Special Specification 7192
Automatic Pumping Station

1. DESCRIPTION

1.1. Construct one pumping station located as shown on the plans that is complete, functional, and fully automatic consisting of the components listed below:

1.2. Articles.

2. APPROVAL

Upon approval of the above items, construct the pumping station or any portion of it pertaining to the approved items.

If an approved item requires dimensional changes or alterations of the project plans, prepare at no expense to the Department, the necessary plans and submit electronically to the Engineer for approval. Upon approval, proceed with that portion of the pumping station affected by the change.

No changes are permitted in the list of equipment or shop drawings once approved, unless authorized in writing by the Engineer. Approved equipment and plans constitute final plans for construction of the pumping station. Approval, in no way relieves the Contractor or equipment suppliers of any responsibilities described elsewhere in these specifications.

3. OPERATIONS AND MAINTENANCE MANUALS

Upon determination of the equipment to be used in this station and before final acceptance of this project, furnish the Engineer three (3) books each containing the following:

Submit documents with 8-1/2 in. x 11 in. text pages, bound in 3-ring/D binders with durable plastic covers. Subdivide contents with permanent page dividers, logically organized to the Table of Contents, with tab titling clearly printed under reinforced laminated plastic tabs. Prepare Table of Contents for each volume, with each Product or system description identified.

Part 1 – Directory: Listing of names, addresses, and telephone numbers of Design Consultant, Contractor, Subcontractors, and major equipment suppliers.

Part 2 - Operation and maintenance instructions, arranged by system. For each category, identify names, addresses, and telephone numbers of subcontractors and suppliers and include the following:

- Significant design criteria
- List of Equipment
- Parts list for each component
- Operating instructions
- Maintenance instructions for equipment and systems
- Maintenance instructions for special finishes, including recommended cleaning methods and materials and special precautions identifying detrimental agents

Part 3 - Project documents and certificates, including the following:

- Shop drawings and product data
- Air and water balance reports
- Certificates
- Photocopies of warranties

Equipment Operation and Maintenance (O&M) Data - Furnish O&M Manuals, prepared by manufacturers for all equipment. Manuals must contain, as a minimum, the following:

- Equipment functions, normal operating characteristics and limiting conditions
- Assembly, installation, alignment, adjustment, and checking instructions
- Operating instructions for start-up, normal operation, regulation and control, normal shutdown and emergency shutdown
- Lubrication and detailed maintenance instructions. Maintenance instructions are to include detailed plans giving location of each maintainable part and lubrication point and

detailed instructions on disassembly and reassembly of equipment
- Troubleshooting guide
- Complete spare parts list with predicted life of parts subject to wear, lists of spare parts recommended on hand for both initial start-up and for normal operating inventory, and local or nearest source of spare parts availability
- Outline, cross-section, and assembly plans; engineering data; wiring diagram
- Test data and performance curves
- The complete sequence and full description of operating instructions, noting all precautions.
- The parts list for each item of mechanical and electrical equipment with predicted life of parts subject to wear, list of spare parts recommended on hand for both initial start-up and for normal operating inventory, and local or nearest source of spare parts availability.

Bound copies of warranties and guarantees with dates of expiration, also names and addresses of persons providing warranties and guarantees.

4. COMPONENTS

4.1 Concrete.

Provide concrete in accordance with Item 421, "Hydraulic Cement Concrete." For concrete in slabs, use Class A with Grade 3 aggregate. For concrete used as grout in walls, bond beams and lintels, use Class A with Grade 6 aggregate.

- Use non-shrinkable grout, where specified, that conforms to ASTM C827, and has a specified compressive strength at 28 days of 5000 psi.
- Ensure the detailing of concrete reinforcement bars and accessories conforms to the recommendations of the latest edition of the ACI Detailing Manual
- Mix, transport, and place concrete in accordance with the latest edition of ACI 301 and Items 420, "Concrete Sub structures," and 421, "Hydraulic Cement Concrete."
- Provide concrete cover protection for reinforcement bars as follows (see ACI 318 for conditions not noted):
    - Footings: 3 in.
    - Grade Beams:

Top	2 in.
Sides (Board Formed)	2 in.
(Earth Formed)	3 in.
Bottom	3 in.
Slabs on Grade (Top)	2 in.
Pilaster and Plinths	2 in.

- Provide standard bar chairs and spacers as required to maintain the concrete cover protection specified.
- Use concrete reinforcement bars conforming to ASTM A615, Grade 60, with supplementary requirements (S1). No. 3 bars may conform to ASTM A615 Grade 40, with supplementary requirements (S1) unless noted otherwise. The "N" designation is acceptable in lieu of the "S" designation requirement; however, meet the other requirements of supplement S1. Do not tack weld, heat, or cut reinforcement bars unless indicated on the contract documents or approved by the Engineer.
- Lap reinforcement designated as "continuous" 36 bar diameters at splices unless noted otherwise. Locate reinforcement bar splices in grade beams at the centerline of supports for bottom bars and at mid-span for top bars. Provide standard ACI hooks for top and

bottom bars at discontinuous ends of grade beams.

