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SECTION F

TECHNICAL SPECIFICATIONS

LAKEVIEW LIFT STATION RENOVATION PROJECT

FOR

COMMUNITY SERVICES AREA 64
SPRING VALLEY LAKE, CA.

PROJECT NO.: 30.30.0023

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PUMP STATION COMPLETION AND COMMISSIONING

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Contractor shall furnish all labor, equipment and incidentals required to perform system start up as specified, including all preparatory work necessary for the full, normal operation of the pump station. Start-up shall be considered for the start of each pumping unit. If multiple start-ups are planned by the Contractor for the start of multiple pumping units, this Specification shall apply for each start-up.

B. The Contractor shall bear all costs related to commissioning the pump station in accordance with the Plans and these Special Provisions, including all repairs, adjustments, and retests deemed necessary by the Engineer and District during startup/commissioning to pass all tests herein and to place the pump station into autonomous service.

PART 2 - PRODUCTS (Not Applicable)

PART 3 – EXECUTION

3.1 CONTRACTOR REQUEST FOR PUMP STATION COMMISSIONING

A. Contractor is required to perform all civil, mechanical, electrical, utility (i.e., gas, electrical, internet, etc.), control systems, instrumentation, and all other work necessary for normal pump station startup and operations, including but not limited to installations, operational testing/confirmation, calibrations, systems integration, The start-up commissioning will demonstrate that all of the functionality meets the specifications and requires the contractor to demonstrate that any and all equipment that is connected via a communications interface provides what is required to make the station operational.

B. Upon completion of the work specified in Paragraph 3.1.A, above, Contractor shall submit in writing to the Engineer a request to commence pump station startup/commissioning as specified herein below. Said request shall confirm that the Contractor has performed all work specified in Paragraph 3.1.A, above, and that the pump station is operational.

3.2 START-UP TEAM

A. The Start-up Team Members shall be comprised of the following personnel:

1. Designer (Engineer-of-Record or designee)
2. Electrical Designer (Electrical Engineer-of-Record or designee)
3. Engineer (i.e., District Engineer or designee)
4. District Pump Station Operator
5. Contractor
6. Controls Systems Subcontractor/Commissioning Representative
7. Mechanical Subcontractor
8. Electrical Subcontractor
9. Ultrasonic Level Controller and Sensor Representative
10. Pump Manufacturer's Representative
11. Other Manufacturers' Representatives and Subcontractors, as required.
12. Districts SCADA System Integrator Representative

Services required herein of Start-up Team Members 5 through 12 shall be provided at the sole expense of the Contractor through final acceptance of the pump station by the Engineer. Further, where the term "Contractor" is referenced herein, it shall be understood to mean the Contractor and Startup Team Members 6 through 12.

D. Contractor is responsible for organizing and running the startup and commissioning testing and documentation for each piece of equipment on the day of commissioning. The function of each piece of equipment shall be demonstrated by the Contractor to the Engineer and other District representatives present at the commissioning by the Contractor. This shall include filling the wet well as required to validate that all modes of operation function. The Engineer's and District's role is to observe the startup only.

3.3 PRE-START-UP CHECK LIST:

A. Prior to commissioning/start-up of the lift station, the Contractor shall submit to the Engineer for review and approval Test Plans and Inspection Check Sheets outlining the step-by-step procedures necessary for verifying individual system function and overall pump station operations and protocols. The procedures listed in the following paragraphs are intended to provide general guidance only to the Contractor in preparing the Test Plans, Startup Test Plan and Check Sheets; therefore, the Contractor's Test Plans may need to include additional details and intermediate procedures. Further, the Test Plans shall include which Team Members will be involved in each test procedure and which Team Members are allowed to operate equipment and perform troubleshooting procedures, including safety protocols and any Cal-OSHA and California Contractor's State License Board requirements and regulations.

B. After approval of the Test Plans and Check Sheets specified in subparagraph B above, the Designer, Electrical Designer, Engineer, Contractor, District Operator(s), and any other required personnel/Start-up Team Members shall meet prior to the field start-up to make sure the following items have been accomplished:

1. General:

   a. Contractor's Test Plans have been approved by the Engineer and the Contractor has distributed electronic (PDF) copies of said Plans to all Team Members.
   b. Inspection Check Sheets prepared by the Contractor have been reviewed and approved by the Engineer.
   c. All electrical equipment has been installed and adjusted by the supplier as specified.
   d. All mechanical equipment specified has been installed properly and anchored. All bolts and nuts are tight.
   e. All certifications required for the installation of the equipment, including but not limited to, torque testing of all wire terminations, completed calibration forms from the manufacture, adjustments of all equipment (including but not limited to Ultrasonic Level Controller, automatic transfer switch, flow meters, SCADA communications, and SCADA screens).

2. Piping:

   a. Suction pipe, unless submerged, is vacuum tight. Fasteners are tight at all pipe connections.
   b. Pipe supports are installed properly and strain in the equipment (particularly in valve bodies) is eliminated.
   c. Piping is level or continuously rising to prevent formation of air pockets, and air-relief valves and air bleeds are installed where specified.
   d. Harness bolts are installed properly in sleeve and expansion joint connections (unless pipe is externally restrained so that joint cannot separate).
   e. The piping has been pressure tested and all pipelines to all equipment have been flushed.

3. Pumps:

a. Pumps are level and there is no strain in the pump casing or guide rails.
b. Seals are adjusted and do not leak.
c. Shaft seals are lubricated as required.
d. Coupling is installed.
e. Verify pumps are installed per manufacturer's recommendations.

4. Motors:
   a. Motor nameplate data (horsepower, speed, and electrical characteristics) agree with the Specifications.
   b. Factory control diagrams are available at the site.
   c. The equipment has been lubricated as specified by the supplier.
   d. Wiring connections are tight.
   e. Temperature overload device is operational.

3.4 PRE-ENERGIZING INSPECTION

A. Wiring – Input/Output Testing Procedure

1. Power up SCADA Panel. (this will require that the main switch gear is operational; however, do not turn on the breakers associated with the pumps.
2. While looking at the digital inputs on the SCADA Programmable Logic Controller (PLC), operate each Hand Operation switch and validate that the correct bits come on.
3. Repeat the process by energizing the relay or field input identified on the SCADA panel drawing for the remaining digital inputs (including the , and pump seal).
4. Test Modbus Remote Terminal Unit (RTU) over Ethernet for all alarms. Ensure correct Modbus addresses are programmed.
5. Contractor to verify that the radio is communicating and aimed in the correct direction and re-aligned.

B. Electrical:

1. Electrical gear must be vacuumed out thoroughly to remove construction dust and debris.
2. Every circuit breaker and disconnect switch should be opened before the utility turns on the power.
3. Cable and circuit are identified per Specification requirements.

4. All electrical secondary and low-voltage compartments are isolated by barriers from high-voltage compartments.
5. Nameplates, warning, and "danger--high voltage" signs are installed.
6. Perform high potential (megger) tests at Service Entrance Section for 1 minute on feeder cables.
7. Switchgear schematic control diagrams are correct. See that transformer nameplate data, high-voltage warning signs, and high and low voltage compartment isolation are in place.
8. No-load tap on transformer.
9. Ground pad and proper grounding.
10. Control centers are National Electrical Manufacturers Association (NEMA) class as specified.
11. Bus rating conforms to Specifications.
12. The circuit breaker is sized properly, of the proper type, and is adjusted as specified in the Electrical Plans.
13. Motor starters are sized properly and provided with proper thermal overload relays on each leg as specified.
14. Wiring and conduit from the controller to the motor is sized per NEC and NEMA standards, as a minimum.
15. Automatic transfer switches are furnished and operational as specified.
16. Check all Underwriters Laboratory (UL) labeling of electrical gear, including Service Entrance Section (SES), transformer, and panelboards.
17. If combination motor-circuit protectors and magnetic starters are furnished, determine that the motor-circuit protectors are sized in accordance with manufacturer's recommendations. Adjust the current limiters properly.
18. Feeder circuit breakers are installed, sized, and adjusted as specified in the Electrical Plans.
19. Main circuit interrupters are rated as specified and capable of carrying full rated current to feed the breakers as specified in the Electrical Plans.
20. Current and potential transformers are sized and electrically connected as specified.
21. All control switches are furnished and operate as required.
22. Relay panels are furnished with subpanels, control relays, timing relays, repeat cycle timers, protective relays, phase failure relays, timers, and latching relays and are adjusted as required. Terminal block wiring and all necessary appurtenances are complete.
23. Fuse blocks are furnished and sized properly.
24. Elapsed-time meters are furnished and can be adjusted as specified.
25. Manual motor starters are furnished for low-voltage, low horsepower, single-phase equipment and have proper current protection.

26. Line disconnect devices or circuit breakers are furnished for manual starters.
27. The spare parts for switchgear are supplied as specified.

3.5 ENERGIZING THE STATION

A.Contractor shall perform the following (this will occur prior to doing any control system testing):

1. Close the main circuit breaker or fusible switch. This will be the first time that the switchboard bus is energized. Never stand in front of a circuit breaker or switch when operating it.
2. Test for correct voltage range.
3. Test for correct phase sequence.

   Check calibration of all instrumentation equipment and recalibrate all new and salvaged equipment to manufacturer's specifications, as necessary. Note: Although instrumentation may have been calibrated for new equipment before leaving the factory, it may have suffered vibration and shock from transportation and dampness from sitting in a non-energized state for several months.
4. Test manual control devices. Operate start, stop, jog, etc., devices to determine if the contacts and circuit breakers respond correctly.
5. Test safety devices. Close power devices manually and manually actuate the safety device to determine if the power device trips.
6. Test automatic control systems for placing all equipment in the automatic mode and simulating operation of the various control devices to determine if the power devices function correctly. Simulation of control device operation should be accomplished as close to the process as possible. This simulated test shall be done with a test tank or hydrant filling the wet well at an observed rate, and all level control, flow control, and pump control devices shall be tested as operational during this simulated wet well level fill.
7. Check actual motor nameplates against motor starter application data and install correct motor overload heaters. Follow the same procedure for power fuses on high voltage motor starters.
8. Bump motors. Before bumping any motor, verify that reverse rotation will not damage mechanical equipment. If mechanical equipment can be damaged by reverse rotation, open coupling or remove drive belts as applicable.
9. Analog wiring shall be checked for correct polarity and ground continuity at each termination point in the loop.

10. All control and monitoring loops shall be checked for signal continuity from source (such as field instrument/equipment, control panel, etc.) to end destination.
11. All system hardware component equipment shall be tested to verify proper operation of the equipment as stand-alone units. Tests shall include the following:

    a. AC/DC power checks.
    b. Power fail/restart tests.
    c. Diagnostics checks.
    d. Test demonstrating that all specified equipment functional capabilities are working properly.
    e. All system components shall be tested to verify that communication between units is working properly.

14. Conduct a complete system checkout and adjustment, including calibration of all instruments, tuning of control loops, checking operation functions, and testing of final control actions.
15. Exercise field signals between field equipment and instrumentation and each Input/Output Panel through the workstation graphic display.
16. The integrated field test shall be performed to verify all equipment/instrumentation is operating properly as a fully integrated system with the PLC, and that the intended monitoring and control functions are fully implemented and operational.
17. Following software testing and demonstration that all lift station systems are functioning properly and in accordance with the Special Provisions, and after full integration of the SCADA system, the Process Control System, including field sensors/transducers and instruments, shall be running, fully operational, and monitored for a continuous 1-week period with the temporary bypass system on standby in case of failure. Failure is defined as any event in which the primary or secondary systems fail to automatically and autonomously operate the lift station, and, in which, human intervention is required to restore operations or to implement the temporary bypass system.

3.6 TESTING OF THE PUMP STATION

A. Contractor shall perform the following:

1. Utilize the Contractor provided startup testing procedures.
2. Verify SCADA screens and that both SCADA and local panel alarms are functioning properly during all testing. Functioning properly to mean that

IO from local site is being observed as triggering local alarms and hardwired alarms/cutoffs/lockouts and SCADA operator is also able to view all intended IO. IO must be confirmed as in correct state in both field and by remote SCADA operator. All reversed or mis-calibrated logic between field panels/instruments and SCADA screens to be corrected before test deemed acceptable.

3. Ultrasonic Level Controller Representative shall be on-site during startup and confirm the Ultrasonic Level Controller is installed correctly and is functioning within the parameters specified in the Plans, these Special Provisions, and the manufacturer's specifications and in conjunction with the secondary level control systems.

4. Testing Pumps in Hand Operation

   A. Using Pump 1, drain the wet well by placing the pump in auto (pump 2 shall be off) and filling the wet well until the pump starts and run until the pump stops (low-level float will stop the pump). When the pump first turns on, place the HOA switch in off and verify the start float level.

   B. Place the pump back in automatic and verify the level on the Ultrasonic level sensor when the pump stops.

   C. Visually verify that the pump intake is submerged, and the pump stopped per the drawings.

   D. Repeat steps A, B, and C for Pump 2.

5. Float Operation Testing

   A. Contractor to refill the wet well up to the level that will start the primary pump. Verify Ultrasonic Level Controller Lead Start (See Plans). Once verified, turn the pumps off and verify that the primary pump started at the level indicated in the plans.

   B. With the PLC off, the Ultrasonic Level Controller disconnected, place both Pumps 1 and 2 in Auto, continue filling the wet well until the high float turns on both pumps. Measure the length of time it takes to drain the wet well until the pumps are turned off by hitting the low float switch. Design Engineer to record this time, and, based upon the volume of water pumped, validate that the flow rates designed for the lift station are being achieved. Upon pump shutdown, note the water surface elevation in the wet well and again after 5-minutes to verify closure of the check valve.

6. Ultrasonic Level Controller Operation

   A. Turn on the Hydroranger or equivalent Ultrasonic Level Controller, turn off the PLC outputs, and refill the wet-well to validate that the first pump is turned on when it reaches the high-level (Ultrasonic Level Controller High Level Alarm – See Plans). Verify that the Ultrasonic Level Controller turns the pumps off (as indicated by the Ultrasonic Level Controller) before the low-level float is activated (can be verified by the low-level float light coming on in the pump control panel).

   B. Repeat Steps 6 and 7 with 480-volt breaker for the lead pump turned off and both pumps placed in Auto. Verify that the lag pump will turn on (Ultrasonic Level Controller Lag Start – see Table 3.6) (as indicated by the Ultrasonic Level Controller). Verify that both pumps are being called (as noted by the pump contactor showing "closed", Pump 1 will not run as the 480-volt breaker is turned off).

9. Testing of each component and associated on/off points and alarms for each pump station control – i.e., PLC, Ultrasonic Level Transducer and Floats shall be tested in groups. Issues associated with each group shall be resolved before proceeding to test the subsequent group.
10. Test alarms associated with Ultrasonic Level Controller highs and lows. Check SCADA for all associated alarms.
11. Turn off Ultrasonic Level Controller, add water to the wet well, and test high level float activation of pumps. Test that both pumps start and then pump to the low-level float and verify that both pumps shut down upon reaching the low-level float. Check SCADA for all associated alarms.
12. Shut down power to the station and check the proper starting of the generator and the operation of the transfer switch. Check SCADA for proper corresponding indications and alarms.
13. Manually test both pumps and check voltage and amperage of each. Compare readings with corresponding SCADA data. Voltage to be verified within 5% of motor nameplate. Amperage of observed FLA to be verified less than motor nameplate.
14. Repeat test on Ultrasonic Level Controller – Verify lead, lag, start, stop, and pumps alternate. Check SCADA for proper indications while testing operation.

15. Restore normal power to station and verify transfer switch, alarms and indicators return to normal positions. Verify all alarms and indicators on SCADA.
16. Demonstrate locking of Transfer Switch control panel or install locking device.
17. Energize the Station Control Panel HAND button enabling local control. Open the manually operated discharge valve slowly and fill the discharge header and the force main or transmission pipeline slowly. Check for undue motor and pump noise and vibration. Both force mains need to be fully filled with water for testing.
18. De-energize the pump.
19. Open the discharge shut-off valve. Contractor to fill wet well with potable water to allow each pump to operate in accordance with the testing of PLC, Ultrasonic Level Transducer, Floats and Flow Meter to the satisfaction of the District.
20. Contractor to coordinate with the District for inspection of the pump operation. The District's lead plumber and lead electrician (or designees) shall be present during startup and testing.
21. Contractor shall be responsible for providing water for use in testing the operation of the pump station from the local water source used during construction.
22. After each pump has been tested individually, open all of the suction and discharge valves and operate the station as specified.
23. Pump station shall be fully functional for a period of one week with the temporary bypass pumps in standby. Contractor to coordinate with District and obtain District's acceptance of the Pump Station prior to removal of temporary pumps.

END OF SECTION 00 16 55

SECTION 01 01 00

SUMMARY OF WORK

PART 1 – GENERAL

1.1 WORK INCLUDED

A. The work to be performed under this Contract shall consist of furnishing all tools, equipment, materials, supplies, and manufactured articles and furnishing all labor, transportation and services, including fuel, power, water, and essential communications, and performing all work, or other operations required for the fulfillment of the Contract in strict accordance with the Contract Documents. The work shall be complete, and all work, materials, and services not expressly indicated or called for in the Contract Documents which may be necessary for the complete and proper construction of the work in good faith shall be provided by the Contractor as though originally so indicated, at no increase in cost to the District.

1.2 RELATED WORK SPECIFIED ELSEWHERE (NOT USED)

1.3 WORK COVERED BY CONTRACT DOCUMENTS

The work generally includes, but is not limited to, furnishing all products, labor, equipment, material, transportation, and incidental services to construct the following:

1. Upgrade the existing sewer lift station including, but not limited to selective site demolition, hauling, off-site legal disposal, erosion control, coordination, assistance, collaboration and appurtenances necessary for the Contractor to establish the temporary sewer bypass, pumps, piping, and electrical equipment installation, start-up and commissioning, traffic control and all other work as indicated on the construction drawings and as specified herein and as necessary to complete the project in its entirety.

2. Groundwater may be encountered in excavations. The cost of dewatering, water control and legal disposal, permitting, treatment, additional shoring, and all other related work, will be paid for at the unit price as shown in the bid items.

3. All excavations may encounter varying soil and excavation conditions. All types of condition including rock removal and shoring due to unstable slopes, will be considered as part of the various items of work and no further compensation shall be made.

1.4 PROJECT LOCATION

A. The Project is located in County Service Area 64 – San Bernardino County next to Spring Valley Lake. Refer to the project plans for specific location of the project work.

1.5 WORK BY OTHERS (NOT USED)

PART 2 – MEASUREMENT AND PAYMENT

GENERAL

The CONTRACTOR shall provide all labor, materials, equipment and incidentals for the work described within these specifications and construction drawings. Payment for each bid item shall be included in the contract unit price or lump sum price shown on the Bidder's proposal. Measurement for payment of lump sum items will be based on the component parts listed in the Bid Items, as required in this specification. Payment for component parts will be based on the Schedule of Values approved by the District. The cost breakdown shall include quantities and items aggregating the Bid Item in payments during construction. All measurements of quantities shall be approved by the District. Payment for each bid item shall include full compensation for all labor, materials, tools, and equipment necessary to complete the work as shown on the construction drawings and within these specifications and no additional compensation shall be allowed. This includes the cost of work not specifically listed in the Bid Schedule or Schedule of Values but, is necessary to complete the project as described and shown in the Contract Documents. Work for which no separate payment has been provided will be considered a subsidiary obligation of the Contractor, and the cost therefore shall be included in the applicable contract price for the item to which the work applies. All measurements of work done will be made by the District or its representative.

2.1 MOBILIZATION

Payment for Mobilization shall be made at the contract lump sum, complete and in accordance with the Contract Documents, and as directed by the District. The Contract Price shall include, but is not limited to the following principal items: obtaining all permits, insurance, and bonds; preparing schedule and schedule of values; mobilizing labor force, equipment and construction facilities onto site; providing field offices and storage yard (if Contractor deems necessary); securing construction water supply; providing power necessary for construction, providing all temporary construction fencing; providing on-site sanitary facilities; posting OSHA requirements and establishing safety programs; performing all work and documentation necessary for the mobilization, demobilization, bonding, and permitting for construction of the project as described within the Contract Documents. This work also includes the cost for maintaining and submitting the project record drawings at the end of the project. All work shall be considered as compensated for in the contract lump sum and no additional compensation shall be made thereafter.

2.2 BYPASS OPERATIONS

Payment for Bypass Operations shall be made at the contract lump sum, complete and in accordance with the Contract Documents, and as directed by the District. Payment for this bid item shall include, but not be limited to, the preparation of a bypass plan to be submitted by the Contractor for approval by the District, and furnishing all labor, materials, incidentals, and equipment to construct, establish, operate, and maintain all bypass pumping required to perform the Work as described in the Contract Documents. The work of this item shall include implementing a 24 hour per day/7 day per week operation and maintenance program throughout the required duration of the bypass pumping operation and shall include all excavation, pipe, fittings, submersible pumps, redundant pumps, labor, power acquisition and utility coordination, generators (whisper-quiet type for emergency use only), fuel, compliance with all noise ordinances and regulations, pavement removal and restoration, moving of bypass equipment, and removal at job completion. The rehabilitated lift station shall be fully functional for a period of one week with the temporary bypass pumps in standby. The Contractor shall obtain all necessary permits for the bypassing and ensure complete pumping redundancy. All work shall be considered as compensated for in the lump sum price and no additional compensation shall be made thereafter.

2.3 REMOVE SLOPED CONCRETE FILL

Payment for Remove Sloped Concrete Fill shall be made at the contract lump sum, complete and in accordance with the Contract Documents, and as directed by the District. Payment for this bid item shall include furnishing all labor, materials, incidentals, and equipment to perform the Work as described in the Contract Documents. This work also include the cost for proper waste handling and disposal at an authorized refuse location. All work shall be considered as compensated for in the lump sum price and no additional compensation shall be made thereafter. Contractor will utilize own means and methods and will be solely responsible for damage and ensued costs from demolition.

2.4 DEMOLITION AND LEGAL DISPOSAL AS SHOWN ON SHEET 5 OF 12 – EXISTING PUMPS, VENTS, SUPPORTS AND PLATFORMS

Payment for Demolition – Existing Pumps, Vents, Supports and Platforms shall be made at the contract lump sum, complete and in accordance with the Contract Documents, and as directed by the District. Payment for this bid item shall include furnishing all labor, materials, incidentals, and equipment to perform the Work as described in the Contract Documents. This work also include the cost for proper waste handling and disposal at an authorized refuse location. All work shall be considered as compensated for in the lump sum price and no additional compensation shall be made thereafter. Contractor will utilize own means and methods and will be solely responsible for damage and ensued costs from demolition.

2.5 FLYGT SUBMERSIBLE PUMPS (Q=810, GPM, TDH=19.7 FEET) OR APPROVED EQUAL – EQUIPMENT PRIMARY PUMP

Payment for Flygt Submersible Pumps (Q=810 GPM, TDH=19.7 Feet) or Approved Equal – Equipment Primary Pump shall be made at the contract unit price, complete and in accordance with the Contract Documents, and as directed by the District. Payment for this bid item shall include furnishing all materials to perform the Work as described in the Contract Documents. All work shall be considered as compensated for in the contract unit price and no additional compensation shall be made thereafter.

2.6 FLYGT SUBMERSIBLE PUMPS (Q=810, GPM, TDH=19.7 FEET) OR APPROVED EQUAL – EQUIPMENT BACKUP PUMP

Payment for Flygt Submersible Pumps (Q=810 GPM, TDH=19.7 Feet) or Approved Equal – Equipment Backup Pump shall be made at the contract unit price, complete and in accordance with the Contract Documents, and as directed by the District. Payment for this bid item shall include furnishing all materials to perform the Work as described in the Contract Documents. All work shall be considered as compensated for in the contract unit price and no additional compensation shall be made thereafter

2.7 PRIMARY PUMP INSTALLATION

Payment for Primary Pump Installation shall be made at the contract lump sum, complete and in accordance with the Contract Documents, and as directed by the District. Payment for this bid item shall include furnishing all labor, incidentals, and equipment to perform the Work as described in the Contract Documents. All work shall be considered as compensated for in the lump sum price and no additional compensation shall be made thereafter.

2.8 BACKUP PUMP DELIVERY TO DISTRICT YARD

Payment for Backup Pump Delivery to District Yard shall be made at the contract lump sum, complete and in accordance with the Contract Documents, and as directed by the District. Payment for this bid item shall include furnishing all labor, incidentals, and equipment to perform the Work as described in the Contract Documents. All work shall be considered as compensated for in the lump sum price and no additional compensation shall be made thereafter.

2.9 6-INCH, 8-INCH, AND 10-INCH DIP FORCE MAIN

Payment for construction of new 6-inch, 8-inch, and 10-inch DIP Force main will be made at the contract unit price, complete and in accordance with the Contract Documents, and as directed by the District. Measurement of installed pipeline shall be made to the nearest foot along the centerline projection of the pipeline into a horizontal plane. The Contract Price for work under this item shall include but is not limited to furnishing all labor, material, tools, and equipment and performing all work required for construction of the 6-inch, 8-inch, 10-inch DIP Force Main appurtenances including all pipe, fittings and appurtenances, pipe spools, transition couplings, protection of existing utilities in place, hydrostatic testing, thrust blocks, restrained joints, pipe coatings,and all other work necessary to complete construction of the 6-inch, 8-inch, 10-inch DIP Force Main. All work shall be considered as compensated for in the unit price and no additional compensation shall be made thereafter.

2.10 MISC. PIPING SPOOLS AND FITTINGS

Payment for construction of Misc. Piping Spools and Fittings will be made at the lump sum price, complete and in accordance with the Contract Documents, and as directed by the District. The Contract Price for work under this item shall include but is not limited to furnishing all labor, material, tools, and equipment and performing all work required for construction of the Misc. Piping Spools and Fittings appurtenances including all pipe, fittings and appurtenances, pipe spools, transition couplings, pipe casing spacers, base bends, protection of existing utilities in place, thrust blocks, pipe supports, restrained joints, pipe coatings, and all other work necessary to complete construction of the Misc. Piping Spools and Fittings. All work shall be considered as compensated for in the lump sum price and no additional compensation shall be made thereafter.

2.11 STRUCTURAL PIPE SUPPORT FABRICATION AND INSTALLATION

Payment for construction of Structural Pipe Support Fabrication and Installation will be made at the lump sum price, complete and in accordance with the Contract Documents, and as directed by the District. The Contract Price for work under this item shall include but is not limited to furnishing all labor, structural calculations, material, tools, and equipment and performing all work required for construction and completion of the Structural Pipe Support Fabrication and Installation. All work shall be considered as compensated for in the lump sum price and no additional compensation shall be made thereafter.

2.12 CONTROL PANEL FABRICATION AND INSTALLATION

Payment for construction of Control Panel Fabrication and Installation will be made at the lump sum price, complete and in accordance with the Contract Documents, and as directed by the District. The Contract Price for work under this item shall include but is not limited to furnishing all labor, material, tools, and equipment and performing all work required for construction and completion of Control Panel Fabrication and Installation. All work shall be considered as compensated for in the lump sum price and no additional compensation shall be made thereafter.

2.13 CONCRETE PAD – ELECTRICAL CONTROL PANEL

Payment for construction of new Concrete Pad – Electrical Control Panel will be made at the contract unit price, complete and in accordance with the Contract Documents, and as directed by the District. The Contract Price for work under this item shall include furnishing all labor, material, tools, and equipment and performing all work required to complete the installation of Concrete Pad – Electrical Control Panel including, but not limited to, steel reinforcing concrete placement and concrete curing, and all other work necessary to complete the installation. All work shall be considered as compensated for in the unit price and no additional compensation shall be made thereafter.

2.14 CONCRETE PAD – PUMP DISCONNECT

Payment for construction of new Concrete Pad – Pump Disconnect will be made at the contract unit price, complete and in accordance with the Contract Documents, and as directed by the District. The Contract Price for work under this item shall include furnishing all labor, material, tools, and equipment and performing all work required to complete the installation of Concrete Pad – Electrical Control Panel including, but not limited to, steel reinforcing concrete placement and concrete curing, and all other work necessary to complete the installation. All work shall be considered as compensated for in the unit price and no additional compensation shall be made thereafter.

2.15 RTU CONTROL PANEL AND INSTALLATION

Payment for construction of RTU Control and Installation will be made at the lump sum price, complete and in accordance with the Contract Documents, and as directed by the District. The Contract Price for work under this item shall include but is not limited to furnishing all labor, material, tools, and equipment and performing all work required for construction and completion of RTU Control and Installation. All work shall be considered as compensated for in the lump sum price and no additional compensation shall be made thereafter.

2.16 CONDUIT AND CONDUCTORS

Payment for construction of Conduit and Conductors will be made at the lump sum price, complete and in accordance with the Contract Documents, and as directed by the District. The Contract Price for work under this item shall include but is not limited to furnishing all labor, material, tools, and equipment and performing all work required for construction and completion of Conduit and Conductors. All work shall be considered as compensated for in the lump sum price and no additional compensation shall be made thereafter.

2.17 SENSORS AND INSTALLATION

Payment for construction of Sensors and Installation will be made at the lump sum price, complete and in accordance with the Contract Documents, and as directed by the District. The Contract Price for work under this item shall include but is not limited to furnishing all labor, material, tools, and equipment and performing all work required for construction and completion of Sensors and Installation. All work shall be considered as compensated for in the lump sum price and no additional compensation shall be made thereafter.

2.18 GROUNDING AND BONDING

Payment for construction of Grounding and Bonding will be made at the lump sum price, complete and in accordance with the Contract Documents, and as directed by the District. The Contract Price for work under this item shall include but is not limited to furnishing all labor, material, tools, and equipment and performing all work required for construction and completion of Grounding and Bonding. All work shall be considered as compensated for in the lump sum price and no additional compensation shall be made thereafter.

2.19 WELL JUNCTION BOXES/EQUIPMENT RACK

Payment for construction of Well Junction Boxes/Equipment Rack will be made at the lump sum price, complete and in accordance with the Contract Documents, and as directed by the District. The Contract Price for work under this item shall include but is not limited to furnishing all labor, material, tools, and equipment and performing all work required for construction and completion of Well Junction Boxes/Equipment Rack. All work shall be considered as compensated for in the lump sum price and no additional compensation shall be made thereafter.

2.20 FALL PROTECTION

A. Payment for construction of Fall Protection will be made at the lump sum price, complete and in accordance with the Contract Documents, and as directed by the District. The Contract Price for work under this item shall include but is not limited to furnishing all labor, material, tools, and equipment and performing all work required for construction and completion of Fall Protection. Fall Protection will be all inclusive with the work and shall be ordered to fit the desired hatch opening sizes. All work shall be considered as compensated for in the lump sum price and no additional compensation shall be made thereafter.
   a. Contactor shall provide Fall Protection Hatch Safety Net dimensions and photos of existing structure/hatches to a District approved manufacturer. The selected Fall Protection Hatch Safety Net shall be made of high strength polyester netting with 316 stainless steel components, USF Fabrication quality or better.

2.21 LADDER AND HARDWARE

Payment for construction of Ladder and Hardware will be made at the lump sum price, complete and in accordance with the Contract Documents, and as directed by the District. The Contract Price for work under this item shall include but is not limited to furnishing all labor, material, tools, and equipment and performing all work required for construction and completion of Ladder and Hardware. All work shall be considered as compensated for in the lump sum price and no additional compensation shall be made thereafter.

2.22 EPOXY COATING

Payment for construction of Epoxy Coating – Wet Well will be made at the lump sum price, complete and in accordance with the Contract Documents, and as directed by the District. The Contract Price for work under this item shall include but is not limited to furnishing all labor, material, tools, and equipment and performing all work required for construction and completion of Epoxy Coating. All work shall be considered as compensated for in the lump sum price and no additional compensation shall be made thereafter.

2.23 SITE RESTORATION

Payment for Site Restoration shall be made at the contract lump sum price, complete and in accordance with the Contract Documents, and as directed by the District. The Contract Price for work under this item shall include furnishing all labor, material, tools, and equipment and performing all work required to complete the restoration of the project sites including, but not limited to all salvaging of existing materials, landscaping inventory, landscape removal, landscape and hardscape replacement in kind, irrigation repair/replacement, and any replacement of other public or private property damaged during the course of construction. All work shall be considered as compensated for in the lump sum price and no additional compensation shall be made thereafter.

2.24 INSTALL CORROSION COUPON

Payment for Install Corrosion Coupon shall be made at the contract unit price, complete and in accordance with the Contract Documents, and as directed by the District. The Contract Price for work under this item shall include furnishing all labor, material, tools, and equipment and performing all work required to complete Install Corrosion Coupon All work shall be considered as compensated for in the contract unit price and no additional compensation shall be made thereafter.

2.25 PUMP STATION START-UP AND COMISSIONING

A. Payment for Pump Station Start-Up and Commissioning shall include full compensation for furnishing all labor, materials, equipment, tools, water for testing, and incidentals and for doing all the work necessary to prepare Test Plans and Check Sheets and to commission the pump station in accordance with the Plans and as specified in these Specifications and shall be paid as follows, and no additional compensation will be made therefor.

1. 25% of the contract lump sum amount shall be paid upon approval of the Test Plans and Check Sheets by the Engineer.
2. 75% of the contract lump sum amount shall be paid after the Pump Station is commissioned and is fully functional for an uninterrupted period of one week with temporary bypass pumps in standby.

PART 3 – EXECUTION

3.1 WORK SEQUENCE:

A. The general sequence of work shall be as follows:

1. Submit proposed schedule of work, insurance and bonds. The Contractor is responsible for supplying electrical power for the entire project length. Before beginning work, coordinate with Southern California Edison regarding electric service for the entire length of the project. Obtain required permits, licenses, and construction easements. After construction survey, call Underground Service Alert (DIGALERT) and utility owners to obtain mark out of buried utilities.
2. Contractor is responsible for obtaining construction water and meter from the for any temporary water usage throughout duration of construction.
3. Secure laydown/staging areas. Contractor shall obtain approval for use of any public or private rights-of-way.
4. Take pre-construction photographs of the existing facility.
5. Submit shop drawings and other submittals required by the plans or Contract Documents.
6. Begin manufacturing and shipping materials and equipment after receiving approved submittals.
7. Complete work according to approved Proposed Work Schedule.
8. Perform hydrostatic testing and Pump Station Start-Up and Commissioning.
9. Complete Punch List items.
10. Finalize clean up and restore construction areas.
11. Provide warranty as specified.

3.2 CONTRACTOR USE OF PROJECT SITE

A. The Contractor's use of the project site shall be limited to its construction operations. On-site storage of materials, on-site fabrication facilities, and field offices located within public right-of-way require approval from the AGENCY.

B. The Contractor shall install signs, barricades and lights necessary to ensure public safety and safety of District's operators and personnel. Provide plates across ditches to enable safe access of District's personnel to facilities or the public across excavations within public right-of-way that can not be backfilled at the end of the day. Traffic control during hours of construction work shall be in accordance with the District approved traffic control plans included in this bid package.

3.3 DISTRICT USE OF THE PROJECT SITE

A. The District may utilize all or part of the existing facilities during the entire period of construction for the conduct of the District's normal operations. The Contractor shall cooperate and coordinate with the District to facilitate the District's operations and to minimize interference with the District's operations at the same time. In any event, the District shall be allowed access to the project site during the period of construction.

END OF SECTION 01 01 00

SECTION 01 33 00

SUBMITTALS

PART 1 – GENERAL

1.1 WORK INCLUDED

A. The Contractor shall submit to the Engineer shop drawings, project data and samples required by specification sections.

1.2 SCHEDULES

A. The Contractor shall prepare and submit a Construction Schedule prior to beginning work.

B. The Contractor shall prepare and submit a separate schedule listing dates for submission of shop drawings and projected return dates.

PART 2 – PRODUCTS

2.1 SHOP DRAWINGS

A. Original drawings, prepared by Contractor, Subcontractor, Supplier or Distributor, which illustrate portions of the Work; showing fabrication, layout, setting or erection details including, but not limited to the following:

1. Mechanical equipment
2. Valves and operators (w/specific locations)
3. Piping and fittings (w/specific locations)
4. Electrical wiring diagrams
5. Concrete mix designs (with specific locations), grouts, etc.
6. Paintings, coatings, liners, etc.
7. Corrosion Detection Systems

B. Shop drawing submittals shall be prepared by a qualified detailer.

C. Identify details by reference to sheet numbers and detail shown on Contract Drawings.

2.2 PROJECT DATA

A. Manufacturer's standard schematic drawings:

1. Modify drawings to delete information which is not applicable to project.

2. Supplement standard information to provide additional information applicable to project.

B. Manufacturer's catalog sheets, brochures, diagrams, schedules, performance charts, illustrations, and other standard descriptive data.

1. Clearly mark each copy to identify pertinent materials, products or models.

2. Show dimensions and clearances required.

3. Show performance characteristics and capacities.

4. Show wiring diagrams and controls.

2.3 SAMPLES

A. Physical examples to illustrate materials, equipment or workmanship, and to establish standards by which completed work is judged.

B. Office samples of sufficient size and quantity to clearly illustrate:

1. Functional characteristics of product or material, with integrally related parts and attachment devices.

2. Full range of color samples.

3. Flanges, fittings, bolts, etc.

PART 3 – EXECUTION

3.1 SUBMISSION REQUIREMENTS

A. Allow a minimum of 14 days for District's review.

B. Electronic submissions in .pdf format are acceptable.

C. Accompany submittals with transmittal letter, in duplicate, containing:

1. Date.

2. Project title and number.

3. Contractor's name and address.

4. Notification of deviations from Contract Documents.

5. Other pertinent data.

D. Submittals must include:

1. Date of submittal and revision dates.

2. Project title and number.

3. The names of:

    a. Engineer.
    b. Contractor.
    c. Subcontractor.
    d. Supplier.
    e. Manufacturer.
    f. Separate detailer when pertinent.

4. Identification of product or material.
5. Relation to adjacent structure or materials.
6. Field dimensions clearly identified as such.
7. Identification of deviations from Contract Documents.
8. Contractor's stamp, initialed or signed, certifying to review of submittal, verification of field measurements and compliance with Contract Documents.

3.2 RESUBMISSION REQUIREMENTS

A. Shop Drawings:

1. Revise initial drawings as required and resubmit as specified for initial submittal.

2. Indicate on drawings any changes which have been made other than those requested by Engineer.

B. Project Data and Samples:

1. Submit new datum and samples as required for initial submittal.

3.3 DISTRIBUTION OF SUBMITTALS AFTER REVIEW

A. Distribute copies of Shop Drawings and Project Datum which carry Engineer's stamp, to:

1. Contractor's file.

2. Job site file.

3. Record Documents file.

4. Other prime contractors.

5. Subcontractors.

6. Supplier.

7. Fabricator.

B. Distribute samples as directed.

END OF SECTION 01 33 00

SECTION 01 71 13

MOBILIZATION / DEMOBILIZATION

PART 1 - GENERAL

1.1 SUMMARY

A. Mobilization shall consist of preparatory work and operations, including, but not limited to those necessary: for the move-on operations of personnel, labor, equipment, supplies, and incidentals to the Project Site; for the establishment of all offices, storage yards, buildings, hook-up and disconnects for utility services, and other facilities necessary for work on the Project; maintenance of haul roads and other facilities; for the payment of premium bonds and insurance for the project; for all necessary costs of acquiring equipment, including purchase and mobilization expenses; for all permits and fees; for maintaining the Contractor's staging area; and, for all other work and operations which must be performed and costs that must be incurred incident to the initiation of meaningful work at the site and for which payment is not otherwise provided under the contract

Staging and stockpiling of equipment and materials shall be within the limits of work as shown on the Plans or within the Contractor-designated laydown area located outside limits of work, unless otherwise approved by the Engineer and District. Any cost related to mobilization/Demobilization, Permits, Insurance, Bonds and General Conditions is considered included in the price bid for the various work items and no additional payment will be made, therefore.

1.2 PROJECT CONDITIONS

A. Contractor shall perform a pre-construction survey of the existing project site and staging area, including photographic and video documentation of existing conditions, for submission to the Engineer.

B. All facilities, plants, and equipment which are established at or brought to the worksite by the Contractor shall conform to the requirements of these Special Provisions unless the Engineer specifically directs otherwise, in writing, for a specific item or items. The Contractor shall be solely responsible for the adequacy of all facilities, plants, and all utilities, structures and facilities, and other site features that are to remain in place from damage caused by impact, settlement, lateral movement, undermining, washout, and other hazards created by excavation, construction of facilities, and compaction operations equipment.

C. Demobilization is intended to compensate the Contractor for operations including, but not limited to, those necessary: for the movement of personnel, equipment, supplies, and incidentals off the project site; for the removal of offices, buildings, plants, temporary utilities, and other facilities from the project site, including transportation; and, for the cleanup restoration of the project site, storage yard, and staging areas.

1.3 SUBMITTALS

A. Staging and Storage Area Layout Plan

B. Pre-construction survey of the existing project site and staging area, including photographic and video documentation of existing conditions.

PART 2 - PRODUCTS

2.1 WATER

A. The Contractor shall furnish and maintain an adequate supply of suitable quality water as required for construction and for domestic use. The Contractor shall investigate the availability of suitable water, make all arrangements for the purchase of the water, and provide all facilities necessary to furnish water for use during construction. The Contractor shall not draw any water from a fire hydrant for use on the work without first obtaining a permit from the appropriate Agency.

PART 3 - EXECUTION

3.1 CONTRACTOR'S STAGING AND STORAGE AREA.

A. The Contractor's staging and storage area location shall be determined in coordination with the Engineer. This area may be used for the Contractor's operations, staging, and storage. The staging and storage area shall be kept in a neat and orderly condition at all times. The Engineer reserves the right to direct the Contractor to correct any deficiencies in the maintenance of the staging and storage area and the Contractor shall promptly comply with the directives of the Engineer.

B. The Contractor's field offices, if needed for this project, shall be located within the staging area.

C. The Contractor shall be responsible for verifying the condition of any existing pavement near and adjacent to the staging and storage area for use to support their construction equipment, stockpiles and materials storage. Damaged pavement, as a result of the Contractor's use of this area, shall be restored to a new paved condition to the satisfaction of the Engineer.

3.2 NOISE CONTROL

A. The Contractor shall endeavor to keep the noise level resulting from their operations to a minimum at all times.

END OF SECTION 01 71 13

SECTION 01 77 00

CONTRACT CLOSEOUT

PART 1 – GENERAL

1.1 REQUIREMENTS INCLUDED:

A. Administrative process for closing out the Work in accordance with the General Conditions of the Contract Documents and this section.

1.2 SUBSTANTIAL COMPLETION:

A. Substantial completion shall be defined as “the time and date at which the Work has progressed to the point where, in the opinion of District, the Work is sufficiently complete, in accordance with the General Conditions of the Contract Documents, so that the Work can be occupied and/or utilized for the purposes for which it is intended. Substantial Completion cannot occur before the Project is issued a Certificate of Occupancy (or Completion, if applicable) by the governing building department that allows Owner to utilize the entire Project for the purposes for which it is intended.”

B. When Contractor considers the Work is substantially complete, he shall submit to the District:

1. A written notice that the Work, or designated portion thereof, is substantially complete in accordance with the General Conditions of the Contract Documents.

2. A list of items to be completed or corrected.

C. Within a reasonable time after receipt of such notice, the District will conduct an inspection to determine the status of completion.

D. Should the District determine that the Work is not substantially complete:

1. The District will promptly notify the Contractor, in writing, giving the reasons, therefore.

2. Contractor shall remedy the deficiencies in the Work and send a second written notice to substantial completion to the District.

3. The District will re-inspect the Work.

1.3 FINAL INSPECTION:

A. When Contractor considers the Work is complete, they shall submit written certification in accordance with the items below and the General Conditions of the Contract Documents that:

1. Contract Documents have been reviewed.

2. Work has been completed in accordance with Contract Documents.

3. Work has been completed with the list of items to be corrected.

4. Equipment and systems have been tested in the presence of the Owner's representative and are operational.

5. Work is completed and ready for final inspection.

B. The District will make an inspection to verify the status of completion with reasonable promptness after receipt of such certification.

C. Should the District consider that the Work is incomplete or defective:

1. The District will promptly notify the Contractor in writing, listing the incomplete or defective work.

2. Contractor shall take immediate steps to remedy the stated deficiencies and send a second written certification to the District that the Work is complete.

3. The District will re-inspect the Work.

D. When the District finds that the Work is acceptable under the General Conditions of the Contract Documents, the District shall request the Contractor to make closeout submittals.

1.4 RE-INSPECTION FEES:

A. Should the District perform re-inspections due to failure of the Work to comply with the claims of status of completion made by the Contractor:

1. Contractor will compensate the District for such additional services.

1.5 CONTRACTOR'S CLOSEOUT SUBMITTALS TO DISTRICT:

A. Evidence of compliance with requirements of governing authorities.

B. Project Record Documents.

C. Operating and Maintenance Data, Instructions to District Personnel, if necessary.

D. Warranties and Bonds.

E. Keys and Keying Schedule.

F. Spare Parts and Maintenance Materials.

G. Certificate of Insurance for Products and Completed Operations.

H. Contractor's Final Affidavit.

I. Lien Waivers from Subcontractors and Suppliers.

1.6 FINAL ADJUSTMENT OF ACCOUNTS

A. Submit a final statement of accounting to the District.

B. Statement shall reflect all adjustments to the Contract Sum:

1. The original Contract Sum.

2. Additions and deductions resulting from:

a. Previous Change Orders

b. Unit Prices
c. Deductions for uncorrected Work
d. Penalties and Bonuses
e. Deductions for liquidated damages
f. Deductions for re-inspection payments
g. Other adjustments

3. Total Contract Sum, as adjusted.

4. Previous payments.

5. Adjustment in Contract Time.

6. Sum remaining due.

C. District will prepare a final Change Order, reflecting approved adjustment to the Contract Sum, which were not previously made by Change Orders.

1.7 FINAL APPLICATION FOR PAYMENT:

A. Contractor shall submit the final Application for Payment in accordance with procedures and requirement stated in the General Conditions.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION 01 77 00

SECTION 01 78 23

OPERATION AND MAINTENANCE MANUALS

PART 1 – GENERAL

1.1 RELATED INFORMATION

A. Compile product data and related information appropriate for District’s maintenance and operation of products furnished under the Contract.

1. Prepare operating and maintenance data as specified in this Section and as referenced in other pertinent sections of these Special Provisions for all new and modified equipment.

2. Documentation for settings for protective relays, breakers, and Ultrasonic Level Transducer.

B. Instruct District's personnel in the maintenance of products and in the operation of equipment and systems.

C. Any cost related to the preparation, purchase, acquiring, duplication and/or submittal of all items under this section shall be considered included in the price bid for the various work items and no additional payment will be made therefor.

1.2 FORM OF SUBMITTALS

A. Prepare data in the form of an instructional manual in hard-copy and electronic format (flash drive) for use by District's personnel.

B. Hard-Copy Format:

1. Size: 8-1/2 in. x 11 in.
2. Text: Manufacturer's printed data, or neatly typewritten.
3. Drawings:

a. Provide reinforced punch binder tab, bind in with text.
b. Fold larger drawings to the size of the text pages.

4. Provide fly-leaf for each separate product, or each piece of operating equipment.

a. Provide typed description of product, and major component parts of equipment.

5. Cover: Identify each volume with typed or printed title "OPERATING AND MAINTENANCE INSTRUCTIONS". List:

    a. Title of Project.
    b. Date Work completed and accepted by the District.
    c. Identity of separate structures, as applicable.
    d. Identity of general subject matter covered in the manual.

C. Binders:

1. Commercial quality expandable catalog binders with durable and cleanable plastic covers.
2. When multiple binders are used, correlate the data into related consistent groupings.

D. Electronic format shall be in both PDF and MS Word. Copies of manuals shall be submitted to the Engineer in MS Word and converted from MS Word to PDF format on flash drive, or other digital media approved by the Engineer. Submit electronic files only after approval of hard copies by the Engineer.

1.3 CONTENT OF MANUAL

A. Neatly typewritten table of contents for each volume arranged in a systematic order, and Contractor, name of responsible principal, address, and telephone number.

1. A list of each product required to be included, indexed to the content of the volume.
2. List, with each product, the name, address, and telephone number of:

    a. Manufacturer and model number/product identification.
    b. Subcontractor or installer.
    c. Maintenance Contractor, as appropriate.
    d. Identify the area of responsibility of each.
    e. Local source of supply for parts and replacement.

3. Identify each product-by-product name and other identifying symbols as set forth in Contract Documents.

B. Product Data:

1. Include only those sheets which are pertinent to the specific product.
2. Annotate each sheet to:

    a. Clearly identify the specific product or part installed.

b. Clearly identify the data applicable to the installation.
c. Delete references to inapplicable information.

C. Drawings:

1. Supplement product data with drawings as necessary to clearly illustrate relations of component parts of equipment and systems.
2. Coordinate drawings with information in Project Record Documents to assure correct illustration of completed installation.
3. Do not use Project Record Documents as maintenance drawings.

D. Supplemental product data not included in the manufacturer's literature, as necessary, for the specific installation:

1. Organize in a consistent format under separate headings for different procedures.
2. Provide a logical sequence of instructions for each procedure.

E. Copy of each Warranty issued. Warranty shall include, but is not limited to: Warranty provider; warrantied part or equipment; warranty duration; warranty coverage and exemptions; and Warranty provider contact information (United States phone number, United States business address, website, e-mail address, etc.)

F. Provide information sheet for District's personnel. Submit:

a. Written operating instructions, including the steps and safety precautions necessary to operate individual equipment, as well as the overall pump station, as designed.
b. Procedures to be implemented in the event of failure.
c. Instances which might affect the validity of warranties.

1.4 MANUAL FOR EQUIPMENT AND SYSTEMS

A. Submit three (3) complete paper copies and one (1) electronic copy of manual on flash drive in final form.

B. Content, for each unit of equipment and system, as appropriate:

1. Description of unit and component parts.

a. Function, normal operating characteristics, and limiting conditions.
b. Performance curves, engineering data and tests.

c. Complete nomenclature and commercial number of all replaceable parts.

2. Operating procedures:

a. Start-up, break-in, routine and normal operating instructions.
b. Shutdown.
c. Manual operations
d. Automatic operations
e. Operations during routine and non-routine maintenance procedures
f. Operating during an emergency - instructions.
g. High Flow periods and Low Flow Periods operating instructions.
h. Alignment, adjusting and checking.

3. Servicing and lubrication schedule:

a. List of lubricants required for each piece of equipment.
b. Schedule for manufacturer recommended maintenance.

c. Items to include: bearings, valve actuators, pump guide rails and runners, swing check valve hinges, door hinges, flood gate hinges and seals, hatch springs/hinges.

4. Manufacturer's printed operating and maintenance instructions.
5. Original manufacturer's parts list, illustrations, assembly drawings and diagrams required for maintenance.
6. Other data as required under pertinent sections of these Special Provisions.

1.5 SUBMITTAL SCHEDULE

A. Submit one copy of completed data in draft final form at least fifteen days prior to system testing/station commissioning.

1. Copy will be returned after final inspection or acceptance, with comments for incorporation into the final.

B. Submit specified number of copies of approved data, incorporating all comments, in final form, no more than 10 working days after final inspection or acceptance.

1.6 INSTRUCTION OF DISTRICT'S PERSONNEL

A. Prior to final inspection or acceptance, fully instruct District's designated operating and maintenance personnel in the operation, adjustment and maintenance of all products, equipment, and systems.

B. Operating and maintenance manual shall constitute the basis of instruction.

   1. Review contents of manual with personnel in full detail to explain all aspects of operations and maintenance.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 01 78 23

SECTION 01 78 39

PROJECT RECORD DRAWINGS

PART 1 – GENERAL

1.1 PROJECT RECORD DOCUMENTS

A. Maintain at the site for the District one record copy of:

1. Drawings.
2. Specifications.
3. Addenda.
4. Change Orders and other Modifications to the Contract.
5. Engineer Field Orders or written instructions.
6. Reviewed Shop Drawings.
7. Field test records.

B. The Contractor shall bear all costs related to this section and all materials, work and appurtenances shall be considered included in the bid price for the various work items and no additional payment will be made therefor.

1.2 MAINTENANCE OF DOCUMENTS

A. Store documents in approved location apart from documents used for construction.

B. Maintain documents in a clean, dry, legible condition and in good order. Do not use record documents for construction purposes.

C. Make documents available at all times for inspection by District. Record drawing information shall be maintained concurrently with Pay Requests.

1.3 MARKING DEVICES

A. Provide ink marking pens for recording information in a color code.

1.4 RECORDING

A. Label each document "PROJECT RECORD" in neat large, printed letters.

B. Record information currently with construction progress.

1. Do not conceal any work until required information is recorded.

2. Contractor shall mark clearly on the record drawing any changes, modifications, or deviations from the issued construction documents.

3. For construction documents that are constructed per plan, the contractor shall acknowledge on each sheet that the as-built condition is per the plan.

C. Drawings shall be drawn to record actual construction:

1. Horizontal location of pipes shall be provided at every fitting. Any deviations from the alignment shown on the drawings must be noted.

2. Vertical location of piping shall be provided at fittings and tie-ins. Vertical location shall be pipe elevation as called for on the drawings.

3. Horizontal and vertical locations of pumps shall be provided, including base plate. Horizontal locations shall be located vertically and horizontally by two measurements to permanent surface reference points.

4. All fittings, including sleeves and valves shall be located vertically and horizontally by two measurements to permanent surface reference points.

5. Field changes of dimension and detail.

6. Changes made by Field Order or by Change Order.

7. Details not on original Contract Drawings.

D. Specifications and Addenda; legibly mark each Section to record:

1. Manufacturer, trade name, catalog number, and supplier of each item actually installed.

2. Changes made by Field Order or by Change Order.

1.5 SUBMITTAL

A. The contractor shall submit progress record drawings with each pay application for review by the District. Applications for payment submitted without progress record drawings may not be reviewed.

B. The contractor shall submit progress record drawings with the notification of substantial completion.

C. At contract close-out, Record Documents shall be submitted to District in the following formats:

   1. Electronic PDF of redlined drawings.

D. Accompany submittal with transmittal letter in duplicate, containing:

   1. Date.
   2. Project title and number.
   3. Contractor's name and address.
   4. Title and number of each record document.
   5. Signature of Contractor or his authorized representative.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION 01 78 39

SECTION 02 41 13

SELECTIVE SITE DEMOLITION

PART 1 – GENERAL

1.1 SUMMARY

A. Work Included:

This section shall consist of:

- Existing Utility Verification and Location,
- Abandon Miscellaneous Conduits and Piping,
- Remove Existing Pumps, Piping and Electrical Equipment,
- Removal of Concrete Fill,
- Removal of Existing Grating and Ladders,
- Removal of Miscellaneous Piping.

