND HANDLING

A. Deliver, store, and handle materials, components, and equipment in manufacturer's protective packaging.

B. Store components and equipment in temperature and humidity controlled environment in original manufacturer's sealed containers. Maintain ambient temperature between 50 and 85 degrees Fahrenheit (10 and 29.4 degrees Celsius), and not more than 80 percent relative humidity, non-condensing.

C. Open each package; verify contents against packing list; and file copy of packing list, complete with package identification, for inclusion in operation and maintenance data.

D. Mark packing list with the same designations assigned to materials, components, and equipment for recording in the system labeling schedules that are generated by software.

E. Save original manufacturer's containers and packing materials and deliver as directed under provisions covering extra materials.

1.10 PROJECT CONDITIONS

A. **Environmental Conditions:** System shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

   1. Indoor, Uncontrolled Environment: NEMA 250, [Type 3R] [Type 4] [Type 12] [Type 12K] enclosures. System components installed in [non-air-conditioned] [non-temperature-controlled] indoor environments shall be rated for continuous operation
in ambient conditions of 0-120 degrees Fahrenheit dry bulb and 20 to 90 percent relative humidity, non-condensing.

2. Outdoor Environment: NEMA 250, NEMA 250, [Type 3] [Type 3R] [Type 3S] [Type 4] [Type 4X] enclosures. System components installed in locations exposed to weather shall be rated for continuous operation in ambient conditions of 0-120 degrees Fahrenheit dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation where exposed to rain as specified in NEMA 250, winds up to 85 mph (136 kph).

1.11 SMS STARTUP and COMMISSIONING

A. The security system vendor shall be responsible for startup and commissioning of the Security Management System including the following tasks:

1. Setup of the SMS system configuration including User Groups, credentials, reports, DVR and cameras.

2. Installation and commissioning of all door and gate entry/exit systems and components.

3. Installation and commissioning of all input cards for external security signals such as hatches and doors.

4. Testing of SMS software in conjunction with installed security hardware.

PART 2 -- PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Manufacturer: The security management system shall be:


2. OR Approved Equal

2.2 SMS SOFTWARE

A. Security Management System (SMS) Software

1. Lenel Systems International “Truportal”.

2. OR Approved Equal

2.3 COMPONENTS

A. Security Management System (SMS) Hardware: The SMS shall be equipped with the access control field hardware required to receive alarms and administer all access granted or denied decisions. All field hardware must be designed to meet UL 294 requirements. The SMS must be able to retrieve device serial numbers from all field hardware, excluding card readers and keypads. Depending upon the configuration, the SMS field hardware must be able to include any or all of the following components:

1. Intelligent Dual Reader Controller.
2. Base System Controller: GOE-SYS-2D2R OR Approved equal.

3. Input Control Module (ICM): GOE-ADD-IO OR Approved equal.

4. Dual Door Reader Interface Module (DRI): GOE-ADD-2D2R OR Approved equal.

5. T-100 Proximity Readers OR Approved equal.

6. T-525W Keypad & Proximity Readers OR Approved equal.

7. Power supplies and enclosures.

8. UL, CUL, and CE listed power supplies and enclosures.

B. The SMS Digital Video Recorder shall be:

1. Lenel TVR-10 (4 channel with 1GB of storage).

2. OR Approved Equal.

C. The SMS Digital Cameras shall be:

D. For indoor applications:

1. TVD-TIR2-HR (530 TVL Color, 3.5-8mm auto iris varifocal lens, 24 VAC/12VDC).

2. OR Approved Equal.

E. For Outdoor applications:

1. UVD-XP3DNR-VA2 (day/night, 540 TVL, 2.8-10mm auto iris varifocal lens, 24 VAC/12VDC).

2. OR Approved Equal.

2.4 SMS CONFIGURATION PC REQUIREMENTS

A. PC Requirements

B. Laptop, Desktop or Tablet:

1. Intel® Pentium 4, 2.8Ghz

2. 1GB Memory.

3. 512 GB

4. 10/100 Ethernet Network.

5. 1280 x 1024 screen resolution.

2.5 INTERNET ACCESS

A. Wireless access to the internet with static IP address.
1. 8 to 10 MBS download rate and 2 to 5 MBS upload rate.

2. 8 GB minimum per month data transfer cap.


B. Integrated broadband router (always on) connection of the SMS equipment to the internet.

1. Basis of Design Access service: Cradle Point COR IBR600, or equal.

**PART 3 -- EXECUTION**

3.1 EXAMINATION

A. Examine substrates, areas, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of electronic security system.

B. Examine rough-in for embedded and built-in anchors to verify actual locations of intrusion detection connections before electronic security system installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SYSTEM INTEGRATION

A. Integrate electronic security system with the following systems and equipment:

1. Electronic door hardware.

2. Intercommunications and program systems.

3. Public address and mass notification systems.

4. Door Access control.

5. Entry/Exit Gate Access control.

6. Fire-alarm system.

7. Perimeter security system.

8. Video surveillance.

3.3 INSTALLATION

A. Install electronic security system in accordance with manufacturer’s written instructions.

B. Wiring Method: Install wiring in metal raceways. Conceal raceway except in unfinished spaces and as indicated. Minimum conduit size shall be 1/2-inch. Control and data transmission wiring shall not share conduit with other building wiring systems.

C. Wiring Method: Cable, concealed in accessible ceilings, walls, and floors when possible.

- END OF SECTION -
SECTION 410000 - EQUIPMENT GENERAL PROVISIONS

PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide equipment and appurtenant WORK, complete and operable, in accordance with the Contract Documents.

B. The provisions of this Section shall apply to equipment throughout the Contract except where otherwise indicated.

C. Equipment Arrangement: Unless specifically indicated otherwise, the arrangement of equipment indicated is based upon information available at the time of design and is not intended to show exact dimensions particular to a specific manufacturer. Some aspects of the Drawings are diagrammatic and some features of the illustrated equipment arrangement may require revision to meet the actual equipment requirements. Structural supports, foundations, piping and valve connections, and electrical and instrumentation connections indicated may have to be altered to accommodate the equipment provided. No additional payment will be made for such revisions and alterations. Substantiating calculations and drawings shall be submitted prior to beginning the installation of equipment.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Equipment shall be in accordance with the following standards, as applicable and as indicated in each equipment specification:

3. American Society of Mechanical Engineers (ASME).
5. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE).
10. Manufacturer’s published recommendations and specifications.

B. The following standards are referenced in this Section:

ASME B16.1 Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800
1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 013300 - Contractor Submittals.

B. Shop Drawings: Furnish complete drawings and technical information for equipment, piping, valves, and controls. Where indicated or required by the ENGINEER, Shop Drawings shall include clear, concise calculations showing equipment anchorage forces and the capacities of the anchorage elements proposed by the CONTRACTOR.

The shop drawing submittals for all equipment and tributary pipe lengths weighing over 400 lbs, and mounted to floors, ceiling, walls or on roofs, are to include calculations that show the wind and/or seismic forces (lateral, uplift, downward) and all connections to carry these forces in the structure. The calculations are to include an analysis using the parameters in Section 2.2 below

C. Spare Parts List: The CONTRACTOR shall obtain from the manufacturer and submit at the same time as Shop Drawings a list of suggested spare parts for each piece of equipment. CONTRACTOR shall also furnish the name, address, and telephone number of the nearest distributor for each piece of equipment.

D. Torsion and Vibration Analyses

1. The CONTRACTOR shall arrange for and submit torsional and lateral vibration analyses for the following equipment types:


   b. Pumps, blowers, and compressors with constant speed drives of 500 horsepower and greater.

   c. Pumps, blowers and compressors with variable speed drives of 100 horsepower and greater.
d. Vertical pumps with universal joints and extended shafts.

e. Other equipment as indicated.

E. **Rotodynamics Analysis:** An experienced specialist from the manufacturer or a highly qualified third party engineer, such as Engineering Dynamics, Mechanical Solutions, or equal, approved in writing by the ENGINEER, shall perform a complete torsional and lateral vibration analysis for each motor, driven equipment, and variable frequency drive system. The stress analysis shall demonstrate that in no case shall the maximum stress on any component exceed the endurance limits of the motor-flywheel-coupling-driven equipment train materials of construction. Calculation of shaft deflection in the vicinity of the seal journal shall be submitted. Shaft design criteria shall be as indicated. Submit calculations of lateral vibration analysis for the VFD, motor with flywheel, couplings, drive shaft and pump assembly. Submit calculations of torsional analysis for the complete rotating assembly. The analysis report shall include the specific items as follows:

1. The undamped torsional natural frequencies of the complete train shall be at least 25 percent above or 25 percent below any possible (steady state) excitation frequency within the specified operating speed range from minimum to maximum continuous speed respectively.

2. When torsional frequencies fall within the margin specified, a finite element analysis of the rotating assembly shall be prepared to determine the endurance stress factor of safety of the shaft material. The endurance fatigue stress factor of safety is below in a paragraph entitled Shafting. Remedial measures such as adjusting the VFD to jump the critical torsional frequencies will not be acceptable.

3. The CONTRACTOR shall submit a detailed report of the analysis:
   a. A description of the method used to calculate the natural frequencies.
   b. A diagram of the mass elastic system.
   c. A table of the mass moment and torsional stiffness of each element of the mass elastic system.
   d. Campbell Diagram.
   e. A mode shape diagram with peak stresses shown for each resonant frequency.
   f. This analysis shall identify the dry and wet lateral critical(s), plus the torsional critical(s) speeds.
   g. This WORK shall be performed prior to fabrication of the machinery, and it is subject to review by the ENGINEER.

F. Certifications that equipment and equipment supports comply with seismic and wind design criteria from Code.

1.4 **QUALITY ASSURANCE**

A. **Costs:** Responsibility shall be the CONTRACTOR'S for performing and paying the costs of inspection, startup, testing, adjustment, and instruction services performed by factory representatives. The OWNER will pay for costs of power and water. If available, the OWNER'S operating personnel will provide assistance in the field testing.
B. **Inspection:** The CONTRACTOR shall inform the local authorities, such as building and plumbing inspectors, fire marshal, OSHA inspectors, and others, to witness required tests for piping, plumbing, fire protection systems, pressure vessels, safety systems, and related items to obtain required permits and certificates, and shall pay inspection fees.

C. **Quality and Tolerances:** Tolerances and clearances shall be as shown on the Shop Drawings and shall be closely adhered to.

1. Machine WORK shall be of high-grade workmanship and finish, with due consideration to the special nature or function of the parts. Members without milled ends and which are to be framed to other steel parts of the structure may have a variation in the detailed length of not greater than 1/16-inch for members 30-feet or less in length, and not greater than 1/8-inch for members over 30-feet in length.

2. Castings shall be homogeneous and free from non-metallic inclusions and defects. Surfaces of castings which are not machined shall be cleaned to remove foundry irregularities. Casting defects not exceeding 12.5 percent of the total thickness and where defects will not affect the strength and serviceability of the casting may be repaired by approved welding procedures. The ENGINEER shall be notified of larger defects. No repair welding of such defects shall be carried out without the ENGINEER’S written approval. If the removal of metal for repair reduces the stress resisting cross-section of the casting by more than 25 percent or to such an extent that the computed stress in the remaining metal exceeds the allowable stress by more than 25 percent, then the casting may be rejected. Costs of casting new material shall be the CONTRACTOR’S responsibility as part of the WORK.

3. Materials shall meet the physical and mechanical properties in accordance with the reference standards.

D. **Machine Finish:** The type of finish shall be the most suitable for the application and shall be shown in micro-inches in accordance with ANSI B46.1. The following finishes shall be used:

1. Surface roughness not greater than 63 micro-inches shall be required for surfaces in sliding contact.

2. Surface roughness not greater than 250 micro-inches shall be required for surfaces in contact where a tight joint is not required.

3. Rough finish not greater than 500 micro-inches shall be required for other machined surfaces.

4. Contact surfaces of shafts and stems which pass through stuffing boxes and contact surfaces of bearings shall be finished to not greater than 32 micro-inches.

E. **Manufacturer’s Experience:** Equipment manufacturer shall have a record of at least 5 years of successful, troublefree operation in similar applications and size equal or larger than the equipment in this Contract.
PART 2 – PRODUCTS

2.1 GENERAL REQUIREMENTS

A. **Noise Level:** When in operation, no single piece of equipment shall exceed the OSHA noise level requirement of 105 dBA for one hour exposure per day.

B. **High Noise Level Location:** The CONTRACTOR shall provide one personal hearing protection station at each high noise level location. Locations are defined as follows:

1. **Outdoor Location:** Any single equipment item or any group of equipment items that produce noise exceeding OSHA noise level requirements for a 2 hour exposure. Where such equipment is separated by a distance of more than 20-feet, measured between edges of footings, each group of equipment shall be provided with a separate hearing protection station.

2. **Indoor Location**
   a. Any single equipment item or any group of equipment items located within a single room not normally occupied, that produces noise exceeding OSHA noise level requirements for a 2 hour exposure.
   b. Any single equipment item or any group of equipment items located within a single room normally occupied by workers that produces noise exceeding OSHA noise level requirements for an 8 hour exposure.

C. **Personal Hearing Protection:** The CONTRACTOR shall furnish 3 pairs of high attenuation hearing protectors in the original unopened packaging. The ear protectors shall be capable of meeting the requirements of ANSI S12.6 and shall produce a noise level reduction of 25 dBA at a frequency of 500 Hz. The hearing protectors shall have fluid filled ear cushions and an adjustable, padded headband. The protectors shall be stored in a weatherproof, labeled, steel cabinet, provided at an approved location near the noise producing equipment.

D. **Drive Trains and Service Factors:** Service factors shall be applied in the selection or design of mechanical power transmission components. Components of drive train assemblies between the prime mover and the driven equipment shall be designed and rated to deliver the maximum peak or starting torque, speed, and horsepower. All of the applicable service factors shall be considered, such as mechanical (type of prime mover), load class, start frequency, ventilation, ambient temperature, and fan factors. Drive train components include couplings, shafts, gears and gear drives, drive chains, sprockets, and V-belt drives. Unless otherwise indicated, the following load classifications shall apply in determining service factors:
<table>
<thead>
<tr>
<th>Type of Equipment</th>
<th>Service Factor</th>
<th>Load Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blowers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>centrifugal or vane</td>
<td>1.0</td>
<td>Uniform</td>
</tr>
<tr>
<td>lobe</td>
<td>1.25</td>
<td>Moderate Shock</td>
</tr>
<tr>
<td>Centrifugal Fans</td>
<td>1.0</td>
<td>Uniform</td>
</tr>
<tr>
<td>Reciprocating Air Compressors</td>
<td>2.0</td>
<td>Heavy Shock</td>
</tr>
<tr>
<td>multi-cylinder</td>
<td>2.0</td>
<td>Heavy Shock</td>
</tr>
<tr>
<td>single-cylinder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pumps</td>
<td></td>
<td></td>
</tr>
<tr>
<td>centrifugal or rotary</td>
<td>1.0</td>
<td>Uniform</td>
</tr>
<tr>
<td>reciprocating</td>
<td>1.8</td>
<td>Moderate Shock</td>
</tr>
<tr>
<td>Cranes or Hoists</td>
<td>1.25</td>
<td>Moderate Shock</td>
</tr>
</tbody>
</table>

E. Mechanical Service Factors

<table>
<thead>
<tr>
<th>Mechanical Service Factors</th>
<th>Electric Motor</th>
<th>Internal Combustion Engine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uniform</td>
<td>1.25</td>
<td>1.50</td>
</tr>
<tr>
<td>Moderate Shock</td>
<td>1.50</td>
<td>1.75</td>
</tr>
<tr>
<td>Heavy Shock</td>
<td>2.00</td>
<td>2.25</td>
</tr>
</tbody>
</table>

F. For thermal rating adjustments such as start frequency, ambient temperature, and hourly duty cycle factor, ventilation factor, and fan factor, refer to gear manufacturer sizing information.

G. For service factors of electric motors, see Section 16460 - Electric Motors.

H. Where load classifications are not indicated, service factors shall be for standard load classifications and for flexible couplings.

I. **Welding:** Unless otherwise indicated, welding shall conform to the following:

1. Latest revision of AWWA D100.
2. Latest revision of AWWA C206.
3. Composite fabricated steel assemblies that are to be erected or installed inside a hydraulic structure, including any fixed or movable structural components of mechanical equipment, shall have continuous seal welds to prevent entrance of air or moisture.
4. Welding shall be by the metal-arc method or gas-shielded arc method as described in the American Welding Society's "Welding Handbook" as supplemented by other pertinent standards of the AWS. Qualification of welders shall be in accordance with the AWS Standards.

5. In assembly and during welding, the component parts shall be adequately clamped, supported, and restrained to minimize distortion and for control of dimensions. Weld reinforcement shall be as specified by the AWS code. Upon completion of welding, weld splatter, flux, slag, and burrs left by attachments shall be removed. Welds shall be repaired to produce a workmanlike appearance with uniform weld contours and dimensions. Sharp corners of material that are to be painted or coated shall be ground to a minimum of 1/32-inch on the flat.

J. Protective Coating: Equipment shall be painted or coated in accordance with Section 099600 - Protective Coatings, unless otherwise indicated. Non-ferrous metal and corrosion-resisting steel surfaces shall be coated with grease or lubricating oil. Coated surfaces shall be protected from abrasion or other damage during handling, testing, storing, assembly, and shipping.

K. Potable Water Contact: Materials immersed in or exposed to potable water shall be listed as compliant with NSF Standard 61.

L. Protection of Equipment: Equipment shall be boxed, crated, or otherwise protected from damage and moisture during shipment, handling, and storage. Equipment shall be protected from exposure to corrosive fumes and shall be kept thoroughly dry. Pumps, motors, drives, electrical equipment, and other equipment having anti-friction or sleeve bearings shall be stored in weathertight storage facilities prior to installation. For extended storage periods, plastic equipment wrappers should be avoided to prevent accumulation of condensate in gears and bearings. In addition, motor space heaters shall be energized and shafts shall be rotated. Equipment delivered to the Site with rust or corroded parts shall be rejected. If equipment develops defects during storage, it shall be disassembled, cleaned, and recoated to restore it to original condition.

M. Identification of Equipment Items

1. At the time of shipping, each item of equipment shall have a legible identifying mark corresponding to the equipment number in the Contract Documents for the particular item.

2. After installation, each item of equipment shall be given permanent identification.

   a. Pumps, compressors, vacuum pumps, and other electric motor driven equipment of 150 horsepower or less shall receive acrylic plastic nametags in accordance with Section 101400 – Signage.

   b. Pumps, compressors, vacuum pumps, and other electric motor driven equipment larger than 150 horsepower shall receive stainless steel plate nametags in accordance with Section 101400.

N. Vibration Isolators: Compressors, vacuum pumps, and inline fans shall be provided with restrained spring-type vibration isolators or pads per manufacturer's written recommendations. Vibration isolations shall be provided with seismic restraint.

O. Shop Fabrication: Shop fabrication shall be performed in accordance with the Contract Documents and the Shop Drawings.
P. **Controls:** Equipment and system controls shall be in accordance with Division 40 - Instrumentation.

2.2 **EQUIPMENT SUPPORTS AND FOUNDATIONS**

A. **Equipment Supports:** Unless otherwise indicated, equipment supports, anchors, and restrainers shall be adequately designed for static, dynamic, wind, and seismic loads as stated in the 2009 International Building Code (IBC), Chapter 16 and ASCE 7-05. Submitted design calculations for equipment supports and anchorage shall bear the signature and seal of an Registered Professional Engineer licensed in the State of California, unless otherwise indicated. Calculations shall account for forces and distribution of forces on supporting structures resulting from normal operation, normal operation plus seismic loadings, normal operation plus wind loadings, as well as the other load combinations stated the 2009 IBC.

1. Wall-mounted equipment weighing more than 250 pounds or which is within 18-inches above the floor shall be provided with fabricated steel supports. Pedestals shall be of welded steel. If the supported equipment is a panel or cabinet or is enclosed with removable sides, the pedestal shall match the supported equipment in appearance and dimensions.

B. **Wind Load:** The wind load shall be calculated in accordance with ASCE 7-05, Chapter 6, using the following design parameters:

1. Wind Speed: 85 mph
2. Exposure: D
3. Importance Factor: \( I_w = 1.15 \)

C. **Seismic Loads:** The seismic lateral and vertical forces shall be calculated in accordance with the ASCE 7-05, Chapters 11 and 13, using the following design parameters:

1. Site Class: D
2. Seismic Use Group IV
3. Seismic Design Category (SDC) D
4. Seismic Importance Factor: \( I_e = 1.5 \)
5. Short Period Spectral Acceleration \( S_s = 0.67 \, g \)
6. 1 Second Period Spectral Acceleration \( S_1 = 0.27 \, g \)

D. **Anchors:** The Anchorage of all pumps is to comply with the requirements of Occupancy Category IV facilities. Anchor bolts shall be in accordance with Section 05 50 00 - Miscellaneous Metalwork, and shall be designed to resist the above loads. Anchor bolt calculations shall clearly show that the capacity of the anchor and the capacity of the concrete that the anchor is embedded in are adequate to resist all loads stated in the 2009 IBC and ASCE 7-05, including lateral wind and lateral and vertical seismic loads. Reduction factors associated with edge distance, embed length, and bolt spacing shall all be considered and based on the actual dimensions of the concrete that resists the anchorage forces. Anchor bolt details shall include required bolt diameter, embed, and...
edge distances. Further, the design of Anchors shall consider the ductility requirements stated in ASCE 7-05, Chapter 13, Section 13.4.2 and Chapter 15, Section 15.7.3. Anchor bolt calculations and details shall be submitted and shall bear the signature and seal of a Registered Professional Engineer licensed in the State of California.

E. **Equipment Foundations:** Mechanical equipment, tanks, control cabinets, enclosures, and related equipment shall be mounted on minimum 3 ½-inch high concrete bases, unless otherwise indicated. Equipment foundations are indicated on Drawings. The CONTRACTOR, through the equipment manufacturer, shall verify the size and weight of equipment foundation to insure compatibility with equipment. The dimensions of all concrete bases shall be sufficient to provide the edge distances required by the anchor bolt calculations.

2.3 **COUPLINGS**

A. Mechanical couplings shall be provided between the driver and the driven equipment. Flexible couplings shall be provided between the driver and the driven equipment to accommodate slight angular misalignment, parallel misalignment, end float, and to cushion shock loads. Unless otherwise indicated or recommended by the equipment manufacturer, coupling type shall be furnished with the respective equipment as follows:

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Coupling Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical turbine and mixed flow pumps</td>
<td>3 piece spacer for solid shaft or double nut for hollow shaft</td>
</tr>
<tr>
<td>Air compressors / vacuum pumps</td>
<td>Gear or flexible disc pack</td>
</tr>
</tbody>
</table>

B. Each coupling size shall be determined based on the rated horsepower of the motor, speed of the shaft, and the load classification service factor. The CONTRACTOR shall have the equipment manufacturer select or recommend the size and type of coupling required to suit each specific application.

C. **Differential Settlement:** Where differential settlement between the driver and the driven equipment may occur, 2 sets of universal type couplings shall be provided.

D. **Taper-Lock** or equal bushings may be used to provide for easy installation and removal of shafts of various diameters.

2.4 **SHAFTING**

A. **General:** Shafting shall be continuous between bearings and shall be sized to transmit the power required. Keyways shall be accurately cut in line. Shafting shall not be turned down at the ends to accommodate bearings or sprockets whose bore is less than the diameter of the shaft. Shafts shall rotate in the end bearings and shall be turned and polished, straight, and true.

B. **Design Criteria:** Shafts shall be designed to carry the steady state and transient loads suitable for unlimited number of load applications, in accordance with ASME B106.1M - Design of Transmission Shafting. Where shafts are subjected to fatigue stresses, such as frequent start and stop cycles, the mean stress shall be determined by using the modified Goodman Diagram. The maximum torsional stress shall not exceed the endurance limit of the shaft after application of the factor of safety of 2 in the endurance
C. **Materials:** Shafting materials shall be appropriate for the type of service and torque transmitted. Environmental elements such as corrosive gases, moisture, and fluids shall be taken into consideration. Materials shall be as indicated unless furnished as part of an equipment assembly.

1. Low carbon cold-rolled steel shafting shall conform to ASTM A 108, Grade 1018.
2. Medium carbon cold-rolled shafting shall conform to ASTM A 108, Grade 1045.
3. Other grades of carbon steel alloys shall be suitable for service and load.
4. Corrosion-resistant shafting shall be stainless steel or Monel, whichever is most suitable for the intended service.

D. **Differential Settlement:** Where differential settlement between the driver and the driven equipment may occur, a shaft of sufficient length with 2 sets of universal type couplings shall be provided.

2.5 **GEARS AND GEAR DRIVES**

A. Unless otherwise indicated, gears shall be of the spur, helical, or spiral-bevel type, designed and manufactured in accordance with AGMA Standards, with a service factor suitable for load class, mechanical service and thermal rating adjustment, a minimum L-10 bearing life of 60,000 hours, and a minimum efficiency of 94 percent. Peak torque, starting torque, and shaft overhung load shall be checked when selecting the gear reducer. Worm gears shall not be used unless specifically approved by the ENGINEER.

B. Gear speed reducers or increasers shall be of the enclosed type, oil- or grease-lubricated and fully sealed, with a breather to allow air to escape but keep dust and dirt out. The casing shall be of cast iron or heavy-duty steel construction with lifting lugs and an inspection cover for each gear train. An oil level sight glass and an oil flow indicator shall be provided, located for easy reading.

C. Gears and gear drives that are part of an equipment assembly shall be shipped fully assembled for field installation.

D. Material selections shall be left to the discretion of the manufacturer, provided the above AGMA values are met. Input and output shafts shall be adequately designed for the service and load requirements. Gears shall be computer-matched for minimum tolerance variation. The output shaft shall have 2 positive seals to prevent oil leakage.

E. Oil level and drain locations shall be easily accessible. Oil coolers or heat exchangers with required appurtenances shall be provided when necessary.

F. Where gear drive input or output shafts from one manufacturer connect to couplings or sprockets from a different manufacturer, the CONTRACTOR shall have the gear drive manufacturer furnish a matching key taped to the shaft for shipment.

2.6 **DRIVE CHAINS**

A. Power drive chains shall be commercial type roller chains meeting ASME Standards.
B. A chain take-up or tightener shall be provided in every chain drive arrangement to provide easy adjustment.

C. A minimum of one connecting or coupler link shall be provided in each length of roller chain.

D. Chain and attachments shall be of the manufacturer's best standard material and be suitable for the process fluid.

2.7 SPROCKETS

A. General: Sprockets shall be used in conjunction with chain drives and chain-type material handling equipment.

B. Materials: Unless otherwise indicated, materials shall be as follows:

1. Sprockets with 25 teeth or less, normally used as a driver, shall be made of medium carbon steel in the 0.40 to 0.45 percent carbon range.

2. Type A and B sprockets with 26 teeth or more, normally used as driven sprockets, shall be made of minimum 0.20 percent carbon steel.

3. Large diameter sprockets with Type C hub shall be made of cast iron conforming to ASTM A 48, Class 30.

C. Sprockets shall be accurately machined to ASME Standards. Sprockets shall have deep hardness penetration in tooth sections.

D. Finish bored sprockets shall be furnished complete with keyseat and set screws.

E. To facilitate installation and disassembly, sprockets shall be of the split type or shall be furnished with Taper-Lock bushings as required.

F. Idler sprockets shall be provided with brass or Babbitt bushings, complete with oil hole and axial or circumferential grooving with stainless steel tubing and grease fitting extended to an accessible location. Steel collars with set screws may be provided in both sides of the hub.

2.8 V-BELT DRIVES

A. V-belts and sheaves shall be of the best commercial grade and shall conform to ASME, MPTA, and RMA Standards.

B. Unless otherwise indicated, sheaves shall be machined from the finest quality gray cast iron.

C. Sheaves shall be statically balanced. In some applications where vibration is a problem, sheaves shall be dynamically balanced. Sheaves operating at belt speeds exceeding 6,500 fpm may be required to be of special materials and construction.

D. To facilitate installation and disassembly, sheaves shall be provided complete with Taper-Lock or QD bushings as required.

E. Finish bored sheaves shall be complete with keyseat and set screws.
F. Sliding motor bases shall be provided to adjust the tension of V-belts.

2.9 DRIVE GUARDS

A. Power transmission trains, prime movers, machines, shaft extensions, and moving machine parts shall be guarded to conform with the Division of Industrial Safety General Industrial Safety Orders latest edition. The guards shall be constructed of minimum 10-gauge expanded, flattened steel with smooth edges and corners, galvanized after fabrication, and securely fastened. Where required for lubrication or maintenance, guards shall have hinged and latched access doors.

2.10 BEARINGS

A. General: Bearings shall conform to the standards of the American Bearing Manufacturers Association, Inc. (ABMA).

B. To assure satisfactory bearing application, fitting practice, mounting, lubrication, sealing, static rating, housing strength, and lubrication shall be considered in bearing selection.

C. Re-lubricatable type bearings shall be equipped with a hydraulic grease fitting in an accessible location and shall have sufficient grease capacity in the bearing chamber.

D. Lubricated-for-life bearings shall be factory-lubricated with the manufacturer's recommended grease to insure maximum bearing life and best performance.

E. Anti-Friction Type Bearing Life: Except where otherwise indicated, bearings shall have a minimum L-10 life expectancy of 5 years or 20,000 hours, whichever occurs first. Where so indicated, bearings shall have a minimum rated L-10 life expectancy corresponding to the type of service, as follows:

<table>
<thead>
<tr>
<th>Type of Service</th>
<th>Design Life, years</th>
<th>L-10 Design Life, hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(whichever comes first)</td>
<td></td>
</tr>
<tr>
<td>8-hour shift</td>
<td>10</td>
<td>20,000</td>
</tr>
<tr>
<td>16-hour shift</td>
<td>10</td>
<td>40,000</td>
</tr>
<tr>
<td>Continuous</td>
<td>10</td>
<td>60,000</td>
</tr>
</tbody>
</table>

F. Bearing housings shall be of cast iron or steel and bearing mounting arrangement shall be as indicated or as recommended in the published standards of the manufacturer. Split-type housings may be used to facilitate installation, inspection, and disassembly.

G. Sleeve Type Bearings: Sleeve-type bearings shall have a cast iron or ductile iron housing and Babbitt or bronze liner. Bearing housing shall be bolted and doweled to the lower casing half. These housings shall be provided with cast iron caps bolted in place and the bearing end caps shall be bored to receive the bearing shells. Sleeve bearings shall be designed on the basis of the maximum allowable load permitted by the bearing manufacturer. If the sleeve bearing is connected to an equipment shaft with a coupling, the coupling transmitted thrust will be assumed to be the maximum motor or equipment thrust. Lubricant, lubrication system, and cooling system shall be as recommended by the bearing manufacturer.
H. **Plate Thrust Bearings:** Thrust bearings shall be the **Kingsbury** Type, designed and manufactured to maintain the shaft in the fixed axial position without undue heating or the necessity of adjustment or attention. Bearings shall be oil lubricated to suit the manufacturer's standard method of lubrication for the specific bearing. If bearing cooling is required, manufacturer shall provide necessary piping, filters, and valves.

2.11 **PIPING CONNECTIONS**

A. **Pipe Hangers, Supports, and Guides:** Pipe connections to equipment shall be supported, anchored, and guided to avoid stresses and loads on equipment flanges and equipment. Supports and hangers shall be in accordance with Section 431052 - Pipe Supports.

B. **Flanges and Pipe Threads:** Flanges on equipment and appurtenances shall conform to ASME B16.1, Class 125, or B16.5, Class 150, unless otherwise indicated. Pipe threads shall be in accordance with ASME B1.20.1 and Section 431050 - Piping, General.

C. **Flexible Connectors:** Flexible connectors shall be installed in piping connections to engines, blowers, compressors, and other vibrating equipment and in piping systems in accordance with the requirements of Section 431050. Flexible connectors shall be harnessed or otherwise anchored to prevent separation of the pipe where required by the installation.

D. **Insulating Connections:** Insulating bushings, unions, couplings, or flanges, as appropriate, shall be used in accordance with the requirements of the Section 431050.

2.12 **GASKETS AND PACKINGS**

A. Gaskets shall be in accordance with Section 431050.

B. Packing around valve stems and reciprocating shafts shall be of compressible material, compatible with the fluid being used. Chevron-type "V" packing shall be **Garlock No. 432, John Crane Everseal,** or equal.

C. Packing around rotating shafts (other than valve stems) shall be "O" rings, stuffing boxes, or mechanical seals, as recommended by the manufacturer and approved by the ENGINEER, in accordance with Section 432000 - Pumps, General.

2.13 **NAMEPLATES**

A. Equipment nameplates of stainless steel shall be engraved or stamped and fastened to the equipment in an accessible location with No. 4 or larger oval head stainless steel screws or drive pins. Nameplates shall contain the manufacturer's name, model, serial number, size, characteristics, and appropriate data describing the machine performance ratings.

2.14 **TOOLS AND SPARE PARTS**

A. **Tools:** The CONTRACTOR shall furnish one complete set of special wrenches and other special tools necessary for the assembly, adjustment, and dismantling of the equipment. Tools shall be of best quality hardened steel forgings with bright finish. Wrench heads shall have work faces dressed to fit nuts. Tools shall be suitable for professional work and manufactured by **Snap On, Crescent, Stanley,** or equal. The set of tools shall be neatly mounted in a labeled toolbox of suitable design provided with a hinged cover.
B. Spare parts shall be furnished as indicated in the individual equipment sections. Spare parts shall be suitably packaged in a metal box and labeled with equipment numbers by means of stainless steel or solid plastic nametags attached to the box.

2.15 EQUIPMENT LUBRICANTS

A. The CONTRACTOR shall provide lubricants for equipment during shipping, storage, and prior to testing, in accordance with the manufacturer’s recommendations. Lubricants that could come in contact with potable water shall be food grade lubricants. After successful initial testing, final testing, and satisfactory completion startup testing per Section 017500 - Startup, the CONTRACTOR shall conduct one complete lubricant change on all equipment. In addition, the CONTRACTOR shall be responsible for the proper disposal of used lubricants. The OWNER will then be responsible for subsequent lubricant changes.

PART 3 -- EXECUTION

3.1 SERVICES OF MANUFACTURER

A. Inspection, Startup, and Field Adjustment: Where required by individual sections, an authorized, experienced, and competent service representative of the manufacturer shall visit the Site for the number of Days indicated in those sections to witness or perform the following and to certify in writing that the equipment and controls have been properly installed, aligned, lubricated, adjusted, and readied for operation.

1. Installation of equipment.
2. Inspection, checking, and adjusting the equipment and approving its installation.
3. Startup and field testing for proper operation, efficiency, and capacity.
4. Performing field adjustments during the test period to ensure that the equipment installation and operation comply with requirements.

B. Instruction of the OWNER’S Personnel

1. Where required by the individual equipment sections, an authorized training representative of the manufacturer shall visit the Site for the number of Days indicated in those sections to instruct the OWNER’S personnel in the operation and maintenance of the equipment, including step-by-step troubleshooting with necessary test equipment. Instruction shall be specific to the models of equipment provided.

2. The representative shall have at least 2 years experience in training. A resume of the representative shall be submitted.

3. Training shall be scheduled 3 weeks in advance of the scheduled session.

4. Proposed training material and a detailed outline of each lesson shall be submitted for review. Review comments from the ENGINEER shall be incorporated into the material.

5. The training materials shall remain with the trainees after the session.
6. The OWNER may videotape the training for later use by the OWNER’S personnel.

C. **Vibration Monitoring:** For the equipment types listed in paragraph 1.3D, the CONTRACTOR shall arrange for at least 2 Site visits by the manufacturer's specialist during testing of the equipment covered by torsional and vibration analysis submittals to measure the amount of vibration and prepare written recommendations for keeping the vibration within acceptance limits. If vibration readings exceed the specified or the applicable referenced standard vibration limits for the type of equipment, the CONTRACTOR shall make necessary corrections for the equipment to meet the acceptance criteria.

3.2 **INSTALLATION**

A. **General:** Equipment shall be installed in accordance with the manufacturer’s written recommendations.

B. **Alignment:** Equipment shall be field tested to verify proper alignment.

3.3 **PACKAGED EQUIPMENT**

A. When any system is furnished as pre-packaged equipment, the CONTRACTOR shall coordinate space and structural requirements, clearances, utility connections, signals, and outputs with Subcontractors to avoid later change orders.

B. If the packaged system has any additional features (as safety interlocks, etc.) other than required by the Contract Documents, the CONTRACTOR shall coordinate such features with the ENGINEER and provide material and labor necessary for a complete installation as required by the manufacturer.

3.4 **FIELD ASSEMBLY**

A. Studs, cap screws, bolt and nuts used in field assembly shall be coated with *Never Seize* compound, or equal.

3.5 **WELDING**

A. Welds shall be cleaned of weld-slag, splatter, etc. to provide a smooth surface.

3.6 **FIELD TESTS**

A. Where indicated by the individual equipment sections, equipment shall be field tested after installation to demonstrate satisfactory operation without excessive noise, vibration, or overheating of bearings or motor.

B. The following field testing shall be conducted:

1. Start equipment, check, and operate the equipment over its entire operating range. Vibration level shall be within the amplitude limits as indicated or as recommended by the reference applicable standards.

2. Obtain concurrent readings of motor voltage, amperage, capacity, vibration, and bearing temperatures.

3. Operate equipment indicated in Section 017500.
C. The ENGINEER shall witness field-testing. The CONTRACTOR shall notify the ENGINEER of the test schedule 3 Days in advance.

D. In the event that any equipment fails to meet the test requirements, the equipment shall be modified and retested until it satisfies the requirement.

- END OF SECTION -
SECTION 410166 - PROFILE WIRE SCREENS, BLANK PANELS, AND REFUGIA

PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide banded stainless steel Fish Screen panel assemblies, banded painted steel Blank panel assemblies, stainless steel Fish Refugia assemblies, painted steel Blank Fish Refugia assemblies, a lifting mechanism for the Screens and Blank Panels, and a lifting mechanism for the Fish Refugias and Blank Fish Refugias as shown and specified, in accordance with the requirements of the Contract Documents. Each fish screen panel assembly or blank panel assembly is to arrive on site pre-assembled. Blank panel assemblies include both full size and half size Blank panel assemblies as shown in the Contract Drawings. Unless otherwise noted, Blank panel assemblies as specified herein implies both full size and half size Blank panel assemblies.

B. Quantity: Provide Fish Screen panel assemblies, Blank panel assemblies, Fish Refugia assemblies, and Blank Fish Refugia complete, of the quantity, size and design as shown and specified in Contract Documents. Each Fish Screen panel assembly is comprised of a profile wire screen section as shown and specified in the Contract Documents. Each Blank panel assembly is comprised of a steel plate section as shown and specified in the Contract Documents. Each Fish Refugia assembly and Blank Fish Refugia assembly are comprised of materials and shapes as shown on the Drawings.