B. Existing improvements, adjacent property, utilities, and other facilities that are not called for or otherwise required for removal to accommodate this project shall be protected in-place from injury or damage. Any cost related to the protection of these facilities is considered included in the price bid for the various work items and no additional payment will be made therefor. Existing facilities damaged by the Contractor shall be restored to pre-damage condition by the Contractor without cost to the District.

B. Reference Standards:
1. Standard Specifications for Public Works Construction (Greenbook), referred to collectively hereinafter as SSPWC.

1.2 RELATED SECTIONS

1. Section 11 90 00 – Pumps General
2. Section 33 41 00 – Utility Piping
3. Section 22 14 23 – Pumping Stations

1.3 PROJECT CONDITIONS

A. Protect all utilities, structures and facilities, and other site features that are to remain in place from damage caused by impact, settlement, lateral movement, undermining, washout, and other hazards created by excavation, construction of facilities, and compaction operations.

B. The District and Engineer do not warrant the accuracy or completeness of the locations and type of existing utilities and substructures shown on the Plans.

1.4 SUBMITTALS

A. Mix design for concrete used for utility plugs.

B. Procedures and schedule for Lakeview Lift Station temporary shut down and demolition.

C. Temporary Bypass and Operations system

PART 2 – PRODUCTS

2.1 CONCRETE

A. Concrete used for plugging abandoned utilities shall conform to SSPWC Section 201-1 for Class 520-C-2500 as shown on the Plans.

PART 3 – EXECUTION

3.1 EXISTING UTILITY LOCATION AND VERIFICATION

The Contractor is responsible for accurately locating, by potholing or other suitable methods, all existing utilities such as service connections and substructures, to prevent unwanted damage to such facilities and to identify any conflicts with the proposed work.

The Contractor shall perform all utility markout, locating, status verification, and potholing work prior to the start of construction. **This includes walking the existing work site with District representatives to identify the location and type of utilities that may not be shown on the plans.**

The Contractor shall fill all potholes on the same day of excavation, and, if no trenching is performed within 10 working days, fully restore all potholes and any damaged surrounding areas to their original condition unless otherwise allowed by the District.

The Contractor will coordinate with the District or other utility owners to obtain record information and to verify the operational status of utilities in conflict with the proposed construction.

The Contractor shall notify the District, in writing, of any conflicts between existing utilities and the proposed work a minimum of 5 working days in advance of the work to provide adequate time, and space for any changes to the work needed to avoid unforeseen conflicts. The Contractor shall perform utility location and status verification far enough in advance of the Work to provide the written notification specified in this section.

The Written notification shall include date of utility location, method of utility location, method of operational status verification, type, size, and material of utility, horizontal location, depth from existing pavement or ground surface to top and bottom of utility, suspected ownership of utility, and date on which any conflict with the utility will impact the critical path.

The Contractor shall not be entitled to an extension of Contract time or compensation for delay if direction is provided by the District within 5 working days from receipt of the Contractor's written notification of the utility conflict.

3.2 ABANDON EXISTING UTILITY

A. When existing utilities have been or are to be abandoned and are found to interfere with construction, the interfering portion shall be removed, and the remaining open portions securely sealed. The Contractor shall conduct this abandonment process at the location shown on the plans and as required to accommodate the construction.

B. The status of existing utilities requiring removal shall be verified by the Contractor prior to removal. The Contractor shall immediately notify the District of any utility requiring removal, found to be or believed to be live.

C. Where the internal dimension of the conduit is less than or equal to 12-inches, the seal shall consist of a wall (plug) of concrete not less than 8-inches thick as shown on the Plans.

3.3 REMOVE EXISTING GRATING AND MISCELLANEOUS APPURTENANCES

A. The existing grating, ladders, miscellaneous piping, and other existing components specified for removal shall be demolished. The existing wet well and lift station structure, remaining piping, and any remaining conduits shall be protected in place with tape or other suitable protection to prevent demolition debris from falling in or damaging the portions of the lift station to remain.

B. Voids left by the demolition of any items shall be backfilled with concrete.

3.4 REMOVE EXISTING SCREW PUMPS

A. After the removal of existing grating and miscellaneous appurtenances, the existing screw pumps will be removed. The existing wet well and lift station structure, remaining piping, and any remaining conduits not to be abandoned shall be protected in place with tape or other suitable protection to prevent demolition debris from falling in or damaging the portions of the lift station to remain.

3.5 REMOVE EXISTING CONCRETE FILL

A. After the removal of the existing screw press pumps, contractor shall chip away at the existing concrete fill as shown on the plans until it is flush with the surrounding structure. Contractor shall grind smooth the concrete base. The Contractor shall take care to not damage the existing sewer lift station structure.

B. Voids left by demolition of the removal of concrete fill shall be backfilled with concrete.

3.6 CONSTRUCTION ODOR CONTROL

A. Contractor shall take measures to minimize odors during construction/rehabilitation of the lift station. This shall include installing plugs at the influent gravity pipe and discharge gravity pipe to prevent odors from the mainline bypass setup (installed by District) from entering the lift station wet well and discharge vault. Work by the contractor shall be carried out to minimize disruption to the plugs and potential leakage of odors into the work zone.

B. Existing wet well, screw pumps and discharge vault shall have the sewage pumped/removed and disposed of immediately after the bypass operation and plugs are installed to minimize any extended residence time of remaining sewage in the wet well and potential for odors. After wet well is cleaned, the demolition phase of contractor's work may begin.

C. Contractor shall monitor the plugs periodically (once per week) to verify they are in good working condition and not allowing to escape into the work area or surrounding neighborhood.

END OF SECTION 02 41 13

SECTION 03 30 00

CAST-IN-PLACE CONCRETE

PART 1 GENERAL

1.1 SUMMARY

A. Work Included:

This section shall consist of:

- Formwork,
- Reinforcement,
- Accessories,
- Cast-in-place concrete, and
- Finishing and curing.

B. Reference Standards:

This Technical Specification makes reference to the Standard Specifications for Public Works Construction (Greenbook), hereinafter as SSPWC.

1.2 SUBMITTALS

A. Shop Drawings:

1. Reinforcing placing plan shall be submitted in accordance with the requirements of Section 303-1.7.1 of the SSPWC.

B. Concrete mix design shall be submitted in accordance with the requirements of Section 201-1.1 of the SSPWC.

C. Product Data.

1. Product data and source of material as applicable for chemical admixtures, aggregates, Portland cement and supplementary cementitious materials shall be submitted in accordance with the requirements of Section 201-1.1 of the SSPWC.

2. Certifications for reinforcing materials shall be submitted in accordance with the requirements of Section 201-2.4 of the SSPWC.

3. Product data for waterstops including details for placement of waterstops and details for vertical and horizontal waterstop joint and corner construction and installation.

1.3 QUALITY CONTROL

A. Testing of Portland Cement Concrete shall be in accordance with the requirements of Section 201-1.1.5 of the SSPWC.

PART 2 PRODUCTS

2.1 FORM MATERIALS AND ACCESSORIES

A. Form materials shall conform to the requirements of Section 303-1.3 of the SSPWC.

B. Provide ribbed type waterstops conforming to the requirements of COE CRD C 572 or equal and manufactured from virgin polyvinyl chloride plastic compound.

1. Construction Joints:
   a. Provide flat ribbed 6-inch by 3/8-inch construction joints, such as Greenstreak Group Inc, Catalog Number 786 Or equal.

2. Manufacturers:
   a. Vinylex Corporation, catalog numbers as specified above, www.vinylex.com Or equal.
   b. The Euclid Chemical Company/Tamms Industries, Inc., www.euclidchemical.com Or equal.
   c. W. R. Meadows, Inc., www.wrmeadows.com. Greenstreak, www.greenstreak.com or Equal.
   d. Approved equal.

2.2 PORTLAND CEMENT CONCRETE

A. Portland Cement Concrete shall conform to the requirements of Section 201-1 of the SSPWC.

B. Portland Cement Concrete used for construction of manholes and other miscellaneous structures shall meet the mix design requirements of the *Sewer & Storm Drainage Facilities* section of Table 201-1.1.2(A) of the SSPWC for the various elements constructed unless noted otherwise.

C. Portland Cement Concrete used for construction of all other miscellaneous structures shall meet the mix design requirements of the *Miscellaneous* section of Table 201-1.1.2(A) of the SSPWC for the various elements constructed unless noted otherwise.

2.3 REINFORCEMENT

A. Reinforcement shall be Grade 60 billet steel conforming to ASTM A 615 and shall conform to the requirements of Section 201-2 of the SSPWC.

2.4 CONCRETE CURING MATERIALS

A. Concrete Curing compound shall conform to the requirements of Section 201-4 of the SSPWC.

2.5 GROUT

A. High strength non-shrink grout shall conform to the requirements of non-shrink grout according to Section 201-7 of the SSPWC.

2.6 CONTROLLED LOW STRENGTH MATERIAL

A. CLSM shall conform to the requirements of Section 201-6 of the SSPWC and shall be 190-E-400.

PART 3 EXECUTION

3.1 GENERAL

A. Concrete structures shall be constructed in conformity with the Plans and these Technical Specification. Concrete for use in work constructed under this section shall conform to the requirements contained herein and the requirements of Section 201-1 of the SSPWC as referenced herein.

B. The compressive strength of the concrete referred to in this section will be based on the results of concrete test cylinders made and tested by the contractor in accordance with the requirements contained herein and the requirements of Section 201-1 of the SSPWC as referenced herein.

C. Subgrade for concrete structures shall be prepared in accordance with the requirements of the Plans and these Technical Specification and Section 303-1.2 of the SSPWC.

3.2 FORMWORK ERECTION

A. Formwork erection, shoring and bracing shall conform to the requirements of Section 303-1.3 and 303-1.6 of the SSPWC.

3.3 INSERTS, EMBEDDED COMPONENTS, AND OPENINGS

A. Provide formed openings where required for work to be embedded in and passing through concrete members.

B. Coordinate work of other sections in forming and setting openings, slots, recesses, chases, sleeves, bolts, anchors, and other inserts.

C. Install concrete accessories straight, level, and plumb.

D. Install waterstops continuous without displacing reinforcement.

3.4 REINFORCEMENT PLACEMENT

A. Placing Reinforcement shall conform to the requirements of Section 303-1.7 of the SSPWC.

3.5 PLACING CONCRETE

A. Placing Concrete shall conform to the requirements of Section 303-1.8 of the SSPWC.

3.6 FORM REMOVAL

A. Removal of forms shall conform to the requirements of Section 303-1.4 of the SSPWC.

3.7 FINISHING

A. Surface finishes shall conform to the requirements of Section 303.1.9 of the SSPWC.

   1. Unless noted otherwise all exposed formed surfaces shall receive at Class 1 Surface Finish.

B. Surfaces to receive waterproofing shall be finished to meet the requirements of the waterproofing system manufacturer.

3.8 CURING AND PROTECTION

A. All concrete shall be cured in conformance with the requirements of Section 303-1.10 of the SSPWC.

3.9 FIELD QUALITY CONTROL

A. Perform field inspection and testing in accordance with ACI 318 and the requirements for special inspections according to the 2010 California Building Code as required on the Plans.

B. Reinforcement Inspection:

   1. Inspect for correct materials, fabrication, sizes, locations, spacing, concrete cover, and splicing.

C. Strength Test Samples:

   1. Sample concrete and make one set of three cylinders for every 150 cu yds or less of each class of concrete placed each day and for every 5,000 sf of surface area for slabs and walls.

D. Field Testing:

1. Measure slump and temperature for each compressive strength concrete sample.

2. Measure air content in air entrained concrete for each compressive strength concrete sample.

E. Cylinder Compressive Strength Testing:

1. Test Method: ASTM C39/C39M.

2. Test Acceptance: In accordance with ACI 318.

3. Test two cylinders at 28 days.

4. Test one cylinder at 56 days.

5. Dispose remaining cylinders when testing is not required.

3.10 DEFECTIVE CONCRETE

A. Modify or replace concrete not conforming to required lines, details, and elevations, as directed by the District.

END OF SECTION 03 30 00

SECTION 05 50 00

METAL FABRICATIONS

PART 1 - GENERAL

1.3 SUMMARY

A. Work Included:

This section shall consist of:

- Access Ladders.
- Structural supports for miscellaneous piping and attachments.

B. Reference Standards:

1. This Technical Specification makes references to the 2021 Standard Specifications for Public Works Construction (Greenbook),
2. ASTM International.
    a. ASTM A36/A36M – Standard Specification for Carbon Structural Steel.
    b. ASTM A53/A53M – Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
    c. ASTM A123/A123M – Standard Specification for Zinc (Hot-Dipped Galvanized) Coatings on Iron and Steel Products.
    d. ASTM A153/A153M – Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
    e. ASTM A240/A240M – Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
    f. ASTM A269 – Standard Specification for Seamless and Welded Austenitic Stainless-Steel Tubing for General Service
    g. ASTM A276 – Standard Specification for Stainless Steel Bars and Shapes.
    h. ASTM A297/A297M – Standard Specification for Steel Castings, Iron-Chromium and Iron-Chromium-Nickel, Heat Resistant, for General Application.
    i. ASTM A307 – Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength.
    j. ASTM A312/A312M – Standard Specification for Seamless and Welded Austenitic Stainless-Steel Pipes.

k. ASTM A325 – Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.
l. ASTM A354 – Standard Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners.
m. ASTM A500/A500M – Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
n. ASTM A501 – Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
o. ASTM A554 – Standard Specification for Welded Stainless Steel Mechanical Tubing.
p. ASTM A563 – Standard Specification for Carbon and Alloy Steel Nuts.
q. ASTM A572/A572M – Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.
r. ASTM A653/A653M – Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
s. ASTM A666 – Standard Specification for Annealed or Cold-Worked Austenitic Stainless-Steel Sheet, Strip, Plate, and Flat Bar.
t. ASTM A992/A992M – Standard Specification for Structural Steel Shapes.
u. ASTM B177 – Standard Guide for Chromium Electroplating on Steel for Engineering Use.
v. ASTM F1554 – Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength.

3. American Welding Society:

a. AWS A2.4 – Standard Symbols for Welding, Brazing, and Nondestructive Examination.
b. AWS D1.1 – Structural Welding Code – Steel.
c. AWS D1.6 – Structural Welding Code – Stainless Steel.

1.2 RELATED SECTIONS

A. Section 03 30 00 – Cast-In-Place Concrete.

1.3 SUBMITTALS

A. Shop Drawings: Submit shop drawings which show details, dimensions, sizes of material, and all information and data necessary for the fabrication of metal work.

Shop drawings shall conform to and be submitted in accordance with the requirements of Section 304-1.1.1 of the Standard Specifications.

B. Welders Certificates: Certify welders employed on the Work, verifying AWS qualification within previous 12 months.

1.4 QUALITY ASSURANCE

A. Perform Work in accordance with the requirements of Section 304 of the Standard Specifications.

1.5 FIELD MEASUREMENTS

A. Verify field measurements are as indicated on shop drawings prior to fabrication.

PART 2 - PRODUCTS

2.1 MATERIALS – STAINLESS STEEL

A. Bars and Shapes: ASTM A276; Type 316.

B. Tubing: ASTM A269; Type 316.

C. Pipe: ASTM A312/A312M, seamless; Type 316.

D. Plate, Sheet and Strip: ASTM A240/A240M OR ASTM A666; 316.

E. Bolts, Nuts, and Washers: ASTM A354.

F. Welding Materials: AWS D1.6; type required for materials being welded.

2.2 STRUCTURAL SUPPORTS

A. Miscellaneous structural supports shall be constructed of the materials and sizes and shapes as indicated on the Plans.

2.4 STRUCTURAL SUPPORTS

A. Miscellaneous structural supports shall be constructed of the materials and sizes and shapes as indicated on the Plans.

2.5 FABRICATION

A. Fit and shop assemble items in largest practical sections, for delivery to site.

B. Fabricate items with joints tightly fitted and secured.

C. Supply components required for anchorage of fabrications. Fabricate anchors and related components of same material and finish as fabrication, except where specifically noted otherwise.

2.6 FINISHES

A. Galvanized Finishes: Where indicated on the Plans, metal fabrications shall receive a galvanized finish in accordance with the following:

1. Clean surfaces of rust, scale, grease, and foreign matter prior to finishing.
2. Do not prime surfaces in direct contact with concrete or where field welding is required.
3. Galvanizing: ASTM A123/A123M; Hot-Dipped Galvanized After Fabrication.
4. Galvanizing for Fasteners, Connectors, and Anchors:

   a. Hot-Dipped Galvanizing: ASTM A153/A153M.
   b. Mechanical Galvanizing: ASTM B695; Class 50 minimum.

B. Stainless Steel Finishes: Satin Polished Finish: Number 4, satin directional polish parallel with long dimension of finished face.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify field conditions are acceptable and are ready to receive Work.

3.2 PREPARATION

A. Clean and strip primed steel items to bare metal where site welding is required.

B. Supply steel items required to be cast into concrete with setting templates to appropriate sections.

3.3 INSTALLATION

A. Methods and Equipment used for completing and installing work covered by this section shall be in accordance with the requirements of Section 304-1.2 of the Standard Specifications.

B. Fabrication and erection of metal fabrications shall be in accordance with the requirements of Section 304-1.4 of the Standard Specifications.

C. Workmanship and finish for metal fabrications shall be in accordance with the requirements of Section 304-1.5 of the Standard Specifications.

D. Joints and connections for metal fabrications shall be in accordance with the requirements of Section 304-1.6 of the Standard Specifications.

E. Anchorage for metal fabrications shall be in accordance with the details provided on the Plans and the requirements of Section 304-1.7 of the Standard Specifications.

F. Welding for metal fabrications shall be in accordance with the detail provided on the Plans and the requirements of Section 304-1.9 of the Standard Specifications.

3.4 QUALITY CONTROL

A. Inspections of metal fabrications work shall be in accordance with the requirements of Section 304-1.3 of the Standard Specifications.

END OF SECTION 05 50 00

WSECTION 22 14 23

PUMPING STATIONS

PART 1 - GENERAL

1.3 SUMMARY

A. Work Included:

This section shall consist of:

- Sewer Pump Station Installation

B. Reference Standards: This Technical Specification makes reference to the 2021 Standard Specifications for Public Works Construction (Greenbook).

1.2 SUBMITTALS

A. Pumps

B. Discharge Piping

C. Force Main Piping and couplings in wet well

D. Temporary Bypass Pump and Piping

PART 2 - PRODUCTS

2.1 PUMPS

A. Furnish and install two Flygt Non-Clog Submersible Sewage Pump (Q=810 GPM, 19.7 TDH) Model FP3127 LT3 ~ 491 or Approved Equal. Each pump shall be equipped with a 7.5-HP submersible electric motor connected for operation on 460 volts, 3-phase, 1750 RPM, wire service, with 50 feet of submersible cable (SUBCAB) suitable for submersible pump applications. The power cable shall be sized according to NEC and ICEA standards and have P-MSHA Approval.

B. Furnish and deliver one Flygt Non-Clog Submersible Sewage Pump (Q=810 GPM, 19.7 TDH) Model FP3127 LT3 ~ 491 or Approved Equal to the District operations yard. Each pump shall be equipped with a 7.5-HP submersible electric motor connected for operation on 460 volts, 3-phase, 1750 RPM, wire service, with 50 feet of submersible cable (SUBCAB) suitable for submersible pump applications. The power cable shall be sized according to NEC and ICEA standards and have P-MSHA Approval. Contractor shall coordinate with District staff.

C. The pump shall be supplied with a mating cast iron 6-inch discharge connection and be capable of delivering: 810 GPM at 19.7 Feet Total Dynamic Head (TDH). Shut off head shall be 30 feet (minimum). The pumps shall be automatically and firmly connected to the discharge connection, guided by no less than two guide bars extending from the top of the station to the discharge connection. There shall be no need for personnel to enter the wet-well. Sealing of the pumping unit to the discharge connection shall be accomplished by a machined metal to metal watertight contact. Sealing of the discharge interface with a diaphragm, O-ring or profile gasket will not be acceptable. No portion of the pump shall bear directly on the sump floor. Each pump shall be fitted with 40 feet of stainless-steel cable or lifting chain. The working load of the lifting system shall be 50% greater than the pump unit weight.

D. Major pump components shall be of grey cast iron, ASTM A-48, Class 35B, with smooth surfaces devoid of blow holes or other irregularities. The lifting handle shall be of stainless steel. All exposed nuts or bolts shall be AISI type 316 stainless steel construction. All metal surfaces in contact with the pumpage, other than stainless steel or brass, shall be protected by a factory applied spray coating of acrylic dispersion zinc phosphate primer with a polyester resin paint finish on the exterior of the pump.

1. Sealing design shall incorporate **metal-to-metal contact** between machined surfaces. Critical mating surfaces where watertight sealing is required shall be machined and fitted with Nitrile or optional Viton rubber O-rings. Fittings will be the result of controlled compression of rubber O-rings in two planes and O-ring contact of four sides without the requirement of a specific torque limit.
2. Rectangular cross-sectioned gaskets requiring specific torque limits to achieve compression shall not be considered as adequate or equal. No secondary sealing compounds, elliptical O-rings, grease, or other devices shall be used.

E. Motors are sufficiently cooled by the surrounding environment or pumped media. A water jacket is not required.

F. The cable entry seal design shall preclude specific torque requirements to insure a watertight and submersible seal. The cable entry shall consist of a single cylindrical elastomer grommet, flanked by washers, all having a close tolerance fit against the cable outside diameter and the entry inside diameter and compressed by the body containing a strain relief function, separate from the function of sealing the cable. The assembly shall provide ease of changing the cable when necessary, using the same entry seal. The cable entry junction chamber and motor shall be separated by a stator lead sealing gland or terminal board, which shall isolate the interior from foreign material gaining access through the pump top. Epoxies, silicones, or other secondary sealing systems shall not be considered acceptable.

G. The pump motor shall be a National Electrical Manufacturers Association (NEMA) B design, induction type with a squirrel cage rotor, shell type design, housed in an air filled, watertight chamber. The stator windings shall be insulated with moisture resistant Class H insulation rated for 180°C (356°F). The stator shall be insulated by the trickle impregnation method using Class H monomer-free polyester resin resulting in a winding fill factor of at least 95%. The motor shall be inverter duty rated in accordance with NEMA MG1, Part 31. The stator shall be heat-shrink fitted into the cast iron stator housing. The use of multiple step dip and bake-type stator insulation process is not acceptable. The use of bolts, pins or other fastening devices requiring penetration of the stator housing is not acceptable. The motor shall be designed for continuous duty handling pumped media of 40°C (104°F) and capable of no less than 30 evenly spaced starts per hour. The rotor bars and short circuit rings shall be made of cast aluminum. Thermal switches set to open at 125°C (260°F) shall be embedded in the stator end coils to monitor the temperature of each phase winding. These thermal switches shall be used in conjunction with and supplemental to external motor overload protection and shall be connected to the control panel. The junction chamber containing the terminal board, shall be hermetically sealed from the motor by an elastomer compression seal. Connection between the cable conductors and stator leads shall be made with threaded compression type binding posts permanently affixed to a terminal board. The motor and the pump shall be produced by the same manufacturer.

1. The combined service factor (combined effect of voltage, frequency, and specific gravity) shall be a minimum of 1.15. The motor shall have a voltage tolerance of plus or minus 10%. The motor shall be designed for operation up to 40°C (104°F) ambient and with a temperature rise not to exceed 80°C. A performance chart shall be provided upon request showing curves for torque, current, power factor, input/output kW and efficiency. This chart shall also include data on starting and no-load characteristics.
2. The power cable shall be sized according to the National Electrical Code (NEC) and Insulated Cable Engineers Association (ICEA) standards and shall be of sufficient length to reach the junction box without the need of any splices. The outer jacket of the cable shall be oil resistant chlorinated polyethylene rubber. The motor and cable shall be capable of continuous submergence underwater without loss of watertight integrity to a depth of 65-feet or greater.
3. The motor horsepower shall be adequate so that the pump is non-overloading throughout the entire pump performance curve from shut-off through run-out.

H. The power cable shall be sized according to the NEC and ICEA standards and shall be of sufficient length to reach the junction box without the need of any splices. The power cable shall be of a shielded design in which an overall tinned copper shield is included, and each individual phase conductor is shielded with an aluminum coated foil wrap. The outer jacket of the cable shall be oil resistant chlorinated polyethylene rubber. The cable shall be capable of continuous submergence underwater without loss of watertight integrity to a depth of 65 feet or greater.

I. The pump shaft shall rotate on two bearings. Motor bearings shall be permanently grease lubricated. The upper bearing shall be a single deep groove ball bearing. The lower bearing shall be a two-row angular contact bearing to compensate for axial thrust and radial forces. Single row lower bearings are not acceptable. The minimum L10 bearing life shall be 50,000 hours at any usable portion of the pump curve.

J. Each pump shall be provided with a tandem mechanical shaft seal system consisting of two totally independent seal assemblies. The seals shall operate in a lubricant reservoir that hydro-dynamically lubricates the lapped seal faces at a constant rate. The lower, primary seal unit, located between the pump and the lubricant chamber, shall contain one stationary and one positively driven rotating, corrosion, and abrasion resistant tungsten-carbide ring. The upper, secondary seal unit, located between the lubricant chamber and the motor housing, shall contain one stationary and one positively driven rotating, corrosion and abrasion resistant tungsten-carbide seal ring.

Each seal interface shall be held in contact by its own spring system. The seals shall require neither maintenance nor adjustment nor depend on direction of rotation for sealing. The position of both mechanical seals shall depend on the shaft. Mounting of the lower mechanical seal on the impeller hub will not be acceptable. For special applications, other seal face materials shall be available.

The following seal types shall not be considered acceptable or equal to the dual independent seal specified: shaft seals without positively driven rotating members, or conventional double mechanical seals containing either a common single or double spring acting between the upper and lower seal faces. No system requiring a pressure differential to offset pressure and to effect sealing shall be used.

Each pump shall be provided with a lubricant chamber for the shaft sealing system. The lubricant chamber shall be designed to prevent overfilling and to provide lubricant expansion capacity. The drain and inspection plug, with positive anti-leak seal shall be easily accessible from the outside. The seal system shall not rely upon the pumped media for lubrication. The motor shall be able to operate dry without damage while pumping under load.

Where a seal cavity is present in the seal chamber, the area about the exterior of the lower mechanical seal in the cast iron housing shall have cast in an integral concentric spiral groove. This groove shall protect the seals by causing abrasive particulate entering the seal cavity to be forced out away from the seal due to centrifugal action.

Seal lubricant shall be non-hazardous.

J. Pump and motor shaft shall be the same unit. The pump shaft is an extension of the motor shaft. Couplings shall not be acceptable. The shaft shall be stainless steel – ASTM A479 S43100-T.

If a shaft material of lower quality than stainless steel – ASTM A479

S43100-T is used, a shaft sleeve of stainless steel – ASTM A479 S43100T is used to protect the shaft material. However, shaft sleeves only protect the shaft around the lower mechanical seal. No protection is provided in the oil housing and above. Therefore, the use of stainless-steel sleeves will not be considered equal to stainless steel shafts.

K. The impeller shall be of Hard-Iron™ (ASTM A-532 (Alloy III A) 25% chrome cast iron), dynamically balanced, semi-open, multi-vane, backswept, non-clog design. The impeller vane leading edges shall be mechanically self-cleaned upon each rotation as they pass across a spiral groove located on a replaceable insert ring.

The impeller shall have vanes hardened to RC 45 and shall be capable of handling solids, fibrous materials, heavy sludge and other matter found in wastewater. The screw shape of the impeller inlet shall provide an inducing effect for the handling of sludge and rag-laden wastewater. The impeller shall be capable of momentarily moving axially upwards a distance of 15mm/0.6-in. to allow larger debris to pass through and immediately return to normal operating position.

L. The pump volute shall be a single piece grey cast iron, ASTM A-48, Class 35B, non-concentric design with smooth passages of sufficient size to pass any solids that may enter the impeller. Minimum inlet and discharge size shall be as specified. The volute shall have a replaceable suction cover insert ring in which are cast spiral-shaped, sharp-edged groove(s). The spiral groove(s) shall provide trash release pathways and sharp edge(s) across which each impeller vane leading edge shall cross during rotation so to remain unobstructed. The insert ring shall be cast of Hard-

Iron™ (ASTM A-532 (Alloy III A) 25% chrome cast iron) and provide effective sealing between the multi-vane semi-open impeller and the volute housing.

M. All stators shall incorporate thermal switches in series to monitor the temperature of each phase winding. The thermal switches shall open at 125°C (260°F), stop the motor and activate an alarm.

A leakage sensor shall be available as an option to detect water in the stator chamber. The Float Leakage Sensor (FLS) is a small float switch used to detect the presence of water in the stator chamber. When activated, the FLS will stop the motor and send an alarm both local and/or remote. **USE OF VOLTAGE SENSITIVE SOLID-STATE SENSORS AND TRIP TEMPERATURE ABOVE 125°C (260°F) SHALL NOT BE ALLOWED.**

The thermal switches and FLS shall be connected to a Mini CAS (Control and Status) monitoring unit. The Mini CAS shall be designed to be mounted in any control panel.

2.2 PUMP STATION APPURTENANCES

A. Stainless Steel Guide Bar Bracket and Cable Holder Hooks

B. Vent Piping

C. Pump Station Controller in NEMA 12 enclosure

D. Pressure Transducer and Backup Level Floats

2.3 PUMP CONTROLLER

A. Contractor to provide new pump control panel.

B. Pump Control Panel shall have the HOA switches, indicator lights, disconnect switches mounted on the front panel.

2.5 TEMPORARY BYPASS PUMPING EQUIPMENT

A. Temporary Pumps

B. Controls

C. Standby Power

D. Temporary Piping and Valves

PART 3 - EXECUTION

3.1 GENERAL

A. Dewater excavations and trenches, as necessary, to allow for construction of the Work as called for on the Plans and in conformance with these Specifications.

3.2 PUMP INSTALLATION

A. Pump station installation shall conform to the details shown on the Plans and shall include the installation of the pumps, force main piping including fittings, couplings, valves, anchor brackets, and pipe penetrations and sealing.

B. Testing shall conform to the following requirements:

1. Pumps: The pump and power cord shall be visually inspected for imperfections, cuts, or nicks.
2. Contractor to refer to manufacturer's specifications for testing procedures.
3. The pump shall have a ground continuity check.
4. The pump is run. Voltage and current are monitored visually, electronically, and the tester listens for any noise or malfunction.
5. Contractor to fill wet well with potable water to allow each pump to cycle a minimum of five times. The alarm system should be cycled a minimum of three times. Contractor is responsible for purchasing and obtaining water needed for testing of the pumps and force main. Contractor is responsible for coordinating discharge of test water to the downstream public sewer with approval from the District.
6. Contractor to coordinate with the District Maintenance Department for inspection of the pump operation. The District's lead plumber and lead electrician (or designates) shall be present during startup and testing.
7. Contractor shall be responsible for providing water for use in testing the operation of the pump station.
8. Contractor shall be responsible for coordinating all work with the SCADA Systems Integrator during installation of the pumps, control panel, RTU and testing and commissioning.

F. The Contractor shall assemble an operations and maintenance manual for the pump stations and provide 2 copies to the District.

3.3 TEMPORARY BYPASS PUMP EQUIPMENT INSTALLATION

A. The existing sewer system includes an upstream manhole in Lakeview Drive that has an overflow manhole. The overflow manhole is intended to be used as the primary bypass system by installing a temporary plug-in conjunction with a bypass pump system to be operated no less than twice a week. The bypass pump system will draw down the wastewater within the overflow manhole to remove settled solids and trash, as well as minimize odors. All bypass operations shall be conducted by the Contractor.

B. The Contractor is responsible for designing and implementing a sewage bypassing/pumping system suitable for completing the work in dry and sanitary conditions. The sewer flow shall be intercepted at an upstream manhole, pumped and conveyed in a closed conduit to the downstream force main until the new sewer pump station is in place and operational.

C. The Contractor shall furnish, install and operate pumps, pipes, appliances and equipment of sufficient capacity to handle all flows to prevent sewage from backing up in the pipeline. Wastewater flow shall not be interrupted. Sewage shall be conveyed in closed conduits and disposed of in downstream sanitary sewer facilities.

D. The pump and bypass lines shall be of adequate capacity to handle the flow. The peak pipeline flow is estimated to be at 810 gallons per minute. Bypass pumping capacity shall be 120% of peak flow with 100% backup pumping capacity connected to the primary pump.

E. During sewer bypass pumping operations, the pumps shall be continuously monitored 24-hours/7-days per week by personnel qualified to operate the pumping equipment. Remote alarm operation shall notify the contractor of any issues associated with pump failure, power failure, high water level. Contractor shall respond immediately to any alarms and resolve the issue. This includes after hour periods when the Contractor may not be conducting other construction activities. The personnel monitoring the pump shall be equipped with a cellular telephone so that additional personnel can be contacted in case of emergency.

F. The Contractor shall have onsite a fully functional and fueled standby pump(s) that can be placed in service if the primary pumping unit malfunctions.

G. The bypass piping shall be a continuous piece of polyethylene solid wall pipe(s) joined by butt-fusion welding or a system of Victaulic® aluminum pipe(s), couplings, and fittings and shall be suitable for traffic loading if installed in areas allowing traffic over installed pipe. Mechanical joints will not be allowed in the polyethylene bypass piping except at the pump, manifold, and discharge connections. The bypass pipe shall be of a pressure class that is compatible with the bypass pump.

H. If sewage backup occurs and enters buildings, the Contractor shall be responsible for clean-up, repair, property damage cost and claims.

I. The Contractor shall prepare a Flow Diversion Plan for review by the City. The Contractor shall observe and comply with all Federal, State, and local laws and ordinances, codes, orders, and regulations which in any manner affect the conduct of the work, specifically as it relates to sewage spills. The Contractor shall be fully responsible for preventing sewage spill(s), containing any sewage spill(s), recovery and legal disposal of any spilled sewage, any fines, penalties, claims, and liability arising from negligently causing a sewage spill(s), and any violation of any law, ordinance, code, order, or regulation as a result of the spill(s).

J. The Contractor shall maintain access for all driveways and streets during the bypass piping operation.

END OF SECTION 22 14 23

SECTION 26 05 00

ELECTRICAL – GENERAL PROVISIONS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. General requirements applicable to all Electrical Work.
2. General requirements for electrical submittals.
3. Electrical Subcontractor Qualification Requirements.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01 33 00 – Submittal Procedures.
   b. Section 01 71 13 – Mobilization.
   c. Section 26 05 53 – Identification for Electrical Systems.
   d. Section 26 05 33 – Raceways and Fittings.
   e. Section 26 05 73 – Short-Circuit, Protective Device Coordination and Arc Flash Study.
   f. Section 26 08 00 - Field Electrical Acceptance Tests.

C. Interfaces to Equipment, Instruments, and Other Components:

1. The Drawings, Specifications, and overall design are based on preliminary information furnished by various equipment manufacturers which identify a minimum scope of supply from the manufacturers. This information pertains to, but is not limited to, instruments, control devices, electrical equipment, packaged mechanical systems, and control equipment provided with mechanical systems.
2. Provide all material and labor needed to install the actual equipment furnished, and include all costs to add any additional conduit, wiring, terminals, or other electrical hardware to the Work, which may be necessary to make a complete, functional installation based on the actual equipment furnished:
3. Make all changes necessary to meet the manufacturer's wiring requirements.
4. Submit all such changes and additions to the Engineer for acceptance.

5. Review the complete set of Drawings and Specifications in order to ensure that all items related to the electrical power and control systems are completely accounted for. Include any such items that appear on the Drawings or in the Specifications from another discipline in the scope of Work:
    a. If a conflict between Drawings and Specifications is discovered, refer conflict to the Engineer as soon as possible for resolution.
6. Loop drawings:
    a. Provide all electrical information required in the preparation of loop drawings including, but not limited to:
        i. Conduit numbers and associated signal(s) contained within each conduit.
        ii. Wire numbers.
        iii. Equipment terminal numbers.
        iv. Junction boxes and signal(s) contained within each junction box.
        v. Equipment power sources, and associated circuit numbers.
        vi. As-built drawings detailing wiring.

D. All Electrical Equipment And Systems For The Entire Project Must Comply With The Requirements Of The Electrical Specifications, Whether Referenced In The Individual Equipment Specifications Or Not:
1. The requirements of the Electrical Specifications apply to all Electrical Work specified in other sections.
2. Inform all vendors supplying electrical equipment or systems of the requirements of the Electrical Specifications.
3. The Owner is not responsible for any additional costs due to the failure of the Contractor to notify all subcontractors and suppliers of the Electrical Specifications requirements.

E. Special Subcontractor Requirements:
1. As specified elsewhere in this Section, provide the Work specified in the Electrical Specifications by a pre-qualified electrical subcontractor.

F. Contract Documents:
1. General:
    a. The Drawings and Specifications are complementary and are to be used together in order to fully describe the Work.
2. Specifications:
    a. The General and Supplementary Conditions of the Contract Documents govern the Work.
    b. These requirements are in addition to all General Requirements.
3. Contract Drawings:

a. The Electrical Drawings show desired locations, arrangements, and components of the Electrical Work in a diagrammatic manner.

b. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate only; exercise professional judgment in executing the Work to ensure the best possible installation:

    i. The equipment locations and dimensions indicated on the Drawings are approximate. Use the shop drawings to determine the proper layout, foundation, and pad requirements, etc. for final installation. Coordinate with all subcontractors to ensure that all electrical equipment is compatible with other equipment and space requirements. Make changes required to accommodate differences in equipment dimensions.

    ii. The Contractor has the freedom to select any of the named manufacturers identified in the individual specification sections; however, the Engineer has designed the spatial equipment layout based upon a single manufacturer and has not confirmed that every named manufacturer's equipment fits in the allotted space. It is the Contractor's responsibility to ensure that the equipment being furnished fits within the defined space.

c. Installation details:

    i. The Contract Drawings include typical installation details the Contractor is to use to complete the Electrical Work. For cases where a typical detail does not apply, develop installation details that may be necessary for completing the Work, and submit these details for review by the Engineer.

    ii. Not all typical installation details are referenced within the Drawing set. Apply and use typical details where appropriate.

d. Schematic diagrams:

    i. All controls are shown de-energized.

    ii. Schematic diagrams show control function only. Incorporate other necessary functions for proper operation and protection of the system.

    iii. Add slave relays, where required, to provide all necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.

    iv. Mount all devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated.

    v. Schematic diagrams are to be used in conjunction with the descriptive operating sequences in the Contract Documents. Combine all information and furnish and coordinated and fully functional control system.

G. Changes And Change Orders:

1. As specified per Section 7 of the General Conditions.

1.02 ELECTRICAL SUBCONTRACTOR QUALIFICATIONS

A. The Electrical Subcontractor Shall Meet or Exceed the Criteria Described Below:

1. The electrical subcontractor shall be licensed in the State of California.
2. The electrical subcontractor shall have successfully completed electrical construction on three water or wastewater treatment plant related projects within the past 6 years.
3. The electrical subcontractor shall have, in their employ, the following full-time employees that will be assigned to perform the electrical work of this contract:
   a. A minimum of (1) Licensed Master Electrician who is overall responsible for the supervision of personnel performing the construction, installation startup and testing of all electrical related facilities and systems.
   b. A minimum of (1) Licensed Journeyman Electrician responsible for the daily construction activities and guidance of the electrical contractor's on-site employees. The Licensed Journeyman's primary assignment will be the construction of the electrical facilities of this project until project completion. The Licensed Journeyman shall be certified in Riverside County.
4. The electrical subcontractor shall not be involved in any current or pending litigation which may have a material negative impact on the ability to complete the project. The electrical subcontractor shall provide a statement advising all current or pending litigations.

1.03 REFERENCES

A. Code Compliance:

1. The publications are referred to in the text by the basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of the bid governs.
2. The standards listed are hereby incorporated into this Section.
   a. American National Standards Institute (ANSI).
   b. American Society of Civil Engineers (ASCE):
      i. ASCE 7 - Minimum Design Loads for Buildings and Other Structures.
   c. ASTM International (ASTM).
   d. Illuminating Engineering Society (IES). Institute of Electrical and Electronics Engineers (IEEE).
   e. Insulated Cable Engineers Association (ICEA).
   f. International Code Council (ICC).
      i. International Code Council Evaluation Service (ICC-ES).
         I. AC 156 – Acceptance Criteria for Seismic Certification by Shake Table Testing of Non-Structural Components (ICC-ES AC 156).

g. International Society of Automation (ISA).

h. National Electrical Manufacturers Association (NEMA):

   i. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

i. National Fire Protection Association (NFPA):

   i. 70 - National Electrical Code (NEC).

j. National Institute of Standards and Technology (NIST).

k. Underwriters' Laboratories, Inc. (UL).

B. Compliance With Laws And Regulations:

1. As specified in the General Conditions.

1.04 DEFINITIONS

A. Definitions Of Terms And Other Electrical And Instrumentation Considerations As Set Forth By:

1. IEEE.
2. NETA.
3. IES.
4. ISA.
5. NEC.
6. NEMA.
7. NFPA.
8. NIST.

B. Specific Definitions:

1. FAT: Factory acceptance test.
2. ICSC: Instrumentation and controls subcontractor (henceforth referred to as the SYSTEM SUPPLIER).
3. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
4. PCP: Process control panel: An enclosure containing any of the following devices: PLC, RTU, or RIO.
5. PCIS: Process control and instrumentation system.
6. Space: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that does not physically contain a device but is capable of accepting a device with no modifications to the equipment, i.e., provide all standoffs, bus, and hardware, as part of the space.

7. Spare: That portion of the switchgear, motor control center, panelboard, switchboard, or control panel that physically contains a device with no load connections to be made.
8. System supplier: Refer to Quality Assurance in this Section.
9. VCP: Vendor control panel: Control panels that are furnished with equipment by a vendor other than the ICSC. These panels are shown on the drawings as “BSCP-2”, “CCP-4” and “GSCP” and may contain PLCs, RIO, OIT, HMI, etc.
10. Unequipped space: That portion of the switchgear, motor control center, panelboard, switchboard, or control panel that does not physically contain a device, standoff, bus, hardware, or other equipment.

1.05 SYSTEM DESCRIPTION

A. General Requirements:

1. The Work includes everything necessary for and incidental to executing and completing the Electrical Work indicated on the Drawings and specified in the Specifications and reasonably inferable there from:
    a. The Electrical Drawings are schematic in nature; use the Structural, Architectural, Mechanical, and Civil Drawings for all dimensions and scaling purposes.
2. It is the intent of these Specifications that the entire electrical power, instrumentation, and control system be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all connections, testing, calibration of equipment furnished by others as well as equipment furnished by the Contractor, whether or not specifically mentioned but which are necessary for successful operation.
3. Provide all Electrical Work, including conduit, field wiring, and connections by the electrical subcontractor under the provisions of the Electrical Specifications for all aspects of the Work.
4. Coordinate all aspects of the Work with the electrical subcontractor and other subcontractors before bidding in order to ensure that all costs associated with a complete installation are included. The Owner is not responsible for any change orders due to lack of coordination of the Work between the Contractor, the electrical subcontractor, the other subcontractors, or suppliers.
5. Demolition:
    a. Where demolition is specified or indicated on the Drawings, disconnect all associated electrical equipment, and render the equipment safe.
    b. Remove and dispose of all conduits, wire, electrical equipment, controls, etc. associated with the items and/or areas to be demolished as indicated on the Drawings unless otherwise indicated.
    c. For each piece of equipment to be removed, remove all ancillary components (e.g. instruments, solenoid valves, disconnect switches, etc.).

d. Conduit:

i. Where conduit removal, other than associated with equipment to be removed, is indicated on the Drawings:

I. Remove exposed conduit to the point of encasement or burial.

II. Cut conduit flush and plug or cap encased or buried conduit.

ii. Where conduits are to remain in place and removal is not indicated on the Drawings:

I. Cap conduit open ends.

II. Re-label empty conduits as spare.

e. Remove all wire back to the source for all conduits to be removed or abandoned in place.

f. Provide new nameplates for modified electrical distribution equipment, motor control centers etc. to identify equipment and circuits that are no longer used as spares.

g. Provide new typewritten schedules for all panelboards.

6. Portions of this Project involve installation in existing facilities and interfaces to existing circuits, power systems, controls, and equipment:

a. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, etc.) before starting any Work. Determine all information necessary to document, interface with, modify, upgrade, or replace existing circuits, power systems, controls, and equipment.

b. Provide and document interface with, modifications to, upgrades, or replacement of existing circuits, power systems, controls, and equipment.

7. Provide all trenching, forming, rebar, concrete, back filling, hard surface removal and replacement, for all items associated with the Electrical Work and installation:

a. As specified in the Contract Documents.

8. Defective work:

a. As specified in the General Conditions.

B. Permanent electrical power shall be provided by Southern California Edison (SCE) at voltages indicated on the drawings.

C. Construction Constraints:

1. Contractor shall provide a detailed written electrical construction sequence. Electrical construction sequence shall be in-line or follow the process construction sequence.

2. It is the Contractor's responsibility to provide all necessary temporary power with all temporary distribution equipment, temporary wires, temporary power source, or

temporary generator with fuel, etc. for any shutdown without additional cost to the Owner/City.

3. According to individual circumstances and in compliance with the Drawings, extend or replace conduit and cable connections from existing locations.

4. The standards of documentation, instrument tagging, cable and conductor ferruling, terminal identification and labeling that apply to the new installation apply equally to the existing installation which forms part of the modified system.

1.06 SUBMITTALS

A. Furnish Submittals As Specified In Section 01 33 00 And This Section.

B. General:

1. Instruct all equipment suppliers of submittals and operation and maintenance manuals of the requirements in this Section.

2. Furnish the submittals required by each section in the Electrical Specifications.

3. Adhere to the wiring numbering scheme specified in Section 26 05 53 throughout the Project:

   a. Uniquely number each wire.

   b. Wire numbers must appear on all Equipment Drawings.

4. Use equipment and instrument tags, as indicated on the Drawings, for all submittals.

C. Quality Control Submittals:

1. Factory test certification and reports for all major electrical equipment.

2. As part of the electrical submittal, the contractor shall provide a minimum of 1/2”=1’-0” scaled conduit layout drawings of the electrical equipment in the existing electrical buildings, new electrical buildings, sludge dewatering building, operations building, or major electrical equipment in a mechanical room showing sizes of all equipment and their spatial relationship. Non-electrical equipment shall be approved before finalizing the electrical layout in mechanical rooms.

3. In addition, the Contractor shall submit for the approval electrical installation working drawings for the overall site work. Site plan conduit layout drawings shall be at 1” = 60’-0”.

4. Provide complete conduit and equipment layouts: a scaled plan layout of the new and existing electrical room(s) showing spatial relationships of all equipment as well as the overall size of the room as stated in section 1.06.C.2.

5. Provide a conduit plan for major power, instrumentation, and control conduits, both interior and exterior, showing routing, size and stub up locations for buried or in slab conduits.

6. Concrete floors and/or walls containing concealed conduits shall not be poured until conduit layouts are approved.

7. Plans shall be drawn with ACAD 2019, size 36-inch x 24-inch, and shall be presented in a neat, professional manner. Drawing files shall be provided for review. Note: ACAD drawing files are available from the Engineer.

D. Seismic Requirements:

1. Provide electrical equipment with construction and anchorage to supporting structures designed.

2. For equipment installed in structures designated as seismic design category C, D, E or F, prepare and submit the following:

   a. Statement of seismic qualification, and special seismic certification:

      i. "Statement of seismic qualification:" Provide manufacturer's statement that the equipment satisfies the seismic design requirements of the building code, including the requirements of ASCE 7, Chapter 13.

      ii. "Special seismic certification:" Provide manufacturer's certification that the equipment, when subjected to shake table testing in accordance with ICC-ES AC 156, meets the "Post-Test Functional Compliance Verification" requirements of ICC-ES AC 156 for "Components with Ip = 1.5." Compliance shall include both operability and containment of hazardous materials as appropriate to the unit being tested.

   b. Substantiating test data: With seismic qualification and special seismic certification statements, submit results of testing in accordance with ICC-ES AC 156.

   c. Anchoring design calculations and details:

      i. Submit project-specific drawings and supporting calculations, prepared and sealed by a professional engineer licensed in the state where the Project is being constructed, and showing details for anchoring electrical equipment to its supports and for anchoring supports provided with the equipment to the structure.

3. Exemptions: A "statement of seismic qualification" and a "special seismic certification" are not required for the following equipment:

   a. Temporary or moveable equipment.

   b. Equipment anchored to the structure and having a total weight of 20 pounds or less.

   c. Distribution equipment anchored to the structure and having a total unit weight of 3 pounds per linear foot, or less.

E. Submittal Organization:

1. First page:

   a. Specification section reference.

   b. Name and telephone number of individual who reviewed submittal before delivery to Engineer.

c. Name and telephone number of individual who is primarily responsible for the development of the submittal.

d. Place for Contractor's review stamp and comments.

2. Next pages:

a. Provide confirmation of specification compliance in a tabular form that individually lists each specification section, paragraph, and sub-paragraphs and unequivocally states compliance with said requirement or takes exception to the requirement and lists the reason for said exception and offers alternative means for compliance.

b. Include a response in writing to each of the Engineer's comments or questions for submittal packages which are re-submitted:

i. In the order that the comments or questions were presented throughout the submittal.

ii. Referenced by index section and page number on which the comment appeared.

iii. Acceptable responses to Engineer's comments are either:

I. Engineer's comment or change is accepted and appropriate changes are made.

II. Explain why comment is not accepted or requested change is not made.

III. Explain how requirement will be satisfied in lieu of comment or change requested by Engineer.

iv. Any re-submittal, which does not contain responses to the Engineer's previous comments shall be returned for Revision and Re-submittal.

v. No further review by the Engineer will be performed until a response for previous comments has been received.

3. Remaining pages:

a. Actual submittal data:

i. Organize submittals in exactly the same order as the items are referenced, listed, and/or organized in the specification section.

ii. For submittals that cover multiple devices used in different areas under the same specification section, the submittal for the individual devices must list the area where the device is intended to be used.

F. Submittal Requirements:

1. Furnish submittals that are fully indexed with a tabbed divider for every component.

2. Sequentially number pages within the tabbed sections. Submittals and operation and maintenance manuals that are not fully indexed and tabbed with sequentially numbered pages, or are otherwise unacceptable, will be returned without review.

3. Edit all submittals and operation and maintenance manuals so that the submittal specifically applies to only the equipment furnished.
    a. Neatly cross out all extraneous text, options, models, etc. that do not apply to the equipment being furnished, so that the information remaining is only applicable to the equipment being furnished.
4. Submit copies of shop drawings, and product data:
    a. Show dimensions, construction details, wiring diagrams, controls, manufacturers, catalog numbers, and all other pertinent details.
5. Where submittals are required, provide a separate submittal for each specification section. In order to expedite construction, the Contractor may make more than 1 submittal per specification section, but a single submittal may not cover more than 1 specification section:
    a. The only exception to this requirement is when 1 specification section covers the requirements for a component of equipment specified in another section. (For example, circuit breakers are a component of switchgear. The switchgear submittal must also contain data for the associated circuit breakers, even though they are covered in a different specification section.)
6. Exceptions to Specifications and Drawings:
    a. Include a list of proposed exceptions to the Specifications and Drawings along with a detailed explanation of each.
    b. If there is insufficient explanation for the exception or deviation, the submittal will be returned requiring revision and re-submittal.
    c. Acceptance of any exception is at the sole discretion of the Engineer.
        i. Provide all items (materials, features, functions, performance, etc.) required by the Contract Documents that are not accepted as exceptions.
    d. Replace all items that do not meet the requirements of the Contract Documents, which were not previously accepted as exceptions, even if the submittals contained information indicating the failure to meet the requirements.
7. Specific submittal requirements:
    a. Shop drawings:
        i. Required for materials and equipment listed in this and other sections.
        ii. Furnish sufficient information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these Specifications.
        iii. Shop drawings requirements:
            I. Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
            II. Locations of conduit entrances and access plates.

III. Component layout and identification.

IV. Schematic and wiring diagrams with wire numbers and terminal identification.

V. Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.

VI. Anchoring method and leveling criteria, including manufacturer's recommendations for the Project site seismic criteria.

VII. Weight.

VIII. Finish.

IX. Nameplates:

- As specified in Section 26 05 53.

X. Temperature limitations, as applicable.

b. Product data:

i. Submitted for non-custom manufactured material listed in this and other sections and shown on shop drawings.

ii. Include:

I. Catalog cuts.

II. Bulletins.

III. Brochures.

IV. Quality photocopies of applicable pages from these documents.

V. Identify on the data sheets the Project name, applicable specification section, and paragraph.

VI. Identify model number and options for the actual equipment being furnished.

VII. Neatly cross out options that do not apply or equipment not intended to be supplied.

c. Detailed sequence of operation for all equipment or systems.

G. Operation And Maintenance Manuals:

1. Furnish the Engineer with a complete set of written operation and maintenance manuals 8 weeks before Functional Acceptance Testing.

2. Additional operation and maintenance manual requirements:

a. Completely index manuals with a tab for each section:

i. Each section containing applicable data for each piece of equipment, system, or topic covered.

b. Assemble manuals using the approved shop drawings, and include, the following types of data:

   i. Complete set of 11-inch by 17-inch drawings of all equipment.

   ii. Complete set of control schematics.

   iii. Complete parts list for all equipment being provided.

   iv. Catalog data for all products or equipment furnished.

H. Material And Equipment Schedules:

1. Furnish a complete schedule and/or matrix of all materials, equipment, apparatus, and luminaries that are proposed for use:

   a. Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.

I. Schedule Of Values:

1. In addition to completing all items referred to in the itemized bid proposal, submit per unit material and labor costs used in developing the final bid for the electrical system, for the express purpose of pricing and cost justification for any proposed change orders. In addition to the items shown on the schedule of values, provide per unit material and labor costs for conduit and wire installation for specific types, sizes, and locations as indicated on the Drawings and Conduit Schedule. It is the responsibility of the electrical subcontractor to prove to the Engineer's satisfaction that said per unit costs were used in the development of the final Bid amount.

J. Record Documents:

1. Furnish as specified in Section 01 78 39.

2. Provide Record Documents of all Electrical Drawings.

3. Record Drawing requirements:

   a. Update Record Drawings weekly.

   b. Record Drawings must be fully updated as a condition of the monthly progress payments.

   c. Submit Record Drawings upon completion of the Work for final review.

   d. Clearly and neatly show all changes including the following:

      i. All existing pipe, conduit, wire, instruments or other structures encountered or uncovered during construction.

4. Shop drawings:

   a. Upon completion of the Work, update all shop drawings to indicate the final as-built configuration of the systems:

      i. Provide as-built shop drawings for all electrical equipment on 11-inch by 17-inch paper.

      ii. Size all drawings to be readable and legible on 11-17 inch media.

iii. Provide electronic copies of these documents on CD-ROM or DVD disks in Adobe Acrobat (i.e. PDF extension).

5. Review and corrections:

   a. Correct any record documents or other documents found to be incomplete, not accurate, of poor quality, or containing errors.

   b. Promptly correct and re-submit record documents returned for correction.

K. Test Reports:

1. As specified in Section 26 08 00.

2. Include the following:

   a. A description of the test.

   b. List of equipment used.

   c. Name of the person conducting the test.

   d. Date and time the test was conducted.

   e. All raw data collected.

   f. Calculated results.

   g. Each report signed by the person responsible for the test.

3. Additional requirements for field acceptance test reports are specified in Sections 00 16 55, 40 90 00 and 26 08 00

L. Calculations:

1. Where required by specific Electrical Specifications:

   a. Because these calculations are being provided by a registered professional engineer, they will be reviewed for form, format, and content but will not be reviewed for accuracy and calculation means.

1.07 QUALITY ASSURANCE

A. Furnish All Equipment Listed By And Bearing The Label Of UL Or Of An Independent Testing Laboratory Acceptable To The Engineer And The Authority Having Jurisdiction.

B. System Supplier Responsibilities:

1. Requirements as specified in the Instrumentation and Control Specifications.

2. System supplier:

   a. Due to the critical and complex technical requirements of this Project, all Work (materials, equipment, products, submittals, labor, services, etc.) specified in the Electrical, and Instrumentation and Control Specifications, and shown on the Electrical and Instrumentation Drawings is to be furnished by a single system supplier who has single source responsibility for both the process control and instrumentation systems and the electrical power system.

3. Contractual relationship:

   a. Form a contractual relationship between the electrical subcontractor and the ICSC.

   b. Requirements for the first tier subcontractor:

      i. Contract directly with the Contractor.

      ii. Be either the electrical subcontractor or the ICSC.

   c. Requirements for the second tier subcontractor:

      i. A division of the first tier subcontractor, or

      ii. ii.A joint venture with the first tier subcontractor, or

      iii. iii.A subcontractor to the first tier subcontractor.

   d. The system supplier manages, directs, and supervises all of the Work of its second tier subcontractor. The system supplier is solely responsible for the entire electrical and instrumentation system, including, but not limited to, all Electrical, Instrumentation, and Process Contract Drawings, Electrical Specifications, and Instrumentation and Control Specifications:

      i. Provide any additional conduit, wire, etc.

      ii. Any additional I/O, programming, screens, interface devices needed by the system supplier are to be provided by the electrical subcontractor or the ICSC, under the above outlined working agreement.

      iii. Ensure compatibility between the PCIS system and the electrical system being installed.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Shipping Precautions:

   1. After completion of shop assembly and successful factory testing, pack all equipment in protective crates, and enclose in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture.

   2. Place dehumidifiers, when required, inside the polyethylene coverings.

   3. Skid-mount the equipment for final transport.

   4. Provide lifting rings for moving without removing protective covering.

   5. Display boxed weight on shipping tags together with instructions for unloading, transporting, storing, and handling at the job site.

B. Delivery And Inspection:

   1. Deliver products in undamaged condition, in manufacturer's original container or packaging with identifying labels intact and legible. Include date of manufacture on label.

C. Special Instructions:

1. Securely attach special instructions for proper field handling, storage, and installation to each piece of equipment before packaging and shipment.

1.09 PROJECT OR SITE CONDITIONS

A. Site Conditions:

1. Provide an electrical, instrumentation and control system, including all equipment, raceways, and any other components required for a complete installation that meets the environmental conditions for the Site as specified in the General Requirements and below.

2. Seismic load resistance: Meet CBC 2022

3. Provide electrical equipment with construction and anchorage to supporting structures.

4. Wind load resistance:

   a. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site wind loads in accordance with the 2022 California Building Code.

5. Altitude, temperature and humidity:

   a. Provide all electrical components and equipment fully rated for continuous operation at this altitude, with no additional derating factors applied.

   b. Provide additional temperature conditioning equipment to maintain all equipment in non-conditioned spaces subject to these ambient temperatures, with a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature, as determined by the equipment manufacturer's guidelines:

      i. Provide all power conduits wiring for these devices (e.g. heaters, fans, etc.) whether indicated on the Drawings or not.

6. Outdoor installations:

   a. Provide electrical, instrumentation and control equipment suitable for operation in ambient conditions where the equipment is located.

   b. Provide heating, cooling, and dehumidifying devices incorporated into and included with electrical equipment, instrumentation, and control panels to maintain the enclosures within the rated environmental operating ranges as specified in this Section for the equipment:

      i. Provide all wiring necessary to power these devices.

B. Provide Enclosures For Electrical, Instrumentation And Control Equipment, Regardless Of Supplier Or Subcontractor Furnishing The Equipment, That Meet The Requirements Outlined In NEMA Standard 250 For The Following Types Of Enclosures:

1. NEMA Type 1: Intended for indoor use, primarily to provide a degree of protection from accidental contact with energized parts or equipment.

2. NEMA Type 3R: Intended for either indoor or outdoor use, primarily to protect equipment against ingress of solid foreign objects (falling dirt); to provide a degree of protection with respect to harmful effects on the equipment due to ingress of water (rain, sleet, snow); and that will be undamaged by the external formation of ice on the enclosure.
3. NEMA Type 4: Intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation, and freezing.
4. NEMA Type 4X: Made from corrosion resistant materials (fiberglass reinforced plastic, 316 stainless steel or equal) and are intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing, and corrosion.
5. NEMA Type 7: Enclosures constructed for use in hazardous (classified) locations as defined per NFPA 70.
6. NEMA Type 12: Intended for indoor use, primarily to provide a degree of protection from dust, falling dirt and dripping non-corrosive liquids.

C. Plant Area Electrical Work Requirements:

1. Provide all Electrical Work in accordance with the following table, unless otherwise specifically indicated on the Drawings:

PLANT AREA	**NEMA ENCLOSURE TYPE**	**EXPOSED CONDUIT TYPE**	**ENVIRONMENT W = WET D = DAMP C = CLEAN/DRY X = CORROSIVE H = HAZARDOUS**	**SUPPORT MATERIALS**
All outdoor areas	4X SST	Aluminum for exposed areas. PVC conduit for all instrumentation circuits, VFD conduits below grade or exposed outdoors and below grade conduits and as noted in specification section 26 05 53	Wet/Damp	Stainless Steel

Existing/New Electrical Rooms	1, 12	Aluminum for exposed electrical and PVC conduit for all instrumentation circuits and below grade conduits and as noted in specification section 26 05 53	Clean/Dry	GALV STL
Hazardous Locations	7	Aluminum for exposed electrical and PVC conduit for all instrumentation circuits and below grade conduits and as noted in specification section 26 05 53	Wet/Damp	Stainless Steel

1.10 SCHEDULING

A. General:

1. As specified in Sections 26 08 00 & 40 90 00.
2. Testing requirements are specified in Section 40 90 00, 26 08 00 and other sections.
3. Commissioning and Process Start-up requirements as specified in Section 00 16 55.

B. Pre-Submittal Conference:

1. Before producing any submittals, schedule a pre-submittal conference for the purposes of reviewing the entire Project, equipment, control philosophy, schedules, and submittal requirements.
2. The Contractor, electrical subcontractor, all suppliers, and individual equipment manufacturers furnishing major pieces of equipment must attend.

C. Factory Acceptance Testing (FAT):

1. Where FAT is required for equipment covered by these Specifications, notify the Engineer in writing when the equipment is completed and ready for factory inspection and testing:
   a. Indicate the desired dates for inspection and testing.
   b. Schedule the FAT after approval of the FAT procedures submittal:
      i. Submit a copy of the test procedures including all forms at least 21 days before any scheduled test date.
      ii. Notify the Engineer of the scheduled tests a minimum of 15 days before the date of the test.

1.11 WARRANTY

1. Provide additional warranty as specified in the individual Electrical Specifications.

1.12 SYSTEM START-UP

A. Replace Or Modify Equipment, Software, And Materials That Do Not Achieve Design Requirements After Installation in Order to Attain Compliance with The Design Requirements:

   1. Following replacement or modification, retest the system and perform additional testing to place the complete system in satisfactory operation and obtain compliance acceptance from the Engineer.

1.13 MAINTENANCE

A. Before Substantial Completion, Perform All Maintenance Activities Required By Any Sections Of The Specifications Including Any Calibrations, Final Adjustments, Component Replacements Or Other Routine Service Required Before Placing Equipment Or Systems In Service.

B. Furnish All Spare Parts as Required By Other Sections Of The Specifications.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Provide Similar Items of Same Manufacturer Throughout the Electrical And Instrumentation Portion Of The Project.

B. Allowable Manufacturers Are Specified in Individual Electrical Specifications.

2.02 MATERIALS

A. Furnish All Materials Under This Contract That Are New, Free from Defects, And Standard Products Produced By Manufacturers Regularly Engaged In The Production Of These Products And That Bear All Approvals And Labels As Required By The Specifications.

B. Stainless Steel:

   1. Where stainless steel is indicated or used for any portion of the Electrical Work, provide a non-magnetic, corrosion-resistant alloy, ANSI Type 316, satin finish.
   2. Provide exposed screws of the same alloys.
   3. Provide finished material free of any burrs or sharp edges.
   4. Use only stainless-steel hardware, when chemically compatible, in all areas that are or could be in contact with corrosive chemicals.
   5. Use stainless steel hardware, when chemically compatible, in all chemical areas or areas requiring NEMA Type 4X construction.
   6. Do not use stainless steel in any area containing chlorine, gas or solution, chlorine products or ferric chloride.

2.03 SOURCE QUALITY CONTROL

A. Provide All Equipment That Is New, Free from Defects, And Standard Products Produced By Manufacturers Regularly Engaged In The Production Of These Products.

PART 3 EXECUTION

3.01 EXAMINATION

A. The Electrical Subcontractor Is Encouraged To Visit The Site To Examine The Premises Completely Before Bidding.

B. It Is The Electrical Subcontractor's Responsibility To Be Fully Familiar With The Existing Conditions And Local Requirements And Regulations.

C. Review The Site Conditions And Examine All Shop Drawings For The Various Items Of Equipment In Order To Determine Exact Routing And Final Terminations For All Wiring And Cables.

3.02 INSTALLATION

A. Equipment Locations Shown On Electrical Drawings May Change Due To Variations In Equipment Size Or Minor Changes Made By Others During Construction:

1. Verify all dimensions indicated on the Drawings:

    a. Actual field conditions govern all final installed locations, distances, and levels.

2. Review all Contract Documents and approved equipment shop drawings and coordinate Work as necessary to adjust to all conditions that arise due to such changes.

3. Make minor changes in location of equipment before rough in, as directed by the Owner's representative (Plant Superintendent) and/or Engineer.

4. Provide a complete electrical system:

B. Install all extra conduits, cables, and interfaces as may be necessary to provide a complete and operating electrical system.

C. Install The Equipment In Accordance With The Accepted Installation Instructions And Anchorage Details To Meet The Seismic And Wind Load Requirements At The Project Site.

D. Cutting And Patching:

1. Perform all cutting, patching, channeling, core drilling, and fitting required for the Electrical Work, except as otherwise directed:

    a. Secure the permission of the Engineer before performing any operation likely to affect the strength of a structural member such as drilling, cutting or piercing:

        i. Before cutting, channeling, or core drilling any surface, ensure that no penetration of any other systems will be made:

            I. Verify that the area is clear and free of conduits, cables, piping, ductwork, post-tensioning cables, etc.

    II. Use tone-locate system or X-ray to ensure that area is clear of obstructions.

  b. Review the complete Drawing set to ensure that there are no conflicts or coordination problems before cutting, channeling, or core drilling any surface.

2. Perform all patching to the same quality and appearance as the original work. Employ the proper tradesmen to secure the desired results. Seal around all conduits, wires, and cables penetrating walls, ceilings, and floors in all locations with a fire stop material, typically:

  a. 3M CP 25WB+Caulk.

  b. 3M Fire BarrierPutty.

3. Seal around conduit penetrations of below grade walls with a waterproof, non-shrink, non-metallic grout, unless otherwise indicated on the typical installation details:

  a. Use the installation details indicated on the Drawings as a guide for acceptable sealing methods.

E. Install All Conduits And Equipment In Such A Manner As To Avoid All Obstructions And To Preserve Headroom And Keep Openings And Passageways Clear:

1. Install all conduits and equipment in accordance with working space requirements in accordance with the NEC.

  a. This includes any panel, disconnect switch or other equipment that can be energized while open exposing live parts regardless of whether it is likely to require examination or has serviceable parts.

2. Where the Drawings do not show dimensions for locating equipment, install equipment in the approximate locations indicated on the Drawings.

  a. Adjust equipment locations as necessary to avoid any obstruction or interferences.

3. Where an obstruction interferes with equipment operation or safe access, relocate the equipment.

4. Where the Drawings do not indicate the exact mounting and/or supporting method to be used, use materials and methods similar to the mounting details indicated on the Drawings.

F. Earthwork And Concrete:

1. Install all trenching, shoring, concrete, backfilling, grading and resurfacing associated with the Electrical Work:

  a. Requirements as specified in the Contract Documents.

G. Roof Penetrations:

1. Seal conduit penetrations in accordance with roofing manufacturer’s instructions.

H. Terminations:

1. Provide and terminate all conductors required to interconnect power, controls, instruments, panels, and all other equipment.

I. Miscellaneous Installation Requirements:

1. In case of interference between electrical equipment indicated on the Drawings and the other equipment, notify the Engineer.
2. Location of manholes and pullboxes indicated on the Drawings are approximate. Coordinate exact location of manholes and pullboxes with Mechanical and Civil Work.
3. Provide additional manholes or pullboxes to those shown where they are required to make a workable installation.
4. Circuits of different service voltage:
   a. Voltage and service levels:
      i. Low voltage: 120 V to 480 V.
      ii. Instrumentation: Less than 50 VDC.
   b. Install different service voltage circuits in separate raceways, and junction boxes, manholes, hand holes, and pullboxes.
   c. In manholes, install all cables operating at less than 50 VDC in PVC coated flexible metallic conduit, with corrosion resistant fittings.

J. Labeling:

1. Provide all nameplates and labels as specified in Sections 26 05 53 and 26 05 73.

K. Equipment Tie-Downs:

1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing criteria, which apply to the Site.
2. All control panels must be permanently mounted and tied down to structures in accordance with the Project seismic criteria.

3.03 COMMISSIONING AND PROCESS START-UP

A. As Specified In Section 00 16 55 & 40 90 00.

B. For Owner And Engineer Witnessed ORT, FAT and SAT:

1. The Contractor is responsible for the Owner’s and Engineer’s costs associated with ORT, FAT and SAT as specified in Section 00 16 55 & 40 90 00.

C. Owner Training:

1. As specified in Section 00 16 55 & 40 90 00 and in this Section.

D. Source Testing (ORT, FAT and SAT):

1. Provide source testing and Owner training on electrical equipment as defined in the table below:

Table: Source Testing and Owner Training Requirements:

Section Number	Section Title	Source Testing	Owner Training Requirements	
		(Witnessed or Non-witnessed)	Maintenance (hrs per session)	Operation (hrs per session)
26 29 13	Motor Starters	Witnessed	8	8
26 05 73	Variable Frequency Drives	Witnessed	8	8
40 90 00	Low Voltage Motor Control Centers	Witnessed	8	8

3.04 FIELD QUALITY CONTROL

A. Inspection:

1. Allow for inspection of electrical system installation as specified in Section 26 08 00.
2. Provide any assistance necessary to support inspection activities.
3. Engineer inspections may include, but are not limited to, the following:
    a. Inspect equipment and materials for physical damage.
    b. Inspect installation for compliance with the Drawings and Specifications.
    c. Inspect installation for obstructions and adequate clearances around equipment.
    d. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
    e. Inspect equipment nameplate data to verify compliance with design requirements.
    f. Inspect raceway installation for quality workmanship and adequate support.
    g. Inspect cable terminations.
    h. Schedule structural engineer to inspect all mounting of electrical devices and all penetration and connections to structures.
4. Inspection activities conducted during construction do not satisfy inspection or testing requirements specified in Section 26 08 00.

B. Field Acceptance Testing (Functional Testing):

1. Notify the Engineer when the Electrical Work is ready for field acceptance testing.
2. Perform the field acceptance tests as specified in Section 26 08 00.
3. Record results of the required tests along with the date of test:
   a. Use conduit identification numbers to indicate the portion of circuit tested.

C. Workmanship:

1. Leave wiring in panels, manholes, boxes, and other locations neat, clean, and organized:
   a. Neatly coil and label spare wiring lengths.
   b. Shorten, re-terminate, and re-label excessively used as well as spare wire and cable lengths, as determined by the Engineer.

3.05 CLEANING

A. Remove All Foreign Material and Restore All Damaged Finishes To The Satisfaction Of The Engineer And Owner's Representative (Plant Superintendent).

B. Clean And Vacuum All Enclosures to Remove All Metal Filings, Surplus Insulation and Any Visible Dirt, Dust Or Other Matter Before Energization Of The Equipment Or System Start-Up:

1. Use of compressors or air blowers for cleaning is not acceptable.

C. Clean And Re-Lamp All New and Existing Luminaries That Were Used In The Areas Affected by The Construction And Return All Used Lamps To The Owner's Representative (Plant Superintendent).

D. As Specified in Other Sections of The Contract Documents.

3.06 PROTECTION

A. Protect All Work from Damage or Degradation Until Substantial Completion.

1. Maintain All Surfaces to Be Painted In A Clean And Smooth Condition.

END OF SECTION

SECTION 26 05 19

WIRES AND CABLES

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes:

1. 600-volt class or less wire and cable.

B. Related sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
    a. Section 01 33 00 - Submittals Procedures.
    b. Section 01 71 13 - Mobilization.
    c. Section 26 05 00 - Electrical – General Provisions.
    d. Section 26 05 26 - Grounding Systems.
    e. Section 26 05 53 - Identification for Electrical Systems.

1.02 REFERENCES

A. As specified in Section 26 05 00.

B. ASTM International (ASTM):

1. B 3 - Standard Specification for Soft or Annealed Copper Wire.
2. B 8 - Standard Specification for Concentric-Lay–Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

C. CSA International (CSA).

D. Insulated Cable Engineers Association (ICEA):

1. NEMA WC 70/ICEA S-95-658-1999 - Standard for Nonshielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
2. NEMA WC 57/ICEA S-73-532 - Standard for Control, Thermocouple Extension, and Instrumentation Cables.

E. National Fire Protection Association (NFPA):

1. 70 - National Electrical Code (NEC).

2. 72 - National Fire Alarm and Signaling Code.
3. 101 - Life Safety Code.

F. Telecommunications Industry Association/Electronics Industry Association (TIA/EIA):

1. 568-C.2 - Balanced Twisted-Pair Telecommunication Cabling and Components Standard.

G. Underwriter's Laboratories Inc., (UL):

1. 44 - Thermoset-Insulated Wires and Cables.
2. 1424 - Standard for Cables for Power-Limited Fire-Alarm Circuits.
3. 1569 - Standard for Metal-Clad Cables.
4. 2196 - Standard for Tests for Fire Resistive Cables.
5. 2225 - Standard for Cables and Cable-Fittings For Use in Hazardous (Classified) Locations.

1.03 DEFINITIONS

A. As specified in Section 26 05 00.

B. Definitions of terms and other electrical considerations as set forth in the:

1. ASTM.
2. ICEA.

1.04 SYSTEM DESCRIPTION

A. Furnish and install the complete wire and cable system.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01 33 00 and 26 05 00.

B. Product data:

1. Manufacturer of wire and cable.
2. Insulation:
   a. Type.
   b. Voltage class.
3. American wire gauge (AWG) size.
4. Conductor material.
5. Pulling compounds.

C. Shop drawings:

1. Show splice locations.
   a. For each proposed splice location provide written justification describing why the splice is necessary.01 2

D. Test reports:

1. Submit test reports for meg-ohm tests.

E. Calculations:

1. Submit cable pulling calculations to the Engineer for review and comment for all cables that will be installed using mechanical pulling equipment. Show that the maximum cable tension and sidewall pressure will not exceed manufacturer recommended values:

a. Provide a table showing the manufacturer's recommended maximum cable tension and sidewall pressure for each cable type and size included in the calculations.

b. Submit the calculations to the Engineer a minimum of 2 weeks before conduit installation.

1.06 QUALITY ASSURANCE

A. As specified in Section 26 05 00.

B. All wires and cables shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 26 05 00.

1.08 WARRANTY

A. As specified in Section 26 05 00.

1.09 SYSTEM START-UP

A. As specified in Section 26 05 00.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:

1. 600-volt class wire and cable:

a. General Cable.

b. Allied Wire and Cable.

c. Southwire Company.

2. Instrumentation class wire and cable:

a. Alpha Wire Company.

b. Belden CDT.

c. General Cable BICC Brand.

d. Okonite Company.

e. Rockbestos Surprenant Cable Corporation.

3. Network cables:

    a. Belden CDT.

    b. General Cable.

    c. CommScope.

B. Each ground conductor size (circular mil area) shall be one-third (1/3) of the NEC required size (circular mil area) for a single ground conductor. If one third of the required circular mil area does not correspond to a standard size (circular mil area) of construction, the next largest size of standard construction shall be used. All conductors shall be megger tested after installation and insulation must be in compliance with the Insulated Power Cable Engineers Association Minimum Values of Insulation Resistance.

C. Manufacturers:

1. General Cable .

2. Southwire.

3. Allied Wire and Cable.

2.02 MATERIALS

A. Conductors:

1. Copper in accordance with ASTM B 3.

2.03 MANUFACTURED UNITS

A. General:

1. Provide new wires and cables manufactured within 1 year of the date of delivery to the Site.

2. Permanently mark each wire and cable with the following at 24-inch intervals:

    a. AWG size.

    b. Voltage rating.

    c. Insulation type.

    d. UL symbol.

    e. Month and year of manufacture.

    f. Manufacturer's name.

3. Identify and mark wire and cable as specified in Section 26 05 53:

    a. Use integral color insulation for Number 2 AWG and smaller wire.

    b. Wrap colored tape around cable larger than Number 2 AWG.

B. 600-volt class wire and cable:

1. Provide AWG or kcmil sizes as indicated on the Drawings:

    a. When not indicated on the Drawings, size wire as follows:

i. In accordance with the NEC:

I. Use 75-degree Celsius ampacity ratings.

II. Ampacity rating after all derating factors, equal to or greater than rating of the overcurrent device.

ii. Provide Number 12 AWG minimum for power conductors.

iii. Provide Number 14 AWG minimum for control conductors.

2. Provide Class B stranding in accordance with ASTM B 8:

a. Provide Class C stranding where extra flexibility is required.

3. Insulation:

a. XHHW-2.

b. 90 degrees Celsius rating.

4. Multiconductor cables:

a. Number and size of conductors as indicated on the Drawings.

b. Individual conductors with XHHW-2 insulation.

c. Overall PVC jacket.

d. Tray cable rated.

e. Color-coding for control wire in accordance with ICEA Method 1, E-2 in accordance with NEMA WC 57/ICEA S-73-532.

f. Ground conductor: Insulated green:

i. Sized in accordance with NEC, unless otherwise noted on the electrical drawings.

C. Instrumentation class cable:

1. Type TC.

2. Suitable for use in wet locations.

3. Voltage rating: 600 volts.

4. Temperature rating:

a. 90 degrees Celsius rating in dry locations.

b. 75 degrees Celsius rating in wet locations.

5. Conductors:

a. Insulation:

i. Flame-retardant PVC, 15 mils nominal thickness, with nylon jacket 4 mils nominal thickness.

b. Number 16 AWG stranded and tinned.

c. Color code:

i. Pair: Black and white.

ii. Triad: Black, white and red.

iii. Multiple pairs or triads:

I. Color-coded and numbered.

6. Drain wire:
   a. 18 AWG.
   b. Stranded, tinned.
7. Jacket:
   a. Flame retardant, moisture, and sunlight resistant PVC.
   b. Ripcord laid longitudinally under jacket to facilitate removal.
8. Shielding:
   a. Individual pair/triad:
      i. Minimum 1.35-mil double-faced aluminum foil/polyester tape overlapped to provide 100 percent coverage.
   b. Multiple pair or triad shielding:
      i. Group shield: Minimum 1.35-mil double-faced aluminum foil/polyester tape overlapped to provide 100 percent coverage.
      ii. Completely isolate group shields from each other.
      iii. Cable shield: 2.35 mils double-faced aluminum and synthetic polymer backed tape overlapped to provide 100 percent coverage.
   c. All shielding to be in contact with the drain wire.

D. Network cables:

E. Instrumentation, Type B-No. 16 AWG, Twisted, Shielded Pair Cable:

1. Use this instrumentation cable, where shown on drawings.
   a. Outer Jacket: 45-mil nominal thickness.
2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
3. Dimension: 0.31-inch nominal OD.
4. Conductors:
   a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8
   b. 20 AWG, seven-strand tinned copper drain wire.
   c. Insulation: 15-mil nominal PVC.
   d. Jacket: 4-mil nominal nylon.

e. Color Code: Pair conductors black and red.

5. Manufacturers:

   a. Okonite Co.

   b. Alpha Wire Corp.

6. The following test shall be performed on instrumentation and control system cables. All tests shall be end-to-end test of installed cables with the ends supported in free air, not adjacent to any ground object. All test data shall be recorded on forms acceptable to the Engineer. Complete records of all tests shall be made and delivered to the Engineer.

   a. Continuity tests shall be performed by measuring wire/shield loop resistances of signal cable as the wires, taken one at a time, are shorted to the channel shield. No loop resistance measurement shall carry by more than ± 2 ohms from the calculated average loop resistance valve.

   b. Insulation resistance tests shall be performed by using a 500 volt megohmeter to measure the insulation resistance between each channel wire and channel shield, between individual channel shields in a multi-channel cable, between each individual channel and the overall cable shield in multi-channel cable, between each wire and ground, and between each shield and ground. Values of resistance less than 10 megohms shall be unacceptable.

2.04 ACCESSORIES

A. Wire ties:

   1. One of the following or equal:

      a. T&B "Ty-Rap" cable ties.

      b. Panduit cable ties.

B. Wire markers:

   1. As specified in Section 26 05 53.

2.05 GROUNDING CONDUCTORS

A. Equipment: Stranded copper with green, Type USE/RHH/RHW-XLPE for No.6 and larger, other use THHN/THWN, insulation.

B. Direct Buried: 4/0 Bare tinned stranded copper, unless otherwise noted on drawings

2.06 SOURCE QUALITY CONTROL

A. Assembly and testing of cable shall comply with the applicable requirements of ICEA S-95-658-1999.

B. Test Type XHHW-2 in accordance with the requirements of UL 44.

PART 3 - EXECUTION

3.01 INSTALLATION

A. As specified in Section 26 05 00.

B. Color-coding:

1. Color-coding shall be consistent throughout the facility.
2. The following color code shall be followed for all 240/120 volt and 208/120 volt systems:
   a. Phase A - Black.
   b. Phase B - Red.
   c. Phase C - Blue.
   d. Single phase system - Black for one hot leg, red for the other.
   e. Neutral - White.
   f. High phase or wild leg - Orange.
   g. Equipment ground - Green.
3. The following color code shall be followed for all 480/277 volt systems:
   a. Phase A - Brown.
   b. Phase B - Orange.
   c. Phase C - Yellow.
   d. Neutral - Gray.
   e. Equipment ground - Green.
4. The following color code shall be followed for all 120 VAC control wiring:
   a. Power - Red.
   b. Neutral - White.
5. The following color code shall be followed for all general purpose DC control circuits:
   a. Grounded conductors - White with blue stripe.
   b. Ungrounded conductors - Blue.
6. Switch legs shall be violet. Three-way switch runners shall be pink.
7. Wires in intrinsically safe circuits shall be light blue.
8. Wire colors shall be implemented in the following methods:
   a. Wires manufactured of the desired color.
   b. Continuously spiral wrap the first 6 inches of the wire from the termination point with colored tape:
      i. Colored tape shall be wrapped to overlap 1/2 of the width of the tape.

C. Install conductors only after the conduit installation is complete, and all enclosures have been vacuumed clean, and the affected conduits have been swabbed clean and dry:

1. Install wires only in approved raceways.
2. Do not install wire:
    a. In incomplete conduit runs.
    b. Until after the concrete work and plastering is completed.

D. Properly coat wires and cables with pulling compound before pulling into conduits:
1. For all Number 4 AWG and larger, use an approved wire-pulling lubricant while cable is being installed in conduit:
    a. Ideal Products.
    b. Polywater Products.
    c. 3M Products.
    d. Greenlee Products.
    e. Or equal as recommended by cable manufacturer.
    f. Do not use oil, grease, or similar substances.

E. Cable pulling:
1. Prevent mechanical damage to conductors during installation.
2. For cables Number 1 AWG and smaller, install cables by hand.
3. For cables larger than Number 1 AWG, power pulling winches may be used if they have cable tension monitoring equipment.
4. Provide documentation that maximum cable pulling tension was no more than 75 percent of the maximum recommended level as published by the cable manufacturer. If exceeded, the Engineer may, at his discretion, require replacement of the cable.
5. Ensure cable pulling crews have all calculations and cable pulling limitations while pulling cable.
6. Make splices or add a junction box or pullbox where required to prevent cable pulling tension or sidewall pressure from exceeding 75 percent of manufacturer’s recommendation for the specified cable size:
    a. Make splices in manholes or pull boxes only.
    b. Leave sufficient slack to make proper connections.

F. Use smooth-rolling sheaves and rollers when pulling cable into cable tray to keep pulling tension and bending radius within manufacturer’s recommendations.

G. Install and terminate all wire in accordance with manufacturer's recommendations.

H. Neatly arrange and lace conductors in all switchgear, panelboards, pull boxes, and terminal cabinets by means of wire ties:
1. Do not lace wires in gutter or panel channel.
2. Install all wire ties with a flush cutting wire tie installation tool:

a. Use a tool with an adjustable tension setting.

3. Do not leave sharp edges on wire ties.

I. Terminate stranded conductors on equipment box lugs such that all conductor strands are confined within the lug:

1. Use ring type lugs if box lugs are not available on the equipment.

J. Splices:

1. Provide continuous circuits from origin to termination.

2. If approved by the Engineer, splices shall be allowed for long wire or cable lengths that exceed standard manufactured lengths:

a. Splice box NEMA rating requirements as specified in Section 26 05 00.

b. Make splices in labeled junction boxes for power conductors.

c. Make splices for control and instrument conductors in terminal boxes:

i. Provide terminal boards with setscrew pressure connectors, with spade or ring lug connectors.

3. Clearly label junction and terminal boxes containing splices with the word "SPLICE LOCATED WITHIN".

4. Leave sufficient slack at junction boxes and termination boxes to make proper splices and connections. Do not pull splices into conduits.

5. Install splices with compression type butt splices and insulate using a heat-shrink sleeve:

a. In NEMA Type 4 or NEMA Type 4X areas, provide heat-shrink sleeves that are listed for submersible applications.

6. Splices in below grade pull boxes, in any box subject to flooding, and in wet areas shall be made waterproof using:

a. A heat shrink insulating system listed for submersible applications.

b. Or an epoxy resin splicing kit.

K. Apply wire markers to all wires at each end after being installed in the conduit and before meg-ohm testing and termination.

L. Instrumentation class cable:

1. Install instrumentation class cables in separate raceway systems from power cables:

a. Install instrument cable in PVC conduit within non-dedicated manholes or pull boxes.

b. Install cable without splices between instruments or between field devices and instrument enclosures or panels.

2. Do not make intermediate terminations, except in designated terminal boxes as indicated on the Drawings.

3. Shield grounding requirements as specified in Section 26 05 26.

M. Multi-conductor cable:

1. Where cable is not routed in conduit with a separate ground conductor, use one conductor in the cable as a ground conductor:

a. Use an internal ground conductor, if it is no smaller than as indicated on the Drawings and in accordance with NEC requirements for equipment ground conductor size.

b. Where 2 parallel cables are used, and the internal ground conductor in each cable does not meet NEC requirements for the combined circuit, use 4-conductor cable, with one of the full-sized conductors serving as ground.

N. VFD cable:

1. Install cables in raceway.

2. Install cables as per manufacturer's recommendation. Provide all necessary connectors as recommended by the VFD cable manufacturer and install accordingly.

3.02 COMMISSIONING AND PROCESS START-UP

A. As specified in Section 00 16 55.

3.03 FIELD QUALITY CONTROL

A. As specified in Section 26 05 00.

B. Grounding:

1. As specified in Section 26 05 00.

3.04 PROTECTION

A. As specified in Section 26 05 00.

END OF SECTION

SECTION 26 05 26

GROUNDING SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes:

1. Grounding materials and requirements.

B. Related sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01 33 00 – Submittals Procedures.
   b. Section 01 71 13 – Mobilization.
   c. Section 26 05 00 – Electrical – General Provisions.
   d. Section 26 08 00 - Field Electrical Acceptance Tests.

1.02 REFERENCES

A. As specified in Section 26 05 00.

B. ASTM International (ASTM):

1. B 3 - Standard Specification for Soft or Annealed Copper Wire.
2. B 8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

C. Institute of Electrical and Electronics Engineers (IEEE):

1. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.

D. Underwriters Laboratories, Inc. (UL):

1. 467 - Ground and Bonding Equipment.

1.03 DEFINITIONS

A. As specified in Section 26 05 00.

1.04 SYSTEM DESCRIPTION

A. Ground equipment and raceway systems so that the completed installation conforms to all applicable code requirements.

B. Provide a complete electrical grounding system as indicated on the Drawings and as specified including but not limited to:

1. Grounding electrodes.
2. Bonding jumpers.
3. Ground connections.

C. Provide bonding jumpers and wire, grounding bushings, clamps and appurtenances required for complete grounding system to bond equipment and raceways to equipment grounding conductors.

D. The ground system resistance (electrode to ground) of the completed installation, as determined by tests specified in Section 26 05 26, shall be:

1. 5 ohms or less for industrial systems.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01 33 00 and 26 05 00.

B. Product data and Catalog cut sheets:

1. Exothermic weld connectors.
2. Mechanical connectors.
3. Compression connectors.
4. Ground rods.
5. Ground conductors (if not submitted with 26 05 19).
6. Grounding wells, etc. as needed for grounding system.

1.06 QUALITY ASSURANCE

A. As specified in Section 26 05 00.

B. All grounding components and materials shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 26 05 00.

1.08 WARRANTY

A. As specified in Section 26 05 00.

1.09 SYSTEM START-UP

A. As specified in Section 26 05 00.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Compression connectors: One of the following or equal:

1. FCI Burndy.
2. Thomas & Betts.
3. Approved Equal.

B. Exothermic connectors: One of the following or equal:

1. Erico.
2. Harger.
3. Burndy Weld.
4. Approved Equal.

C. Ground rods: One of the following or equal:

1. Erico.
2. Harger.
3. Conex.
4. Approved Equal.

D. Ground cable: One of the following or equal:

1. Nehring.
2. Harger.
3. Southwire.
4. Approved Equal.

E. Precast ground well boxes: One of the following or equal:

1. Brooks Products, 3-RT Valve Box.
2. Christy Concrete Products, G12 Valve Box.
3. Approved Equal.

2.02 MATERIALS

A. Ground rod:

1. Minimum: 5/8-inch diameter, as shown on drawing, 20 feet long.
2. Uniform 10 mil covering of electrolytic copper metallically bonded to a rigid steel core:
   a. The copper-to-steel bond shall be corrosion resistant.
3. In accordance with UL 467.
4. Sectional type joined by threaded copper alloy couplings.

5. Fit the top of the rod with a threaded coupling and steel-driving stud.

B. Ground cable:

1. Requirements:

a. Soft drawn (annealed).

b. Concentric lay, coarse stranded in accordance with ASTM B 8.

c. Bare tinned copper in accordance with ASTM B 3.

2. Size is as indicated on the Drawings, but not less than required by the NEC.

C. Compression connectors:

1. Manufactured of high copper alloy specifically for the particular grounding application.

2. Suitable for direct burial in earth and concrete.

3. Identifying compression die number inscription to be impressed on compression fitting.

D. Exothermic welds:

1. Current carrying capacity equal to that of the conductor.

2. Permanent molecular bond that cannot loosen or corrode over time.

3. Will not deteriorate with age.

E. Equipment grounding conductors:

1. Conductors shall be the same type and insulation as the load circuit conductors:

a. Use 600-volt insulation for the equipment grounding conductors for medium voltage systems.

2. Minimum size in accordance with the NEC.

F. Grounding electrode conductors:

1. Minimum size in accordance with the NEC.

G. Main bonding jumpers and bonding jumpers:

1. Minimum size in accordance with the NEC.

2.03 ACCESSORIES

A. Precast ground well boxes:

1. Minimum 10 inch interior diameter.

2. Traffic-rated cast iron cover.

3. Permanent “GROUND” marking on cover.

PART 3 - EXECUTION

3.01 INSTALLATION

A. As specified in Section 26 05 00.

B. Provide a separate, green insulated, grounding conductor in each raceway independent of raceway material:

1. Multi-conductor power and control cables shall include an integral green insulated grounding conductor.
2. Provide a separate grounding conductor in each individual raceway for parallel feeders.

C. Provide a separate grounding conductor for each motor and connect at motor terminal box. Do not use bolts securing motor box to frame or cover for grounding connectors:

1. When grounding motors driven by variable frequency drives (VFD) comply with the requirements of the VFD manufacturer.

D. Provide a grounding type bushing with lug for connection of grounding conductor for conduits that originate from each motor control center section, switchboard, or panelboard:

1. Individually bond these raceways to the ground bus in the equipment.

E. Provide grounding type bushings with lugs for connection of grounding conductor at both ends of metallic conduit runs. Bond ground bushings to the grounding system.

F. Provide a green insulated wire-grounding jumper from the ground screw to a box grounding screw and, for grounding type devices, to equipment grounding conductor.

G. Interconnect the secondary switchgear, motor control center, or panelboard neutral bus to the ground bus in the secondary switchgear, motor control center, or panelboard compartment, only at service entrance point or after a transformer.

H. Duct bank ground system:

1. Provide a bare copper grounding conductor the entire length of each duct bank, embedded in the concrete of the duct bank as indicated on the Drawings and specified in the Specifications.
2. Bond duct bank ground conductors together where duct banks join, merge, intersect, or split.

I. Grounding at service (600 V or Less):

1. Connect the neutral to ground only at one point within the enclosure of the first disconnecting means on the load side of the service transformer.

J. Ground connections:

1. All connections to the ground grid system, the duct bank grounding system, equipment, ground rods, etc., shall be made using exothermic welds as indicated on the Drawings, UL listed, and labeled for the application.
2. Make ground connections in accordance with the manufacturer's instructions.

3. Do not conceal or cover any ground connections until the Engineer or authorized representative has established and provided written confirmation that every grounding connection is as indicated on the Drawings and specified in the Specifications.

K. Grounding electrode system:

1. Ground ring:
   a. Provide all trenching and materials necessary to install the ground ring as indicated on the Drawings.
   b. Ground ring conductor shall be in direct contact with the earth, or where embedded, concrete, of the size as indicated on the Drawings.
   c. Minimum burial depth 36 inches or as indicated on the Drawings.
   d. Re-compact disturbed soils to original density in 6-inch lifts.
2. Ground rods:
   a. Locations as indicated on the Drawings.
   b. Length of rods forming an individual ground array shall be equal in length.
   c. Drive ground rods and install grounding conductors before construction of concrete slabs and duct banks.
   d. Pre-crimp all ground rods, as recommended by the manufacturer, before crimping connector to ground rod.
3. Metal underground water pipe:
   a. Bond metal underground domestic water pipe to grounding electrode system.
4. Metal frame of building or structure:
   a. Bond metal frame of building or structure to grounding electrode system.
5. Extend grounding conductors through concrete to accessible points for grounding equipment and electrical enclosures.
6. Install grounding system at each structure where switchgear, motor control centers, switchboards, panelboards, panels, or other electrical equipment are installed.

L. Shield grounding:

1. Shielded instrumentation cable shall have its shield grounded at one end only unless shop drawings indicate otherwise:
   a. The grounding point shall be at the control panel or at the power source end of the signal carried by the cable.
2. Terminate the shield drain wire on a dedicated terminal block.
3. Use manufacturer’s terminal block jumpers to interconnect ground terminals.
4. Connection to the panel main ground bus shall be via a green No. 12 conductor to the main ground bus for the panel.

M. Where indicated on the Drawings, install ground rods in precast ground test wells.

3.02 COMMISSIONING AND PROCESS START-UP

A. As specified in Section 00 16 55.

3.03 FIELD QUALITY CONTROL

A. As specified in Section 26 05 00.

B. Measure grounding electrode system resistance to ground in accordance with IEEE 81.

C. Grounding system shall be tested using 3-point method fall of potential. Dry weather grounding resistance shall measure less than 5 ohms to be considered approved.

3.04 ADJUSTING

A. Under the direction of the Engineer, add additional parallel connected ground rods and/or deeper driven rods until the ground resistance measurement meets the specified resistance requirements:

1. Use of salts, water, or compounds to attain the specified ground resistance is not acceptable.

3.05 PROTECTION

A. As specified in Section 26 05 00.

END OF SECTION

WSECTION 26 05 33

RACEWAYS AND FITTINGS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Metallic conduits.
2. Nonmetallic conduits.
3. Conduit bodies.
4. Conduit fittings and accessories.
5. Conduit installation.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01 33 00 - Submittal Procedures.
   b. Section 01 71 13 - Mobilization.
   c. Section 26 05 00 - Electrical – General Provisions.
   d. Section 26 05 33 - Identification for Electrical Systems.
   e. Section 26 05 43 - Underground Electrical Ducts.

1.02 REFERENCES

A. As Specified In Section 26 05 00.

B. American National Standards Institute (ANSI):

1. C80.1 - Electrical Rigid Steel Conduit.
2. C80.3 - Steel Electrical Metallic Tubing.
3. C80.5 - Electrical Rigid Aluminum Conduit.
4. C80.6 - Electrical Intermediate Metal Conduit.

C. National Electrical Manufacturer's Association (NEMA):

1. RN-1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Steel Conduit.

2. TC2 - Electrical Polyvinyl Chloride (PVC) Conduit.
3. TC3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
4. TC7 - Smooth-Wall Coilable Electrical Polyethylene Conduit.
5. TC13 - Electrical Nonmetallic Tubing.
6. TC14 - Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

D. Underwriters Laboratories (UL):
1. 1 - Standard for Flexible Metal Conduit.
2. 6 - Standard for Electrical Rigid Metal Conduit - Steel.
3. 6A - Standard for Electrical Rigid Metal Conduit - Aluminum, Red Brass, and Stainless Steel.
4. 360 - Standard for Liquid-Tight Flexible Steel Conduit.
5. 651 - Standard for Schedule 40 and 80 Rigid PVC Conduit and Fittings.
6. 651B - Standard for Continuous Length HDPE Conduit.
7. 797 - Standard for Electrical Metallic Tubing - Steel.
8. 1242 - Standard for Electrical Intermediate Metal Conduit - Steel.
9. 1653 - Standard for Electrical Nonmetallic Tubing.
10. 1660 - Standard for Liquid-Tight Flexible Nonmetallic Conduit.
11. 1684 - Standard for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

1.03 DEFINITIONS

A. As Specified In Section 26 05 00.

B. Specific Definitions and Abbreviations:
1. Conduit bodies: A separate portion of a conduit system that provides access through a removable cover to the interior of the system at a junction of 2 or more conduit sections. Includes, but not limited to: shapes C, E, LB, T, X, etc.
2. Conduit fitting: An accessory that serves primarily a mechanical purpose. Includes, but not limited to: bushings, locknuts, hubs, couplings, reducers, etc.
3. GRC: Galvanized rigid steel conduit.
4. PCS: PVC coated rigid steel conduit.
5. PCA: PVC coated rigid aluminum conduit.
6. IMC: Intermediate metallic conduit.
7. EMT: Electrical metallic tubing.
8. PVC: Polyvinyl chloride rigid nonmetallic conduit.
9. HDPE: High density polyethylene conduit.

10. SLT: Sealtight – liquid-tight flexible conduit.
11. EFLX: Explosionproof flexible conduit.
12. FLX: Flexible metallic conduit.
13. NFC: Nonmetallic flexible conduit.
14. ENT: Electrical nonmetallic tubing.
15. RAC: Rigid aluminum conduit.
16. FRD: Fiberglass reinforced duct.
17. NPT: National pipe thread.

1.04 SYSTEM DESCRIPTION

A. Provide Conduits, Conduit Bodies, Fittings, Junction Boxes And All Necessary Components, Whether Or Not Indicated On The Drawings, As Required, To Install A Complete Electrical Raceway System.

1.05 SUBMITTALS

A. Furnish Submittals As Specified In Sections 01 33 00 And 26 05 00.

B. Product Data:

1. Furnish complete manufacturer's catalog sheets for every type and size of conduit, fitting, conduit body, and accessories to be used on the Project.
2. Furnish complete manufacturer's recommended special tools to be used for installation if required.
3. Certified test results for PVC-coated metallic conduit showing the adhesive bond is stronger than the tensile strength of the PVC.

C. Certifications:

1. Furnish PVC-coated conduit manufacturer's certification for each installer.

D. Record Documents:

1. Incorporate all changes in conduit routing on electrical plan drawings.
2. Dimension underground and concealed conduits from building lines.
3. Furnish hard copy drawings and electronic files in 22 inch by 34-inch AutoCAD format Version: 2015 and PDF format.

E. Installation Drawings: Installation Drawings, Including Individual Conduit Numbers, Routing, Sizes, Cable Sizes, And Circuit Numbers For Each Conduit.

1.06 QUALITY ASSURANCE

A. As Specified In Section 26 05 00.

B. All Conduits, Conduit Bodies, And Fittings Shall Be UL Listed And Labeled.

C. Every Installer Of PCA Or PCS Conduits Shall Be Certified By The Manufacturer For Installation Of The Conduit.

1.07 DELIVERY, STORAGE, and HANDLING

A. As Specified In Section 26 05 00.

B. Do Not Expose Type PVC, FRD, NFC And ENT To Direct Sunlight.

C. Do Not Store Conduit In Direct Contact With The Ground.

D. Do Not Store Aluminum Conduit In Contact With Concrete.

1.08 PROJECT or SITE CONDITIONS

A. As Specified In Section 26 05 00.

1.09 SEQUENCING

A. Before Installing Any Conduit Or Locating Any Device Box:

1. Examine the complete set of Drawings and Specifications, and all applicable shop drawings.

2. Verify all dimensions and space requirements and make any minor adjustments to the conduit system as required to avoid conflicts with the building structure, other equipment, or the work of other trades.

1.10 WARRANTY

A. As Specified In Section 26 05 00.

1.11 SYSTEM START-UP

A. As Specified In Section 26 05 00.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Galvanized Rigid Steel Conduit:

1. One of the following or equal:

a. Western Tube and Conduit.

b. Allied Tube and Conduit.

c. Wheatland Tube Co.

B. Polyvinyl Chloride Coated Rigid Steel Conduit:

1. One of the following or equal:

a. Robroy Industries.

b. Ocal, Inc.

c. Calbond.

C. Intermediate Metallic Conduit:

1. One of the following or equal:

a. Allied Tube and Conduit.

b. Western Tube and Conduit.

D. Electrical Metallic Tubing:

1. One of the following or equal:

a. Allied Tube and Conduit.

b. Western Tube and Conduit.

E. Rigid Aluminum Conduit:

1. One of the following or equal:

a. Allied Tube and Conduit.

b. Patriot Aluminium Products.

c. Republic Conduit.

d. Wheatland Tube Co.

F. Polyvinyl Chloride Coated Aluminum Conduit:

1. One of the following or equal:

a. Robroy Industries.

b. Ocal, Inc.

c. Calbond.

G. Flexible Metallic Conduit:

1. One of the following or equal:

a. AFC Cable Systems.

b. Southwire.

c. Electri-flex Company.

H. Flexible Nonmetallic Conduit:

1. One of the following or equal:

a. Electriflex.

b. Carlon.

c. Anaconda.

d. Liquatite.

I. Sealtight Liquid-Tight Flexible Conduit:

1. One of the following or equal:

a. Southwire.

b. AFC Cable Systems.

c. Electriflex.

d. Anaconda.

J. Explosionproof Flexible Conduit:
   1. One of the following or equal:
      a. Appleton.
      b. Crouse Hinds.
      c. Hubbell Killark.
K. Rigid Nonmetallic Polyvinyl Chloride Conduit:
   1. One of the following or equal:
      a. Carlon.
      b. Cantex.
      c. Triangle Conduit and Cable.
L. Electrical Nonmetallic Tubing:
   1. One of the following or equal:
      a. Carlon Flex-Plus Blue.
      b. Specified Technologies, Inc.
M. High Density Polyethylene Conduit:
   1. One of the following or equal:
      a. Carlon.
      b. Endot Industries.
      c. Blue Diamond Industries.
N. Inner Duct:
   1. One of the following or equal:
      a. Carlon.
      b. Endot Industries.
      c. MaxCell.
O. Fiberglass Reinforced Duct:
   1. One of the following or equal:
      a. Champion Fiberglass.
      b. Smith Fiberglass.
      c. FRE Composites.
P. Conduit Bodies:
   1. One of the following or equal:
      a. Crouse-Hinds.
      b. Appleton.

c. O-Z / Gedney.

d. Ocal.

e. Robroy.

f. Calbond.

g. Carlon.

Q. Joint Compound:

1. Thomas and Betts.

2. Or Equal.

R. Galvanized Rigid Steel Conduit Expansion Fittings:

1. One of the following or equal:

a. Crouse-Hinds.

b. Appleton.

c. O-Z / Gedney.

S. Conduit Sleeve:

1. One of the following or equal:

a. Crouse-Hinds.

b. Appleton.

c. O-Z / Gedney.

T. Conduit Seals:

1. One of the following or equal:

a. Appleton.

b. Crouse-Hinds.

c. O-Z / Gedney.

U. Conduit Through Wall And Floor Seals:

1. The following or equal:

a. O-Z/Gedney:

i. Type "WSK".

ii. Type “CSM”.

2.02 COMPONENTS

A. GRC:

1. All threads: NPT standard conduit threads with a 3/4-inch taper per foot:

a. Running conduit threads are not acceptable.

2. Hot-dip galvanized inside and out:

a. Ensures complete coverage and heats the zinc and steel to a temperature that ensures the zinc alloys with the steel over the entire surface.

b. Electro-galvanizing is not acceptable.

3. Manufactured in accordance with:

a. UL-6.

b. ANSI C80.1.

B. PCS:

1. The steel conduit, before PVC coating, shall be new, unused, hot-dip galvanized material, conforming to the requirements for type GRC.

2. Coated conduit NEMA Standard RN-1:

a. The galvanized coating may not be disturbed or reduced in thickness during the cleaning and preparatory process.

3. Factory bonded PVC jacket:

a. The exterior galvanized surfaces shall be coated with primer before PVC coating to ensure a bond between the zinc substrate and the PVC coating.

b. Nominal thickness of the exterior PVC coating shall be 0.040 inch except where part configuration or application of the piece dictate otherwise.

c. PVC coating on conduit and associated fittings shall have no sags, blisters, lumps, or other surface defects and free of holes and holidays.

d. The PVC adhesive bond on conduit and fittings shall be greater than the tensile strength of the PVC plastic coating:

i. Confirm bond with certified test results.

4. A urethane coating shall be uniformly and consistently applied to the interior of all conduit and fittings:

a. Nominal thickness of 0.002 inch.

b. Conduit having areas with thin or no coating are not acceptable.

c. All threads shall be coated with urethane.

5. The PVC exterior and urethane interior coatings applied to the conduit shall afford sufficient flexibility to permit field bending without cracking or flaking at temperature above 30 degrees Fahrenheit (-1 degree Celsius).

6. PCS conduit bodies and fittings:

a. Malleable iron.

b. The conduit body, before PVC coating, shall be new, unused material and shall conform to appropriate UL standards.

        c. The PVC coating on the outside of conduit bodies shall be 0.040 inch thick and have a series of longitudinal ribs to protect the coating from tool damage during installation.
        d. 0.002-inch interior urethane coating.
        e. Utilize the PVC coating as an integral part of the gasket design.
        f. Stainless steel cover screws heads shall be encapsulated with plastic to assure corrosion protection.
        g. A PVC sleeve extending 1 conduit diameter or 2 inches, whichever is less, shall be formed at each female conduit opening.
            i. The inside diameter of the sleeve shall be the same as the outside diameter of the conduit to be used.
            ii. The sleeve shall provide a vapor and moisture tight seal at every connection.

C. IMC:
    1. Hot-dip galvanized and chromated, including threads.
    2. Conduit interior coated with a silicone epoxy-ester lubricant.
    3. NPT standard conduit threads with a 3/4-inch taper per foot.
        a. Running conduit threads are not acceptable.
        b. Hot galvanized after cutting.

D. EMT:
    1. Hot-dip galvanized inside and out and finally exterior chromated and lacquered:
        a. Electro-galvanizing is not acceptable.
    2. Organic corrosion resistant I.D. coating.

E. RAC:
    1. Material:
        a. Extruded from 6063 alloy in temper designation T-1.
        b. Maximum 1/10 percent copper content.
        c. Containing lubricating inside liners.
    2. NPT standard threads with a 3/4-inch taper per foot:
        a. Running conduit threads are not acceptable.
    3. Provide aluminum fittings and conduit bodies.

F. PCA:
    1. The aluminum conduit, before PVC coating, shall be new, unused, aluminum conduit and shall conform to the requirements for Type RAC.

2. Factory bonded PVC jacket:

   a. Nominal thickness of the exterior PVC coating shall be 0.040 inch except where part configuration or application of the piece dictate otherwise.

   b. PVC coating on conduit and associated fittings shall have no sags, blisters, lumps, or other surface defects and free of holes and holidays.

3. The PVC adhesive bond on conduit and fittings shall be greater than the tensile strength of the PVC plastic coating:

   a. Confirm bond with certified test results.

4. A urethane coating shall be uniformly and consistently applied to the interior of all conduit and fittings:

   a. Nominal thickness of 0.002 inch.

   b. Conduit having areas with thin or no coating are not acceptable.

   c. All threads shall be coated with urethane.

5. The PVC exterior and urethane interior coatings applied to the conduit shall afford sufficient flexibility to permit field bending without cracking or flaking at temperature above 30 degrees Fahrenheit (-1 degree Celsius).

6. PCA conduit bodies and fittings:

   a. Copper-free cast aluminum.

   b. The conduit body, before PVC coating, shall be new, unused material and shall conform to appropriate UL standards.

   c. The PVC coating on the outside of conduit bodies shall be 0.040 inch thick and have a series of longitudinal ribs to protect the coating from tool damage during installation.

   d. 0.002-inch interior urethane coating.

   e. Utilize the PVC coating as an integral part of the gasket design.

   f. Stainless steel cover screws heads shall be encapsulated with plastic to assure corrosion protection.

   g. A PVC sleeve extending 1 conduit diameter or 2 inches, whichever is less, shall be formed at each female conduit opening.

      i. The inside diameter of the sleeve shall be the same as the outside diameter of the conduit to be used.

      ii. The sleeve shall provide a vapor and moisture tight seal at every connection.