1.2 QUALITY ASSURANCE

A. Manufacturer's Experience: Unless otherwise directed by the ENGINEER, all equipment furnished shall have a record of at least 5 years of successful, trouble free operation in similar applications, from the same manufacturer.

1.3 CONTRACTOR SUBMITTALS

A. Submit complete shop drawings in accordance with Section 013300 - Contractor Submittals.

B. The delivery of profile wire screen, blank panel, and fish refugia shop drawings is expected to be a "Critical Path" item on the Contractor's schedule. Suppliers are advised that the schedule for the completion of the construction of the Joint Intake and Fish Screen Project is time sensitive and suppliers shall review the Contractor's schedule to ensure the Contractor's required delivery dates can be met. Suppliers shall not be relieved of liability under the contract for any loss sustained by the Contractor as a result of any delay. All required submittals made by the suppliers must be accurate, timely, and complete. Suppliers shall review Section 011400 - Construction Constraints paragraph 1.8 for approved submittal schedule.

C. Shop Drawings: Shop drawings shall include but are not limited to the following.

1. The design of this section shall comply with Section 410000 - Equipment General Provisions.

2. Dimensional drawings showing compliance with the requirements of these specifications including tolerances, non-metallic materials and adhesives.
3. Design calculations, signed and stamped by a structural engineer registered in the State of California, including loading conditions, support of the panel assemblies, and lifting assemblies.

4. Results of finite element modelling of the Fish Screen panel assemblies and Blank panel assemblies.

5. Storage and handling instructions.

D. **Tolerances:** Tolerances and clearances shall be as shown or specified herein. Machine work shall in all cases be of high-grade workmanship and finish, with due consideration to the special nature or function of the parts.

**PART 2 -- PRODUCTS**

2.1 **GENERAL DESCRIPTION**

A. **Fish Screen Panel Assemblies**

1. Construction: Fish Screens shall be an all welded construction fabricated from ASTM A-276, Type 304 stainless steel. The screen surface shall be of smooth bar of a tapered profile wire shape with inwardly enlarging openings to minimize the likelihood of debris entrapment. Screen wires shall be vertically oriented, and continuous over the length or width of each panel assembly as specified herein. Looped wire construction is not acceptable. Screen wires shall be welded or mechanically retained to stainless steel support bars to form a panel.

2. Fish Screen panels shall be welded to stainless steel support bars and backing bars sufficient to withstand the specified loading conditions within the specified tolerances. The wires, support bars, backing bars, and frame members shall be welded to form a single Fish Screen panel assembly unit as shown on the drawings. Welds shall be smooth, without burrs or irregularities.

3. Fish Screen frame shall be fabricated of ASTM A-276, Type 304 stainless steel and shall be designed to the tolerances shown and specified. Fish screen panel assemblies shall be furnished with ultra high molecular weight (UHMW) polyethylene bars securely attached in the locations shown with Type 304 stainless steel screws countersunk 1/16 inch.

B. **Blank Panel Assemblies**

1. Construction: Blank panels shall be an all welded construction fabricated from ASTM A-36, structural steel. The panel surface shall be of smooth steel plate.

2. Blank panels shall be welded to steel support bars and backing bars sufficient to withstand the specified loading conditions within the specified tolerances. The plate, support bars, backing bars, and frame members shall be welded to form a single Blank panel assembly unit as shown on the drawings. Welds shall be smooth, without burrs or irregularities.

3. Blank panel frame shall be fabricated of ASTM A-36, structural steel and shall be designed to the tolerances shown and specified. Blank panel assemblies shall be shop coated per the requirements in Section 099600. Blank panel assemblies shall be furnished with ultra high molecular weight (UHMW) polyethylene bars of the
same design and mounting methods as those for the Fish Screen panel assemblies, securely attached in the locations shown with Type 304 stainless steel screws countersunk 1/16 inch.

C. Fish Refugia Assemblies

1. Construction: Fish Refugia panels shall be an all welded construction fabricated from ASTM A-276, Type 304 stainless steel. The panel surface shall be as shown.

2. All members shall be welded to form a single Fish Refugia panel assembly unit as shown on the drawings. Welds shall be smooth, without burrs or irregularities.

D. Blank Fish Refugia Assemblies

1. Construction: Blank Fish Refugia panels shall be an all welded construction fabricated from ASTM A-36, structural steel. The panel surface shall be as shown.

2. All members shall be welded to form a single Blank Fish Refugia panel assembly unit as shown on the drawings. Welds shall be smooth, without burrs or irregularities.

E. Steel lifting mechanism shall be designed and provided by the CONTRACTOR. Location of lifting eyes or lifting pins shall be incorporated on or in the top framing member of each panel to accept the lifting mechanism, to be designed by the CONTRACTOR and approved by the ENGINEER. Lifting mechanism design shall be such that the suspension of the panels under a load of twice the dead weight of the panels can be supported without deformation of the panel. Lifting mechanism shall be shop coated per the requirements in Section 099600. One lifting mechanism is required for the Fish Screen panel assemblies and Blank panel assemblies, and one lifting mechanism is required for the Fish Refugia assemblies and Blank Fish Refugia assemblies. Provide a minimum of one additional spare of each lifting mechanism.

2.2 DESIGN CHARACTERISTICS

A. The CONTRACTOR shall design the Fish Screen panel assemblies in accordance with the following criteria:

1. Clear Opening (Wire Spacing) 1.75 mm

2. Maximum Gap Tolerance 1.75 mm (between a neighboring pair of any members exposed to the riverside surface)

3. Minimum Open Area 40%

4. Wire Orientation (Installed) Vertical

5. Maximum Allowable Stress 60% of Yield
B. The CONTRACTOR shall design the Blank panel assemblies in accordance with the following criteria:

1. Maximum Gap Tolerance 1.75 mm
   (between a neighboring pair of any members exposed to the riverside surface)

2. Maximum Allowable Stress 60% of Yield

C. **Loading**: Fish Screen and Blank panels shall be designed for lifting by the lifting holes or lifting pins and for in-place loading assuming only support from the frames and backing angles. In-place loading includes the Fish Screen or Blank panel assembly installed at the lowest possible position, with a full height stack of additional Fish Screen or Blank panel assemblies resting on top as shown in the Drawings.

1. **Design Loads**
   a. Ultimate Loads: 187 psf (3 ft. hydraulic differential)
   b. Working Loads: 62 psf (1.0 ft. hydraulic differential), plus 10 lbs per vertical linear foot concentrated load imposed by the Mechanical Screen Cleaner System pushing into the screen face as specified in Section 410174.

2. **Panel Design Criteria – Fish Screen and Blank Panels**
   a. Maximum panel deflection under working loads shall not exceed 1/4-inch from the surface plane when unloaded.
   b. Maximum allowable stress (Section 2.2.A) shall not be exceeded in any member under ultimate loads.
   c. All welds shall be in accordance with AWS guidelines and shall be sufficient to develop the full strength of the joining members under the loadings specified.

3. The front face of the Fish Screen panel assemblies and Blank panel assemblies to the finish face of the adjacent support column shall be 1/16 inch plus or minus to the dimension shown.

D. **Tolerances**: The CONTRACTOR shall design and fabricate the Fish Screen panel assemblies and Blank panel assemblies so as to ensure that the completed assembled panels are within the tolerances specified below while under a no load conditions in the installed orientation.

1. The panel assembly surface shall be flat to within 1/8 inch plus or minus when measured using a 4-foot straightedge at any location or orientation on the screen face.

2. The diagonal dimensions of the panels shall be within 1/8 inch.

3. The front face of the installed panels to the finish surface of the adjacent support column or wall shall be 1/16 inch plus or minus.

4. Panel width shall be within 1/16 inch plus or minus.
5. The maximum gap between a panel assembly, and the bottom of the structure, the guide rails, and an adjacent panel (as installed above or below), is 1.75 mm.

E. Fish Screen Manufacturers, or Approved Equal

1. Hendrick Screen Company

2.3 SPARE PARTS

A. The following spare parts shall be provided:

1. UHMW Seals – 2 full sets of seals for each type or size of panel assembly.

2. A quantity of 20 of each type and size of fastening hardware use to secure the UHMW seals to the Fish Screen panel assemblies, Blank panel assemblies, Fish Refugia assemblies, and Blank Fish Refugia assemblies.

3. One complete Fish Screen panel assembly.

4. One complete full size Blank panel assembly.

5. One complete half size Blank panel assembly.

6. One complete Fish Refugia assembly.

7. One complete Blank Fish Refugia assembly.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. General: Prior to initial installation each panel assembly shall be completely assembled and dimensions verified. If a panel assembly does not fit properly corrective measures shall be taken by the contractor to adjust, trim or reset the frame or mounting surfaces.

B. Installation Procedures

1. Guide rails shall be installed, plumbed, and welded into place as indicated in the drawings.

2. UHMW pads on the Fish Screen panel assemblies and Blank panel assemblies shall be machined as required to achieve gaps of less than 1.75mm at all joints and edges. No gaps greater than 1.75mm or holes greater than 3/32” diameter shall be allowed. This gap tolerance does not apply to the Fish Refugia assemblies and Blank Fish Refugia assemblies.

3. After proper installation, the full weight of the panel assemblies stacked above should be resting on each other and on the the bottom ledge of the structure below the panels.

4. If a panel assembly does not fit properly, corrective measures shall be taken by the CONTRACTOR to adjust, trim, or reset the panels.
5. The CONTRACTOR shall demonstrate to the ENGINEER and the OWNER that the Fish Screen panel assemblies and Blank panel assemblies may be interchanged and the max gap tolerance can be met at all times without modifications or additional work required beyond removal and replacement of the panels using the lifting mechanism.

6. The CONTRACTOR shall demonstrate to the ENGINEER and the OWNER that the Fish Refugia assemblies and Blank Fish Refugia assemblies may be interchanged without modifications or additional work required beyond removal and replacement of the panels using the lifting mechanism.

C. To ensure proper cleaning of the fish screen and maintaining the positive barrier to small fish, maintaining a smooth, flat and uniform surface is critical. Contractor shall coordinate work such that specified tolerances are achieved or bettered. Loose shims will not be allowed. Shimming to obtain surface tolerances shall be done by replacement of wear bars, permanent metal shims of the same material as the frame, fully welded to the frame, or other approved methods. Final adjustments shall not compromise the fish tightness (gap allowance), or future removal or installation of the panels.

D. **Marking:** All screen panels shall be marked with a permanent stamp or etched on the outside face of the panels at the top. Numbers shall be minimum 1 ½" in height.

- END OF SECTION -
PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall furnish, test and adjust, install, and place in satisfactory operation screen cleaner system and appurtenances, complete, in accordance with the requirements of the Contract Documents.

B. The CONTRACTOR shall furnish and install rail, ancillary steel, and supports required for the screen cleaner system. There are no OWNER supplied parts or services involved with the screen cleaner system.

C. All components of the screen cleaner system shall be suitable for outdoor use in operating temperatures ranging from 0 to +110°F for year-round operation.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Codes: All codes referenced herein, are specified in Section 014219 - Reference Standards.

B. Commercial Standards

AGMA American Gear Manufacturers Association

ASME American Society of Mechanical Engineers

ASTM A36 Specification for Structural Steel.

AWS American Welding Society

CMA Crane Manufacturers Association of America.

NEMA National Electrical Manufacturers Association

OSHA Occupational Safety and Health Administration

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Section 013300 - Submittals.

B. Section 055000 - Miscellaneous Metalwork.

C. Section 099600 - Protective Coatings.

D. Section 410000 - Equipment General Provisions.

E. Division 26 as applicable
1.4 SUBMITTALS

A. **Shop Drawings:** The CONTRACTOR shall submit complete shop drawings of all equipment, in accordance with the requirements in Section 013300 - Submittals. Such shop drawings shall include all electrical requirements, weights, wheel loads, bearing loads and capacities, dimensions (including tolerances), drive assembly details, control diagrams, and clearances required.

B. **Coordination:** CONTRACTOR shall coordinate work between the screen cleaner fabricator and the electrical supplier and other suppliers as necessary to ensure a well coordinated installation.

C. **O & M Manuals:** The CONTRACTOR shall furnish copies of complete operating and maintenance instruction of all screen cleaner systems as specified in Section 013300. O&M manuals shall include detailed troubleshooting procedures and suggested periodic maintenance.

D. **Tools and Spare Parts:** The CONTRACTOR shall supply one complete set of special wrenches or other special tools necessary for the assembly, operation, adjustment, and dismantling of the equipment. All tools shall be of best quality and furnished in labeled tool boxes of suitable design.

Each piece of equipment shall be furnished with one year's supply of lubricants (non-hazardous to aquatic life), as well as spare parts as recommended by the supplier, such as seals, washers, rings, shims, bushings, bearings, and any other parts subject to wear or frequent (two years or less) replacement. All parts shall be properly labeled and identified with the name and number of the equipment to which they belong.

At a minimum, CONTRACTOR shall provide the following spare parts:

<table>
<thead>
<tr>
<th>Part</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nylon Brush (9-feet, 3-inches long)</td>
<td>2</td>
</tr>
<tr>
<td>Brush head</td>
<td>1</td>
</tr>
<tr>
<td>Brush head wheel, including bearings</td>
<td>2</td>
</tr>
<tr>
<td>Parking wheel, including bearings</td>
<td>1</td>
</tr>
<tr>
<td>Complete idler sheave assembly, w/ brackets, bearings, shaft, and hardware</td>
<td>5</td>
</tr>
<tr>
<td>Large sheaves, w/ bearings</td>
<td>7</td>
</tr>
<tr>
<td>Cleaner trolley</td>
<td>2</td>
</tr>
</tbody>
</table>

1.5 QUALITY ASSURANCE

A. **Inspection and Testing Requirements:** ENGINEER shall be granted access to fabrication facilities during fabrication to inspect the screen cleaner and view the shop tests. After installation, the CONTRACTOR shall inspect, test, and adjust all screen cleaner systems in the presence of the ENGINEER and OWNER, for proper operation and conformance with the Contract Documents. The CONTRACTOR shall instruct the OWNER's personnel in the operation and maintenance of the subject equipment.
B. **Acceptance Criteria and Tolerances:** The OWNER reserves the right to reject any equipment not conforming with the tolerances, or performance specified. Field tests shall be in accordance with paragraph 3.4 of this specification.

**PART 2 -- PRODUCTS**

2.1 **GENERAL**

A. The CONTRACTOR shall assume full responsibility for a coordinated and functional design and shall conform to the best engineering practice for the operating conditions given in these specifications. The CONTRACTOR shall be fully responsible for the satisfactory operation and testing of the screen cleaners.

B. The screen cleaners and associated equipment shall be in accordance with applicable regulations and standards of the NEMA; OSHA part 1910 of the Title 29 of the Code of Federal Regulations; and national and local electrical codes.

C. **Safety Requirements:** Handrails, screens and guards shall be provided whenever necessary for the protection of operators or others from injury. All guards, cases, and covers shall be easily removable for maintenance.

D. The CONTRACTOR shall verify all dimensions and clearances in the field prior to fabrication and shall be responsible for the proper fitting and operation of the equipment. The CONTRACTOR shall verify the motor size, power supply, and other electrical, mechanical, and structural coordination items during fabrication.

E. All welding shall be performed as specified in Section 410000 - Equipment General Provisions.

2.2 **PRINCIPLE OF OPERATION**

A. The Screen Cleaner shall operate in such a manner as to sweep material from the face of the fish screens by a combination of brush action and hydraulic action from the trailing eddy. Each unit shall travel parallel to the face of the screens over the entire length of the screen in a single operation.

The screen cleaner shall park in the downstream position with the brush heads off of the screen surface, and the brush bristles off the surface of the structure. When a cleaning cycle is initiated, the screen cleaner shall travel upstream, powered by a drum drive. The cleaner starts up slowly and ramps up to the “fast” speed. The cleaner travels at the “fast” speed until the upstream transition switch is passed then ramps down to the slow speed, then slows to a stop at the upstream end. When the screen cleaner reaches the upstream end, the mast travels up onto lifters, lifting the brush heads off the screen face and comes to a complete stop after the upstream stop switch is reached. The process is then reversed: the cleaner travels downstream to parked position and engages the limit switch to end cycle. Total screen cleaning time at maximum speed is less than 2 minutes.

The unit will be controlled by the hardwired controls and the Programmable Logic Controller (PLC) and powered by a Variable Frequency Drive in the Motor Control Center (MCC). Information regarding the status and alarms from the package unit shall be transmitted to the RD 2035 SCADA system and the WDCWA SCADA system as shown and specified on the drawings I-1 and I-2. The Screen Cleaner system PLC shall provide the additional outputs required for the SCADA interface functions and also have
additional inputs for initiation of the cleaning cycle from either of the two SCADA systems. All automatic screen cleaning controls shall be included with the Screen Cleaner control system package.

B. The screen cleaner system shall consist of three major assemblies: the upper cleaner assembly, lower screen cleaner assembly, and the drive system

1. Upper Screen Cleaner Assembly: Shall consist of two double-wheeled trolleys joined by a steel member and special fittings. The upper screen cleaner assembly serves to join the drive cable to the lower screen cleaner assembly.

2. Lower Screen Cleaner Assembly: Includes masts comprised of steel pipe, the brush heads and brush assemblies, counterweights, deck, and associated components.

3. Drive System: The screen cleaner is driven by a cable as shown on the contract drawings. Power is applied to the cable by an electric motor. Constant tension is maintained in each cable by means of a steel counter weight. The cable shall be 3/8-inch diameter, and shall have a minimum breaking point of 10,000 pounds. The drive unit shall be as manufactured by Allied Power Products Inc., K&N Industrial Equipment, or equal. Performance conditions include:

   - Line Pull: 2,900 lbs (with 450-lbs on return cable).
   - Design Friction: 0.10
   - Max Line Speed: 120 fpm
   - Motor: Motor shall be suitable for 460 VAC, 3 phase, 60 hz inverter grade for variable speed service with a variable frequency drive and a Totally Enclosed Fan Cooled enclosure. Motor shall also include supplemental external cooling fan and brake 120 VAC, 1 Phase. Rated power output of the drive shall be minimum 15.0 hp.
   - Drums: Tread diameter shall be 12.0”. Groove radius shall be 0.199 to 0.202-inches.

2.3 DESIGN REQUIREMENTS

A. The trolley wheels and rail shall be suitably matched to facilitate true linear motion for the screen cleaner without any noticeable binding or vibration.

B. Control Speeds

   1. Linear travel: Variable between 0 and 2 feet per second each direction.

C. General Design Requirements

   1. Contractor shall determine required bearing capacities, drive unit capacity, shaft sizing and support sizing based on the performance requirements. Drum drive assembly shall be designed to maintain alignment between the geared angle drive unit and the shaft and the shaft and the support bearings within the tolerances recommended by the bearing manufacturers.

   2. Primary operation control shall be by the hardwired controls and PLC in the MCC.

   3. All dimensions and tolerances shown on the contract drawings shall be strictly adhered to.
D. **Brush Head:** The brush head assembly shall be designed to provide equal and uniform pressure along the length of the brush in contact with the screen. The head shall include necessary pivots, hinges and bearing, suitable for constant immersion in water. The brush shall be of sufficient length to span the entire height of the screen. All lubricants shall be food grade. Brushes shall have an overall trim of 3”. Bristles shall be 0.060-in. Nylon 6-6, level installed in a galvanized steel No. 10 channel backing. Brush as manufactured by *Industrial Brush Corporation of Pomona, CA; American Brush Company or equal.* Nylon or polyurethane wheels shall be incorporated into the head design to prevent contact of steel parts with the screen.

E. **Trolleys:** The screen cleaner shall incorporate two TC/American Model 3T-12400-4SR trolleys with Model SW-4B-2A stud swivel. These trolleys are matched to the trolley rail described below.

F. **Trolley Rail**
   1. Shall consist of a top flange plate, web plate, and a specially rolled bottom tee section with a high carbon-manganese alloy steel raised operation flange. The section shall have a minimum tensile strength of 125,000 psi and a yield strength of 65,000 psi. Trolley rail shall deflect less than 1/600th of its length.
   2. The design of the trolley rail shall incorporate a 1” minimum expansion joint located in alignment with the expansion joint of the concrete structure, as shown on the Drawings. The trolley shall travel smoothly across the trolley rail expansion joint with the expansion joint fully open or closed.
   3. Manufacturers, or Equal: *TC/American Model 3RL11-21.*

2.4 MATERIALS

A. Unless otherwise shown or specified, materials of construction shall be hot-dipped galvanized structural steel (ASTM - A36). All components shall be designed for outdoor service over an operating temperature range from 0 to +110 °F for year-round operation.

2.5 MECHANICAL AND ELECTRICAL EQUIPMENT

A. **General:** All mechanical and electrical equipment shall conform to applicable sections of divisions 055000, 410000, and 260000. All fastening of equipment shall be adequate to hold equipment in its proper place and alignment during all phases of operation. All steel castings, steel forgings, and rolled or forged steel wheels and sheaves shall be properly annealed. All torsional transmitting loads shall be made by suitable keys.

B. See Section 410000 - Equipment General Provisions for general mechanical requirements.

C. See Section 260000 series specifications for general electrical, and control system requirements.

D. Control Panel: Control panel shall have all controls required for operation of the mechanical screen cleaner system on the outside face of the panel, to allow operation during inclement weather without opening the panel and exposing the internals of the panel to the elements. Provide a hinged, lockable shroud over the controls on the front face of the panel which may be opened and placed in an upward resting position during operation of the controls. The control panel shall provide for the status to and control
from the pump station RTU, RTU-100 and future WDCWA PLC as indicated on E-10, E-11 and I-1 of the Contract drawings and as summarized below:

1. System Ready (Power on and in Auto) indication status

2. Brush Cleaner Position status

3. Drive Run and VFD status

4. Remote Call to Start control

D. **Limit and proximity switches:** Limit and proximity switches shall be provided as required to control cleaner travel. Limit switches shall be provided in accordance with Section 260515 and as indicated on the Contract drawings.

E. **Drip Pans and Covers:** Suitable drip pans shall be provided to collect oil and grease which may drip into the water from open gears and other operating parts, including all bearings which cannot be made drip proof. It is essential that every precaution be taken to meet this requirement. All drip pans shall be provided with means for cleaning and draining. Dust covers shall be provided, where necessary, to protect sliding and rotating parts and to prevent dust from mixing with the lubricant.

F. **Bolts, Nuts, Washers, Cotterpins:** Shall be type 316 SS, unless otherwise specified. (See Section 055000).

G. **Shaft Couplings:** All shaft couplings used shall be in regular production by a recognized manufacturer of couplings and shall be of adequate design for the torques to be transmitted. Rigid couplings will be permitted only between bearings which are more than six (6) feet apart. Full flexible couplings for offset and angular misalignment shall be used between motors and driven equipment.

H. **Keys and Keyways:** The size of the keys shall be such as to be within safe bearing and shear limits for the materials in contact.

I. **Setscrews.** All setscrews shall have case-hardened cup points. When installed, heads shall be flush with surface. Setscrews shall not be used for transmitting torsion.

J. **Power Supply:** The power supply for the drive motor shall be 480 V, three phase power controlled by a variable frequency drive. Power supply to the electrical pickup system shall originate as shown on the electrical drawings. Electrical conduits shall be routed so as not to interfere with operations and shall be hidden from view wherever possible, while maintaining accessibility for repairs.

K. **Drum Drive:** The idler and drive drums shall be fabricated from Grade 4140 alloy steel, hardened to a minimum Rockwell C 50. Drum drive housing shall be fastened with tapered pins (2 per panel) and bolts to insure mechanical after field assembly. Endplates shall be included to provide a square assembly of the sides. Entire assembly shall be fastened to a 1-inch thick sole plate between the adjacent deck structure and drum drive assembly. Drive unit shall be a face mount type with hollow shaft drive equal to **SEW Eurodrive.** Idler drum shaft and opposite drive drum shaft bearings shall be exterior flange mounted, self aligning, ±1.50 spherical roller bearings with readily accessible grease fittings equal to **Browning SFC1100.** Shaft shall be sized to interference fit with the bearings, drive, and drums. See Section 410000 of the specifications for additional performance requirements. Cable penetrations shall be sized and located to provide a
minimum 0.5-inches from the cable to the housing and 0.375-inches clearance between the cable and the lower drum under all cable positions (depending on tensioner sheave location).

L. **Coating:** Drum drive assembly shall be coated per system FM-16 of Section 099600 – Protective Coatings. Do not coat joining surfaces of steel enclosure/frame nor drum grooves.

M. **Caster Wheels:** All caster wheels shall contain sealed ball or roller bearings, as indicated on the Drawings or otherwise shown. The sealed bearing cartridges shall be press-fit into the hub of each wheel, and a hardened spanner bushing shall be mounted via a suitable press-fit, through the inner races of both bearings. The caster wheel shall be mounted via a smooth shanked bolt through the spanner bushing.

N. **Sheaves:** All sheaves shall be hardened steel with pressed in flanged roller bearings, sealed on the outside (flange side) only, with inner and outer hardened races. Each sheave axle assembly shall consist of a hollow axle w/ nut and lock-washer, a hardened spanner bushing drilled for lubrication, and sealed retaining thrust-washers. Washers shall be used as shims as required to prevent side movement and retain sealed retaining thrust washers against the spanner bushing. Components for axle assemblies shall be as manufactured by Albion Caster, or equal.

O. **Grease Lines:** All greasable locations, shall be fitted with grease lines to allow ready access to grease fittings from the main deck level. Grease lines shall be routed to, and mounted on the main deck level handrail and terminate at 24” above the top of the deck for convenient access. Grease lines shall be routed in ¾” galvanized steel conduit for protection, securely attached to the structure. All conduits shall be routed such that there will be no low points in which water may accumulate, and shall be routed so as not to interfere with operations, while maintaining accessibility for repairs.

**PART 3 -- EXECUTION**

3.1 **GENERAL REQUIREMENTS**

A. All equipment shall be installed in strict accordance with the manufacturer’s printed instructions and the Contract Documents. The CONTRACTOR shall be responsible for coordination between the electrical, mechanical, structural, and screen cleaner suppliers to ensure proper installation and operation.

3.2 **WORKMANSHIP**

A. Workmanship shall be in accordance with the referenced standards and codes.

3.3 **INSTALLATION/ERECTION**

A. Care shall be taken, that the structural integrity of all beams, columns, walls and floors will be maintained at all times. Sheaves shall be positioned to minimize the fleet angle from adjacent sheaves. Idler sheaves shall be positioned to along a line (plus or minus 0.125-inches) between the tensioner sheave and the sheave at the opposite end of the trolley beam.
3.4 EXECUTION OF TEST PROCEDURES/VALIDATION

A. After completion of the WORK, the CONTRACTOR shall test all equipment to the satisfaction of the ENGINEER.

B. **Shop Tests**: Tests to be performed in the fabricator's shop, in the presence of the ENGINEER, shall include but not be limited to the following:

1. Suspend the lower screen cleaner assembly by the lifting eyes for inspection on testing in the presence of the ENGINEER.

C. **Field Tests**: Tests to be performed in the field, in the presence of the ENGINEER, shall include but not be limited to the following:

1. Measure time required for the screen cleaner to accelerate from standstill to a distance of 15 feet from its starting point.

2. Measure time required for the screen cleaner to traverse the full length of its travel.

3. Check manual operation of carriage speed and direction control.

4. Test and adjust electrical pickup for proper operation.

5. Verify that all mating parts are in alignment and that there are no noticeable deflections or vibrations.

6. Automatic control system hardwired controls are furnished and tested by the CONTRACTOR. PLC programming and system testing as outlined in Section 017500 – Startup.

- END OF SECTION -
PART 1 – GENERAL

1.1 THE REQUIREMENT

A. Provide the piping systems indicated, complete and operable, in accordance with the Contract Documents.

B. The provisions of this Section shall apply to piping sections in Divisions 33 and 43.

C. The mechanical Drawings define the general layout, configuration, routing, method of support, pipe size, and pipe type.

D. The mechanical Drawings are not pipe construction or fabrication drawings.

E. Where pipe supports and spacing are indicated on the Drawings and are referenced to a Standard Detail, the CONTRACTOR shall use that Detail.

F. Where pipe supports are not indicated on the Drawings, it is the CONTRACTOR'S responsibility to develop the details necessary to design and construct mechanical piping systems to accommodate the specific equipment provided, and to provide spacers, adapters, and connectors for a complete and functional system.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 013300 – Contractor Submittals.

B. **Shop Drawings:** Shop Drawings shall contain the following information:

   1. Drawings: Layout drawings including necessary dimensions, details, pipe joints, fittings, specials, bolts and nuts, gaskets, valves, appurtenances, anchors, guides, and material lists. Fabrication drawings shall indicate spacers, adapters, connectors, fittings, and pipe supports to accommodate the equipment and valves in a complete and functional system.

   2. Thermoplastic Pipe Joints: Submit solvent cement manufacturer’s catalog indicating that the recommended product is suitable for each fluid service application.

   3. Gasket Material: Submit gasket manufacturer’s catalog indicating that the recommended product is suitable for each fluid service application.

   4. Modular Seals for Pipe: Manufacturer’s catalog sheet showing materials and installation procedures.

C. **Samples:** Performing and paying for sampling and testing as necessary for certifications are the CONTRACTOR'S responsibility.

D. **Certifications**

   1. Necessary certificates, test reports, and affidavits of compliance shall be obtained by the CONTRACTOR.
2. A certification from the pipe fabricator that each pipe will be manufactured subject to the fabricator’s or a recognized Quality Control Program. An outline of the program shall be submitted to the ENGINEER for review prior to the manufacture of any pipe.

1.3 MATERIAL DELIVERY, STORAGE, AND PROTECTION

A. Piping materials, fittings, valves, and accessories shall be delivered in a clean and undamaged condition and stored off the ground for protection against oxidation caused by ground contact.

B. Defective or damaged materials shall be replaced with new materials.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Extent of Work

1. Pipes, fittings, and appurtenances shall be provided in accordance with the requirements of the applicable Sections of Divisions 33 and 43 and as indicated.

2. Materials in contact with potable water shall be listed as compliant with NSF Standard 61.

B. Pipe Supports: Pipes shall be adequately supported, restrained, and anchored in accordance with Section 431052 – Pipe Supports, and as indicated.

C. Lining: Application, thickness, and curing of pipe lining shall be in accordance with the applicable Sections of Division 33, unless otherwise indicated.

D. Coating

1. Application, thickness, and curing of coating on buried pipe shall be in accordance with the applicable Sections of Division 33, unless otherwise indicated.

2. Pipes above ground or in structures shall be coated in accordance with Section 099600 – Protective Coating.

E. Pressure Rating: Piping systems shall be designed for the maximum expected pressure as defined in Section 017430 – Pressure Pipe Testing and Disinfection, or as indicated on the Piping Schedule, whichever is greater.

F. Inspection

1. Pipe shall be subject to inspection at the place of manufacture.

2. During the manufacture, the ENGINEER shall be given access to areas where manufacturing is in progress and shall be permitted to make inspections necessary to confirm compliance with requirements.
G. Tests
   1. Except where otherwise indicated, materials used in the manufacture of the pipe shall be tested in accordance with the applicable specifications and standards.
   2. The CONTRACTOR shall be responsible for performing material tests.

H. Welding Requirements
   1. Qualification of welding procedures used to fabricate pipe shall be in accordance with the provisions of AWS D1.1 - Structural Welding Code or the ASME Boiler and Pressure Vessel Code, Section 9, whichever is applicable.
   2. Welding procedures shall be submitted for the ENGINEER's review.

I. Welder Qualifications
   1. Welding shall be performed by skilled welders and welding operators who have adequate experience in the methods and materials to be used.
   2. Welders shall be qualified under the provisions of AWS D1.1 or the ASME Boiler and Pressure Vessel Code, Section 9, whichever is applicable.
   3. Machines and electrodes similar to those used in the WORK shall be used in qualification tests.
   4. Qualification testing of welders and materials used during testing is part of the WORK.

2.2 PIPE FLANGES

A. General
   1. Flanges shall be provided with flat faces and shall be attached with bolt holes straddling the vertical axis of the pipe unless otherwise indicated.
   2. Attachment of the flanges to the pipe shall conform to the applicable requirements of AWWA C207.
   3. Flange faces shall be perpendicular to the axis of the adjoining pipe.
   4. Flanges for miscellaneous small diameter pipes shall be in accordance with the standards indicated for these pipes.

B. Pressure Ratings
   1. 150 psig or less: Flanges shall conform to either AWWA C207 - Steel Pipe Flanges for Waterworks Service--Sizes 4 In. Through 144 In., Class D, or ASME B16.5 - Pipe Flanges and Flanged Fittings, 150 lb class.
   2. 150 psig to 275 psig: Flanges shall conform to either AWWA C207 Class E or Class F, or ASME B16.5 150 lb class.
   3. 275 psig to 700 psig: Flanges shall conform to ASME B16.5, 300 lb class.
4. Selection Based on Test Pressure
   a. Do not expose AWWA flanges to test pressures greater than 125 percent of rated capacity.
   b. For higher test pressures, the next higher rated AWWA flange or an ANSI-rated flange shall be selected.

C. Blind Flanges
   1. Provide blind flanges in accordance with AWWA C207, or as indicated for miscellaneous small pipes.
   2. Blind flanges for pipe sizes 12-inches and greater shall be provided with lifting eyes in the form of welded or screwed eye bolts.

D. Flange Coating: Machined faces of metal blind flanges and pipe flanges shall be coated with a temporary rust-inhibitive coating to protect the metal until the installation is completed.

E. Flange Bolts
   1. Bolts and nuts shall conform to the requirements of Section 055000 – Miscellaneous Metalwork.
   2. Use all-thread studs on valve flange connections where space restrictions preclude the use of regular bolts.

F. Insulating Flanges: Insulated flanges shall be provided with bolt holes 1/4-inch diameter greater than the bolt diameter.

G. Insulating Flange Sets
   1. Insulating flange sets shall be furnished on all piping connections where two dissimilar metals are to be connected in order to prevent corrosion. Each insulating flange set shall consist of an insulating gasket, insulating sleeves and washers, and a steel washer.
   2. Insulating sleeves and washers shall be one piece when flange bolt diameter is 1-1/2 inch or smaller and shall be made of acetal resin.
   3. For bolt diameters larger than 1-1/2 inches, insulating sleeves and washers shall be 2-piece and shall be made of polyethylene or phenolic material.
   4. Steel washers shall be in conformance with ASTM A 325 - Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.
   5. Insulating gaskets shall be full-face.

H. Insulating Flange Manufacturer, or Equal
   1. JM Red Devil, Type E
   2. Maloney Pipeline Products Co.
3. **PSI Products, Inc.**

I. Flange Gaskets

1. Gaskets for flanged joints used in general water and wastewater service shall be full-faced type, with material and thickness in accordance with AWWA C207, suitable for temperatures to 700 degrees F, a pH of one to 11, and pressures to 1000 psig.

2. Blind flanges shall be provided with gaskets covering the entire inside face of the blind flange and shall be cemented to the blind flange.

3. Ring gaskets will not be accepted unless otherwise indicated.

4. Flange gaskets shall be: **John Crane, Style 2160; Garlock, Style 3000**; or equal.

5. Gaskets for flanges for PVC and CPVC piping used in general water and wastewater service shall be full-faced, 1/8-inch thick, and made of ethylene propylene rubber (EPR) having a Type A durometer hardness of 50 to 70 when tested in accordance with ASTM D 2240.

6. When the mating flange has a raised face, provide a flat ring gasket filler between the PVC flange and gasket and the adjacent flange.

7. Gaskets for flanged joints used in chemicals, air, solvents, hydrocarbons, steam, chlorine and other fluids shall be made of materials compatible with the service, pressure, and temperature.

2.3 **THREADING INSULATING CONNECTIONS**

A. **General:** Threaded insulating bushings, unions, or couplings, as appropriate, shall be furnished for joining threaded pipes of dissimilar metals and for piping systems where corrosion control and cathodic protection are involved.

B. **Materials:** Threaded insulating connections shall be constructed of nylon, Teflon, polycarbonate, polyethylene, or other non-conductive materials, and shall have ratings and properties to suit the service and loading conditions.

2.4 **MECHANICAL-TYPE COUPLINGS (GROOVED OR BANDED PIPE)**

A. **General**

1. Provide cast mechanical-type couplings where indicated, conforming to the requirements of AWWA C606 - Grooved and Shouldered Joints.

2. Bolts and nuts shall conform to the requirements of Section 055000 – Miscellaneous Metalwork.

3. Gaskets for mechanical-type couplings shall be compatible with the piping service and fluid utilized, in accordance with the coupling manufacturer's recommendations.

4. The wall thickness of grooved piping shall conform to the coupling manufacturer's recommendations to suit the highest expected pressure.
5. In order to avoid excessive load on equipment caused by pipe movement due to steady state or transient pressure conditions, equipment connections with mechanical-type couplings shall be provided with rigid grooved couplings or flexible type coupling with harness in sizes where rigid type couplings are not available, unless thrust restraint is provided by other means.

6. Mechanical type couplings shall be bonded.

7. The CONTRACTOR shall have the coupling manufacturer's service representative verify the correct choice and application of couplings and gaskets, and the workmanship, to assure a correct installation.

8. In order to assure uniform and compatible piping components, grooved fittings, couplings, and valves shall be furnished by the same manufacturer as the coupling.

9. Grooving tools shall be from the same manufacturer as the grooved components.

B. Steel Pipe Couplings Manufacturer, or Equal
   1. Gustin-Bacon (Aeroquip Corp.) (banded or grooved)
   2. Victaulic Style 41 or 44 (banded, flexible)
   3. Victaulic Style 77 (grooved, flexible or rigid)
   4. Victaulic Style 07 or HP-70 (grooved, rigid)

C. Ductile Iron Pipe Couplings Manufacturer, or Equal
   1. Gustin-Bacon, (Aeroquip Corp.)
   2. Victaulic Style 31 (flexible or rigid grooving)
      Note: Ductile iron pipe couplings shall be provided with flush seal gaskets.

D. PVC Pipe Couplings Manufacturer, or Equal
   1. Gustin-Bacon, (Aeroquip Corp)
   2. Victaulic Style 775
      Note: Couplings for PVC pipe shall be furnished with radius cut or standard roll grooved pipe ends.

2.5 SLEEVE–SPLIT TYPE COUPLINGS (Depend-O-Lok, or equal)

A. General: Provide sleeve-split type couplings where indicated.

B. Construction
   1. Couplings shall be of the split-type, consisting of one- or 2-piece housing, gasket assembly, bolts and nuts, and end rings.
   2. The double arch cross section that closes around the pipe ends shall be smooth in order to allow for expansion or contraction requirements.
3. The pipe ends with steel end rings affixed shall provide restraint requirements.

4. As the coupling closes, it shall confine the elastomeric gasket beneath the arches of the sleeve to create a radial seal.

5. The axial seal shall squeeze the closure plates as the bolts pull the coupling snug around the pipe.

6. The coupling shall permit angular pipe deflection, flexibility, contraction and expansion, as designed by the manufacturer.

7. The coupling housing shall be designed for internal pressure and external loads as determined by the design procedures of AWWA M-11.

8. The coupling shell thickness of the steel coupling shall be calculated using the formula:

\[ T = \frac{PwDy}{2Fs} \]

Where:

- \( T \) = steel coupling thickness, in.
- \( Dy \) = pipe outside diameter, in.
- \( Pw \) = Design working pressure, psi
- \( Fs \) = 50 percent of minimum yield point of steel, psi

9. Coupling design calculations shall be stamped and signed by a registered engineer and shall be included in the Shop Drawing submittal for couplings.

10. The sealing members shall be comprised of 2 O-ring gaskets and an elastomer sealing pad bonded to sealing plate.

11. Internal pressure shall not be required to make the seal.

C. Materials

1. Unless otherwise indicated, the coupling housing material shall be the same material as the piping.

2. Couplings
   a. Carbon steel couplings shall be fabricated from ASTM A 36.
   b. Stainless steel couplings shall be fabricated from ASTM A 240, T-304, 304L, 316, or 316L.

3. End Rings
   a. Carbon steel end rings shall conform to ASTM A 108 Grade 1018.
   b. Stainless steel end rings shall conform to ASTM A 276 T-316L.
4. Bolts and nuts shall be in conformance with the requirements of Section 055000 – Miscellaneous Metalwork.

5. Gaskets
   a. Gaskets shall be composed of EPDM conforming to ASTM D 2000 for air service up to 240 degrees F.
   b. Gaskets for general water or sewerage service within the temperature range of minus 20 to plus 180 degrees F shall be composed of isoprene or EPDM conforming to ASTM D 2000.

6. Carbon steel couplings shall be fusion bond epoxy-coated inside and outside of the coupling in accordance with the requirements of Section 099600 – Protective Coating.

7. Wrapping
   a. Couplings installed underground shall be provided with Depend-O-Wrap tape or equal.
   b. The application of wrapping material shall be in conformance with AWWA C209.

D. Pipe Preparation
   1. Ends of pipes shall be prepared for the flexible split sleeve type couplings inspected and approved by the coupling manufacturer.
   2. The pipe outside diameter and roundness tolerances shall comply with tolerances listed in AWWA C219.
   3. Plain ends for use with couplings shall be smooth and round for a distance of 12 inches from the end of the pipe.
   4. End Rings
      a. Provide end rings with couplings when restraint is required.
      b. Carbon steel end rings shall be constructed of ASTM A 108 Grade 1018.
      c. Stainless steel end rings shall conform to ASTM A 276 T-316L.
   5. Where the split-type coupling is used to take up thermal expansion or contraction (Depend-O-Lok F X E or equal) at the pipe joint, one end ring shall be fixed to one end of the pipe in order to keep the coupling in the proper location.
   6. Fully-Restrained Joints
      a. Where the split-type coupling is used for a fully-restrained pipe joint (Depend-O-Lok F X F or equal) at the pipe joint, one end ring shall be welded to each of the pipe ends to fit beneath the coupling and shall be protected by the coating.
      b. Welding design and specification shall be in conformance with the coupling manufacturer’s recommendations.
E. **Sleeve-Split Type Couplings Manufacturer, or Equal: Depend-O-Lok**

2.6 **SLEEVE-TYPE COUPLINGS**

A. **General**

1. Provide sleeve-type couplings where indicated.

2. The CONTRACTOR will not be allowed to substitute a sleeve-split coupling, or any other type in lieu of sleeve coupling unless approved by the ENGINEER.

B. **Construction**

1. Sleeve couplings shall be in accordance with AWWA C219 - Standard for Bolted Sleeve-Type Couplings for Plain-End Pipe.

2. Couplings shall be constructed of steel with steel bolts, without pipe stop.

3. Couplings shall be of sizes to fit the indicated pipe and fittings.

4. The middle ring shall be not less than 1/4-inch thick or at least the same wall thickness as the pipe to which the coupling is connected.

5. If the strength of the middle ring material is less than the strength of the pipe material, the thickness of the middle ring shall be increased to have the same strength as the pipe.

6. The coupling shall be either 5 or 7 inches long for sizes up to and including 30-inch and 10 inches long for sizes greater than 30-inch, for standard steel couplings, and 16 inches long for long-sleeve couplings.

7. The followers shall be single-piece contoured mill sections welded and cold-expanded as required for the middle rings, and of sufficient strength to accommodate the number of bolts necessary to obtain adequate gasket pressures without excessive rolling.

8. The shape of the follower shall be of such design as to provide positive confinement of the gasket.

9. Bolts and nuts shall be in accordance with the requirements of Section 055000 – Miscellaneous Metalwork.

10. Buried sleeve-type couplings shall be epoxy-coated at the factory as indicated.

C. **Pipe Preparation**

1. Where indicated, prepare the ends of the pipe for flexible steel couplings.

2. Plain ends for use with couplings shall be smooth and round for a distance of 12 inches from the ends of the pipe, with an outside diameter not more than 1/64 inch smaller than the nominal outside diameter of the pipe.

3. The middle ring shall be tested by cold-expanding a minimum of one percent beyond the yield point, in order to proof-test the weld to the strength of the parent metal.
4. The weld of the middle ring shall be subjected to air test for porosity.

D. Gaskets

1. Gaskets for sleeve-type couplings shall be rubber-compound material that will not deteriorate from age or exposure to air under normal storage or use conditions.

2. Gaskets for wastewater and sewerage applications shall be composed of Buna N, Grade 60, or equivalent suitable elastomer.

3. The rubber in the gasket shall meet the following specifications:
   a. Color: jet black
   b. Surface: non-blooming
   c. Durometer Hardness: 74, plus and minus 5
   d. Tensile Strength: 1000 psi minimum
   e. Elongation: 175 percent minimum

4. The gaskets shall be immune to attack by impurities normally found in water or wastewater.

5. Gaskets shall meet the requirements of ASTM D 2000 - Classification System for Rubber Products in Automotive Applications, AA709Z, meeting Suffix B13 Grade 3, except as indicated above.

6. Where sleeve couplings are used in water containing chloramine or other fluids which attack rubber materials, gasket material shall be compatible with the piping service and fluid utilized.

E. Piping Connection to Equipment

1. Where piping connects to mechanical equipment such as pumps, compressors, and blowers, bring the piping to the equipment connection aligned and perpendicular to the axis of the flange or fitting for which the piping is to be connected.

2. The piping shall not impose excessive stress to the equipment connection to cause misalignment of the equipment.

3. The CONTRACTOR shall assign the responsibility to the equipment manufacturer to review the piping connection to the equipment and submit any modifications to the ENGINEER for review.

F. Insulating Sleeve Couplings: Where insulating couplings are required, both ends of the coupling shall be provided with a wedge-shaped gasket which assembles over a sleeve of an insulating compound material compatible with the fluid service in order to obtain insulation of coupling metal parts from the pipe.

G. Restrained Joints

1. Sleeve-type couplings on pressure lines shall be harnessed unless thrust restraint is provided by other means.
2. Harnesses shall be designed by the pipe manufacturer in accordance with AWWA Manual M11, or as indicated.

3. Harness sets shall be designed for the maximum test pressure of the pipe in which they are installed.

4. Where harness sets are installed near the suction and discharge of the pump, harness bolts shall have zero elongation in order to prevent misalignment of the pump imparted by the thrust within the piping system.

H. Sleeve-Type Couplings Manufacturer, or Equal

1. **Dresser, Style 38**

2. **Ford Meter Box Co., Inc., Style FC1 or FC3**

3. **Smith-Blair, Style 411**

2.7 FLANGED COUPLING ADAPTERS AND DISMANTLING JOINTS

A. Provide couplings where indicated.

B. The CONTRACTOR will not be allowed to substitute any other type of coupling in lieu of the couplings as specified herein unless approved by the ENGINEER.

C. The coupling shall be rated as indicated.

D. Construction

1. Coupling bodies shall be fabricated from steel, ASTM A 512 - Cold-Drawn butt-weld Carbon Steel Mechanical Tubing or A 513 - Electric-Resistance Welded Carbon and Alloy Steel Mechanical Tubing with steel bolts, without pipe stop.

2. Provide flanges in conformance with AWWA C207.

3. Couplings shall be of sizes to fit the indicated pipe and fittings.

4. The body shall be not less than 1/4 inch thick or at least the same wall thickness as the pipe to which the coupling is connected.

5. If the strength of the body material is less than the strength of the pipe material, the thickness of the middle ring shall be increased to have the same strength as the pipe.

6. The follower flange shall be fabricated from steel, ASTM A 576 - Steel Bars, Carbon, Hot Wrought, Special Quality or AISI C1012.

7. The shape of the follower shall be of such design as to provide positive confinement of the gasket.

8. Bolts and nuts shall be in accordance with the requirements of Section 055000 – Miscellaneous Metalwork.

9. Buried couplings shall be epoxy-coated at the factory as indicated.
E. Seals

1. Seal elastomer materials for couplings shall be selected to be compatible with the fluid service, pressure and temperature. They shall be composed of elastomeric-compound material that will not deteriorate from age or exposure to air under normal storage or use conditions.

2. Where couplings are used in water containing ozone or chloramines, seal material shall be Viton-A.

3. Where couplings are used for fluids which are not compatible with rubber materials, the elastomeric seal material shall be compatible with the piping service and fluid utilized.

F. Piping Connections to Equipment

1. Where couplings are shown to connect piping to mechanical equipment such as pumps, compressors, and blowers, the piping shall be aligned with the equipment point of connection and shall be perpendicular to the axis of the flange or fitting for which the piping is to be connected.

2. The piping shall not impose excessive stress to the equipment connection to cause misalignment of the equipment.

3. The CONTRACTOR shall assign the responsibility to the equipment manufacturer to review the piping connection to the equipment and submit any modifications to the ENGINEER for review.

G. Restrained Joints on flanged coupling adapters

1. Flanged coupling adapters on pressure lines shall be harnessed unless thrust restraint is provided by other means.

2. Harnesses shall be designed by the pipe manufacturer in accordance with AWWA Manual M11, or as indicated.

3. Harness sets shall be designed for the maximum test pressure of the pipe in which they are installed.

4. Where harness sets are installed near the suction and discharge of the pump, harness bolts shall have zero elongation in order to prevent misalignment of the pump imparted by the thrust within the piping system.

5. Other means of restraining the coupling such as set screws will not be accepted.

H. Flanged Couplings Adapter Manufacturer, or Equal

1. Smith-Blair, Model 913

2. Dresser, Model 128-W

3. JCM, Model 303
I. Dismantling Joints Manufacturer, or Equal

1. Smith-Blair, Model 975
2. Dresser, Model 131
3. JCM, Model 309

2.8 FLEXIBLE CONNECTORS

A. Low-Temperature

1. Flexible connectors shall be installed in piping connections to pumps, engines, blowers, compressors, and other vibrating equipment, and where indicated.

2. Flexible connectors for service temperatures up to 180 degrees F shall be flanged-reinforced neoprene or butyl spools, rated for a minimum working pressure of 110 psig.

3. Provide connectors complete with control rods and galvanized steel split retaining rings.

4. The final material selection shall be approved by the manufacturer.

5. The CONTRACTOR shall submit Shop Drawings and calculations.

6. Manufacturers, or Equal

B. High-Temperature

1. Install flexible connectors in engine exhaust piping and where indicated.

2. Connectors shall be sufficient to compensate for thermal expansion and contraction and to isolate vibration between the engine and the exhaust piping system.

3. Connectors shall be stainless steel bellows-type, flanged, and rated for minimum 150 psig, 2000 degrees F.

2.9 EXPANSION JOINTS

A. Piping subject to expansion and contraction shall be provided with sufficient means to compensate for such movement without exertion of undue forces to equipment or structures, accomplished with expansion loops, bellow-type expansion joints, or sliding-type expansion joints.

B. Expansion joints shall be provided with flanged ends and constructed of stainless steel, Monel, rubber, or other materials best suited for each individual service.

C. Submit detailed calculations and manufacturer’s Shop Drawings of proposed expansion joints, piping layouts, and anchors and guides, including information on materials, temperature, and pressure ratings.
2.10 PIPE THREADS
A. Pipe threads shall be in conformance with ASME B1.20.1 - Pipe Threads, General Purpose (inch), and be made up with Teflon tape unless otherwise indicated.

2.11 PIPE INSULATION
A. Hot and cold liquid piping, flues, and engine exhaust piping shall be insulated as indicated and in accordance with the requirements of Section 431070 – Pipe, Ductwork, and Equipment Insulation.
B. No unprotected hot piping shall be within reach of operating personnel or other persons.
C. Pre-insulated pipe for underground service shall be in accordance with the requirements of Section 431068 – Pre-Insulated Pipe.

2.12 MODULAR MECHANICAL SEALS FOR PIPING PENETRATIONS
A. Where indicated and where required in order to prevent flow of water or air, the passages of piping through wall sleeves and cored openings shall be sealed with modular interlocking link mechanical closures.
B. Individual links shall be constructed of EPDM rubber, be suitable for temperatures between minus 40 and plus 250 degrees F, and be shaped to fill the annular space between the outside of the pipe and the inside of the wall sleeve or cored opening.
C. Assemble the links using Type 316 stainless steel bolts and nuts to form a continuous rubber belt around the pipe.
D. Pressure plates under each bolt and nut shall be fabricated of a corrosion-resistant composite material.
E. After the seal assembly is positioned in the sleeve, tighten the bolts against the pressure plates to expand the rubber links and form the watertight seal.
F. Sizing and installation of sleeves and assemblies shall be in accordance with the manufacturer's recommendations.
G. Modular Mechanical Seals Manufacturer, or Equal: Thunderline Corporation, Link-Seal.

2.13 HEAT TRACING
A. Pipes subject to freezing shall be protected by heat tracing in accordance with the requirements of Section 260550 – Electric Heat Tracing.

2.14 CATHODIC PROTECTION
A. Where indicated, buried piping shall be cathodically protected in accordance with the requirements of Section 264213 – Buried Galvanic Cathodic Protection.

2.15 AIR AND GAS TRAPS
A. Air and gas pipes shall slope to low points and shall be provided with drip legs, shut-off valves, strainers, and traps.
B. Pipe the traps to the nearest drain.

C. Air and gas traps shall be not less than 150-lb iron body float-type, with a copper or stainless steel float.

D. Bracket, lever, and pins shall be constructed of stainless steel.

E. Drain traps shall be provided with threaded connections.

F. Air and Gas Traps Manufacturer, or Equal
   2. Spirax Sarco, Inc.

PART 3 – EXECUTION

3.1 GENERAL

A. Install piping, fittings, and appurtenances in accordance with the requirements of applicable Sections of Division 33 and Division 43.

B. Proprietary manufactured couplings shall be installed in accordance with the coupling manufacturer’s recommendation.

C. Care shall be taken to insure that piping flanges, mechanical-type couplings, sleeve-type couplings, flexible connectors, and expansion joints are properly installed as follows:
   1. Gasket surfaces shall be carefully cleaned and inspected prior to making up the connection.
   2. Each gasket shall be centered properly on the contact surfaces.
   3. Connections shall be installed to prevent inducing stress to the piping system or the equipment to which the piping is connected.
   4. Contact surfaces for flanges, couplings, and piping ends shall be aligned parallel, concentric, and square to each axis at the piping connections.

5. Flange Bolts

   a. Flange bolts shall be initially hand-tightened with the piping connections properly aligned.

   b. Bolts shall be tightened with a torque wrench in a staggered sequence to the AISC-recommended torque for the bolt material.

6. Harness, Thrust Restraint, and Tie Rod Bolts

   a. Harness, thrust restraint, and tie rod bolts used for sleeve couplings, flange coupling adapters, or flexible joints shall be tightened gradually and equally at diametrically opposite sides until snug, in order to prevent misalignment and to insure that all studs carry equal loads.
b. In order to prevent induced stress or misalignment, do not over-torque connections to adjoining pump or equipment.

7. Groove ends shall be clean and free from indentations, projections, and roll marks in the area from the pipe end to the groove.

8. After installation, joints shall meet the indicated leakage rate.

9. Flanges shall not be deformed nor cracked.

D. Lined Piping Systems

1. The lining manufacturer shall take full responsibility for the complete, final product and its application.

2. Pipe ends and joints of lined pipes at screwed flanges shall be epoxy-coated in order to assure continuous protection.

E. Core Drilling: Where core drilling is required for pipes passing through existing concrete, core drilling locations shall be determined by radiograph of concrete construction in order to avoid damage to embedded raceways and reinforcing bars.

F. Cleanup

1. After completion of the WORK, cuttings, joining and wrapping materials, and other scattered debris shall be removed from the Site.

2. The entire piping system shall be handed over in a clean and functional condition.

- END OF SECTION -
PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide identification for exposed piping and valves, complete and in place, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

   ANSI A13.1 Scheme for the Identification of Piping Systems

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 013300 - Contractor Submittals.

B. Shop Drawings: A list of suggested wording for each valve tag, prior to fabrication.

C. Samples: One sample of each type of identification device.

PART 2 – PRODUCTS

2.1 IDENTIFICATION OF PIPING

A. Except as indicated below for very short pipe lengths, identify exposed piping larger than 2-inches nominal size for the pipe contents and direction of flow.

1. Marker Type

   a. Snap Around: Vinyl or polyester sheet with UV-resistant ink, preshaped and sized to tightly curl around the pipe and remain in position.

   b. Adhesive: Vinyl or polyester sheet with UV-resistant ink, shaped similar to pipe curvature and coated with pressure sensitive adhesive.

2. Marker Area: Sized per pipe size according to ANSI A13.1; color from the table below.

3. Lettering: Sized per pipe size according to ANSI A13.1; color from the table below.

4. Arrows: At least 2 arrows at each marker area, showing direction of flow.

B. Pipe 2-inches and smaller shall be identified by plastic plates made from laminated 3 layer plastic with engraved black letters on white background.

C. Pipe identification shall be as manufactured by Brady, Seton, or equal.

2.2 EXISTING IDENTIFICATION SYSTEMS

A. In installations where existing piping identification systems have been established, the CONTRACTOR shall follow the existing system. Where existing identification systems
are incomplete, utilize the existing system as far as practical and supplement with the indicated system.

2.3 IDENTIFICATION OF VALVES AND SHORT PIPE LENGTHS

A. Identifying devices for valves and the sections of pipe that are too short to be identified with markers and arrows shall be identified with metal or plastic tags.

B. Metal tags shall be stainless steel with embossed lettering. Plastic tags shall be solid black plastic laminate with white embossed letters. Tags shall be designed to be firmly attached to the valves or short pipes or to the structure immediately adjacent to such valves or short pipes.

C. Wording on the valve tags shall describe the exact function of each valve, e.g., "HWR-BALANCING," "CLS THROTTLING," "RAS-PUMP SHUT-OFF," etc.

PART 3 – EXECUTION

3.1 GENERAL

A. Markers and identification tags shall be installed in accordance with the manufacturer’s printed instructions, and shall be neat and uniform in appearance. Tags and markers shall be readily visible from all normal working locations.

3.2 VALVE TAGS

A. Valve tags shall be permanently attached to the valve or structure by means of 2 stainless steel bolts or screws.

3.3 MARKER LOCATIONS

A. Each pipe shall be marked at:

1. Intervals of 20-feet in straight runs.
2. At least once in every room.
3. Within 2-feet of turns, elbows, and valves.
4. On the upstream side of tees, branches, and other distribution points.
5. On both sides of walls and floors through which the piping passes.
### 3.4 IDENTIFICATION COLORS

A. Conform to the following color codes.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Identification</th>
<th>Pipe Color</th>
<th>Marker Color</th>
<th>Letter Color</th>
</tr>
</thead>
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<tr>
<td>A</td>
<td>Air</td>
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<td>white</td>
<td></td>
</tr>
<tr>
<td>BD</td>
<td>Bottom drain</td>
<td>green</td>
<td>white</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Condensate</td>
<td>yellow</td>
<td>black</td>
<td></td>
</tr>
<tr>
<td>CD</td>
<td>Chemical drain and vent</td>
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<td>black</td>
<td></td>
</tr>
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<td>Chlorine (gas or liquid state)</td>
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<td>black</td>
<td></td>
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<td></td>
</tr>
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<td></td>
</tr>
<tr>
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<td>white</td>
<td></td>
</tr>
<tr>
<td>EE</td>
<td>Engine exhaust</td>
<td>yellow</td>
<td>black</td>
<td></td>
</tr>
<tr>
<td>EWR</td>
<td>Engine cooling water return</td>
<td>green</td>
<td>white</td>
<td></td>
</tr>
<tr>
<td>EWS</td>
<td>Engine cooling water supply</td>
<td>green</td>
<td>white</td>
<td></td>
</tr>
<tr>
<td>FC</td>
<td>Ferric chloride</td>
<td>yellow</td>
<td>black</td>
<td></td>
</tr>
<tr>
<td>FOR</td>
<td>Fuel oil return</td>
<td>yellow</td>
<td>black</td>
<td></td>
</tr>
<tr>
<td>FOS</td>
<td>Fuel oil supply</td>
<td>yellow</td>
<td>black</td>
<td></td>
</tr>
<tr>
<td>HWR</td>
<td>Domestic hot water return</td>
<td>yellow</td>
<td>black</td>
<td></td>
</tr>
<tr>
<td>HWS</td>
<td>Domestic hot water supply</td>
<td>yellow</td>
<td>black</td>
<td></td>
</tr>
<tr>
<td>IA</td>
<td>Instrument air</td>
<td>blue</td>
<td>white</td>
<td></td>
</tr>
<tr>
<td>LO</td>
<td>Lube oil</td>
<td>yellow</td>
<td>black</td>
<td></td>
</tr>
<tr>
<td>LPG</td>
<td>Liquified petroleum gas</td>
<td>yellow</td>
<td>black</td>
<td></td>
</tr>
<tr>
<td>LSP</td>
<td>Landscape sprinkler system</td>
<td>green</td>
<td>white</td>
<td></td>
</tr>
<tr>
<td>NG</td>
<td>Natural gas</td>
<td>yellow</td>
<td>black</td>
<td></td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
<td>Color</td>
<td>Identification</td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>--------------------------------------------------</td>
<td>---------</td>
<td>----------------</td>
<td></td>
</tr>
<tr>
<td>OF</td>
<td>Overflow</td>
<td>green</td>
<td>white</td>
<td></td>
</tr>
<tr>
<td>PA</td>
<td>Plant air</td>
<td>blue</td>
<td>white</td>
<td></td>
</tr>
<tr>
<td>PD</td>
<td>Plant drain</td>
<td>green</td>
<td>white</td>
<td></td>
</tr>
<tr>
<td>PW</td>
<td>Potable water</td>
<td>green</td>
<td>white</td>
<td></td>
</tr>
<tr>
<td>RW</td>
<td>Raw water</td>
<td>green</td>
<td>white</td>
<td></td>
</tr>
<tr>
<td>RWL</td>
<td>Rain water leader</td>
<td>green</td>
<td>white</td>
<td></td>
</tr>
<tr>
<td>SA</td>
<td>Sample lines</td>
<td>yellow</td>
<td>black</td>
<td></td>
</tr>
<tr>
<td>SC</td>
<td>Spare chemical</td>
<td>yellow</td>
<td>black</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>Sanitary drains and vents</td>
<td>yellow</td>
<td>black</td>
<td></td>
</tr>
<tr>
<td>SDR</td>
<td>Storm drain</td>
<td>green</td>
<td>white</td>
<td></td>
</tr>
<tr>
<td>SPD</td>
<td>Sump pump discharge</td>
<td>green</td>
<td>white</td>
<td></td>
</tr>
<tr>
<td>SS</td>
<td>Sanitary sewer</td>
<td>yellow</td>
<td>black</td>
<td></td>
</tr>
<tr>
<td>UW</td>
<td>Utility water (non-potable water)</td>
<td>yellow</td>
<td>black</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>Vacuum</td>
<td>blue</td>
<td>white</td>
<td></td>
</tr>
<tr>
<td>WLO</td>
<td>Waste lube oil</td>
<td>yellow</td>
<td>black</td>
<td></td>
</tr>
</tbody>
</table>
PART 1 – GENERAL

1.1 THE REQUIREMENT

A. Provide pipe supports, hangers, guides, and anchors, complete and in place, as indicated in accordance with the Contract Documents.

B. Where pipe support systems are not indicated on the Drawings, the CONTRACTOR shall design and provide the supports in accordance with this Section.

C. Seismic and Wind Forces

1. Pipe support details indicated in the Contract Drawings are not designed to resist seismic and wind forces.

2. The CONTRACTOR shall arrange for the services of a registered professional engineer experienced in pipe support design to design such pipe supports in accordance with the design parameters stated in Part 2 below.

3. The CONTRACTOR shall provide additional supports as needed to resist such forces.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 013300 – Contractor Submittals.

B. Shop Drawings

1. Submit Shop Drawings which shall include the following information:

   a. Drawings of pipe supports, hangers, anchors, and guides.

   b. Calculations for special supports and anchors, stamped and signed by a professional engineer registered in the State of California.

PART 2 – PRODUCTS

2.1 PIPE SUPPORTS AND FOUNDATIONS

A. Pipe Supports: Unless otherwise indicated, Pipe supports, anchors, and restrainers shall be adequately designed for static, dynamic, wind, and seismic loads as stated in the 2009 International Building Code (IBC), Chapter 16 and ASCE 7-05. Submitted design calculations for equipment supports and anchorage shall bear the signature and seal of an Registered Professional Engineer licensed in the State of California, unless otherwise indicated. Calculations shall account for forces and distribution of forces on supporting structures resulting from normal operation, normal operation plus seismic loadings, normal operation plus wind loadings, as well as the other load combinations stated the 2009 IBC.

1. Wall-mounted piping weighing more than 250 pounds or which is within 18-inches above the floor shall be provided with fabricated steel supports. Pedestals shall be
of welded steel. If the supported equipment is a panel or cabinet or is enclosed with removable sides, the pedestal shall match the supported equipment in appearance and dimensions.

B. **Wind Load:** The wind load shall be calculated in accordance with ASCE 7-05, Chapter 6, using the following design parameters:

1. Wind Speed: 85 mph
2. Exposure: D
3. Importance Factor: \( I_w = 1.15 \)

C. **Seismic Loads:** The seismic lateral and vertical forces shall be calculated in accordance with the ASCE 7-05, Chapters 11 and 13, using the following design parameters:

1. Site Class: D
2. Seismic Use Group: IV
3. Seismic Design Category (SDC): D
4. Seismic Importance Factor: \( I_e = 1.5 \)
5. Short Period Spectral Acceleration: \( S_s = 0.67 \) g
6. 1 Second Period Spectral Acceleration: \( S_1 = 0.27 \) g

D. **Anchors:** The Anchorage of all piping is to comply with the requirements of Occupancy Category IV facilities. Anchor bolts shall be in accordance with Section 05 50 00 - Miscellaneous Metalwork, and shall be designed to resist the above loads. Anchor bolt calculations shall clearly show that the capacity of the anchor and the capacity of the concrete that the anchor is embedded in are adequate to resist all loads stated in the 2009 IBC and ASCE 7-05, including lateral wind and lateral and vertical seismic loads. Reduction factors associated with edge distance, embed length, and bolt spacing shall all be considered and based on the actual dimensions of the concrete that resists the anchorage forces. Anchor bolt details shall include required bolt diameter, embed, and edge distances. Further, the design of Anchors shall consider the ductility requirements stated in ASCE 7-05, Chapter 13, Section 13.4.2 and Chapter 15, Section 15.7.3. Anchor bolt calculations and details shall be submitted and shall bear the signature and seal of a Registered Professional Engineer licensed in the State of California.

E. **Equipment Foundations:** Mechanical equipment, tanks, control cabinets, enclosures, and related equipment shall be mounted on minimum 3 ½-inch high concrete bases, unless otherwise indicated. Equipment foundations are indicated on Drawings. The CONTRACTOR, through the equipment manufacturer, shall verify the size and weight of equipment foundation to insure compatibility with equipment. The dimensions of all concrete bases shall be sufficient to provide the edge distances required by the anchor bolt calculations.
2.2 GENERAL REQUIREMENTS

A. Code Compliance

1. Piping systems and pipe connections to equipment shall be properly anchored and supported in order to prevent undue deflection, vibration, and dislocation due to seismic events, line pressures, pipe weight, fluid weight, liquid movement, thermal changes, vibration, probable forces applied during construction, and stresses on piping, equipment, and structures.

2. Supports and parts thereof shall conform to the requirements of ASME B31.1 - Power Piping, except as supplemented or modified in this Section.

3. Supports for plumbing piping shall be in accordance with the latest edition of the applicable plumbing code or local administration requirements.

B. Structural Members

1. Wherever possible, pipes shall be supported from structural members.

2. Where it is necessary to frame structural members between existing members, such supplementary members shall be provided by the CONTRACTOR.

3. Supplementary members shall be in accordance with the requirements of the Building Code and the American Institute of Steel Construction, and shall be as acceptable to the ENGINEER.

C. Pipe Hangers

1. Pipe hangers shall be capable of supporting the pipe in operation, allowing free expansion and contraction of the piping and preventing excessive stress on equipment.

2. Hangers shall have a means of vertical adjustment after erection.

3. Hangers shall be designed to prevent becoming disengaged by any movement of the supported pipe.

4. Hangers subject to shock, seismic disturbances, or thrust imposed by the actuation of safety valves shall include hydraulic shock suppressors.

5. Hanger rods shall be subjected to vertical loading only.

D. Hangers Subject to Horizontal Movements

1. At all hanger locations, lateral bracing shall be designed to resist Seismic loads.

2. At hanger locations where lateral or axial movement is anticipated, suitable linkage shall be provided to permit such movement.

3. Where horizontal pipe movement is greater than 1/2 inch, or where the hanger rod deflection from the vertical is greater than 4 degrees from the cold-to-hot position of the pipe, the hanger rod and structural attachment shall be offset in such a manner that the rod is vertical in the hot position.
E. Spring-Type Hangers

1. Spring-type pipe hangers shall be provided for piping subject to vibration or vertical expansion and contraction, such as engine exhausts and similar piping.

2. Spring-type hangers shall be sized to the manufacturer’s printed recommendations and the loading conditions encountered.

3. Variable spring supports shall be provided with means to limit misalignment, buckling, eccentric loading, or to prevent overstressing of the spring, and with means to indicate the compression of the spring.

4. Supports shall be capable of accommodating at least 4 times the maximum travel due to thermal expansion.

F. Thermal Expansion

1. Wherever expansion and contraction of piping is expected, a sufficient number of expansion loops or expansion joints shall be provided, together with the necessary rolling or sliding supports, anchors, guides, pivots, and restraints permitting the piping to expand and contract freely away from the anchored points.

2. Components shall be structurally suitable to withstand the imposed loads.

G. Heat Transmission: Supports, hangers, anchors, and guides shall be designed and insulated such that excessive heat will not be transmitted to the structure or to other equipment.

H. Riser Supports: Where practical, risers shall be supported on each floor with riser clamps and lugs, independent of the connected horizontal piping.

I. Freestanding Piping

1. Freestanding pipe connections to equipment such as chemical feeders and pumps shall be firmly attached to steel frames fabricated from angles, channels, or I-beams anchored to the structure.

2. Exterior, freestanding overhead piping shall be supported on fabricated pipe stands consisting of pipe columns anchored to concrete footings, or with horizontal, welded steel angles, and U-bolts or clamps securing the pipes.

J. Materials of Construction

1. Pipe support assemblies, including framing, hardware, and anchors, shall be of steel construction, galvanized after fabrication, unless otherwise indicated.

2. Submerged supports, as well as piping, conduits, and equipment in hydraulic structures within 24 inches of the water level, shall be supported with support assemblies, including framing, hardware, and anchors constructed of Type 316 stainless steel, unless otherwise indicated.

3. Piping in chemical and corrosive areas shall be supported with support assemblies, including framing, hardware, and anchors constructed of Type 316 stainless steel or FRP, unless otherwise indicated.
K. **Point Loads**

1. Meters, valves, heavy equipment, and other point loads on PVC, FRP, or other plastic pipes, shall be supported on both sides, according to manufacturer's recommendations, in order to avoid undue pipe stresses and failures.

2. In order to avoid point loads, the supports on PVC, FRP, or other plastic piping shall be equipped with extra wide pipe saddles or galvanized steel shields.

L. **Concrete Anchors**

1. Unless otherwise indicated, concrete anchors for pipe supports shall be according to the following table; consult the ENGINEER for any anchor applications not appearing on the table.

2. Anchor embedment shall be in accordance with the requirements of Section 055000 – Miscellaneous Metalwork.

<table>
<thead>
<tr>
<th>Pipe Support Application</th>
<th>Type of Concrete Anchor</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Concrete</td>
<td>Use embedded concrete insert anchors on a grid pattern. Use <strong>Grinnell (Anvil International)</strong>, Tolco, or equal.</td>
</tr>
<tr>
<td>Existing Concrete</td>
<td>Use non-shrink grouted anchors, metallic type expansion anchors, or epoxy anchors.</td>
</tr>
<tr>
<td></td>
<td>Exceptions: Metallic type expansion anchors and epoxy anchors are not permitted for pipe supports subject to vibrating loads. Epoxy anchors are not permitted where the concrete temperature is in excess of 100 deg F or higher than the limiting temperature recommended by the manufacturer. Epoxy anchors are not accepted where anchors are subject to vibration or fire.</td>
</tr>
<tr>
<td>Vibratory Loads and High-Temperature Conditions</td>
<td>Use non-shrink grouted anchors</td>
</tr>
</tbody>
</table>

M. **Noise Reduction:** In order to reduce the transmission of noise in piping systems, copper tubes in buildings and structures shall be wrapped with a 2-inch wide strip of rubber fabric or similar suitable material at each pipe support, bracket, clip, or hanger.

**2.3 SUPPORT SPACING**

A. Supports for piping with the longitudinal axis in approximately a horizontal position shall be spaced to prevent excessive sag, bending, and shear stresses in the piping, with special consideration given where components such as flanges and valves impose concentrated loads.

B. Pipe support spacing shall not exceed the maximum indicated spans.
C. For temperatures other than ambient temperatures or those listed, and for other piping materials or wall thicknesses, the pipe support spacings shall be modified in accordance with the pipe manufacturer’s recommendations.

D. Vertical supports shall be provided to prevent the pipe from being overstressed from the combination of loading effects.

E. Steel Pipe

1. Install supports for steel pipe in accordance with the requirements of AWWA: Manual of Practice MOP-11.

2. For steel pipe sizes not indicated, the support spacing shall be designed such that the stress on the pipe does not exceed 5,000 psi.

3. Where support spacing is not indicated on the Drawings, the CONTRACTOR shall use the spacing indicated in the following schedule, for the indicated support condition:

<table>
<thead>
<tr>
<th>Nominal Pipe Diameter, in</th>
<th>Maximum Span, ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>6</td>
</tr>
<tr>
<td>3/4 and 1-1/2</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>6</td>
<td>17</td>
</tr>
<tr>
<td>8 and 10</td>
<td>19</td>
</tr>
<tr>
<td>12 and 14</td>
<td>23</td>
</tr>
<tr>
<td>16 and 18</td>
<td>25</td>
</tr>
<tr>
<td>20 and greater</td>
<td>30</td>
</tr>
<tr>
<td>Nominal Pipe Diameter, in</td>
<td>Maximum Spans for WELDED FABRICATED STEEL PIPE Supported in Minimum 120 degree Contact Saddles, feet</td>
</tr>
<tr>
<td>--------------------------</td>
<td>---------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>Pipe Wall Thickness, in</td>
</tr>
<tr>
<td></td>
<td>3/16</td>
</tr>
<tr>
<td>24</td>
<td>33</td>
</tr>
<tr>
<td>26</td>
<td>34</td>
</tr>
<tr>
<td>28</td>
<td>34</td>
</tr>
<tr>
<td>30</td>
<td>34</td>
</tr>
<tr>
<td>32</td>
<td>34</td>
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<tr>
<td>34</td>
<td>35</td>
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<tr>
<td>36</td>
<td>35</td>
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<tr>
<td>38</td>
<td>35</td>
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<td>40</td>
<td>35</td>
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<td>42</td>
<td>35</td>
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<td>45</td>
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<td>48</td>
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<tr>
<td>51</td>
<td>--</td>
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<tr>
<td>54</td>
<td>--</td>
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<tr>
<td>57</td>
<td>--</td>
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<tr>
<td>60</td>
<td>--</td>
</tr>
<tr>
<td>63</td>
<td>--</td>
</tr>
<tr>
<td>66</td>
<td>--</td>
</tr>
<tr>
<td>72</td>
<td>--</td>
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<tr>
<td>78</td>
<td>--</td>
</tr>
<tr>
<td>84</td>
<td>--</td>
</tr>
<tr>
<td>90</td>
<td>--</td>
</tr>
<tr>
<td>96</td>
<td>--</td>
</tr>
</tbody>
</table>
F. Ductile Iron Pipe

1. Install supports for in accordance with the recommendations of the Ductile Iron Pipe Research Association (DIPRA) Design of Ductile Iron Pipe on Supports.