G. FLX:

1. Materials:

   a. Single strip aluminum alloy.

   b. Single strip steel hot-dip galvanized on all 4 sides before conduit fabrication.

2. Interlocking design formed from continuous metal strip for integrity and flexibility.
3. Manufactured in accordance with:
    a. UL-1.

H. NFC:

1. Provide liquid-tight and corrosion resistant flexible nonmetallic conduit and fittings.
2. Fabricated from a hard PVC spiral completely surrounded by flexible PVC:
    a. UL listed for sunlight resistance.
    b. Suitable for use at conduit temperatures of 80 degrees Celsius dry, 60 degrees Celsius wet, and 60 degrees Celsius oil resistant.
3. Temperature range -20 degrees Celsius to +80 degrees Celsius.

I. SLT:

1. Temperature rated for use in the ambient temperature at the installed location but not less than the following:
    a. General purpose:
        i. Temperature range -20 degrees Celsius to +80 degrees Celsius.
    b. Oil resistant:
        i. Temperature range -20 degrees Celsius to +60 degrees Celsius.
2. Sunlight resistant, weatherproof, and watertight.
3. Manufactured from single strip steel, hot-dip galvanized on all 4 sides before conduit fabrication.
4. Strip steel spiral wound resulting in an interior that is smooth and clean for easy wire pulling.
5. Overall polyvinyl chloride jacket.
6. With integral copper ground wire, built in the core, in conduit trade sizes 1/2 inch through 1-1/4 inch.

J. EFLX:

1. Suitable for the hazardous Class and Group where installed:
    a. As specified in Section 26 05 00.
2. Metallic braid shall provide continuous electrical path.
3. Stainless steel construction.
4. Provide fittings and unions as required for the installation.

K. PVC:

1. Extruded from virgin polyvinyl chloride compound:

a. Schedule 40 unless otherwise specified.
b. Schedule 80 extra heavy wall where specified.

2. Rated for 90 degrees Celsius conductors or cable.
3. Rated for use in direct sunlight.

L. Ent:
1. Corrugated thermoplastic construction.
2. Trade sizes 1/2 inch through 2 inches.

M. HDPE:
1. High density polyethylene.
2. Smooth wall.
3. Schedule 40**.**
4. Manufacturered in accordance with:
   a. UL 651B.
   b. NEMA TC-7.

N. Inner Duct:
1. HDPE and fabric inner duct are considered interchangeable.
2. HDPE inner duct:
   a. High density polyethylene.
   b. Corrugated.
   c. Resin properties:
      i. Density, g/cm^3: 0.941 to 0.955.
      ii. Melt index g/10 minute Condition E: 0.05 to 0.5.
      iii. Flexural modulus, MPa (pounds per square inch): 80,000 minimum.
      iv. Tensile strength at yield (pounds per square inch): 3,000 minimum.
      v. Environmental stress crack resistance condition B, F_{10}: 96 hours minimum.
      vi. Brittleness temperature: -75 degrees Celsius.
   d. Size: 1.25-inch.
   e. Colors: gray.
3. Fabric inner duct:
   a. White polyester and nylon resin polymer textile.
   b. Standard outdoor textile inner duct:
      i. 3-inch multi-cell inner duct containing pull tape in each cell.
   c. Color-coded.

d. Pull tape:

i. 1250 lb.

ii. Synthetic fiber polyester, flat woven.

iii. Printed sequential footage marks.

O. PVC Conduit DB-120:

1. Use only where approved for use as service entrance conduit, by the serving utility company.

2. Red in color.

3. Install per utility company standards unless otherwise indicated on the Drawings.

P. FRD:

1. Suitable for use at -40 degrees Celsius to 110 degrees Celsius.

2. Integral bell and spigot either glued together or assembled with an integral urethane tri-seal gasket held in place with a retainer ring.

3. For underground use only.

4. Conduit and fittings shall be pigmented with UV inhibiting carbon black.

Q. Conduit Bodies:

1. Material consistent with conduit type:

a. Malleable iron bodies and covers when used with type GRC conduit.

b. Cast aluminum bodies and covers when used with type RAC.

c. PVC bodies and covers when used with type PVC.

d. PVC-coated malleable iron bodies and covers when used with type PCS.

e. PVC-coated copper-free cast aluminum bodies and covers when used with type PCA.

f. Malleable iron or aluminum bodies with pressed steel or aluminum covers when used with EMT conduit.

2. Conduit bodies to conform to Form 8, Mark 9, or Mogul design:

a. Mogul design conforming to NEC requirements for bending space for large conductors for conduit trade sizes of 1 inch and larger with conductors #4 AWG and larger, or where required for wire bending space.

3. Gasketed covers attached to bodies with stainless steel screws secured to threaded holes in conduit body.

2.03 ACCESSORIES

A. Connectors And Fittings:

1. Manufactured with compatible materials to the corresponding conduit.

B. Insulated Throat Metallic Bushings:

1. Construction:
   a. Malleable iron or zinc plated steel when used with steel conduit.
   b. Aluminum when used with aluminum conduit.
   c. Positive metallic conduit end stop.
   d. Integrally molded non-combustible phenolic insulated surfaces rated 150 degrees Celsius.
   e. Use fully insulated bushings on nonmetallic conduit system made of high impact 150 degrees Celsius rated non-combustible thermosetting phenolic.

C. Insulated Grounding Bushings:
1. Construction:
   a. Malleable iron or steel, zinc plated, with a positive metallic end stop.
   b. Integrally molded non-combustible phenolic insulated surfaces rated 150 degrees Celsius.
   c. Tin plated copper grounding saddle for use with copper or aluminum conductors.

D. Electrical Unions (Erickson Couplings):
1. Construction:
   a. Malleable iron for use with steel conduit.
   b. Aluminum for use with aluminum conduit.
   c. Concrete tight, 3-piece construction.
   d. Rated for Class I Division 1 Group D in hazardous areas.

E. FLX Fittings:
1. Provide insulated die-cast connectors with ridges that thread into the inside of the conduit to achieve a force fit.
2. Binding screw connectors are not acceptable.

F. SLT Fittings:
1. Construction:
   a. Malleable iron.
   b. Furnished with locknut and sealing ring.
   c. Liquid-tight, rain-tight, oil-tight.
   d. Insulated throat.
   e. Furnish as straight, 45-degree elbows and 90-degree elbows.
   f. Designed to prevent sleeving:
      i. Verify complete bonding of the raceway jacket to the plastic gasket seal.

g. Equipped with grounding device to provide ground continuity irrespective of raceway core construction. Grounding device, if inserted into raceway and directly in contact with conductors, shall have rolled over edges for sizes under 5 inches.

h. Where terminated into a threadless opening using a threaded hub fitting, a suitable moisture resistant/oil resistant synthetic rubber gasket shall be provided between the outside of the box or enclosure and the fitting shoulder. Gasket shall be adequately protected by and permanently bonded to a metallic retainer.

2. Corrosion resistant and outdoor SLT fittings:

a. Construction:

i. PVC-coated liquid-tight fittings with a bonded 0.040-inch thick PVC coating on the metal connector to form a seal around the SLT conduit.

ii. Insulated throat and an integral sealing ring.

G. Hubs For Threaded Attachment Of Steel Conduit To Sheet Metal Enclosures:

1. Construction:

a. Insulated throat.

b. PVC coated when used in corrosive areas.

c. Bonding locknut.

d. Recessed neoprene O-ring to assure watertight and dust-tight connector.

e. One half (1/2)-inch through 1-1/4-inch steel zinc electroplated.

f. One and one half (1-1/2)-inch through 6-inch malleable iron zinc plated.

g. Aluminum with aluminum conduit.

2. Usage:

a. All conduits in damp, wet, outdoor, and corrosive areas shall use threaded hubs for connections to sheet metal enclosures.

H. Sealing Fittings:

1. Construction:

a. 40 percent wire fill capacity.

b. PVC-coated when used in corrosive areas.

c. Malleable ductile iron with steel conduit.

d. Aluminum with aluminum conduit.

e. Crouse-Hinds Type EYSR where required for submersible cables.

f. Crouse-Hinds Type EYD where drains are required.

g. Crouse-Hinds Type EYS where drains are not required.

h. UL listed for use in Class I, Division 1, Groups A, B, C, D; Class I, Division 2, Groups A, B, C, D; Class II, Divisions 1 and 2; Groups E, F, and G.

2. Sealing compound:

   a. Fiber filler and cement as recommended by the sealing fitting manufacturer.

   b. Approved for the conditions and use.

      i. Not affected by surrounding atmosphere or liquids.

   c. Melting point shall be 200 degrees Fahrenheit minimum.

I. PVC Fittings:

1. Shall include the following:

   a. Couplings.

   b. Terminal adapters.

   c. Female adapters.

   d. Caps.

   e. Reducer bushings.

   f. Duct couplings.

   g. End bells.

   h. Expansion couplings.

   i. Duct couplings 5 degree.

   j. C - pull fittings.

   k. E - pull fittings.

   l. LB - pull fittings.

   m. LL - pull fittings.

   n. LR - pull fittings.

   o. T - pull fittings.

   p. X - pull fittings.

   q. Service entrance caps.

2. Materials:

   a. All devices shall be made of PVC, using the same materials as used for Type PVC conduit.

   b. All metal hardware shall be stainless steel.

J. Through Wall And Floor Seals:

1. Materials:

   a. Body: casting of malleable or ductile iron with a hot-dip galvanized finish.

b. Grommet: neoprene.

c. Pressure rings: PVC coated steel.

d. Disc material: PVC coated steel.

e. Aluminum when used with conduit type RAC.

K. Expansion/Deflection Couplings:

1. Use to compensate for movement in any directions between 2 conduit ends that they connect.

2. Shall allow movement of 3/4 inch from the normal in all directions.

3. Shall allow angular movement for a deflection of 30 degrees from normal in any direction.

4. Constructed to maintain electrical continuity of the conduit system.

5. Materials:

a. End couplings: Bronze or galvanized ductile iron.

b. Sleeve: Neoprene.

c. Bands: Stainless steel.

d. Bonding jumper: Tinned copper braid.

L. Expansion Couplings:

1. Shall allow for expansion and contraction of conduit:

a. Permitting 8-inch movement, 4 inches in either direction.

2. Constructed to maintain electrical continuity of the conduit system.

3. Materials:

a. Head: Malleable or ductile iron.

b. Sleeve: Steel.

c. Insulating bushing: Phenolic.

d. Finish: Hot-dip galvanized.

e. Aluminum when used with conduit type RAC.

M. Inner Duct Couplings And Fittings:

1. HDPE inner duct:

a. Couplings:

i. Self-threading.

ii. Nonmetallic.

b. Fittings:

i. Multi-access fitting:

I. 4 hole.

II. Sized for conduit containing inner duct.

ii. Duct plugs:

I. Sized for inner duct diameter.

II. Install in all both ends of all unused ducts.

iii. Split plugs:

I. Sized for inner duct and cable diameters.

II. Install at both ends of all utilized ducts.

2. Fabric inner duct:

a. Termination bags:

i. Inflation-type bags for sealing and securing around one or more textile inner ducts and cables within 2-inch outside diameter or larger conduit.

N. EMT Connectors And Couplings:

1. Construction:

a. Compression connectors and couplings shall be concrete tight.

b. All connectors shall have insulated throats.

c. All connectors shall be compression type.

O. Conduit Markers:

1. As specified in Section 26 05 53.

2.04 SOURCE QUALITY CONTROL

A. As Specified In Section 26 05 00.

2.05 CONDUIT APPLICATION

1. Aluminum: Exposed indoor and outdoor runs in non-corrosive areas.
2. PVC Schedule 40: Underground, embedded in or under structural concrete slabs or in concrete-encased duct banks.
3. PVC Schedule 80: Underground, exposed indoor and outdoor runs in “Corrosive” areas.
4. Aluminum conduit installed in concrete or below grade shall be completely covered with two (2) coats of bitumastic paint or with heat shrink tubing (Raychem or equal).
5. EMT conduit shall be used in administrative areas, laboratories, lunchrooms and similar dry, clean areas, above ground.

PART 3 - EXECUTION

3.01 INSTALLATION

A. As Specified In Section 26 05 00.

B. General:

1. Conduit routing:

a. The Electrical Drawings are diagrammatic in nature:

i. Install conduit runs as specified with schematic representation indicated on the Drawings and as specified.

ii. Modify conduit runs to suit field conditions, as accepted by the Engineer:

I. Make changes in conduit locations that are consistent with the design intent but are dimensionally different, or routing to bypass obstructions.

II. Make changes in conduit routing due to the relocation of equipment.

iii. The Electrical Drawings do not indicate all required junction boxes and pull boxes:

I. Provide junction boxes and pull boxes to facilitate wire pulling as required:

- To meet cable manufacturer's pulling tension requirements.
- To limit total conduit bends between pull locations.

II. Install junction boxes and pull boxes at locations acceptable to the Engineer.

b. The Contractor is responsible for any deviations in general location, conduit size, routing, or changes to the conduit schedule without the express written approval or direction by the Engineer:

i. The Engineer is the sole source in determining whether the change is constituted as a deviation:

ii. Perform any changes resulting in additional conduits, or extra work from such deviations.

iii. Incorporate any deviations on the Record Documents.

c. Owner reserves the right to deduct the amount of applicable reimbursement, equivalent to the cost of the engineering effort required to show those unauthorized changes on As-built Drawings.

2. Use only tools recommended by the conduit manufacturer for assembling conduit system.

3. Provide adequate clearances from high-temperature surfaces for all conduit runs. Provide minimum clearances as follows:

a. Clearances of 6 inches from surfaces 113 degrees Fahrenheit to 149 degrees Fahrenheit.

b. Clearances of 12 inches from surfaces greater than 149 degrees Fahrenheit.

c. Keep conduit at least 6 inches from the coverings on hot water and steam pipes, 18 inches from the coverings on flues and breechings and 12 inches from fuel lines and gas lines.

d. Where it is necessary to route conduit close to high-temperature surfaces, provide a high-reflectance thermal barrier between the conduit and the surface.

4. Support conduit runs on water-bearing walls a minimum of 7/8-inch away from wall on an accepted preformed channel:

   a. Do not run conduit within water-bearing walls unless otherwise indicated on the Drawings.

5. Do not install 1 inch or larger conduits in or through structural members unless approved by the Engineer.

6. Run conduit exposed to view parallel with or at right angles to structural members, walls, or lines of the building:

   a. Install straight and true conduit runs with uniform and symmetrical elbows, offsets, and bends.

   b. Make changes in direction with long radius bends or with conduit bodies.

7. Install conduit with total conduit bends between pull locations less than or equal to 270 degrees.

8. Route all exposed conduit to preserve headroom, access space and work space and to prevent tripping hazards and clearance problems:

   a. Install conduit runs so that runs do not interfere with proper and safe operation of equipment and do not block or interfere with ingress or egress, including equipment removal hatches.

   b. Route conduit to avoid drains or other gravity lines. Where conflicts occur, relocate conduit as required.

9. Conduit may be run in concrete members or slabs with permission of the Engineer or as indicated on the Drawings:

   a. Refer to the typical details for conduit spacing and size requirements.

10. When installing conduit through existing slabs or walls make provisions for locating any possible conflicting items where conduit is to penetrate. Use tone signal or X-ray methods to make certain that no penetrations will be made into existing conduit, piping, cables, post-tensioning cables, etc.

11. Plug conduits brought into pull boxes, manholes, handholes, and other openings until used to prevent entrance of moisture.

12. Install conduit through wall and floor seals where indicated on the Drawings.

13. For existing and new 2-inch and larger conduit runs, snake conduits with conduit cleaner equipped with a cylindrical mandrel of a diameter not less than 85 percent of nominal diameter of conduit:

a. Remove and replace conduits through which mandrel will not pass.

14. Provide all sleeves and openings required for the passage of electrical raceways or cables even when these openings or sleeves are not specifically indicated on the Drawings.

15. Install complete conduit systems before conductors are installed.

16. Provide metallic conduits terminating in transformer, switchgear, motor control center or other equipment conduit windows with grounding bushings and ground with a minimum No. 6 AWG ground wire.

17. Underground and embedded conduits:

    a. Install underground conduits, including conduit runs below slabs-on-grade in concrete-reinforced duct bank construction:

        i. As specified in Section 26 05 43.

    b. Make underground conduit size transitions at handholes and manholes.

    c. Install spare conduits in underground duct banks towards top center of runs to allow for ease of installation of future cables as conduits enter underground manholes and handholes.

C. Lighting And Receptacle Conduits:

1. Install conduit runs for lighting and receptacle circuits, whether or not indicated on the Drawings:

    a. Minimum conduit size:

        i. 3/4 inch for exposed conduits.

        ii. 1 inch for underground or in slab conduits.

2. Provide conduit materials for the installed location as specified in Section 26 05 00.

D. Hazardous Areas:

1. As specified in Section 26 05 00 for hazardous areas and specific Class and Division.

2. As specified in Section 26 05 33 for hazardous area conduit installation requirements.

E. Conduit Usage:

1. Exposed conduits:

    a. Rigid conduit:

        i. Install the rigid conduit type for each location as specified in Section 26 05 00.

        ii. Minimum size: 3/4-inch.

    b. Flexible conduit:

i. Use flexible conduit for final connections between rigid conduit and motors, vibrating equipment, instruments, control equipment or where required for equipment servicing:

I. Use type SLT with rigid metallic conduit.

II. Use type NFC with PVC conduit.

III. Use type EFLX in Class I Division 1 locations.

IV. Use type FLX in finished areas.

ii. Minimum size: 3/4-inch:

I. 1/2 when required for connection to instruments.

iii. Maximum length:

I. Fixed equipment:

Conduit Trade Size	**Flexible Conduit Length (in)**
3/4	18
1	18
1-1/4	18
1-1/2	18
2	36
2-1/2	36
3	36
3-1/2	38
4	40

II. Removable instruments or hinged equipment:

- As required to allow complete removal or full movement without disconnecting or stressing the conduit.

2. Concrete encased and embedded conduits:

a. Type PVC Schedule 40 and PVC coated rigid metallic conduit as specified below:

i. Use Type PCS in underground and embedded installation as follows:

I. Stub-up and risers to grade floor or equipment from nonmetallic conduits.

II. Entering and exiting underground or embedded conduit runs a minimum 12 inches above and below grade or finished floor.

III. For any and all bends where the total deflection is greater than 45 degrees.

b. Minimum size:

i. 2 inches in duct banks unless otherwise indicated on the Drawings.

ii. 1 inch for in slab conduits unless otherwise indicated on the Drawings.

3. Direct buried and sand bedded ductbank conduits:

a. Type PCS.

b. Minimum size: 1 inch.

4. Directional drill conduits:

a. Type HDPE.

5. PVC coated rigid metallic conduit:

a. Use specifically manufactured or machined threading dies to manufacturer's specifications to accommodate the PVC jacket.

6. EMT:

a. May be used when specified in Section 26 05 00.

b. Provide supports spaced at minimum 5 feet on center and within 2 feet of each outlet box, junction box, pull box, cabinet, or other enclosure.

7. GRC:

a. Conduit shall be cut square and reamed before threading.

8. PVC:

a. Conduit terminations shall be via threaded adapters into threaded hubs on the junction boxes or conduit bodies.

b. Conduit terminations into boxes without threaded hubs shall utilize a threaded adapter and a flat neoprene washer on the outside of the box.

i. Use a locknut on the inside of the box to tighten the adapter to the box.

c. Route conduit to afford it the maximum physical protection.

i. If necessary, cover conduit to afford additional protection when it cannot be shielded by the structure or machinery frames.

I. Use Schedule 80 where exposed runs may be subject to physical damage.

9. ENT:

a. Install each conduit in 1 piece without couplings.

b. Utilize concrete type threaded adapters for connections to boxes and type PCS conduit.

10. RAC:

a. Do not use aluminum conduit below grade, cast in concrete or on concrete or masonry in contact with earth.

b. When installing RAC on concrete surfaces mount RAC on nonmetallic channel so that only the nonmetallic channel is in contact with the concrete.

c. When penetrating concrete walls and/or floors use O-Z Gedney rubber gasketed through wall and floor seals so that the aluminum conduit is completely isolated from the concrete by the rubber seal material.

11. Inner duct (applicable for fiber optic cable only):

a. Install inner duct in PVC conduit as indicated on the Drawings.

b. Each inner duct conduit shall be a separate color.

F. Conduit Joints And Bends:

1. General:

a. Where conduit is underground, under slabs on grade, exposed to the weather or in NEMA Type 4 or NEMA Type 4X locations, make joints liquid-tight.

b. Keep bends and offsets in conduit runs to an absolute minimum.

c. All bends shall be symmetrical.

d. For all types of high-voltage conductors, provide bends as required for lead-covered conductors of equivalent outside diameter.

e. The following conduit systems shall use large radius sweep elbows:

i. Underground conduits.

ii. Conduits containing medium voltage cables.

iii. Conduits containing shielded cables.

iv. Conduits containing fiber optic cables.

f. Provide large radius factory-made bends for 1-1/4-inch trade size or larger.

g. Make field bends with a radius of not less than the requirements found in the NEC:

i. The minimum bending radius of the cable must be less than the radius of the conduit bend.

ii. Make all field bends with power bending equipment or manual benders specifically intended for the purpose:

I. Make bends so that the conduit is not damaged and the internal diameter is not effectively reduced.

II. For the serving utilities, make bends to meet their requirements.

h. Replace all deformed, flattened, or kinked conduit.

2. Threaded conduit:

a. Cut threads on rigid metallic conduit with a standard conduit cutting die that provides a 3/4-inch per foot taper and to a length such that all bare metal exposed by the threading operation is completely covered by the couplings or fittings used. In addition, cut the lengths of the thread such that all joints become secure and wrench tight just preceding the point where the conduit ends would butt together in couplings or where conduit ends would butt into the ends or shoulders of other fittings.

b. Thoroughly ream conduit after threads have been cut to remove burrs.

c. Use bushings or conduit fittings at conduit terminations.

d. On exposed conduits, repair scratches and other defects with galvanizing repair stick, Enterprise Galvanizing “Galvabar” or CRC “Zinc It.”

e. Coat conduit threads with an approved electrically conductive sealant and corrosion inhibitor that is not harmful to the conductor insulation:

   i. Apply to the male threads and tighten joints securely.

   ii. Clean excess sealant from exposed threads after assembly.

f. Securely tighten all threaded connections.

g. Any exposed threaded surface must be cleaned and coated with a galvanizing solution so that all exposed surfaces have a galvanized protective coating.

3. PVC:

a. Use approved solvent-weld cement specifically manufactured for the purpose. Spray type cement is not allowed.

b. Apply heat for bends so that conduit does not distort or discolor. Use a spring mandrel as required to assure full inside diameter at all bends:

   i. Utilize a heater specifically for PVC conduit as recommended by the conduit manufacturer.

G. Conduit Sealing And Drainage:

1. Conduit drainage and sealing other than required for hazardous and classified areas:

a. Provide sealing and drainage in vertical drops of long (in excess of 20 feet), exterior, above grade conduit runs at the points at which the conduit enter buildings, switchgear, control panels, lighting panelboards, and other similar enclosures.

b. Provide seal fittings with drains in vertical drops directly above grade for exterior, above grade conduit runs that are extended below grade.

c. Provide conduit seals with drains in areas of high humidity and rapidly changing temperatures:

   i. Where portions of an interior raceway pass through walls, ceilings or floors that separate adjacent areas having widely different temperatures.

d. Provide conduit seals similar to O/Z Gedney (Type CSM) on all conduits between corrosive and non-corrosive areas.

e. Seal one end only of all underground conduits at highest point with O/Z Gedney sealing (non-hazardous) filling, or equal.

2. Install seals with drains at any location along conduit runs where moisture may condense or accumulate. This requirement includes, but is not limited to, the following locations: control panels, junction boxes, pullboxes, or low points of conduit.

H. Expansion Or Expansion/Deflection Fittings:

1. General:

a. Align expansion coupling with the conduit run to prevent binding.

b. Follow manufacturer's instructions to set the piston opening.

c. Install expansion fittings across concrete expansion joints and at other locations where necessary to compensate for thermal or mechanical expansion and contraction.

d. Furnish fittings of the same material as the conduit system.

2. For metallic conduit provide expansion or expansion/deflection couplings, as appropriate, where:

a. Install expansion fittings a minimum of every 200 feet in straight conduit runs.

3. For PVC provide expansion or expansion/deflection couplings, as appropriate, where length change due to temperature variation exceeds 2 inches:

a. Rigidly fix the outer barrel of the expansion coupling so it cannot move.

b. Mount the conduit connected to the piston loosely enough to allow the conduit to move as the temperature changes.

I. Empty Conduits:

1. Provide a polyethylene rope rated 250 pounds tensile strength in each empty conduit more than 10 feet in length.

2. Provide one empty 3/4-inch conduit for each four spare unused circuits or spaces of each flush mounted branch circuit panelboard. Terminate empty 3/4-inch conduits in individual junction boxes that are accessible to enable extension of future branch circuits.

3. Seal ends of all conduit with approved, manufactured conduit seals, caps or plugs immediately after installation:

a. Keep ends sealed until immediately before pulling conductors.

J. Miscellaneous:

1. Provide electrical unions at all points of union between ends of rigid conduit systems that cannot otherwise be coupled:

a. Running threads and threadless couplings are not allowed.

2. Replace any conduit installed that the Engineer determines does not meet the requirements of this Specification.

3. Provide conduit housekeeping curb around all embedded or below-grade conduits exiting or entering the slab.

3.02 COMMISSIONING AND PROCESS START-UP

A. As Specified In Section 00 16 55.

3.03 FIELD QUALITY CONTROL

A. As Specified In Section 26 05 00.

3.04 PROTECTION

A. As Specified In Section 26 05 00.

END OF SECTION

SECTION 26 05 34

BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Device boxes.
2. Raceway system boxes.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01 33 00 - Submittal Procedures.
   b. Section 01 71 13 - Mobilization.
   c. Section 26 05 00 – Electrical - General Provisions.

1.02 REFERENCES

A. As Specified In Section 26 05 00.

B. ASTM International (ASTM):

1. A 47 - Standard Specification for Ferritic Malleable Iron Castings.
2. D 149 - Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
3. D 495 - Standard Test Method for High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation.
4. D 570 - Standard Test Method for Water Absorption of Plastics.
5. D 648 - Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position.
6. D 790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
7. D 792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

C. Joint Industry Conference (JIC).

D. Underwriters Laboratories, Inc. (Ul):

1. 94 - Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

1.03 DEFINITIONS

A. As Specified In Section 26 05 00.

B. Specific Definitions:

1. Arcing parts: Circuit breakers, motor controllers, switches, fuses, or any device intended to interrupt current during its operation.

2. Raceway system boxes: Boxes that are used for wire and cable pullboxes, conduit junction boxes, or terminal boxes.

1.04 SYSTEM DESCRIPTION

A. Provide outlet boxes for devices such as switches, receptacles, telephone and computer jacks, security systems, junction, and pullboxes for use in the raceway systems, etc.

B. Provide boxes as indicated on the drawings or as needed to complete the raceway installation.

1.05 SUBMITTALS

A. Furnish Submittals as Specified in Sections 01 33 00 And 26 05 00.

B. Product Data:

1. Manufacturer.
2. Materials.
3. Dimensions:
    a. Height.
    b. Width.
    c. Depth.
    d. Weight.
    e. NEMA rating.
4. Conduit entry locations.
5. Catalog cut sheets.
6. Installation instructions.

C. Shop Drawings:

1. Include identification and sizes of pull boxes.

1.06 QUALITY ASSURANCE

A. As Specified In Section 26 05 00.

B. Regulatory Requirements:

1. Outlet boxes shall comply with all applicable standards of:
    a. JIC.
    b. NEC.
    c. NEMA.
    d. UL.

1.07 **DELIVERY, STORAGE, AND HANDLING**

A. As Specified In Section 26 05 00.

1.08 **PROJECT OR SITE CONDITIONS**

A. As Specified In Section 26 05 00.

1.09 **SEQUENCING**

A. As Specified In Section 26 05 00.

1.10 **WARRANTY**

A. As Specified In Section 26 05 00.

1.11 **SYSTEM START-UP**

A. As Specified In Section 26 05 00.

PART 2 - PRODUCTS

2.01 **MANUFACTURERS**

A. One Of The Following Or Equal:
1. Pressed steel boxes:
    a. Steel City.
    b. Appleton.
    c. Crouse - Hinds.
    d. Thomas & Betts.
2. Plastic and/or fiberglass boxes:
    a. Hoffman.
    b. Carlon.
    c. Stahlin.
3. Plastic coated boxes:
    a. Rob Roy.
    b. OCAL.
4. Cast device boxes:
    a. Appleton.

b. Crouse - Hinds.

c. OZ/Gedney.

5. Floor outlet boxes with 1-inch conduit knockouts:

   a. Steel City, 640 Series.

   b. Hubbell type B25 with S2530 coverplate.

6. Floor outlet boxes in open areas:

   a. Hubbell.

7. Formed steel enclosures:

   a. Hoffman.

   b. Thomas and Betts.

   c. Stahlin.

   d. Rittal.

8. Stainless steel enclosures:

   a. Hoffman.

   b. Stahlin.

   c. Rittal.

9. Pressed steel boxes and concrete boxes:

   a. Appleton.

   b. Steel City.

   c. Cooper/Crouse Hinds.

   d. OZ Gedney.

2.02 **MANUFACTURED UNITS**

1. Stainless steel:

   a. NEMA Type 4X:

      i. Boxes in locations subject to flooding or temporary submersion:

I. NEMA Type 6.

   b. Fabricated from 14-gauge Type 316 stainless steel.

   c. All seams continuously welded.

   d. Door:

      i. Rolled lip around 3 sides.

      ii. Attached to enclosure by means of a continuous stainless steel hinge and pin.

   e. Neoprene door gasket to provide a watertight seal:

i. Attached with an adhesive.

ii. Retained by a retaining strip.

f. Fabricate all external removable hardware for clamping the door to the enclosure body from heavy gauge stainless steel:

i. With a hasp and staple for padlocking.

g. Provide large enclosures with doors and body stiffeners for extra rigidity.

h. No holes or knockouts.

i. Finish:

i. Brushed.

j. Stainless steel external mounting brackets when surface mounted.

2.03 ACCESSORIES

A. Fasteners:

1. Electroplated or stainless steel in boxes with wiring devices.
2. Screws, nuts, bolts, and other threaded fasteners:

   a. Stainless steel.

B. Provide Breather and Drain Fittings Where Appropriate.

C. Internal Panels:

1. Provide internal panels where required for mounting of terminal strips or other equipment.
2. With plated steel shoulder studs.
3. Steel with white polyester powder finish.

D. Floor Stand Kit When Shown:

1. Fabricated from 12-gauge steel.
2. Bottom plate 11 gauge.
3. Heights:

   a. 12 inches.

4. Do not provide external mounting brackets, when a floor stand kit is used.

PART 3 - EXECUTION

3.01 INSTALLATION

A. As Specified In Section 26 05 00.

B. General:

1. Provide materials and construction suitable for environmental conditions at the location of the box as specified in Section 26 05 00.

2. Provide outlet box materials to match the conduit system:
   a. EMT - Pressed metal boxes.
   b. GRC - Cast ferrous boxes.
   c. RAC - Aluminum (copper free) boxes.
   d. PCS - PVC coated cast ferrous boxes.
   e. PVC - PVC boxes.
   f. PCA - PVC coated aluminum boxes.
3. Solid type gang boxes:
   a. For more than 2 devices.
   b. For barriered outlets.
4. Support all wall mounted NEMA Type 4 or NEMA Type 4X boxes to maintain a minimum of 7/8-inch free air space between the back of the enclosure and the wall:
   a. Use machined spacers to maintain air space; built-up washers are not acceptable.
   b. Use stainless steel or nylon materials for spacers.
5. Use cast malleable iron boxes when box must support other devices.
6. Boxes serving luminaires or devices:
   a. Use as pull boxes wherever possible.
7. In finished areas:
   a. Provide specific pull or junction boxes only as indicated on the Drawings or as directed.
8. Fit all cast boxes and pressed steel boxes for flush mounting in concrete with cast, malleable box covers and gaskets.
9. In terminal boxes, furnish terminals as indicated on the Drawings, with a minimum of 50 percent spare terminals:
   a. Furnish wireways for discrete and analog/DC wiring.
   b. Separate analog wiring from 120 V discrete or power wiring.
10. Size boxes in accordance with NEC requirements and to provide sufficient room for the future components and cables indicated on the Drawings.
11. For fire-rated construction, provide materials and installation for use in accordance with the listing requirements of the classified construction.

C. Outlet Boxes:

1. Locate outlet boxes as indicated on the Drawings:
   a. Adjust locations so as not to conflict with structural requirements or other trades.

2. Use deep threaded-hub malleable iron or aluminum boxes:
   a. In hazardous areas.
   b. Where exposed to the weather.
   c. In unheated areas.
   d. Where subject to mechanical damage:
      i. Defined as exposed boxes less than 10 feet above the floor.
   e. To act as a pull box for conductors in a conduit system.
   f. Accommodate wiring devices.
3. Use deep threaded-hub plastic coated malleable iron boxes in corrosive and NEMA Type 4X area and when the conduit system is PVC coated steel.
4. Outlet boxes may be used as junction boxes wherever possible.

D. Pull Boxes And Junction Boxes:
   1. Size pull boxes in accordance with NEC requirements and to provide sufficient room for any future conduits and cables as indicated on the Drawings.
   2. Install pull boxes such that access to them is not restricted.

E. For Boxes Not Indicated:
   1. Provide types and mountings as required to suit the equipment and that will be consistent with the conduit system and environmental conditions as indicated in Section 26 05 00.
   2. Outlet, switch, and junction boxes for flush-mounting in general purpose locations:
      a. One-piece, galvanized, pressed steel.
   3. Ceiling boxes for flush mounting in concrete:
      a. Deep, galvanized, pressed steel.
   4. Outlet, switch, and junction boxes where surface mounted in exposed locations:
      a. Cast ferrous boxes with mounting lugs, zinc or cadmium plating finish.
   5. Outlet, control station, and junction boxes for installation in corrosive locations:
      a. Fiberglass reinforced polyester, stainless steel, or plastic-coated steel to match the conduit system.
      b. Furnished with mounting lugs.
   6. Boxes for concealed conduit system:
      a. Non-fire rated construction:
         i. Depth: To suit job conditions and comply with the NEC.
         ii. For luminaries: Use outlet boxes designed for the purpose:
            I. 50 pounds or less: Box marked “For Fixture Support.”

II. More than 50 pounds: Box listed and marked with the weight of the fixture to be supported (or support luminaire independent of the box.)

iii. For ceiling suspended fans:

I. 35 pounds or less: Marked "Acceptable for Fan Support."

II. More than 35 pounds, up to 70 pounds: Marked "Acceptable for Fan Support up to 70 pounds (or support fan independent of the box)."

iv. For junction and pull boxes: Use galvanized steel boxes with flush covers.

v. For switches, receptacles, etc:

I. Plaster or cast-in-place concrete walls: Use 4-inch or 4-11/16-inch galvanized steel boxes with device covers.

II. Walls other than plaster or cast-in-place concrete: Use type of galvanized steel box which will allow wall plate to cover the opening made for the installation of the box.

3.02 COMMISSIONING AND PROCESS START-UP

A. As Specified In Section 00 16 55.

3.03 FIELD QUALITY CONTROL

A. As Specified In Section 26 05 00.

3.04 CLEANING

A. As Specified In Section 26 05 00.

3.05 PROTECTION

A. As Specified In Section 26 05 00.

END OF SECTION

SECTION 26 05 43

UNDERGROUND ELECTRICAL DUCT SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Electrical underground duct banks.
2. Duct bank installation requirements.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01 33 00 - Submittal Procedures.
   b. Section 01 71 13 - Mobilization.
   c. Section 03 30 00 - Cast-In-Place Concrete.
   d. Section 26 05 33 - Raceways and Fittings.
   e. Section 26 05 00 - Electrical – General Provisions.

1.02 REFERENCES

A. As specified in Section 26 05 00.

1.03 DEFINITIONS

A. As specified in Section 26 05 00.

1.04 SYSTEM DESCRIPTION

A. Provide trenching, forming, rebar, spacers, conduit, concrete, backfill, and compaction necessary for the complete installation of the duct banks.

B. Provide reinforced concrete duct banks for all conduits installed below grade, on the site, below structures, or in contact with the earth, unless otherwise indicated on the Drawings.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01 33 00 and 26 05 00.

B. Product Data:

1. PVC conduit spacers.
2. Detectable underground marking tape.
3. Pull line.

C. Provide applicable submittal documents as specified in:

1. Section 03 30 00.

D. Shop Drawings:

1. Submit site plan drawings of duct banks including underground profiles indicating all underground utilities.

1.06 QUALITY ASSURANCE

A. As specified in Section 26 05 00.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 26 05 00.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 26 05 00.

B. Field conditions and related requirements:

1. Underground water table may be near or above the location of new duct banks.
2. Include cost for necessary dewatering, and cleaning equipment to perform work in underground duct banks, pull boxes and manholes, before installation.

1.09 WARRANTY

A. As specified in Section 26 05 00.

1.10 SYSTEM START-UP

A. As specified in Section 26 05 00.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Conduit Spacers:

1. One of the following or equal:
    a. Carlon Snap-Loc.
    b. Cantex.
    c. Osburn Associates, Inc.

B. Detectable underground marking tape:

1. One of the following or equal:
    a. Blackburn Manufacturing Company.

b. Pro-Line Safety Products.

c. Panduit.

C. Pull Line:

1. One of the following or equal:

a. Arnco.

b. Greenlee.

c. Osburn Associates, Inc.

2.02 MATERIALS

A. Provide conduit as specified in Section 26 05 33:

1. Use duct suitable for use with 90-degree Celsius rated conductors.

B. Provide reinforcing steel as specified in Section 03200:

1. Provide minimum Number 4 reinforcing steel.

2.03 MANUFACTURED UNITS

A. Conduit Spacers:

1. Provide conduit spacers recommended by the conduit manufacturer or specified above.

2. Saddle type.

3. Non-metallic, non-corrosive, non-conductive.

4. Interlocking type:

a. Vertical interlocking.

b. Horizontal interlocking.

5. Suitable for concrete encasement.

6. Molded-in rebar holder.

7. Accommodates 2-inch through 6-inch conduit sizes.

8. Relieves the conduit from both horizontal and vertical stresses.

B. Pull Line:

1. Minimum 1/4-inch wide, flat design.

2. Polyester.

3. Minimum pulling strength 1,200 pounds.

4. Sequential footage markings.

C. Detectable Marking Tape:

1. Provide detectable tape, locatable by a cable or metal detector from above the undisturbed grade.

2. Aluminum core laminated between polyethylene film.

3. Six-inch wide red tape imprinted with black lettering "CAUTION - BURIED ELECTRIC UTILITIES."

2.04 MIXES

A. Concrete mix requirements as specified in Section 03 30 00.

B. Provide a red-oxide conduit encasement coloring agent as specified in Section 03 30 00.

PART 3 - EXECUTION

3.01 INSTALLATION

A. As specified in Section 26 05 00.

B. Duct Banks:

1. Install duct banks encased in concrete at least 24 inches below finish grade, unless otherwise indicated on the Drawings.

2. Damage minimization:

a. Conduit should not be left exposed in an open trench longer than is necessary.

b. Protect all underground duct banks against damage during pouring of concrete or backfilling.

3. All plastic conduit fittings to be joined should be exposed to the same temperature conditions for a reasonable length of time before assembly.

4. Provide American Wire Gauge bare copper ground wire the entire length of duct bank and bond to the grounding system as indicated on the Drawings and every 20 feet to steel reinforcing bar.

5. Install underground ducts to be self-draining:

a. Slope duct banks away from buildings to pull boxes.

b. Slope duct banks uniformly from manholes/pull boxes to manholes/pull boxes or both ways from high points between pull boxes.

c. Slope a minimum of 1/2 inch per 10 feet.

6. Where new duct banks join to existing manholes/pull boxes make the proper fittings and fabricate the concrete envelopes to ensure smooth durable transitions, as indicated on the Drawings.

7. Install pull line in spare conduits:

a. Provide adequate pull line at both ends of conduits to facilitate conductor pulling.

b. Cap above ground spare conduit risers at each end with screw-on conduit caps.

C. Duct Spacing:

1. Separate conduits with manufactured plastic spacers using a minimum space between the outside surfaces of adjacent conduits of 1.5 inches:
    a. Separate medium voltage ducts a minimum of 7.5 inches on center.
2. Install spacers to maintain uniform spacing of duct assembly a minimum of 4 inches above the bottom of the trench during concrete pour. Install spacers on 8-foot maximum intervals:
    a. Due to some distortion of conduit from heat, and other means, it may be necessary to install extra spacers within the duct bank:
        i. Install the intermediate set of spacers within normal required spacing to maintain the proper horizontal clearance:
            I. Clearance is required to allow the proper amount of concrete to infiltrate vertically among the duct to ensure proper protection.
3. Spacers shall not be located at the center of a bend:
    a. Locate spacer in the tangent, free of the coupling on fabricated bends.
    b. Locate spacers midway between the tangent and the center bend on trench formed sweeps.

D. Terminating:
1. Use bell ends in duct at entrances into cable vaults.
2. Make conduit entrances into cable vaults tangential to walls of cable vault.
3. Form trapezoidal transitions between duct bank and cable vaults as needed in order to ensure adequate cable bending radius for the duct bank-to-vault transition.
4. New manhole or handhole applications, provide a single opening or “window” per duct bank, sized to accommodate the duct bank envelope.

E. Concrete:
1. Install concrete as specified in Section 03 30 00.
2. Provide nonferrous tie wires to prevent displacement of the conduits during pouring of concrete:
    a. Tie wire shall not act as a substitute for spacers.
3. Install minimum 3-inch cover around conduit and rebar.
4. Consolidation of encasement concrete around duct banks shall be by hand pudding, with no mechanical vibration.
5. Conduit is subject to temperature rise. As concrete cures, allow the free end to expand by pouring the concrete from the center of the run or from one tie in point.

F. Marking Tape:
1. Install a detectable marking tape 12 inches above the duct bank the entire length of the duct bank.

G. For conduit installations beneath building slabs:

1. Install steel reinforced concrete duct banks under all building slabs as indicated on the Drawings:

   a. Concrete for encasement under building slabs need not be colored red.

   b. For duct banks crossing under building footers or foundations, install the top of the duct bank a minimum of 12 inches below the footer.

   c. Where duct banks enter through building walls, foundation walls, stem walls, etc. make connections as indicated on the Drawings.

   d. Where duct banks terminate with conduit risers entering building walls, install an expansion/deflection fitting or a flat-wise elbow (elbow parallel to building wall) in order to accommodate differential movement between the conduits and structure.

H. Restore all surfaces to their original condition as specified in Section 01 01 00, unless otherwise specified.

I. Marking piers:

1. Provide permanent concrete cylinder marking piers, on grade, centered on duct bank and located at every bend in duct bank or wherever duct bank enters a building, vault, or other structure:

   a. Provide a cylinder, 6 inches in diameter:

      i. Top of cylinder 1/2 inch below the top of finished grade.

   b. Provide a 3-inch high "E" embossed in top of cylinder:

      i. Minimum of 2 inches deep.

   c. Provide 2-inch arrows embossed in top of cylinder showing the direction of the duct bank:

      i. Minimum of 2 inches deep.

3.02 COMMISSIONING AND PROCESS START-UP

A. As specified in Section 00 16 55.

3.03 FIELD QUALITY CONTROL

A. As specified in Section 26 05 00.

3.04 CLEANING

A. Clean conduits of dirt and debris by use of an appropriately sized steel mandrel no less than 1/2 inch smaller than the inside diameter of the conduit.

3.05 PROTECTION

A. As specified in Section 26 05 00.

B. Provide shoring and pumping to protect the excavation and safety of workers.

C. Protect excavations with barricades as required by applicable safety regulations.

END OF SECTION

SECTION 26 05 53

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Identification of electrical equipment, devices, and components.
2. Material, manufacturing, and installation requirements for identification devices.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01 33 00 - Submittal Procedures.
   b. Section 01 71 13 - Mobilization.
   c. Section 26 05 00 - Electrical – General Provisions.
   d. Section 26 05 33 - Raceways and Fittings.

1.02 REFERENCES

A. As specified in Section 26 05 00.

B. Occupational Safety and Health Administration (OSHA).

1.03 DEFINITIONS

A. As specified in Section 26 05 00.

1.04 SYSTEM DESCRIPTION

A. Nameplates:

1. Provide a nameplate for each piece of electrical equipment and devices, control panel and control panel components.
2. Provide all nameplates of identical style, color, and material throughout the facility.
3. Device nameplates information:
   a. Designations as indicated on the Drawings and identified on the Process and Instrumentation Drawings.

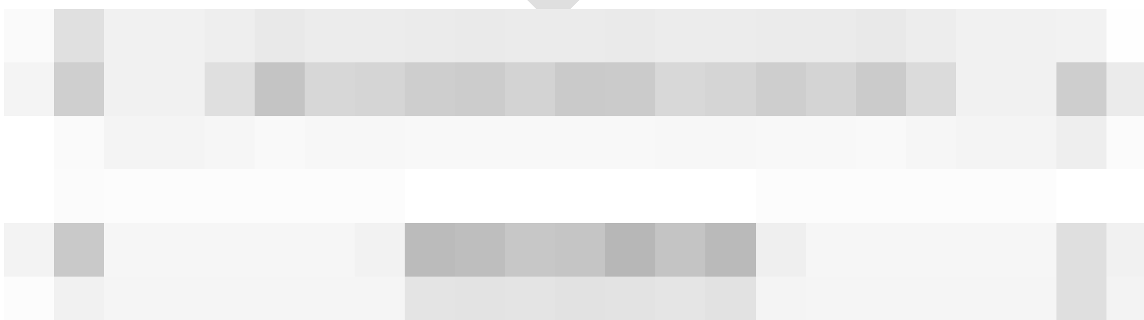
B. Wire Numbers:

1. Coordinate the wire numbering system with all vendors of equipment so that every field wire has a unique number associated with it for the entire system:

   a. Wire numbers shall correspond to the wire numbers on the control drawings or the panel and circuit numbers for receptacles and lighting.
   b. Wire numbers shall correspond to the terminal block number to which they are attached in the control panel.
   c. Internal panel wires on a common terminal shall have the same wire number.
   d. Multi-conductor cables shall be assigned a cable number that shall be attached to the cable at intermediate pull boxes and stub-up locations beneath freestanding equipment. All multi-conductor and instrumentation cables shall be identified at pull points as described above:

      i. Label armored multi-conductor cable using the conduit number as indicated on the Drawings, following the requirements for conduit markers in Section 26 05 53.

2. Provide the following wiring numbering schemes throughout the project for field wires between well pump control panel, RTU panel, and field instruments.



OR

Where:

ORIGIN LOC.= Designation for originating panel or device

ORIGIN TERM.= Terminal designation at originating panel or device

DEST. LOC.= Designation for destination panel or device

DEST. TERM.= Terminal designation at destination panel or device or PLC

3. I/O address at destination panel:

   a. Identify equipment and field instruments as the origin.
   b. PCPs are always identified as the destination.
   c. Location is the panel designation for VCP, LCP, or PCP. For connections to MCCs, location is the specific starter tag and loop number. Location is the tag

and loop number for motor starters, field instruments, and equipment. Any hyphen in the panel designation or tag and loop number shall be omitted.

d. Terminal designation is the actual number on the terminal block where the conductor terminates at field devices and vendor control panels. For multi-conductor cables, all terminal numbers shall be shown, separated by commas.

e. Terminal designations at motor leads shall be the motor manufacturer's standard terminal designation (e.g. T1, T2, T3, etc.).

f. Terminal designations at PCPs where the field conductor connects to field terminal blocks for a PLC input or output shall be the PLC address (Note: the following PLC I/O numbering scheme is typical for Allen-Bradley, the numbering scheme should be modified to match that of the actual PLC manufacturer used for the project):

   i. Discrete Point: W:X:Y/Z

      Analog Point: W:X:Y.Z

      Where:

      W = I for input, O for output

      X = PLC number (1, 2, 3…)

      Y = Slot number (01, 02, 03…)

      Z = Terminal number (00, 01, 02…) for a discrete point or a word number for an analog point (1, 2, 3…)

g. Terminal designations at PCPs where the conductor does not connect to a PLC I/O point shall be the terminal number with a "C" prefix (e.g. C0010). For common power after a fuse or neutrals after a switch, the subsequent points shall have and capital letter suffix starting with "A" (e.g. C0010A).

4. Case 1: Vendor control panel (VCP) to process control panel (PCP):

   Field wire number/label: A-B/C-D

   A = Vendor control panel number without hyphen (VCP#)

   B = Terminal number within VCP (manufacturer's or vendor's standard terminal number)

   C = Process control panel number without hyphen (PCP#)

   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)

   Examples: VCP#-10/PCP#-I:1:01/01

   VCP#-10/PCP#-O:1:10/07

   VCP#-10/PCP#-C0100

5. Case 2: Field instrument to process control panel (PCP):

   Field wire number/label: E-F/C-D

   C =Process control panel number without hyphen (PCP#)

   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)

   E =Field mounted instrument tag and loop numbers without hyphen (EDV#)

   F =Manufacturer's standard terminal number within instrument. Use both terminal numbers for analog points separated by a comma.

   Examples: TIT#-2,3/PCP#-I:1:01.1

   TSH#-1/PCP#-I:2:01/00

6. Case 3: Motor control center (MCC) to process control panel (PCP):

   Field wire number/label: G-B/C-D

   B =Terminal number within Motor Control Center (manufacturer's or vendor's standard terminal number)

   C =Process control panel without hyphen (PCP#)

   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)

   G = Actual starter designation in the motor control center without hyphen (MMS#)

   Examples MMS#-10/PCP#-I:1:01/01

   MMS#-10/PCP#-O:1:10/07

   MMS#-10/PCP#-C0100

7. Case 4: Motor control center (MCC) to vendor control panel (VCP):

   Field wire number/label: G-B/A-B

   A = Vendor control panel number without hyphen (VCP#)

   B = Terminal number within motor control center or vendor control panel (manufacturer's or vendors standard terminal number)

   G = Actual starter designation in the motor control center without hyphen (MMS#)

   Example: MMS#-X2/VCP#-10

8. Case 5: Motor leads to a motor control center (MCC):

   Field wire number/label: H-I/G-B

   B =Terminal number within motor control center (manufacturer's standard terminal number)

G = Actual starter designation in the motor control center without hyphen (MMS#)

H = Equipment tag and loop number without hyphen (PMP#)

I = Motor manufacturer’s standard motor lead identification (e.g. T1, T2, T3, etc.)

Example: PMP-#-T3/MMS#-T3

9. Case 6: Remote or separately mounted starter or variable frequency drive (VFD) to process control panel (PCP):

Field wire number/label: J-B/C-D

B = Terminal number within starter or variable frequency drive (manufacturer’s standard terminal number)

C = Process control panel number without hyphen (VCP#)

D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a “C” prefix if not connected directly to a PLC I/O point (C0010)

J = Starter or variable frequency drive tag and loop number without hyphen (MMS#)

Examples: MMS#-10/PCP#-I:1:01/01

MMS#-10/PCP#-O:2:10/07

MMS#-10/PCP#-C0010

10. Identify all spare conductors as required for other field wires with an “S” prefix:

Example: S MMS#-10/PCP#-C011

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01 33 00 and 26 05 00.

B. Product Data:

1. Nameplates:

a. Color.
b. Size:

i. Outside dimensions.

ii. Lettering.

c. Material.
d. Mounting means.

2. Nameplate schedule:

a. Show exact wording for each nameplate.
b. Include nameplate and letter sizes.

3. Wire numbers:

a. Manufacturer's catalog data for wire labels and label printer.

C. Record documents:

1. Update the conduit schedule to reflect the exact quantity of wire numbers including spares and destination points for all wires.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 26 05 00.

1.07 WARRANTY

A. As specified in Section 26 05 00.

1.08 SYSTEM START-UP

A. As specified in Section 26 05 00.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Nameplates and signs:

1. One of the following or equal:

a. Brady.
b. Seton.

B. Conductor and cable markers:

1. Heat-shrinkable tubing:

a. One of the following or equal:

i. Raychem.

ii. Brady.

iii. Thomas & Betts.

iv. Kroy.

2. Non heat-shrinkable tubing:

a. One of the following or equal:

i. Brady.

ii. Seton.

3. Marker printer:

a. The following or equal:

i. Brady.

4. Pre-printed slip-on sleeve markers:

a. The following or equal:

i. Grafoplast.

ii. Engineer knows of no equal.

C. Conduit and raceway markers:

1. One of the following or equal:

a. Almetek: Mini Tags.
b. Lapp Group: Maxi System.

D. Medium voltage raceway voltage labels:

1. One of the following or equal:

a. Brady.
b. Seton.

2.02 MATERIALS

A. Nameplates:

1. Fabricated from white-center and red face or black-center, white face laminated plastic engraving stock:

a. 3/32-inch thick material.
b. Two-ply.
c. With chamfered edges.
d. Block style engraved characters of adequate size to be read easily from a distance of 6 feet:

i. No characters smaller than 1/8-inch in height.

B. Signs:

1. Automatic equipment and high voltage signs:

a. Suitable for exterior use.
b. In accordance with OSHA regulations.

C. Conductor and cable markers:

1. Machine printed black characters on white tubing.

2. Ten point type or larger.

D. Conduit and raceway markers:

1. Non-metallic:

a. UV resistant holder and letters
b. Black letters on yellow background.
c. Minimum letter height: 1/2-inch.
d. Adhesive labels are not acceptable.

2. Solid brass tags.

a. Minimum thickness: 0.036 inches.
b. Letter characters stamped.
c. Minimum letter height: 3/16-inch.

2.03 SOURCE QUALITY CONTROL

A. Nameplates:

1. Provide all nameplates for control panel operator devices (e.g. pushbuttons, selector switches, pilot lights, etc.):

   a. Same material and same color and appearance as the device nameplates, in order to achieve an aesthetically consistent and coordinated system.

PART 3 - EXECUTION

3.01 INSTALLATION

A. As specified in Section 26 05 00.

B. Nameplates:

1. Attach nameplates to equipment with rivets, bolts or sheet metal screws, approved waterproof epoxy-based cement or install in metal holders welded to the equipment.

2. On NEMA Type 4, NEMA Type 4X, or NEMA Type 7 enclosures, use epoxy-based cement to attach nameplates.

3. Nameplates shall be aligned and level or plumb to within 1/64 inch over the entire length:

   a. Misaligned or crooked nameplates shall be remounted, or provide new enclosures at the discretion of the Engineer.