2. As a minimum, where support spacing is not indicated on the Drawings, the CONTRACTOR shall use the spacing indicated in the following schedule:

<table>
<thead>
<tr>
<th>Nominal Pipe Diameter, inches</th>
<th>Support Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALL DIAMETERS</td>
<td>two supports per pipe length, with one of the two supports located at a joint</td>
</tr>
</tbody>
</table>

G. Copper Tube: Install supports for copper tube in accordance with the recommendations of ANSI/MSS SP-69 Pipe Hangers and Supports - Selection and Application, as indicated in the following schedule:

<table>
<thead>
<tr>
<th>Nominal Tube Size, inches</th>
<th>Support Spacing, feet$^1$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Water Service</td>
</tr>
<tr>
<td>1/4</td>
<td>5</td>
</tr>
<tr>
<td>3/8</td>
<td>5</td>
</tr>
<tr>
<td>1/2</td>
<td>5</td>
</tr>
<tr>
<td>3/4</td>
<td>5</td>
</tr>
<tr>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>1-1/4</td>
<td>7</td>
</tr>
<tr>
<td>1-1/2</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>2-1/2</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>3-1/2</td>
<td>11</td>
</tr>
<tr>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>10</td>
<td>18</td>
</tr>
<tr>
<td>12</td>
<td>19</td>
</tr>
</tbody>
</table>

$^1$ Reference: ANSI/MSS SP-69, Table 3
H. **Schedule 80 PVC Pipe:** Install supports for Schedule 80 PVC pipe as indicated in the following schedule:

<table>
<thead>
<tr>
<th>Nominal Pipe Size, inches</th>
<th>Maximum Support Spacing, feet, at Various Temperatures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>60 deg F</td>
</tr>
<tr>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>1-1/2</td>
<td>6.5</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>14</td>
<td>13.5</td>
</tr>
</tbody>
</table>

Reference: USACE based on Harvel Plastics Product Bulletin 112/401 (rev. 10/1/95), p. 63; spacing values based on test data developed by the manufacturer for the specific product and continuous spans; the piping is insulated and full of liquid with a specific gravity of 1.0.
I. **Schedule 80 CPVC Pipe:** Install supports for Schedule 80 CPVC pipe as indicated in the following schedule:

<table>
<thead>
<tr>
<th>Nominal Pipe Size, inches</th>
<th>Maximum Support Spacing, feet, at Various Temperatures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>73 deg F</td>
</tr>
<tr>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>1-1/2</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>8.5</td>
</tr>
<tr>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>10</td>
<td>11.5</td>
</tr>
<tr>
<td>12</td>
<td>12.5</td>
</tr>
</tbody>
</table>

1 Reference: USACE based on Harvel Plastics Product Bulletin 112/401 (rev, 10/1/95), p.6 63; spacing values based on test data developed by the manufacturer for the specific product and continuous spans; the piping is insulated and full of liquid with a specific gravity of 1.0

J. **Other Pipe Materials:** Support spacing for pipe constructed of other materials shall be based on design temperature and in accordance with the pipe manufacturer's recommendations.

2.4 **MANUFACTURED SUPPORTS**

A. Stock Parts

1. Where not specifically indicated, designs that are generally accepted as exemplifying good engineering practice and using stock or production parts shall be utilized wherever possible.

2. Such parts shall be locally available, new, of best commercial quality, and designed and rated for the intended purpose.

B. Manufacturers, or Equal

1. **Basic Engineers Inc.**

2. **Bergen-Paterson Pipesupport Corp.**

3. **Grinnell Corp. (Anvil International)**

4. **NPS Products, Inc.**
5. **Power Piping Company**

6. **Tolco Incorporated**

2.5 **COATING**

A. **Galvanizing:** Unless otherwise indicated, fabricated pipe supports other than stainless steel or non-ferrous supports shall be blast-cleaned after fabrication and hot-dip galvanized in accordance with ASTM A 123 - Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

B. **Other Coatings:** Other than stainless steel or non-ferrous supports, supports shall receive protective coatings in accordance with the requirements of Section 099600 – Protective Coating.

**PART 3 – EXECUTION**

3.1 **INSTALLATION**

A. **General**

1. Pipe supports, hangers, brackets, anchors, guides, and inserts shall be fabricated and installed in accordance with the manufacturer's printed instructions and ASME B31.1 - Power Piping.

2. Concrete inserts for pipe hangers and supports shall be coordinated with the formwork.

B. **Appearance**

1. Pipe supports and hangers shall be positioned in order to produce an orderly, neat piping system.

2. Hanger rods shall be vertical, without offsets.

3. Hangers shall be adjusted to line up groups of pipes at the proper grade for drainage and venting, as close to ceilings or roofs as possible, and without interference with other WORK.

3.2 **FABRICATION**

A. **Quality Control**

1. Pipe hangers and supports shall be fabricated and installed by experienced welders and fitters, using the best welding procedures available.

2. Fabricated supports shall be neat in appearance without sharp corners, burrs, or edges.

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PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide steel pipe and appurtenances, complete and in place, in accordance with the Contract Documents.

B. The requirements of Section 431050 - Piping, General apply to the WORK of this Section.

PART 2 -- PRODUCTS

2.1 PIPE MATERIAL

A. General: Unless otherwise indicated, galvanized and black steel pipe shall conform to ASTM A 53 - Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless or ASTM A 106 - Seamless Carbon Steel Pipe for High Temperature Service, Grade B, and shall be Schedule 40 or 80, as indicated in the Piping Schedule. Galvanized steel pipe shall not be cement mortar lined unless so indicated.

B. Sediment Control System Service: Black steel pipe shall conform to ASTM A53-Pipe Steel, Black and Hot-Dipped, Zinc Coated Welded and Seamless and shall be schedule 40. Pipe shall shop lined and coated in accordance with Section 099610.

2.2 PIPE JOINTS

A. Black steel pipe for general service shall have screwed ends with NPT threads, welded joints, or flanged joints. Screwed joints shall be made up with Teflon tape and welded joints may have butt-weld fittings, socket-weld fittings, or flanges. Where indicated, black steel pipe shall have grooved ends for shouldered couplings or plain ends for sleeve-type couplings.

B. Galvanized steel pipe shall have screwed ends with NPT threads made up with Teflon tape. Where indicated, galvanized steel pipe shall have grooved ends for shouldered couplings or plain ends for sleeve-type couplings.

2.3 FITTINGS

A. Common Use: The following fittings shall be provided for galvanized or black steel pipe, as indicated in the Piping Schedule:

1. Threaded malleable iron fittings conforming to ASME B 16.3 - Malleable-Iron Threaded Fittings, Classes 150 and 300.

2. Threaded cast iron fittings conforming to ASME B 16.4 - Cast Iron Threaded Fittings, Class 125 and 250.

3. Forged steel socket welded fittings conforming to ASME B 16.11 - Forged Fittings, Socket - Welding and Threaded.
4. Butt welding fittings conforming to ASME B 16.9 - Factory-Made Wrought Steel Butt Welding Fittings, Schedule 40 or 80, as indicated.


6. Flanged cast iron fittings conforming to ASME B 16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250 and 800.

7. Flanged steel fittings conforming to ASME B 16.5 - Pipe Flanges and Flanged Fittings, Steel Nickel Alloy and Other Special Alloys.

8. Grooved ductile iron fittings with grooving dimensions conforming to AWWA C606 - Joints, Grooved and Shouldered Type.

9. Compression-type steel fittings with armored Buna S gaskets for plain end pipe.

B. Special Applications: High tensile alloy steel corrosion-resistant bolts and nuts shall be used with each set of flanged unions. Unions shall be rated for 500 lb. CWP service pressure, reducing-type, straight-type or blind-type, as required for the installation. Blind unions shall be provided as cleanouts where indicated, and straight unions shall be provided adjacent to each threaded valve or piece of equipment. Unions shall be as manufactured by Henry Valve Company, Vogt Valve Co., or equal.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. General: Pipes shall be installed in a neat and workmanlike manner, properly aligned, and cut from measurements taken at the Site to avoid interferences with structural members, architectural features, openings, and equipment. Exposed pipes shall afford maximum headroom and access to equipment, and where necessary, piping shall be installed with sufficient slopes for venting or drainage of liquids and condensate to low points. Installation shall be free from defects.

B. Supports and Anchors: Piping shall be firmly supported with fabricated or commercial hangers or supports in accordance with Section 431052 - Pipe Supports. Where necessary to avoid stress on equipment or structural members, the pipes shall be anchored or harnessed. Expansion joints and guides shall compensate for pipe expansion due to temperature differences.

C. Valves and Unions: Water, steam, condensate, gas, vacuum, and air supply piping to fixtures, groups of fixtures, and equipment shall be provided with a shutoff valve and union, unless the valve has flanged ends. Low points in water systems and driplegs in steam, gas, and air systems shall have drainage valves. Unions shall be provided at threaded valves, equipment, and other devices requiring occasional removal or disconnection.

D. Branch Connections: Branch connections in horizontal runs of air and gas piping shall be made from the top of the pipe, to avoid drainage of condensate into the equipment.
3.2 PIPE PREPARATION

A. Prior to installation, each pipe length shall be carefully inspected, be flushed clean of any debris or dust, and be straightened if not true. Ends of threaded pipes shall be reamed and filed smooth. Fittings shall be equally cleaned before assemblage.

3.3 PIPE JOINTS

A. **Threaded Joints:** Pipe threads shall conform to ASME B 1.20.1 - Pipe Threads, General Purpose (inch), and shall be full and cleanly cut with sharp dies. Not more than 3 threads shall remain exposed after installation.

B. **Welded Joints:** Welded joints shall conform to the specifications and recommendations of ASME B 31.1 - Power Piping. Welding shall be done by skilled and qualified welders per Section 15000 - Piping, General.

C. **Grooved Joints:** Grooves for grooved couplings and fittings shall be made with specially designed grooving tools to the manufacturer's recommendations and conform to AWWA C 606. Grooves shall be clean and sharp without flaws, and the pipe ends shall be accurately cut at 90 degrees to the pipe axis.

D. **Push On Joints:** Push on joints and gasket installation shall be in accordance with the manufacturer's recommendations and lubricants. Pipe ends shall be beveled to facilitate assembly. Lubricants shall be suitable for potable water service and shall be kept clean in closed containers.

3.4 INSPECTION AND FIELD TESTING

A. **Inspection:** Finished installations shall be carefully inspected for proper supports, anchoring, interferences, and damage to pipe, fittings, and coating. Any damage shall be repaired.

B. **Field Testing:** Prior to enclosure or burying, piping systems shall be pressure tested as required in the Piping Schedule for a period of not less than one hour without exceeding the tolerances listed in the Piping Schedule. Where no pressures are indicated, the pipes shall be subject to 1-1/2 times the maximum working pressure. The CONTRACTOR shall furnish test equipment, labor, materials, and devices as part of the WORK. For additional testing requirements, refer to Section 017430 - Pressure Pipe Testing and Disinfection.

1. Leakage may be determined by loss of pressure, soap solution, chemical indicator, or other positive and accurate method. Fixtures, devices, or other accessories which are to be connected to the lines and which would be damaged if subjected to the test pressure shall be disconnected and ends of the branch lines plugged or capped as required during the testing procedures.

2. Leaks shall be repaired, and the system shall be re-tested until no leaks are found.

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PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide stainless steel pipe and appurtenances, complete and in place, in accordance with the Contract Documents.

B. The requirements of Section 431050 - Piping, General apply to the WORK of this Section.

PART 2 – PRODUCTS

2.1 PIPE MATERIAL

A. Unless otherwise indicated, stainless steel pipe shall be in accordance with ASTM A 312 - Seamless and Welded Austenitic Stainless Steel Pipe, Type 316, seamless, Schedule 40, with screwed fittings for sizes up to and including 2-1/2 inches and welded fittings or flanged fittings for sizes 3-inches and larger. Stainless steel pipe 12-inches in diameter and larger shall be in accordance with ASTM A 409 - Welded Large Diameter Austenitic Steel Pipe for Corrosive or High-Temperature Service, or A 778 - Welded, Unannealed Austenitic Stainless Steel Tubular Products, Type 316, of the schedules indicated, with welded or flanged joints.

2.2 PIPE JOINTS

A. Stainless steel pipe for sizes 2-1/2 inches and smaller shall have screwed ends with NPT threads made up with Teflon tape. Stainless steel pipe 3-inches and larger and where indicated shall have welded joints with socket-welding fittings, butt-welding fittings, or socket welding flanges. Stainless steel flanges shall have stainless steel bolts and nuts. Where indicated, stainless steel pipe shall have grooved ends for shouldered couplings, except that no pipe with less than Schedule 40 wall thickness shall be grooved. Where indicated, stainless steel pipe shall have plain ends for sleeve-type couplings.

2.3 FITTINGS

A. Threaded Fittings: Forged stainless steel fittings conforming to ASME B 16.11 - Forged Fittings, Socket-Welding and Threaded, Type 316.

B. Socket-Welding Fittings: Forged stainless steel fittings conforming to ASME B 16.11, Type 316.


D. Grooved Fittings: Wrought stainless steel grooved fittings conforming to ASTM A 403 and ASME B 16.9, with grooving conforming to AWWA C606 - Grooved and Shouldered Joints, Type 316.
E. **Flanged Fittings:** Type 316 stainless steel flanged fittings and flanges conforming to ASME B 16.5 - Pipe Flanges and Flanged Fittings.

F. **Pressure Class:** Unless otherwise indicated, fittings shall be in accordance with the pressure classes called for in the Piping Schedule. Where not indicated, the fittings shall have the same pressure rating as the pipe.

**PART 3 – EXECUTION**

3.1 **INSTALLATION**

A. **General:** Stainless steel pipe shall be installed in a neat and workmanlike manner, properly aligned and cut from measurements taken at the Site to avoid interferences with structural members, architectural features, openings, and equipment. Exposed pipe shall afford maximum headroom and access to equipment, and where necessary piping shall be installed with sufficient slopes for venting or drainage of liquids and condensate to low points. Installation shall be free from defects.

B. **Supports and Anchors:** Piping shall be firmly supported with fabricated or commercial hangers or supports in accordance with Section 431052 - Pipe Supports. Where necessary to avoid stress on equipment or structural members, the pipe shall be anchored or harnessed. Expansion joints and guides shall compensate for pipe expansion due to temperature differences.

C. **Valves and Unions:** Unless otherwise indicated, connections to fixtures, groups of fixtures, and equipment shall be provided with a shutoff valve and union, unless the valve has flanged ends. Unions shall be provided at threaded valves, equipment, and other devices requiring occasional removal or disconnection.

3.2 **PIPE PREPARATION**

A. Prior to installation, each pipe length shall be carefully inspected, be flushed clean of any debris or dust, and be straightened if not true. Ends of threaded pipes shall be reamed and filed smooth. Fittings shall be equally cleaned before assembly.

3.3 **PIPE JOINTS**

A. **Threaded Joints:** Pipe threads shall conform to ASME B 1.20.1 - Pipe Threads, General Purpose (inch), and shall be full and cleanly cut with sharp dies. Not more than 3 threads shall remain exposed after installation.

B. **Welded Joints:** Welded joints shall conform to the specifications and recommendations of ASME B 31.1 - Power Piping. Welding shall be done by skilled and qualified welders per Section 431050 - Piping, General.

1. Field welding shall be minimized to the greatest extent possible by use of couplings and prefabrication of pipe systems at the factory. Pipe butt welds may be performed at the Site, providing the butt welds are performed only with an inert gas shielded process and that other indicated welding requirements are followed rigidly.

2. Residue, oxide, and heat stain shall be removed from any type of field weld and the affected areas adjacent by the use of stainless steel wire brushes, followed by cleaning with an agent such as **Eutectic Company's Euclean** or equal, followed by complete removal of the agent.
C. **Grooved Joints**: Grooves for grooved couplings and fittings shall be made with specially designed grooving tools to the manufacturer’s recommendations and conforming to AWWA C606. Grooves shall be clean and sharp without flaws, and the pipe ends shall be accurately cut at 90 degrees to the pipe axis.

3.4 INSPECTION AND FIELD TESTING

A. **Inspection**: The finished installation shall be carefully inspected for proper supports, anchoring, interferences, and damage to pipe, fittings, and coating. Defects shall be repaired.

B. **Field Testing**: Prior to enclosure or burying, piping systems shall be pressure tested as required in the Piping Schedule, for a period of not less than one hour without exceeding the tolerances listed in the Piping Schedule. Where no pressures are indicated, the pipes shall be subject to 1-1/2 times the maximum working pressure. The CONTRACTOR shall furnish test equipment, labor, materials, and devices as part of the WORK. For additional testing requirements refer to Section 017430 - Pressure Pipe Testing and Disinfection.

1. Leakage may be determined by loss of pressure, soap solution, chemical indicator, or other positive and accurate method. Fixtures, devices, or other accessories which are to be connected to the lines and which would be damaged if subjected to the test pressure shall be disconnected and ends of the branch lines plugged or capped as required during the testing procedures.

2. Leaks shall be repaired, and the system shall be re-tested until no leaks are found.

- END OF SECTION -
PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide copper tube for water, gas, and vacuum service, complete and in place, in accordance with the Contract Documents.

B. The requirements of Section 431050 - Piping, General apply to the WORK of this Section.

C. Any pipe, plumbing fitting or fixture, solder, or flux used in the installation or repair of any public water system or any plumbing in a facility providing water for human consumption, shall be “lead free” except when necessary for the repair of leaded joints of cast iron pipes.

1. Lead free means not more than 0.2 percent lead when used with respect to solder and flux, not more than 8 percent when used with respect to pipes and pipe fittings, and not more than 4 percent with respect to plumbing fixture.

PART 2 -- PRODUCTS

2.1 PIPE MATERIAL

A. Copper water tube shall conform to the requirements of ASTM B 88 - Seamless Copper Water Tube, and shall be soft temper tube in rolls for buried locations, or hard drawn lengths for other applications. Unless otherwise indicated, copper water tube shall be of Type K wall thickness.

2.2 JOINTS

A. Copper water tube shall have either soldered joints, flared ends and fittings, or compression type joints. Soldered joints shall be made with 95 - 5 percent tin-antimony solder or with silver solder. Buried piping shall have flared or compression type joints. No soft-soldered joints will be allowed on buried piping. No solders containing more than 0.2 percent of lead shall be used.

2.3 FITTINGS

A. Soldered Fittings: Soldered fittings shall conform to ANSI B 16.18 - Cast Copper Alloy Solder Joint Pressure Fittings, or to ASME B 16.22 - Wrought Copper and Copper Alloy Solder - Joint Pressure Fittings. The soldering flux shall be the manufacturer’s approved type for the fitting and solder used.

B. Flared Fittings: Flared fittings shall conform to ASME B 16.26 - Cast Copper Alloy Fittings for Flared Copper Tubes.

C. Compression Fittings: Compression type fittings shall be brass fittings as manufactured by Crawford Company - SWAGELOK, Parker-Hannifin - CPI, or equal.
D. **Flanged Fittings:** Cast copper alloy flanges and flanged fittings shall be in accordance with ASME B 16.24 - Cast Copper Alloy Pipe Flanges and Flanged Fittings, and ASTM B 62 - Composition Bronze or Ounce Metal Castings, with 150 lb. ratings, or as indicated.

**PART 3 – EXECUTION**

### 3.1 INSTALLATION

A. **General:** Copper tubes shall be installed in a neat and workmanlike manner, properly aligned, and cut from measurements taken at the Site to avoid interferences with structural members, architectural features, openings, and equipment. Exposed tubing shall afford maximum headroom and access to equipment, and where necessary, tubing shall be installed with sufficient slopes for venting or drainage of liquids and condensate to low points. Installations shall be without defects.

B. **Supports and Anchors:** Tubing shall be firmly supported with fabricated or commercial hangers, brackets, or supports in accordance with Section 431052 - Pipe Supports. Where necessary to avoid stress on equipment or structural members, the tubes shall be anchored or harnessed. Expansion joints and guides shall compensate for expansion due to temperature differences.

C. **Valves and Unions:** Unless otherwise indicated, tubing to fixtures, groups of fixtures, and equipment shall be provided with a shutoff valve and union, unless the valve has flanged ends. Low points in water systems and driplegs in steam, gas, and air systems shall have drainage valves. Unions shall be provided at threaded valves, equipment, and other devices requiring occasional removal or disconnection.

D. **Branch Connections:** Branch connections in horizontal runs of air and gas tubing shall be made from the top of the main to avoid drainage of condensate into the equipment.

### 3.2 PREPARATION

A. Prior to installation, each tube length shall be carefully inspected, flushed clean of any debris or dust, and be straightened, if not true. Ends of tubes shall be reamed and filed smooth. Fittings shall be equally cleaned before assembly.

### 3.3 JOINTS

A. **Brazed and Soldered Joints:** Brazed and soldered joints shall conform to the manufacturer’s recommendations and to the specifications and recommendations of ASME B 31.1 - Power Piping. Brazing shall be done by skilled and qualified welders per Section 431050 - Piping, General. Prior to the application of flux, the ends of tubes shall be thoroughly dried and cleaned.

### 3.4 INSPECTION AND FIELD TESTING

A. **Inspection:** Finished installations shall be carefully inspected for proper joints and supports, anchoring, interferences, and damage to tubing, fittings, and coating. Defective WORK shall be repaired.

B. **Field Testing:** Prior to enclosure or burying, tubing systems shall be pressure tested as required in the Piping Schedule, for a period of not less than one hour without exceeding the tolerances listed in the Piping Schedule. Where no pressures are indicated, the tubes shall be subject to 1-1/2 times the maximum working pressure. The CONTRACTOR shall furnish test equipment, labor, materials, and devices as part of the
WORK. For additional testing requirements refer to Section 017430 - Pressure Pipe Testing and Disinfection.

1. Leakage may be determined by loss of pressure, soap solution, chemical indicator, or other positive and accurate method. Fixtures, devices, or other accessories which are to be connected to the lines and which would be damaged if subjected to the test pressure shall be disconnected and ends of the branch lines be plugged or capped as required during the testing procedures.

2. Leaks shall be repaired, and the piping shall be re-tested until no leaks are found.

- END OF SECTION -
PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide a receiver-mounted vacuum pump, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 431200 - Blowers, Compressors, and Vacuum Pumps, General, apply to the WORK of this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 431200.

PART 2 -- PRODUCTS

2.1 VACUUM PUMPS

A. Operating Conditions: Vacuum pump operating conditions shall be as follows:

<table>
<thead>
<tr>
<th>Identification number</th>
<th>C-301</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Indoors</td>
</tr>
<tr>
<td>Service</td>
<td>Continuous</td>
</tr>
<tr>
<td>Elevation above sea, ft</td>
<td>40</td>
</tr>
<tr>
<td>Min vacuum pump displacement, cfm</td>
<td>17</td>
</tr>
<tr>
<td>Min continuous vacuum, inHg</td>
<td>-20</td>
</tr>
<tr>
<td>Motor size, min, hp</td>
<td>1.25</td>
</tr>
<tr>
<td>Motor speed, max rpm</td>
<td>1800</td>
</tr>
<tr>
<td>Vacuum pump speed, max rpm</td>
<td>1800</td>
</tr>
<tr>
<td>Size of receiver, gal</td>
<td>60</td>
</tr>
<tr>
<td>Max noise level, dBA</td>
<td>68</td>
</tr>
</tbody>
</table>

B. Equipment Requirements: The vacuum pump shall consist of tank-mounted rotary vane vacuum pump unit of the air-cooled, single-stage, direct drive, lubricated type, certified for saturated air service.
C. **Equipment Construction:** Basic equipment construction and materials required shall be as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common base-plate (mounted on receiver)</td>
<td>cast-iron or steel, with sliding motor base</td>
</tr>
<tr>
<td>Casing</td>
<td>cast iron</td>
</tr>
<tr>
<td>Rotor</td>
<td>precision-machined, with radial fins</td>
</tr>
<tr>
<td>Rotor vanes</td>
<td>Non-metallic</td>
</tr>
<tr>
<td>Lubrication</td>
<td>Recirculating oil lubrication, filtered</td>
</tr>
<tr>
<td>Safety shut-down switches</td>
<td>low oil level and high temperature</td>
</tr>
</tbody>
</table>

D. **Drive:** Drive shall be direct-type with heavy-duty TEFC electric motor suitable for installation in the area indicated, for 480-volt, 3-phase, 60-Hz supply.

E. **Receiver:** The vacuum pump shall be securely mounted on an ASME approved horizontal welded steel tank with integral legs, suitable for the working pressure and size indicated above. The tank shall have threaded connections for an inlet, outlet, drain, vacuum gage, and vacuum switch. The receiver shall be securely mounted to the floor with restrained, heavy-duty vibration isolators and anchor bolts. The inlet and outlet of the receiver tank shall be on opposite ends, and the outlet shall be on top of the tank, to promote condensation fallout within the tank.

F. **Control Panel:** The vacuum pump shall be controlled from a tank mounted control panel in a NEMA 4 enclosure with hinged door and finished to match the skid. The panel shall be completely pre-wired to provide a fully automatic operation and include the following features:

1. Circuit breaker
2. Magnetic starter with solid state O/L unit
3. Push buttons in front panel
4. Running light in front panel
5. Warning light for low oil
6. Adjustable time delay off relay
7. Contact for remote trouble alarm
8. Elapsed time meter
9. Label all wires; tape markings are not acceptable
10. Stainless steel or heavy plastic labels for all controls and functions
11. The Local Control Panel shall be sized to properly accommodate all equipment and accessories needed. The size shall accommodate the field conduits and wiring.

G. The vacuum switch shall be connected to the control panel and the vacuum pump, as indicated.

H. A solenoid valve shall be provided between the tank outlet and the pump inlet. The solenoid valve shall open when energized.

I. Controls shall conform to the following:

1. The vacuum pump will receive a contact closure permissive to run from remote equipment.
   a. Furnish terminals to land the field wiring
   b. Label the terminals for the purpose
   c. Ship with jumper installed for field removal

2. The vacuum shall start, and the solenoid valve shall energize to open, upon closure of remote contact.

3. The solenoid valve shall remain energized/open until the vacuum switch reaches its low pressure setting.

4. When the low pressure setting is reached, the solenoid valve shall de-energize/close, and the time delay off relay shall be activated.

5. The vacuum pump shall continue to run to reduce condensate in the oil, until the time delay relay off end of time period is reached.
   a. The vacuum pump will remain active as long as the remote equipment runs

J. Accessories: Units shall be provided complete with the following accessories, each:

1 receiver drain cock
1 receiver inlet valve
1 set of restrained, heavy-duty spring-type vibration isolators
1 set of galvanized anchor bolts and nuts
1 vacuum relief valve
1 inlet check valve
1 inlet screen/filter
1 inlet condensate knock-out pot, 3-gallon minimum condensate capacity
1 discharge silencer
1 vacuum switch for automatic start/stop control
1 vacuum gage with valve
1 disconnect switch, and all other controls and appurtenances indicated
K. **Spare Parts:** Provide the following spare parts:

1. Replacement oil – 5 complete oil changes
2. Replacement oil filter – 5 complete oil changes
3. All other parts which are frequently replaced as a part of regular anticipated maintenance – 2 complete changes

L. **O & M Manuals:** Provide complete operations and maintenance manuals in accordance with Section 013300. Printed instructions relating to proper maintenance, including lubrication, and parts lists indicating the various parts by name, number, and diagram where necessary, shall be provided. A recommended spare parts list shall be included. Instructions for field procedures for erection, adjustments, inspection, and testing shall be provided prior to installation of the vacuum pump.

M. **Guarantee, Warranty:** After completion, the CONTRACTOR shall furnish to the OWNER the manufacturer's written guarantee, that the equipment will operate with the published efficiencies, pressures, and flow ranges and meet these specifications. The CONTRACTOR shall also furnish the manufacturer's warranties as published in its literature.

N. **Manufacturers, or Equal**

1. Dekker, Dura-Vane RVL020W
2. US Vacuum, Torrvac TCV Series
3. Airtech
4. Quincy (Colt Industries)

**PART 3 -- EXECUTION**

3.1 **INSTALLATION**

A. **General:** Equipment shall be installed in accordance with the Shop Drawings and as indicated.

B. General installation requirements shall be as indicated in Section 410000 - Equipment General Provisions.

C. **Exhaust:** The pump exhaust line shall run to the outside of the building, with an exhaust silencer.

D. **Mount:** The unit to be mounted on a horizontal, hot dip galvanized 60-gallon receiver designed for maximum vacuum service, anchored to the floor slab, using heavy duty, restrained spring-type vibration isolators.

- END OF SECTION -
PART 1 – GENERAL

1.1 THE REQUIREMENT

A. Provide pumps and pumping appurtenances, complete and operable, as indicated in accordance with the Contract Documents.

B. The provisions of this Section shall apply to pumps and pumping equipment throughout the Contract Documents, except where otherwise indicated.

C. The requirements of Section 410000 – Equipment General Provisions, apply to this Section.

D. Unit Responsibility

1. The pump manufacturer shall be made responsible for furnishing the WORK and for the coordination of design, assembly, testing, and installation of the WORK of each specific pump Section.

2. The CONTRACTOR shall be responsible to the OWNER for compliance with the requirements of each specific pump Section.

E. Single Manufacturer: Where 2 or more pump systems of the same type or size are required, provide pumps produced by the same manufacturer.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 013300 – Contractor Submittals.

B. Shop Drawings

1. Submit pump name, identification number, and specification Section number.

2. Performance Information

a. Submit performance data curves showing head, capacity, horsepower demand, NPSH required, and pump efficiency over the entire operating range of the pump.

b. Require the equipment manufacturer to indicate separately the head, capacity, horsepower demand, overall efficiency, and minimum submergence required at the design flow conditions and the maximum and minimum flow conditions.

c. Submit performance curves at intervals of 100 RPM from minimum speed to maximum speed for each centrifugal pump equipped with a variable speed drive.
3. Operating Range
   a. Require the manufacturer to indicate the limits on the performance curves recommended for stable operation without surge, cavitation, or excessive vibration.
   b. Provide a stable operating range as wide as possible, based on actual hydraulic and mechanical tests.

4. Submit assembly and installation drawings, including shaft size, seal, coupling, bearings, anchor bolt plan, part nomenclature, material list, outline dimensions, and shipping weights.

5. Submit data, in accordance with the requirements of Section 260510 – Electric Motors, for the electric motor proposed for each pump.

6. Submit an elevation of the proposed local control panel, showing panel-mounted devices, details of enclosure type, a single-line diagram of power distribution, current draw of the panel, and a list of all terminals required to receive inputs or to transmit outputs from the local control panel.

7. Submit a wiring diagram of field connections, with identification of terminations between local control panels, junction terminal boxes, and equipment items.

8. Submit a complete electrical schematic diagram.

C. Technical Manual: Submit a Technical Manual containing the required information indicated in Section 013300 – Contractor Submittals and each specific pump Section.

D. Spare Parts List: Submit a spare parts list containing the required information indicated in Section 013300 – Contractor Submittals and each specific pump Section.

E. Factory Test Data
   1. Submit signed, dated, and certified factory test data for each pump system which requires factory testing.
   2. Submit these data before shipment of equipment.

F. Certifications
   1. Submit the manufacturer's certification of proper installation.
   2. Submit the CONTRACTOR's certification of satisfactory field testing.

PART 2 – PRODUCTS

2.1 GENERAL
   A. Compliance with the requirements of the specific pump Sections may necessitate modifications to the manufacturer's standard equipment.
B. Performance Curves

1. Provide centrifugal pumps with a continuously rising curve or with the system operating range not crossing the pump curve at 2 different capacities or “dip region.”

2. Unless otherwise indicated, the required shaft horsepower for the entire pump assembly at any point on the performance curve shall not exceed the rated horsepower of the motor or engine or encroach on the service factor.

C. Compatibility

1. Provide entirely compatible components of each pump system provided under the specific pump Sections.

2. In each unit of pumping equipment, incorporate basic mechanisms, couplings, electric motors or engine drives, variable speed controls, necessary mountings, and appurtenances.

2.2 MATERIALS

A. Provide materials suitable for the intended application.

B. For materials not indicated, provide high-grade, standard commercial quality, free from defects and imperfections that might affect the serviceability of the product for the purpose for which it is intended, and conforming to the following requirements:

1. Provide cast iron pump casings and bowls constructed of close-grained gray cast iron, conforming to ASTM A 48 - Gray Iron Castings, Class 30, or equal.

2. Provide bronze pump impellers conforming to ASTM B 62 - Composition Bronze or Ounce Metal Castings, or B 584 - Copper Alloy Sand Castings for General Applications, where dezincification does not occur.

3. Provide pump shafts constructed of Type 416 or 316 stainless steel.

4. Miscellaneous stainless steel parts shall be of Type 316.

5. Provide anchor bolts, washers, and nuts in standard service (non-corrosive application) of galvanized steel in accordance with the requirements of Section 055000 – Miscellaneous Metalwork.

6. Provide anchor bolts, washers, and nuts in corrosive service as defined in Section 055000 – Miscellaneous Metalwork, of stainless steel in accordance with Section 055000 – Miscellaneous Metalwork.

C. Materials in contact with potable water shall be listed as compliant with NSF Standard 61.

2.3 PUMP COMPONENTS - GENERAL

A. Flanges and bolts.

B. Provide suction and discharge flanges conforming to ASME B16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800 or ASME B16.5 - Pipe Flanges and Flanged Fittings dimensions.
C. Provide bolts shall be in accordance with the requirements of Section 055000 – Miscellaneous Metalwork.

D. Lubrication

1. Vertical pump shafts of clean water pumps shall be product water-lubricated, unless otherwise indicated.

2. Provide deep-well pumps and pumps with dry barrels with water- or oil-lubricated bearings and seals, and enclosed line shafts.

3. Pumps for sewage, sludge, and other process fluids shall be lubricated as indicated.

E. **Hand holes:** Provide hand holes on pump casings shaped to follow the contours of the casing in order to avoid any obstructions in the water passage.

F. **Drains:** Pipe gland seals, air valves, cooling water drains, and drains from variable speed drive equipment to the nearest floor sink or drain, using galvanized steel pipe or copper tube that is properly supported with brackets.

G. **Grease Lubrication:** For vertical propeller, mixed-flow, and turbine pumps, other than deep well pumps, of bowl sizes 10-inch and larger, provide a stainless steel tube attached to the column for grease lubrication of the bottom bearing.

H. **Stuffing Boxes**

1. Where stuffing boxes are indicated for the pump seal, provide stuffing boxes of the best quality, using the manufacturer's suggested materials best suited for the specific application.

2. For sewage, sludge, drainage, and liquids containing sediments, provide fresh-water-flushed seals, using lantern rings.

3. If fresh water is not available, the seal shall be flushed with product water cleaned by a solids separator as manufactured by **John Crane Co., Lakos (Claude Laval Corp.),** or equal.

4. Conventional Packing Gland Type Seal

   a. Unless otherwise indicated, provide packing material of Teflon braiding, containing 50 percent ultrafine graphite impregnation in order to satisfy the requirements listed in the table below.

   b. Acceptable ring materials are asbestos-free die-molded packing rings of braided graphite material free of PTFE, **Chesterton 1400R** or equal, for non-potable water service, and braided PTFE material, **Chesterton 1725** or equal, that is listed under NSF Standard 61 for potable water service.
c. Seal Requirements

<table>
<thead>
<tr>
<th>Shaft speeds</th>
<th>up to 2500 fpm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>up to 500 deg F</td>
</tr>
<tr>
<td>pH range</td>
<td>0 - 14</td>
</tr>
</tbody>
</table>

5. Mechanical Seals (Split-Type)

a. Provide split-type mechanical seals that are fresh water-flushed, unless otherwise indicated in which case use product water cleaned by a solids separator as indicated above.

b. Provide mechanical seals as manufactured by the following, or equal:

<table>
<thead>
<tr>
<th>Sewage, Sludge, or Wastewater Pumps</th>
<th>Double seals</th>
<th>John Crane Type 3710, Flowserve Type PSS2, Chesterton Type 442</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abrasives, Grit, or Lime Slurry Pumps</td>
<td>Double seals</td>
<td>Split seals are not recommended.</td>
</tr>
<tr>
<td>Chemicals or Corrosive Liquid Pumps</td>
<td>Single seals</td>
<td>Split seals are not recommended because of leakage.</td>
</tr>
<tr>
<td>Water Pumps (Hot and cold)</td>
<td>Single seals</td>
<td>John Crane Type 3710, Flowserve Type PSS II, Chesterton Type 442</td>
</tr>
</tbody>
</table>

6. Where indicated, circulate a buffer fluid at a minimum 20 psi above discharge pressure, or as required by the manufacturer, in order to maintain reliable seal performance.

7. Equip mechanical seals with nonclogging, flexible–mounted seats with elastomer secondary seals.

8. Provide wetted metal parts constructed of Type 316 stainless steel, Alloy 20, or Hastelloy B or C, whichever has the best corrosion resistance to the pumped fluid.

9. Provide double-balanced dual cartridge seals in order to allow for seal integrity in case of flush water pressure reversal.

10. Provide springs in single and double seals, in the non-wetted end of the seal.

11. Deliver fresh water to the seals through appropriate size piping with plug valves, strainers, pressure regulators, electrically operated solenoid valves, and rotameters.

12. Wiring shall comply with the requirements of Division 16 – Electrical, and solenoid control shall comply with the requirements of Division 17 – Instrumentation and Control.
2.4 PUMP APPURTE NANCES

A. **Nameplates:** Equip each pump with a stainless steel nameplate indicating serial number(s), rated head and flow, impeller size, pump speed, and manufacturer’s name and model number.

B. **Solenoid Valves**
   1. Require the pump manufacturer to provide solenoid valves on the water or oil lubrication lines and on cooling water lines.
   2. Provide solenoid valve electrical ratings compatible with the motor control voltage.

C. **Gauges**
   1. Except for sample pumps, sump pumps, and hot water circulating pumps, equip pumps with pressure gauges installed at the pump discharge lines.
   2. Provide pump suction lines with compound gauges.
   3. Located gauges in a representative location, where not subject to shock or vibrations, in order to achieve true and accurate readings.
   4. Where subject to shock or vibrations, wall-mount the gauges or attach the gauges to galvanized channel floor stands and connect by means of flexible connectors.
   5. Provide pressure and compound gauges in accordance with the requirements of Section 409108 – Pressure Measuring.

2.5 FACTORY TESTING

A. Conduct the following tests on each indicated pump system:
   1. **Motors**
      a. Test electric motors in accordance with the requirements of Section 260510 – Electric Motors.
      b. Furnish test results to the pump manufacturer prior to the pump test.
   2. **Variable Frequency Drives**
      a. Test variable frequency drives in accordance with the requirements of Section 263940 – Medium Voltage Variable Speed Drives.
      b. Furnish test results to the pump manufacturer prior to the pump test.
   3. **Factory Non-witnessed Test**
      a. Test centrifugal pump systems with drives 10 hp up to and including 125 hp at the pump factory in accordance with the American National Standard for Centrifugal Pump Tests (ANSI/HI 1.6) acceptance Level “1U” or the American National Standard for Vertical Pump Tests (ANSI/HI 2.6) as approved by ANSI and published by the Hydraulic Institute.
b. For sump pumps and sample pumps, acceptance shall be in accordance with Level “2” of ANSI/HI 1.6, unless otherwise indicated.

c. Perform tests using the complete pump system to be furnished, including the Project motor and variable speed drive if equipped with variable speed drive.

d. For pumps with motors smaller than 100 hp, the manufacturer’s certified test motor will be accepted.

e. Testing of prototype models will not be accepted.

f. Conduct the following minimum tests and submit the test results:

1) Hydrostatic Test

2) Performance Test

   a) Conduct performance testing at maximum speed, obtain a minimum of 5 hydraulic test readings between shutoff head and 25 percent beyond the maximum indicated capacity, and record on data sheets as defined by the Hydraulic Institute standards;

   b) For variable speed driven pumps, test each pump between maximum and minimum speed at 100-RPM increments;

   c) Submit pump curves showing head, flow, bhp, and efficiency results;

3) Mechanical Test

4) NPSH

   a) Perform a net positive suction head required test (NPSHr3), if required by the specific pump Section.

   b) If not required by the specific pump Section, submit the published manufacturer-calculated NPSHr3 curve.


g. Submit certification signed by a senior official of the pump manufacturer that the pump shaft horsepower demand did not exceed the rated motor horsepower of 1.0 service rating at any point on the curve.

h. Submit test results to the ENGINEER for review prior to delivery to the Site.

4. Factory Witnessed Tests

   a. Factory-test pumps, variable speed drives, and motors, 150 hp and larger, as complete assembled systems in accordance with the indicated factory test procedure and witnessed above by the OWNER and ENGINEER.

   b. Give the ENGINEER a minimum of 2 weeks notification prior to the test.

   c. Costs for OWNER and ENGINEER shall be borne by the CONTRACTOR and shall be included in the Contract Price, including travel and subsistence costs for 2 people excluding salaries.
d. Submit test results to the ENGINEER.

e. No equipment shall be shipped until the test data have been approved by the ENGINEER.

5. Acceptance: In the event of failure of any pump to meet any of the requirements, make necessary modifications, repairs, or replacements in order to conform to the requirements of the Contract Documents, and re-test the pump until found satisfactory.

PART 3 – EXECUTION

3.1 MANUFACTURER’S SERVICES

A. Inspection, Startup, and Field Adjustment

1. Where required by the specific pump Section, furnish an authorized service representative of the manufacturer at the Site continuously to supervise the following items and to certify in writing that the equipment and controls have been properly installed, aligned, lubricated, adjusted, and readied for operation:

   a. installation of the equipment;
   
   b. inspection, checking, and adjusting the equipment;
   
   c. startup and field testing for proper operation; and
   
   d. performance of field adjustments to ensure that the equipment installation and operation comply with the indicated requirements.

B. Instruction of OWNER's Personnel

1. Where required by the individual pump Section, furnish an authorized training representative of the manufacturer at the Site for the number of Days indicated in the specific pump Section, to instruct the OWNER's personnel in the operation and maintenance of the equipment, including step-by-step troubleshooting with necessary test equipment.

2. Furnish instruction specific to the model of equipment provided.

3. Qualifications

   a. Furnish a representative with at least 2 years experience in training.
   
   b. Submit a resume for the representative.

4. Schedule the training a minimum of 3 weeks in advance of the first session.

5. Lesson Plan Review

   a. Submit the proposed training material and a detailed outline of each lesson for review.
   
   b. Incorporate review comments into the material.
6. The trainees will keep the training materials.

7. The OWNER may videotape the training for later use with the OWNER’s personnel.

3.2 INSTALLATION

A. General: Install pumping equipment in accordance with the manufacturer’s written recommendations.

B. Alignment

1. Field-test the equipment in order to verify proper alignment and freedom from binding, scraping, shaft runout, or other defects.

2. Measure the pump drive shafts just prior to assembly in order to ensure correct alignment without forcing.

3. Ensure that the equipment is secure in position and neat in appearance.

C. Lubricants: Provide the necessary oil and grease for initial operation.

3.3 PROTECTIVE COATING

A. Coat materials and equipment in accordance with the requirements of Section 099600 – Protective Coating.

3.4 FIELD TESTS

A. Field-test each pump system after installation in order to demonstrate:

1. satisfactory operation without excessive noise and vibration;

2. no material loss caused by cavitation;

3. no overheating of bearings; and,

4. indicated head, flow, and efficiency at the design point.

B. Conduct the following field testing:

1. Startup, check, and operate the pump system over its entire speed range.

2. If the pump is driven by a variable speed drive, test the pump and motor at 100-RPM increments.

3. If the pump is driven at constant speed, test the pump and motor at the maximum RPM.

4. Unless otherwise indicated, vibration shall be within the amplitude limits recommended by the Hydraulic Institute standards at a minimum of 4 pumping conditions defined by the ENGINEER.

5. Obtain concurrent readings of motor voltage, amperage, pump suction head, and pump discharge head for at least 4 pumping conditions at each pump rotational
speed, at 100-RPM increments if equipped with a variable speed drive or at maximum RPM if equipped with a constant speed drive.

6. Check each power lead to the motor for proper current balance.

7. Bearing Temperatures
   a. Determine bearing temperatures by a contact-type thermometer.
   b. Precede this test with a run time sufficient to stabilize bearing temperatures, unless an insufficient liquid volume is available to furnish such a run time.

8. Ensure that electrical and instrumentation tests conform to the requirements of the Section under which that equipment is specified.

C. Witnessing
   1. Field testing will be witnessed by the ENGINEER.
   2. Furnish 3 Days advance notice of field testing.

D. If the pumping system fails to meet the indicated requirements, modify or replace the pump and re-test as indicated above until it satisfies the indicated requirements.

E. Certification
   1. After each pumping system has satisfied the requirements, certify in writing that it has been satisfactorily tested and that final adjustments have been performed.
   2. Certification shall include the date of the field tests, a listing of persons present during the tests, and the test data.

F. The CONTRACTOR shall be responsible for costs of field tests, including related services of the manufacturer’s representative, except for power and water, which the OWNER will bear.

G. If available, the OWNER’S operating personnel will provide assistance in field testing.

- END OF SECTION -
SECTION 432115 - VERTICAL TURBINE PUMPS

PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide vertical turbine pumps and drives with associated appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 432000 - Pumps, General apply to this Section.

C. The Supplier shall examine the Site conditions, intended application, and operation of the pump system and recommend the pump that will best satisfy the indicated requirements.

PART 2 – PRODUCTS

2.1 GENERAL DESCRIPTION

A. Identification

<table>
<thead>
<tr>
<th>Pump Name</th>
<th>WDCWA Raw Water Pump</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment Number</td>
<td>P-510, P-520, P-530, P-540</td>
</tr>
<tr>
<td>Quantity</td>
<td>4</td>
</tr>
<tr>
<td>Location</td>
<td>Intake Pump Station</td>
</tr>
</tbody>
</table>

B. Operating Conditions: The WORK of this Section shall be suitable for long term operation under the following conditions:

<table>
<thead>
<tr>
<th>Duty</th>
<th>Continuous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drive</td>
<td>Variable speed</td>
</tr>
<tr>
<td>Ambient environment</td>
<td>Indoors</td>
</tr>
<tr>
<td>Ambient temperature, degrees F</td>
<td>35 to 108</td>
</tr>
<tr>
<td>Ambient relative humidity, percent</td>
<td>15 to 80</td>
</tr>
<tr>
<td>Fluid service</td>
<td>Screened raw water from the Sacramento River containing typical suspended river sediment</td>
</tr>
<tr>
<td>Fluid temperature, degrees F</td>
<td>40 to 80</td>
</tr>
<tr>
<td>Fluid pH range</td>
<td>6 to 8</td>
</tr>
<tr>
<td>Fluid specific gravity</td>
<td>1.0</td>
</tr>
</tbody>
</table>
C. Performance Requirements*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project site elevation, ft, msl</td>
<td>40</td>
</tr>
<tr>
<td>Maximum shutoff head, ft</td>
<td>310</td>
</tr>
<tr>
<td>Design flow capacity, gpm</td>
<td>6,940</td>
</tr>
<tr>
<td>Design flow bowl head TDH, ft</td>
<td>175</td>
</tr>
<tr>
<td>Design flow minimum bowl efficiency, percent</td>
<td>84</td>
</tr>
<tr>
<td>Maximum flow capacity at maximum speed, gpm</td>
<td>10,000</td>
</tr>
<tr>
<td>Maximum flow bowl head TDH, ft, plus 10-feet, minus 0-feet</td>
<td>55</td>
</tr>
<tr>
<td>Maximum flow minimum bowl efficiency, percent</td>
<td>55</td>
</tr>
<tr>
<td>Maximum flow minimum available NPSH, ft absolute</td>
<td>42.4</td>
</tr>
<tr>
<td>Minimum flow capacity at maximum speed, gpm</td>
<td>4,800</td>
</tr>
<tr>
<td>Minimum flow bowl head TDH at maximum speed, ft, plus or minus 5-ft</td>
<td>210</td>
</tr>
<tr>
<td>Minimum flow bowl efficiency, percent</td>
<td>70</td>
</tr>
<tr>
<td>Maximum pump speed, rpm</td>
<td>1,200</td>
</tr>
<tr>
<td>Minimum pump speed, rpm</td>
<td>670</td>
</tr>
<tr>
<td>Maximum motor speed, rpm</td>
<td>1,200</td>
</tr>
<tr>
<td>Minimum motor size, hp</td>
<td>400</td>
</tr>
</tbody>
</table>

* For design pump systems curves refer to “Pump Performance” chart provided at the end of this section.
D. Pump Dimensions

<table>
<thead>
<tr>
<th>Description</th>
<th>Refer to Contract Drawings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length from base plate to suction bell, ft</td>
<td></td>
</tr>
<tr>
<td>Minimum column diameter, in</td>
<td>18</td>
</tr>
<tr>
<td>Minimum discharge flange nominal diameter, in</td>
<td>18</td>
</tr>
<tr>
<td>Discharge flange rating ANSI, Class</td>
<td>150</td>
</tr>
<tr>
<td>Minimum column line shaft diameter, in</td>
<td>Per Manufacturer Requirements</td>
</tr>
<tr>
<td>Maximum bowl or bell diameter, whichever is greater, in</td>
<td>31</td>
</tr>
</tbody>
</table>

2.2 PUMP REQUIREMENTS

A. Materials of Construction: Materials of construction of vertical turbine pumps shall conform to the following requirements:

<table>
<thead>
<tr>
<th>Description</th>
<th>Cast Iron / Bronze Fitted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bowl</td>
<td>Cast Iron ASTM A48 Cl 30</td>
</tr>
<tr>
<td>Impeller</td>
<td>Lead-free Al. Bronze ASTM B-148-953 or 952</td>
</tr>
<tr>
<td>Shaft</td>
<td>416SS</td>
</tr>
<tr>
<td>Column Pipe</td>
<td>Steel, ASTM A36 schedule 30 minimum</td>
</tr>
<tr>
<td>Discharge Head Bearing</td>
<td>Lead Free Bronze per pump manufacturer recommendation</td>
</tr>
<tr>
<td>Bowl Bearings</td>
<td>Lead Free Bronze Backed Rubber “Marine” Style, bowl bearings to be placed on a hard chrome bearing journals</td>
</tr>
<tr>
<td>Suction Bearing</td>
<td>Lead Free Bronze per pump manufacturer recommendation</td>
</tr>
<tr>
<td>Bolting</td>
<td>316SS</td>
</tr>
<tr>
<td>Anti-Vortex Suppressor</td>
<td>316SS</td>
</tr>
</tbody>
</table>
### B. **Pump Construction:** Construction of vertical turbine pumps shall conform to the following requirements.

<table>
<thead>
<tr>
<th>Component</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bowls</strong></td>
<td>Interior and exterior of sizes 16-inches and larger coated with fusion bonded epoxy in accordance with Section 099600 - Protective Coating, except that DFT shall be 10- to 12-mils.</td>
</tr>
<tr>
<td><strong>Impeller</strong></td>
<td>Statically and dynamically balanced. Impeller shall be balanced to ISO 1940 G6.3</td>
</tr>
<tr>
<td><strong>Impeller shaft method of connection</strong></td>
<td>Double keyed with Type 316 stainless steel shaft keys</td>
</tr>
<tr>
<td><strong>Wear rings</strong></td>
<td>Wear Rings Shall be replaceable with minimum 50 BHN difference in hardness between bowl and impeller wear rings.</td>
</tr>
<tr>
<td><strong>Suction bell and vortex suppressor</strong></td>
<td>Suction bell shall be the same material and coating as the bowl. Vortex suppressor shall be designed and mounted to the suction bell as shown on the drawings. Vortex suppressor shall be Type 316 SS.</td>
</tr>
<tr>
<td><strong>Column</strong></td>
<td>Steel pipe not less than Schedule 30, epoxy-lined and coated, in maximum 10-ft lengths, flanged with registered fit and 316 SS through bolting. All flange faces shall be machined after welding onto the column.</td>
</tr>
<tr>
<td><strong>Line shaft and couplings</strong></td>
<td>Type 416 stainless steel for water lubricated shaft in maximum 10-ft lengths, sized for a critical speed of min 20 percent above max operating speed. Shaft coupling shall be Type 316 stainless steel, threaded or keyed to the shaft.</td>
</tr>
<tr>
<td><strong>Shaft lubrication</strong></td>
<td>Fresh water lubricated, with solenoid valve.</td>
</tr>
<tr>
<td></td>
<td>Discuss with pump manufacturer and mechanical engineer.</td>
</tr>
<tr>
<td><strong>Shaft enclosing tube</strong></td>
<td>Schedule 80 steel integrally welded with outer column. The coating of the enclosing tube exterior shall match that of the column pipe ID.</td>
</tr>
<tr>
<td><strong>Shaft seal</strong></td>
<td>Fresh water lubricated packed tension nut provided with injection port below the packing.</td>
</tr>
<tr>
<td></td>
<td>Fresh water to be obtained from external water source.</td>
</tr>
<tr>
<td><strong>Line shaft bearings</strong></td>
<td>Extra length spiral grooved sleeve-type bearings at maximum 5-feet centers for enclosed shaft</td>
</tr>
<tr>
<td><strong>Discharge head</strong></td>
<td>Fabricated carbon steel, interior epoxy-lined, exterior epoxy prime compatible with finish coat in field, reinforced to withstand pump thrust, with flange connections, base plate,</td>
</tr>
</tbody>
</table>
and minimum 1-1/4 inch 3000 lb. forged steel half-couplings for air valve, pressure switch, and drain connections. Per specification 460100 Equipment, General Provisions, Seismic calculations shall be prepared by the pump manufacturer and submitted to the ENGINEER for review.

When a vibration and torsional analysis is required per Specification 432000 Pumps, General; the pump manufacturer shall include a structural vibration and torsional analysis of the fabricated discharge head. The analysis shall be performed using finite element analysis methods commonly utilized in commercially available FEA computer codes or other proven computer programs. Results of this analysis shall be included in the Rotodynamic Analysis Report submittal.

### Vibration and torsional analysis

Submit a vibration and torsional analysis is required per Specification 432000 Pumps, The pump manufacturer shall include a structural vibration and torsional analysis of the fabricated discharge head. The analysis shall be performed using finite element analysis methods commonly utilized in commercially available FEA computer codes or other proven computer programs. Results of this analysis shall be included in the Rotodynamic Analysis Report submittal.

### Motor shaft coupling

3 piece, heavy-duty adjustable spacer coupling, with registered fit, to allow for impeller adjustment for solid shaft motors

### Bottom bearing

Close tolerance sleeve type with length min 2-1/2 times shaft diameter, permanently grease-lubricated for suction bell with non-soluble grease.

### Bowl bearing lubrication

Product-lubricated

### Sole plate

Extra-heavy, hot dip galvanized carbon steel sole plate, drilled and tapped to match discharge head.

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**C. Drive**

1. Each pump shall be provided with a vertical, solid shaft, premium efficiency, inverter duty, high thrust open, drip proof, 4000 volt, 3 phase, 60 Hertz heavy duty, electric motor in accordance with Section 260512 – Large Induction Motors. Each electric motor shall be designed to accept the total unbalanced thrust imposed by the pump.

2. Each pump shall be provided with a variable speed drive in accordance with Section 263940 – Medium Voltage Variable Frequency Drives. The variable frequency drive
controller and components shall be housed in a local control panel indicated in Section 409200 - Control Panels.

D. Anti-Vortex Suppressor

1. Provide anti-vortex suppressor to mount at the bottom of the suction bell as depicted on the Drawings.

2. Design anti-vortex suppressors to minimize solids plugging and to break up vortices entering the pump. Open area of an anti-vortex suppressor shall have an open area of at least 4 times the suction pipe area. Anti-vortex suppressors shall be fabricated of welded type 316 stainless steel plates of 3/16-inch minimum thickness, of an overall cylindrical shape, with the bottom consisting of a perpendicular grid arrangement of vertical plates, and the circumference of the suppressor consisting of vertical plates oriented radially inward. Anti-vortex suppressor shall be based on designs which have undergone computerized modeling, physical hydraulic modeling, or field testing of at least 5 years, and have proven to suppress the formation of vortices.

2.3 PUMP CONTROLS

A. Pumps shall be controlled in accordance with Section 409010 - Control Strategies.

2.4 SPARE PARTS

A. One complete set of the following spare parts shall be furnished:

1. One suction bell bearing assembly
2. One set of impeller, bowl and discharge case bearings
3. One set of impeller with wear ring installed
4. One set of wear rings per stage
5. One set of pump shaft bearings
6. Two sets of gaskets and O-rings

2.5 MANUFACTURERS, OR APPROVED EQUAL

A. Flowserve Pumps

B. Weir Floway Pumps

PART 3 – EXECUTION

3.1 SERVICES OF MANUFACTURER

A. Inspection, Startup, and Field Adjustment: The service representative of the manufacturer shall be continuously at the Site during installation to furnish the services required by Section 460100.

B. Instruction of OWNER'S Personnel: The training representative of the manufacturer shall be present at the Site for 1 Day to furnish the services required by Section 460100.
C. For the purposes of this paragraph, a Day is defined as an 8 hour period at the Site, excluding travel time. The 8 hour period shall be completed over a minimum of two (2) calendar days.

D. The ENGINEER may require that the inspection, startup, and field adjustment services above be furnished in 3 separate trips.

- END OF SECTION -
PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide vertical mixed-flow pumps and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 432000 - Pumps, General apply to this Section.

C. The Supplier shall examine the Site conditions, intended application, and operation of the pump system and recommend the pump which will best satisfy the indicated requirements.

D. Submit torsional and lateral analysis for the pumps.

PART 2 – PRODUCTS

2.1 GENERAL DESCRIPTION

A. Identification

<table>
<thead>
<tr>
<th>Pump Name</th>
<th>RD2035 Raw Water Pump</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment Number</td>
<td>P-110, P-120, P-130, P-140, P-150</td>
</tr>
<tr>
<td>Quantity</td>
<td>5</td>
</tr>
<tr>
<td>Location</td>
<td>Intake Pump Station</td>
</tr>
</tbody>
</table>

B. Operating Conditions: The WORK of this Section shall be suitable for long term operation under the following conditions:

<table>
<thead>
<tr>
<th>Duty</th>
<th>Continuous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drive</td>
<td>Constant speed</td>
</tr>
<tr>
<td>Ambient environment</td>
<td>Indoors</td>
</tr>
<tr>
<td>Ambient temperature, degrees F</td>
<td>35 to 108</td>
</tr>
<tr>
<td>Ambient relative humidity, percent</td>
<td>15 to 80</td>
</tr>
<tr>
<td>Fluid service</td>
<td>Raw water</td>
</tr>
<tr>
<td>Fluid temperature, degrees F</td>
<td>40 to 80</td>
</tr>
<tr>
<td>Fluid pH range</td>
<td>6 to 8</td>
</tr>
<tr>
<td>Fluid specific gravity</td>
<td>1.0</td>
</tr>
<tr>
<td>Project site elevation, ft msl</td>
<td>40</td>
</tr>
</tbody>
</table>
C. Performance Requirements

<table>
<thead>
<tr>
<th>Performance Requirement</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum shutoff head, ft</td>
<td>130</td>
</tr>
<tr>
<td>Design/Minimum flow capacity, gpm</td>
<td>35,912</td>
</tr>
<tr>
<td>Design/Minimum flow bowl head TDH, ft</td>
<td>26.01</td>
</tr>
<tr>
<td>Design/Minimum flow minimum bowl efficiency, percent</td>
<td>76</td>
</tr>
<tr>
<td>Design/Minimum flow minimum available NPSH, ft absolute</td>
<td>37.9</td>
</tr>
<tr>
<td>Head at Best Efficiency Point, ft, plus or minus 5-feet</td>
<td>20.0</td>
</tr>
<tr>
<td>Best Efficiency Point minimum bowl efficiency, percent</td>
<td>83</td>
</tr>
<tr>
<td>Maximum flow capacity at maximum speed, gpm</td>
<td>42,250</td>
</tr>
<tr>
<td>Maximum flow pump head TDH, ft, plus 10-feet, minus 0-feet</td>
<td>10.34</td>
</tr>
<tr>
<td>Maximum flow minimum bowl efficiency, percent</td>
<td>65</td>
</tr>
<tr>
<td>Maximum flow minimum available NPSH, ft absolute</td>
<td>44.3</td>
</tr>
<tr>
<td>Motor size, hp</td>
<td>400</td>
</tr>
</tbody>
</table>

For additional information regarding the performance characteristics of the pumps, refer to the “Pump Performance” chart provided at the end of this Section.

D. Pump Dimensions

<table>
<thead>
<tr>
<th>Pump Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length from base plate to suction bell, ft</td>
<td>Refer to Contract Drawings</td>
</tr>
<tr>
<td>Minimum column diameter, in</td>
<td>36</td>
</tr>
<tr>
<td>Discharge diameter, in</td>
<td>42</td>
</tr>
<tr>
<td>Discharge flange rating ANSI, psi</td>
<td>75</td>
</tr>
<tr>
<td>Minimum column shaft diameter, in</td>
<td>Per Manufacturer Requirements</td>
</tr>
<tr>
<td>Maximum bowl or bell diameter (including vortex strainer), whichever is greater, in</td>
<td>60</td>
</tr>
</tbody>
</table>
### 2.2 PUMP REQUIREMENTS

**A. Pump Construction:** Construction of vertical mixed-flow pumps shall conform to the following requirements:

<table>
<thead>
<tr>
<th>Component</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suction and Discharge Bowls</td>
<td>Cast-iron. Interior water passages and exterior surfaces coated with 10- to 12-mils vitreous enamel for sizes 18-inches and smaller; interior and exterior of sizes 20-inches and larger coated with fusion bonded epoxy in accordance with Section 099600 - Protective Coating, except that DFT shall be 10- to 12-mils.</td>
</tr>
<tr>
<td>Impeller</td>
<td>Lead-free aluminum bronze per ASTM B148-953, statically and dynamically balanced</td>
</tr>
<tr>
<td>Impeller and shaft method of connection</td>
<td>Type 316 stainless steel shaft key</td>
</tr>
<tr>
<td>Bowl and impeller wear rings</td>
<td>Nickel aluminum bronze per B148-95520 BHN for impeller and bowl, replaceable; or type 316 stainless steel, replaceable</td>
</tr>
<tr>
<td>Bowl shaft</td>
<td>Stainless steel, Type 410, 416, or 316</td>
</tr>
<tr>
<td>Suction bell and vortex suppressor</td>
<td>Vortex suppressor on suction bell, Type 316</td>
</tr>
<tr>
<td>Column</td>
<td>Steel pipe, not less than Schedule 30, epoxy-lined and coated, in maximum 10-ft lengths, flanged with registered fit and through bolting. Flange faces shall be machined after welding onto the column.</td>
</tr>
<tr>
<td>Line shaft and couplings</td>
<td>Carbon steel enclosed line shaft, ASTM A 108, Grade 1045 shaft in maximum 10-ft lengths, sized for a critical speed of min 20 percent above max operating speed Enclosed Shaft coupling shall be Type 316 stainless steel, threaded or keyed to the shaft.</td>
</tr>
<tr>
<td>Journals at bearings and shaft seal</td>
<td>Shafts turned, ground, and polished with min 8-mils thick hard chrome. Shaft seal with tension plate for oil lubrication.</td>
</tr>
<tr>
<td>Shaft lubrication</td>
<td>Food grade oil lubricated, with solenoid valve and minimum 2-gallon capacity oil reservoir</td>
</tr>
<tr>
<td>-------------------</td>
<td>--------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Shaft enclosing tube</td>
<td>Steel, schedule 80, with tube supports as required</td>
</tr>
<tr>
<td>Discharge head and line shaft bearings</td>
<td>Bronze per ASTM B584-932, extra length spiral grooved sleeve-type at maximum 5-feet centers for enclosed shaft</td>
</tr>
<tr>
<td>Discharge head</td>
<td>Fabricated steel, reinforced to withstand pipe thrust, epoxy-lined with flange, base plate, and minimum 1-1/4 inch, 3000 lb forged steel half-couplings for air valve, pressure switch, and drain connections. Seismic calculations shall be submitted to the ENGINEER for review</td>
</tr>
<tr>
<td>Motor coupling</td>
<td>3-piece, heavy-duty adjustable coupling with registered fit, to allow for impeller adjustment for solid shaft motors</td>
</tr>
<tr>
<td>Suction case and bowl bearings</td>
<td>Close tolerance sleeve type, permanently grease-lubricated for suction bell with non-soluble grease, or with Type 316 stainless steel grease tube and fitting extended to base plate</td>
</tr>
<tr>
<td>Sole plate</td>
<td>Extra-heavy, hot dip galvanized carbon steel sole plate, drilled and tapped to match discharge head. Contractor shall coordinate with pump manufacturer size of floor opening to insure adequate clearance for removal and installation of the pumps.</td>
</tr>
</tbody>
</table>

B. Direct drive with vertical solid shaft, electric, heavy-duty, high thrust, premium efficiency motor capable of accepting the total, unbalanced thrust imposed by the pump and suitable for 480 volt, 3 phase, 60 Hz power supply, in accordance with Section 260510 - Electric Motors.

C. Anti-Vortex Suppressor

1. Provide anti-vortex suppressor to mount at the bottom of the suction bell as depicted on the Drawings.

2. Design anti-vortex suppressors to minimize solids plugging and to break up vortices entering the pump. Open area of an anti-vortex suppressor shall have an open area of at least 4 times the suction pipe area. Anti-vortex suppressors shall be fabricated of welded type 316 stainless steel plates of 3/16-inch minimum thickness, of an overall cylindrical shape, with the bottom consisting of a perpendicular grid arrangement of vertical plates, and the circumference of the suppressor consisting of vertical plates oriented radially inward. Anti-vortex suppressor shall be based on
designs which have undergone computerized modeling, physical hydraulic modeling, or field testing of at least 5 years, and have proven to suppress the formation of vortices.

2.3 PUMP CONTROLS

A. Pumps shall be controlled in accordance with Section 409300 - Control Strategies.

2.4 SPARE PARTS

A. One complete set of the following spare parts shall be furnished:

1. One suction case bearing assembly
2. One set of bowl and discharge case bearings
3. One impeller
4. One set of bowl liners
5. One set of pump shaft bearings
6. Two sets of gaskets and O-rings

2.5 MANUFACTURERS OR EQUAL

A. Casade Pump Company

B. Prime Pump

C. Johnston Pump Company (Sulzer Pumps)

PART 3 -- EXECUTION

3.1 SERVICES OF MANUFACTURER

A. **Inspection, Startup, and Field Adjustment:** The service representative of the manufacturer shall be present continuously at the Site to furnish the services required by Section 432000.

B. **Instruction of OWNER'S Personnel:** The training representative of the manufacturer shall be present at the Site for 1 Day to furnish the services required by Section 432000.

C. For the purposes of this paragraph, a Day is defined as an 8 hour period at the Site, excluding travel time.

D. The ENGINEER may require that the inspection, startup, and field adjustment services above be furnished in 3 separate trips.

- END OF SECTION -
PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide submersible sump pumps and appurtenant WORK, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 410000 - Equipment General Provisions apply to the WORK of this Section.

C. The Supplier shall examine the Site conditions, intended application, and operation of the pump system and recommend the pump that will satisfy the indicated requirements.

PART 2 – PRODUCTS

2.1 SEDIMENT CONTROL PUMPS

A. Identification

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>P-410</td>
<td></td>
</tr>
<tr>
<td>P-420</td>
<td></td>
</tr>
</tbody>
</table>

B. Operating Conditions: The WORK of this Section shall be suitable for long term operation under the following conditions:

<table>
<thead>
<tr>
<th>Duty</th>
<th>Continuous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drive</td>
<td>Constant speed</td>
</tr>
<tr>
<td>Ambient environment</td>
<td>Submerged</td>
</tr>
<tr>
<td>Ambient temperature, degrees F</td>
<td>40 to 80</td>
</tr>
<tr>
<td>Fluid service</td>
<td>Raw water</td>
</tr>
<tr>
<td>Fluid temperature, degrees F</td>
<td>40 to 80</td>
</tr>
<tr>
<td>Fluid pH range</td>
<td>6 to 8</td>
</tr>
<tr>
<td>Fluid specific gravity</td>
<td>1.0</td>
</tr>
<tr>
<td>Project site elevation, ft. a.s.l</td>
<td>40</td>
</tr>
<tr>
<td>Minimum available NPSH, ft absolute</td>
<td>40.9</td>
</tr>
<tr>
<td>Maximum size of spheres to pass, in. dia</td>
<td>0.07 (1.75 mm)</td>
</tr>
</tbody>
</table>
C. Performance Requirements

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum shutoff head, ft</td>
<td>220</td>
</tr>
<tr>
<td>Design flow capacity, gpm</td>
<td>1120</td>
</tr>
<tr>
<td>Design flow pump head, TDH ft</td>
<td>122</td>
</tr>
<tr>
<td>Design flow minimum pump efficiency, percent</td>
<td>40</td>
</tr>
<tr>
<td>Maximum flow capacity, gpm</td>
<td>1500</td>
</tr>
<tr>
<td>Maximum flow pump head, TDH ft, plus or minus 10-feet</td>
<td>110</td>
</tr>
<tr>
<td>Maximum flow minimum pump efficiency, percent</td>
<td>42</td>
</tr>
<tr>
<td>Minimum flow capacity, gpm</td>
<td>575</td>
</tr>
<tr>
<td>Minimum flow pump head, TDH ft, plus or minus 30-feet</td>
<td>160</td>
</tr>
<tr>
<td>Minimum flow pump efficiency, percent</td>
<td>27</td>
</tr>
<tr>
<td>Maximum motor speed, rpm</td>
<td>1750</td>
</tr>
<tr>
<td>Maximum motor size, hp</td>
<td>125</td>
</tr>
</tbody>
</table>

D. Pump Dimensions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump discharge size, inches</td>
<td>10-inches via increaser as required</td>
</tr>
<tr>
<td>Discharge flange rating, psi</td>
<td>150</td>
</tr>
</tbody>
</table>

2.2 PUMP REQUIREMENTS

A. Construction: Construction of submersible sump pumps shall conform to the following requirements:

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump casing</td>
<td>Cast iron</td>
</tr>
<tr>
<td>Impeller</td>
<td>Recessed cast iron</td>
</tr>
<tr>
<td>Bearings</td>
<td>Permanently lubricated ball and sleeve type</td>
</tr>
<tr>
<td>Shaft</td>
<td>Stainless steel, series 400</td>
</tr>
<tr>
<td>Seal</td>
<td>Mechanical seal</td>
</tr>
<tr>
<td>Mounting Method</td>
<td>Slide rail with stainless steel chain and hook</td>
</tr>
<tr>
<td>Pump Connection</td>
<td>Flange</td>
</tr>
</tbody>
</table>

B. Drive: Enclosed, submerged, electric 1750 rpm motor, suitable for 480 volt, 3 phase, 60 Hz ac power supply, with armored cable, in accordance with Section 260510 - Electric Motors.

C. Control: Pumps shall be controlled in accordance with Section 409300 - Control Strategies.
2.3 PROTECTIVE COATING
   A. Pumps shall be coated in accordance with Section 099600 - Protective Coating.

2.4 MANUFACTURERS, OR EQUAL
   A. ABS Pumps, Inc.
   B. Aurora Pumps
   C. Yeomans-Morris-Chicago Pump Company
   D. Crane-Deming
   E. Flygt Corporation
   F. Goulds Pumps Inc.
   G. Pacific Pumping Company

PART 3 -- EXECUTION

3.1 INSTALLATION
   A. Pumping equipment shall be installed in accordance with the Shop Drawings and as indicated.
   B. General installation requirements shall be in accordance with Section 432000 - Pumps, General.

- END OF SECTION -
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PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. Provide valves, actuators, and appurtenances, complete and operable, as indicated in accordance with the Contract Documents.

B. The requirements of Section 410000 – Equipment General Provisions, apply to the WORK of this Section.

C. Apply the provisions of this Section to all valves and valve actuators except where otherwise indicated.

D. Valves and actuators in particular locations may require a combination of units, sensors, limit switches, and controls, as indicated.

E. Support

1. Where a valve is to be supported by means other than the piping to which it is attached, obtain from the valve manufacturer a design for its support and foundation that satisfies the criteria in Section 410000 – Equipment General Provisions.

2. Submit the support design, including drawings and calculations sealed by an engineer, with the Shop Drawings.

3. Provide the support after the design has been approved.

F. Unit Responsibility

1. Make a single manufacturer responsible for the coordination of design, assembly, testing, and furnishing of each valve; however, the CONTRACTOR shall be responsible to the OWNER for compliance with the requirements of each valve Section.

2. Unless indicated otherwise, the responsible manufacturer shall be the manufacturer of the valve.

G. Single Manufacturer: Where 2 or more valves of the same type and size are required, the valves shall be furnished by the same manufacturer.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 013300 – Contractor Submittals.

B. Furnish the following information on Shop Drawings:

1. valve name, size, Cv factor, pressure rating, identification number (if any), and specification section number;

2. complete information on the valve actuator, including size, manufacturer, model number, limit switches, and mounting;
3. cavitation limits for control valves;

4. assembly drawings showing part nomenclature, materials, dimensions, weights, and relationships of valve handles, hand wheels, position indicators, limit switches, integral control systems, needle valves, and control systems;

5. data in accordance with Section 260510 – Electric Motors, for electric motor-actuated valves;

6. complete wiring diagrams and control system schematics; and,

7. a valve-labeling schedule, listing the valves to be furnished with stainless steel tags, indicating in each case the valve location and the proposed wording for the label.

C. Furnish a technical manual containing the required information for each valve, as indicated.

D. Furnish a spare parts list, containing the required information for each valve assembly, as indicated.

E. Factory Test Data

1. Where indicated, submit signed, dated, and certified factory test data for each valve requiring certification, before shipping the valve.

2. Furnish a certification of quality and test results for factory-applied coatings.

PART 2 – PRODUCTS

2.1 PRODUCTS

A. General

1. Provide valves and gates of new and current manufacture.

2. Provide shut-off valves 6-inch and larger with actuators with position indicators.

3. Provide gate valves 18-inch and larger, or where chain wheel is required, with spur gear and hand wheel.

4. Provide buried valves with valve boxes and covers containing position indicators and valve extensions.

5. Provide manual shut-off valves mounted higher than 7 feet above the working level with chain actuators.

B. Valve Actuators: Unless otherwise indicated, provide valve actuators in accordance with Section 433012 – Valve and Gate Actuators.

C. Protective Coating

1. Coat the exterior surfaces of valves and the wet interior surfaces of ferrous valves of sizes 4-inch and larger in accordance with the requirements of Section 099600 – Protective Coating.
2. The valve manufacturer shall certify in writing that the required coating has been applied and tested in the manufacturing plant prior to shipment, in accordance with the indicated requirements.

3. Do not epoxy-coat the flange faces of valves.

D. Valve Labeling

1. Except when such requirement is waived by the ENGINEER in writing, provide a label on shut-off valves and control valves except for hose bibbs and chlorine cylinder valves.

2. Furnish a label composed of 1/16-inch plastic or stainless steel, a minimum of 2 inches by 4 inches in size, as indicated in Section 431051 – Piping Identification Systems, and permanently attached to the valve or on the wall adjacent to the valve as directed by the ENGINEER.

E. Valve Testing

1. As a minimum, unless otherwise indicated or recommended by the reference standards, test valves 3 inches in diameter and smaller in accordance with the manufacturer's standard procedure.

2. Factory-test valves 4 inches in diameter and larger as follows:
   a. Hydrostatic Testing
      1) Subject valve bodies to an internal hydrostatic pressure equivalent to twice the water-rated pressure of the valve.
      2) Metallic valves rating pressures shall be at 100 degrees F.
      3) Plastic valves rating pressures shall be at 73 degrees F, or at a higher temperature according to material type.
      4) During the hydrostatic test, there shall be no leakage through the valve body, end joints, or shaft seals, nor shall parts of the valve be permanently deformed.
      5) Allow a test duration of at least 10 minutes, in order to allow visual examination for leakage.
   b. Seat Testing
      1) Test the valves for leaks in the closed position, with the pressure differential across the seat equal to the water rated pressure of the valve.
      2) Provide a test duration of at least 10 minutes, in order to allow visual examination for leakage.
      3) The leakage rate shall be the more stringent of the following:
         a) as recommended by the reference standard for that type of valve; or,
b) leakage past the closed valve not to exceed one fluid ounce per hour per inch diameter for metal seated valves, and drop-tight for resilient seated valves.

c. Performance Testing

1) Shop-operate the valves from the fully-closed to the fully-open position, and reverse under no-flow conditions in order to demonstrate that the valve assembly operates properly.

F. Certification: Prior to shipment of valves over 12-inches in size, submit certified, notarized copies of the hydrostatic factory tests, showing compliance with the applicable standards of AWWA, ANSI, or ASTM.


2.2 MATERIALS

A. General

1. Provide materials suitable for the intended application.

2. Provide materials in contact with potable water listed as compliant with NSF Standard 61.

3. Ensure that materials not indicated are of high-grade standard commercial quality, free from defects and imperfections that might affect the serviceability of the product for the purpose for which it is intended.

4. Unless otherwise indicated, provide valve and actuator bodies conforming to the following requirements:


b. Ductile Iron: ASTM A 536 - Ductile Iron Castings, or to ASTM A 395 - Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures


d. Bronze: ASTM B 62 - Composition Bronze or Ounce Metal Castings, and valve stems not subject to dezincification shall conform to ASTM B 584 - Copper Alloy Sand Castings for General Applications

e. Stainless Steel: Stainless steel valve and operator bodies and trim shall conform to ASTM A 351 - Steel Castings, Austenitic, for High-Temperature Service, Grade CF8M, or shall be Type 316 stainless steel

f. PVC: Polyvinyl chloride materials for valve body, flanges, and cover shall conform to Cell Classification 12454
g. CPVC: Chlorinated Poly Vinyl Chloride materials for valve body, flanges, and cover shall conform to Cell Classification 23447

h. NSF Standard 14: Materials shall be listed for use in contact with potable water.

2.3 VALVE CONSTRUCTION

A. Bodies

1. Provide valve bodies that are cast, molded (in the case of plastic valves), forged, or welded, of the materials indicated, and with smooth interior passages.

2. Provide wall thicknesses uniform and in agreement with the applicable standards for each type of valve, without casting defects, pinholes, and other defects that could weaken the body.

3. Perform welds on welded bodies by certified welders and ground welds smooth.

4. Provide valve ends as indicated, and rated for the maximum temperature and pressure to which the valve will be subjected.