C. Conductor and Cable Markers:

1. Apply all conductor and cable markers before termination.

2. Heat-shrinkable tubing:

   a. Tubing shall be shrunk using a heat gun that produces low temperature heated air.
   b. Tubing shall be tight on the wire after it has been heated.
   c. Characters shall face the open panel and shall read from left to right or top to bottom.
   d. Marker shall start within 1/32 inch of the end of the stripped insulation point.

3. Non heat-shrinkable tubing:

   a. Tubing shall be sized for the wire and insulation on which it is to be placed.
   b. Tubing shall be tight on the wire.
   c. Characters shall face the open panel and shall read from left to right or top to bottom.
   d. Marker shall start within 1/32 inch of the end of the stripped insulation point.

D. Conduit Markers:

1. Furnish and install conduit markers for every conduit in the electrical system that is identified in the conduit schedule or part of the process system:

2. Mark conduits at the following locations:

a. Each end of conduit that are greater than 10 feet in length.
b. Where the conduit penetrates a wall or structure.
c. Where the conduit emerges from the ground, slab, etc.
d. The middle of conduits that are 10 feet or less in length.

3. Mark conduits after the conduits have been fully painted.
4. Position conduit markers so that they are easily read from the floor.
5. Attach non-metallic conduit markers with nylon cable ties:
   a. Provide ultraviolet resistant cable ties for conduit markers exposed to direct sunlight.
6. Attach brass tags with Type 316 stainless steel wires.
7. Mark conduits before construction review by Engineer for punch list purposes.
8. Label intrinsically safe conduits in accordance with the requirements of the NEC.

E. Signs and Labeling:

1. Furnish and install permanent warning signs at mechanical equipment that may be started automatically or from remote locations:
   a. Fasten warning signs with round head stainless steel screws or bolts.
   b. Locate and mount in a manner to be clearly legible to operations personnel.
2. Furnish and install permanent and conspicuous warning signs on equipment (front and back), doorways to equipment rooms, pull boxes, manholes, etc. where the voltage exceeds 600 volts.
3. Furnish and install warning signs on equipment that has more than one source of power.
   a. Warning signs to identify every panel and circuit number of the disconnecting means of all external power sources.
4. Place warning signs on equipment that has 120 VAC control voltage source used for interlocking.
   a. Identify panel and circuit number or conductor tag for control voltage source disconnecting means.

3.02 COMMISSIONING AND PROCESS START-UP

A. As specified in Section 00 16 55.

3.03 FIELD QUALITY CONTROL

A. Replace any nameplates, signs, conductor markers, cable markers, or raceway labels that in the sole opinion of the Engineer do not meet the Engineer’s aesthetic requirements.

END OF SECTION

SECTION 26 05 73

SHORT-CIRCUIT, PROTECTIVE DEVICE COORDINATION & ARC-FLASH STUDY

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Short-circuit fault analysis study.
2. Protective device coordination study.
3. Arc-flash hazard study.

B. Related Sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01 33 00 - Submittal Procedures.
   b. Section 01 71 13 - Mobilization.
   c. Section 26 05 00 - Electrical – General Provisions.

1.02 REFERENCES

A. As specified in Section 26 05 00.

B. Institute of Electrical and Electronics Engineers (IEEE):

1. 141 - IEEE Recommended Practice for Electric Power Distribution for Industrial Plants (Red Book).
2. 242 - IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (Buff Book).
3. 315 - IEEE Standards Electrical and Electronics Graphic and Letter Symbols and Reference Designations.
4. 399 - IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis (Brown Book).
5. 902 - IEEE Guide for Maintenance, Operation and Safety on Industrial and Commercial Power Systems (Yellow Book).

6. 1015 - IEEE Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems - Corrigendum 1 (Blue Book).
7. 1584 - IEEE Guide for Performing Arc Flash Hazard Calculations.

C. National Fire Protection Association (NFPA):

1. 70E - Standard for Electrical Safety in the Workplace.

1.03 DEFINITIONS

A. As specified in Section 26 05 00.

1.04 SYSTEM DESCRIPTION

A. General Study Requirements:

1. Scope:

a. The short-circuit fault analysis, protective device coordination, and arc-flash hazard studies shall include all new and modified electrical distribution system Lakeview Lift Station or modified under this contract as shown on drawings and as describes in this specification. The end result shall be a fully protected, and properly coordinated, system with proper arc flash safety labels and personal protective equipment recommendations Electrical equipment, in the power distribution system including, but not limited to:

i. Utility equipment.
ii. Main Breakers.
iii. Automatic Transfer Switches.
iv. Generators.
v. Transformers:
   I. Including all dry-type transformers.
vi. Motor control centers.
vii. Freestanding variable frequency drives and starters.
viii. Disconnect switches.
ix. Motors.
x. Panelboards:
   I. Including all 480-volt and 208-volt systems.
xi. Vendor control panels.
xii. HVAC equipment.

b. Study scenarios, as applicable:

i. The studies shall include all possible electrical system configurations, for example:
   I. Operation on normal (utility) source.

II. Operation on generator source.

III. Parallel operation on normal and generator sources.

IV. Main-breakers closed; tie-breaker open.

V. Either main-breaker open, tie-breaker closed.

2. Obtain, for all equipment, the required data for preparation of the study including, but not limited to:

   a. Transformer kilovolt-ampere (kVA) and impedances.

   b. Generator impedances.

   c. Generator decrement curves.

   d. Bus withstand ratings.

   e. Cable and bus data.

   f. Protective device taps, time dials, instantaneous pickups, and time-delay settings.

3. Obtain the Electric Utility information on the minimum and maximum available fault current, minimum and maximum utility impedances, utility protective device settings including manufacturer and model number, interrupting ratings, X/R ratios, and model information one level above the point of connection:

   a. Utility tolerances and voltage variations.

4. Contractor shall furnish all field data as required for the power system studies. The Engineer performing the short-circuit, protective device coordination and arc flash hazard analysis studies shall furnish the Contractor with a listing of required data immediately after award of the contract. The Contractor shall expedite collection of the data to eliminate unnecessary delays and assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to the release of the equipment for manufacturing. As-built drawings for existing electrical equipment are available if requested to the Owner.

5. Obtain equipment layouts and configurations from the manufacturer's final submittal requirements and project layout drawings as required.

6. Bus and conductor data:

   a. Use impedances of the actual installed or specified conductors, unless otherwise indicated.

   b. Use cable and bus impedances calculated at 25 degrees Celsius, unless otherwise indicated.

   c. Use 600-volt cable reactance based on typical dimensions of actual installed or specified conductors, unless otherwise indicated.

   d. Use bus withstand values for all equipment having buses.

   e. Use medium-voltage cable reactances based on typical dimensions of shielded cables with 133-percent insulation levels, unless otherwise indicated.

7. Motors:
    a. Each motor shall be individually modeled:
        i. Grouping of motors for fault contribution current is not acceptable.
    b. Motors with variable frequency drives may be assumed to have no contribution to fault current.
8. Use the equipment, bus, and device designations as indicated on the Drawings for all studies.

B. Short-circuit fault analysis study additional requirements:
1. The short-circuit fault analysis shall be performed and submitted in 2 phases:
    a. Initial short-circuit fault analysis:
        i. Based on the Contract Documents and Electric Utility information.
        ii. The initial short-circuit fault analysis study shall indicate the estimated available short-circuit current at the line side terminals of each piece of equipment covered by the scope of the study.
        iii. Provide a list of assumptions used in the initial study.
    b. Final short-circuit fault analysis:
        i. The final short-circuit fault analysis shall modify the initial analysis as follows:
            I. Utilize the actual equipment provided on the project.
            II. Utilize conductor lengths based on installation.
2. Calculate 3-phase bolted fault, line-to-line fault, line-to-ground fault, double line-to-ground fault, short-circuit 1/2 cycle momentary symmetrical and asymmetrical RMS, 1-1/2 and 4 cycle, interrupting symmetrical RMS, and 30-cycle steady-state short-circuit current values at each piece of equipment in the distribution system.
3. Evaluate bus bracing, short-circuit ratings, fuse interrupting capacity and circuit-breaker-adjusted interrupting capacities against the fault currents, and calculate X/R values:
    a. Identify and document all devices and equipment as either inadequate or acceptable.
4. Calculate line-to-ground and double line-to-ground momentary short-circuit values at all buses having ground-fault devices.
5. Provide calculation methods, assumptions, one-line diagrams, and source impedance data, including utility X/R ratios, typical values, recommendations, and areas of concern.

C. Protective device coordination study additional requirements:

1. Furnish protective device settings for all functions indicated on the Drawings including, but not limited to:
   a. Current.
   b. Voltage:
      i. Provide settings for all voltage relays based upon actual utility and generator tolerances and specifications.
   c. Frequency:
      i. Provide settings for all frequency relays based upon actual utility and generator tolerances and specifications.
   d. Negative sequence.
   e. Reverse power.
   f. Machine protection functions:
      i. Provide settings for all motor and generator protective relays based on the manufacturer's recommended protection requirements.
2. Provide log-log form time-current curves (TCCs) graphically indicating the coordination proposed for the system:
   a. Include with each TCC a complete title and one-line diagram with legend identifying the specific portion of the system covered by the particular TCC:
      i. Typical TCCs for identical portions of the system, such as motor circuits, are acceptable as allowed by the Engineer.
   b. Include a detailed description of each protective device identifying its type, function, manufacturer, and time-current characteristics:
      i. These details can be included on the TCC.
   c. Include a detailed description of each protective device tap, time dial, pickup, instantaneous, and time delay settings:
      i. These details can be included on the TCC.
3. TCCs shall include all equipment in the power distribution system where required to demonstrate coordination. Include utility relay and fuse characteristics, medium-voltage equipment protective relay and fuse characteristics, low-voltage equipment circuit breaker trip device characteristics, transformer characteristics, motor and generator characteristics, and characteristics of other system load protective devices:
   a. Include all devices down to the largest branch circuit and largest feeder circuit breaker in each motor control center, main breaker in branch panelboards, and fused disconnect switches.
   b. Provide ground fault TCCs with all adjustable settings for ground fault protective devices.

c. Include manufacturing tolerances and damage bands in plotted fuse and circuit breaker characteristics.

d. On the TCCs, show transformer full load currents, transformer magnetizing inrush, ANSI transformer withstand parameters, and transformer damage curves.

e. Cable damage curves.

f. Terminate device characteristic curves at a point reflecting the maximum symmetrical or asymmetrical fault current to which the device is exposed based on the short-circuit fault analysis study.

g. Coordinate time interval medium-voltage relay characteristics with upstream and downstream devices to avoid nuisance tripping.

4. Site generation: When site generation (including cogeneration, standby, and emergency generators) is part of the electrical system, include phase and ground coordination of the generator protective devices:

   a. Show the generator decrement curve and damage curve along with the operating characteristic of the protective devices.

5. Suggest modifications or additions to equipment rating or settings in a tabulated form.

D. Arc-flash hazard study additional requirements:

1. Include the calculated arc-flash boundary and incident energy (calories/square centimeter) at each piece of equipment in the distribution system:

   a. Perform study with 15 percent arcing fault variation as defined by IEEE 1584.

   b. Perform arc-flash calculations at minimum and maximum utility and generator fault contributions.

   c. Perform arc-flash calculations for both the line side and load side of the switchgear, switchboard, motor control center, and panelboard main breakers.

   d. Perform arc-flash calculations for all short-circuit scenarios with all motors on for 3 to 5 cycles and with all motors off.

   e. Protective device clearing time shall be limited to 2 seconds, maximum.

2. Provide executive summary of the study results:

   a. Provide summary based upon worst case results.

3. Provide a detailed written discussion and explanation of the tabulated outputs:

   a. Include all scenarios.

4. Provide alternative device settings to allow the Owner to select the desired functionality of the system:

   a. Minimize the arc-flash energy by selective trip and time settings for equipment maintenance purposes.

b. Identify the arc-flash energy based upon the criteria of maintaining coordination and selectivity of the protective devices.

E. Electrical system study meetings:

1. The individual conducting the short-circuit fault analysis, protective device coordination, and the arc-flash hazard studies shall meet with the Owner and Engineer 3 times.

2. The purpose of the 3 meetings is as follows:

   a. Initial meeting:

      i. Meet with the Owner and Engineer to discuss the scope of the studies.

      ii. Discuss the Owner's operational requirements for both normal operation and maintenance.

   b. Preliminary results meeting:

      i. This meeting will be held after the studies have been completed, reviewed, and accepted by the Engineer.

      ii. The purpose of this meeting is to inform the Owner of the results of the study and impacts on normal operation and maintenance including:

         I. Protective device coordination problems and recommended solutions.

         II. Explanation of the arc-flash hazard study results and its potential impact on operations.

         III. Recommendations for reduction of arc-flash category levels including reduction of protective device settings or changes in operational practices.

   c. Final meeting:

      i. Discuss changes to the studies based on the previous meeting.

      ii. Discuss with the Owner how changes to the electrical system may change the arc-flash hazard category.

      iii. Deliver the final electrical system studies report.

3. The meetings will be at the Owner's facility:

   a. Provide a minimum of 3 weeks notice to the Owner and Engineer in advance of the projected meeting date.

   b. Submit a draft of the meeting agenda when each meeting is requested.

4. Meeting materials:

   a. Prepare and provide the following materials:

      i. Meeting agenda. Include, at a minimum, the scope of the meeting, estimated time length for the meeting, and meeting goals.

      ii. 6 copies of the project one-line diagrams for the initial meeting.

iii. 6 copies of the submitted studies.

F. By virtue of the fact that this is a professional study, the Owner reserves the right to modify the requirements of the study to comply with its operational requirements. The protective device coordination study and the arc-flash hazard study shall be modified based on the results of the meetings with the Owner.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01 33 00 and 26 05 00.

B. Initial studies and reports:

1. Include the following in the initial short-circuit current report:

   a. List of all devices included in the studies.

   b. A description of all operating scenarios.

   c. Form and format of arc-flash labels.

C. Final studies and reports:

1. Format and quantity:

   a. Provide 6 bound copies of all final reports.

   b. Provide 3 complete sets of electronic files on CD or DVD media, including the electrical system model(s), configuration files, custom libraries, and any other files used to perform the studies and produce the reports. Also provide an electronic version of the bound reports in PDF format.

   c. Provide the number of copies specified in Section 01 33 00.

2. Include the sections below in the final report:

   a. Copies of correspondence and data obtained from the electric utility company.

   b. Letter certifying the inspection and verification of existing equipment.

   c. One-line diagrams:

      i. The following information shall be included at a minimum:

         I. Motor horsepower.

         II. Transformer data:

         - kVA.
         - Configuration.

         III. Cable data:

         - Insulation.
         - Size.
         - Length.

      ii. One-line diagrams shall be fully legible at 11-inch by 17-inch size.

d. Include in the short-circuit fault analysis study:

i. Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.

ii. Normal system connections and those that result in maximum fault conditions.

iii. Tabulation of circuit breaker, fuse, and other protective device ratings compared to maximum calculated short-circuit duties.

iv. Fault current calculations for the cases run including a definition of terms and guide for interpretation of computer software printouts.

e. Protective device coordination study shall include:

i. Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.

ii. List all requirements used in the selection and setting criteria for any protective devices.

iii. Manufacturer's time-current curves for circuit breakers, fuses, motor circuit protectors, and other protective devices for all new equipment.

iv. TCCs graphically indicating the coordination proposed for the system on log-log graphs. At least 3 of the copies shall be in color.

v. Tabulation of relay, fuse, circuit breaker, and other protective devices in graphical form with a one-line diagram to display area coordination.

vi. Where coordination could not be achieved, an explanation shall be included in the report to support the statement along with recommendations to improve coordination. Recommended equipment modifications or settings shall be in a tabulated form.

f. Include in the arc-flash hazard study:

i. Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.

ii. Normal system connections and those that result in maximum arc-flash conditions.

iii. Arc-flash raw data, calculations, and assumptions.

iv. Arc-flash label data:

I. Identifying the content of each label.

II. Identifying the location of each label.

D. Certification:

1. Submit written certification, sealed and signed by the professional engineer conducting the study, equipment supplier, and electrical subcontractor stating that the data used in the study is correct.

E. Submit the credentials of the individual(s) performing the study and the individual in responsible charge of the study.

F. The Engineer will review all studies and reports. After review, the Engineer will make recommendations and/or require changes to be made to the short-circuit fault analysis, protective device coordination, or arc-flash hazard studies. These changes shall be provided as part of the scope of work.

G. Submit course outline for Owner's training.

1.06 QUALITY ASSURANCE

A. As specified in Section 26 05 00.

B. Qualifications of the entity responsible for electrical system studies:

1. The studies shall be performed, stamped, and signed by a professional engineer registered in the state where the project is located.
2. A minimum of 5 years of experience in power system analysis is required for the individual in responsible charge of the studies.
3. The short-circuit fault analysis, protective device coordination, and arc-flash hazard studies shall be performed with the aid of a digital computer program:
    a. Point-to-point calculations are not acceptable.

C. The study shall be performed by an independent firm.

1.07 SEQUENCING

A. Site visit to gather data on the existing facility systems for all studies:

1. Make multiple trips as required to obtain all data for the short-circuit fault analysis, protection device coordination, and arc flash hazard studies. Field data collection shall be part of the Contractor's scope.

B. An initial, complete short circuit and arc flash study must be submitted and reviewed before Engineer will approve Shop Drawings for switchgear, unit sub stations, breakers, MCC'S, switchboard, VFD'S, manufactured industrial control panels and circuit breaker panelboard equipment. Failure to do so will delay the approval of major equipment submittals.

C. Initial electrical system study meeting, if required.

D. Final arc-flash meeting and final short-circuit fault analysis, protective device coordination, and arc-flash hazard studies. All comments and modifications from the initial study shall be incorporated in the final study submittal.

E. Set all electrical equipment as per final study and label equipment with approved arc-flash labels.

F. Owner's Training.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Electrical system study software:

1. Powertools by SKM Systems Analysis.

B. The software file of the approved study shall be submitted on a thumb drive.

2.02 COMPONENTS

A. Arc-flash hazard labels:

1. Dimensions:

a. Minimum 5 inches by 3.5 inches.

2. Materials:

a. Polyester with polyvinyl polymer over-laminate.

b. Self-adhesive.

c. Resistant to:

i. UV.

ii. Chemicals and common cleaning solvents.

iii. Scuffing.

iv. Wide temperature changes.

3. Contents:

a. Short-circuit bus identification.

b. Calculated incident energy (calories/square centimeter) range:

i. Based on worst-case study results.

c. Hazard/risk personnel protective equipment category number.

d. Arc-flash protection boundary.

e. Shock hazard boundary:

i. The Contractor may provide separate labels for indication of the shock hazard boundary.

f. Description of the combined level of personnel protective equipment.

4. Color scheme:

a. For locations above 40 calories/square centimeter:

i. White label with red "DANGER" strip across the top.

ii. Black lettering.

b. For locations below 40 calories/square centimeter:

i. White label with orange "WARNING" strip across the top.

ii. Black lettering.

PART 3 - EXECUTION

3.01 INSTALLATION

A. As specified in Section 26 05 00.

B. After review and acceptance of the arc-flash hazard study by the Engineer, install all arc-flash hazard labels:

1. Install labels at all locations required by NFPA, ANSI, or IEEE standards.
2. At a minimum, install labels in the following locations:
   a. The front of each main or incoming service compartment.
   b. The front of each low-voltage switchgear section.
   c. The front of each medium-voltage circuit breaker door.
   d. The front of each accessible auxiliary or conductor compartment.
   e. Each accessible rear or side vertical section.
   f. Each motor control center compartment.
   g. Each panelboard covered by the study.
   h. Each control panel, individual starter or VFD, or other equipment covered by the scope of the study.
3. Install labels prior to equipment energization.

C. After review and acceptance of the arc-flash hazard study and protective device coordination study by the Engineer, adjust protective device settings per final study prior to equipment energization.

1. Devices that require power for configuration may be set during energization, but before any subfed loads are energized.
2. Ensure that settings for upstream equipment are set prior to energizing downstream devices.

3.02 COMMISSIONING AND PROCESS START-UP

A. As specified in Section 00 16 55.

3.03 FIELD QUALITY CONTROL

A. As specified in Section 26 05 00.

B. The individual performing the arc-flash hazard study shall direct the installation of the arc-flash hazard labels:

1. Remove and replace any improperly applied labels.
2. Repair the equipment finish damaged by removal of any label.
3. Install labels to within 1/64 inch of level or plumb across the entire dimension of the label.

END OF SECTION

SECTION 26 05 90

MISCELLANEOUS ELECTRICAL DEVICES

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Furnish and install all miscellaneous equipment as hereinafter specified and as shown on the Drawings.

1.02 SUBMITTALS

A. Submit to the ENGINEER, in accordance with Specification Section 01 33 00, detailed catalog information or drawings with sufficient detail to determine compliance with the specifications including describing electrical and physical characteristics of all equipment specified.

1.03 REFERENCE STANDARDS

A. Equipment enclosures shall have NEMA rating suitable for the location in which they are installed, as specified in Section 26 05 00.

PART 2 - PART 2 – PRODUCTS

2.01 MATERIALS

A. Disconnect Switches:

1. Disconnect switches shall be heavy-duty, NEMA type H, quick-make, quick-break, visible blades, 600 volt, 3 pole with full cover interlock. All current carrying parts shall be copper.
2. Enclosure type shall be NEMA 4X, 316 stainless steel with copper lugs. Exterior hardware to be 316 SS.
3. Lugs shall be copper.
4. Exterior hardware to be 316 SS.
5. Switches shall be horsepower rated as manufactured by the Square D Co., or approved equal.
6. Control wiring shall not pass through any disconnect enclosure. A junction box shall be provided and constructed of the same material as the disconnect switch. The junction box is to be utilized to separate power and control wiring prior to the disconnect enclosure. Feeder wiring shall be fed from the disconnect switch and control wiring shall be wired from the junction box directly to the equipment being controlled.
7. Each disconnect shall be provided with a plastic nameplate, affixed to the enclosure without screws, identifying the equipment served, voltage, and circuit designation.

B. Fused Disconnect Switches:

1. Fused disconnect switches with rejection clips shall be NEMA 4X heavy duty, quick make, quick break, visible blades, 600 Volt, 3 Pole with full cover interlock, interlock defeat and flange mounted operating handle unless otherwise noted. All current carrying parts shall be copper.
2. Fuses shall be rejection type, 600 Volt, 200,000 AIC dual element, time delay, Bussman Fusetron Class RK-5 or equal.
3. Enclosure type shall be NEMA 4X, 316 stainless steel with copper lugs. Exterior hardware to be 316 SS.
4. NEMA 7 enclosures shall be cast aluminum.
5. Lugs shall be copper.
6. Exterior hardware to be 316 SS.
7. Switches shall be horsepower rated as manufactured by the Square D Co., or approved equal.
8. Control wiring shall not pass through any disconnect enclosure. A junction box shall be provided and constructed of the same material as the disconnect switch. The junction box is to be utilized to separate power and control wiring prior to the disconnect enclosure. Feeder wiring shall be fed from the disconnect switch and control wiring shall be wired from the junction box directly to the equipment being controlled.
9. Each disconnect shall be provided with a plastic nameplate, affixed to the enclosure without screws, identifying the equipment served, voltage, and circuit designation.

C. Magnetic Motor Starters:

1. Motor starters shall be 2 or 3 pole, single or 3 phase as required, 60 Hz, 600 Volt, magnetically operated, full voltage non-reversing unless otherwise shown in the drawings. NEMA sizes shall be as required for the horsepower shown on the drawings.
2. Two speed starters shall be for single or two winding motors as required by the actual motor furnished or as shown on the drawings.
3. Each motor starter shall have a 120 Volt operating coil, and control power transformer. Starters shall have motor overload protection in each phase. Auxiliary contacts shall be provided as required or as shown in the drawings. A minimum of one N.O. and one N.C. auxiliary contacts shall be provided in addition to the contacts shown on the drawings.
4. Overload relays shall be non-adjustable, ambient compensated and manually reset.
5. Control power transformers shall be sized for additional load where required. Transformer secondaries shall be equipped with time delay fuses.
6. Built-in control stations and indicating lights shall be furnished as specified herein where shown on the drawings.

7. NEMA 4X enclosures shall be 304 stainless steel.
8. NEMA 7 enclosures shall be cast aluminum.
9. Each enclosure/starter shall be provided with a plastic nameplate, affixed to the enclosure without screws, identifying the equipment served, voltage, and circuit designation.
10. Starters shall be as manufactured by the Square D Co., or approved equal.

D. Combination Magnetic Motor Starters:

1. Motor starters shall be a combination motor circuit protector and contactor, 2 or 3 pole, single or 3 phase as required, 60 Hz, 600 Volt, magnetically operated, full voltage non-reversing unless otherwise shown on the drawings. NEMA sizes shall be as required for the horsepowers shown on the drawings. Motor circuit protectors shall be molded case with adjustable magnetic trip only. They shall be specifically designed for use with magnetic motor starters. Motor circuit protectors shall be current limiting type, with additional current limiters if required. Combination motor starters shall be fully rated for 22,000 Amps RMS symmetrical.
2. Two speed starters shall be for single or two winding motors as required by the actual motor furnished or as shown on the drawings.
3. Each motor starter shall have a 120 Volt operating coil, and control power transformer. Starters shall have motor overload protection in each phase. Auxiliary contacts shall be provided as required or as shown on the drawings. A minimum on one N.O. and one N.C. auxiliary contacts shall be provided in addition to the contacts shown on the drawings.
4. Overload relays shall be non-adjustable, ambient compensated and manually reset.
5. Control power transformers shall be sized for additional load where required. Transformer secondaries shall be equipped with time delay fuses.
6. Built-in control stations and indicating lights shall be furnished as specified herein where shown on the drawings.
7. NEMA 4X enclosures shall be 304 stainless steel.
8. NEMA 7 enclosures shall be cast aluminum.
9. Each enclosure/starter shall be provided with a plastic nameplate, affixed to the enclosure without screws, identifying the equipment served, voltage, and circuit designation.
10. Starters shall be as manufactured by the Square D Co., or approved equal.

E. Control Stations and Indicators:

1. Control stations shall be heavy duty type, with full size (30.5 mm) NEMA 4X or 7 operators, indicators, etc.

2. Indicators shall be full voltage and push to test type. Indicators located indoors shall be LED type and indicators located outdoors shall be incandescent lamp type.
3. NEMA 4x enclosures shall be 304 stainless steel.
4. NEMA 7 enclosures shall be cast aluminum.
5. Each station shall be provided with a plastic nameplate, affixed to the enclosure without screws, identifying the equipment served, voltage, and circuit designation.
6. Starters shall be as manufactured by the Square D Co., or approved equal.

F. Dry Type Lighting Transformers.

1. Transformers shall be dry type, two-winding with KVA and voltage ratings as shown on the Drawings.
2. Transformers shall be UL listed in accordance with applicable ANSI C89.2, NEMA ST-20 and IEEE Standards.
3. Transformers shall be provided in NEMA 1 enclosures unless otherwise noted on the drawings or as required by Section 16 05 00. Where a NEMA 4X and/or stainless steel enclosures is required, the transformers shall be totally enclosed, non-ventilated heavy gauge steel enclosure.
4. Transformers shall be furnished with hot dipped galvanized mounting hardware. Where NEMA 4X and/or stainless steel enclosure is required, the hardware shall be 304 stainless steel.
5. Core and coil shall be completely embedded within a resin compound for quiet and low temperature operation.
6. Four full capacity taps shall be furnished, two 2-1/2% above and two 2-1/2% below rated primary voltage.
7. Maximum insulation temperature rise of 80°C. Windings shall be copper.
8. Transformers shall be as shall be as manufactured by the Square D Co., or approved equal.

G. Wireway:

1. NEMA 1 wireway shall be gasketed painted steel with stainless steel cover.
2. NEMA 4X wireway shall be 304 Stainless Steel with gasketed clamped covers
3. As manufactured by the Hoffman Engineering Co. or equal.

H. Control Relays:

1. Control relays shall be heavy duty machine type, with 10 amp, 300 Volt convertible contacts. Number of contacts and coil voltage shall be as shown on the drawings. General use relays shall be Square D Co., Class 8501 Type X, similar by Cutler Hammer, Allen Bradley or Siemens. Latching relays shall be

Square D Co., Class 8501 Type X, similar by Cutler Hammer, Allen-Bradley or Siemens.

2. Time delay relays shall be pneumatic, 600 Volt, 20 Amp contacts with calibrated knob operated adjustment and numerical time dial. On delay and off delay types and timing ranges shall be as shown on the drawings or as required for proper operation of the actual equipment furnished. Relays shall be Agastat Model 7012 or 7022 or equal.

I. Detectable Polyethylene Warning Tape:

1. Warning tape shall be 5 mil red polyethylene film, 6 inch minimum width. Tape shall be capable of being detected by either conductive or inductive location techniques.

2. Warning tape shall be Mutual Industries Part No. 17774 or equal.

J. Terminal Blocks:

1. Terminal blocks shall be 600 Volt, channel mounted, with tubular screw and pressure plate.

2. Terminal blocks shall be Bulletin 1492-CA1 as manufactured by the Allen-Bradley Co. or equal.

K. JIC Boxes for GF Receptacles:

1. JIC boxes shall be 6-inches x 6-inches x 4-inches aluminum continuous hinge clamp cover boxes, Hoffman Catalog No. A-606 CHAL with type L23 stainless steel fast operating JIC clamp or equal.

2. Install 1-1/2 inch bushings in the bottom of box for cord and plug to pass through.

L. Corrosion Inhibitors:

1. All equipment enclosures, terminal boxes, etc., located in a NEMA 4X rated area (where shown on the drawings) that contain electrical or electronic equipment or terminal strips shall be furnished with an internally mounted, chemically treated corrosion inhibitor pad.

2. The corrosion inhibitor pads shall be as manufactured by Hoffman Engineering Co., or 3M or equal.

M. Equipment Mounting Stands:

1. Mounting stands shall be custom fabricated from ¼ inch 316 stainless steel plate and 3-inch stainless steel channel, unless otherwise shown on the drawings.

2. All hardware shall be 316 stainless steel.

N. Terminal Cabinets:

1. Interiors shall be so designed that control relays and terminal blocks can be replaced or added without disturbing adjacent units. Each cabinet shall be furnished a minimum of 50 spare terminals.

2. All interiors shall be completely factory assembled with control realys, terminal blocks, insulating barriers, etc. All 120 Volt AC and DC terminal blocks shall be isolated from each other by insulating barriers or separate enclosures.

3. All wiring within the cabinets shall be grouped together in harnesses and secured to the structure.

4. All shielded cables shall terminate in separate cabinets. A third terminal shall be provided for each twisted pair and the shield for each connected thereto, unless otherwise noted on manufacturer's shop drawings.

5. Terminal blocks shall be tubular screw type with pressure plates and shall be rated 600 Volts. Terminal blocks shall be Allen Bradley or equal.

6. Boxes shall be made of 14 gauge galvanized steel and shall be of sufficient size to provide a minimum of 4 inches of wiring space on all sides and between adjacent terminal blocks. A minimum 2-inch spare shall be provided between control relays. A minimum of four mounting studs shall be furnished without knockouts. Holes for raceways shall be drilled on the job.

7. A single or double hinged door shall cover the front of each terminal cabinet. Doors shall have a neoprene gasket, vault type handle, three-point catch and lock. Two keys shall be supplied for each lock. All locks shall be keyed alike. A terminal block schedule shall be provided with each terminal point numbered and identified (Typewritten) as to function.

8. All exterior and interior steel surfaces of the cabinets shall be properly cleaned and finished with ANSI 61 grey over a rust inhibiting phosphatized coating conforming to ANSI A55.1. The finish paint shall be of a type to which field applied paint will adhere.

9. Cabinets in wet, damp, corrosive and all outdoor locations shall be NEMA 4X 304 Stainless Steel.

10. Cabinets shall be Hoffman Engineering Co, with latch kit hardware or be an equal product.

O. Intrinsically Safe Relays:

1. Intrinsically safe relays should be solid state type with 5 amp output contacts, suitable for use on a 120 Volt, 60 Hz power and shall be FM approved for pilot devices in Class 1, Division 1, Group D hazardous atmosphere.

2. Intrinsically safe relays shall be Gems Solid State Safe-Pak as manufactured by Gems Sensors or equal.

P. Push Buttons, Selector Switches, and Indicating Lights

1. Remote-mounted push buttons, selector switches, and indicating lights located outdoors and in areas identified as "Corrosive Area" shall be heavy duty, oiltight type with synthetic rubber boots and include any special gasketing required to make the complete station watertight. Provide NEMA Type 4X watertight, corrosion-resistant enclosures constructed of stainless steel for devices located in

areas identified as “corrosive area” and NEMA Type 4 watertight enclosures for devices located outdoors in noncorrosive areas.

2. Remote-mounted push buttons, selector switches, and indicating lights located indoors shall be heavy duty, oiltight type with NEMA Type 12 enclosures.
3. Provide Allen-Bradley Bulletin 800H; Square D Class 9001, Type SK; Siemens or equal.

PART 3 - PART 3 - EXECUTION

3.01 INSTALLATION

A. Spares

1. Provide three spare fuses of each type and ampere rating installed.

B. Installing Intrusion Alarm Switches

1. The switches shall be interfaced with the PLC. Mount switch on inside hatch or doorframe such that when the hatch cover or door is opened, the normally open switch contacts shall close and, when hatch cover or door is closed, the normally open switch contacts shall open.

C. Field Testing

1. Operate each disconnect switch three times, under load, and verify that all phases of the load are disconnected each time.
2. Operate push button and selector switches and verify that the equipment controlled operates per the drawings or other sections of these specifications.
3. Photoelectric Switch: Simulate nighttime by placing object over sensor or witness nighttime automatic controls. Verify lights turn on and off.
4. Time Switches: Test per manufacturer's recommendations.

END OF SECTION

SECTION 26 08 00

FIELD ELECTRICAL ACCEPTANCE TESTS

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes:

1. Responsibilities for testing the electrical installation.
2. Adjusting and calibration.
3. Acceptance tests.

B. Related sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01 33 00 - Submittal Procedures.
   b. Section 01 71 13 - Mobilization.
   c. Section 26 05 00 - Electrical – General Provisions.
   d. Section 26 05 26 - Grounding System.

C. Copyright information:

1. Some portions of this Section are copyrighted by the InterNational Electrical Testing Association, Inc (NETA). See NETA publication ATS for details.

1.02 REFERENCES

A. As specified in Section 26 05 00.

B. American National Standards Institute (ANSI).

C. ASTM International (ASTM):

1. D 877 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
2. D 923 - Standard Practices for Sampling Electrical Insulating Liquids.
3. D 924 - Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.
4. D 971 - Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method.

5. D 974 - Standard Test Method for Acid and Base Number by Color-Indicator Titration.
6. D 1298 - Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
7. D 1500 - Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale).
8. D 1524 - Standard Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field.
9. D 1533 - Standard Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration.
10. D 1816 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using VDE Electrodes.
11. D 2285 - Standard Test Method for Interfacial Tension of Electrical Insulating Oils of Petroleum Origin Against Water by the Drop Weight Method.
12. D 3612 - Standard Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography.

D. Institute of Electrical and Electronics Engineers (IEEE):

1. 43 - IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
2. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.
3. 95 - IEEE Recommended Practice for Insulation Testing of AC Electric Machinery (2300 V and Above) With High Direct Voltage.
4. 421.3 - IEEE Standard for High-Potential Test Requirement for Excitation Systems for Synchronous Machines.
5. 450 - IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.
6. 1106 - IEEE Recommended Prictice for Installation, Maintenance, Testing, and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications.
7. 1188 - IEEE Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications.
8. C57.13 - IEEE Standard Requirements for Instrument Transformers.
9. C57.13.1 – IEEE Guide for Field Testing of Relaying Current Transformers.
10. C57.13.3 - IEEE Guide for Grounding of Instrument Transformer Secondary Circuits and Cases.
11. C57.104 - IEEE Guide for the Interpretation of Gases Generated in Oil-Immersed Transformers.

E. Insulated Cable Engineer’s Association (ICEA).

F. InterNational Electrical Testing Association (NETA).

1. ATS-2009 Standard for Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems.

G. International Electrotechnical Commission (IEC).

H. Manufacturer's testing recommendations and instruction manuals.

I. National Fire Protection Association (NFPA):

1. 70 – National Electrical Code (NEC).

2. 110 - Standard for Emergency and Standby Power Systems.

J. National Institute of Standards and Technology (NIST).

K. Specification sections for the electrical equipment being tested.

L. Shop drawings.

1.03 DEFINITIONS

A. As specified in Sections 01 71 13 and 26 05 00.

B. Specific definitions:

1. Testing laboratory: The organization performing acceptance tests.

1.04 SYSTEM DESCRIPTION

A. Testing of all electrical equipment installed under this Contract in accordance with the manufacturer's requirements and as specified in this Section.

B. Conduct all tests in the presence of the Engineer or the Engineer's representative:

1. The Engineer will witness all visual, mechanical, and electrical tests and inspections.

C. The testing and inspections shall verify that the equipment is operational within the tolerances required and expected by the manufacturer, and these Specifications.

D. Responsibilities:

1. Contractor responsibilities:

a. Ensure that all resources are made available for testing, and that all testing requirements are met.

2. Electrical subcontractor responsibilities:

a. Perform routine tests during installation.

b. Demonstrate operation of electrical equipment.

c. Commission the electrical installation.

d. Provide the necessary services during testing, and provide these services to the testing laboratory, Contractor, and other subcontractors, including but not limited to:

i. Providing electrical power as required.

ii. Operating of electrical equipment in conjunction with testing of other equipment.

iii. Activating and shutting down electrical circuits.

iv. Making and recording electrical measurements.

v. Replacing blown fuses.

vi. Installing temporary jumpers.

3. Testing laboratory responsibilities:

a. Perform all acceptance tests specified in this Section.

b. Provide all required equipment, materials, labor, and technical support during acceptance tests.

E. Upon completion of testing or calibration, attach a label to all serviced devices:

1. The label shall indicate the date serviced and the company that performed the service.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01 33 00 and 26 05 00.

B. Manufacturers' testing procedures:

1. Submit manufacturers' recommended testing procedures and acceptable test results for review by the Engineer.

C. Test report:

1. Include the following:

a. Summary of Project.

b. Description of equipment tested.

c. Description of tests performed.

d. Test results.

e. Conclusions and recommendations.

f. Completed test forms.

g. List of test equipment used and calibration dates.

h. LAN cable test reports.

D. Testing laboratory qualifications:

1. Submit a complete resume and statement of qualifications from the proposed testing laboratory detailing their experiences in performing the tests specified:

a. This statement will be used to determine whether the laboratory is acceptable, and shall include:

i. Corporate history and references.

ii. Resume of individual performing test.

iii. Equipment list and test calibration data.

E. Division of responsibilities:

1. Submit a list identifying who is responsible for performing each portion of the testing.

1.06 QUALITY ASSURANCE

A. As specified in Section 26 05 00.

B. Testing laboratory qualifications:

1. The testing laboratory may be qualified testing personnel from the electrical subcontractor's staff or an independent testing company.
2. Selection of the testing laboratory and testing personnel is subject to approval by the Engineer based on testing experience and certifications of the individuals and testing capabilities of the organization.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 26 05 00.

1.08 SEQUENCING

A. At least 30 days before commencement of the acceptance tests, submit the manufacturer's complete field testing procedures to the Engineer and to the testing laboratory, complete with expected test results and tolerances for all equipment to be tested.

B. Perform testing in the following sequence:

1. Perform routine tests as the equipment is installed including:
   a. Insulation-resistance tests.
   b. Continuity tests.
   c. Rotational tests.
2. Adjusting and preliminary calibration.
3. Acceptance tests.
4. Demonstration.
5. Commissioning and plant start-up.

1.09 WARRANTY

A. As specified in Section 26 05 00.

PART 2 - PRODUCTS - NOT USED

PART 3 - EXECUTION

3.01 PREPARATION

A. Test instrument calibration:

1. Utilize a testing laboratory with a calibration program which maintains all applicable test instrumentation within rated accuracy.
2. The accuracy shall be traceable to the NIST in an unbroken chain.
3. Calibrate instruments in accordance with the following frequency schedule:
    a. Field instruments: 6 months maximum.
    b. Laboratory instruments: 12 months maximum.
    c. Leased specialty equipment where accuracy is guaranteed by the lessor (such as Doble): 12 months maximum.
4. Dated calibration labels shall be visible on all test equipment.
5. Maintain an up-to-date instrument calibration record for each test instrument:
    a. The records shall show the date and results of each calibration or test.
6. Maintain an up-to-date instrument calibration instruction and procedure for each test instrument.

B. Do not begin testing until the following conditions have been met:

1. All instruments required are available and in proper operating condition.
2. All required dispensable materials such as solvents, rags, and brushes are available.
3. All equipment handling devices such as cranes, vehicles, chain falls and other lifting equipment are available or scheduled.
4. All instruction books, calibration curves, or other printed material to cover the electrical devices are available.
5. Data sheets to record all test results are available.

3.02 COMMISSIONING AND PROCESS START-UP

A. As specified in Section 00 16 55.

3.03 FIELD QUALITY CONTROL

A. Switchgear:

1. Visual and mechanical inspection:
    a. Compare equipment nameplate data with the Contract Documents.
    b. Inspect physical and mechanical condition.
    c. Inspect anchorage, alignment, grounding and required area clearances.
    d. Inspect equipment for cleanliness.

e. Verify that circuit breaker/fuse sizes and types correspond to the approved submittals and the coordination study as well as to the circuit breaker's address for microprocessor-communication packages.

f. Verify that current and voltage transformer ratios correspond to that indicated on the Drawings.

g. Verify that wiring connections are tight and that wiring is secure to prevent damage during routine operation of moving parts.

h. Inspect bolted electrical connections for high resistance using one of the following methods:

    i. Use of low-resistance ohmmeter.

    ii. Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:

        I. Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.

i. Mechanical and electrical interlocks:

    i. Attempt closure on locked-open devices.

    ii. Attempt to open locked-closed devices.

    iii. Make/attempt key-exchanges in all positions.

j. Lubrication requirements:

    i. Verify appropriate lubrication on moving current-carrying parts.

    ii. Verify appropriate lubrication on moving and sliding surfaces.

k. Inspect insulators for evidence of physical damage or contaminated surfaces.

l. Verify correct barrier and shutter installation and operation.

m. Exercise all active components.

n. Inspect all indicating devices for correct operation.

o. Verify that filters are in place and/or vents are clear.

p. Perform visual and mechanical inspection of instrument transformers as specified in this Section.

q. Perform visual and mechanical inspection of surge arresters as specified in this Section.

r. Inspect control power transformers:

    i. Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.

    ii. Verify that primary and secondary fuse/circuit breaker ratings match the submittal drawings.

iii. Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.

2. Electrical tests:

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.

b. Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground for 1 minute.

i. Perform test in accordance with NETA ATS tables.

c. Perform a dielectric withstand voltage test on each bus section, each phase to ground with phases not under test grounded, in accordance with manufacturer's published data :

i. Refer to NETA ATS tables in the absence of manufacturer's published data.

ii. The test voltage shall be applied for 1 minute.

d. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 VDC for 300-volt rated cable and 1,000 VDC for 600-volt rated cable. Apply the test voltage for 1 minute:

i. For solid state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.

e. Perform electrical tests on instrument transformers as specified in this Section.

f. Perform ground-resistance tests:

i. Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral and derived neutral points.

g. Determine the accuracy of all meters and calibrate watthour as specified in this Section. Verify multipliers.

h. Control power transformers:

i. Perform insulation-resistance tests. Perform measurements from winding-to-winding and each winding-to-ground:

I. Test voltages shall be in accordance with NETA ATS tables or as specified by the manufacturer.

II. Perform a turns-ratio test on all tap positions.

ii. Perform secondary wiring integrity test:

I. Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source:

- Verify correct potential at all devices.

iii. Verify correct secondary voltage by energizing primary winding with system voltage:

I. Measure secondary voltage with the secondary wiring disconnected.

iv. Verify correct function of control power transfer relays located in switchgear with multiple control power sources.

i. Voltage transformers:

i. Perform secondary wiring integrity test:

I. Verify correct potential at all devices.

ii. Verify correct secondary voltage by energizing primary winding with system voltage.

j. Perform current injection tests on the entire current circuit of each switchgear or switchboard:

i. Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 ampere flows in the secondary circuit:

I. Verify the correct magnitude of current at each device in the circuit.

ii. Perform current tests by primary injection with magnitudes such that a minimum current of 1.0 ampere flows in the secondary circuit:

I. Verify the correct magnitude of current at each device in the circuit.

k. Perform system function tests.

l. Verify operation of space heaters.

m. Perform phasing check on double-ended or dual-source equipment to ensure correct bus phasing from each source.

n. Perform electrical tests of surge arresters as specified in this Section.

3. Test values:

a. Compare bolted connection resistance values to values of similar connections:

i. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

b. Bolt-torque levels shall be in accordance with manufacturer's published data:

i. Refer to NETA ATS tables in the absence of manufacturer's published data.

c. Insulation-resistance values of bus insulation shall be in accordance with manufacturer's published data:

i. Refer to NETA ATS tables in the absence of manufacturer's published data.

ii. Investigate insulation values less than the allowable minimum.

iii. Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.

d. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.

e. Insulation-resistance values for control wiring shall not be less than 2 megohms.

f. Instrument transformer test values as specified in this Section.

g. Investigate grounding system resistance values that exceed 0.5 ohm.

h. Meter accuracy shall be in accordance with manufacturer's published data.

i. Control power transformers:

   i. Insulation-resistance values of control power transformers shall be in accordance with manufacturer's published data:

      I. Refer to NETA ATS tables in the absence of manufacturer's published data.

      II. Investigate insulation values less than the allowable minimum.

   ii. Turns-ratio test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio.

      I. Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.

   iii. Secondary wiring shall be as indicated on the Drawings and specified in the Specifications.

   iv. Secondary voltage shall be as indicated on the Drawings.

   v. Control transfer relays shall perform as designed.

j. Voltage transformers:

   i. Secondary wiring shall be as indicated on the Drawings and specified in the Specifications.

   ii. Secondary voltage shall be as indicated on the Drawings.

k. Current-injection tests shall prove current wiring is as indicated on the Drawings and specified in the Specifications.

l. Results of system function tests shall match the drawings and Specifications.

m. Heaters shall be operational.

n. Phasing checks shall prove the switchgear or switchboard phasing is correct and in accordance with the system design.

o. Results of electrical tests on surge arresters shall be as specified in this Section.

B. Dry type transformers:

1. Visual and mechanical inspection:

   a. Compare equipment nameplate data with the Contract Documents.

   b. Inspect physical and mechanical condition.

   c. Inspect anchorage, alignment, and grounding.

d. Verify that resilient mounts are free and that any shipping brackets have been removed.

e. Inspect equipment for cleanliness.

f. Inspect bolted electrical connections for high resistance using one of the following methods:

   i. Use of low-resistance ohmmeter.

   ii. Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:

      I. Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.

g. Verify that as-left tap connections are as specified.

2. Electrical tests:

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.

b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground:

   i. Apply voltage in accordance with manufacturer's published data.

      I. Refer to NETA ATS tables in the absence of manufacturer's published data.

c. Calculate dielectric absorption ration or polarization index.

d. Perform turns ratio tests at all tap positions.

e. Verify correct secondary voltage, phase-to-phase and phase-to-neutral after energization and before loading.

3. Test values:

a. Compare bolted connection resistance values to values of similar connections:

   i. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

b. Bolt-torque levels shall be in accordance with manufacturer's published data:

   i. Refer to NETA ATS tables in the absence of manufacturer's published data.

c. Tap connections are left as found unless otherwise specified.

d. Minimum insulation-resistance values of transformer insulation shall be in accordance with manufacturer's published data:

   i. Refer to NETA ATS tables in the absence of manufacturer's published data.

   ii. Investigate insulation values less than the allowable minimum.

e. The dielectric absorption ratio or polarization index shall not be less than 1.0.

f. Turns-ratio results should not deviate more than 1/2 percent from either the adjacent coils or calculated ratio.

g. Phase-to-phase and phase-to-neutral secondary voltages shall be in agreement with nameplate data.

   i. Water in insulating fluids, if applicable: ASTM D 1533.

   ii. Power-factor or dissipation-factor: ASTM D 924.

h. Remove a sample of insulating liquid in accordance with applicable standards. Sample shall be tested for the following:

   i. Dissolved-gas analysis: IEEE C57.104 or ASTM D 3612.

i. Perform electrical tests on instrument transformers as specified in this Section:

j. Test surge arresters as specified in this Section.

k. Test transformer neutral grounding impedance device if applicable.

l. Verify operation of cubicle or air terminal compartment space heaters.

C. Low voltage cables, 600 volt maximum:

1. Visual and mechanical inspection:

   a. Compare cable data with the Drawings and Specifications.

   b. Inspect exposed sections of cable for physical damage and correct connection as indicated on the Drawings.

   c. Inspect bolted electrical connections for high resistance by 1 of the following methods:

      i. Use of low-resistance ohmmeter.

      ii. Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:

         I. Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.

   d. Inspect compression applied connectors for correct cable match and indentation.

   e. Inspect for correct identification and arrangement.

   f. Inspect cable jacket insulation and condition.

2. Electrical tests:

   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.

   b. Perform insulation resistance test on each conductor with respect to ground and adjacent conductors:

      i. Applied potential shall be 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable.

ii. Test duration shall be 1 minute.

c. Perform continuity tests to insure correct cable connection.

d. Verify uniform resistance of parallel conductors.

3. Test values:

a. Compare bolted connection resistance values to values of similar connections:

i. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

b. Insulation-resistance values shall be in accordance with manufacturer's published data:

i. Refer to NETA ATS tables in the absence of manufacturer's published data.

ii. Investigate values of insulation-resistance less than the allowable minimum.

c. Cable shall exhibit continuity.

d. Investigate deviations in resistance between parallel conductors.

D. Low voltage molded case and insulated case circuit breakers:

1. Visual and mechanical inspection:

a. Compare equipment nameplate data with the Contract Documents.

b. Inspect physical and mechanical condition.

c. Inspect anchorage and alignment.

d. Verify that all maintenance devices are available for servicing and operating the breaker.

e. Verify the unit is clean.

f. Verify the arc chutes are intact.

g. Inspect moving and stationary contacts for condition and alignment.

h. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.

i. Perform all mechanical operator and contact alignment tests on both the breaker and its operating mechanism in accordance with manufacturers published data.

j. Operate circuit breaker to ensure smooth operation.

k. Inspect bolted electrical connections for high resistance by one of the following methods:

i. Use of low-resistance ohmmeter.

ii. Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:

*I.*Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.

l. Inspect operating mechanism, contacts, and arc chutes in unsealed units.

m. Verify cell fit and element alignment.

n. Verify racking mechanism operation.

o. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

p. Perform adjustments for final protective device settings in accordance with the coordination study.

q. Record as-found and as-left operation counter readings.

2. Electrical tests:

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.

b. Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed and across each open pole:

i. Apply voltage in accordance with manufacturer's published data.

ii. Refer to NETA ATS tables in the absence of manufacturer's published data.

c. Perform a contact/pole-resistance test.

d. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 VDC for 300-volt rated cable and 1,000 VDC for 600-volt rated cable. Apply the test voltage for 1 minute:

i. For solid state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.

e. Determine long-time pickup and delay by primary current injection.

f. Determine short-time pickup and delay by primary current injection.

g. Determine ground-fault pickup and delay by primary current injection.

h. Determine instantaneous pickup value by primary current injection.

i. Test functions of the trip unit by means of secondary injection.

j. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data.

k. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, antipump function and trip unit battery condition:

i. Reset all trip logs and indicators.

l. Verify operation of charging mechanism.

3. Test values:

a. Compare bolted connection resistance values to values of similar connections:

i. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

b. Bolt-torque levels shall be in accordance with manufacturer's published data:

i. Refer to NETA ATS tables in the absence of manufacturer's published data.

c. Insulation-resistance values shall be in accordance with manufacturer's published data:

i. Refer to NETA ATS tables in the absence of manufacturer's published data.

ii. Investigate values of insulation-resistance less than the allowable minimum.

d. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data:

i. If manufacturer's data is not available, investigate any values which deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.

e. Insulation-resistance values of control wiring shall not be less than 2 megohms.

f. Long-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current characteristic tolerance band including adjustment factors:

i. If manufacturer's curves are not available, trip times shall not exceed the value shown in NETA ATS tables.

g. Short-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.

h. Ground fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.

i. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances:

i. Refer to NETA ATS tables in the absence of manufacturer's published data.

j. Pickup values and trip characteristics shall be within manufacturer's published tolerances.

k. Minimum pickup voltage of the shunt trip and close coils shall conform to the manufacturer's published data:

i. Refer to NETA ATS tables in the absence of manufacturer's published data.

l. Breaker open, close, trip, trip-free, antipump, and auxiliary features shall function as designed.

m. The charging mechanism shall operate in accordance with manufacturer's published data.

E. Protective relays, electromechanical and solid-state:

1. Visual and mechanical inspection:

a. Compare equipment nameplate data with the Contract Documents.

b. Inspect relays and cases for physical damage. Remove shipping restraint material.

c. Verify the unit is clean.

d. Relay case:

   i. Tighten case connections.

   ii. Inspect cover for correct gasket seal.

   iii. Clean cover glass. Inspect shorting hardware, connection paddles, and knife switches.

   iv. Remove any foreign material from the case.

   v. Verify target reset.

e. Relay:

   i. Inspect relay for foreign material, particularly in disk slots of the damping and electromagnets.

   ii. Verify disk clearance. Verify contact clearance and spring bias.

   iii. Inspect spiral spring convolutions. Inspect disk and contacts for freedom of movement and correct travel. Verify tightness of mounting hardware and connections. Burnish contacts. Inspect bearings and pivots.

f. Set relays in accordance with coordination study.

2. Electrical tests:

   a. Perform an insulation-resistance test on each circuit-to-frame. Procedures for performing insulation-resistance tests on solid-state relays shall be determined from the relay manufacturer's published data.

   b. Inspect targets and indicators:

      i. Determine pickup and dropout of electromechanical targets.

      ii. Verify operation of all light-emitting diode indicators.

      iii. Set contrast for liquid-crystal display readouts.