B. Valve End Connections

1. Unless otherwise indicated, valves 2-1/2 inches in diameter and smaller may be provided with threaded end connections.

2. Provide valves 3 inches in diameter and larger with flanged end connections.

C. Bonnets

1. Connect valve bonnets to the body by clamping, screwing, or flanging.

2. Provide bonnets of the same material, temperature, and pressure rating as the body.

3. Make provisions for the stem seal with the necessary glands, packing nuts, and yokes.

D. Stems

1. Provide valve stems of the materials indicated, or, if not indicated, of the best commercial material for the specific service, with adjustable stem packing, O-rings, chevron V-type packing, or other suitable seal.

2. Where subject to dezincification, ensure that bronze valve stems conform to ASTM B 62, containing not more than 5 percent of zinc or more than 2 percent of aluminum, with a minimum tensile strength of 30,000 psi, a minimum yield strength of 14,000 psi, and an elongation of at least 10 percent in 2 inches.

3. Where dezincification is not a problem, bronze conforming to ASTM B 584 may be used, except that the zinc content shall not exceed 16 percent.
E. Stem Guides

1. Provide stem guides spaced 10 feet on centers, unless the manufacturer can demonstrate by calculation that a different spacing is acceptable.

2. Construct submerged stem guides from Type 304 stainless steel.

F. Internal Parts

1. Provide internal parts and valve trim as indicated for each individual valve.

2. Where not indicated, construct valve trim from Type 316 stainless steel or other best-suited material.

G. Nuts and Bolts: Provide nuts and bolts on valve flanges and supports in accordance with the requirements of Section 055000 – Miscellaneous Metalwork.

2.4 VALVE ACCESSORIES

A. Provide valves complete with the accessories required to provide a functional system.

2.5 SPARE PARTS

A. Furnish the required spare parts, suitably packaged and labeled with the valve name, location, and identification number.

B. Furnish the name, address, and telephone number of the nearest distributor for the spare parts of each valve.

C. Spare parts are intended for use by the OWNER, after expiration of the correction of defects period.

2.6 MANUFACTURERS

A. Valve manufacturers shall have a successful record of not less than 5 years in the manufacture of the indicated valves.

PART 3 – EXECUTION

3.1 VALVE INSTALLATION

A. General

1. Install valves, actuating units, stem extensions, valve boxes, and accessories in accordance with the manufacturer's written instructions and as indicated.

2. Adequately brace gates in order to prevent warpage and bending under the intended use.

3. Firmly support valves in order to avoid undue stresses on the pipe.

B. Access: Install valves in a manner to provide easy access for actuation, removal, and maintenance, and to avoid interference between valve actuators and structural members, handrails, and other equipment.
C. Valve Accessories

1. Where combinations of valves, sensors, switches, and controls are indicated, properly assemble and install such items such that systems are compatible and operating properly.

2. Clearly note the relationship between interrelated items on Shop Drawing submittals.

- END OF SECTION -
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PART 1 – GENERAL

1.1 THE REQUIREMENT

A. Provide valve and gate actuators and appurtenances, complete and operable, as indicated in accordance with the Contract Documents.

B. The provisions of this Section apply to valves and gates except where otherwise indicated in the Contract Documents.

C. **Unit Responsibility:** Make the valve or gate manufacturer responsible for the coordination of design, assembly, testing, and installation of actuators on the valves and gates; however, the CONTRACTOR shall be responsible to the OWNER for compliance of the valves, gates, and actuators with the Contract Documents.

D. Where 2 or more valve or gate actuators of the same type or size are required, the actuators shall be produced by the same manufacturer.

E. The requirements of Section 260515 – Local Control Stations and Miscellaneous Electrical Devices apply to the WORK of this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 013300 – Contractor Submittals and Section 433000 – Valves, General.

B. Submit Shop Drawing information for actuators with the valve and gate submittals as a complete package.

C. Submit calculations showing dynamic seating and unseating torques versus the output torque of the actuator.

PART 2 – PRODUCTS

2.1 GENERAL

A. Unless otherwise indicated, provide shut-off and throttling valves and externally actuated valves and gates with manual or power actuators.

B. Provide actuators complete and operable with mounting hardware, motors, gears, controls, wiring, solenoids, hand wheels, levers, chains, and extensions, as applicable.

C. Provide actuators with torque ratings equal to or greater than required for valve seating and dynamic torques, whichever is greater, and capable of holding the valve in any intermediate position between fully-open and fully-closed without creeping or fluttering.

D. Actuator torque ratings for butterfly valves shall be determined in accordance with AWWA C504 - Rubber-Seated Butterfly Valves.

E. Identify wires of motor-driven actuators by unique numbers.
F. Manufacturers

1. Where indicated, certain valves and gates may be provided with actuators manufactured by the valve or gate manufacturer.

2. Where actuators are furnished by different manufacturers, coordinate the selection to result in the fewest number of manufacturers possible.

G. Materials

1. Provide actuators of current models, of the best commercial quality materials, and liberally sized for the required torque.

2. Provide materials suitable for the environment in which the valve or gate is to be installed.

H. Actuator Mounting and Position Indicators

1. Securely mount actuators by means of brackets or hardware specially designed and sized for this purpose and of ample strength.

2. Cast the word "OPEN" on each valve or actuator, with an arrow indicating the direction to open in the counter-clockwise direction.

3. Equip gear and power actuators with position indicators.

4. Where possible, locate manual actuators between 48 and 60 inches above the floor or the permanent working platform.

I. Standards: Unless otherwise indicated and where applicable, provide actuators in accordance with AWWA C 540 - Power-Actuating Devices for Valves and Sluice Gates.

J. Functionality: Coordinate electric, pneumatic, and hydraulic actuators with the power requirements of Division 26 – Electrical, and instrumentation equipment as indicated in Section 409100 – Process Control and Instrumentation Systems.

K. Provide fasteners in accordance with the requirements of Section 055000 – Miscellaneous Metalwork.

L. Provide coatings in accordance with the requirements of Section 099600 – Protective Coating.

2.2 MANUAL ACTUATORS

A. General

1. Unless otherwise indicated, provide valves and gates with manual actuators.

2. Provide valves in sizes up to and including 4 inches with direct-acting lever or hand wheel actuators of the manufacturer's best standard design.

3. Provide valves and gates larger than 4-inch with gear-assisted manual actuators, with an operating pull of maximum 60 pounds on the rim of the hand wheel.
4. Provide buried and submerged gear-assisted valves, gates, gear-assisted valves for pressures higher than 250 psig, valves 30 inches in diameter and larger, and where indicated, with worm gear actuators, hermetically-sealed water-tight and grease-packed.

5. Valves 6-inch to 24-inch diameter may be provided with traveling-nut actuators, worm gear actuators, spur or bevel gear actuators, as appropriate for each valve.

B. Buried Valves

1. Unless otherwise indicated, provide buried valves with extension stems to grade, with square nuts or floor stands, position indicators, and cast-iron or steel pipe extensions with valve boxes, covers, and operating keys.

2. Where indicated, provide buried valves in cast-iron, concrete, or similar valve boxes with covers of ample size in order to allow operation of the valve actuators.

3. Permanently label the valve box covers as required by the local Utility Company or the ENGINEER.

4. Provide wrench-nuts in compliance with AWWA C 500 - Metal-Seated Gate Valves for Water Supply Service.

C. Chain Actuator

1. Provide manually-activated valves with the stem located more than 7 feet above the floor or operating level with chain drives consisting of sprocket-rim chain wheels, chain guides, and operating chains supplied by the valve manufacturer.

2. Construct the wheel and guide from ductile iron, cast iron, or steel.

3. Chains
   a. Fabricate the chain from hot-dip galvanized steel or stainless steel, and extend to 5 feet, 6 inches above the operating floor level.
   b. Provide an extra strong valve stem on chain-actuated valves in order to allow for the extra weight and chain pull.
   c. Provide hooks for chain storage where chains interfere with pedestrian traffic.

D. Floor Boxes

1. Provide hot-dipped galvanized cast iron or steel floor boxes and covers to fit the slab thickness, for operating nuts in or below concrete slabs.

2. For operating nuts in the concrete slab, provide a bronze-bushed cover.

E. Tee Wrenches

1. Furnish buried valves with floor boxes with 2 operating keys or one key per 10 valves, whichever is greater.

2. Size the tee wrenches such that the tee handle will be 2 to 4 feet above ground, and to fit the operating nuts.
F. Manual Worm Gear Actuator

1. Provide an actuator consisting of a single- or double-reduction gear unit contained in a weatherproof cast iron or steel body with cover, and a minimum 12-inch diameter handwheel.

2. Provide the actuator to be capable of a 90-degree rotation, and equip the actuator with travel stops capable of limiting the valve opening and closing.

3. Provide the actuator with spur or helical gears and worm gearing.

4. Provide a self-locking gear ratio in order to prevent "back-driving."

5. Construct the spur or helical gears of hardened alloy steel, and the worm gear of alloy bronze.

6. Construct the worm gear shaft and the hand wheel shaft from 17-4 PH or similar stainless steel.

7. Accurately cut gearing with hobbing machines.

8. Use ball or roller bearings throughout.

9. Provide the output shaft end with a spline in order to allow adjustable alignment.

10. Actuator output gear changes shall be mechanically possible by simply changing the exposed or helical gearset ratio without further disassembly of the actuator.

11. Design gearing for a 100 percent overload.

12. The entire gear assembly shall be sealed weatherproof.

G. Design and rate buried gear actuators for buried service, provide with a stainless steel input shaft, and double-seal on shaft and top cap.

2.3 ELECTRIC MOTOR ACTUATORS

A. General

1. Equipment Requirements: Where electric motor actuators are indicated, attach an electric motor-actuated valve control unit to the actuating mechanism housing by means of a flanged motor adapter piece.

2. Gearing
   a. Provide the motor actuator with the motor, reduction gearing, reversing starter, torque switches, and limit switches in a weather-proof NEMA 4 assembly. Operators shall be NEMA 6P where located below grade and subject to flooding.
   b. Provide a single- or double-reduction unit, consisting of spur or helical gears and worm gearing.
   c. Construct the spur or helical gears of hardened alloy steel, and the worm gear of alloy bronze.
d. Accurately cut gearing with hobbing machines.

e. Power gearing shall be grease- or oil-lubricated in a sealed housing.

f. Use ball or roller bearings throughout.

g. Actuator output speed changes shall be mechanically possible by simply removing the motor and changing the exposed or helical gearset ratio without further disassembly of the actuator.

3. Starting Device

a. Except for modulating valves, design the unit such that a hammer blow is imparted to the stem nut when opening a closed valve or closing an open valve.

b. The device shall allow free movement at the stem nut before imparting the hammer blow.

c. The actuator motor shall attain full speed before the stem load is encountered.

4. Switches

a. Electronic-Type Switches

   1) Limit switches or valve position shall be sensed by a 15-bit, optical, absolute position encoder.

   2) The open and closed positions shall be stored in a permanent, non-volatile memory.

   3) The encoder shall measure valve position continuously, including both motor and hand wheel operation, with or without use of battery.

   4) Provide an electronic torque sensor.

   5) Provide an adjustable torque limit, from 40 to 100 percent of rating in one-percent increments.

   6) The motor shall be de-energized if the torque limit is exceeded and an over-torque alarm provided to the user.

   7) Provide a boost function in order to prevent torque-trip during initial valve unseating, and a “jammed valve” protection feature with automatic retry sequence in order to de-energize the motor if no movement occurs.

   8) Provide valve actuators with electronic type switches as manufactured by Limitorque, Rotork or Auma Actuators, Inc.

b. The actuator shall be wired in accordance with the schematic diagram.

c. Connect wiring for external connections to marked terminals.

d. Provide one 1-inch and one 1-1/2 inch conduit connection in the enclosing case.
e. Mount a calibration tag near each switch, correlating the dial setting to the unit output torque.

f. Switches shall not be subject to breakage or slippages due to over-travel.

g. Do not use traveling-nuts, cams, or microswitch tripping mechanisms.

h. Provide limit switches of the heavy-duty, open contact type, with rotary wiping action.

5. Handwheel Operation

a. Provide a permanently attached handwheel for emergency manual operation.

b. The handwheel shall not rotate during electrical operation.

c. The maximum torque required on the handwheel under the most adverse conditions shall not exceed 60 lb-ft, and the maximum force required on the rim of the handwheel shall not exceed 60 lb.

d. Cast or permanently affix an arrow and either the word "OPEN" or "CLOSE" on the handwheel in order to indicate the appropriate direction to turn the handwheel.

e. Provide a clutch lever to put the actuator into handwheel operation.

f. Provide chain activator handwheels for valves with electric motor actuators having stems more than 7 feet above the floor.

g. Provide the clutch lever with a cable secured to the chain in order to allow disengagement for manual operation.

6. Motor

a. Provide a motor of the totally enclosed, non-ventilated, high-starting torque, low-starting current type, for full-voltage starting.

b. The motor shall be rated at 460 volt, 3 phase, 60 Hz current, with Class F insulation and a motor frame with dimensions in accordance with the latest revised NEMA MG Standards.

c. The observed temperature rise by thermometer shall not exceed 55 degrees C above an ambient temperature of 40 degrees C, when operating continuously for 15 minutes under full-rated load.

d. With a line voltage ranging between 10 percent above to 10 percent below the rated voltage, the motor shall develop full-rated torque continuously for 15 minutes without causing the thermal contact protective devices imbedded in the motor windings to trip or the starter overloads to drop out.

e. Provide bearings of the ball type, and provide thrust bearings where necessary.

f. Provide the bearings with suitable seals in order to confine the lubricant and to prevent the entrance of dirt and dust.
g. Provide watertight motor conduit connections.

h. Motor construction shall incorporate the use of stator and rotor as independent components from the valve operation such that the failure of either item shall not require actuator disassembly or gearing replacement.

i. Provide two Class B thermal contacts or solid-state thermistors embedded within the motor windings in order to protect against over-temperature damage.

j. Provide the motor with a space heater suitable for operation on a 120-volt, single-phase, 60-Hz circuit, unless the entire actuator is of a hermetically sealed, non-breathing design with a separately sealed terminal compartment which prevents moisture intrusion.

k. Provide each electric motor actuator with a local disconnect switch or circuit breaker in order to isolate power from the motor and controller during maintenance activities.

7. Controls

a. Control designated actuators through the use of a microprocessor-based, 2 wire control system.

b. Provide a control system consisting of field units located at each actuator, linked by a shielded twisted pair.

c. Utilize Modbus RS-485 signals over the twisted pair to communicate the digital data to the facility control system.

d. Transfer the data to and from the field units by a RTU as indicated in Division 40 – Instrumentation and Control for Process Systems and sheets I-5 and I-6 of the Contract drawings.

e. The communications protocol between the RTU and the valves shall be RS-485 Modbus only; proprietary network protocols will not be accepted.

f. Provide the hardware and software required to interface the valve network with the RTU in accordance with the respective actuator manufacturer's requirements.

g. Refer to the Instrumentation Drawing GI-3 for the number of networks required and for valve and gate assignments.

h. Communications Network

1) The field units shall be controlled by a 2-wire network that connects the actuators in a loop fashion through the use of RS-485 signals.

2) Modbus protocol shall be utilized.

3) The network shall be tolerant of cable faults.

4) A single cable fault (break, open, or short circuit) shall not cause communication loss to any field unit.
5) Protect network connections by high-level surge protectors, including gas discharge tubes and surge suppression diodes.

6) Surge suppression shall be in compliance with ITU-T and IEC 801.5.

7) Loss of power shall not compromise the redundancy feature of the network.

8) Provide surge immunity to IEC 1000-4-5 requirements, magnetic field immunity to IEC 1000-4-8 requirements, conducted emissions to EN55011 requirements, and radiated, ESD and EFT immunity to EN50082-2 requirements.

9) Loss of power to any field device shall not compromise the integrity of the network loop.

i. Polling System

1) The system shall continuously poll every field unit via the communications path and immediately produce an alarm upon the failure of any single access path.

2) Functions of each field unit shall be programmable and verifiable.

j. Field Unit

1) Enclose a field unit within each actuator.

2) The actuator hardware shall provide the RS-485 network ports to provide a continuous communications path to every field unit.

3) The field unit shall receive commands and requests for information over the network for the following capabilities:

   a) Commands: OPEN valve, CLOSE valve, STOP valve, and LOCKOUT (inhibit local and remote electrical operation); modulating control valves shall receive a positioning control command (0 -100 percent open).

   b) Status: valve OPEN, valve CLOSED, selector switch in REMOTE, and selector switch in LOCAL; provide designated valves with valve position (0 -100 percent) indication.

   c) Alarms: field unit “fuse blown,” “motor overload tripped,” “torque switches tripped,” and "communications failure."

4) Status lights shall be red for "OPEN" and green for "CLOSED."

8. Open/Close Operating Speed

   a. Unless otherwise indicated, electric actuators shall provide a full-close-to-full-open or full-open-to-full-close operating time range from 30 to 55 seconds.
9. Elevated Valves
   a. For valves with electric motor actuators where the valve centerline is located at a height greater than 6 feet above the floor, provide a remote actuator control station at a location no higher than 4 feet above the floor.
   b. Provide conduit and wiring between the actuator controls and the valve actuator for these applications.
   c. Wall-mount the actuator controls beneath the valve at a location approved by the ENGINEER.

B. Electric Motor Actuators (AC Reversing Control Type)

1. General: Where indicated, electric motor actuators shall be the AC reversing type complete with local control station with OPEN/CLOSE and LOCAL/OFF/REMOTE selector switches.

2. Actuator Appurtenances: Provide the actuator for each valve with: a padlockable disconnect switch, OPEN and CLOSE status lights; OPEN, CLOSE, push buttons, LOCKOUT/STOP; and, other indicated devices.

3. Starter
   a. Provide a suitably sized amperage-rated reversing starter with its coils rated for operation on 480-volt, 3-phase, 60-Hz current.
   b. Provide a control power transformer in order to provide a 120-volt source, unless otherwise indicated.
   c. Equip the starter with 3 overload relays of the automatic reset type, and wire the control circuit as indicated.
   d. The integral weatherproof compartment shall contain a suitably sized 120-volt AC, single-phase, 60-Hz space heater in order to prevent moisture condensation on electrical components.
   e. Provide a local power disconnect switch and a close-coupled, padlockable switch with each actuator.

4. Local Control Station
   a. Provide each actuator with a local control station along with the valve actuator assembly.
   b. The station shall include OPEN and CLOSE push buttons, LOCKOUT/STOP, and a LOCAL/OFF/REMOTE selector switch for control. The station shall include OPEN and CLOSE lights, POSITION indication, and OVERTORQUE indication for status.
   c. Where indicated on the Instrumentation Drawings, provide a 2-wire control system as indicated above.
d. The control system shall allow communications to the RTU via a Modbus RS-485 protocol over a twisted shielded-pair cable in order to monitor and control the valve as indicated above and in Section 409300 – Control Strategies.

e. The local control station and local power disconnect may be provided as an integral part of the actuator, or as otherwise indicated or required in order to permit operation by a person at floor elevation and within sight of the valve actuator.

5. Electric Motor Actuators (AC Reversing Control Type) Manufacturer, or Equal
   a. Auma Actuators, Inc.
   b. Limitorque Corp
   c. Rotork

C. Electric Motor Actuators (AC Modulating Control Type)

1. General: Where indicated, modulating electric motor actuators shall be of the AC-modulating type, provided complete with a local control station with power disconnect switch or circuit breaker, LOCAL/OFF/REMOTE switch, non-latching OPEN/CLOSE pushbuttons, and LOCKOUT/STOP pushbutton.

2. Actuator Appurtenances: Provide the actuator for each valve with: a padlockable disconnect switch; OPEN and CLOSED status lights; OPEN, CLOSE, and LOCKOUT/STOP pushbuttons; a LOCAL/OFF/REMOTE selector switch; and, other indicated devices.

3. Control Module: Provide a control module of the electronic solid-state AC type, with control outputs for positioning the valve via 4 to 20 ma input signals.

4. Starter
   a. The actuator shall control a solid-state reversing starter designed for minimum susceptibility to power line surges and spikes.
   b. The solid-state starter and control module shall be rated for continuous modulating applications.
   c. The power supply shall be 480-volt, 3-phase, 60-Hz.
   d. Provide a disconnect switch with each actuator.

5. Construction
   a. The control unit shall be microprocessor-based and shall contain an analog/digital converter, separate input-output switches, non-volatile random access memory for storage of calibration parameters, and push-button calibration elements for field setup.
   b. Potentiometer adjustments shall contain a PID control function internally.
c. The controller shall contain as a standard feature a loss-of-command signal protection selectable to lock in last or lock in pre-set valve position and a valve position output signal in 4 to 20 ma.

d. As an alternative to the construction requirement, provide a motor capable of modulating at a rate of 200 starts per hour at the 50-percent to 85-percent travel range of the valve.

e. Where indicated on the Instrumentation Drawings, provide a 2-wire control system as indicated above.

f. The control system shall allow communications to the RTU via a Modbus RS-485 protocol over a twisted shielded-pair cable in order to monitor and control the valve as indicated above and in Section 409300 – Control Strategies.

g. The control station shall include OPEN and CLOSE push buttons, LOCKOUT/STOP, and a LOCAL/OFF/REMOTE selector switch for control. The station shall include OPEN and CLOSE lights, POSITION indication, and OVERTORQUE indication for status.

h. The system shall allow the control of the open, close, or percent open function when the LOCAL/REMOTE switch is in the REMOTE position.

i. Provide each actuator with a frequency shut-down system, which when pre-programmed shall function as directed upon receipt of an ESD signal.

6. Electric Motor Actuators (AC Modulating Control Type) Manufacturer, or Equal

   a. Limitorque

   b. Rotork

   c. Auma Actuators, Inc.

D. Electric Motor Actuators (DC Modulating Control Type)

   1. Equipment Requirements: Where indicated, provide electric motor actuators of the DC modulating control type, and attach to the actuating mechanism housing.

   2. Actuator Assembly: The assembly shall include a DC motor, reduction gearing, a control unit, limit-switches, and required accessories, within one enclosure.

   3. Control Unit

      a. Provide an electric motor-operated control unit suited for an input power supply of 90 to 140 volts, 60 Hz AC, and to operate satisfactorily when input power is within those limits.

      b. Power will be supplied at 120 volts, single-phase, 60 Hz AC.

      c. Provide a control unit suited to receive an input set-point signal from an external source of 4 to 20 ma DC with properly selected calibrating resistor.
4. Control Panel
   a. Provide each actuator with a separate local control panel for attachment to the valve actuator assembly.
   b. Provide the panel with an OPEN/CLOSE/AUTO/HOLD selector switch and suitable for indoor or outdoor installation, as required.

5. Electric Motor Actuators (DC Modulating Control Type) Manufacturer, or Equal
   a. **EIM, Futronic-III**
   b. **Limiterque Corp., Modutronic-10**

E. 120 V Quarter-Turn and Multi-Turn Electric Valve Operators (6-Inches and Smaller)
   1. Provide 120-volt, single-phase, motor-operated valve operators suitable for use with quarter-turn ball valves, multi-turn diaphragm valves, and multi-turn globe valves.
   2. Provide operators with the following characteristics and features:
      a. reversing capacitor-start motor rated for operation on 120 VAC, 60 Hz, single-phase;
      b. output torque as required for valve application and pressure differential;
      c. integral motor overload protection, with auto-reset;
      d. permanently-lubricated gear train;
      e. **OPEN/CLOSE Control**
         1) For OPEN/CLOSE control, provide 4 single-pole, double-throw cam-actuated limit switches (2 OPEN, 2 CLOSED);
         2) Use one set of limit switches for both motor control and local indication;
         3) Make the other set available for connection to remote monitoring;
         4) Provide adjustable limit switch contacts rated for not less than 5 amps at 120 VAC;
      f. **Local Control Station: OPEN/CLOSE**
         1) corrosion-resistant, NEMA 4X, for mounting near valve actuator;
         2) Provide 2-position selector switch for LOCAL/REMOTE selection and 2 pushbuttons, OPEN and CLOSE;
         3) Provide OPEN and CLOSE indicating lights operating at 120 VAC for connection to valve control limit switches;
g. Modulating Control
   1) For modulating control, provide an electronic positioner and feedback potentiometer;
   2) The positioner shall use a 4 to 20 ma signal to adjust the valve opening;
   3) Feedback potentiometer shall be 0 to 1000 ohms;

h. Local Control Station Modulating
   1) corrosion resistant, NEMA 4X, for mounting near valve actuator;
   2) Provide 2-position selector switch for LOCAL/REMOTE selection, one OPEN and one CLOSE push button, a resistance-to-current converter with 4 to 20 ma output, and a zero to 100 percent electronic valve position indicator; and,

i. Disconnect Switch
   1) Provide a local power disconnect switch, NEMA 4X, for disconnecting the 120 VAC power to the valve; and,
   2) Install the disconnect in the field within sight of the valve actuator, in accordance with the requirements of NPFA 70.

3. Refer to the Drawings for the control diagram wiring interface.

4. Two-wire control systems are not required for this actuator.

5. 120 V Quarter-Turn and Multi-Turn Electric Valve Operators (6-Inches and Smaller) Manufacturer, or Equal
   a. RCS
   b. Asahi/America, Quarter Master

2.4 HYDRAULIC (OIL) GATE ACTUATORS

A. Hydraulic (Oil) Power System
   1. Performance Requirements
      a. General
         1) Provide one (1) complete hydraulic power system designed for automatic control of the three (3) slide gates as indicated on the Drawings.
         2) Provide the hydraulic power system with necessary accessories, such as pressure gauges, relief valves, oil level sight glass, pressure and level switches, filters, pressure reducing valves, operating and isolating valves, nameplates, electrical and control wiring, and other appurtenances for a complete and operable installation
3) Size the hydraulic power system to operate only one hydraulic actuator/gate at a time.

4) Size each hydraulic actuator to open and close each slide gate against the hydraulic conditions indicated.

b. System Responsibility

1) Design each oil hydraulic system as part of the slide gate, fully integrated into the control system.

2) The manufacturer of the gates shall be responsible for furnishing the gates and the hydraulic system and shall assume overall system responsibility.

3) The hydraulic actuator manufacturer shall provide satisfactory evidence of at least 10 installations of similar systems that have been successfully in service for at least 5 years, and submit the list of previous installations to the ENGINEER.

c. The oil hydraulic actuation system shall be furnished with a single factory-assembled, complete and operational, self-contained hydraulic power package consisting of the following:

1) hydraulic oil reservoir, complete with sight glass, breather, drain valve, high and low level switch

2) hydraulic pumps: provide 2: one duty plus one standby

3) duplex oil filters: at return and supply; with isolation valves

4) four-way solenoid valves

5) pilot operated check valves installed at the inlet and outlet to the hydraulic cylinders

6) necessary flow control valves to adjust the opening and closing times of the gates

7) flow switches

8) pressure relief valve connected in the piping return to the reservoir

9) piping, valves, starters, and PLC controls
d. Operational Capacity

1) Design the hydraulic power system in accordance with JIC H-1 - Joint Industrial Council, Hydraulic Standards for Industrial Equipment and General Purpose Machine Tools. The hydraulic power system shall provide adequate volume and pressure for the operation of one gate at a time per below:

<table>
<thead>
<tr>
<th>Gate Tag Number</th>
<th>Size, inches</th>
<th>Operating Head, ft</th>
<th>Operating Cycle, minutes</th>
<th>Location of Connected Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>G-101, G-102, G-103</td>
<td>5'-0&quot; wide by 9'-4&quot; high opening</td>
<td>3</td>
<td>Normal opening or closing times = 10 minutes, adjustable from 2 to 15 minutes</td>
<td>Intake Wetwell (submerged)</td>
</tr>
</tbody>
</table>

2) The hydraulic power system does not need to be sized to operate all three gates simultaneously.

3) The connected equipment size shall be determined based on a minimum operating time of 2 minutes as the worst case scenario to open or close a single gate.

e. Operation

1) Opening and closing times shall be independently adjustable by the use of flow control valves, one on each flow direction.

2) Provide these adjustments with safety wires in order to prevent tampering by non-authorized personnel.

2. Power Systems Construction

a. Pumps

1) Provide 2 positive displacement pumps, of the variable-axial piston type and with a discharge pressure of 3,000 psig, mounted on top of or below the reservoir.

2) Provide each pump with a capacity of not less than 1.5 times the combined flow rate of the connected cylinders in gpm.

3) The pumps shall be suitable for continuous operation.

4) Provide each pump complete with a direct-connected, heavy-duty, electric motor suitable for a 480-volt, 3-phase, 60-Hz supply.

5) Provide necessary unloader valves, check valves, pilot valves, safety valves, air release valves, drain valves, and control valves, and install in accessible locations.
6) Provide a hand-pump, complete with flanged flexible connectors, piping connections and valves, and mount to the reservoir in order to pressurize the system and open or close a gate in case of a power failure.

7) Provide a manually-operated pump with a check and isolation valve, and install in parallel to the motor-operated pump.

b. Hydraulic Fluid

1) Connect the hydraulic cylinder to a hydraulic power unit utilizing a food grade oil with a viscosity of 18.2 centistokes to 35 centistokes at 100 degrees F at a pressure of 14 MPa (2000 psi).

2) The manufacturer shall submit with the Shop Drawings a statement in writing that wetted parts of the hydraulic system are suitable for extended operation with the hydraulic fluid.

3) Provide a food-grade rated hydraulic fluid with antifoam, anti-wear, rust prevention, and water-separating characteristics suitable for the service.

c. Hydraulic Cylinders

1) The gate manufacturer shall furnish the torque unit and hydraulic cylinder.

2) Provide a double-acting hydraulic cylinder; constructed of bronze or stainless steel alloy, precision-machined, bored, and honed to a micro-finish of 0.5 microns or better, suitable for corrosive environments, and suitable for partially and fully submerged service.

3) Design the hydraulic cylinder to operate at maximum hydraulic pressure of 2,000 psig.

4) Fitted the cylinder with cushions at both ends in order to prevent slamming of the valve.

5) Size the cylinder to provide sufficient opening and closing thrust under design pressure conditions.

6) Apply a minimum 50 percent safety factor to the maximum operating load in order to allow for line loss and other system pressure drops.

7) Size the piston rod to safely withstand 1.50 times the full cylinder output at maximum system pressure.

8) Provide each cylinder with 2 flexible hose connectors rated for the service, and 2 isolation valves.

9) The exterior coating system shall be of the same material as that used for the main valve.

10) Provide heads and piston constructed of carbon steel, with Teflon wearing rings on the piston.

11) Construct the piston rod of stainless steel, with a micro-finish and hard chrome plating, running in oversized bronze bearings.
12) Provide seals composed of Buna N or Viton to be compatible with the hydraulic fluid.

13) Either within the cylinder or on the gate, provide an adjustable means for positively stopping the gate in both the open and closed positions.

14) Provide a visual and an electrical indication of gate OPENED and CLOSED positions.

15) The cylinder shall operate the gate and shall regulate the opening and closing speed.

16) Provide each unit with flow control valves, pilot-operated check valves, and solenoid valves, with an integral manual override permitting manual operation of the valve in the event of loss of electrical power to the cylinder controls.

17) Couple the gate actuator mechanism to the cylinder.

18) Rigidly secure the cylinder to the mechanism housing to prevent pivoting, rotating, and swinging during operation.

19) Totally enclose the cylinder piston rods in the mechanism housing.

20) Design the hydraulic system with a factor of safety of 4.

21) Provide each hydraulic cylinder with cylinder position sensors rated for submersion to indicate full travel in the extended and retracted positions via SPDT contacts. Sensors shall be stainless steel, installed in threaded ports on the cylinder body or with bolted headpiece. Sensors shall be provided with vendor supplied submersible cable and quick-connect termination at the sensor. The sensors shall be “GO Switch”, Series 70 or Stroke-to-GO switches, as manufactured by TopWorx, Inc., or equal.

d. Piping

1) Provide necessary piping and valving within the unit and between the unit and the connected valve cylinders and equipment.

2) Construct the piping system of seamless black steel pipe, conforming to ANSI/ASME B 31.1 - Power Piping, designed for a maximum velocity of 15 feet per second, and a maximum operating pressure of 3,000 psig.

3) Provide a pipe wall thickness to give a minimum factor of safety of 4.

4) The piping, connections, and fittings shall be of the 3,000-lb, forged steel, socket-welded type conforming to ASTM A 105 - Forging, Carbon Steel, for Piping Components.

5) Provide 3,000-lb socket-welded flange connections, limited to valve ends and tank connections only.

6) Provide restraint expansion and vibration isolation joints on the suction and discharge of each pump.
7) Provide reinforced rubber with a termination kit rated for 3,000 psig, in order to connect the piping and the hydraulic cylinder.

8) Provide individual lines to connected equipment with isolating valves at the power unit.

e. Valves

1) Provide solenoid controls, isolation, flow control, and check valves suitable for the required pressure and service.

2) Valves shall have zero leakage at test pressure.

3) Provide solenoid valves with a manual override.

4) Fit the control valves that open or close the hydraulic cylinder with hand-operated levers such that they can be operated manually if necessary.

5) Provide valves as manufactured by Rexroth, Parker Hannifin, or equal.

f. Filters and Filter Elements: Provide 150-micron pump suction filters and 10-micron reservoir return line filters, replaceable. Provide both filters with an internal bypass and visual clogging indicators.

g. Dual Filters

1) Provide dual filters in parallel located at the oil return-to-reservoir and the pump discharge for each pump, with isolation valves such that maintenance can be performed without interruption to the service.

2) Provide filters as manufactured by Cuno or equal.

h. Oil Reservoir

1) The reservoir shall serve as the mounting base for the other equipment as far as practicable.

2) Provide the reservoir with the capacity to contain 125 percent of the total return oil volume, and sufficient retention time to eliminate the need for an oil cooler.

3) Provide internal baffles or other design features in order to allow time for air bubbles to separate from the discharged oil before reaching the pump suction.

4) The reservoir shall be of heavy, welded-steel construction, with welded supports, pipe connections, hand hole, level gauge with cast aluminum or steel armor, drain valve, vent with coalescing filter, and welded pads for the support of the auxiliary equipment and pumps.

5) Provide a secondary containment with a capacity of 125 percent of the total tank volume.
i. Painting and Coating

1) Coat the equipment provided under this Section in accordance with the requirements of Section 099600 – Protective Coating.

2) In the case of proprietary items that do not comply with the indicated requirements, submit full details of the coating treatment used on these proprietary items for the approval of the ENGINEER.

3) If the ENGINEER does not approve the proposed coating, provide the indicated treatment.

3. Power and Controls

a. Provide the system complete with required electrical components, including pump starters, controls, PLC, UPS, branch circuit protection, magnetic circuit breakers, control transformers, elapsed time meter, pressure switches, level switches, pilot lights and selector switches.

b. The system shall be controlled by a PLC, provided by the gate manufacturer, and as manufactured by Allen Bradley, to be located in the hydraulic system local control panel.

c. The oil hydraulic cylinder actuator system shall not react to utility failures on its own.

d. Normal System Operation: Provide a 4-way double solenoid valve for normal opening and closing operation to pressurize each hydraulic cylinder actuator.

e. Provide a HAND-OFF-AUTO switch in order to allow for manual start and stop operation of the pumps.

f. Provide front panel controls, equipment status and alarm status indication that meets or exceeds the controls shown on Sheet I-8 of the Contract Drawings.

g. Provide relay contacts for remote indication that meets or exceeds the controls shown on Sheet I-8 of the Contract Drawings.

h. Provide automatic controls in order to:

   1) start the first pump when an actuator is called to operate

   2) start the second pump and initiate an alarm if the first pump fails

   3) alternate operation between the 2 pumps

   4) If variable-displacement, pressure-compensating pumps are provided, only Items 2 and 3 above shall apply.

i. Control Cabinet

   1) Locate electrical control devices and wiring terminations in an enclosed cabinet with a NEMA rating in accordance with the designations of Section 260000 – Electrical Work, General.
2) The cabinet shall be mounted on the power unit.

3) Provide terminal blocks for interconnection to other indicated control devices.

4) Controls shall be suitable for a 120-volt power supply.

j. Provide protection devices to perform the following functions:
   1) low oil pressure: alarm
   2) low-low oil pressure: shutdown
   3) high oil pressure: alarm
   4) low reservoir oil level: alarm
   5) low-low reservoir oil level: alarm and pump shutdown
   6) high filter differential pressure: alarm
   7) All of the alarms shall be transmitted to each main pump PLC.

4. Supplies and Spare Parts
   a. Furnish the following supplies and spare parts:
      1) oil as required to test, flush, and initially fill the hydraulic system
      2) oil equal to one total volume of what’s required for the entire system for future use
      3) packing, gaskets, O-rings, and seals: 2 sets
      4) oil filter cartridges: 3 sets
      5) fuses: 2 sets
      6) motor and pump bearings: one set
      7) solenoid valves: one set
      8) relief valves: one set
   b. Store the spare parts in toolboxes identified with the equipment number by means of stainless steel or solid plastic nametags attached to the box.

5. Hydraulic Power System Manufacturer, or Equal
   a. Rodney Hunt
   b. B.H. Bettis/Shafer
PART 3 – EXECUTION

3.1 SERVICES OF MANUFACTURER

A. **Field Adjustments:** The adjustment of actuator controls and limit switches in the field for the required function shall be performed by field representatives of the manufacturers of valves or gates with hydraulic, or electric actuators.

3.2 INSTALLATION

A. Install valve and gate actuators and accessories in accordance with the requirements of Section 433000 – Valves, General.

B. Locate the actuators to be readily accessible for operation and maintenance without obstructing walkways.

C. Do not mount actuators where shock or vibrations will impair their operation, and do not attach the support systems to handrails, process piping, or mechanical equipment.

3.3 HYDRAULIC (OIL) POWER SYSTEM INSTALLATION

A. Before installation, piping components shall undergo the following pickling process:
   1. Remove extraneous materials;
   2. Remove oils or grease in an alkaline bath;
   3. Rinse with water;
   4. Coat vulnerable surfaces of valves, flanges, and the like;
   5. Acid-pickle;
   6. Dry; and,
   7. Inspect piping before closing cleaned pipes.

B. Cleaning
   1. After installation, thoroughly inspect and clean the piping to remove machining burrs and foreign materials, including mill scale, dirt, rust, oil, grease, weld spatter, and cutting chips.
   2. Cleaning may be accomplished by hot oil flush or other approved method.
   3. Perform cleaning in strict accordance with the manufacturer's written instructions.

C. Field-Testing
   1. After installation, hydraulically test the fluid power system and piping to 150 percent of the maximum working pressure.
   2. Prior to painting, test the reservoir for leakage by hot oil or other approved method.
3. Perform operational tests on equipment and devices in order to demonstrate proper function.