3. Functional operation:

   a. 2/62 timing relay:

      i. Determine time delay.

      ii. Verify operation of instantaneous contacts.

   b. 21 distance relay:

      i. Determine maximum reach.

      ii. Determine maximum torque angle.

      iii. Determine offset.

iv. Plot impedance circle.

c. 24 volts/hertz relay:

i. Determine pickup frequency at rated voltage.

ii. Determine pickup frequency at a second voltage level.

iii. Determine time delay.

d. 25 sync check relay:

i. Determine closing zone at rated voltage.

ii. Determine maximum voltage differential that permits closing at zero degrees.

iii. Determine live line, live bus, dead line, and dead bus set points.

iv. Determine time delay.

v. Verify dead bus/live line, dead line/live bus and dead bus/dead line control functions.

e. 27 undervoltage relay:

i. Determine dropout voltage.

ii. Determine time delay.

iii. Determine time delay at a second point on the timing curve for inverse time relays.

f. 32 directional power relay:

i. Determine minimum pickup at maximum torque angle.

ii. Determine closing zone.

iii. Determine maximum torque angle.

iv. Determine time delay.

v. Verify time delay at a second point on the timing curve for inverse time relays.

vi. Plot the operating characteristic.

g. 40 loss of field (impedance) relay:

i. Determine maximum reach.

ii. Determine maximum torque angle.

iii. Determine offset.

iv. Plot impedance circle.

h. 46 current balance relay:

i. Determine pickup of each unit.

ii. Determine percent slope.

iii. Determine time delay.

i. 46N negative sequence current relay:

    i. Determine negative sequence alarm level.

    ii. Determine negative sequence minimum trip level.

    iii. Determine maximum time delay.

    iv. Verify 2 points on the $(I_2)^2t$ curve.

j. 47 phase sequence or phase balance voltage relay:

    i. Determine positive sequence voltage to close the normally open contact.

    ii. Determine positive sequence voltage to open the normally closed contact (undervoltage trip).

    iii. Verify negative sequence trip.

    iv. Determine time delay to close the normally open contact with sudden application of 120 percent of pickup.

    v. Determine time delay to close the normally closed contact upon removal of voltage when previously set to rated system voltage.

k. 9R thermal replica relay:

    i. Determine time delay at 300 percent of setting.

    ii. Determine a second point on the operating curve.

    iii. Determine pickup.

l. 49T temperature (RTD) relay:

    i. Determine trip resistance.

    ii. Determine reset resistance.

m. 50 instantaneous overcurrent relay:

    i. Determine pickup.

    ii. Determine dropout.

    iii. Determine time delay.

n. 51 time overcurrent:

    i. Determine minimum pickup.

    ii. Determine time delay at 2 points on the time current curve.

o. 55 power factor relay:

    i. Determine tripping angle.

    ii. Determine time delay.

p. 59 overvoltage relay:

i. Determine overvoltage pickup.

ii. Determine time delay to close the contact with sudden application of 120 percent of pickup.

q. 60 voltage balance relay:

i. Determine voltage difference to close the contacts with 1 source at rated voltage.

ii. Plot the operating curve for the relay.

r. 63 transformer sudden pressure relay:

i. Determine rate-of-rise or the pickup level of suddenly applied pressure in accordance with manufacturer's published data.

ii. Verify operation of the 63 FPX seal-in circuit.

iii. Verify trip circuit to remote operating device.

s. 64 ground detector relay:

i. Determine maximum impedance to ground causing relay pickup.

t. 67 directional overcurrent relay:

i. Determine directional unit minimum pickup at maximum torque angle.

ii. Determine closing zone.

iii. Determine maximum torque angle.

iv. Plot operating characteristics.

v. Determine overcurrent unit pickup.

vi. Determine overcurrent unit time delay at 2 points on the time current curve.

u. 79 reclosing relay:

i. Determine time delay for each programmed reclosing interval.

ii. Verify lockout for unsuccessful reclosing.

iii. Determine reset time.

iv. Determine close pulse duration.

v. Verify instantaneous overcurrent lockout.

v. 81 frequency relay:

i. Verify frequency set points.

ii. Determine time delay.

iii. Determine undervoltage cutoff.

w. 85 pilot wire monitor:

i. Determine overcurrent pickup.

ii. Determine undercurrent pickup.

iii. Determine pilot wire ground pickup level.

x. 87 differential:

i. Determine operating unit pickup.

ii. Determine the operation of each restraint unit.

iii. Determine slope.

iv. Determine harmonic restraint.

v. Determine instantaneous pickup.

vi. Plot operating characteristics for each restraint.

4. Control verification:

a. Functional tests:

i. Verify that each of the relay contacts performs its intended function in the control scheme including breaker trip tests, close inhibit tests, 86 lockout tests, and alarm functions.

b. In-service monitoring:

i. After the equipment is initially energized, measure magnitude and phase angle of all inputs and compare to expected value

5. Test values:

a. When not otherwise specified, use manufacturer's recommended tolerances.

b. When critical test points are specified, the relay shall be calibrated to those points even though other test points may be out of tolerance.

F. Protective relays, microprocessor based:

1. Visual and mechanical inspection:

a. Record model number, style number, serial number, firmware revision, software revision and rated control voltage.

b. Verify operation of light-emitting diodes, display, and targets.

c. Record passwords for all access levels.

d. Clean the front panel and remove foreign material from the case.

e. Check tightness of connections.

f. Verify that the frame is grounded in accordance with manufacturer's instructions.

g. Set the relay in accordance with the coordination study.

h. Download settings from the relay. Print a copy of the settings for the report and compare the settings to those specified in the coordination study.

i. Connect back-up battery.

j. Set clock if not controlled externally.

2. Electrical tests:

   a. Perform insulation-resistance tests from each circuit to the grounded frame in accordance with the manufacturer's published data.

   b. Apply voltage or current to all analog inputs and verify correct registration of the relay meter functions.

   c. Functional operation:

      i. Check functional operation of each element used in the protection scheme.

      ii. 2/62 timing relay:

         I. Determine time delay.

         II. Verify operation of instantaneous contacts.

      iii. 21 distance relay:

         I. Determine maximum reach.

         II. Determine maximum torque angle.

         III. Determine offset.

         IV. Plot impedance circle.

      iv. 24 volts/hertz relay:

         I. Determine pickup frequency at rated voltage.

         II. Determine pickup frequency at a second voltage level.

         III. Determine time delay.

      v. 25 sync check relay:

         I. Determine closing zone at rated voltage.

         II. Determine maximum voltage differential that permits closing at zero degrees.

         III. Determine live line, live bus, dead line, and dead bus setpoints.

         IV. Verify dead bus/live line, dead line/live bus and dead bus/dead line control functions.

         V. Determine time delay.

      vi. 27 undervoltage relay:

         I. Determine dropout voltage.

         II. Determine time delay.

         III. Determine time delay at a second point on the timing curve for inverse time relays.

vii. 32 directional power relay:

*I.*Determine minimum pickup at maximum torque angle.

*II.*Determine closing zone.

*III.*Determine maximum torque angle.

*IV.*Determine time delay.

*V.*Verify time delay at a second point on the timing curve for inverse time relays.

*VI.*Plot the operating characteristic.

viii.40 loss of field (impedance) relay:

*I.*Determine maximum reach.

*II.*Determine maximum torque angle.

*III.*Determine offset.

*IV.*Plot impedance circle.

ix. 46 current balance relay:

*I.*Determine pickup of each unit.

*II.*Determine percent slope.

*III.*Determine time delay.

x. 46N negative sequence current relay:

*I.*Determine negative sequence alarm level.

*II.*Determine negative sequence minimum trip level.

*III.*Determine maximum time delay.

*IV.*Verify 2 point on the $(I_2)^2t$ curve.

xi. 47 phase sequence or phase balance voltage relay:

*I.*Determine positive sequence voltage to close the normally open contact.

*II.*Determine positive sequence voltage to open the normally closed contact (undervoltage trip).

*III.*Verify negative sequence trip.

*IV.*Determine time delay to close the normally open contact with sudden application of 120 percent of pickup.

*V.*Determine time delay to close the normally closed contact upon removal of voltage when previously set to rated system voltage.

xii. 49R thermal replica relay:

*I.*Determine time delay at 300 percent of setting.

*II.*Determine a second point on the operating curve.

*III.*Determine pickup.

xiii.49T temperature (RTD) relay:

*I.*Determine trip resistance.

*II.*Determine reset resistance.

xiv.50 instantaneous overcurrent relay:

*I.*Determine pickup.

*II.*Determine dropout.

*III.*Determine time delay.

xv. 51 time overcurrent:

*I.*Determine minimum pickup.

*II.*Determine time delay at 2 points on the time current curve.

xvi.55 power factor relay:

*I.*Determine tripping angle.

*II.*Determine time delay.

xvii.59 overvoltage relay:

*I.*Determine overvoltage pickup.

*II.*Determine time delay to close the contact with sudden application of 120 percent of pickup.

xviii.60 voltage balance relay:

*I.*Determine voltage difference to close the contacts with 1 source at rated voltage.

*II.*Plot the operating curve for the relay.

xix.63 transformer sudden pressure relay:

*I.*Determine rate-of-rise or the pickup level of suddenly applied pressure in accordance with manufacturer's published data.

*II.*Verify operation of the 63 FPX seal-in circuit.

*III.*Verify trip circuit to remote operating device.

xx. 64 ground detector relay:

*I.*Determine maximum impedance to ground causing relay pickup.

xxi.67 directional overcurrent relay:

*I.*Determine directional unit minimum pickup at maximum torque angle.

*II.*Determine closing zone.

*III.*Determine maximum torque angle.

*IV.*Plot operating characteristics.

*V.*Determine overcurrent unit pickup.

*VI.*Determine overcurrent unit time delay at 2 points on the time current curve.

xxii.79 reclosing relay:

*I.*Determine time delay for each programmed reclosing interval.

*II.*Verify lockout for unsuccessful reclosing.

*III.*Determine reset time.

*IV.*Determine close pulse duration.

*V.*Verify instantaneous overcurrent lockout.

xxiii. 81 frequency relay:

*I.*Verify frequency setpoints.

*II.*Determine time delay.

*III.*Determine undervoltage cutoff.

xxiv.85 pilot wire monitor:

*I.*Determine overcurrent pickup.

*II.*Determine undercurrent pickup.

*III.*Determine pilot wire ground pickup level.

xxv.87 differential:

*I.*Determine operating unit pickup.

*II.*Determine the operation of each restraint unit.

*III.*Determine slope.

*IV.*Determine harmonic restraint.

*V.*Determine instantaneous pickup.

*VI.*Plot operating characteristics for each restraint.

d. Control verification:

xxvi.Functional tests:

*I.*Check operation of all active digital inputs.

*II.*Check all output contacts or SCRs preferably by operating the controlled device such as circuit breaker, auxiliary relay, or alarm.

*III.*Check all internal logic functions used in the protection scheme.

*IV.*For pilot schemes, perform a loop-back test to check the receive and transmit communications circuits.

*V.*For pilot schemes, perform satellite synchronized end-to-end tests.

*VI.*For pilot schemes with direct transfer trip (DTT) perform transmit and received DTT at each terminal.

*VII.*Upon completion of testing reset all min/max recorders, communications statistics, fault counters, sequence of events recorder and all event records.

xxvii.In-service monitoring:

*I.*After the equipment is initially energized, measure magnitude and phase angle of all inputs and compare to expected values.

G. Instrument transformers:

1. Visual and mechanical inspection:

a. Compare equipment nameplate data with the Contract Documents.

b. Inspect physical and mechanical condition.

c. Verify correct connection of transformers with system requirements.

d. Verify that adequate clearances exist between primary and secondary circuit wiring.

e. Verify the unit is clean.

f. Inspect bolted electrical connections for high resistance using one of the following methods:

i. Use of low-resistance ohmmeter.

ii. Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:

*I.*Refer to manufacturer’s instructions for proper foot-pound levels or NETA ATS tables.

g. Verify that all required grounding and shorting connections provide contact.

h. Verify correct operation of transformer withdrawal mechanism and grounding operation.

i. Verify correct primary and secondary fuse sizes for voltage transformers.

j. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

k. Verify instrument transformer polarities match the 3-line diagrams.

2. Electrical tests - current transformers:

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.

b. Perform insulation-resistance test of each current transformer and its secondary wiring with respect to ground at 1,000 VDC for 1 minute:

   i. For solid state devices that cannot tolerate the applied voltage, follow the manufacturer’s recommendation.

c. Perform a polarity test of each current transformer in accordance with IEEE C57.13.1.

d. Perform a ratio verification test using the voltage or current method in accordance with IEEE C57.13.1.

e. Perform an excitation test on current transformers used for relaying applications in with accordance with IEEE C57.13.1.

f. Measure current circuit burdens at transformer terminals in accordance with IEEE C57.13.1.

g. Perform an excitation test on transformers used for relaying applications in accordance with IEEE C57.13.1.

h. When applicable perform insulation-resistance tests on the primary winding with the secondary grounded:

   i. Test voltages shall be in accordance with NETA ATS tables.

i. When applicable perform dielectric withstand tests on the primary winding with the secondary grounded:

   i. Test voltages shall be in accordance with NETA ATS tables.

j. Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer’s published data.

k. Verify that current transformer secondary circuits are grounded and have only 1 grounding point in accordance with IEEE C57.13.3:

   i. That grounding point should be located as specified by the Engineer in the Contract Documents.

3. Electrical tests - voltage transformers:

   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.

   b. Perform insulation-resistance tests winding-to-winding and winding-to-ground:

      i. Test voltage shall be applied for 1 minute in accordance with NETA ATS requirements.

      ii. For solid state devices that cannot tolerate the applied voltage, follow the manufacturer’s recommendation.

   c. Perform a polarity test on each voltage transformer to verify the polarity marks on H_1- X_1 relationship as applicable.

   d. Perform a turns ratio test on all tap positions.

e. Measure voltage circuit burdens at transformer terminals.

f. Perform a dielectric withstand test on the primary windings with the secondary windings grounded:

   i. The dielectric voltage shall be in accordance with NETA ATS tables.

   ii. Apply the test voltage for 1 minute.

g. Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturers published data.

h. Verify that voltage transformer secondary circuits are grounded and have only 1 grounding point in accordance with IEEE C57.13.3:

   i. That grounding point should be located as specified by the Engineer in the Contract Documents.

4. Test values:

   a. Compare bolted connection resistance values to values of similar connections:

      i. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

   b. Bolt-torque levels shall be in accordance with manufacturer's published data:

      i. Refer to NETA ATS tables in the absence of manufacturer's published data.

   c. Insulation-resistance values of instrument transformers shall be in accordance with manufacturer's published data:

      i. Refer to NETA ATS tables in the absence of manufacturer's published data.

   d. Polarity results shall agree with transformer markings.

   e. Ratio errors shall be in accordance with IEEE C57.13.

   f. Excitation results for current transformers shall match the curve supplied by the manufacturer or be in accordance with IEEE C57.13.1.

   g. Measured burdens shall be compared to instrument transformer ratings.

   h. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the current transformer primary winding is considered to have passed the test.

   i. Power-factor or dissipation-factor values shall be compared to manufacturer's published data:

      i. In the absence manufacturer's published data the comparison shall be made to similar breakers.

   j. Test results shall indicate that the circuits have only 1 grounding point.

H. Metering devices:

   1. Visual and mechanical inspection:

      a. Compare equipment nameplate data with the Contract Documents.

b. Inspect physical and mechanical condition.

c. Inspect bolted electrical connections for high resistance using one of the following methods:

   i. Use of low-resistance ohmmeter.

   ii. Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:

      I. Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.

d. Record model number, serial number, firmware revision, software revision, and rated control voltage.

e. Verify operation of display and indicating devices.

f. Record passwords.

g. Verify unit is grounded in accordance with manufacturer's instructions.

h. Set all required parameters including instrument transformer ratios, system type, frequency, power demand methods/intervals, and communications requirements.

i. Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case shorting contacts as applicable.

j. Verify the unit is clean.

k. Verify freedom of movement, endplay, and alignment of rotating disk(s).

2. Electrical tests:

   a. Apply voltage or current as appropriate to each analog input and verify correct measurement and indication.

   b. Confirm correct operation and setting of each auxiliary input/output feature including mechanical relay, digital, and analog.

   c. After initial system energization, confirm measurements and indications are consistent with loads present.

   d. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.

   e. Verify accuracy of meter at all cardinal points.

   f. Calibrate meters in accordance with manufacturer's published data.

   g. Verify all instrument multipliers.

   h. Verify that current transformer, and voltage transformer secondary circuits are intact.

3. Test values:

   a. Compare bolted connection resistance values to values of similar connections:

i. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

b. Bolt-torque levels shall be in accordance with manufacturer's published data:

i. Refer to NETA ATS tables in the absence of manufacturer's published data.

c. Meter accuracy shall be in accordance with manufacturer's published data.

d. Calibration results shall be within manufacturer's published tolerances.

e. Instrument multipliers shall be in accordance with system design specifications.

f. Test results shall confirm the integrity of the secondary circuits of current and voltage transformers.

I. Grounding systems:

1. Visual and mechanical inspection:

a. Inspect ground system for compliance with that indicated on the Drawings, specified in Specifications, and in the NEC.

b. Inspect physical and mechanical condition.

c. Inspect bolted electrical connections for high resistance using one of the following methods:

i. Use of low-resistance ohmmeter.

ii. Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:

*I.*Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.

d. Inspect anchorage.

2. Electrical tests:

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.

b. Perform fall of potential test or alternative test in accordance with IEEE 81 on the main grounding electrode or system.

c. Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, the system neutral and any derived neutral points.

3. Test values:

a. Grounding system electrical and mechanical connections shall be free of corrosion.

b. Compare bolted connection resistance values to values of similar connections:

i. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

c. Bolt-torque levels shall be in accordance with manufacturer's published data:

   i. Refer to NETA ATS tables in the absence of manufacturer's published data.

d. The resistance between the main grounding electrode and ground shall be as specified in Section 26 05 26. Investigate point-to-point resistance values that exceed 0.5 ohm.

J. Rotating machinery:

1. Visual and mechanical inspection:

   a. Compare equipment nameplate information with the Contract Documents.

   b. Inspect physical and mechanical condition.

   c. Inspect anchorage, alignment, and grounding.

   d. Inspect air baffles, filter media, cooling fans, slip rings, brushes, brush rigging, and shaft current discharge devices.

   e. Inspect bolted electrical connections for high resistance using one of the following methods:

      i. Use of low-resistance ohmmeter.

      ii. Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:

         I. Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.

   f. Perform special tests such as gap spacing and machine alignment if applicable.

   g. Manually rotate the rotor and check for problems with the bearings or shaft.

   h. Rotate the shaft and measure and record the shaft extension runout.

   i. Verify correct application of appropriate lubrication and lubrication systems.

   j. Verify that resistance temperature detector (RTD) circuits conform to that indicated on the Drawings.

2. Electrical tests:

   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.

   b. Perform insulation-resistance test in accordance with IEEE 43:

      i. On motors 200 horsepower and smaller, test duration shall be 1 minute. Calculate dielectric absorption ratio.

      ii. On motors larger than 200 horsepower, test duration shall be 10 minutes. Calculate polarization index.

   c. Perform dc dielectric withstand voltage tests on machines rated at 2,300 volts and greater in accordance with IEEE 95.

      i. IEEE 95 for dc dielectric withstand voltage tests.

ii. NEMA MG1 for ac dielectric withstand voltage tests.

d. Perform phase-to-phase stator resistance test on machines rated at 2,300 volts and greater.

e. Perform insulation power-factor or dissipation-factor tests.

f. Perform power-factor tip-up tests.

g. Perform surge comparison tests.

h. Perform insulation-resistance test on insulated bearings in accordance with manufacturer's published data.

i. Test surge protection devices as specified in this Section.

j. Test motor starter as specified in this Section.

k. Perform resistance tests on resistance temperature detector (RTD) circuits.

l. Verify operation of motor space heater.

m. Perform vibration test.

n. Perform a rotation test to ensure correct shaft rotation.

o. Measure running current and evaluate relative to load conditions and nameplate full-load amperes.

3. Test values:

a. Inspection:

i. Air baffles shall be clean and installed in accordance with the manufacturer's published data.

ii. Filter media shall be clean and installed in accordance with the manufacturer's published data.

iii. Cooling fans shall operate.

iv. Slip ring alignment shall be within manufacturer's published tolerances.

v. Brush alignment shall be within manufacturer's published tolerances.

vi. Brush rigging shall be within manufacturer's published tolerances.

b. Compare bolted connection resistance values to values of similar connections:

i. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

c. Bolt-torque levels shall be in accordance with manufacturer's published data:

i. Refer to NETA ATS tables in the absence of manufacturer's published data.

d. Air-gap spacing and machine alignment shall be in accordance with manufacturer's published data.

e. The recommended minimum insulation-resistance ($IR_{1\ min}$) test results in megohms shall be as specified in this Section.

i. The polarization index value shall not be less than 2.0.

ii. The dielectric absorption ratio shall not be less than 1.4.

f. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.

g. Investigate phase-to-phase stator resistance values that deviate by more than 10 percent.

h. Power factor or dissipation factor values shall be compared to manufacturer's published data:

i. In the absence of manufacturer's published data compare values of similar machines.

i. Tip-up values shall indicate no significant increase in power factor.

j. If no evidence of distress, insulation failure, or waveform nesting is observed by the end of the total time of voltage application during the surge comparison test, the test specimen is considered to have passed the test.

k. Bearing insulation-resistance measurements shall be within manufacturer's published tolerances:

i. In the absence of manufacturer's published data compare values of similar machines.

l. Test results of surge protection devices shall be as specified in this Section.

m. Test results of motor starter equipment shall be as specified in this Section.

n. RTD circuits shall conform to the design intent and machine protection device manufacturer's published data.

o. Heaters shall be operational.

p. Vibration amplitudes shall not exceed values in NETA ATS tables:

i. If values exceed those in the NETA ATS tables, perform a complete vibration analysis.

q. Machine rotation should match required rotation of connected load.

r. Running phase-to-phase voltages should be within 1.0 percent. Running currents shall be balanced and proportional to load condition and nameplate data.

K. Rotating machinery, synchronous motors and generators:

1. Visual and mechanical inspection:

a. Compare equipment nameplate data with the Contract Documents.

b. Inspect physical and mechanical condition.

c. Inspect anchorage, alignment, and grounding.

d. Inspect air baffles, filter media, cooling fans, slip rings, brushes, and brush rigging.

e. Inspect bolted electrical connections for high resistance using one or more of the following methods:

   i. Use of low-resistance ohmmeter.

   ii. Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:

   iii. Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.

f. Perform special tests such as air-gap spacing and machine alignment.

g. Manually rotate the rotor and check for problems with the bearings or shaft.

h. Rotate the shaft and measure and record the shaft extension runout.

i. Verify the application of appropriate lubrication and lubrication systems.

j. Verify that resistance temperature detector (RTD) circuits conform to that indicated on the Drawings.

2. Electrical tests:

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.

b. Perform insulation-resistance tests in accordance with IEEE 43.

   i. Machines larger than 200 horsepower (150 kilowatts):

      I. Test duration shall be for 10 minutes. Calculate polarization index.

   ii. Machines 200 horsepower (150 kilowatts) and less:

      II. Test duration shall be for 1 minute. Calculate dielectric-absorption ratio.

c. On machines rated at 2300 volts and greater perform dielectric withstand voltage tests in accordance with:

   i. 3.1 IEEE 95 for dc dielectric withstand voltage tests.

   ii. 3.2 NEMA MG1 for ac dielectric withstand voltage tests.

d. Perform phase-to-phase stator resistance test on machines 2,300 volts and greater.

e. Perform insulation power-factor or dissipation-factor tests.

f. Perform power-factor or dissipation-factor tip-up tests.

g. Perform surge comparison tests.

h. Perform insulation-resistance test on insulated bearings in accordance with manufacturer's published data.

i. Test surge protection devices as specified in this Section.

j. Test motor starter as specified in this Section.

k. Perform resistance tests on resistance temperature detector (RTD) circuits.

l. Verify operation of machine space heater, if applicable.

m. Perform vibration test.

n. Perform insulation-resistance tests on the main rotating field winding, the exciter-field winding, and the exciter-armature winding in accordance with IEEE 43.

o. Perform an AC voltage-drop test on all rotating field poles.

p. Perform a high-potential test on the excitation system in accordance with IEEE 421.3.

q. Measure resistance of machine-field winding, exciter-stator winding, exciter-rotor windings, and field discharge resistors.

r. Perform front-to-back resistance tests on diodes and gating tests of silicon-controlled rectifiers for field application semiconductors.

s. Prior to re-energizing, apply voltage to the exciter supply and adjust exciter-field current to nameplate value.

t. Verify that the field application timer and the enable timer for the power-factor relay have been tested and set to the motor drive manufacturer's recommended values.

u. Record stator current, stator voltage, and field current for the complete acceleration period including stabilization time for a normally loaded starting condition. From the recording determine the following information:

    i. Bus voltage prior to start.

    ii. Voltage drop at start.

    iii. Bus voltage at machine full-load.

    iv. Locked-rotor current.

    v. Current after synchronization but before loading.

    vi. Current at maximum loading.

    vii. Acceleration time to near synchronous speed.

    viii. Revolutions per minute (RPM) just prior to synchronization.

    ix. Field application time.

    x. Time to reach stable synchronous operation.

v. Plot a V curve of stator current versus excitation current at approximately 50 percent load to check correct exciter operation.

w. If the range of exciter adjustment and machine loading permit, reduce excitation to cause power factor to fall below the trip value of the power-factor relay. Verify relay operation.

3. Test values:

a. Inspection:

i. Air baffles shall be clean and installed in accordance with manufacturer's published data.

ii. Filter media shall be clean and installed in accordance with manufacturer's published data.

iii. Cooling fans shall operate.

iv. Slip ring alignment shall be within manufacturer's published tolerances.

v. Rush alignment shall be within manufacturer's published tolerances.

vi. Brush rigging shall be in accordance with manufacturer's published data.

b. Compare bolted connection resistance values to values of similar connections:

i. Investigate any values that deviate from similar bolted connections by more than 50 percent of the lowest value.

c. Bolt-torque levels should be in accordance with manufacturer's published data:

i. Refer to NETA ATS tables in the absence of manufacturer's published data.

d. Air-gap spacing and machine alignment shall be in accordance with manufacturer's published data.

4. Test values - electrical:

a. Compare bolted connection resistance values to values of similar connections:

i. Investigate any values that deviate from similar bolted connections by more than 50 percent of the lowest value.

b. The recommended minimum insulation-resistance ($IR_{1\ min}$) test results in megohms shall be as specified in this Section.

i. The polarization index value shall not be less than 2.0.

ii. The dielectric absorption ratio shall not be less than 1.4.

c. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.

d. Investigate phase-to-phase stator resistance values that deviate by more than 5 percent.

e. Power-factor or dissipation-factor values shall be compared to manufacturer's published data:

i. In the absence manufacturer's published data the comparison shall be made to similar breakers.

f. Tip-up values shall indicate no significant increase in power factor or dissipation factor.

g. If no evidence of distress, insulation failure, or lack of waveform nesting is observed by the end of the total time of voltage application during the surge comparison test, the test specimen is considered to have passed the test.

h. Insulation-resistance of bearings shall be within manufacturer's published tolerances:

i. In the absence of manufacturer's published tolerances, the comparison shall be made to similar machines.

i. Test results of surge protection devices shall be as specified in this Section.

j. Test results of motor starter equipment shall be as specified in this Section.

k. RTD circuits shall be in accordance with system design intent and machine protection device manufacturer's published data.

l. Heaters shall be operational.

m. Vibration amplitudes of the uncoupled and unloaded machine shall be in accordance with manufacturer's published data:

i. In the absence of manufacturer's published data, vibration amplitudes shall not exceed values as specified in this Section.

ii. If values exceed those specified in this Section, perform complete vibration analysis.

n. The individual pole-pole ac voltage drop shall not exceed 10 percent variance from the average value (average value test voltage divided by number of coils) applicable to all of the poles.

o. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the winding is considered to have passed the test.

p. The measured resistance values of motor-field windings, exciter-stator windings, exciter-rotor windings, and field-discharge resistors shall be compared to manufacturer's published data:

i. In the absence of manufacturer's published data, the comparison shall be made to similar machines.

q. Resistance test results of diodes and gating tests of silicon-controlled rectifiers shall be in accordance with industry standards and system design requirements.

r. Exciter power supply shall allow exciter-field current to be adjusted to nameplate value.

s. Application timer and enable timer for power-factor relay test results shall comply with manufacturer's recommended values.

t. Recorded values shall be in accordance with system design requirements.

u. Plotted V-curve shall indicate correct exciter operation.

v. When reduced excitation falls below trip value for the power-factor relay, the relay shall operate.

L. Motor starters, low voltage:

1. Visual and mechanical inspection:

a. Compare equipment nameplate information with the Contract Documents.

b. Inspect physical and mechanical condition.

c. Inspect anchorage, alignment, and grounding.

d. Verify the unit is clean.

e. Inspect contactors:

i. Verify mechanical operation.

ii. Verify contact gap, wipe, alignment, and pressure, are in accordance with manufacturer's published data.

f. Motor-running protection:

i. Verify overload element rating is correct for its application.

ii. If motor running protection is provided by fuses, verify correct fuse rating.

g. Inspect bolted electrical connections for high resistance using one of the following methods:

i. Use of low-resistance ohmmeter.

ii. Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:

*I.*Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.

h. Lubrication requirements:

i. Verify appropriate lubrication on moving current-carrying parts.

ii. Verify appropriate lubrication on moving and sliding surfaces.

2. Electrical tests:

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.

b. Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase to ground with the starter closed, and across each open pole for 1 minute:

i. Test voltage shall be in accordance with manufacturer's published data.

ii. Refer to NETA ATS tables in the absence of manufacturer's published data.

c. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 VDC for 300-volt rated cable and 1,000 VDC for 600-volt rated cable. Apply the test voltage for 1 minute:

i. For solid state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.

d. Test motor protection devices in accordance with manufacturer's published data.

e. Test circuit breakers as specified in this Section.

f. Perform operational tests by initiating control devices.

3. Test values:

a. Compare bolted connection resistance values to values of similar connections:

i. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

b. Bolt-torque levels shall be in accordance with manufacturer's published data:

i. Refer to NETA ATS tables in the absence of manufacturer's published data.

c. Insulation-resistance values shall be in accordance with manufacturer's published data:

i. Refer to NETA ATS tables in the absence of manufacturer's published data.

ii. Investigate values of insulation-resistance less than the allowable minimum.

d. Insulation-resistance values of control wiring shall not be less than 2 megohms.

e. Motor protection parameters shall be in accordance with manufacturer's published data.

f. Circuit breaker test results shall as specified in this Section.

g. Control devices shall perform in accordance with system design requirements.

M. Surge arresters, low-voltage:

1. Visual and mechanical inspection:

a. Compare equipment nameplate data with the Contract Documents.

b. Inspect physical and mechanical condition.

c. Inspect anchorage, alignment, grounding, and clearances.

d. Verify the arresters are clean.

e. Inspect bolted electrical connections for high resistance using one of the following methods:

i. Use of low-resistance ohmmeter.

ii. Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:

*I.*Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.

f. Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.

g. Verify that stroke counter is correctly mounted and electrically connected, if applicable.

h. Record stroke counter reading.

2. Electrical tests:

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.

b. Perform an insulation-resistance test on each arrester, phase terminal- to-ground:

i. Apply voltage in accordance with manufacturers published data.

ii. Refer to NETA ATS tables in the absence of manufacturer's published data.

c. Test grounding connection as specified in this Section.

3. Test values:

a. Compare bolted connection resistance values to values of similar connections:

i. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

b. Bolt-torque levels shall be in accordance with manufacturer's published data:

i. Refer to NETA ATS tables in the absence of manufacturer's published data.

c. Insulation-resistance values shall be in accordance with manufacturer's published data:

i. Refer to NETA ATS tables in the absence of manufacturer's published data.

ii. Investigate insulation values less than the allowable minimum.

d. Resistance between the arrester ground terminal and the ground system shall be less than 0.5 ohm.

3.04 CLEANING

A. As specified in Section 26 05 00.

B. After the acceptance tests have been completed, dispose of all testing expendables, vacuum all cabinets, and sweep clean all surrounding areas.

3.05 PROTECTION

A. As specified in Section 26 05 00.

END OF SECTION

SECTION 26 24 10

PANELBOARDS

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes:

1. Panelboards serving feeder circuits and branch circuits.

B. Related sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01 33 00 - Submittal Procedures.
   b. Section 01 71 13 - Mobilization.
   c. Section 26 05 00 - Electrical – General Provisions.
   d. Section 26 05 53 - Identification for Electrical Systems.
   e. Section 26 43 13 - Surge Protective Devices.

1.02 REFERENCES

A. As specified in Section 26 05 00.

B. Underwriter's Laboratories, Inc. (UL):

1. 67 - Standard for Panelboards.

1.03 DEFINITIONS

A. As specified in Section 26 05 00.

1.04 SYSTEM DESCRIPTION

A. Circuit breaker panelboards as indicated in the panelboard schedules, one-lines, and where indicated on the Drawings:

1. Service voltage and configuration as indicated on the panel schedules.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01 33 00 and 26 05 00.

B. Product data:

1. Manufacturer of panelboard.

2. Bill of material.
3. Assembly ratings including:
    a. Voltage.
    b. Phase.
    c. Continuous current.
    d. Short circuit interrupting rating.
4. NEMA enclosure type.
5. Cable terminal sizes based upon actual feeder and sub-feeder conductors used.
6. Furnish circuit breaker submittals as necessary.
7. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in Section 26 05 00:
    a. Manufacturer’s statement of seismic qualification with substantiating test data.
    b. Manufacturer’s special seismic certification with substantiating test data.

C. Shop drawings:
1. Drawings to contain:
    a. Overall panelboard dimensions, interior panel dimensions, and wiring gutter dimensions:
        i. Height.
        ii. Length.
        iii. Width.
    b. Weight.
    c. Anchoring locations.
    d. Breaker layout drawing with dimensions:
        i. Location of the main, branches, solid neutral, and ground.
    e. Conduit entry/exit locations.
        i. Identify all conduit entry/exit locations and restrictions.
    f. Individual panel schedules identifying breaker locations, ratings, and nameplate designations within the panelboard, for every panelboard.

D. Installation instructions:
1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
2. For equipment installed in structures designated as seismic design category A or B:
    a. Provide manufacturer’s installation instructions and anchoring details for connecting equipment to supports and structures.

3. For equipment installed in structures designated as seismic design category C, D, E, or F:

   a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in Section 26 05 00.

   b. Submit anchoring drawings with supporting calculations.

   c. Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.

E. Operations and maintenance manual:

1. Provide a complete manual for the operation and maintenance of the panelboard, circuit breakers, devices, and accessories:

   a. Including but not limited to:

      i. Instruction narratives and bulletins.

      ii. Renewal parts lists.

      iii. Time-current curves for all devices.

F. Calculations:

1. Detailed calculations or details of the actual physical testing performed on the panelboard to prove the panelboard is suitable for the seismic requirements at the Project Site.

1.06 QUALITY ASSURANCE

A. As specified in Section 26 05 00.

B. Panelboards shall be UL listed and labeled.

1. Where indicated as service entrance equipment, panelboards shall be UL labeled and listed "Suitable for Service Entrance."

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 26 05 00.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 26 05 00.

1.09 WARRANTY

A. As specified in Section 26 05 00.

1.10 SYSTEM START-UP

A. As specified in Section 26 05 00.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:

1. Schneider Electric/Square D Company.
2. Approved Equal.

B. Circuit breakers:

1. Same manufacturer as the panelboard.

2.02 EQUIPMENT

A. Provide panelboards with:

1. Molded-case circuit breakers with trip ratings as shown on the panel schedules.
2. Spares and spaces for future circuit breakers in panels as shown on the panel schedules.

B. Short circuit rating:

1. Provide panelboards with short-circuit ratings as indicated on the Drawings:
2. Testing method in accordance with UL 67.
3. Mark each panelboard with its maximum short circuit rating at the supply voltage.
4. Panelboards shall be fully rated.
5. Provide a UL label meeting NEC requirements on the dead front of series rated panelboards with the following information:
   a. Size and type of upstream device.
   b. Allowed branch devices:
      i. UL series short-circuit ratings.

2.03 COMPONENTS

A. Enclosure:

1. NEMA enclosure type as indicated on the Drawings.
   a. Where not indicated on the Drawings, as specified in Section 26 05 00 for the installed location.
2. Minimum width: 20 inches.
3. Gutter space in accordance with the NEC:
   a. Minimum of 4 inches of gutter space.
4. Dead-front, no live parts when the panelboard is in service.
5. Enclose the entire panelboard bus assembly in a corrosion resistant galvanized steel cabinet.
6. 4-piece front to provide ease of wiring access.
7. Lockable, hinged door over the protective devices with a flush, cylinder tumbler-type lock with catch and door pull.
   a. Minimum 2 keys per panelboard.

b. Key all panelboard locks alike.

i. Match locks on existing panelboards to the extent possible.

8. Circuit directory frame and card on the inside of the door.

9. Door-in-door construction consists of a one-piece front with 2 doors:

a. The smaller door provides access to all device handles and rating labels and shall be lockable.

b. The larger door provides access to all conductors and wiring terminals.

10. Interior design such that replacement of circuit breakers does not require disturbing adjacent units or removal of the main bus connectors.

11. Provide NEMA Type 4X enclosures with a NEMA Type 4X stainless steel outer enclosure (with a hinged door) and a NEMA Type 1 interior panelboard.

B. Bus:

1. General:

a. Tin-plated copper

2. Phase bus:

a. Full size and height without reduction.

b. Sized in accordance with UL standards to limit temperature rise on any current carrying part to a maximum of 50 degrees Celsius:

i. Limit current density to less than 1,000 amps per square inch.

c. Insulate all current carrying parts from ground and phase-to-phase with a high dielectric strength insulator.

3. Ground bus:

a. Copper, solidly bonded.

4. Neutral bus:

a. Provide where indicated on the Drawings.

b. 100 percent rated.

c. Provide lugs for each outgoing feeder requiring a neutral connection.

5. Provide insulation barriers over the vertical bus behind the dead front shield to provide increased safety during field service.

C. Lugs:

1. UL listed for copper and aluminum wire:

a. Provide lugs rated for 75-degree Celsius terminations.

b. Provide bolted or compression main lug terminations as required for the incoming cable size.

D. Circuit breakers: As indicated on the Drawings:

1. Provide all circuit breakers with bolt-on connections:
    a. Plug-in circuit breakers are not allowed.

2.04 ACCESSORIES

A. Surge protective devices:
    1. Furnish panelboards with surge protective devices as indicated on the Drawings.
    2. As specified in Section 26 43 13.

B. Nameplates:
    1. As specified in Section 26 05 53.
    2. Install on outside of door.
    3. Indicating:
        a. Panel designation.
        b. Voltage.
        c. Number of phases and configuration.

C. Circuit identification labels:
    1. Provide index cards behind heavy clear plastic in cardholders on the inside of the doors.
    2. Type all information on the cards using designations in the panel schedules.
    3. Laminated on both sides.

D. Pad locking mechanism:
    1. Provide a pad locking attachment to allow circuit breakers to be locked in the off position.
    2. At a minimum, provide 1 mechanism per panelboard:
        a. Provide multiple mechanisms if required to accommodate all circuit breaker frame sizes in the panelboard.

2.05 FINISHES

A. Finish stand-alone panelboards with a primer, rust-resistant phosphate undercoat, and 2 coats of oven-baked enamel with manufacturer’s standard gray.

B. Finish panelboards mounted in motor control centers to match the motor control center finish and color.

PART 3 - EXECUTION

3.01 INSTALLATION

A. As specified in Section 26 05 00.

B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.

C. General:

1. Surface, flush or MCC mounted as indicated on the Drawings.
2. Mount rigidly to structural members with exposed surfaces plumb and level to within 1/32 inch.
3. Perform work in accordance with the manufacturer's instructions and shop drawings.
4. Provide all brackets, hangers, supports, and hardware for mounting as required.
5. In all NEMA Type 4 and NEMA Type 4X locations, mount panelboards on 7/8-inch deep stainless steel preformed channel, with channel running vertically from top to bottom of panelboard:
   a. Use only stainless steel mounting hardware.
6. Mount panelboard so that top operating handle is not more than 6 feet-7 inches above the operating floor.

3.02 COMMISSIONING AND PROCESS START-UP

A. As specified in Section 01 71 13.

B. Factory testing:

1. Perform standard factory tests on the panelboards:
2. Test in accordance with the latest version of NEMA and UL standards.

3.03 FIELD QUALITY CONTROL

A. As specified in Section 26 05 00.

3.04 CLEANING

A. As specified in Section 26 05 00.

3.05 PROTECTION

A. As specified in Section 26 05 00.

3.06 SCHEDULES

A. Circuiting within the panelboard shall match the panel schedules as indicated on the Drawings.

B. Provide typewritten schedule in each panelboard.

END OF SECTION

SECTION 26 26 50

ELECTRIC MOTORS

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes:

1. Low voltage motors up to 500 horsepower.

B. Related sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01 33 00 - Submittal Procedures.
   b. Section 01 71 13 - Mobilization.
   c. Section 26 05 00 - Electrical – General Provisions.
   d. Section 26 08 00 - Field Electrical Acceptance Tests.

1.02 REFERENCES

A. As specified in Section 26 05 00.

B. American Bearing Manufacturers Association (ABMA):

1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
2. 11 - Load Ratings and Fatigue Life for Roller Bearings.

C. American Petroleum Institute (API):

1. 670 - Vibration, Axial Position, and Bearing Temperature Monitoring Systems.

D. ASTM International (ASTM).

1. B-117 - Standard Practice for Operating Salt Spray (Fog) Apparatus.

E. Institute of Electrical and Electronic Engineers (IEEE):

1. 43 - IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
2. 112 - IEEE Standard Test Procedure for Polyphase Induction Motors and Generators.
3. 114 - Standard Test Procedure for Single-Phase Induction Motors.

4. 303 - Recommended Practice for Auxiliary Devices for Rotating Electrical Machines in Class 1, Division 2 and Zone 2 Locations.
5. 841 - Standard for Petroleum and Chemical Industry-Premium-Efficiency, Severe Duty, Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors - Up to and Including 370 kW (500 hp).
6. 1349 - Guide for Application of Electric Motors in Class I, Division 2 Hazardous (Classified) Locations.

F. National Electrical Manufacturers' Association (NEMA):

1. MG-1 - Motors and Generators.
2. MG-2 - Safety Standard for Construction and Guide for Selection, Installation, and Use of Electric Motors and Generators.

G. Underwriters Laboratories Inc. (UL):

1. 674 - Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations.

1.03 DEFINITIONS

A. As specified in Section 26 05 00.

1.04 SYSTEM DESCRIPTION

A. Furnish and install electric motors and accessories as specified in this Section and the Sections specifying driven equipment to provide a complete and operable installation.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01 33 00 and 26 05 00.

B. Submit completed motor data sheets for each motor supplied:

1. Conform to data sheet in the appendix of this Section.
2. Manufacturer's or other data sheets are not acceptable.

C. Product data:

1. Descriptive bulletins.
2. Machine tag and loop number as indicated on the Drawings and in the specification section number of the driven machine.
3. Complete electrical data.
4. Torque, current, and power factor vs. speed curves:
   a. At 100 percent rated voltage for all full voltage started and VFD driven motors.
   b. For motors on reduced voltage start at 70, 80, 90 and 100 percent rated voltage.
5. Additional data for motors installed in classified areas:
   a. Temperature code.
   b. Hazardous area approval indicating Class, Division and Group:

i. For motors driven by variable frequency drives, provide manufacturer's certification that the motor is suitable for operation in the hazardous area when driven by a variable frequency drive.

6. Accessories data:
   a. Power factor correction capacitors:
      i. Size in KVAR, for all motors not connected to variable frequency drives.
   b. Motor winding heaters:
      i. Voltage.
      ii. Watts.
   c. Winding temperature detectors:
      i. Type.
      ii. Rating.
   d. Moisture detectors.
7. Mechanical data:
   a. Bearing design and bearing life calculations.
   b. Resonant frequencies for all VFD-driven motors 50 horsepower or greater.

D. Shop drawings:
1. Motor weight.
2. Frame size.
3. Conduit box (es), size(s), and location(s).
4. Outline drawings with dimensions.
5. Installation details for the project seismic criteria.

E. Test reports:
1. Factory test reports with test reference standard identified.

F. Certification:
1. When motors are driven by variable speed drive systems, submit certification that selected motor:
   a. Is capable of satisfactory performance under the intended load.
   b. Meets the requirements of the latest edition of NEMA MG-1 Part 31.
   c. Is matched to the type of variable frequency drive specified.

G. Calculations:
1. Where site conditions specified in Section 26 05 00 exceed manufacturer's ratings, provide derating calculations for each motor.

1.06 QUALITY ASSURANCE

A. As specified in Section 26 05 00.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 26 05 00.

B. Motors 200 hp and larger:

1. Rotate shaft 90 degrees once per month.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 26 05 00.

1.09 WARRANTY

A. As specified in Section 26 05 00.

1.10 SYSTEM START-UP

A. As specified in Section 26 05 00.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:

1. US Motors.
2. General Electric.
3. Reliance.
4. Toshiba.
5. Baldor.

2.02 EQUIPMENT

A. 3-phase induction motors - general:

1. Voltage:
    a. All motors 1/2 hp and larger shall be rated 460 V, 3 phase unless otherwise indicated on the Drawings.
    b. Dual voltage motors rated 230/460 V, 3 phase are acceptable provided all leads are brought to the conduit box.
2. Motors driving identical machines shall be identical.
3. All motors greater than 1 hp and up to 500 hp shall meet the "NEMA Premium Efficiency" percent listed in NEMA MG-1.
4. Horsepower as indicated on the Drawings:
    a. Horsepower ratings indicated on the Drawings are based on vendor's estimates. Provide motors sized for the load of the actual equipment furnished without operating in the service factor.

5. Service factor:
   a. 1.15 service factor on sine wave power.
   b. 1.0 when driven by VFD.
6. Torque:
   a. Provide motors that develop sufficient torque for acceleration to full speed at voltage 10 percent less than motor nameplate rating.
   b. When started using reduced voltage starters:
      i. Provide motors that develop sufficient torque for acceleration to full speed.
   c. NEMA Design B except where driven load characteristics require other than normal starting torque:
      i. In no case shall starting torque or breakdown torque be less than the values specified in NEMA MG-1.
7. Enclosures:
   a. As specified in the individual equipment Specifications or in this Section.
   b. Totally enclosed fan cooled:
      i. Cast iron conduit box.
      ii. Tapped drain holes with Type 316 stainless steel plugs for frames 286T and smaller, and automatic breather and drain devices for frames 324T and larger.
   c. Explosion-proof:
      i. Tapped drain holes with corrosion resistant plugs for frames 286T and smaller and automatic breather and drain devices for frames 324T and larger.
   d. Lifting devices: All motors weighing 265 pounds (120 kilograms) or more shall have suitable lifting devices for installation and removal.
8. Manufactured with cast iron frames in accordance with NEMA MG-1 or manufacturer's standard material for the specified rating.
9. Nameplates:
   a. Provide all motors with a permanent, stainless-steel nameplate indelibly stamped or engraved with:
      i. NEMA standard motor data.
      I. Indicate compliance with NEMA MG-1 Part 31 for inverter duty motors.
      ii. AFBMA bearing numbers and lubrication instructions.
10. Hardware:

a. Type 316 stainless steel.

11. Conduit boxes:

a. Cast iron or stamped steel.

b. Split from top to bottom.

c. Provide gaskets at the following interfaces:

i. Frames and conduit boxes.

ii. Conduit boxes and box covers.

d. Rotatable through 360 degrees in 90-degree increments.

i. Where available based on the size of the conduit box.

e. Exceeding the dimensions defined in NEMA MG-1.

f. Provide grounding lugs inside conduit boxes for motor frame grounding.

12. Motor bearings:

a. Antifriction.

b. Regreasable and initially filled with grease for horizontal motors, vertical motors per manufacturer's standard design.

c. Bearings and lubrication suitable for ambient temperature and temperature rise.

d. Suitable for intended application and have ABMA L-10 rating life of 60,000 hours or more.

e. Fit bearings with easily accessible grease supply, flush, drain, and relief fittings using extension tubes where necessary.

f. Where specified in the equipment Specifications, provide split-sleeve type hydrodynamic radial bearings. Provide a bearing isolator to protect bearings from contaminants.

13. Insulation systems:

a. Motors installed in ambient temperatures 40 degrees Celsius or less:

i. Provide Class F insulation.

ii. Design temperature rise consistent with Class B insulation.

iii. Rated to operate at an ambient temperature of 65 degrees Celsius at the altitude where the motor will be installed.

b. Motors installed in ambient temperatures between 40 degrees Celsius and 50 degrees Celsius:

i. Provide Class F insulation.

ii. Design temperature rise consistent with Class B insulation.

iii. Rated to operate at an ambient temperature of 65 degrees Celsius at the altitude where the motor will be installed.

c. Motors installed in ambient temperatures between 50 degrees Celsius and 65 degrees Celsius:

i. Provide Class H insulation.

ii. Design temperature rise consistent with Class F insulation.

iii. Rated to operate at an ambient temperature of 65 degrees Celsius at the altitude where the motors will be installed.

14. Motor leads:

a. Insulated leads with non-wicking, non-hydroscopic material. Class F insulation.

15. Noise:

a. Maximum operating noise level in accordance with NEMA MG-1.

B. Submersible motors:

1. Enclosures:

a. Totally enclosed non-ventilated (TENV) watertight casing.

b. Inner and outer shaft seals separated by an oil chamber.

2. Cooling:

a. Suitable for continuous operation in totally, partially or non submerged condition without overheating.

b. Convection cooling by the surrounding environment or pump cooling by circulating a portion of the pumped media through a cooling water jacket as recommended by the manufacturer based on horsepower and application.

3. Electrical cables:

a. Wire unit without splices. Coordinate with Contractor to ensure cables of adequate length.

b. Epoxy encapsulated cable entry into terminal box.

4. Insulation:

a. Sealed moisture resistant windings.

b. Class H.

5. Motor protection:

a. Provide temperature detection in motor windings.

b. Provide moisture detection in motor housing.

c. Other detection and protection functions specified in the in the driven equipment Section.

2.03 ACCESSORIES

A. Winding temperature detectors:

1. Provide factory installed winding temperature detector with leads terminating in the conduit box:
    a. Where required by the driven equipment Specification or as indicated on the Drawings.
    b. RTD type, 2 per phase, 100 ohm platinum.
2. Temperature switches with normally closed contacts as indicated on the Drawings.
3. Provide motor thermostat in lieu of RTU type for stage 3 aerator motors.

B. Bearing temperature detectors:

1. Where required by the driven equipment Specification or as indicated on the Drawings.
2. RTD type and wiring matches the winding RTDs.

C. Vibration detectors:

1. Where required by the driven equipment Specification.
2. As specified in the driven equipment Specification.

PART 3 - EXECUTION

3.01 INSTALLATION

A. As specified in Section 26 05 00.

B. Install motors in accordance with manufacturer's instructions.

C. Install shaft grounding ring on VFD driven motors in accordance with the manufacturer's instructions.

3.02 COMMISSIONING AND PROCESS START-UP

A. As specified in Section 00 16 55.

B. Factory testing:

1. Motors less than 250 horsepower:
    a. Perform manufacturer's standard production tests including but not limited to:
        i. No load current.
        ii. High potential test.
        iii. Winding resistance.
    b. Furnish copies of standard test reports on prototype or identical units.

3.03 FIELD QUALITY CONTROL

A. As specified in Section 26 05 00.

B. Before start-up, perform insulation resistance test on each motor furnished or installed on this project:

1. Windings energized to 1,000 volts DC for 1 minute.
2. Resistance measured at the end of the test, recorded, and submitted to the Engineer for review.
3. Inform the Engineer of any unusual or unacceptable test results.
4. This test is in addition to the acceptance tests in Section 26 05 53.

3.04 PROTECTION

A. As specified in Section 26 05 00.

MOTOR DATA SHEET

MOTOR/ EQUIPMENT		MOTOR	
SPECIFICATION NUMBER OF DRIVEN			

MOTOR NAMEPLATE DATA

MANUFACTU		MODEL/SERI		MODEL NO.	
FRAM		ENCLOSU		NEMA	
HP		SERVICE		RPM	
INSULATION		VOLTS		FULL LOAD	
AMBIENT		PHASE		NO LOAD AMPS	
DESIGN TEMP		HERTZ		LOCK ROTOR	
				INRUSH CODE	

	100%	75% LOAD	50% LOAD
GUARANTEED MINIMUM			
GUARANTEED MINIMUM POWER			
MAXIMUM SIZE OF POWER FACTOR CORRECTION		KVAR	

ACCESSORIES

MOTOR WINDING		VOLTS		WATTS	
WINDING THERMAL					
WINDING TEMP SWITCHES					
RTD:					
TYPE		QUANTITY PER		# OF WIRES	
NOMINAL		NOMINAL		COEFFICIE	

RECOMMENDED ALARM	______	DEGREES CELSIUS	RECOMMENDED TRIP	______	DEGREES CELSIUS

SPECIAL APPLICATIONS

INVERTER DUTY* ____ PART WINDING ____ WYE - DELTA ____

2 SPEED, 1 WINDING ______ 2 SPEED, 2 WINDING ______

AREA CLASSIFICATION:

CLASS ______ DIVISION ______ GROUP ______ TEMP ______

Conforms to NEMA MG-1 Part 31.

END OF SECTION

SECTION 26 29 13

MOTOR STARTERS

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes:

1. Motor starters and contactors.

B. Related sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.

2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.

3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.

a. Section 01 33 00 - Submittal Procedures.

b. Section 01 71 13 - Mobilization.

c. Section 26 05 00 - Electrical – General Provisions.

d. Section 26 05 53 - Identification for Electrical Systems.

e. Section 26 05 19 - Wires and Cables.

1.02 REFERENCES

A. As specified in Section 26 05 00.

B. International Electrotechnical Commission (IEC):

1. 60 947-4 - Low-Voltage Switchgear and Control Gear.

2. 801-1 - Electromagnetic Compatibility for Industrial-Process Measurement and Control Equipment - Part 1: General Information.

C. National Electrical Manufacturer's Association (NEMA):

1. ICS 2 - Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 V.

D. Underwriters Laboratories (UL):

1. 508 - Standard for Industrial Control Equipment.

2. 508A - Standard for Industrial Control Panels.

1.03 DEFINITIONS

A. As specified in Section 26 05 00.

B. Specific definitions and abbreviations:

1. FVNR: Full voltage non-reversing.
2. FVR: Full voltage reversing.
3. TS1W: 2 speed 1 winding (consequent pole).
4. TS2W: 2 speed 2 winding.
5. PWS: Part winding start.
6. RVAT: Reduced voltage auto transformer.
7. RVSS: Reduced voltage solid state.
8. Overload relay class: A classification of an overload relay time current characteristic by means of a number which designates the maximum time in seconds at which it will operate when carrying a current equal to 600 percent of its current rating.

1.04 SYSTEM DESCRIPTION

A. General requirements:

1. Starters for motor control centers, individual enclosed starters, or control panels.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01 33 00 and 26 05 00:

1. Submit motor starter data with equipment submittal.

B. Product data:

1. Manufacturer.
2. Catalog cut sheets.
3. Technical information.
4. Complete nameplate schedule.
5. Complete bill of material.
6. List of recommended spare parts.
7. Confirmation that the overload relay class for each starter meets the requirements of the equipment and motor supplier.
8. Electrical ratings:
    a. Phase.
    b. Wire.
    c. Voltage.
    d. Ampacity.
    e. Horsepower.
9. Individually enclosed starters:

a. Dimensions:
    i. Height.
    ii. Width.
    iii. Depth.
    iv. Weight.
b. Enclosure information:
    i. NEMA rating.
    ii. Materials.
c. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in Section 26 05 00:
    i. Manufacturer's statement of seismic qualification with substantiating test data.
    ii. Manufacturer's special seismic certification with substantiating test data.

10. Furnish circuit breaker submittals as specified in Section 26 05 90.

C. Shop drawings:

1. Elementary and schematic diagrams:
    a. Provide 1 diagram for every starter and contactor.
    b. Indicate wire numbers for all control wires on the diagrams:
        i. Wire numbering as specified in Section 26 05 53.
    c. Indicate interfaces with other equipment on the drawings.
2. Individually enclosed starters:
    a. Layout drawings:
        i. Complete dimensioned component and starter unit layout drawings.
        ii. Allowable top and bottom conduit windows.

D. Installation instructions:

1. Detail the complete installation of the individually enclosed starters including rigging, moving, and setting into place.
2. For equipment installed in structures designated as seismic design category A or B:
    a. Provide manufacturer's installation instructions and anchoring details for connecting equipment to supports and structures.
3. For equipment installed in structures designated as seismic design category C, D, E, or F:
    a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in Section 26 05 00.

b. Submit anchoring drawings with supporting calculations.

c. Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.

E. Operation and maintenance manuals:

1. Submit complete operating and maintenance instructions presenting full details for care and maintenance of equipment furnished or installed under this Section. Including but not limited to:

a. Electrical ratings:

i. Phase.

ii. Wire.

iii. Voltage.

iv. Ampacity.

b. Complete bill of material.

c. Manufacturer's operating and maintenance instructions starter and/or contactor component parts, including:

i. Protective devices (fuses, breakers, overload relays, heater elements, etc.).

ii. Pilot devices.

d. Complete renewal parts list.

e. As-built drawings:

i. Furnish as-built drawings for each starter and contactor indicating final:

I. Wire numbers.
II. Interfaces with other equipment.

ii. 11-inch by 17-inch format.

F. Certifications:

1. Provide manufacturer's certification that the reduced voltage solid state starter will reliably control the acceleration and deceleration of the driven load at the installed conditions:

a. Failure of the manufacturer to provide said certification will be interpreted to mean that the manufacturer has agreed that the reduced voltage solid state starter is matched to the driven load at the installed conditions and will function without fault.

b. If the reduced voltage solid-state starter fails to perform as desired, replace or modify the reduced voltage solid-state starter in order to achieve the desired operational conditions, as directed by the Engineer.

1.06 QUALITY ASSURANCE

A. As specified in Section 26 05 00.

B. Regulatory requirements:

1. All starters and components shall be UL listed and labeled:

a. UL 508 - Industrial Control Equipment.

b. UL 508A - Industrial Control Panels.

2. NEMA ICS 2 - Industrial Control and System Controllers; Contactors and Overload Relays Rated: 600 Volts.

3. Combination starters shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 26 05 00.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 26 05 00.

1.09 SCHEDULING

A. Reduced voltage solid state starters (SSS):

1. Submit certification that the RVSS will reliably accelerate and decelerate the driven load at the installed conditions as part of the equipment submittal.

2. SSS start-up and testing by manufacturer after connection to equipment.

3. SSS training by manufacturer after start-up and testing, and before plant commissioning.

1.10 WARRANTY

A. As specified in Section 26 05 00.

1.11 SYSTEM START-UP

A. As specified in Section 26 05 00.

B. SSS:

1. Provide the services of the manufacturer's technical representative for start-up, adjustment, and troubleshooting, a minimum of 2 hours per starter at the Owner's facility.

1.12 MAINTENANCE

A. Spare parts:

1. Provide the following spare parts, suitably packaged and labeled with the corresponding equipment number:

a. One spare fuse of each size and type per starter.

b. One of each type of circuit board used in the RVSS starters, including but not limited to:

i. Control board.

ii. Power board.

iii. Bridge rectifier.

iv. Inverter module.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:

1. NEMA starters and contactors:
   a. Schneider Electric/Square D.
   b. Or Approved Equal.
2. Reduced voltage solid state starters:
   a. Schneider Electric/Square D.
   b. Or Approved Equal.
3. Manual motor starters:
   a. Schneider Electric/Square D.
   b. Or Approved Equal.

2.02 MANUFACTURED UNITS

A. General:

1. Provide combination type starters with motor circuit protector or thermal-magnetic circuit breaker and control power transformer with ratings as indicated on the Drawings.
2. NEMA size, design, and rated:
   a. NEMA Size 1 minimum.
3. Coordinate motor circuit protector, thermal magnetic circuit breaker, or fusible disconnect, and overload trip ratings with nameplate horsepower and current ratings of the installed motor:
   a. If motors provided are different in horsepower rating than those specified or indicated on the Drawings, provide starters coordinated to the actual motors furnished.
4. Provide starters NEMA Size 2 and larger with arc quenchers on load breaking contacts.
5. Mount extended overload reset buttons to be accessible for operation without opening starter enclosure door.

B. Full voltage starters (FVNR, FVR, TS1W, TS2W):

1. Across-the-line full voltage magnetic starters.
2. Rated for 600 volts.
3. Electrical characteristics as indicated on the Drawings.

4. Provide positive, quick-make, quick-break mechanisms, pad lockable enclosure doors.
5. Furnish starter with solid state electronic overload relays.
6. Double-break silver alloy contacts.
7. Reversing starters provided with both mechanical and electrical interlocks to prevent line shorts and energizing both contactors simultaneously.
8. Provide 2-speed, 2-winding motor starters consisting of two 3-pole contactors and 2 sets of overload relays assembled together:
   a. Provided with conductors that are both mechanically and electrically interlocked to prevent energizing both contactors simultaneously.

2.03 COMPONENTS

A. Molded case circuit breakers:
   1. Circuit breaker type and ratings as indicated on the Drawings.
   2. Provide as specified in Section 26 05 90.
B. Contactors:
   1. NEMA size as indicated on the Drawings.
   2. Electrically held:
      a. For lighting loads designed to withstand the initial inrush currents of ballast and lamp loads.
   3. Factory adjusted and chatter free.
   4. Auxiliary contacts:
      a. Contact ratings as per NEMA A 600 rating:
         i. Auxiliary contacts rated 10 amps at 600 volts.
      b. Provide all contacts indicated in the Drawings, and any additional contacts required for proper operation.
      c. Provide at least 1 normally open and 1 normally closed spare auxiliary contact.
   5. Constructed in accordance with the following standards:
      a. UL 508.
      b. IEC 947-4.
         i. Type 1 coordination when protected by a circuit breaker.
         ii. Type 2 coordination when protected by a suitable UL listed fuse.
      c. IEC 801-1 parts 2 through 6.
C. Overloads:
   1. Solid state electronic:

a. Selectable Class 10, 20, 30 protection.

b. Ambient insensitive:

   i. Operating temperature: -20 to 70 degrees Celsius.

c. Thermal memory.

d. Protective functions:

   i. Motor overcurrent.

   ii. Phase unbalance (adjustable.)

   iii. Phase loss.

   iv. Ground fault protection.

e. Self-powered.

f. Provide current transformers for metering of motor current.

g. Visible trip indicator.

h. Push-to-trip test.

i. Isolated normally open alarm contact.

j. Normally closed trip contact.

k. Manual reset.

2. Solid state electronic with communications:

   a. Selectable Class 10, 20, 30 protection.

   b. Ambient insensitive:

      i. Operating temperature: -20 to 70 degrees Celsius.

   c. Thermal memory.

   d. Protective functions:

      i. Motor overcurrent.

      ii. Phase unbalance (adjustable.)

      iii. Phase loss.

      iv. Ground fault:

         I. Provide zero sequence current transformer where indicated on the Drawings.

   e. 120 VAC powered.

   f. Provide current transformers for metering of motor current.

   g. Visible trip indicator.

   h. Push-to-trip test.

   i. Isolated normally open alarm contact.

j. Normally closed trip contact.

k. Manual reset.

l. Communications:

i. Ethernet IP.

D. Control power transformer:

1. Furnish integral control power transformer capacity to power:

a. All motor controls; Motor and starter accessories indicated on the Drawings or specified.

2. Primary and secondary fusing as indicated on the Drawings:

a. Fusing sized by the manufacturer for the rating of the transformer furnished.

3. Control power transformer secondary voltage:

a. As indicated on the Drawings.

E. Enclosures for individually enclosed starters:

1. NEMA type specified for the location as specified in Section 26 05 00.

2. Flange-mounted handle mechanism to operate disconnect switch or circuit breaker:

a. Door mounted operators or operator handles are not acceptable.

b. Handle mechanism features:

i. Engaged with the disconnect device at all times as an integral part of the unit independent of the door position.

ii. Lockable in the Off position.

iii. Mechanically interlocked so that the disconnect cannot be switched to the On position with the door open:

I. Provide a means for qualified personnel to defeat this interlock during maintenance and testing.

iv. Lockable in the On position:

I. This feature shall not prevent the circuit breaker from operating during a fault condition.

3. Provide a thermostatically controlled space heater for equipment located outdoors or in unheated areas:

a. Powered from the control power transformer.

2.04 ACCESSORIES

A. Lugs and terminals:

1. For all external connections of No. 6 AWG and larger.

2. UL listed for either copper or aluminum conductors.

B. Surge protective devices:

1. Furnish surge protection devices across the coil of each starter, contactor, and relay.

C. Pilot devices:

1. Provide pilot lights, switches, elapsed time meters, and other devices as specified or as indicated on the Drawings.
2. As specified in Section 40 90 15.

D. Nameplates and wire markers:

1. As specified in Section 26 05 53.

E. Motor management and protection relay:

1. As indicated on the Drawings.
2. As specified in Section 26 26 50.

F. Conformal coating:

1. Provide conformal coating material applied to electronic circuitry and printed circuit boards to act as protection against moisture, dust, temperature extremes, and chemicals such as H_2S and chlorine.

2.05 SOURCE QUALITY CONTROL

A. SSS starters:

1. The manufacturer of the respective SSS starter shall supply certified test results to confirm that the controller has been tested to substantiate designs according to applicable ANSI and NEMA standards.
2. The tests shall verify not only the performance of the unit and integrated assembly, but also the suitability of the enclosure venting, rigidity, and bus bracing. In addition, the unit shall be factory tested in accordance with ANSI standards.
3. The SSS starter manufacturer shall test for noise immunity on both input and output power connections and provide test results to the Engineer. Noise testing shall be performed in accordance with NEMA ICS 2-230.40.

PART 3 - EXECUTION

3.01 INSTALLATION

A. As specified in Section 26 05 00.

B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.

C. Starters in control panels:

1. Install as specified in Section 40 90 15.

D. Individually enclosed starters:

1. Furnish all cables, conduit, lugs, bolts, expansion anchors, sealants, mounting structures and other accessories needed to completely install the starters.

2. Assemble and install the starters in the locations and with the layouts indicated on the Drawings.

3. Install floor-standing starters on a 3-1/2 inch raised concrete housekeeping pad:

   a. Provide structural leveling channels in accordance with the manufacturer's recommendations to provide proper alignment of the units.

   b. Weld and/or bolt the starter frame to the leveling channels.

4. Provide openings in top or bottom of the enclosure for conduit only, no additional openings will be allowed:

   a. Mis-cut holes will require that the entire enclosure or removable panel be replaced. No hole closers or patches will be allowed.

5. Bundle circuits together and terminate in each unit:

   a. Tie with nylon wire ties as specified in Section 26 05 19.

   b. Label all wires at each end with wire numbers shown on the approved control drawings.

   c. Make all connections to and from the motor starter via terminal blocks.

6. Furnish all mounting brackets, stands, etc. that may be required to physically mount the motor starter.

E. Manual motor starters:

1. Provide complete mounting brackets and hardware as necessary for complete support of manual motor starter at locations indicated on the Drawings.

2. Mount manual motor starter rigidly to exposed building or equipment structural members.

3.02 COMMISSIONING AND PROCESS START-UP

A. As specified in Section 00 16 55.

B. Factory testing:

1. Owner and Engineer will witness the factory acceptance test as specified in Section 26 05 00.

3.03 FIELD QUALITY CONTROL

A. As specified in Section 26 05 00.

3.04 ADJUSTING

A. Make all adjustments as necessary and recommended by the manufacturer, Engineer, or testing firm.

B. Set all overloads and motor circuit protectors based on the nameplate values of the installed motor.

3.05 CLEANING

A. As specified in Section 26 05 00.

3.06 PROTECTION

A. As specified in Section 26 05 00.

END OF SECTION

SECTION 26 43 13

SURGE PROTECTIVE DEVICES

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes:

1. High-energy surge protective devices.

B. Related sections:

1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
   a. Section 01 33 00 - Submittal Procedures.
   b. Section 01 71 13 - Mobilization.
   c. Section 26 05 00 - Electrical – General Provisions.
   d. Section 26 08 00 - Field Electrical Acceptance Tests.

1.02 REFERENCES

A. As specified in Section 26 05 00.

B. Institute of Electrical and Electronics Engineers (IEEE):

1. C62.41 – Recommended Practice on Surge Voltages in Low Voltage AC Power Circuits.
2. C62.45 –Guide on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits.
3. C62.62- Standard Test Specifications for Surge Protective Devices for Low Voltage AC Power Circuits.

C. Underwriters Laboratory:

1. 1449, 3rd Edition, Standard for Surge Protective Devices.

1.03 DEFINITIONS

A. As specified in Section 26 05 00.

B. Specific definitions:

1. SPD: Surge protective device.
2. SAD: Silicon avalanche diode.

3. MOV: Metal oxide varistor.
4. MCOV: Maximum continuous operating voltage.
5. I_n: Nominal discharge current.
6. VPR: Voltage protection rating.
7. SCCR: Short circuit current rating.

1.04 SYSTEM DESCRIPTION

A. Surge protective devices as an integral component of the electrical equipment or externally mounted as indicated on the Drawings.

1.05 SUBMITTALS

A. Furnish submittals as specified in Sections 01 33 00 and 26 05 00.

B. Product data:

1. Furnish complete product data confirming detailed compliance or exception statements to all provisions of this Section.
2. Manufacturer’s catalog cut sheets indicating:
    a. Manufacturer and model numbers.
    b. Ratings of each SPD including but not limited to:
        i. Short circuit current rating.
        ii. Nominal discharge current.
        iii. Maximum continuous operating voltage.
        iv. Voltage protection rating.
        v. System voltage.
        vi. System frequency.
        vii. Surge current capacity.
3. Submit independent test data from a nationally recognized testing laboratory verifying the following:
    a. Overcurrent protection.
    b. UL 1449.

C. Shop drawings:

1. Provide electrical and mechanical drawings by the manufacturer that detail:
    a. Unit dimensions.
    b. Weights.
    c. Components.
    d. Field connection locations.
    e. Mounting provisions.

f. Connection details.

g. Wiring diagram.

D. Operation and maintenance manuals:

1. Provide the manufacturer's manual with installation, start-up, spare parts lists, and operating instructions for the specified system.

1.06 QUALITY ASSURANCE

A. As specified in Section 26 05 00.

B. Provide SPD units that are designed, manufactured, tested and installed in compliance with the following codes and standards:

1. Institute of Electrical and Electronics Engineers (IEEE C62.41, C62.45, C62.62).

2. Federal Information Processing Standards Publication 94 (FIBS PUB 94).

3. National Electrical Manufacturer Association.

4. National Fire Protection Association (NFPA 20, 75 and 780).

5. National Electric Code (NFPA 70).

6. Underwriters Laboratories (UL 1449 3rd Edition and UL 1283).

7. International Electrotechnical Commission (IEC 801).

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 26 05 00.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 26 05 00.

1.09 SEQUENCING

A. Coordinate with and provide SPD equipment to the electrical equipment manufacturer before final assembly and factory testing.

1.10 WARRANTY

A. As specified in Section 26 05 00.

B. Extended warranty:

1. Furnish a manufacturer's full 5-year parts and labor warranty from date of shipment against any part failure when installed in compliance with manufacturer's written instructions, UL listing requirements, and any applicable national, state, or local electrical codes.

2. Warranty shall include:

a. Direct, factory-trained employees must be available within 48 hours for assessment of the problem.

b. A 24-hour toll-free 800-number for warranty support.

1.11 SYSTEM START-UP

A. As specified in Section 26 05 00.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:

1. Schneider Electric/Square D.
2. Approved Equal.

2.02 MANUFACTURED UNITS

A. Provide Type 1 or Type 2 SPD units as required for the locations indicated on the Drawings.

B. Electrical requirements:

1. SPD ratings are to be consistent with the nominal system operating voltage, phase, and configuration as indicated on the Drawings.
2. MCOV:
    a. For the SPD and all components in the suppression path (including all MOVs, SADs, and selenium cells): Greater than 115 percent of the nominal system operating voltage.
3. Operating frequency:
    a. 47 to 63 hertz.
4. SCCR:
    a. 65 kAIC minimum, but not less than the equipment it is connected to as indicated on the Drawings.
    b. The SCCR shall be marked on the SPD in accordance with UL 1449 and the NEC.
5. Nominal discharge current I_n:
    a. 20 kA.
6. Maximum VPR:

Modes	240/120	208Y/120	480Y/277
L-N, L-G, N-G	900	900	1,500
L-L	1,200	1,200	2000

7. Peak surge current:
    a. Service entrance locations:
        i. 240 kA per phase minimum.
        ii. 120 kA per mode minimum.
    b. Branch locations:
        i. 120 kA per phase, minimum.

ii. 60 kA per mode minimum.

C. Protection modes:

1. Provide SPD protection modes as follows:

a. Line to Neutral (L-N) where applicable.

b. Line to Ground (L-G).

c. Neutral to Ground (N-G), where applicable.

D. Environmental requirements:

1. Storage temperature:

a. -40 degrees to +50 degrees Celsius.

2. Operating temperature:

a. -0 degrees to +60 Celsius.

3. Relative humidity:

a. 5 percent to 95 percent.

4. Audible noise:

a. Less than 45 dBa at 5 feet (1.5 m).

5. Operating altitude:

a. Zero to 12,000 feet above sea level.

E. Provide surge protective devices that are suitable for application in IEEE C62.41 Category A, B and C3 environments, as tested to IEEE C62.45.

2.03 COMPONENTS

A. Enclosure:

1. Located in electrical equipment as indicated on the Drawings.

2. External mounting:

a. NEMA Type 4X enclosure:

i. No ventilation openings.

b. Hinged cover requiring a tool for internal access.

c. Internal drawing pocket.

d. All monitoring indications must be visible without opening the door.

B. Internal connections:

1. Provide low impedance copper plates for intra-unit connections:

a. Attach surge modules using bolted connections to the plates for low impedance connections.

2. Size all connections, conductors, and terminals for the specified surge current capacity.

C. Surge diversion modules:

1. MOV:

a. Where multiple MOVs are used in parallel, utilize computer matched MOVs to within 1 volt variance and tested for manufacturer's defects.

D. Overcurrent protection:

1. Individually fuse all components, including suppression, filtering, and monitoring components:

a. Rated to allow maximum specified nominal discharge current capacity.

b. Overcurrent protection that limits specified surge currents is not acceptable.

E. Connections:

1. Provide terminals to accommodate wire sizes up to #2 AWG.

2.04 ACCESSORIES

A. Unit status indicators:

1. Provide red and green solid-state indicators, with printed labels, on the front cover to redundantly indicate on-line unit status:

a. The absence of the green light and the presence of the red light indicate that surge protection is reduced and service is needed to restore full operation.

b. Indicates the status of protection on each mode or phase.

B. Dry contacts for remote monitoring:

1. Electrically isolated Form C dry contacts (1 A/125 VAC) for remote monitoring of system integrity, and indication of under voltage, phase and/or power loss.

C. Provide an audible alarm which activates under any fault condition.

1. Provide an alarm On/Off switch to silence the alarm.

2. A visible LED will confirm whether alarm is On or Disabled.

3. Locate both switches and the audible alarm on the unit’s front cover.

D. Provide transient counter to count transient voltage surges:

1. LCD readout located on the unit’s front cover.

2. Counter to utilize batteries with a 10-year nominal life or non-volitile memory to maintain accurate counts in the event of power loss.

E. Provide a self-contained remote monitoring panel to allow remote annunciation of the system status:

1. Input power to the monitoring panel: Provide a 6-foot input power cord with a NEMA Type 5-15 plug.

2. Provide an audible alarm, red and green LEDs, an alarm On/Off switch to silence and a push-to-test alarm switch.

F. Interconnection cable:

1. Interconnect the SPD to the power system using a manufacturer furnished assembly of low impedance coaxial cables installed in flexible conduit.
2. Cable designed to transmit transients with minimal voltage drop.
3. UL listed.

2.05 SOURCE QUALITY CONTROL

A. Permanently affix surge rating to the SPD.

B. Perform manufacturer’s standard factory test.

1. Perform testing in accordance with UL 1449.

PART 3 - EXECUTION

3.01 INSTALLATION

A. As specified in Section 26 05 00.

B. Follow the manufacturer's recommended installation practices and comply with all applicable codes.

C. Special techniques:

1. Install the SPD with as short and straight conductors including ground conductor as practically possible:
    a. Twist the input conductors together to reduce input conductor inductance.
2. Interconnect the SPD to the power system using a manufacturer supplied interconnection cable consisting of low impedance coaxial cables installed in a flexible conduit.
3. Do not subject SPD to insulation resistance testing.

3.02 COMMISSIONING AND PROCESS START-UP

A. As specified in Section 00 16 55.

3.03 FIELD QUALITY CONTROL

A. As specified in Section 20 08 00.

3.04 PROTECTION

A. As specified in Section 26 05 00.

Manufacturer	**Leibert**	**Square D**	**GE**	**GE**	**Current Technologies**	**Current Technologies**
Model	**SI (Interceptor)**	**Surgelogic External**	**TR7000**	**Tranquell**	**Select**	**TransGuard**
Voltage Protection Rating	UL 1449 3rd Edition (VPR w/o integral disconnect)					
120/240						
L-N	700	700	**900**	**900**	600	550
N-G	700	700	700	700	700	800
L-G	700	700	800	800	600	600
L-L	1000	1200	1200	1200	900	900
120/208						
L-N	700	700	**900**	**900**	600	550
N-G	700	700	700	700	700	800
L-G	700	700	800	800	600	600
L-L	1000	1200	1200	1200	900	900
277/480						
L-N	1000	1200	**1500**	**1500**	1200	1050
N-G	1000	1200	1200	1200	1500	1200
L-G	1200	1200	1200	1200	1200	1025
L-L	1800	2000	2000	2000	1800	**1825**
240						
L-G	1200	700	1200	1200	Not Published	Not Published
L-L	1000	1200	1800	1800	Not Published	Not Published
480						
L-G	1800		1800	1800	Not Published	Not Published
L-L	1800		3000	3000	Not Published	Not Published
Location Type	Type 1, 2	Type 2	Type 2	Type 2	Type 1,2	Type 1, 2
Short Circuit Current	200kAIC	200kAIC	200kAIC	65/200kAIC (3)	200kAIC	200kAIC
Bkr Required (2)	No	Yes	Yes	Yes	No	No
Nominal Discharge Current (In)	20kA	20kA	20kA	20kA	20kA	20kA

Manufacturer	**Leibert**	**Square D**	**GE**	**GE**	**Current Technologies**	**Current Technologies**
Model	**SI (Interceptor)**	**Surgelogic External**	**TR7000**	**Tranquell**	**Select**	**TransGuard**
Environmental Requirements						
Storage Temperature	-55 to +85C	-40 to +65C				
Operating Frequency	47-63Hz					47-63 Hz
Operating Temperature	-40 to +60C	-4 to +65C	-40 to +65C	-40 to +65C	-40 to +60C	-40 to +60C
Relative Humidity	0-95%		0-95%	0-95%	5-95%	5-95%
Operating Altitude	0-18000 Ft	0-12000 Ft				
Enclosure (NEMA)	4	3R/4X	1/4/4X/12	1/4/4X/12	4/12	4/12
Life Cycle Peak Surge Current per Mode	10 kA, 20 kV, IEEE Cat. C3					
60KA Per Mode Per Phase	15000 30000	10000	5000	5000	**3500**	**3500**
120KA Per Mode Per Phase	15000 30000	10000	20000	20000	12000	**5000**
Sizes (Mode)						
60,000A 120,000A	160kA/Phase 250kA/Phase	120kA/Phase 240kA/Phase	65kA 125kA	65kA 125kA	60kA 150kA	60kA 125kA
Warranty (Years)	10 parts/5 labor	10	5	5	20	15
Counter	Opt	Yes	Yes	Yes	Opt	Yes
Alarm Contacts	Yes	Yes	Yes	Yes	Opt	Yes
Visible Display	LEDs	LEDs	LEDs	LEDs	LEDs	LEDs
Audible Alarm	Yes	Yes	Yes	Yes	Opt	Yes
Diagnostics	Yes	Yes	Yes	Yes	Opt	Yes

Manufacturer	Leibert	Square D	GE	GE	Current Technologies	Current Technologies
Model	**SI (Interceptor)**	**Surgelogic External**	**TR7000**	**Tranquell**	**Select**	**TransGuard**

Notes:

(1)GE includes fused disconnect. The GE design incorporates 1 MOV per phase, therefore each MOV is individually fused. The clamping voltage data includes disconnect and fuses. Revise section 2.060C when specifying GE.
(2)Breaker required for Type 2 protection.
(3)65 kAIC for 65 kA model, 200 kAIC for 125 kA model.
(4)Cutler-Hammer does not test/publish life cycle peak surge current data.

END OF SECTION

SECTION 33 05 14

MANHOLES AND STRUCTURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Epoxy Lining of Existing Sewer Lift Station Structure

1.2 REFERENCES

A. American Concrete Institute:

1. American Concrete Institute (ACI) 530/530.1 - Building Code Requirements for Masonry Structures and Specifications for Masonry Structures.

B. ASTM International:

1. ASTM A48/A48M - Standard Specification for Gray Iron Castings.
2. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
3. ASTM C361 - Standard Specification for Reinforced Concrete Low Head Pressure Pipe.
4. ASTM C478 - Standard Specification for Precast Reinforced Concrete Manhole Sections.
5. ASTM C497 - Standard Test Methods for Concrete Pipe, Manhole Sections, or Tile.
6. ASTM C913 - Standard Specification for Precast Concrete Water and Wastewater Structures.
7. ASTM C923 - Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals.
8. ASTM C990 – Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants

C. This Technical Specification makes reference to the 2021 Standard Specifications for Public Works Construction (Greenbook) referred to hereinafter as “Standard Specifications”.

1.3 SUBMITTALS

A. Product Data: Submit selected Epoxy Liner for Approval

PART 2 - PRODUCTS

2.1 STRUCTURE EPOXY LINER

A. Sewer Manhole shall be coated with Neopoxy NPR-5300, Warren Environmental S-301, or Raven 405 Epoxy Spray-Applied System, 200 mils, single application. Trowel on coatings are not allowed. Coating shall be spray applied.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify items provided by other sections of Work are properly sized and located.

B. Verify built-in items are in proper location, and ready for roughing into Work.

3.2 PREPARATION

A. Inspect precast concrete manholes and structures immediately prior to placement in excavation to verify manholes and structures are internally clean and free from damage. Remove and replace damaged units.

B. Inspect existing structure immediately prior to application of epoxy liner. Verify existing structure is clean and free from damage.

3.3 INSTALLATION - GENERAL

A. Line structures with epoxy per specifications and as shown on the Plans.

END SECTION 33 05 14

SECTION 33 41 00

UTILITY PIPING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipe and fittings.
2. Accessories.
3. Underground pipe markers.
4. Connection to existing pipes.
5. Vent Piping.

1.2 REFERENCES

A. American Association of State Highway and Transportation Officials:

1. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.

B. ASTM International:

1. ASTM B177 – Standard Test Method for Operating Salt Spray (Fog) Testing.

2. ASTM C14 - Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe.

3. ASTM C76 – Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.

4. ASTM C443 - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.

5. ASTM C923 - Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals.

6. ASTM C924 – Standard Practice for Testing concrete Pipe Sewer Lines by Low-Pressure Air Test Method.

7. ASTM C 969 – Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines.

8. ASTM C1103 – Standard Practice for Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines.

9. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)).

10. ASTM D714 – Standard Test Method for Evaluating Degree of Blistering of Paints.

11. ASTM D1238 – Measuring Flow Rates of Thermoplastics by Extrusion Plastometer.

12. ASTM D1248 –Polyethylene Plastics Molding and Extrusion Materials.

13. ASTM D1505 – Density of Plastics by Density-Gradient Technique.

14. ASTM D1599 – Test for Short Term Rupture Strength of Plastic Pipe, Tubing, and Fitting.

15. ASTM D1693 – Environmental Stress Cracking of Ethylene Plastics.

16. ASTM D1784 – Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.

17. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3)).

18. ASTM D1785 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) .

19. Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.

20. ASTM D1928 – Preparation of Compression Molded Polyethylene Test Samples.

21. ASTM D2152 – Test Method for Degree of Fusion of Extruded Poly (Vinyl Chloride) (PVC) Pipe and Molded Fittings by Acetone Immersion.

22. ASTM D2241 – Poly (Vinyl Chloride) (PVC) Plastic Pipe (SDR-PR).

23. ASTM D2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.

24. ASTM D2564 - Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems.

25. ASTM D2657 – Heat Joining of Thermoplastic Pipe and Fittings.

26. ASTM D2665 – Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.

27. ASTM D2729 - Standard Specification for Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.

28. ASTM D2837 – Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials.

29. ASTM D2855 - Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings.

30. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

31. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

32. ASTM D3034 - Standard Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.

33. ASTM G95 – Standard Test Method for Resistance to Cathodic Disbondment by the Attached Cell Method.

C. American Water Works Association:

1. AWS Standard Qualification Procedure.

D. American Water Works Association:

1. AWWA C104 – American National Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.

2. AWWA C105 - American National Standard for Polyethylene Encasement for Ductile-Iron Pipe Systems.

3. AWWA C110 - American National Standard for Ductile-Iron and Grey-Iron Fittings, 3 in. through 48 in. (75 mm through 1200 mm), for Water and Other Liquids.

4. AWWA C111 - American National Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.

5. AWWA C150 - ANSI Standard for the Thickness Design of Ductile Iron Pipe.

6. AWWA C151 - American National Standard for Ductile-Iron Pipe, Centrifugally Cast, for Water.

7. AWWA M23 – AWWA Manual of Supply Practices PVC Pipe – Design and Installation, Second Edition.

1.3 SUBMITTALS

A. Polyvinyl chloride pipe materials

B. Ductile Iron Pipe Materials

C. Pipeline layout diagrams

D. Valve types and materials

E. Precast structure design shop drawings

F. Grout materials

G. Pipe Supports

H. Pipe Coatings

1.4 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum three years documented experience.

B. Contractor: Company specializing in performing Sewer and Sewer Lift Station Work specified in this section with minimum three years documented experience.

C. Installer: Company specializing in performing work of this section with minimum three years documented experience.

D. Welder: Welder Certifications specializing in performing work of this section with minimum three years documented experience.

1.5 DELIVERY, STORAGE, AND HANDLING

A. The Contractor shall exercise special care during the unloading, handling, and storage of all pipe to ensure that the pipe is not cut, gouged, scored, or otherwise damaged. Any pipe segment which has cuts in the pipe wall exceeding 10 percent of the wall thickness shall be cut out and removed from the site at the Contractor's expense.

B. The pipe shall be stored so that it is not deformed axially or circumferentially which may hinder pipe installation. No vertical load shall be placed on pipe during storage. Contractor shall test all pipe for ovality prior to installation. Pipe not meeting specified requirements shall be replaced with new material.

C. All plastic pipes shall have an ultraviolet inhibitor and shall also be stored in a covered area on blocks, such that no individual pipes weight shall bear on another pipe segment. Pipes shall be supported so as not to allow the pipe to sag along its length between blocks during storage.

D. Block individual and stockpiled pipe lengths to prevent moving.

1.6 FIELD MEASUREMENTS

A. Verify field measurements and elevations are as indicated.

1.7 COORDINATION

A. Coordinate the Work with other trades and operations at the site.

PART 2 PRODUCTS

2.1 DUCTILE PIPE AND FITTINGS

A. Dual spigot centrifugally cast ductile iron pipe conforming to AWWA C150 or AWWA C151, 250 minimum pressure class flanged ends. Joints shall conform to ANSI/AWWA C111/A21.11.

1. Manufacturers:

a. U.S. Pipe

b. American Ductile Iron Pipe Company

c. Or approved equal

2. Outside Coating: Paint in accordance with:

a. System No.10 – Exposed Metal, Corrosive Environment, as described in these Special Provisions for pipe within wet well. :

1) Type: High build epoxy coat having a minimum volume solid of 60%, with an inorganic zinc prime coat
2) Surface Preparation: SSPC-SP 10
3) Prime Coat: Self curing, two component inorganic zinc rich coating recommended by the manufacturer for overcoating with a high build epoxy finish coat. Minimum Zinc content must be 12 pounds per gallon. Provide Ameron 3105, Kopcoat Inorganic No. 701, Engard 519, or approved equal. Apply to thickness of 3 mils.
4) Finish Coat: Provide Ameron 383HS, Kopcoat Hi-Gard, engard 460 HS, or approved equal. Apply to minimum dry film thickness of 12 mils total.

3. Lining:

a. Pipe and fittings: Protecto 401 Ceramic Epoxy for Sewer Force Mains.

a. Valves: Fusion Bonded Epoxy in a uniform thickness, conforming to AWWA C116.

4. Field cut pipe: Pipe shall be cut and reconditioned to make up the next joint per pipe and pipe liner manufacturer's recommendations. Remove any sharp, rough edges that might otherwise damage the joint of coupling. Freshly cut ends shall be immediately coated with Cement Mortar Liner joint compound, and compatible with interior lining of pipe. Pipe that is to be cut in the field shall be "Gauged Full Length" pipe. Field gauge all field cut ends and ensure it to be within manufacturer's tolerances. Cut ends found to be outside of manufacturer's tolerances shall be rounded in accordance with manufacturer's recommendations.

5. Cast iron and ductile iron specials and fittings shall conform to ANSI A21.10 (AWWA C110) or ANSI 21.53 (AWWA C153) with joints as shown on the Drawings or a required elsewhere in these specifications or for the installation.

6. Interior lining of specials and fittings shall match the adjoining specified pipe lining. All standard fittings shall be factory lined with cement mortar lining.

7. Flanges shall meet or exceed ANSI B16.1, Class 250 unless otherwise indicated, or required for the installation.

8. Flanges for spool pieces shall be factory installed threaded flanges. Flanges for fittings shall be cast integrally with the fitting.

9. Where specified, called for on the drawings, or otherwise required for thrust restraint, mechanical joints shall be made using retainer glands with set screws or clamping lugs. Retainer glands shall be as manufactured by EBAA Iron, Tyler Pipe, or equal.

10. Rubber gasket for mechanical or push-on joints shall meet ANSI A21.11 (AWWA C111), vulcanized natural or vulcanized synthetic rubber.

11. Flanged gaskets shall be full face, 1/16-inch thick cloth inserted rubber or metallic packing.

12. Bolts and nuts for all service conditions (above ground, submerged and buried) shall be Type 316 stainless steel.

13. Valves shall be factory lined with Fusion Bonded Epoxy.

2.2 RESTRAINED FLANGE ADAPTERS

A. Restrained flange adapters shall be fully restrained and constructed of ASTM A536 ductile iron and have flanged bolt circles that are compatible with ANSI/AWWA C110/A21.10 (125# /Class 150 bolt pattern).

B. Restraint for flange adapter shall consist of a plurality of individual actuated gripping wedges to maximize restraint capability. Torque limiting actuating screws shall be used to insure proper initial set of gripping wedges.

C. The flange adapters shall be capable of deflection during assembly or permit lengths of pipe to be field cut to allow a minimum 0.6-inch gap between the end of the pipe and the mating flange without affecting the integrity of the seal.

D. All internal surfaces of the gasket ring (wetted parts) shall be lined with a minimum of 15 mils of fusion bonded epoxy conforming to the applicable requirements of ANSI/AWWA C213. Sealing gaskets shall be constructed of EPDM. The coating and gaskets shall meet ANSI/NSF-61. Exterior surfaces of the gasket ring shall be coated with a minimum of 6 mils of fusion bonded epoxy conforming to the applicable requirements of ANSI/AWWA C116/A21.16.

E. Pressure rating shall be a minimum of 250 psi.

2.3 UNDERGROUND PIPE MARKERS

A. Manufacturers:
1. Presco – Underground Warning Tape, Detectable.
2. Reef Industries, Inc. – Terra Tape, Detectable
3. Or equal.

B. Furnish materials in accordance with OSHA standards.

C. Plastic Ribbon Tape: Bright colored blue, continuously printed, minimum 3 inches wide by 4-mil thick, manufactured for direct burial service.

2.4 ACCESSORIES

A. Grout: Specified in Section 03 30 00.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify excavation base is ready to receive work and excavations, dimensions, and elevations are as indicated on drawings.

3.2 PAINT COATING FERROUS SURFACES

A. Field apply paint and protective coating systems for all above ground pipes and appurtenances where shown on the plans that are not otherwise shop coated. Do not apply coating material if the relative humidity exceeds 80 percent or if the surface temperature is less than 5º F. above the dew point.

B. Surface to be coated must be cleaned as specified in subsection 310-2.5.1, part (c) of the SSPWC and these Special Provisions.

C. Surfaces to be coated must be cleaned and coated in conformance with manufacturer's recommendations for coating for the type of material being used. The metal must be cleaned after blasting with clean, dry compressed air. Use of rugs to remove residual dust after sandblasting will not be permitted.

D. Before blast cleaning, remove all oil, grease or other contaminants by solvent cleaning per Subsection 310-2.3, "Solvent Cleaning," of the SSPWC.

E. Shop applied primer must be by spray equipment.

F. Apply intermediate and top coat after priming and cure. White zinc salt, if present, must be cleaned off primed surface before applying intermediate coat.

G. Apply the appropriate System No. protective system as specified in these Special Provisions.

1. System No. 5 – Submerged Metal, Wastewater

   a. Type: Two component, three coat epoxy system.
   b. Surface Preparation: SSPC-SP 10.
   c. Coating System: Apply three coats. Apply to a minimum dry film thickness of 12 mils.

2. System No.10 – Exposed Metal, Corrosive Environment, as described in these Special Provisions for pipe within wet well
   a. Type: High build epoxy coat having a minimum volume solids of 60%, with an inorganic zinc prime coat
   b. Surface Preparation: SSPC-SP 10
   c. Prime Coat: Self curing, two component inorganic zinc rich coating recommended by the manufacturer for overcoating with a high build epoxy finish coat. Minimum Zinc content must be 12 pounds per gallon. Provide Ameron 3105, Kopcoat Inorganic No. 701, Engard 519, or approved equal. Apply to thickness of 3 mils.

d. Finish Coat: Provide Ameron 383HS, Kopcoat Hi-Gard, engard 460 HS, or approved equal. Apply to minimum dry film thickness of 12 mils total.

3. System No. 20 -- Exposed Metal, Exterior

a. Type: Gloss synthetic enamel with OSHA safety color coding.
b. Surface Preparation: SSPC-SP 1. Apply one coat of vinyl wash primer on galvanized, zinc, or bronze surfaces use Sinclair No. 7113, or approved equal.
c. Prime Coat: Sinclair No. 15 (non-ferrous or ferrous) or No. 25 (galvanized or zinc), 2 mils or approved equal.
d. Intermediate Coat: Sinclair No. 248, 1.5 mils or approved equal.
e. Finish Coat: Sinclair or approved equal – color per owner.

3.3 INSTALLATION - GENERAL

A. All pipe installation shall be in accordance with manufacturer's recommendations. Contractor shall immediately notify District of any conflicts between manufacturer's recommendations and drawings.

B. Lay pipe to slope gradients noted on drawings. Begin at downstream end and progress upstream.

C. Assemble and handle pipe in accordance with manufacturer's instructions except as modified on the Drawings or by Engineer.

D. Keep pipe and fittings clean until work is completed and accepted by Engineer. Cap open ends during periods of work stoppage.

E.

3.4 PROTECTION OF FINISHED WORK

A. Protect pipe from damage or displacement.

END OF SECTION 33 41 00

SECTION 40 90 00

PROCESS INSTRUMENTATION AND CONTROL SYSTEM

GENERAL REQUIREMENTS

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. The overall system general requirements are given in this section. These requirements apply to each additional section of these specifications as noted herein and as specified in the associated sections.

B. Work includes engineering, furnishing, installing, testing, documenting, and placing in operation a **Process Instrumentation and Control System (PICS)**. The Work is associated with the design and construction of the San Bernardino County Lakeview Lift Station. Training of the DISTRICT's personnel is also included. The work is specified in this Section and as further specified in the following sections:

1. Specification Section 40 90 10: Process Instrumentation and Control System (PICS) - Field Instruments.
2. Specification Section 40 90 15: Process Instrumentation and Control System (PICS) - Control Panels.
3. Specification Section 40 90 16: Process Instrumentation and Control System (PICS) - Well Pump Control Panels.

C. All work covered by this specification, except as noted below, shall be performed by one of the following firms, who are henceforth referred to as the SYSTEM SUPPLIER:

1. TESCO
2. SI (Systems Integrated)
3. Approved firm dictated by SB County

D. The SYSTEM SUPPLIER shall be specifically responsible for furnishing and making operational the following major PICS elements:

1. Float switch operation within well and control panel
2. Ultrasonic level operation within well and control panel.
3. Well pump control panel.
4. Addition of I/O outlined in construction plans to existing SCADA.

E. The various SUPPLIERS shall furnish all labor, materials, equipment, programming, services and incidentals required to install and place into operation a digital computer-based PICS configured as shown on the Contract Drawings, and as specified herein.

F. The SUPPLIERS shall provide all equipment, materials, programming, software, calibrations and services that are required to successfully interface and interconnect the PICS and any other control systems and associated equipment that are specified or designated in any drawings or provisions of these specifications for the purpose of providing a fully integrated and functional control system.

G. The SUPPLIERS may duplicate software logic code and database and graphics applications, as required, while still meeting the functional specifications. The ENGINEER may require modifications to the submitted graphics, reports and control logic without change to the contract price. All engineering development required by the SUPPLIERS will be in accordance with the Conditions of this Contract.

H. The CONTRACTOR shall ensure that the SUPPLIERS coordinate closely with suppliers of other specialty equipment to ensure the required inputs and outputs for the PICS are available.

I. Division of Work. It is the ultimate responsibility of the CONTRACTOR to furnish a complete and fully operable PICS that reliably performs the specified functions. The CONTRACTOR is to assume full responsibility for additional costs which may result from unauthorized deviations from the specifications.

J. The CONTRACTOR shall be responsible for:

1. Including within the electrical subcontractor's scope:
    a. Installation of fiber optic cabling furnished by the SUPPLIERS. Termination within SUPPLIERS provided control panels and enclosures shall be performed by the SUPPLIERS. The electrical contractor shall make all other necessary fiber terminations.
    b. Provision, installation and termination of field and power wiring to PICS supplied control panels and field elements. Termination shall be made in accordance with final accepted interconnection diagrams developed by the SUPPLIERS. The electrical subcontractor shall mark on the interconnect diagram the field wire numbers used for each termination point. The SUPPLIERS shall finalize the interconnect diagrams by including these field wire numbers in the final as built version.
    c. Installation and termination of all specialty cables furnished by the SUPPLIERS.
2. Including within the mechanical subcontractor's scope installation of any in-line instrumentation. Installation shall be made in accordance with the manufacturer's recommendations and under the direction of the SUPPLIERS.
3. Equipment storage and protection until installed following the storage and handling instructions recommended by the SUPPLIERS. Anti-static and winterization requirements shall be per the SUPPLIERS's instructions and the SUPPLIERS shall periodically verify that these instructions are followed.
4. Incorporating all necessary components into the system. Schedules included in the referenced specification sections do not necessarily indicate the complete component requirements of the PICS.
5. Ensuring that the SUPPLIERS coordinates work with other Sections of the Specifications.

6. Requiring the SUPPLIERS to observe and advise on the installation of equipment furnished by SUPPLIERS and installed by CONTRACTOR to the extent required to certify, with the operational check-out tests, that the equipment will perform as required.
7. Ensuring that information on equipment provided under other Sections and needed by the SUPPLIERS to coordinate the PICS is provided in a timely manner.

K. Equipment found to be defective prior to system acceptance shall be replaced and installed at no additional cost to the DISTRICT.

L. In the bid price, the SUPPLIERS shall provide for obtaining the services of authorized field personnel from the manufacturers of specialty instruments and from the suppliers of application software packages as necessary. Should these personnel be required during installation, start-up and checkout of the respective portions of the PICS, such services shall be provided at no additional cost to the DISTRICT.

1.02 RELATED WORK

A. Section 33 – Mechanical. Installation of all mechanical piping and fittings, as well as in-line instruments supplied with and/or supplied for the PICS.

B. Section 26 - Electrical. All conduits are provided and installed under Section 26, Electrical. With the exception of certain specified special manufacturer's cables, all wiring and cables are provided and installed under Section 26, Electrical.

C. Field devices such as motorized valves, pump motors, solenoid valves, etc. and local control panels for specialized subsystems such as chemical feed systems, etc. are supplied and installed under other Sections of these Specifications.

1.03 SYSTEM DESCRIPTION

A. The PICS shall comprise the following major subsystems interconnected as described below:

1. Install float switches per construction plans and integrate with pump control panel.
2. Install ultrasonic level sensor per construction plans and integrate with pump control panel.
3. Integrate proposed I/O indicated on construction plans to existing PLC/SCADA. system
4. Existing PLC to be re-programmed as needed.
5. Add additional I/O modules as necessary.
6. A PICS system network interconnecting the HMI and PLC subsystems and the security system components.

1.04 SYSTEM INTEGRATION PLAN

A. Prior to any other shop drawing submittals, the SUPPLIERS shall submit a System Integration Plan (SIP). Other submittals received before this submittal will be returned without review.

B. The SIP shall identify, and provide details of, all PICS functions. This shall include the following elements:

1. Field.
2. Existing PLC modification.
3. System Inputs and Outputs.
4. Network/communications.

C. Field. Provide an Excel spreadsheet that covers all field instruments. For each instrument define the following:

1. Tag Number.
2. Instrument Type.
3. Specification Section supplied under.
4. Signal Type and power requirement.
5. Range (include display units) or On/Off states as applicable.

D. PLC. Provide an Excel spreadsheet that covers all PLC. For each, define the following:

1. PLC Designation Number, make and model number.
2. Location.
3. New or modified.
4. A list of I/O modules that will exist at project completion.

E. System Inputs and Outputs (I/O). Provide an Excel spreadsheet that lists all system I/O for the complete PICS. For each point, the list shall include the following:

1. PICS database tag number.
2. Signal Description.
3. I/O Type.
4. Range or On/Off state as applicable.

F. Network/communications. This shall provide the following information:

1. Network/communications diagram showing all Ethernet switches, media converters, radios where applicable, etc.
2. Identification of all used and available switch ports by type (copper or fiber).
3. Assigned IP addresses.

G. HMI system. This shall provide the following information:

1. Listing of HMI system hardware upon completion of the Work.
2. Listing of all HMI software and license numbers.
3. Software drivers to be used for PLC communications.
4. HMI system block diagram.

H. Following PLC programming, revise the system I/O spreadsheet to include all pseudo points (differentiated from physical I/O) that are used by the HMI.

I. Provide a fully updated SIP as part of the final system documentation.

1.05 SUBMITTALS

A. Furnish, as prescribed under the General Requirements, all required submittals covering the items included under this section and its associated sections of the work.

B. Submit complete, neat, orderly, and indexed submittal packages. Handwritten diagrams are not acceptable and all documentation submittals shall be made using CADD generated utilities.

C. Partial submittals or submittals that do not contain sufficient information for complete review or are unclear will not be reviewed and will be returned by the Engineer as not approved.

D. Provide all shop drawing submittals on thumb drive in PDF format.

E. In addition to the shop drawing submittals required in the related specification sections, submit the submittals defined below covering the complete system.

1. System Performance. This submittal shall be a written description of how the operator will control the system and the system's subsequent response. Every piece of controllable equipment shall be separately described and the following information included:
    a. Use of local manual controls.
    b. Use of OIT/HMI software controls.
    c. Use of automatic controls.
2. Each functional description shall specifically identify any interlocks (hardware and software) and OIT/HMI alarms generated.
3. Operator Screens. This submittal shall include color copies of all proposed new and modified OIT/HMI operator screens. Modified graphics shall specifically indicate the revised portions.
4. Field Acceptance Test Plan. This submittal shall define the steps to be conducted during the required witnessed acceptance testing. The test shall be conducted in accordance with the general requirements set forth in Part 3 hereof. The submitted plan shall meet the following requirements:
    a. Each of the equipment covered in the system performance submittal shall be tested.
    b. For each equipment test, the required operator control actions and system response shall be demonstrated on the complete system, including each operator action, the response and appropriate HMI display/alarm updates.

F. The Contractor and System Supplier are hereby specifically advised that the above submittals shall be Approved or Approved As Noted prior to any witnessed performance testing.

G. Loop Diagram Submittal. This submittal may be made in conjunction with the submittals required under related specification sections. Loop diagrams, consisting of complete wiring and/or plumbing diagrams for each control loop showing all terminal numbers, the location of the dc power supply, the location of any booster relays or common dropping resistors, surge arrestors, etc. The loop diagrams shall meet the minimum requirements of ISA S5.4 plus divide each loop diagram into four areas for identification of element locations: PICS I/O point(s), panel face, back-of-panel, and field, respectively.

H. Test Procedures: Submit the procedures proposed to be followed during all required testing. Procedures shall include test descriptions, forms, and check lists to be used to control and document the required tests.

I. Test Reports: Upon completion of each required test, document the test by submitting a copy of the signed off test procedures to the Engineer.

1.06 FINAL DOCUMENTATION

A. After the demonstration tests have been completed and as a part of the final acceptance requirements, submit the PICS record drawings. Record drawings shall include, corrected for any changes that may have been made up through Substantial Completion:

1. System block diagram.
2. Network architecture diagram.
3. Instrument loop wiring diagrams.
4. Panel wiring diagrams.
5. Panel elevations.
6. Interconnection diagrams showing terminal numbers at each wiring termination.

B. Record drawings shall be developed or converted to AutoCAD Version 2020. Provide the following:

1. Two copies of all AutoCAD and pdf files on separate Compact Disks.
2. Five 11 x 17 hard copies each contained within its own binder.

C. Operating and Maintenance (O&M) Manuals: Provide the specified number of complete sets of three-ring bound O&M manuals in accordance with Specification 01 78 23. Provide separate manuals for each Specification Section, clearly marked. Include descriptive material, drawings, and figures bound in appropriate places. Include:

1. Cross references to 3rd party O&M manuals.
2. Additional operating and maintenance instructions in sufficient detail to facilitate the operation, removal, installation, adjustment, calibration and maintenance of each component provided with the PICS.
3. Internal wiring diagrams (not already shown on the panel wiring diagram record drawings) for all components provided in the PICS that clearly show all terminal block number designations and wire numbers.

4. Bill of Materials identifying the manufacturer and complete part number of all components.
5. All the submittal data for each component from the approved shop drawing submittals with corrections made on approved as noted items.
6. A Compact Disk containing the shop drawing data in PDF format in the binder sleeve.

D. Provide a final System Integration Plan.

E. Refer to the individual specification sections of the PICS for final documentation requirements that are in addition to the above.

1.07 QUALITY CONTROL

A. Base bids for the SUPPLIERS shall be as listed in the Contract Proposal. SUPPLIERSs seeking ENGINEER approval shall have extensive experience in systems of similar size and complexity. Panel fabrication shop shall be a UL listed panel shop. Acceptance of alternates shall be made based on price, location of the fabrication shop, accessibility of personnel, PLC programming knowledge, and DISTRICT confidence. The SUPPLIERS shall be subcontracted by and paid by the CONTRACTOR.

B. The SUPPLIERS shall meet all of the requirements of these specifications, and, unless specifically stated otherwise, no prior acceptance of any subsystem, equipment, or materials has been made.

C. All equipment furnished by the SUPPLIERS shall be of the latest and most recent design and shall have overall accuracy as guaranteed by the manufacturer.

D. Materials and equipment used shall be U.L. approved wherever such approved equipment and materials are available.

E. Component equipment shall be as supplied by one of the manufacturers named in the individual specification sections or approved equal. The design of the PICS is based on the first-named manufacturer's equipment if there is a difference.

F. To facilitate the DISTRICT's operation and maintenance, products shall be of the same major manufacturer, with panel mounted devices of the same type and model as far as possible.

G. In order to insure the interchangeability of parts, the maintenance of quality, the ease of interfacing between the various subsystems, and the establishment of minimums with regard to ranges and accuracy, strict compliance with the above requirements shall be maintained.

H. The SUPPLIERS shall designate a single point of contact for interface with the ENGINEER on this project. The ENGINEER reserves the sole right to approve or reject this point of contact.

I. The SUPPLIERS's selected project personnel shall meet the following requirements:

1. Project engineer shall have at least 10 years' experience in installing similar systems and shall have a minimum of secondary education in the field of electronics or similar technical discipline.

2. Project technician assisting the project engineer for field element calibration and check out shall have at least five years experience in installing similar systems.
3. Key staff resumes shall be submitted for ENGINEER’s approval with the Project Plan as further detailed under submittals.

J. Service Facility: The SUPPLIERS shall have an established service facility from which qualified technical service personnel and parts may be dispatched upon call. Such a service facility shall be no more than six (6) hours travel time from the jobsite.

K. The SUPPLIERS shall provide experienced personnel on-site to coordinate and/or perform installation, termination, and adjustment; on-site testing; DISTRICT training; and startup assistance for the PICS.

L. The SUPPLIERS shall provide, on-site, an experienced project engineer to supervise and coordinate all of the on-site PICS activities. An experienced technician may be provided to assist the project engineer in field element installation, field calibration, and checkout tests. The SUPPLIERS's project engineer shall be on- site during the period required to effect all of the critical on-site activities related to the PICS, particularly the software debugging, PICS training, and witnessed testing activities.

1.08 STANDARDS

A. The design, testing, assembly, and methods of installation of the wiring materials, electrical equipment and accessories proposed under this Contract shall conform to the National Electrical Code and to applicable state and local requirements. UL listing and labeling shall be adhered to under this Contract.

B. Any equipment that does not have a UL, FM CSA, or other approved testing laboratory label shall be furnished with a notarized letter signed by the supplier stating that the equipment famished has been manufactured in accordance with the National Electric Code and OSHA requirements.

C. Any additional work needed resulting from any deviation from codes or local requirements shall be at no additional cost to the DISTRICT.

D. International Society of Automation (ISA) and National Electrical Manufacturers Association (NEMA) standards shall be used where applicable in the design of the PICS.