4. Check adjustable devices for range of adjustment and provide final adjustment.

D. Inspection, Startup, and Field Adjustment

1. Furnish an authorized representative of the manufacturer who shall visit the Site and witness the following:
   a. Installation of the equipment, for not less than 2 Days;
   b. Inspection, checking, and adjusting the equipment, for not less than one Day.
   c. Startup and field-testing for proper operation, for not less than one Day.

E. **Instruction of OWNER's Personnel:** The authorized service representative shall visit the Site for not less than 2 Days in order to instruct the OWNER'S personnel in the operation and maintenance of the equipment, including step-by-step troubleshooting procedures with necessary test equipment.

   - END OF SECTION -
PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide butterfly valves and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 410000 - Equipment General Provisions apply to this Section.

C. The requirements of Section 433000 - Valves, General apply to this Section.

D. The requirements of Section 433012 - Valve Actuators apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 433000.

B. Shop Drawings

1. Complete Shop Drawings of butterfly valves and actuators.

2. Drawings showing valve port diameter complete with dimensions, part numbers, and materials of construction.

3. Dynamic seating and unseating torque for motor actuated valves.

4. Certified statement of proof-of-design tests from the valve manufacturer. Valve manufacturer shall state that the valves proposed for this project will be manufactured with identical basic type of seat design and materials of construction to the prototype evaluated under the proof of design testing.

5. Manufacturer's certification that the valve complies with applicable provisions of AWWA C504 – Rubber-Seated Butterfly Valves.

1.3 QUALITY ASSURANCE

A. Valves shall be subjected to performance, leakage, and hydrostatic tests in accordance with procedures and acceptance criteria established by AWWA C504.

PART 2 – PRODUCTS

2.1 RUBBER SEATED BUTTERFLY VALVES 25 TO 150 PSI (AWWA)

A. General: Butterfly valves for steady-state water working pressures and steady-state differential pressure up to 150 psi and for fresh water service having a pH range from 6 to 10 and temperature range from 33 to 125 degrees F shall conform to AWWA C504 and be as indicated. Valves subjected to steady state working pressures and steady state differential pressures from 25 to 150 psi in sizes 3-inches through 24-inches shall be rated for Class 150B with actuator sized for Class 150B. Valves 30 inches through 72-inches shall be of the class indicated. Valves larger than 72-inches shall be of the class indicated, designed in accordance with the intent of AWWA C504. If the operating
conditions such as flow, velocity, and differential pressures are not indicated, the valve body and shaft shall be sized for the pressure class rating of the valve.

B. Valves shall be of the body type, pressure class, end joint, and actuator indicated.

C. **Construction:** Unless otherwise indicated, materials of construction shall be in accordance with AWWA C504, suitable for the service. Seats shall be positively clamped or bonded into the disc or body of the valve, but cartridge-type seats that rely on a high coefficient of friction for retention shall not be acceptable. Seat material shall be guaranteed to last for at least 75 percent of the number of cycles in the AWWA C504 proof-of-design test without premature damage.

<table>
<thead>
<tr>
<th>Description</th>
<th>Material Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valve bodies</td>
<td>Gray iron, ASTM A 48, Class 40 or Gray iron, ASTM A 126, Class B, or Ductile iron, ASTM A 536, grade 65-45-12 or 70-50-05</td>
</tr>
<tr>
<td>End flanges</td>
<td>Same material as valve bodies</td>
</tr>
<tr>
<td>Valve shafts</td>
<td>Stainless steel ASTM A 240 or A 276, Type 316</td>
</tr>
<tr>
<td>Valve discs</td>
<td>Same material as valve bodies</td>
</tr>
<tr>
<td>Rubber seats</td>
<td>New natural or synthetic rubber</td>
</tr>
<tr>
<td>Seat mating surfaces</td>
<td>Stainless steel, ASTM A 240 or A 276, Type 316</td>
</tr>
<tr>
<td>Clamps and retaining rings</td>
<td>Type 316 retaining rings and cap screws.</td>
</tr>
<tr>
<td>Valve bearings</td>
<td>Self lubricating materials per AWWA C504</td>
</tr>
<tr>
<td>Shaft seals</td>
<td>Resilient non-metallic materials suitable for service</td>
</tr>
<tr>
<td>Painting and coating</td>
<td>Refer to Section 09800 – Protective Coating</td>
</tr>
</tbody>
</table>

D. **Manual Actuators:** Unless otherwise indicated, manually-actuated butterfly valves shall be equipped with a handwheel and 2-inch square actuating nut and position indicator. Screw-type (traveling nut) actuators will not be permitted for valves 30-inches in diameter and larger.

E. **Worm Gear Actuators:** Valves 30-inches and larger, as well as submerged and buried valves, shall be equipped with worm-gear actuators, lubricated and sealed to prevent entry of dirt or water into the housing.

F. **Electric Actuators:** Electric actuators shall meet the requirements of AWWA C540. Electric actuators in open and close service shall be rated to produce output torque of at least 1.5 times the required valve maximum seating or maximum dynamic torque, whichever is greater. For valves in modulating service with dynamic torque exceeding the seating torque, the rated output torque of the actuator shall be twice the dynamic torque required by the valve. Actuator rated torque is defined as pullout torque rated at 10 percent below the rated voltage of the motor. The torque switch shall be field set at
no greater than 60 percent and 50 percent of the maximum actuator rated torque for open/close service and modulating service, respectively. After plant startup, the manufacturer shall prepare a certification including a torque curve to demonstrate that the torque requirements have been met.

G. Manufacturers, or Equal

1. DeZURIK Water Controls, Corporation

2. Henry Pratt Company

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Exposed butterfly valves shall be installed with a means of removing the complete valve assembly without dismantling the valve or operator. Installation shall be in accordance with Section 433000.

- END OF SECTION -
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SECTION 433016 - CHECK VALVES

PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide check valves and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 433000 - Valves, General apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 433000.

PART 2 – PRODUCTS

2.1 SWING CHECK VALVES (2-1/2 INCHES AND SMALLER)

A. General: Swing check valves for steam, water, oil, or gas in sizes 2-1/2 inches and smaller shall be suitable for a steam pressure of 150 psi and a cold water pressure of 300 psi. Units shall have screwed ends unless otherwise indicated, and screwed caps.

B. Body: The valve body and cap shall be of bronze conforming to ASTM B 763 - Copper Alloy Sand Castings for Valve Application, or ASTM B 584 with threaded ends conforming to ASME B1.20.1 - Pipe Threads, General Purpose (inch).

C. Disc: Valves for steam service shall have bronze or brass discs conforming to ASTM B 16 - Free-Cutting Brass Rod, Bar, and Shapes for Use in Screw Machines, and for cold water, oil, and gas service replaceable composition discs.

D. Hinge Pin: The hinge pins shall be of bronze or stainless steel.

E. Manufacturers, or Equal

1. Crane Company

2. Milwaukee Valve Company

3. Stockham Valves and Fittings

4. Wm. Powell Company

2.2 INTERNAL SPRING-LOADED CHECK VALVES (GLOBE STYLE)

A. General: Internal spring-loaded check valves for water pumps, compressors, gas, air, and steam shall be of the full-flow internal spring-loaded poppet type. The valves shall be designed for a water-working pressure of not less than 150 psi unless otherwise indicated.

B. Body: The bodies of valves 3-inches and larger shall be of cast iron conforming to ASTM A 126 with 125 lb flanged ends conforming to ASME B 16.1 unless otherwise indicated. Where necessary, there shall be a positive, watertight seal between the
removable seat and the valve body. The stem guide shall be integrally cast with the body or screwed into the body.

C. Valves smaller than 3-inches shall have bronze bodies with screwed ends conforming to ASME B 1.201, suitable for a minimum working pressure of 200 psi, and a temperature of 250 degrees F, unless otherwise indicated. The type of bronze shall be suitable for the intended service.

D. **Disc and Stem:** The disc and stem of all valves in sizes 3-inches and larger shall be of bronze conforming to ASTM B 584 - Copper Alloy Sand Castings for General Applications, or stainless steel. The stem shall have 2 point bearings. The downstream bearing shall have a bronze or other suitable bushing, to provide a smooth operation.

E. Valves smaller than 3-inches shall have discs and retaining rings of Teflon, nylon, or other suitable material, and stems of bronze, brass, or stainless steel, suitable for the intended service.

F. **Stem Guide:** The stem guide shall be either firmly fixed in the valve body to prevent it from sliding into the adjacent pipe and damaging the pipe lining, or the valve manufacturer shall provide each valve with one matching flange compatible with the adjacent pipe and its lining to prevent damage to the lining. The compatible flange shall be part of the Shop Drawing submittal.

G. **Seat:** Valves for general service at temperatures up to 250 degrees F shall have bubble-tight shut-off with resilient seats of Buna-N, Teflon, or other suitable material. Valves for steam service and temperatures over 250 degrees F shall have metal-to-metal seating of bronze or stainless steel, as recommended by the manufacturer for the specific service condition. Resilient seats shall be firmly attached to the seating ring by compression molding or other acceptable method.

H. **Spring:** Valves in sizes 3-inches and larger shall have Type 316 stainless steel springs, and valves smaller than 3-inches shall have stainless steel or beryllium copper springs, as suitable for the service. The spring tension of the valves shall be designed for the individual pressure condition of each valve.

I. Manufacturers, or Equal

1. **APCO (Valve and Primer Corp.)**

2. **CPV (Combination Pump Valve Company)**

3. **Miller Valve Co., Inc.**

4. **VAL-MATIC (Valve and Manufacturing Corporation)**

2.3 **SLANTING (TILTING) DISC CHECK VALVES**

A. **General:** Slanting disc check valves for water service shall have a seating angle of approximately 55 degrees. Valves shall have replaceable seat rings and disc rings. The water passage cross-sectional area shall be equal to the full pipe area. Valves shall have sufficient clearance around the pivot pins to permit free seating of the disc without binding and shall be guaranteed not to stick in the closed position. Slanting disc check valves shall have position indicators and 2 flanged connections for attachment of dashpots or hydraulic snubbers. The valves shall be designed for a water working pressure of 150 psi, unless otherwise indicated.
B. **Body:** The valve body shall be of cast iron conforming to ASTM A 48 - Gray Iron Castings, or A 126, Class B, with flanged ends conforming to ASME B 16.1, Class 125, unless otherwise indicated.

C. **Disc:** The valve disc shall be designed with an "airfoil" configuration of cast iron or ductile iron, with bronze seating face, except for valves 10-inches or smaller, which may have solid bronze or aluminum bronze discs. The disc shall be partially balanced with a short travel to resist slamming.

D. **Seat Ring:** The seat ring shall be of centrifugally-cast bronze, aluminum bronze, or stainless steel, with beveled edges, firmly clamped or screwed into the valve body.

E. **Pins:** The pivot pins and bushings shall be of stainless steel, bronze, or aluminum bronze to allow free movement of the disc without binding.

F. Manufacturers, or Equal
   1. APCO (Valve and Primer Corporation)
   2. Golden Anderson
   3. Henry Pratt

### 2.4 METAL BALL AND LIFT CHECK VALVES

A. **General:** Metal ball check valves for saturated steam, oil, water, and gas in sizes 1/2-up to 1-inch shall be used for horizontal installation only. Lift check valves for LP gas in sizes 1/4-up to 2-inches shall be used for horizontal installation only.

B. **Construction:** The ball check valve body and cap shall be bronze ASTM B 584. Ball disc shall be stainless steel construction, as best suited for each individual service condition. The union cap shall provide a tight joint and be easily dismantled when necessary. They shall have screwed connections. The valves shall be suitable for a maximum working non-shock pressure of 150 psi saturated steam or non-shock cold water, oil, and gas rating of 300 psi.

C. The lift check valve body, and cap shall be leaded bronze ASTM B 763. Disc shall be special composition, as best suited for petroleum service condition. The disc shall be secured to the disc by means of a disc retaining nut. To protect against leakage on light oils and gases, the disc shall be sealed into the holder. The union cap shall provide a tight joint, easily dismantled when necessary. They shall have screwed connections. The valves shall be suitable for a maximum working non-shock pressure of 400 psi cold water, oil, gas, LP gases, and volatile fluids.

D. **Manufacturers, or Equal:** Crane.

### 2.5 PLASTIC DIAPHRAGM CHECK VALVES

A. **General:** Plastic diaphragm check valves shall be the type which require no system pressure for sealing and operate silently with minimal pressure drop in either horizontal or vertical flow conditions. They shall utilize either an elastomer diaphragm or teflon encapsulated spring to cause closure.

B. **Construction:** The valve bodies shall be PVC, CPVC, polypropylene (PP), or polyvinylidene fluoride (PVDF) as indicated on the piping schedule. Union connections
shall be either NPT or socket ends conforming to ASME B 16.5 Class 150. They shall give bubble tight shutoff without dependence on gravity direction, mounting position, or reverse flow. Seats and seals shall be EPDM, Buna-N, or Viton, as best suited for the service. Inlet pressure ratings shall be 150 psi at 73 degrees F for PVC and PVDF and 100 psi at 73 degrees F for PP.

C. Manufacturers or Equal: Plastic-O-Matic Valves, Inc.

PART 3 – EXECUTION

3.1 GENERAL

A. Valves shall be installed in accordance with provisions of Section 433000 - Valves, General.
SECTION 433018 - BALL VALVES

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide ball valves and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 433000 - Valves, General apply to this Section.

C. The requirements of Section 433012 - Valve and Gate Actuators apply to this Section.

D. The requirements of Section 411500 - Chemical Feeding Equipment, General apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 433000 - Valves, General.

PART 2 -- PRODUCTS

2.1 METAL BALL VALVES (4-INCHES AND SMALLER)

A. General: Unless otherwise indicated, general purpose metal ball valves in sizes up to 4-inches shall have actuators in accordance with Section 433012 - Valve and Gate Actuators.

B. Body: Ball valves up to and including 1-1/2 inches in size shall have bronze or carbon steel 2 or 3 piece bodies with screwed ends for a pressure rating of not less than 600 psi WOG. Valves 2-inches to 4-inches in size shall have bronze or carbon steel 2 or 3 piece bodies with flanged ends for a pressure rating of ANSI 125 psi or 150 psi unless otherwise indicated.

C. Balls: The balls shall be solid chrome-plated brass or bronze, or stainless steel, with standard port (single reduction) or full port openings.

D. Stems: The valve stems shall be of the blow-out proof design, of bronze, stainless steel, or other acceptable construction, with reinforced teflon seal.

E. Seats: The valve seats shall be of teflon or Buna-N, for bi-directional service and easy replacement.

F. Manufacturers, or Equal

1. Conbraco Industries, Inc. (Apollo)
2. ITT Engineered Valves
3. Neles-Jamesbury, Inc.
4. Watts Regulator
5. Worcester Controls
2.2 PLASTIC BALL VALVES

A. **General:** Plastic ball valves for corrosive fluids shall be made of polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC), polypropylene (PP), or polyvinylidene fluoride (PVDF), as recommended by the manufacturer for the specific application. Valves shall have manual actuators in accordance with Section 433012 - Valve and Gate Actuators, unless otherwise indicated.

B. **Construction:** Plastic ball valves shall have union ends or flanged ends to mate with ANSI B 16.5, class 150 flanges for easy removal. The balls shall have full size ports and teflon seats. Body seals, union O-ring seals, and stem seals shall be in accordance with the corrosion resistance requirements of Section 411500. External (without entering into the wetted area) seat packing adjustment is preferred. Metal reinforced stems to prevent accidental breakage are preferred. Ball valves for sodium hypochlorite solution service shall be drilled through the ball or body per valve manufacturer recommendation to relieve offgas and equalize pressure across the valve. The valves shall be suitable for a maximum working non-shock pressure of 150 psi at 73 degrees F for PVC and CPVC, with decreasing ratings for higher temperatures and other plastics.

C. Manufacturers, or Equal
   1. ASAHI-America
   2. George Fischer, Inc.
   3. NIBCO Inc., (Chemtrol)
   4. Plast-O-Matic Valves, Inc.
   6. Watts Regulator

PART 3 – EXECUTION

3.1 GENERAL

A. Valves shall be installed in accordance with Section 433000. Care shall be taken that valves in plastic lines are well supported at each end of the valve.

- END OF SECTION -
SECTION 433022 - GATE VALVES

PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide gate valves and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 433000 - Valves, General apply to this Section.

C. The requirements of Section 433012 - Valve and Gate Actuators apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 433000.

PART 2 – PRODUCTS

2.1 GENERAL

A. Buried valves shall be of the inside screw, non-rising stem type. The valve actuators shall be as indicated, with counter-clockwise opening stems, in accordance with Section 433012.

B. Gate valves 18-inches and larger shall be provided with a bypass line and isolation valve.

2.2 METAL-SEATED GATE VALVES (3-INCHES AND LARGER)

A. **Construction:** Metal-seated gate valves for water and sewage service shall conform to AWWA C 500 - Metal-Seated Gate Valves for Water Supply Service. The valve bodies shall be of cast iron conforming to ASTM A 126 - Gray Iron Castings for Valves, Flanges, and Pipe Fittings, or ductile iron conforming either to ASTM A 395 - Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures, or to ASTM A 536 - Ductile Iron Castings, with flanged, bell and spigot, or mechanical joint-ends as indicated. Body and bonnet wall thickness shall be equal to or greater than the minimum wall thickness as listed in Table 2 of AWWA C500. The design working water pressure shall be 200 psig for valves 12-inches and smaller and 150 psig for larger valves. The valves may be of the double-disc type for tighter shut-off, or of the solid-wedge type, with rising or non-rising stem. For sewage or fluids containing solids, an outside thread shall be used. Valves 14-inches and larger installed in vertical pipes shall be fitted with bronze slides, tracks, rollers, and scrapers to assist the travel of the gate assembly. Gate valves 14-inches and larger shall be furnished with bypass assemblies.

B. **Actuators:** Unless otherwise indicated, gate valves shall have manual actuators in accordance with Section 433012.

C. Manufacturers, or Equal

1. Clow Valve Co.

2. Kennedy Valve
3. M & H Valve Company

4. Milwaukee Valve Company, Inc.

2.3 RESILIENT-SEATED GATE VALVES

A. General: Resilient-seated gate valves may be provided in lieu of metal-seated double-disc or solid-disc gate valves, at the discretion of the ENGINEER.

B. Construction: Resilient-seated gate valves shall conform to AWWA C509 - Resilient-Seated Gate Valves for Water and Sewerage Systems or AWWA C515 - Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Service. The valves shall be suitable for a minimum design working water pressure of 150 psig, with flanged, bell and spigot, or mechanical joint ends. The valve body, bonnet, and disc shall be of cast iron or ductile iron and the disc or body shall be rubber-coated. Body and bonnet wall thickness shall be equal to or greater than the minimum wall thickness as listed in Table 1 of AWWA C509 or AWWA C515. The stem, stem nuts, glands, and bushings shall be bronze, with the stem seal per AWWA C509 or AWWA C515.

C. Pressure Ratings

1. AWWA C509 valves that are 3, 4, 6, 8, and 12 inches in size shall be rated for 200 psig minimum design working water pressure, and 16-, 20-, 24-, and 30-inch valves shall be rated for 150 psig minimum design working water pressure.

2. AWWA C515 valves 3- through 36-inch with outside screw-and-yoke (OS&Y) rising stem and 3- through 16-inch for non-rising-stem (NRS), shall be rated for 200 psig minimum design working water pressure.

D. Protective Coating: Valves shall be factory coated in accordance with Section 09800 - Protective Coating. The CONTRACTOR shall submit a test report from a coating inspector that the coating is holiday-free. The CONTRACTOR shall be aware that it may retain the services of a third party coating applicator to achieve the holiday-free requirement.

E. Actuators: Unless otherwise indicated, resilient-seated gate valves shall have manual actuators in accordance with Section 15201.

F. Manufacturers, or Equal

1. Mueller Company

2. M & H

3. Clow

2.4 GATE VALVES (SMALLER THAN 3-INCHES)

A. Construction: Gate valves smaller than 3-inches, for general purpose use, shall be non-rising stem, heavy-duty type for industrial service, with screwed or soldered ends to match the piping. The bodies shall have union bonnets of bronze conforming to ASTM B 62 - Composition Bronze or Ounce Metal Castings. The stems shall be of bronze conforming to ASTM B 62, or ASTM B 371 - Copper-Zinc-Silicon Alloy Rod. The solid wedges shall be of bronze conforming to ASTM B 62. The valves shall have malleable iron handwheels unless otherwise indicated, and stem seals shall be of Teflon-
impregnated or other acceptable non-asbestos packing. Valves shall have a pressure rating of minimum 125 psi steam and 200 psi coldwater, unless otherwise indicated.

B. Manufacturers, or Equal

1. Crane Company
2. Milwaukee Valve Company
3. Wm. Powell Company
4. Stockham Valves and Fittings
5. Walworth Company

PART 3 -- EXECUTION

3.1 GENERAL

A. Gate valves shall be installed in accordance with the provisions of Section 433000. Care shall be taken that valves in plastic lines are well supported at each end of the valve.
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SECTION 433052 - MISCELLANEOUS VALVES

PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide miscellaneous valves and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 433000 - Valves, General, apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 433000.

PART 2 -- PRODUCTS

2.1 AIR-VACUUM AND AIR-RELEASE VALVES

A. **Air and Vacuum Valves:** Air and vacuum valves shall be capable of venting large quantities of air while pipelines are being filled, and allowing air to re-enter while pipelines are being drained. They shall be of the size indicated, with flanged or screwed ends to match piping. Bodies shall be of high-strength cast iron. The float, seat, and moving parts shall be constructed of Type 316 stainless steel. Seat washers and gaskets shall be of a material insuring water tightness with a minimum of maintenance. Valves shall be designed for minimum 150 psi water-working pressure, unless otherwise indicated.

B. **Air-Release Valves:** Air-release valves shall vent accumulating air while system is in service under pressure and be of the size indicated. Valves shall meet the same general requirements as indicated for air and vacuum valves except that the vacuum feature will not be required. Valves shall be designed for a minimum water-working pressure of 150 psi, unless otherwise indicated.

C. **Combination Air Valves:** Combination air valves shall combine the characteristics of air and vacuum valves and air release valves by exhausting accumulated air in systems under pressure and releasing or re-admitting large quantities of air while a system is being filled or drained, respectively. Valves shall have the same general requirements as indicated for air and vacuum valves.

D. **Sewage Air Release Valves:** Sewage air release valves shall vent accumulating gases during system operation. Valves shall have long float stems and bodies to minimize clogging. The same general requirements shall apply as indicated for air and vacuum valves. Each sewage air release valve shall be furnished with the following backwash accessories, fully assembled on the valve:

1. Inlet shut-off valve.
2. Blow-off valve.
3. Clear water inlet valve.
4. Rubber supply hose.
5. Quick disconnect couplings.

E. Manufacturers, or Equal

1. **APCO (Valve and Primer Corporation)**
2. **Crispin - Multiplex Manufacturing Company**
3. **GA Industries**
4. **Val-Matic (Valve and Manufacturing Corporation)**

2.2 AIR AND VACUUM VALVES FOR VERTICAL TURBINE PUMPS

A. An air and vacuum valve for the vertical turbine pump shall be installed on the pump discharge pipe indicated. The valve shall vent large quantities of air out through the orifice when pump starts, close tight when liquid enters, and permit large quantities of air to re-enter through orifice when pump stops, to prevent vacuum forming in the pump column. They shall be of the size indicated, with flanged or screwed ends to match piping. Bodies shall be of high-strength cast iron. The float, seat, and moving parts shall be constructed of Type 316 stainless steel. Seat washers and gaskets shall be of a material insuring water tightness with a minimum of maintenance. The discharge orifice shall be fitted with a double-acting throttling device to regulate and restrict air venting, which shall establish a pressure loading on the rising column of water and eliminate damaging shock to the pump, controls, and valves during pump start. On pump stop, a double-acting throttling device shall automatically open, allowing full line unrestricted air re-entry to prevent any vacuum from forming in the pump column. The valve shall be designed for minimum 150 psi water-working pressure.

B. Manufacturer, or Equal

1. **APCO (Valve and Primer Corporation)**
2. **Val-Matic (Valve and Manufacturing Corporation)**

2.3 BACKFLOW PREVENTER VALVES

A. General

1. Provide backflow preventers that work on the reduced pressure principle.
2. Provide drain lines with air gaps.
3. The backflow preventer valves shall be in accordance with AWWA C511 – Reduced-Pressure Principle Backflow Prevention Assembly.

B. Construction

1. The preventers shall consist of 2 spring-loaded check valves, an automatic differential pressure relief valve, drain valves, and shut-off valves.
2. The body material shall be bronze or cast iron, for a working pressure of not less than 150 psig, with bronze or stainless steel trim.
C. Maintenance Access

1. Provide separate access covers for the check valves and the relief valve.
2. Provide top-entry access to check valve components.

D. Manufacturers, or Equal

1. Cla-Val Company
2. Febco (CMB Industries)
3. Watts, ACV
4. Wilkins Regulator Division (Zurn Industries)

2.4 CORPORATION STOPS

A. Unless otherwise indicated, corporation stops shall be made of solid brass for key operation, with screwed ends with corporation thread or iron pipe thread, as required.

B. Manufacturer, or Equal

1. Ford Meter Box Company, Inc.
2. James Jones Company (Watts, ACV)
3. Mueller Company

2.5 SOLENOID VALVES

A. Solenoid valves shall be of the size, type, and class indicated and shall be designed for not less than 150 psi water-working pressure. Valves for water, air, or gas service shall have brass or bronze body with screwed ends, stainless steel trim and spring, Teflon or other resilient seals with material best suited for the temperature and fluid handled. Unless otherwise indicated, for chemicals and corrosive fluids, solenoid valves with PVC, CPVC, polypropylene (PP), polyvinylidene fluoride (PVDF), or Teflon materials of construction, suitable for the specific application shall be provided. Enclosures shall be NEMA rated in accordance with the area designations of Section 260000 - Electrical Work, General. Coil ratings shall be for continuous duty. For electrical characteristics see the electrical Drawings or Specifications.

B. Manufacturers, or Equal

1. For general duty:
   a. Automatic Switch Co. (ASCO), Model RED HAT
   b. Skinner Valve (Parker Hannifin Corporation)
   c. Magnatrol Valve Corporation
   d. J. D. Gould Co.
2. Metallic valves for corrosive fluids:
   a. Valcor Engineering Corporation

3. Plastic valves for corrosive fluids:
   a. +GF+ Plastic Systems, Inc.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Backflow preventers shall be installed in potable water lines where required by applicable codes or regulations, wherever there is any danger of contamination, and where indicated.

B. Valves shall be installed in accordance with the manufacturer’s printed recommendations, and with Section 433052.

C. Backflow preventers, as well as air and vacuum release valves, shall have piped outlets to the nearest acceptable drain, firmly-supported, and installed in such a way as to avoid splashing and wetting of floors and obstruction of traffic.

- END OF SECTION -
PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide hydraulic gates with appurtenances, complete and operable, in accordance with the Contract Documents.

B. The provisions of this Section shall apply to flap gates, slide gates, stop gates, cast iron slide gates, and shear gates, except where otherwise indicated in the Contract Documents.

C. The requirements of Section 410000 – Equipment, General, apply to this Section.

D. The requirements of Section 433012 – Valve and Gate Actuators apply to this Section.

E. Single Manufacturer

1. The CONTRACTOR shall assign to a single manufacturer responsibility for the furnishing and functional operation of the hydraulic gates, including operators and accessories.

2. The designated single manufacturer, however, need not manufacture more than one part of the units, but shall coordinate the design, assembly, testing, and installation of the units.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

AWWA C560 Cast Iron Slide Gates
AWWA C561 Stainless Steel Slide Gates
AWWA C562 Aluminum Slide Gates
AWWA C563 Composite Slide Gates
AWWA C 513 Open Channel Fabricated Metal Slide Gates
ASTM A 276 Stainless Steel Bars and Shapes
ASTM B 21 Naval Brass Rod, Bar, and Shapes
ASTM B 584 Copper Alloy Sand Castings for General Applications

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 013300 – Contractor Submittals.

B. Shop Drawings: Submit Shop Drawings of hydraulic gates as indicated in their respective Section.
C. Technical Manuals

1. Submit complete technical manuals, including printed instructions for proper maintenance, lubrication, and complete parts list indicating the various parts by name, number, and exploded view where necessary.

2. A list of recommended spare parts for the OWNER to store at the facility shall be included.

D. Certification: The CONTRACTOR shall obtain written certification from the designated single manufacturer, addressed to the OWNER, stating that the equipment will efficiently and thoroughly perform the required functions in accordance with these Contract Documents, and that the designated single manufacturer accepts the CONTRACTOR's assignment of responsibility for coordination of gate equipment, including operators, controls, and services required for proper installation and operation.

E. Field Procedures: Prior to installation of the gates, provide instructions for field procedures for installation, adjustments, inspection, and testing.

1.4 QUALITY ASSURANCE

A. Equipment Field Testing

1. The CONTRACTOR shall be responsible for the coordination of the tests of each hydraulic gate in the presence of the manufacturer's factory service representative.

2. Excessive leaks shall be corrected and the equipment retested until found to be satisfactory.

1.5 MANUFACTURER'S SERVICE REPRESENTATIVE

A. Installation and Startup Assistance: Service and testing assistance by the manufacturer's engineering representative for each gate and valve shall be furnished by the CONTRACTOR during installation and startup.

B. Instruction of OWNER's Personnel: The CONTRACTOR shall arrange for the services of a factory service representative to instruct the OWNER's personnel in the operation and maintenance of the equipment.

1.6 SPECIAL WARRANTY REQUIREMENT

A. The CONTRACTOR shall furnish the manufacturer's written guarantee that the hydraulic gates comply with the indicated requirements.

B. The CONTRACTOR shall furnish the manufacturer's warranties as published in its literature.

PART 2 – PRODUCTS

2.1 GENERAL

A. Equipment provided under this Section shall be new, of current manufacture, and shall be the products of reputable manufacturers specializing in the manufacture of such products and which have had previous experience in such manufacture.
B. The CONTRACTOR shall, upon request, furnish the names of not less than 5 successful installations of the manufacturer's equipment of comparable nature to that offered under the Contract.

C. Combinations of manufactured equipment which are provided under these Specifications shall be entirely compatible, and the CONTRACTOR and the manufacturer shall be responsible for the compatible and successful operation of the various components of the units.

D. Indicated and necessary mountings and appurtenances shall be included.

2.2 MATERIALS

A. Materials employed in the manufacture and installation of the hydraulic gates and operators shall be suitable for the intended application. Material not specifically called for shall be high-grade, standard commercial quality, free from defects and imperfection that might affect the serviceability of the product for the purpose for which it is intended.

2.3 HARDWARE

A. Bolts and nuts shall comply with the requirements of Section 055000 – Miscellaneous Metalwork.

2.4 PROTECTIVE COATING

A. Coat ferrous metal in accordance with the requirements of Section 099600 – Protective Coating

2.5 TOOLS AND SPARE PARTS

A. Tools

1. Furnish special tools that are necessary for maintenance and repair of the gates.

2. Such tools shall be suitably stored in metal toolboxes and identified with the equipment number by means of stainless steel or solid plastic nametags attached to the box.

B. Spare Parts

1. Furnish the following spare parts in a box as described above for tools, for air- or hydraulic-actuated gates for each type and size of gate:

   a. one set of directional valves, solenoid or pilot actuated
   b. one set of cylinder actuator seals
   c. one set of filters
   d. one repair kit for the hydraulic pump, containing seals or packing, gaskets, and O-rings

PART 3 – EXECUTION

3.1 INSTALLATION
A. Slide and shear gates shall be installed in strict accordance with the manufacturer's printed recommendations and the indicated requirements.

B. Operators shall be located as to avoid interference with handrails and structural members.

C. Gates with Wall Thimbles
   1. Shortly before setting each gate, apply a 1/8-inch-thick layer of mastic grade polysulfide elastomeric sealant to the back of the gate frame.
   
   2. After setting the gate, the nuts shall be turned down on the anchor bolts far enough only to make them snug and to cause the rubber sealant to begin to ooze out, but not far enough to produce any significant stress to the frame.
   
   3. Excess sealant at the edges shall be removed.
   
   4. The sealant shall be allowed to cure for at least 7 Days, after which the anchor bolt nuts shall be tightened to their final positions.
   
   5. If gaskets are being used, they shall be installed over the studs in one piece, or dovetailed and cemented with a liquid-type gasket material.

D. Damage to surface coatings incurred during shipment or installation shall be repaired.

- END OF SECTION -
SECTION 433060 - CAST IRON SLIDE AND SHEAR GATES

PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide slide and shear gates, complete and operable, as indicated in accordance with the Contract Documents.

B. The requirements of Section 433056 – Hydraulic Gates, General, apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. Shop Drawings

1. Submit the following:
   a. Drawings of gates, frames, slides, and actuators.
   b. Design load calculations for deflection at the maximum expected head.
   c. Calculations for the lifting force generated by 40 pounds effort on the handwheel or crank in order to operate the gate.

1.3 QUALITY ASSURANCE

A. Leakage criteria for field test shall conform to AWWA Standards.

PART 2 – PRODUCTS

2.1 CAST IRON SLIDE GATES

A. Gates shall comply with AWWA C560 - Cast Iron Slide Gates, unless indicated otherwise.

B. Gates shall be new and of current manufacture.

C. Gates shall be adequately braced to prevent warping and bending under the intended usage.

D. Actuators

1. Gate actuators shall be sized, selected, and furnished by the gate manufacturer.

2. Gate actuators throughout the Project shall be products of a single manufacturer.

E. Mounting Requirements

1. Guide frames shall be extended 3 feet, 6 inches above the walkway in order to match the height of the handrail.

2. Where a gate is mounted in an opening between 2 sections of handrail, additional horizontal members shall be added to the gate frame to match the handrail, guardrail, and kickplate spacing of the adjacent railing.
3. Horizontal members shall be arranged such that the railing will not interfere with operation of the actuator.

F. Construction

1. Unless otherwise indicated, materials of construction shall be in accordance with AWWA C560, as suitable for the service.

2. Materials used in the fabrication of the slide gates shall conform to the requirements of the standards designated for each material indicated below:

<table>
<thead>
<tr>
<th>Description</th>
<th>Materials Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mounting Assembly</td>
<td></td>
</tr>
<tr>
<td>Anchor Bolts and Nuts</td>
<td>Stainless Steel, ASTM A 276 Type 316</td>
</tr>
<tr>
<td>Stem Cover</td>
<td>Aluminum, with slots and indicator</td>
</tr>
<tr>
<td>Wall thimble</td>
<td>Cast Iron, ASTM A 48, Class 30</td>
</tr>
<tr>
<td>Gate Assembly</td>
<td></td>
</tr>
<tr>
<td>Frame, Slide, and Guide Rails</td>
<td>Cast Iron, ASTM A-126 B</td>
</tr>
<tr>
<td>Seating Faces and Stem Guide Bushings</td>
<td>Low-Zinc Bronze, ASTM B-98</td>
</tr>
<tr>
<td>Wedges</td>
<td>Low-Zinc Bronze, ASTM B-98</td>
</tr>
<tr>
<td>Fasteners</td>
<td>Stainless Steel, ASTM A 276 Type 316</td>
</tr>
<tr>
<td>Stem Blocks</td>
<td>Low-Zinc Bronze, ASTM B-98</td>
</tr>
<tr>
<td>Flush Bottom Seal Type</td>
<td></td>
</tr>
<tr>
<td>Sill Plate</td>
<td>Cast Iron, ASTM A-126 B</td>
</tr>
<tr>
<td>Seal</td>
<td>Rubber, Neoprene 2000-Grade R-62</td>
</tr>
<tr>
<td>Retainer</td>
<td>Stainless Steel, ASTM A 276 Type 316</td>
</tr>
<tr>
<td>Flush Bottom Seals</td>
<td>Rubber, Neoprene 2000-Grade R-62</td>
</tr>
<tr>
<td>Self-Contained Type</td>
<td></td>
</tr>
<tr>
<td>Yoke</td>
<td>Cast Iron, ASTM A-126 B</td>
</tr>
<tr>
<td>Stem</td>
<td>Stainless Steel, ASTM A 276 Type 316</td>
</tr>
</tbody>
</table>
G. Lifting Devices

1. Provide lifting devices complete with stem, lifting nut, intermediate supports with steady bushings, stem cover, indicator, and gear reducer, hand wheel, crank, electric or hydraulic cylinder, where indicated.

2. The lifting devices shall be weatherproof.

3. Pedestal Mounting
   a. The lifting devices shall be mounted on pedestals constructed of cast iron or fabricated steel.
   b. The pedestals shall have an ample base or bracket area to evenly distribute the load to the supporting concrete structure.

4. The centerline of the manual actuator shall be approximately 3 feet above the base for pedestal-mounted actuators, and approximately 4 feet above the floor for frame-mounted actuators.

5. Power lifting devices shall be in accordance with Section 433012 – Valve and Gate Actuators.

6. Slide gate hoist heads shall be constructed of cast iron.

7. The operating nut shall be constructed of solid bronze, in accordance with ASTM B 584.

8. Operating thrust shall be taken on roller or ball bearings.

9. Parts shall be provided with an alternative lubrication system.

10. Handwheel Crank
    a. The unit shall be designed for a 40-pound maximum effort on the crank in order to operate the gate.
    b. Clockwise movement of the handwheel shall close the gate.
    c. The operating crank shall be easily removable in order to facilitate the use of a portable power operator.

H. Wall Thimbles

1. Unless otherwise indicated, sluice gates shall be provided with cast iron, F-pattern wall thimbles to match the thickness of the walls in which they are installed.

2. Thimbles shall be furnished by the manufacturer of the gates and shall fit the bolt dimensions of the gates.

3. Studs shall be constructed of Type 316 stainless steel.

I. Sealant Manufacturer (for Gates installed with Wall Thimbles), or Equal: The elastomeric sealant shall be Rubber Caulk Sealer as manufactured by the Product Research Company.
J. **Grout**: Gates mounted against concrete walls and without wall thimbles shall be installed with one inch of non-shrink grout between the wall and the gate flange.

K. Manufacturers, or Equal

1. *Rodney Hunt*
2. *Hydro Gate Corp.*
3. *Waterman Gate Company*

**PART 3 -- EXECUTION**

3.1 **INSTALLATION**

A. Slide and shear gates shall be installed in strict accordance with the requirements of Section 433056 – Hydraulic Gates, General.

- END OF SECTION -
PART 1 – GENERAL

1.1 THE REQUIREMENT
A. The CONTRACTOR shall provide fabricated slide gates, complete and operable, in accordance with the Contract Documents.
B. The requirements of Section 055000 – Miscellaneous Metalwork.
C. The requirements of Section 433012 – Valve and Gate Actuators, apply to this Section.
D. The requirements of Section 433056 – Hydraulic Gates, General, apply to this Section.