E. All equipment used on this project to test and calibrate the installed equipment shall be in calibration at the time of use. Calibration shall be traceable to National Institute of Standards (NIS - formally NBS) calibration standards.

F. For the purposes of uniformity and conformance to industry standard, provide analog signal transmission modes of electronic 4-20 ma DC. No other signal characteristics are acceptable.

G. Discrete signals are two-state logic signals. Use 120V ac sources on all discrete signals unless otherwise noted or shown.

H. Fully isolate outputs for transmitted electronic signals between transmitters and receivers, equipment of different manufacturers and between control panels to conform to ISA Standard S 50. 1.

I. Provide appropriately sized electrical transient protection devices for all electrical elements of the system as further defined in the individual specification sections. For field mounted devices, provide protector enclosures to the electrical Subcontractor for mounting and installation.

1.09 WARRANTY AND GUARANTEES

A. In accordance with Section 1, the SUPPLIERS shall furnish to the DISTRICT a written two year guarantee commencing with final acceptance, that all equipment and parts thereof, material and/or workmanship for the field elements, instruments, and control panels are of top quality and free from defects.

B. The SUPPLIERS shall guarantee all equipment whether or not of his own manufacture.

1.10 SPARES AND EXPENDABLES

A. Obtain from the manufacturer(s) and provide the recommended critical spare parts as part of the work. Refer to the individual requirements listed in the associated specification sections for the PICS for specific parts to be provided as a minimum. The spare parts are the property of the DISTRICT.

B. Obtain from the manufacturer(s) and furnish any special tools, calibration equipment and testing apparatus required for the proper adjustment and maintenance of the material provided.

PART 2 - PRODUCTS

THIS PART NOT USED

PART 3 - EXECUTION

3.01 SEQUENCE OF WORK

A. Coordination Meetings: In order to ensure timely performance of the Contract and the system's conformance with these specifications, coordination meetings shall be held during scheduled monthly construction progress meetings at the project site, as necessary based on the progress of the job. The first meeting will be held 30 days after award of the Contract to the CONTRACTOR. The CONTRACTOR and SUPPLIERS shall provide for their attendance at this meeting in their quotation. A schedule for additional coordination meetings (approximately one each month) will be derived at this initial meeting for periodic update, coordination, and conflict resolution during the project duration.

B. Prerequisite Activities and Lead Times: Do not start the following key project activities until the listed prerequisite activities have been completed and lead times have been satisfied:

1. Hardware Purchasing, Fabrication, and Assembly: Associated design related submittals completed (no exceptions, or approved as noted).
2. Shipment: Completion and approval of all design related submittals.
3. Startup: Operational Checkout Tests.

4. DISTRICT Training: DISTRICT training completed and O&M manuals delivered.

5. Demonstration Tests: Operational Check-out Tests, Startup, DISTRICT Training, and Demonstration Test Procedures must be complete. Give 4 weeks' notice prior to the planned test start date.

C. Consoles, Panels, and Panel Mounted Equipment: Consoles, panels, and panel mounted equipment shall be assembled as far as possible at the SUPPLIERS's shop. No work, other than correction of minor defects or minor transit damage, shall be done on the panels at the jobsite.

3.02 PAYMENTS

A. General: All work provided under this Section and its associated Sections for the PICS shall be paid for in accordance with the approved payment Schedule of Values submitted by the CONTRACTOR. The approved Schedule of Values will be the basis for partial payment for work provided for the PICS.

B. Partial Payment for Work Completed: The breakdown in the Schedule of Values allows for the partial payment of work completed for the PICS. Before partial payment is considered for approval, each specific activity must be completed.

C. Substantial Completion: Substantial Completion for the project is as defined in the General Conditions. However, the following requirements must be fulfilled before consideration will be given for Substantial Completion of the PICS:

1. All PICS submittals have been completed.
2. The PICS has successfully completed the Demonstration Tests.
3. The required DISTRICT training has been implemented.
4. All spares, expendables, and test equipment have been received by DISTRICT.

D. Final Acceptance: PICS final acceptance is defined as the date when the ENGINEER issues a written notice of final acceptance. For this Section, the following must have been completed before consideration will be given to the issuance of notice of final acceptance:

1. All punch-list items have been checked off.
2. Revisions to the PICS O&M Manuals have been made (that may have resulted from the Demonstration Tests).

E. Partial Payment Limits: The partial payments for work provided for the PICS shall satisfy the following limiting maximum criteria (percentages of the lump sum pay item for the PICS):

1. Submittals (not including O&M Manuals) 15%
2. Training..5%
3. O&M Manuals 5%
4. Demonstration Tests 10%

3.03 PRODUCT HANDLING

A. Store and protect equipment until installation following the storage and handling instructions recommended by the equipment manufacturers. Place special emphasis on proper anti-static protection of sensitive equipment.

B. Protection During Construction: Throughout this Contract, provide protection for materials and equipment against loss or damage and from the effects of weather. Prior to installation, store items in indoor, dry locations. Provide heating in storage areas for items subject to corrosion under damp conditions. Provide covers for panels and other elements that may be exposed to dusty construction environments. Specific storage requirements shall be in accordance with the SUPPLIERS's recommendations.

C. Corrosion Protection: Protect all consoles, panels, enclosures, and other equipment containing electrical or instrumentation and control devices, including spare parts, from corrosion through the use of corrosion-inhibiting vapor capsules. Prior to shipment, include capsules in the shipping containers, and equipment as recommended by the capsule manufacturer. During the construction period, periodically replace the capsules in accordance with the capsule manufacturer's recommendations. Replace all capsules just prior to Final Acceptance.

D. ESD Protection: Provide for the proper handling, storage, and environmental conditions required for the PICS components deemed static sensitive by the equipment manufacturer. Utilize anti-stat wrist straps and matting during installation of these items to prevent component degradation. Flooring used in control areas shall be reviewed and approved by the SUPPLIERS.

E. Adequately pack manufactured material to prevent damage during shipping, handling, storage and erection. Pack all material shipped to the project site in a container properly marked for identification. Use blocks and padding to prevent movement.

F. Ship materials that must be handled with the aid of mechanical tools in wood-framed crates.

G. Ship all materials to the project site with at least one layer of plastic wrapping or other approved means to make it weatherproof. Anti-stat protection shall be provided for all sensitive equipment.

H. Inspect the material prior to removing it from the carrier. Do not unwrap equipment until it is ready to be installed. If any damage is observed, immediately notify the carrier so that a claim can be made. If no such notice is given, the material shall be assumed to be in undamaged condition, and any subsequent damage that is discovered shall be repaired and replaced at no additional expense to the DISTRICT.

I. The CONTRACTOR shall be responsible for any damage charges resulting from the handling of the materials.

3.04 INSTALLATION

A. Material and Equipment Installation: Install the PICS in locations indicated on the Drawings and follow manufacturers' installation instructions explicitly, unless otherwise indicated. Wherever any conflict arises between manufacturers' instruction and these Contract Documents, follow ENGINEER's decision, at no additional cost. Keep copy of manufacturers' instructions on the jobsite available for review at all times.

B. Install materials and equipment in a workmanlike manner utilizing craftsmen skilled in the particular trade. Provide work which has a neat and finished appearance. Coordinate I&C work with the DISTRICT and work of other trades to avoid conflicts, errors, and delays.

C. Provide finish on instruments and accessories that protects against corrosion by the elements in the environment in which they are to be installed. Finish both the interior and exterior of enclosures. Provide extra paint of each color used in the material from the manufacturer for touch-up purposes.

D. Equipment Finish: Provide materials and equipment with manufacturer's standard finish system. Provide manufacturer's standard finish color, except where specific color is indicated. If manufacturer has no standard color, finish equipment with light gray color.

E. Cleaning and Touch-up Painting: Keep the premises free from accumulation of waste material or rubbish. Upon completion of work, remove materials, scraps, and debris from premises and from interior and exterior of all devices and equipment. Touch-up scratches, scrapes, or chips in interior and exterior surfaces of devices and equipment with finishes matching as nearly as possible the type, color, consistency, and type of surface of the original finish. Clean and polish the exterior of all panels and enclosures upon the completion of the demonstration tests.

F. Control Valves: Verify correctness of installation. Verify calibration and adjustment of all positioners and I/P transducers and verify correct control action. Verify position switch settings. Verify opening and closing speeds and travel stops.

3.05 TRAINING

A. The cost of training programs to be conducted with DISTRICT's personnel shall be included in the Contract price. The training and instruction, insofar as practicable, shall be directly related to the System being supplied.

B. The SUPPLIERS shall provide detailed manuals to supplement the training courses. The manuals shall include specific details of equipment supplied and operations specific to the project.

C. The SUPPLIERS shall make use of teaching aids, manuals, slide/video presentations, etc. After the training services, such materials shall be delivered to DISTRICT.

D. The training program shall represent a comprehensive program covering all aspects of the operation and maintenance of the system.

E. All training schedules shall be coordinated with, and at the convenience of the DISTRICT. Shift training may be required to correspond to the DISTRICT's working schedule.

F. Specific details of the nature and duration of training to be provided are defined in the individual specification sections.

3.06 TESTING - GENERAL

A. All elements of the PICS, both hardware and software, shall be tested to demonstrate that the total system satisfies all of the requirements of the Contract Documents

B. As a minimum, the testing shall include shop tests, operational check-out tests, and Demonstration Tests.

C. Each test shall be in the cause and effect format. The person conducting the test shall initiate an input (cause) and, upon the system producing the correct result (effect), the specific test requirements will have been satisfied.

D. All tests shall be conducted in accordance with, and documented on, prior approved procedures, forms, and checklists. Each specific test to be performed shall be described and a space provided after it for signoff by the appropriate party after its satisfactory completion. Copies of these signoff test procedures, forms, and checklists will constitute the required test documentation.

E. Provide all special testing materials and equipment. Wherever possible, perform tests using actual process variables, equipment, and data. Where it is not practical to test with real process variables, equipment, and data, provide suitable means of simulation. Define these simulation techniques in the test procedures.

F. The SUPPLIERS shall coordinate all of their testing with the CONTRACTOR, the ENGINEER, all affected suppliers, and the DISTRICT.

G. The ENGINEER reserves the right to test or retest any and all specified functions whether or not explicitly stated in the approved test procedures. The ENGINEER's decision shall be final regarding the acceptability and completeness of all testing.

3.07 FACTORY TEST

A. Prior to shipment, perform a factory test on the fully assembled and functioning system as further defined below.

B. Successfully perform a full dry run of the test prior to certifying to the ENGINEER that the system is ready for discretionary DISTRICT and/or ENGINEER witness of a formal test.

C. The intent of this test is to demonstrate to the ENGINEER’s satisfaction that the system is fully operational and debugged prior to shipment and installation. It is recognized that loop tuning, final drive parameter settings, etc. can only be performed in the field. However, subsequent to shipment it should only be necessary to confirm correct wiring and installation and proper control loop operation. The factory demonstration test shall therefore be structured to confirm the functional operation of the complete system.

D. The test system shall, as a minimum, include the following equipment:

1. All Motor Control Centers and stand-alone VFD and SSS cabinets networked to the appropriate Process Control Panel.
2. Test motors connected to representative VFDs and MCC equipment.
3. Simulated I/O for each PCP including each type of signal.

E. Before starting the test, prepare a system inspection log. In the log, record the serial numbers of all major components and document that all portions of the system have been inspected by quality assurance personnel. Include the log in the required test report.

F. Start-up the system from a fully powered down condition demonstrating that the various system elements can be brought on line without adverse consequences. Throughout subsequent testing, use system diagnostics to demonstrate system status under the various fault scenarios.

G. Demonstrate normal operations including the following:

1. Functioning of all control strategies using the operator process graphics.
2. The ability to modify the system including:
   a. Add points to the system database
   b. Develop a new process graphic using the newly added points
   c. Modify a test report to include the new points
   d. Build a trend using one of the new points
3. Message logging and alarm handling
4. Historical data collection and access from the administrative network
5. Correct operation of protective interlock relay logic within the Process Control Panels and MCCs.

H. Demonstrate the ability, from an Operator Workstation, to review, modify, and adjust the following:

1. PLC programs.

I. Demonstrate the system can automatically fully recover (i.e. no loss of data) from failure of an application server.

J. Demonstrate the required UPS back-up duration. This may be performed concurrently with other portions of the test.

K. Demonstrate the system can detect the following failures and that other system functions remain unaffected:

1. Failure of a PLC.
2. Failure of an Operator Work Station
3. UPS failure
4. Utility Failure
5. Pump Overload
6. Level
7. Maintenance
8. Float Failure

9. Float alarm

L. Provide for up to two hours per day of DISTRICT/ENGINEER additional tests.

3.08 OPERATIONAL READINESS TEST (ORT)

A. Prior to startup and demonstration testing, certify that the entire installed PICS (inspected, tested and documented) is ready for operation. These inspections and tests shall include Loop/Component inspections and tests. Toward the end of these checkout tests, down load the HMI software and test the system loop by loop to complete the PICS checkout tests. The SUPPLIERS shall fully debug problems in the system as a whole. Final approval of control software will not be based on written descriptions of software functions alone, but on actual performance in the field.

B. Check the entire PICS for proper installation, calibration and adjustment on a loop-by-loop and component-by-component basis to ensure that it is in conformance with related submittals and the PICS Specifications.

C. The Loop/Component Inspections and Tests shall be implemented using approved forms and checklists. Example sheets are provided at the end of this Specification Section. These shall be developed by the SUPPLIERS and submitted for approval.

D. Maintain the Loop Status Reports and Component Calibration Sheets at the jobsite and make them available to the ENGINEER at any time.

E. Witnessing: These inspections and tests do not require witnessing. However, the ENGINEER will review the Loop Status Sheets and Component Calibration Sheets and spot-check their entries periodically and upon completion of the Operational Check-out Tests. Correct any deficiencies found.

F. Final Documentation: The completed reports and sheets shall be assembled in one document and submitted together with a completed Manufacturer's Check-Out Certification.

3.09 FIELD ACCEPTANCE TEST (FAT)

A. Once the PICS has passed the ORT, the SUPPLIERS shall perform a witnessed Field Acceptance Test (FAT) on the complete PICS. The FAT shall demonstrate that the PICS is operating and in compliance with the Contract requirements. Each specified function shall be demonstrated on a paragraph-by-paragraph, and site-by-site basis.

B. Prior to the FAT, the entire installed PICS shall be certified in writing by the CONTRACTOR that it is ready for operation.

C. The system shall operate for a continuous 100 hours without failure before this test will be considered successful.

D. The FAT shall cover the entire PICS, including control functions, alarms, and status monitoring. Test procedures used for factory tests may be adopted for these tests if modified as required.

3.10 30-Day System Acceptance Test (SAT)

A. After completion of the Field Acceptance Tests, the entire system shall operate for a period of 30 consecutive days, under conditions of full plant process operation, without a single non-field repairable malfunction.

B. Provide complete O&M Manuals for the PICS at the jobsite at least two weeks prior to the SAT.

C. During this test, plant operating and SUPPLIERS personnel shall be present as required. The SUPPLIERS is expected to provide personnel for this test who have an intimate knowledge of the hardware and software of the system.

D. While this test is proceeding, the DISTRICT shall have full use of the system. Only plant operating personnel shall be allowed to operate equipment associated with live plant processes.

E. Any malfunction during the tests shall be analyzed and corrections made by the SUPPLIERS. The ENGINEER and/or DISTRICT will determine whether any such malfunctions are sufficiently serious to warrant a repeat of this test.

F. Any malfunction, during this 30 consecutive day test period, which cannot be corrected within 24 hours of occurrence by the SUPPLIERS's personnel, or more than two similar failures of any duration, will be considered as a non-field-repairable malfunction.

G. Upon completion of repairs, by the SUPPLIERS, the test shall be repeated as specified herein.

H. In the event of rejection of any part or function, the SUPPLIERS shall perform repairs or replacement within 90 days.

I. All data base errors must be corrected prior to the start of each test period. The 30-day test will not be considered successful until all databases are correct.

J. The total availability of the system shall be greater than 99.5 percent during this test period.

1. Availability is given by “(Total Time-Down Time)□ / Total Time".
2. Down times due to power outages or other factors outside the normal protection devices or back-up power supplies provided, shall not contribute to the availability test times above.

K. Upon successful completion of the 30-day Site Acceptance Test and subsequent review and approval of complete system final documentation, the system shall be considered substantially complete and the warranty period shall commence.

Loop Check-out Sheet

Project	DISTRICT's Project No. (if applicable):	Page of
Project	Regulatory Agency Project No. (if	
Project No.:	Date:	

LEAK AND TERMINATION/CONTINUITY CHECKS

DESCRIPTION	FIELD					CONTROL CAB	
	LEAK CHECK(1)			TERM/CONT CHECK(2)		TERM/CONT CHECK(2)	
	Device Tag No.	Process Conn.	Signal Tube	Device Tag No.	Termination Ident.	Device Tag No.	Termination Ident.

1. Leak check for pneumatic signal tubing to be per ISA-PR7.1.

2. Termination/continuity check includes check at terminated equipment for: (a) correct polarity, (b) appropriate signal generation, transmission and reception, and (c) correct shield & ground terminations.

OPERATOR INTERFACE CHECK-OUT

MONITORING POINTS OBSERVED

PARAMETER TYPE	TAG NO.	TAG NO.	TAG NO.	TAG NO.	TAG NO.	TAG NO.
PROCESS VAR						
EQUIP STATUS						
ALARM POINT						

OPERATOR CONTROL FUNCTIONS CHECKED

FUNCTION TYPE	TAG NO.	LOCATION	TAG NO.	LOCATION	TAG NO.	LOCATION

AS LEFT SETTINGS

TAG NO.	SWITCH & ALARM SP	CONTROLLERS

		Gain	Reset, rpm	Deriv. (rate), min	PV Set Point

Describe all interlocks checked, equipment started/stopped, valves/operators stroked. Describe modes of operation checked, and location of operator interface (local/remote).

____

____

____

I certify that the control loop referenced on this page has been completely checked and functions in accordance with applicable drawings and specifications.

Certified by:____ Date:______________

Instrument Calibration Sheet

Project Name:	DISTRICT's Project No. (if
Project	Regulatory Agency Project No.
HDR Project	Date:
Control Loop	

Instrument Tag	Transmitter/gauge span:
Manufacturer:	Switch set-point:
Model No.	Switch dead band:
Serial No.	Switch range:

TRANSMITTERS AND INDICATORS

	INCREASING INPUT			DECREASING INPUT		
% OF SPAN	**INPUT**	**OUTPUT**	**ERROR (% of span)**	**INPUT**	**OUTPUT**	**ERROR (% of span)**
0%						
25%						
50%						
75%						
100%						
Other (if applicable)						
Other (if applicable)						

SWITCHES

	INCREASING INPUT			DECREASING INPUT		
ACTUATION POINT	**INPUT**	**OUTPUT**	**ERROR (% of range)**	**INPUT**	**OUTPUT**	**ERROR (% of range)**
High (Increasing input)						
Low (Decreasing input)						

Maximum allowable error (per Contract Documents): ____

Remarks: ____

____

____

CALIBRATION EQUIPMENT UTILIZED

DEVICE TYPE	MFR/MODEL NO.	ACCURACY	NIST TRACEABILITY?

Certified by:____ Date Certified:__________________

END OF SECTION

SECTION 40 90 10

PROCESS INSTRUMENTATION AND CONTROL SYSTEM

FIELD INSTRUMENTS

PART 1 - GENERAL

1.01. SCOPE OF WORK

A. This Specification Section covers work related to the various field instruments to be supplied with the Process Instrumentation and Control System (PICS).

B. Certain field instruments are furnished with the process equipment by the Division 26 supplier as indicated on the Contract Drawings. They shall, however, be furnished in strict accordance with the requirements set forth herein.

C. All other field instrumentation shall be furnished by the same SYSTEM SUPPLIER furnishing services and equipment as outlined in 40 90 00.

D. The SYSTEM SUPPLIER shall furnish certain field instruments (as shown on the Contract Drawings) fully installed on a FRP Feed Water Instrument Panel.

E. Field instrumentation shall be calibrated per manufacturer standards prior to testing.

1.02. RELATED WORK

A. Specification Section 40 90 00 defines work and general requirements associated with the overall PICS.

B. Specification Section 40 90 15 defines work associated with the control panels that interface the field instrumentation into the overall PICS.

1.03. SUBMITTALS

A. Submit the following Field Instrumentation Shop Drawings in a single package:

1. Catalog information, descriptive literature, wiring diagrams, and shop drawings on all components of the field instruments, including all miscellaneous electrical and mechanical devices furnished under this section.
2. Complete part numbers for all instruments, including any options, shall be identified. Provide manufacturer’s data that correlates to the complete part number including all options.
3. Individual data sheets for all components of the field instruments to supplement the above information by citing all specific features for each specific component (e.g. scale range, materials of construction, special options included, etc.). Each component data sheet shall bear the component name and instrument tag number designation shown in the Drawings and Specifications.
4. Installation details for all field mounted devices to show conformance with the Contract Documents.
5. Configuration documentation for all programmable devices to indicate actual settings used to set the device scale, range, trip points, and other control parameters.

6. Calibration procedures to be used prior to startup.

1.04. SPARE PARTS

A. Spare parts shall be provided in a single package.

B. All spares shall be packed in a manner suitable for long-term storage and shall be adequately protected against corrosion, humidity and temperature.

C. Storage and handling instructions shall be provided with each spare part.

PART 2 - PRODUCTS

2.01. GENERAL REQUIREMENTS

A. Equipment to be installed in a hazardous area shall meet Class, Group, and Division classification as shown on the Contract Electrical Drawings, or comply with the local or National Electrical Code, whichever is the most stringent requirement.

B. All sense line tubing and valves for instruments shall utilize Super Duplex 2507 Steel materials for all concentrate applications and Duplex 2205 Steel elsewhere. All valves shall be provided with lockable handle tabs.

C. All instruments shall be provided with 316SS mounting hardware and floor stands, wall brackets, or instrument racks.

D. All transmitters shall be provided with either integral indicators or conduit mounted indicators in process units, accurate to two percent. Indicator readouts shall be linear in process units.

E. All transmitters located outside shall be equipped with sunshields powder-coat painted white. All NEMA enclosures shall be powder-coat painted white.

2.02. SURGE PROTECTION

A. Surge suppressors and arrestors meeting the requirements of ANSI Standard C-62.41 (latest revision) shall be provided as further detailed below.

B. AC Powered Instruments. Lightning and surge protection shall be provided on both the AC power supply and signal lines. The protectors and the associated instrument/transmitter and power disconnect shall be mounted in a NEMA 3R Stainless Steel, vented enclosure powder-coat painted white with three point latch. The protectors shall meet the following criteria:

1. NEMA 4X small case, conduit mounted enclosure.
2. Response time of less than five nanoseconds.
3. AC Power protection: IEEE/ANSI Std. C-62.41 rated C3 at 330 Volts clamping level.
4. Signal line protection: 10,000 Amp 8 x 20 microsecond surge, clamped at 36 Volts clamping level.
5. Test jacks for low level signal monitoring.
6. Manufacturer/model: ASCO Model 265.

C. Loop Powered Instruments. Lightning and surge protection shall be provided on the 4-20 mA DC signal line. The protectors shall meet the following criteria:

1. Encapsulated in Stainless Steel Pipe nipples for in-line conduit mounting.
2. Response time of less than one nanosecond.
3. Capable of withstanding up to 400 occurrences of 500 Amps at 10 x 1 millisecond.
4. Series resistance of 5 ohms per line.
5. Protection of both lines plus shield.
6. Manufacturer/model: ASCO model 157.

2.03. FIELD INSTRUMENTS

A. Provide the field instruments shown on the Contract Drawings and as further defined herein.

B. Ultrasonic Level Element and Transmitter. The system shall consist of a sensor (Level Element, LE) that uses a non-contact ultrasonic measurement technique to measure the liquid level in a vessel, tank or basin, interconnecting cable, and electronics unit that produces an analog signal proportional to level (Level Indicating Transmitter, LIT) or, in the case of weir applications, flow (Flow Indicating Transmitter, FIT).

1. System Performance:
    a. Overall system accuracy shall be plus or minus 0.25 percent of span or 0.1 inches, whichever is greater, automatically compensated for temperature.
    b. The electronics unit shall contain preset algorithms containing the necessary factors to convert a weir level into a flow value.
    c. The system shall be field calibratable without the use of external calibrators.
2. Sensor Materials:
    a. Chemical tank locations – All Teflon.
    b. Other locations – PVC and Teflon.
3. Ratings:
    a. Electronics Unit – NEMA 4X.
4. Electrical:
    a. Power Requirement - 120 VAC plus or minimum 10 percent, 60 Hertz.
    b. Maximum Power Consumption – 10 Watts.
5. Functional:
    a. Span, output, linearization and digital output scaling shall be adjustable at the transmitter.
    b. Echo status and loss indication shall be provided at the transmitter.
    c. Electronic unit display: 16 character, backlit LCD.

6. Manufacturer, Model series:
   a. Endress & Hauser Prosonic S FMU90 with FDU series sensor.
   b. Rosemount model 1300.
   c. Hydro Ranger 200
   d. Approved equal.

Ultrasonic Level Transmitter			
Loop	**Description**	**Range**	**Units**
1	Wet Well Level US-100	Per Plans	FEET

C. Level Switch, Float. The level switch shall be a direct acting, weighted float suspended on its own cable. As the liquid level rises the float tilts and actuates a hermetically sealed mercury switch inside the float. The cable shall be terminated within a junction box located outside the tank or basin. For multiple float applications, all cables shall terminate in a single junction box.

1. Materials:
   a. Float wetted part – Polypropylene with internal weight.
   b. Cable – PVC jacketed
   c. Junction box – 316 SS
2. Ratings:
   a. Junction box – NEMA 4X
3. Electrical:
   a. Dry contact, hermetically sealed, rated to 4.5 Amps at 120 VAC
   b. Activation Range: 1 inch change in level.
   c. Normally open or normally closed as required for the application
4. Options:
   a. Provide stainless steel supports/mounting accessories as required.
5. Manufacturer, model:
   a. Siemens, model LS
   b. Anchor Scientific, Roto-float type S
   c. ITT Flygt, model ENM-10

2.04. TOOLS AND TEST EQUIPMENT

A. The System Supplier shall provide any items, such as calibration fixtures, patch cables, test leads, etc. necessary for properly checking field operation of equipment supplied under this section.

2.05. SPARES AND EXPENDABLES

A. Provide the following spare parts:

1. Ten percent spare fuses (minimum of 10) of each type and rating supplied.
2. Five percent (minimum of 2) spare surge protection devices of each type used.

PART 3 - EXECUTION

3.01. INSTALLATION

A. Install the PICS field instruments in strict accordance with the respective manufacturer's instructions and recommendations, in locations as shown on the Drawings.

B. Provide surge protection enclosures to the electrical sub-contractor for mounting and installation. The enclosures shall be fully wired internally. Coordinate grounding requirements with Section 26, Electrical.

C. Fully calibrate each instrument.

END OF SECTION

SECTION 40 90 15

PROCESS INSTRUMENTATION AND CONTROL SYSTEM

CONTROL PANELS

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. This Specification Section covers work related to the control panels and enclosures to be supplied with the Plant Instrumentation and Control System (PICS).

B. The control panels, as specified herein, shall be furnished by the same SYSTEM SUPPLIER furnishing services and equipment as outlined in 40 90 00.

C. The SYSTEM SUPPLIER shall furnish all labor, materials, equipment, services and incidentals required to install and place into operation all control panels shown on the Contract Drawings and as specified herein.

D. Furnish the Process Control Panels defined in Specification Section 40 90 00.

F. Provide other control panels and enclosures necessary to house all elements of the complete PICS, including stand alone process indicators and transmitters as shown in the Contract drawings.

G. Size free-standing control panel(s) as necessary to contain all equipment associated with the PICS, including future equipment, and to adequately dissipate heat generated by equipment mounted in or on the panel. It shall not be necessary to provide additional panels to accommodate future system expansion.

H. Smaller surface-mount panels shall be sized to adequately dissipate heat generated by equipment mounted inside or on the panel front face.

I. The SYSTEM SUPPLIER shall design, furnish and install all interior wiring within the control panels and furnish complete wiring diagrams showing the electrical circuits inside the panel and interconnections between the panel and the external instruments and components.

1.02 RELATED WORK

A. Specification Section 40 90 00 defines work and general requirements associated with the overall PICS.

B. Control panels furnished with equipment, under other Sections, shall comply with the requirements herein.

1.03 SUBMITTALS

A. Submit the following control panel shop drawings in a single package:

1. Layout diagrams for all control panels and enclosures. Include panel elevations (front, side, interior), and sizing. Panel front elevations shall be of sufficient scale to allow all engraved nameplates and inscriptions to be legible without the use of schedules.

2. A complete Bill of Materials for each panel cross-referenced to the panel layout drawings and identifying the manufacturer and complete part number of all components.

3. Wiring diagrams for all control panels. Diagrams shall be complete electrical wiring diagrams showing all components and all auxiliary devices such as relays, alarms, fuses, lights, fans, heaters, etc. All wires and terminals shall be numbered on the diagrams, and line cross-references shall be labeled. Include wiring interface to the PLC equipment where applicable. Include on these drawings, a tag number to identify each component, referenced to a component identification list.

4. Power requirements and heat dissipation summary for all control panels. Power requirements shall state required voltages, currents, and phase(s). Heat dissipations shall be maximums and shall be given in Btu/hr. Summary shall be supplemented with calculations.

5. Catalog information, descriptive literature, wiring diagrams, and shop drawings on all components of the field instruments, including all miscellaneous electrical and mechanical devices furnished under this section.

1.04 SPARE PARTS

1. Spare parts shall be provided in a single package:

2. All spares shall be packed in a manner suitable for long-term storage and shall be adequately protected against corrosion, humidity and temperature.

3. Storage and handling instructions shall be provided with each spare part.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Equipment to be installed in a hazardous area shall meet Class, Group, and Division classification as shown on the Contract Electrical Drawings, or comply with the local or National Electrical Code, whichever is the most stringent requirement.

B. Electronic equipment shall utilize printed circuitry suitably coated to prevent contamination by dust, moisture and fungus. Solid-state components shall be conservatively rated for their purpose, to assure optimum long-term performance and dependability over ambient atmosphere fluctuations and 0 to 100 percent relative humidity. The field mounted equipment and system components shall be designed for installation in dusty, humid, and slightly corrosive service conditions.

C. All equipment shall be designed to operate on a 60-Hertz alternating current power source at a normal 120 volts, plus or minus 10 percent, except where specifically noted. All regulators and power supplies required for compliance with the above shall be provided between power supply and interconnected instrument loop. Where equipment requires voltage regulation, constant voltage transformers shall be supplied.

D. All equipment, cabinets and devices furnished hereunder shall be heavy-duty type, designed for continuous industrial service. The system shall contain products of a single MANUFACTURER, insofar as possible, and shall consist of equipment models which are currently in production.

E. The equipment furnished shall be designed to operate satisfactorily between 0 degrees C and 40 degrees C at up to 95 percent Relative Humidity (non condensing).

F. All outdoor panels and enclosures containing electronic or electrical components shall be equipped with sunshields on both sides, the back and the top with a minimum separation of one inch and a maximum separation of one and one-half inches. Sun shields shall be 14 gauge Stainless Steel or 12 gauge Anodized Aluminum or thicker. Finish with reflective white, two part epoxy coating or reflective, white, polyester powder deposited coating.

G. All outdoor control panels and enclosures shall be equipped with 3 ½" stainless steel mounting uni-struts across the width of the back. For free-standing panels the struts shall be located half-way up the panel and six inches from the top. For other panels they shall be located 3" from the top and 3" from the bottom.

H. All switches shall have double-pole, double-throw contacts rated at a minimum of 600 volts-amperes (VA), unless specifically noted otherwise.

I. All equipment shall be designed and constructed so that in the event of a power interruption, the equipment specified hereunder shall resume normal operation without manual resetting when power is restored.

J. All discrete inputs entering the panel shall be wetted by 120 VAC. Provide isolation relays if necessary to accommodate this requirement.

K. All discrete output signals shall be equipped with interposing relays to electrically isolate them from the control system I/O.

2.02 SURGE PROTECTION

A. Surge suppressors and arrestors meeting the requirements of ANSI Standard C-62.41 (latest revision) shall be provided as further detailed below.

1. DC Signals. Lightning and surge protection shall be provided on all 4-20 mA signal wires entering or leaving the panel. The protectors shall meet the following criteria:

a. 35 mm DIN rail mounted with spring terminals.

b. Response time of less than one nanosecond.

c. Operating signal current: up to 0.5 A

d. Capable of withstanding 5,000 Amps at IEEE/ANSI C-62.41 8 x 20 microseconds combination wave.

e. Nominal series resistance of less than 2 ohms each leg

f. Manufacturer/model:

i. Dehn DCO RK ME

ii. Approved equal.

B. AC Signals. Lightning and surge protectors for all incoming discrete signals and single phase AC power supply lines up to 15 Amps service shall meet the following criteria:

1. Serial protection.
2. Failure indicator
3. Response time of less than five nanoseconds.
4. Capable of withstanding up to 10,000 Amps at IEEE/ANSI C-62.41 8 x 20 microseconds combination wave.
5. Manufacturer/model:
   a. Dehn DG S 150
   b. Approved equal.

C. Single phase AC Power (over 15Amps). Lightning and surge protectors for AC power supply lines over 15 Amps service shall meet the following criteria:

1. Parallel protection using MOVs and thermal fusing technology.
2. Failure indicator
3. Response time of less than five nanoseconds.
4. Capable of withstanding up to 6,500 Amps at IEEE/ANSI C-62.41 8 x 20 microseconds combination wave.
5. Manufacturer/model:
   a. EDCO FAS-120AC
   b. Approved equal.

2.03 CONTROL PANELS AND ENCLOSURES

A. Finish:

1. All front panel openings for panel-mounted equipment shall be cut with counter-boring and provided with trim strips as required to give a neat finished appearance.
2. With the exception of stainless steel panels, all steel panel surfaces shall be treated with phosphatized treatment inside and out, and then finished on the exterior with two coats of baked enamel of the approved color. Interiors of panels shall be white, ANSI No. 51.
3. Stainless steel panels shall be No.4 milled, 316 stainless steel.

B. Doors:

1. All control panels shall have a continuous piano hinge door for ease of access on all control panels. A minimum of 80% of the panel interior shall be exposed by doors.

2. NEMA 4X rated panel door openings shall be sealed and fully gasketed.
3. The inside of each door shall be equipped with a print pocket.
4. Two-door enclosures shall have a removable center post.
5. Sealed panel doors shall be equipped with quick-release latches.
6. NEMA 1 rated panel doors shall be equipped with a three-point latching mechanism.

C. Where noted, doors shall be equipped with fully gasketed glass window to allow viewing of internally mounted devices without opening the door.

D. All components and terminals shall be accessible without removing other components except for covers.

E. Surface mounted panels shall have conduit entry from the bottom only. Freestanding, NEMA 1 panels shall have an open area in the bottom for conduit entry.

F. All panels shall be provided with an isolated copper grounding bus to ground all signal and shield connections.

G. The panels defined in section 1.01 herein shall each be equipped with an internal LED light and 120V, 15 amp, duplex utility receptacle.

H. Nameplates:

1. All front-face panel mounted controls and indicators shall be equipped with 10-year outdoor-rated adhesive laminated plastic nameplates to completely define their use. Provide Brady Type BBP31 or BBP33 as applicable or approved equal.
2. All internal components shall be equipped with identification tags
3. Each wire shall be uniquely identified and shall be labeled.

I. Power Supplies.

1. Uninterruptible power supplies (UPS) shall be provided in all control panels not powered by a building UPS as follows:
    a. Size the supplies for all internal equipment plus an additional 20% spare capacity.
    b. Provide 15 minutes battery back-up capability at full load.
    c. Provide relay option card for indication of “On UPS Power” and “Low Battery Level”.
    d. For outdoor panels provide an UPS and battery rated for operation at up to 50 degrees C.
2. Provide two diode-auctioneered DC power supplies for analog signal use.
3. Provide individually fused DC power for field transmitters.
4. PCP-1 and PCP-2 shall contain a DC UPS and power distribution equipment for the MCC Ethernet switches and stacked shunt trip stations.

J. Electrical:

1. Main circuit breaker and branch circuit breaker for each branch circuit as required to distribute power from the main power feed.
2. All breakers accessible when the panel door is open.
3. No more than 20 devices on any single circuit.
4. No more than 12 amps for any branch circuit.
5. Panel (or site) lighting, receptacles, heaters, controls and fans on separate branch circuits.

K. Wiring:

1. Power wiring shall be 300 volt, type THWN stranded copper, No. 14 AWG size, for 120V service.
2. Discrete wiring shall be 300-volt type THWN stranded copper, sized for the current carried, but not smaller than No. 16 AWG.
3. Analog signal wiring shall be 300 volt, stranded copper in twisted shield pairs, no smaller than No. 16 AWG.
4. Panel wiring shall be routed within wire troughs or panduits.
5. Hinge wiring shall be secured at each end with the bend portion protected by a plastic sleeve.
6. Analog or dc wiring shall be separated from any ac power or control wiring by at least six inches.
7. Each wire shall be uniquely identified using plastic, snap-on numbered tags.
8. Terminal blocks shall be provided for all field wiring entering the panel. The greater of 4 or 15% spare terminal blocks shall be provided.
9. No more than one wire per screw and yoke termination.

L. Construction:

1. Minimum metal thickness: 14-gauge.
2. Stiffeners as required to prevent deflection under instrument loading and permit lifting without racking or distortion.
3. When required, removable lifting rings and fill plugs to replace rings after installation.

M. Miscellaneous Equipment:

1. All panels shall be protected from internal corrosion by the use of corrosion – inhibiting vapor capsules, Northern Instruments Model Zerust VC, Hoffman Model A-HCI, or equal.
2. All sealed panels shall be equipped with combination drain/breathers, Crouse-Hinds model ECD18; or equal.

3. When noted on drawings, panels shall be equipped with thermostatically controlled space heaters to maintain internal temperatures above dew point.

N. All panels shall be manufactured items, Hoffman Engineering, or approved equal.

2.04 PANEL COMPONENTS

A. Selector Switch. Units shall meet the following:

1. Heavy-duty, oil-tight, industrial type selector switches rated for NEMA 4 service.
2. Contacts rated for 120-volt ac service at 10 amperes continuous.
3. Number of positions and contact arrangements as required.
4. Factory-engraved legend plate indicating position definition.
5. Panel mounting accommodating panel thickness between 1/16 to ¼ inch.
6. Black knob type operator.
7. Square D Class 9001, Type K; Allen-Bradley type 800T, or approved equal.

B. Pushbutton. Units shall meet the following:

1. Heavy-duty, oil-tight, industrial type push buttons rated for NEMA 4 service.
2. Contacts rated for 120-volt ac service at 10 amperes continuous.
3. Number of positions and contact arrangements as required.
4. Factory-engraved legend plate indicating function.
5. Panel mounting accommodating panel thickness between 1/16 to ¼ inch.
6. Operator: Red extended head for STOP, green flush head for START, black flush head for other functions.
7. Square D Class 9001, Type K; Allen-Bradley type 800T, or approved equal.

C. Indicating Light. Units shall meet the following:

1. Heavy-duty, oil-tight, push-to-test industrial type with integral transformer for 120V AC application.
2. Rated for NEMA 4 service.
3. Screwed on flat-faced lenses in colors shown on the drawings.
4. Factory-engraved legend plates.
5. Square D Class 9001, Type K; Allen-Bradley type 800T, or approved equal.

D. Control/Interposing Relays: All relays shall meet the following:

1. Compact, general-purpose, plug-in type.
2. Socket mounted.
3. Contacts rated for not less than 10 amperes at 120V.
4. Equipped with neon status lights and test buttons.

5. Permanent, legible identification.
6. Potter & Brumfield series KRPA or approved equal.

E. Time Delay Relay. Time delay relays shall meet the following:

1. Available functions: On delay, Off delay, or one shot.
2. Socket mounted.
3. Knob adjustment.
4. Contacts rated for not less than 10 amperes at 120V.
5. Timing range as appropriate for the application.
6. Magnecraft series W211 or approved equal.

F. Terminal Blocks. Terminal blocks shall meet the following requirements:

1. Screw terminals capable of accepting 10-26 AWG wire.
2. Fused disconnect style.
3. DIN-rail mounting.
4. Connectors shall be either copper or steel. Use of aluminum connectors shall not be permitted without prior approval of the Engineer.
5. Phoenix Contact UT4 HES1 or approved equal.

G. Current Switch, Isolator: Units shall receive an isolated 4 to 20 mA dc input signal and shall provide an adjustable contact closure on the selected setpoint. Units shall meet the following:

1. The set point shall be continuously adjustable over the full input span and shall be repeatable within plus or minus 0.1 percent of span.
2. Activation on rising or falling setpoint shall be internally adjustable.
3. Dead band shall be continuously adjustable from 1 to 100 percent of full scale.
4. The contact output shall be an isolated DPDT contact rated for 5 amps at 120V ac.
5. Housed in a NEMA 1 rated enclosure.
6. Operate on an isolated 120 volt, 60 Hz power supply.
7. Moore Industries DCA, AGM Electronics PTA 4034 or 4035, or approved equal.

H. Converter, Current-to-Current, Isolator: Units shall receive a 4 to 20 mA dc input signal and shall produce a repeated, isolated, proportional 4 to 20 MA dc output signal into loads in the range of 0 to 1,200 ohms without load adjustments for a 24V dc supply. Units shall meet the following:

1. Input impedance less than or equal to 50 ohms.
2. Accuracy plus or minus 0.25 percent of span.
3. Multi-turn span and zero adjustment.
4. Operate on an isolated 120 volt, 60 Hz power supply.

5. Moore Industries SCT, AGM Electronics PTA 4000, or approved equal.

2.06 SPARES AND EXPENDABLES

A. Provide the following spare parts:

1. One spare process indicator unit of each type used.
2. One spare d.c. power supply of each type provided.
3. Five percent (rounded up) spare relays of each type provided.
4. Ten percent (rounded up) spare indicator light bulbs of each type and color supplied.
5. Ten percent spare fuses (minimum of 10) of each type and rating supplied.
6. Five percent (minimum of 2) spare surge protection devices of each type used.

B. Provide the following expendables:

1. Two year supply of corrosion inhibitor capsules

PART 3 - EXECUTION

3.01 INSTALLATION

A. Control panels shall be provided to the electrical subcontractor for installation and connection of field and power wiring.

B. Verify the correct installation of all panels supplied under this Specification Section.

END OF SECTION

SECTION 40 90 16

WELL PUMP CONTROL PANELS

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Work includes engineering, furnishing, installing, testing, documenting, and placing in operation a Well Pump Control Panel (WPCP) for the Lakeview Site.

B. All work covered by this specification shall be performed by the SYSTEM SUPPLIER specified under Specification Section 40 90 00.

1.02 QUALITY ASSURANCE

A. Standards:

1. National Electric Code (NEC).
2. Underwriters Laboratories (UL). All control panels shall be UL listed and shall comply with article 409 of the NEC.

1.03 SUBMITTALS

A. Submit detailed drawings concerning for all control panels and all components including:

1. Cabinet assembly and layout drawings to scale.
2. Fabrication specifications with materials of construction of all components.
3. Point-to-point wiring diagrams depicting wiring within the panel and connection to external devices. Free-hand drawings are unacceptable.
4. System interconnect diagram that shows all connections required between component parts of the items covered in this section and between the various other systems specified in this Contract. Number all electrical terminal blocks and field wiring. Identify each line at each termination point with the same number. Do not use this number again for any other purpose in the complete control scheme.
5. Heat Calculations for proper sizing of AC unit to climate control the control panel. 5000 BTU minimum if sunshields are used.
6. Bill of Materials: A list of all components, including all 3rd party software. Group components by type and include component model number and part number, component description, quantity supplied, and reference to component catalog information.
7. Descriptive Information: Catalog information, descriptive literature, performance specifications, internal wiring diagrams, power and grounding requirements, power consumption, and heat dissipation of all elements. Clearly mark all options and features proposed for this project.

8. Installation Details. Equipment installation drawings showing external dimensions, enclosure material and spacing, mounting connections, and installation requirements.

9. A list of, and descriptive literature for, spares, expendables, and test equipment.

B. The data sheet and drawings shall be provided with an index and proper identification and cross-referencing. Each control panel shall be submitted in its entirety.

1.04 PRODUCT DELIVERY, **STORAGE AND HANDLING**

A. After completion of shop assembly, factory test, and approval, all 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. The equipment shall then be skid-mounted for final transport. Lifting rings shall be provided for moving without removing protective covering. Boxed weights shall be shown on shipping tags together with instructions for unloading, transporting, storing and handling at job site.

B. Special instructions for proper field handling, storage and installation required by MANUFACTURER for proper protection, shall be securely attached to each piece of equipment prior to packaging and shipment.

C. Each component shall be tagged to identify its location, tag number, and function in the system. Identification shall be prominently displayed on the outside of the package.

D. Equipment shall not be stored out-of-doors. Equipment shall be stored in dry permanent shelters, and shall be adequately protected against mechanical injury. If any apparatus has been damaged, such damage shall be repaired by the Contractor at his own cost and expense. If any apparatus has been subject to possible injury by water, it shall be thoroughly dried out and put through such tests as directed by the ENGINEER. This shall be at the cost and expense of the CONTRACTOR, or the apparatus shall be replaced by the CONTRACTOR at his own expense.

1.05 WARRANTY AND GUARANTEES

A. The equipment manufacturer shall warrant the units being supplied to the CITY against defects in workmanship and materials for a period of one (1) year from the date of equipment start-up and acceptance. In the event that the equipment fails to perform as specified, the equipment manufacturer shall promptly repair or replace the defective equipment without any cost to the CITY.

PART 2 - PRODUCTS

2.01 GENERAL

A. All components shall be mounted in a manner that shall permit servicing, adjustment, testing, and removal without disconnecting, moving or removing any other component. Components mounted on the inside of panels shall be mounted on a back plate and not directly to the enclosure. Mounting shall be rigid and stable unless shock mounting is required by the manufacturer to protect equipment from vibration. Component mounting shall be oriented in accordance with the component manufacturer's and industry standard practices. All internal components shall be identified with suitable plastic or metal engraved tags attached with drive pins adjacent to (not on) each component identifying the component in accordance with the drawings, specifications, and supplier's data.

B. All control panels shall consist of a main breaker and a motor circuit breaker, Across the Line FVNR starter for each motor and 20 ampere, 120 volt circuit breakers, as required. Control switches shall provide means to operate each pump manually or automatically. Refer to the electrical drawings for additional requirements.

C. Control Panel Construction

1. Panel Enclosure

a. All control panels shall be U.L. listed NEMA 4X Type 316 stainless steel enclosure, with aluminum dead front panel and 3-point latch. The cabinet shall be provided with a padlock staple and drip guard. Minimum metal thickness shall be 14-gauge. Cabinet doors shall be rubber gasketed with continuous hinge. Neoprene gasket shall be provided for removable panels. Cabinet shall have print pocket on interior side of door. Cabinet enclosure shall be as manufactured by Hoffman, or approved equal. Refer to the electrical drawings for additional control information.

b. The enclosure and all internal components shall be rated for 0-50 degrees Centigrade operation. The enclosure shall be equipped with sunshields on both sides, the back and the top with a minimum separation of one inch and a maximum separation of one and one-half inches. Sun shields shall be 14 gauge Stainless Steel or 12 gauge Anodized Aluminum or thicker. Finish with reflective white, two part epoxy coating or reflective, white, polyester powder deposited coating.

d. There shall be permanently affixed to the interior side of the exterior enclosure door both a nameplate and a 10 inch by 12 inch pocket for log storage. The nameplate shall contain the voltage, phase, rated horsepower, speed, date of manufacture, pump and panel manufacturer's name, address and telephone number, pump data, including impeller data, operating point and head, kW input, amps at the operating point and at least two (2) other points on the pump curve.

e. Each control panel shall have a minimum AIC rating of 65,000 amps.

2. Surge Protector

a. A surge protector shall be included and wired to protect motors and control equipment from lightning induced line surges. All surge protectors shall be U.L. listed and installed per respective power company and manufacturer's specifications. Surge protectors shall be attached to the load side of the normal power main breaker. Surge protector shall be as noted on the drawings.

3. Circuit Breakers

a. All main and motor circuit breakers shall be rated for 480-volts and shall have an appropriate locking device to meet OSHA lock-out and tag-out rules. All circuit breakers shall be heavy duty molded case breakers rated 65 KAIC minimum. The handle on the circuit breakers shall be operational through the inner door.

4. Full Voltage-Non Reversing, Across the Line Starter:

    a. Refer to Specification Section 26 29 13 for Motor Starters Specification.

5. Control relays shall be plug-in type with contacts rated at 600 VAC, 10 amperes, noninductive. Time delay relays shall be electronic type.

6. Motor Overload Protection

    a. Overload protection shall be provided by a solid state overload relay that is closed coupled to the contactor. The overload relay shall be self-powered requiring no additional wiring or control power and self-protected from shorts in the motor branch circuit. Each overload shall be adjustable over full 2:0 FLA adjustment range. The overload shall have a +/-2% trip repeatability over its entire operating range. A tamper proof cover shall be provided to discourage unauthorized adjustment of the overload. The standard overload shall provide Class 20 overload protection. The overload shall provide phase loss protection by tripping in three (3) seconds or less under a phase loss condition. The overload shall be capable of protecting the motor in a starting, full load and lightly loaded condition against single phase damage. The overload and phase protection shall not be able to be defeated by any changes to the setting of the overload. The overload shall be ambient insensitive and operate in a temperature range of -22 F, to +159 F. The overload relay shall contain a free normally closed contact rated NEMA A600 with a visible trip indication. N.O. and N.C. isolated alarm contacts shall be installed on the overload relay. The overload shall contain a method manual tripping for test purposes.

7. AC Unit (HVAC)

    a. Provide AC unit adequate for climate control. AC unit shall be 460VAC, NEMA 4X Stainless Steel. Minimum 7000 BTU, Thermal edge or approved equal.

8. Phase Monitor

    a. A phase monitor shall be used to protect electrical components due to phase loss, phase reversal, under voltage and over voltage. The plug base shall be keyed to allow for proper pin alignment. Phase monitors shall be manufactured by Diversified or approved equal.

9. Control Relays

    a. The control relays shall operate from a 24 volt circuit and 120 volt circuits as indicated on the drawings. The relays shall be enclosed, eight-pin and/or eleven-pin plug-in type. The control relays shall contain test button and neon or LED energized indicator. The plug base shall be keyed to allow for proper pin alignment.

    b. Intrinsically safe relays shall be provided as required.

10. Control Relay Sockets

a. Control relay sockets shall be octal-style with clamp on screw terminals. These sockets shall be 600 VAC rated and mounted on DIN railing. All relay sockets shall be keyed to allow for proper pin alignment.

11. Control Terminal Blocks

    a. Control terminal blocks shall be clamp screw type and rated for 600 volts. The amperage rating of control terminal blocks shall accommodate the amperage of the circuit to which it is connected but have a minimum rating of 20 amps. An additional 20 space terminal strip shall be installed in the panel for future expansion.

12. Selector Switches

    a. Selector switches shall be installed on the face of the inner door unit. Selector switches shall contain heavy duty NEMA 4X "Hand-Off-Auto" three position switches to control the operation mode of each pump motor starter. Selector switches shall be manufactured by Square-D Class 9001 or equal.

13. Indicator Lights

    a. On the face of the inner door unit, heavy duty NEMA 4X indicator lights shall be installed. The lights shall indicate the control status of the float control switches, the run condition of the pumps and the condition of the moisture sensor in each pump. The indicator lights shall be 120 volt. Indicators shall be manufactured by Square-D Class 9001 or equal.

14. Elapsed Time Meters

    a. Elapsed time meters shall be mounted on the face of the inner door unit with one for each pump. These meters shall be 115 volt non-resettable type and totalize running time in hours and tenths of hours to 99999.9 hours.

15. Convenience Receptacle

    a. A 15 amp, 120 volt, duplex convenience receptacle shall be installed on the face of the inner door unit for each panel. The receptacle shall contain a single pole, 15 amp circuit breaker for protection. Ground fault interrupt type shall be required.

16. Wiring

    a. All power wires shall be THW, or THWN 75 degree C insulated stranded copper conductors and appropriately sized for the load application. All control circuit wire shall be Type THW, 14 AWG, stranded type copper. All wiring within the enclosure shall be neatly routed by the use of slotted type wiring duct with snap on type covers. Wiring on the rear of the inner door shall be neatly bundled with spiral wiring loom and include a sufficient loop across the hinges to prevent wire binding or damage. Both ends of each conductor shall be permanently identified. Color coding of all wiring is required: RED = 24VAC+; WHITE = Neutral; BLACK = 102VAC+; PURPLE = 12VDC+; GREY = 12VDC-; and GREEN = Equipment Ground.

17. Terminal Points

a. Terminal points of all terminal strips, relays and components shall be permanently identified. All terminal numbers, wire numbers and identifying nomenclature shall correspond to and be shown on electrical schematic diagrams.

18. Nameplates and Labels

a. All circuit breakers, control switches, indicator lights, relays, and other control devices shall be identified with permanently affixed legend plates and lamicoid-type engraved nameplates where applicable. A black and red on white label stating "DANGER, HIGH VOLTAGE, 240 or 480 (use applicable) VOLTS" shall be affixed to the face of the inner door unit.

19. Documentation

a. The panel manufacturer shall furnish a list of components used in the construction of the panel. The list shall include renewal kits needed such as starter contacts, coils, bulbs, relays, alternators, switches and sockets. The list shall include manufacturer of the part, model number and part number.

20. Spare Parts

a. The manufacturer shall furnish the following spare parts for each panel supplied:

i. 1-Phase Monitor

ii. 5-Fuses of each size and type used

iii. 5-Bulbs of each size and type used

iv. 2-Contact renewal kits

b. Spare parts shall be properly packaged and labeled for easy identification without opening the package and delivered at start-up.

21. Electrical Schematic

a. An electrical schematic diagram shall be permanently affixed to the interior side of the exterior enclosure door with a copy supplied to the CITY personnel at start-up. The schematic diagram shall include the rated amperage and voltage for all components.

b. Refer to the electrical drawings for additional control panel requirements.

PART 3 - EXECUTION

3.01 INSPECTION AND TESTING

A. The control panel manufacturer shall provide a minimum of two (2) days start-up and testing services for the installed and completed installation. The services shall include all required adjustments of field and panel devices pertinent to the supplied control panel and training of City personnel on use and maintenance.

3.02 TRAINING/TESTING.

A. Provide 4 hours of on-site training to OWNER personnel to instruct them on the modifications made.

B. Perform a loop-by-loop check on each and every signal to confirm all new system points. This shall include the necessary graphic screen indications are shown.

C. Following the loop checks and under full operating conditions, all the system modifications shall be demonstrated as functioning.

END OF SECTION