1.2 CONTRACTOR SUBMITTALS
A. Shop Drawings
   1. Submit the following:
      a. Drawings of gates, frames, slides, and actuators.
      b. Design load calculations for deflection at the maximum expected head.
      c. Calculations for the lifting force required by the hydraulic gate actuator as required per the Contract Documents in order to operate the gate.

1.3 QUALITY ASSURANCE
A. The leakage allowance for slide gates under the design seating and unseating heads shall conform with the AWWA Standards.
B. Factory Testing
   1. Gates shall be factory-assembled and functionality-tested prior to delivery to the Site.
   2. Test certificates shall be submitted.

PART 2 – PRODUCTS

2.1 GENERAL
A. Gates shall comply with the following Standards:
   1. AWWA C561 Stainless Steel Slide Gates
B. Gates shall be new and of current manufacture, adequately braced in order to prevent warpage and bending under the intended use.
C. Gates shall be designed for compatible mounting to and to be actuated by hydraulic cylinder gate actuators, as specified in Section 433012 – Valve and Gate Actuators.
2.2 STAINLESS STEEL SLIDE GATES

A. Equipment: Provide fabricated stainless steel slide gates according to the following:

<table>
<thead>
<tr>
<th>Gate Equipment No.</th>
<th>G-101, G-102, G-103</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Intake Structure Wetwell (Center Dividing Wall)</td>
</tr>
<tr>
<td>Service</td>
<td>raw water</td>
</tr>
<tr>
<td>Mounting</td>
<td>self-contained, gate mounted guides</td>
</tr>
<tr>
<td>Use</td>
<td>upward opening; intermittent duty</td>
</tr>
<tr>
<td>Size</td>
<td>5'-0&quot; wide X 9'-4&quot; high opening</td>
</tr>
<tr>
<td>Material</td>
<td>stainless steel</td>
</tr>
<tr>
<td>Seating / Unseating</td>
<td>3-ft / 3-ft</td>
</tr>
<tr>
<td>Head, ft</td>
<td></td>
</tr>
<tr>
<td>Actuator Type</td>
<td>hydraulic cylinder, per Section 433012</td>
</tr>
</tbody>
</table>

B. Construction

1. Unless otherwise indicated, materials of construction shall be in accordance with AWWA C561 suitable for the service.

2. Materials used in the fabrication of the slide gates shall conform to the requirements of the standards designated for each material as indicated below:

<table>
<thead>
<tr>
<th>Description</th>
<th>Material Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless Steel Gates</td>
<td></td>
</tr>
<tr>
<td>Slide</td>
<td>ASTM A 276, Type 316, or Type 316 L</td>
</tr>
<tr>
<td>Frame</td>
<td>ASTM A 276, Type 316, or Type 316 L</td>
</tr>
<tr>
<td>Stem and coupling</td>
<td>ASTM A 276, Type 316</td>
</tr>
<tr>
<td>Hardware</td>
<td>ASTM A 276, Type 316</td>
</tr>
<tr>
<td>Guides and seats</td>
<td>UHMW Polyethylene, ASTM D 4020</td>
</tr>
<tr>
<td>Seals</td>
<td>“J” bulb Type, Neoprene ASTM D 2000, or UWMH Polyethylene ASTM D 4020 flat seal. Flat neoprene seals are not acceptable.</td>
</tr>
</tbody>
</table>
C. Manufacturers, or Equal

1. Rodney Hunt Company
2. Hydro Gate Corp.
3. Waterman Gate Company

PART 3 – EXECUTION

3.1 INSTALLATION

A. The slide gates shall be installed in strict accordance with the requirements of Section 433056 – Hydraulic Gates, General.

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SECTION 435200 - HOISTS AND CRANES, GENERAL

PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide the hoisting equipment, ancillary steel, and appurtenances, complete and operable, as indicated in accordance with the Contract Documents.

B. The requirements of this Section apply to all hoists and cranes unless indicated otherwise.

C. The requirements of Section 410000 – Equipment General Provisions, apply to this Section.

1.2 REFERENCE SPECIFICATIONS CODES, AND STANDARDS

A. Commercial Standards

AISC Specifications for the Design, Fabrication, and Erection of Structural Steel for Building

AGMA American Gear Manufacturer’s Association

ANSI B30.11 Overhead and Gantry Cranes

ANSI MH 27.1 Underhung Crane and Monorail Systems

ASTM A 36 Carbon Structural Steel

CMAA A division of Material Handling Industry of America

NEMA National Electrical Manufacturer’s Association

OSHA 29 CFR 1926.550 – Cranes and derricks

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 013300 – Contractor Submittals.

B. Shop Drawings shall include electrical requirements, weights, wheel loads, dimensions, and required clearances.

C. Shop Drawings shall include structural calculations for the Monorails, Traveling Jib Crane, connections and anchorage of each system stamped and signed by a registered engineer in the State of California.

D. Technical Manuals: Include complete operating and maintenance instructions of the hoist and crane systems.
1.4 QUALITY ASSURANCE

A. **Inspection and Testing Requirements:** After installation, the CONTRACTOR shall inspect and test hoists and crane systems in the presence of the manufacturer's service representative, for proper operation and conformance to the indicated requirements.

B. **Acceptance Criteria and Tolerances:** The ENGINEER reserves the right to reject any equipment not conforming to the tolerances, deflections, and lateral stiffness as indicated.

1.5 MANUFACTURER’S SERVICES

A. The CONTRACTOR shall arrange for the hoist or crane manufacturer to furnish the services of a trained, qualified representative for at least one day after the units are installed, for the purpose of inspecting the installation and instructing the OWNER's operating personnel.

PART 2 – PRODUCTS

2.1 GENERAL

A. Equipment of similar design shall be from a single manufacturer.

B. The capacity of each hoist and trolley shall be permanently marked in a conspicuous manner on the equipment.

C. The wire rope reeving shall be of the 2-part double, cross-mounted or similar appropriate type, to provide a true, vertical lift without drift, unless otherwise indicated.

D. Hooks shall be of the safety type with a latch.

E. Motors shall comply with the requirements of Section 260510 – Electric Motors.

F. The CONTRACTOR shall verify dimensions and clearances in the field prior to installation and shall be responsible for the proper fitting and operation of the equipment.

G. Manufacturers, or Equal
   1. ACCO Babcock, Inc.
   2. American Monorail
   3. Cleveland Tramrail
   4. Thern, Inc.

2.2 BASIC MATERIALS

A. Materials shall be new and of the best commercial grade.

B. Where materials are not indicated, the CONTRACTOR shall have the manufacturer use the most suitable selection for the given application and environment.
2.3 PLANT FABRICATED ITEMS
   
   A. Fabrication, assembly, and welding shall be performed by factory-trained specialists and certified welders.

2.4 TOOLS AND SPARE PARTS
   
   A. Tools
      
      1. The CONTRACTOR shall furnish one complete set of special wrenches or other special tools necessary for the assembly, adjustment, and dismantling of the equipment.
      
      2. The tools shall be of best quality and furnished in labeled toolboxes of suitable design.
   
   B. Spare Parts
      
      1. Furnish spare parts as required by the hoist or crane Section.
      
      2. The parts shall be properly labeled and identified with the name and number of the equipment to which they belong.

PART 3 -- EXECUTION

3.1 INSTALLATION
   
   A. Hoist and crane equipment shall be installed in strict accordance with the manufacturer's printed instructions.
   
   B. Workmanship shall be in accordance with the referenced standards and codes.
   
   C. Care shall be taken that the structural integrity of beams, columns, walls, floors, and roofs will be maintained at all times.

3.2 FIELD TESTING
   
   A. After completion of the WORK, the CONTRACTOR shall test hoist and crane equipment in the presence of the manufacturer's field representative, who shall certify in writing that the equipment meets applicable standards and specifications.
   
   B. The Test Loads is to be 110% of the lift load.

   - END OF SECTION -
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PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall furnish and install trolley hoists and monorails systems complete, in accordance with the requirements of the Contract Documents. Each trolley and hoist shall be manual chain operated with push-pull type trolley. Each trolley shall fit the steel monorail beam shown on the Contract Drawings.

B. The requirements of Section 435200 – Hoists and Cranes, General shall apply to this Section. The requirements of Section 410000 – Equipment General Provisions apply to the WORK of this Section.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Codes: All codes, referenced herein, are specified in Section 014219 – “Reference Standards.”

B. Commercial Standards

- AISC Specifications for the Design, Fabrication, and Erection of Structural Steel for Building
- ANSI MH 27.1 Specifications for Underhung Crane and Monorail System
- ASTM A 36 Specification for Structural Steel
- CMAA Crane Manufacturer’s Association of America

1.3 CONTRACTOR SUBMITTALS

A. Shop Drawings: The CONTRACTOR shall submit complete shop drawings of hoist and trolley in accordance with the requirements of the Section 013300 – “Contractor Submittals.” Such shop drawings shall include weights, wheel loads, dimensions, clearances required and other information necessary to determine conformance to the Contract Specifications.

B. OWNER’s Manuals: The CONTRACTOR shall furnish to the ENGINEER copies of complete operating and maintenance instructions of all the hoists and trolleys as specified under “Technical Manuals” in Section 013300 – “Contractor Submittals.”

1.4 QUALITY ASSURANCE

A. Inspection and Testing Requirements: After installation, the CONTRACTOR shall inspect and test the hoist and trolley system in the presence of the manufacturer’s service representative, for proper operation and conformance to the Specifications.

B. Acceptance Criteria and Tolerances: The ENGINEER reserves the right to reject any equipment not conforming to the tolerances, deflections, and lateral stiffness indicated.
1.5 MANUFACTURER'S SERVICES

A. The CONTRACTOR shall arrange for the hoist manufacturer to furnish the services of a trained, qualified representative for at least one day after the units are installed, for the purpose of inspecting the installation and instructing the OWNER's operating personnel.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Equipment of similar design shall be from a single manufacturer.

B. Monorail beam to have minimum structural properties of a W12x53

C. The hoist and trolley capacity shall be as indicated herein. The capacity of each hoist and trolley shall be permanently marked in a conspicuous manner on the equipment.

D. Hooks shall be safety type with latch.

E. The CONTRACTOR shall verify dimensions and clearances in the field prior to installation and shall be responsible for the proper fitting and operation of the equipment.

F. Manufacturers, or Equal

1. ACCO Babcock, Inc.

2. American Monorail

3. Cleveland Tramrail

4. Thern, Inc.

2.2 BASIC MATERIALS

A. Materials shall be new and of the best commercial grade. Where materials are not indicated, the CONTRACTOR shall have the manufacturer use the most suitable selection for the given application and environment.

2.3 PLANT FABRICATED ITEMS

A. Fabrication, assembly, and welding shall be carried out by factory-trained specialists and certified welders.

2.4 Seismic requirements: Calculations shall be performed and signed and stamped for equipment. Calculations shall analyze all lateral loads. Calculations shall include the distribution of forces imposed on the supporting structure and anchors, verifying that each anchor can develop the required resistance forces. Seismic forces shall be as stated in specifications section 41 00 00 Equipment General Provisions. Anchorage for all equipment shall be designed for these forces and the ductility requirements in ASCE 7-05.
### 2.5 HOIST AND TROLLEY

#### A. Equipment

<table>
<thead>
<tr>
<th>Equipment Number</th>
<th>H-436</th>
<th>H-437</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Intake Structure Wetwell - North</td>
<td>Intake Structure Wetwell - South</td>
</tr>
<tr>
<td>Atmosphere</td>
<td>Indoors with 100 percent relative humidity</td>
<td>Indoors with 100 percent relative humidity</td>
</tr>
<tr>
<td>Capacity</td>
<td>6,000 lbs</td>
<td>6,000 lbs</td>
</tr>
<tr>
<td>Monorail Elevation</td>
<td>Refer to Structural Drawings</td>
<td>Refer to Structural Drawings</td>
</tr>
<tr>
<td>Minimum Hook Elevation</td>
<td>Elev. -5.0’</td>
<td>Elev. -5.0’</td>
</tr>
<tr>
<td>Maximum Hook Elevation</td>
<td>Elev. 30.0’</td>
<td>Elev. 30.0’</td>
</tr>
</tbody>
</table>

B. Each hoist and trolley shall be either a single integral unit or a combined system, compatible with the monorail beam shown on the Contract Drawings. Each hoist and trolley both shall be of heavy construction, suited for the intended application. Each hoist and trolley shall be hand chain operated with push-pull type trolley travel mechanism. Hoists shall be designed for minimum operator effort (40 lb) in lifting the rated load. An integral chain bucket for each hoist shall be provided for lift chain take up and storage.

#### C. Construction

- **Hoist** - Hand Chain Type
- **Bearings** - Anti-friction type, lifetime pre-lubricated and sealed
- **Load Block** - Heavy-duty with ball bearing sheave and forged steel swivel hook with anti-friction bearings and safety spring latch
- **Trolley** - Plain type hardened wheels and axles, ball or roller bearings, with hook plate

#### D. Paint

1. The monorails shall be field painted as specified in Section 099600 – “Protective Coatings” (System-100) (Excluding trolley wheel bearing surfaces)
2. The trolleys shall be factory finished in accordance with Section 099600 – “Protective Coatings.”
PART 3 -- EXECUTION

3.1 GENERAL REQUIREMENTS

A. The hoists and trolleys shall be installed in strict accordance with the Manufacturer’s printed instructions.

3.2 WORKMANSHIP

A. The workmanship shall be in accordance with the referenced standards and codes.

3.3 TESTING

A. After completion of the WORK, the CONTRACTOR shall test all hoist and trolley equipment in the presence of the ENGINEER, and correct all defects.

B. The testing shall be in accordance with and using a test load as indicated in Section 435200 – Hoists and Cranes, General.

- END OF SECTION -
SECTION 435250 - TRAVELING JIB CRANE SYSTEM

PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall furnish, test and adjust, install, and place in satisfactory operation the traveling jib crane system and appurtenances, complete and operable, in accordance with the requirements of the Contract Documents.

B. The CONTRACTOR shall furnish and install rail, bumpers, electric drive systems, and controls required for the traveling jib crane system. There are no OWNER supplied parts or services involved with the traveling jib crane system.

C. All components of the traveling jib crane system shall be suitable for outdoor use in operating temperatures ranging from 20 to +110°F for year-round periodic operation.

D. The requirements of this Section 435200 – HOISTS AND CRANES GENERAL and Section 410000 – EQUIPMENT GENERAL PROVISIONS apply to this section.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Codes: All codes referenced herein, are specified in Section 014219 - Reference Standards.

B. Commercial Standards

   AGMA American Gear Manufacturers Association
   ASME American Society of Mechanical Engineers
   ASTM A36 Specification for Structural Steel
   AWS American Welding Society
   CMAA Crane Manufacturers Association of America
   A division of Material Handling Industry of America
   NEMA National Electrical Manufacturers Association
   OSHA Occupational Safety and Health Administration

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Section 013300 - Submittals.

B. Section 055000 - Miscellaneous Metalwork.

C. Section 099600 - Protective Coatings.

D. Section 410000 - Equipment General Provisions.

E. Division 26 as applicable.
1.4 CONTRACTOR SUBMITTALS

A. Shop Drawings: The CONTRACTOR shall submit complete shop drawings of all equipment, in accordance with the requirements in Section 013300 - Submittals. Such shop drawings shall include all electrical requirements, weights, wheel loads, bearing loads and capacities, dimensions (including tolerances), drive assembly details, control diagrams, clearances, protective coating systems, and delivery/handling and erection requirements.

B. Calculations: Complete structural calculations shall be submitted, stamped and signed by a structural engineer licensed in the State of California.

   1. A Summary section shall be included at the beginning of the calculations that details the wheel reaction for all strength level individual loading and each loading combination

C. Coordination: CONTRACTOR shall coordinate work between the traveling jib crane fabricator and other suppliers as necessary to ensure a well-coordinated installation.

D. O & M Manuals: The CONTRACTOR shall furnish copies of complete operating and maintenance instruction of the traveling jib crane system as specified in Section 013300. O&M manuals shall include detailed troubleshooting procedures, suggested periodic maintenance, and cautionary advisories.

E. Certifications: The traveling jib crane system supplier shall submit certificates stating that the traveling jib crane system conforms to all installation, inspection, and testing requirements. An Overload Test Certification shall be provided which states that the traveling jib crane system may be periodically load tested to 125% (+5% / -0%) of the full rated load.

1.5 QUALITY ASSURANCE

A. Inspection and Testing Requirements: ENGINEER shall be granted access to fabrication facilities during fabrication to inspect the traveling jib crane system and view the shop tests. After installation, the CONTRACTOR shall inspect, test, and adjust all traveling jib crane sub-systems in the presence of the ENGINEER and OWNER, for proper operation and conformance with the Contract Documents. The CONTRACTOR shall instruct the OWNER's personnel in the operation and maintenance of the subject equipment.

B. Acceptance Criteria and Tolerances: The ENGINEER and OWNER reserve the right to reject any equipment not conforming with the tolerances, or performance specified. Tests shall be in accordance with paragraph 3.4 of this specification.

1.6 MANUFACTURER'S SERVICES

A. The CONTRACTOR shall arrange for the traveling jib crane system fabricator to furnish the services of a trained, qualified representative for at least two days, after the unit is installed, for the purpose of inspecting the installation and instructing the OWNER's operating personnel.
PART 2 -- PRODUCTS

2.1 GENERAL

A. The CONTRACTOR shall assume full responsibility for a coordinated and functional design and shall conform to the best engineering practice for the operating conditions given in these specifications. The CONTRACTOR shall be fully responsible for the satisfactory operation and testing of the traveling jib crane system. Crane hoisting machinery, controls, and operator interfaces shall be of a common manufacturer and arrangement to the extent possible.

B. The traveling jib crane system and associated equipment shall be in accordance with applicable regulations and standards of the NEMA; OSHA part 1910 of the Title 29 of the Code of Federal Regulations; and national and local electrical codes.

C. Safety Requirements: Handrails, screens and guards shall be provided whenever necessary for the protection of operators or others from injury. All guards, cases, and covers shall be easily removable for maintenance.

D. The CONTRACTOR shall verify all dimensions and clearances in the field prior to fabrication and shall be responsible for the proper fitting and operation of the equipment. The CONTRACTOR shall verify the motor size, power supply, and other electrical, mechanical, and structural coordination items during fabrication.

E. All welding shall be performed as specified in Section 410000 - Equipment General Provisions

F. Wind and seismic loading design criteria shall be as listed in Section 410000 – Equipment General Provisions.

2.2 PRINCIPLE OF OPERATION

A. The traveling jib crane system shall be capable of lifting and lowering a single load as specified herein, swiveling the load about a vertical axis, or transporting the load across the intake structure along a permanent steel railway system, as depicted on the Drawings. Only one of the movements, lifting/lowering, swiveling, or transporting, shall be performed at any one time; multiple simultaneous movements are not permissible.

The traveling jib crane system shall be used to install or remove the fish screen panels or blank panels as specified in Section 410166 – Profile Wire Screens, and shall be used to maintain the mechanical screen cleaning system components as specified in Section 410174 – Mechanical Screen Cleaner System.

The unit will be controlled by the hardwired and remote controls provided with the traveling jib crane system and powered by removable cords as specified herein.

2.3 GENERAL REQUIREMENTS

A. Contractor shall determine required bearing capacities, drive unit capacities, shaft sizing and support sizing based on the performance requirements.

B. The traveling jib crane system shall meet the required dimensions and clearance requirements as shown on the Drawings.
C. Minimum lifting load capacity of the jib crane system and shall be 6,000 lbs. The capacity of each major assembly shall be permanently marked in a conspicuous manner on the equipment.

2.4 MATERIALS

A. Unless otherwise shown or specified, materials of construction shall be structural steel (ASTM - A36), coated per Section 099600 – Protective Coatings. All components shall be designed for outdoor service over an operating temperature range from 20 to +110 °F for year-round operation.

2.5 EQUIPMENT

A. General: All mechanical equipment shall conform to applicable sections of divisions 055000 and 410000. All fastening of equipment shall be adequate to hold equipment in its proper place and alignment during all phases of operation. All steel castings, steel forgings, and rolled or forged steel wheels shall be properly annealed. All torsional transmitting loads shall be made by suitable keys.

B. Bolts, Nuts, Washers, Cotterpins: Shall be type 316 SS, unless otherwise specified. (See Section 055000 – Miscellaneous Metalwork).

C. Shaft Couplings: All shaft couplings used shall be in regular production by a recognized manufacturer of couplings and shall be of adequate design for the torques to be transmitted. Rigid couplings will be permitted only between bearings which are more than six (6) feet apart. Full flexible couplings for offset and angular misalignment shall be used between motors and driven equipment.

D. Keys and Keyways: The size of the keys shall be such as to be within safe bearing and shear limits for the materials in contact.

E. Setscrews: All setscrews shall have case-hardened cup points. When installed, heads shall be flush with surface. Setscrews shall not be used for transmitting torsion.

F. Lubricants: All lubricants shall be of food grade lubricant quality.

G. The traveling jib crane system shall consist of three major assemblies: the drive chassis, the jib crane, and the hoist.

1. Drive Chassis: Shall consist of welded steel framed chassis, four double-wheeled trolleys (two per rail), and a gear reduced two-speed or variable speed 480 VAC electric drive connected to a drive axle via a multiple row chain. Maximum motor horsepower shall be 15 HP. The trolley wheels and rail shall be suitably matched to facilitate true linear motion without any noticeable binding or vibration.

Counterweights consisting of steel, concrete, or gravel filled steel compartments shall be incorporated or attached to the chassis to prevent overturning with the maximum rated or test load, whichever is greater, in the worst loaded condition during or upon starting or stopping any moving operation. If gravel filled compartments are provided, an accessible means of filling or removing the gravel shall be provided with permanent labeling displaying the maximum gravel grade size. Sand filled compartments are not allowed.

A walkable platform shall be incorporated on top of the drive chassis for the purpose of access for inspection and maintenance, and shall be configured to fit within the
dimensions identified on the Drawings. Platform capacity shall be designed for 100 psf load, and shall be permanently marked in a conspicuous manner and capable of an operator’s view prior to standing up on the platform. Platform shall include steps and guardrail as needed to allow safe access.

The drive chassis shall be supplied with separate mechanical and electric motor brakes.

2. Jib Crane: Shall consist of a welded steel base plate and stationary vertical mast, bolted or welded to the drive chassis. Provide a single-speed electric motorized, 360-degree rotating overhung boom, supported by separate radial and axial load roller or tapered roller bearings which mounts at a fixed height to the top of the vertical mast, and cannot be removed without the use of tools. Maximum rotating speed of the jib crane shall be ½ RPM. Jib crane shall be designed such that the load may deviate from plumb by a maximum of 15 degrees from vertical, in-line with the jib crane.

3. Hoist: Shall consist of an electric motorized trolley and chain hoist. Minimum vertical lift travel shall be 45 linear feet below the minimum retracted hook height as shown on the Drawings. The trolley shall move in a single speed and shall be provided with separate mechanical and electric motor brakes, capable of supporting the full load. The hoist shall lift or lower in a low speed or high speed operation. The hook shall be of the safety type with a latch. Weather resistant baskets shall be provided for holding excess chain slack.

4. Manufacturers, or Equal: **K&N Electric Motors Inc.**

H. Rails

1. Rails for the traveling jib crane system shall be sized for continuous support from the underside the rails to the Intake Structure at the locations as shown on the Drawings. Bolted rails clips shall be used. All rail anchors shall be of type 316 stainless steel. Crane wheel sizes and design loading shall be determined based on the rail load bearing capacity.

2. The design of the rails shall incorporate a 1” minimum expansion joint located in alignment with the expansion joint of the concrete structure, as shown on the Drawings. The drive chassis shall travel smoothly across the rail expansion joint with the expansion joint fully open or closed.

3. Manufacturers, or Equal: **TC/American**

I. Bumpers and Bump Stops

1. Bumpers and bump stops shall be designed to absorb and withstand the impact of the traveling jib crane system traveling at maximum speed while suspending the maximum rated load. The impact shall cause no permanent damage to the traveling jib crane system or any of its components, including the bump stops or bumpers, or the concrete structure.

2. Rigid, steel bump stops shall be incorporated into the drive chassis design. The impact surface of each bump stop shall inwards facing towards the middle of the drive chassis, such that in order to impact the stationary bumper, the drive chassis must travel over the stationary bumper until the inward face of the bump stop
impacts the bumper. Bump stops must be offset from the centerline of the drive chassis so as one bump stop will not interfere with the opposing side’s bumper.

3. Stationary steel sprung bumpers shall be anchored to the structural concrete deck surface. The bumpers shall be fabricated and welded of structural steel members, and shall be designed to incorporate a vertically oriented steel strike plate. The strike plate shall be suspended from the fabricated bumper plate with properly rated steel springs, such that the springs absorb the impact force as they compress during an impact. The strike surface of each bumper shall be lined with 1” minimum thick rubber sheet, covering a minimum of 85% of the strike surface area. Bolts with large diameter washers may be used to mount the rubber to the strike surface, but shall be countersunk such that all steel hardware is at least 33% of the rubber width below the strike surface of the rubber.

2.6 ELECTRICAL AND CONTROLS

A. The traveling jib crane system shall be completely wired and ready for service after connection of power to the system. Control shall be local to the traveling jib crane system as specified herein; no additional control or monitoring from a separate independently located panel is required.

B. All motors for the traveling jib crane system shall be totally enclosed non-ventilated, NEMA MG 1, with Class F insulation. For additional motor requirements, refer to Section 260510 – Electric Motors.

C. A single NEMA 4X lockable control panel shall be mounted to the drive chassis, which shall house all electrical power and control components for the complete system. No external operator accessible controls shall be included on the panel exterior other than a power disconnect, and emergency stop pushbuttons as specified herein. Control indicator lamps as required shall be mounted on the front of the control panel.

D. Operating power to the traveling jib crane system shall be via a power cord of suitable length to allow full travel of the drive chassis along the entire rail length. The operator accessible power cord end shall be male twist-lock type, to be plugged into a mating female twist-twist lock receptacle located on the south end of the Intake Structure as shown on the Drawings. Power cord and plug end shall be provided by the traveling jib crane system manufacturer. The mating female receptacle and one additional receptacle shall also be provided by the manufacturer, to be installed by the CONTRACTOR in the field. A suitable amount of excess or slack power cord shall be provided so as not to put the power cord or the plug end of the cord in undue tension during use. The power cord shall be of suitable gauge to provide power to the maximum possible simultaneous load of the traveling jib crane system operation. The outer surface of the power cord shall be abrasion resistant to withstand repeated laydown and retrieval on the concrete top deck surface of the Intake Structure.

E. A motorized cord reel shall be provided on the drive chassis which shall automatically unwind the power cord as the drive chassis travels north, and rewind the power cord as the drive chassis travels south. The reel shall be designed with covers to conceal the cable on the reel when the traveling jib crane system is not in use to deter cable theft. The covers, or an additional compartment as required, shall be designed to allow the plug end of the power cord to be unplugged and stowed in the drive chassis and remain out of sight when not in use.
F. Provide space heaters in any and all electrical panels where condensation may create a hazard or short equipment. Power to the space heaters shall be provided by a separate heater power circuit independent of the power coming from the power cord. The heater power shall be obtain from a portable 120 VAC extension cord which may be plugged into a male receptacle mounted on the south end of the drive chassis, and to a female 120 VAC receptacle on the Intake Structure rated for 20A. The CONTRACTOR shall provide the extension cord rated per the traveling jib crane system manufacturer, of suitable length to lay flat on the top deck of the Intake Structure to be approved by the ENGINEER. The extension cord shall be plugged in to energize the heaters while the traveling jib crane system is not in use in the parked position on the south end of the Intake Structure, and the power cord is rewound and unplugged.

G. All controls shall be performed using a radio control device. No more than one movement function of any type may be performed at any time. The control device shall have adequate radio range for up to 300 feet away, minimum. The control device shall meet FCC Part 15 requirements. Radio control system shall consist of the following:

1. Radio transmitter controller shall be wearable, which must include a shoulder harness with chest plate and shall include joysticks, levers, and pushbuttons as required, along with radio transmitter, antenna, and rechargeable NiMh batteries in a weatherproof housing. Operable controls shall include hoist hook position, jib boom rotation, and drive chassis position.

2. Transmitter shall utilize VHF or UHF unlicensed radio band with transmitting power suitable for crane operation up to 300-foot distance. Modulation shall be narrow band frequency modulation. Baud rates shall be selectable up to 9600 baud. A matching receiver shall be provided to be mounted in the control panel on the drive chassis. Separate antennas shall be provided for the transmitter and the receiver, and each shall be connected with low-loss antenna feeders.

3. Two spare batteries and a 120-VAC plug in type charger shall be provided.

H. A lockable NEMA 4 compartment shall be provided on the drive chassis to allow the radio control device to be stowed away when not in use.

I. Provide two equipment mounted emergency stop push buttons, one on each landside corner of the drive chassis.

J. Limit and proximity switches shall be provided as required to control the travel of the drive chassis. Switches shall be mounted to the underside or through the bottom side of the of the drive chassis and be accessible from above. A removable panel or cover may be provided on top of the drive chassis if required for accessibility. The switches shall utilize the stationary bumpers mounted on the top of the structural deck as shown on the Drawings, as the target which triggers the operation of the switches, and slows and stops the traveling jib crane chassis prior to the bump stops hitting the bumpers. Switches shall be provided in accordance with Section 2605 15 – Industrial Control Panels.

K. Limit switches shall be provided for the upper and lower limits of the hoist travel, which shall de-energize the motor. Lift limiting and overload limiting devices which use a clutch to stop motion shall not be furnished with the hoist.

L. Obstruction Alarm and Contact: Obstruction to the drive chassis shall stop drive chassis movement, a light shall be illuminated at the drive chassis control panel, and an audible alarm shall sound. Obstruction to the jib boom rotation shall stop rotation movement,
and a separate light shall be illuminated at the drive chassis control panel and sound the audible alarm.

M. Refer to Division 26 for additional electrical requirements.

2.7 PROTECTIVE COATING

A. All components of the traveling jib crane system shall be shop coated. Field coating of components is allowed for touch-up only. Safety marking on the drive chassis shall be applied around the horizontal perimeter for a vertical width of 12”, consisting of safety yellow with black diagonal stripes. Safety marking may be applied via a permanent, weather resistant, and UV resistant decal in lieu of a painted coating, if desired.

B. For additional coating requirements refer to Section 099600.

2.8 IDENTIFICATION PLATES

A. Provide aluminum or stainless steel identification plates with clearly legible permanent lettering displaying manufacturer name, model number, capacity in lbs, and other pertinent information as required, for each equipment component.

2.9 TOOLS AND SPARE PARTS

A. **Tools:** The CONTRACTOR shall supply one complete set of special wrenches or other special tools necessary for the assembly, operation, adjustment, and dismantling of the equipment. All tools shall be of best quality and furnished in labeled tool boxes of suitable design.

B. **Spare Parts:** Each piece of equipment shall be furnished with one year's supply of food grade lubricants (non-hazardous to aquatic life), as well as spare parts as recommended by the supplier, such as seals, washers, rings, shims, bushings, bearings, and any other parts subject to wear or frequent (two years or less) replacement. All parts shall be properly labeled and identified with the name and number of the equipment to which they belong.

PART 3 – EXECUTION

3.1 GENERAL REQUIREMENTS

A. All equipment shall be installed in strict accordance with the manufacturer’s printed instructions and the Contract Documents. The CONTRACTOR shall be responsible for coordination between the electrical, mechanical, structural, and traveling jib crane system suppliers to ensure proper installation and operation.

3.2 WORKMANSHIP

A. Workmanship shall be in accordance with the referenced standards and codes.

3.3 INSTALLATION/ERECTION

A. Care shall be taken, that the structural integrity of all beams, columns, walls and floors will be maintained at all times.
B. The traveling jib crane system manufacturer shall provide supervisory erection services. The CONTRACTOR shall furnish the services of a trained, qualified manufacturer’s representative for not less than 3 days to assist, check, and approve the installation and start up the equipment.

C. Post-Erection Inspection: After erection, the installation CONTRACTOR, the manufacturer’s representative and the OWNER shall jointly inspect the crane structure and hoist systems and components to determine compliance with specifications and approved submittals. The manufacturers’ representative will supply a report to the OWNER confirming the crane has been satisfactorily installed and is ready for testing.

3.4 EXECUTION OF TEST PROCEDURES/VALIDATION

A. After completion of the WORK, the CONTRACTOR shall test all equipment to the satisfaction of the ENGINEER.

B. Shop Tests: Tests to be performed in the fabricator’s shop, in the presence of the ENGINEER, shall include but not be limited to the following:

1. Perform all normal and emergency operations for the traveling jib crane system with a suspended load, for inspection and testing in the presence of the ENGINEER.

C. Field Tests: Tests to be performed in the field, in the presence of the ENGINEER, shall include but not be limited to the following:

1. Perform all normal movement operations utilizing the radio control device for the traveling jib crane system, including the full travel of the chassis drive, the full extension and retraction of the hoist, and the rotation of the jib boom under a no-load test, and a subsequent load test as specified herein.

2. Perform all emergency operations for the traveling jib crane system, including stopping the jib crane system using the emergency stops mounted on the chassis drive.

3. Verify that all mating parts are in alignment and that there are no noticeable deflections or vibrations.

4. Testing personnel, test loads, instruments, and other apparatus necessary to conduct field tests on the traveling jib crane system shall be supplied by the CONTRACTOR.

5. Functional and Performance Tests: After erection and inspection, the installation contractor and the manufacturers’ representative shall test the drive chassis, the jib crane, the trolley, and the hoist as specified herein. Test the systems in service to determine that each component of the system operates as specified, is properly installed and adjusted, and is free from defects in material, manufacture, installation, and workmanship. Rectify all deficiencies disclosed by testing and retest the system or component to prove the traveling jib crane system is operational. The installation CONTRACTOR shall furnish test loads, operating personnel, instruments, and other apparatus necessary to conduct field tests on the traveling jib crane system.

6. Test Data: Record test data on appropriate test record forms suitable for retention for the life of the crane. Record operating and startup current measurements for electrical equipment (motors and coils) using appropriate instrumentation (i.e., clamp-on ammeters). Compare recorded values with design specifications or...
manufacturer's recommended values; abnormal differences (i.e., greater than 10 percent from manufacturer's or design values) shall be justified or appropriate adjustments performed. In addition, high temperatures or abnormal operation of any equipment or machinery shall be noted, investigated, and corrected. Record drive chassis, jib boom, trolley, and hoist speeds during each test cycle.

7. No-Load Functional Test: Raise and lower the hoist hook through the full range of normal travel at rated speed for three complete cycles. Raise and lower the hook, testing other speeds of the hoist. Verify proper operation of hoist limit switches. Operate the drive chassis and the trolley in each direction the full distance between end stops. Operate the jib boom's rotation. Operate through the entire speed range and verify proper brake operation.

8. Performance Load Tests, Hoist: Perform the following tests, as specified, with test loads of 50, 100, and 125 percent (plus 5 minus 0 percent) of rated load. If the hoist is equipped with an overload limit device, disconnect it to allow the hoist to lift the test load. Proof test the overload limit device after it is reconnected.

   a. Static Load Test (125 percent only): Check entire structure, holding brake and hoisting components as follows: Raise the test load approximately one foot. Hold the load for 10 minutes. Rotate the load and hook to check bearing operation. Observe lowering that may occur which indicates a weakness in the structure or malfunction of hoisting components or brakes.

   b. Raise and lower and test load through the full lift range. Lower the load to the floor, wait 5 minutes, then raise and lower the load through two more cycles. As a minimum, operate in each speed for each test load. In addition, the dynamic test of test load sequence number 2 (100 percent of rated load) shall be repeated for 10 cycles at rated speed, in order to demonstrate proper operation and repeatability of all functions without component overheating or malfunction. Completely stop the machinery at least once in each direction during each cycle to ensure proper brake operation. The hoist shall not be stopped for more than 15 seconds prior to commencing the next cycle.

   c. Hoist Load Brake (125 percent only): Raise test load approximately 5 feet. With the hoist controller in the neutral position, release (by hand) the holding brake. The load brake should hold the test load. Again with the holding brake in the released position start the test load down (first point) and return the controller to the "off" position as the test load lowers. The load brake should prevent the test load from accelerating.

   d. Hoist Loss of Power Test (125 percent only): Raise the test load to approximately 8 feet. While slowly lowering the test load (first point), disconnect the crane's power source. Verify that the test load does not lower and that the brake is set.

9. Trolley: Operate the trolley the full distance of the jib boom rail in each direction with a test load of 125 percent of rated load on the hook (one cycle). Check proper functioning of all drive speed control points. Verify proper brake action.

10. Jib Crane: With a test load of 125 percent of rated load on the hook, operate the jib boom rotation in one direction with the trolley at the extreme far end of the jib boom rail, and in the opposite direction with the trolley in the same position (one cycle). Check proper functioning of all drive speed control points. Check for any binding of
the bridge end trucks and verify proper brake action. Record deficiencies. Secure from testing if deficiencies are found.

11. Drive Chassis: With a test load of 125 percent of rated load on the hook, the jib boom pointed northward, parallel to the stationary rails on the top deck surface of the intake structure (referred to as the 12:00 position), and the trolley at the extreme far end of the jib boom rail, operate the drive chassis movement in both directions for a minimum of 30 feet in each direction. Repeat the test with the jib boom pointed in the 3:00, and the 6:00 positions.

12. Rated Travel Performance Tests: Repeat travel tests for trolley and drive chassis with a test load of 100 percent of rated load. Repeat the test for five cycles at rated speed to demonstrate proper operation and repeatability of all functions without the overheating or malfunction of any components. Completely stop the machinery at least once in each direction during each cycle to ensure proper brake action. The machinery shall not be stopped for more than 15 seconds prior to commencing the next cycle.

13. Trolley Loss of Power Performance Test: With a test load of 100 percent of rated load, raise the test load approximately midway between the trolley and any permanent obstruction on the operating floor. Starting at a safe distance from walls or other obstructions, attain a slow speed (first point) of trolley travel. While maintaining a safe distance from obstructions, disconnect the main power source at the wall mounted safety switch (disconnect) to simulate a power failure. Verify that the trolley stops and that the brake sets properly. Measure the distance required for the trolley to stop.

14. Jib Crane Loss of Power Performance Test: With a test load of 100 percent of rated load, raise the test load approximately midway between the trolley and any permanent obstruction on the operating floor, and position the trolley at the extreme far end of the jib boom rail. Starting at a safe distance from walls or other obstructions, attain a slow speed (first point) of jib boom rotation. While maintaining a safe distance from obstructions, disconnect the main power source at the wall mounted safety switch (disconnect) to simulate a power failure. Verify that the jib boom rotation stops and that the brake sets properly. Measure the distance required for the jib boom rotation to stop.

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