- Provide 1-No. 4 reinforcement bar x 4.0 ft. at re-entrant corners and around rectangular holes in slabs unless noted otherwise. Place the bars diagonal to the corner with 1 in. clearance from the top and the side of the slab at the corner.
- Submit the following items to the Engineer for approval before using them on this project. Submit shop drawings electronically in accordance with Item 5, "Control of the Work" in the General Notes.
- Submit proposed mix design and test data for each type and strength of concrete in Work.
- Submit laboratory reports prepared by independent testing laboratory stating that materials used comply with requirements of this Section.
- Submit manufacturer's mill certificates for reinforcing steel. Provide specifications for testing when required by Engineer.
- Submit certification from concrete supplier that materials and equipment used to produce and deliver concrete comply with this Specification.
- When required on plans, submit shop drawings showing reinforcement type, quantity, size, length, location, spacing, bending, splicing, support, fabrication details, and other pertinent information.
- For waterstops, submit product information sufficient to indicate compliance with this Section, including manufacturer's descriptive literature and specifications.

4.2 Structural Steel for Wet Well.

- Provide structural steel, rolled shapes and plates conforming to ASTM A-36.
- Ensure structural steel is hot-dip galvanized except for joists and bridging in building, which are to be painted.
- Provide stainless steel expansion anchors that have a 4:1 safety factor with a minimum working capacity as follows:

B	Min. Sheer	Min. Pull-Out	Min.
1/2	2080	1380	2 1/4
5/8	2975	1830	2 7/8
3/4	4280	2530	3 /34
1	6700	4000	4 1/2

- Install the expansion anchors in accordance with the manufacturer's recommendations.
- Submit a list of material and specifications (AISI, ASTM, etc.) for the anchor components, as well as pull out and shear values attained from tests performed in accordance with ASTM E488 by a certified independent testing laboratory. Include the manufacturer's installation instructions in the submittal.
- Detail, fabricate, and erect the structural steel in accordance with AISC "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings," latest edition and amendments, and the AISC "Code of Standard Practice for Steel Buildings and Bridges."
- Provide open web steel joists and bridging for joists conforming to the steel joist institute "Standard Specifications for Open Web Use Steel Joists," latest edition, unless otherwise noted. Use angles or tees for the top chords. Use continuous bridging through open web steel joists and anchor it to spandrel members. Weld joists to bearing plates. Perform welding in accordance with American Welding Society Standard D1.1-80. Use electrodes for shop and field welds conforming to ASTM A233, class E70XX.
- Do not splice structural steel members where not detailed on the contract documents without the prior approval of the Engineer as to location, type of splice, and connection to be made.

- Submit the following items for review by the Engineer.
- Shop Drawings.
    1) Include structural steel items, connections, bolt setting and erection diagrams. Show holes, cuts, reinforcing and other details required to prepare each item for erection and to receive other work. Show location, types and sizes of welds and fastenings and welding process. Indicate type of material for each item. Also indicate whether material will be foreign or domestically manufactured. Give manufacturer and brand of paint for shop coat.
    2) Reproduction of design plans for use as shop drawings will not be allowed.
    3) Provide sufficient detail to permit steel erection without use of design plans.
    4) Do not begin fabrication of structural steel until after shop drawings have been reviewed.
- Certificates.
    - The use of foreign manufactured steel is not allowed and should not be proposed for use, even if the material is tested for conformance to ASTM requirements by a certified independent testing laboratory located in the United States. Do not submit foreign steel certifications or copies of foreign steel test reports for review. Do not begin fabrication until requirements of "Buy American" have been met.
- Provide product data sheets for approval.

4.3 Storm Water Pumps.

Provide pumps of the electric submersible axial flow type. Use motors meeting NEMA standards. Equip each pump with a moisture sensor and a stator temperature sensor. Ensure the moisture sensor turns on blue light in the motor starter section that must be manually reset but does not inhibit pump operation. Provide a stator high temperature sensor that disables the pump until it is manually reset. Provide pumps that are complete with the accessories required for operation as described in this specification. Supply stormwater pumps that are the product of one manufacturer and are identical. Use pump power cables and pump status monitoring cables that are designated for submersible pump applications and meet the NEC code for wire sizes. Install the pumps using experienced pump installation personnel or those under the direct supervision of a qualified representative of the pump manufacturer. Do not use the new pumps for construction dewatering. See Article 8, "Construction Dewatering," for further information.

Provide an electric motor for the storm water pumps 32 HP and operating on 480V, 3-Phase, 60 Hz service. Ensure the motor has a NEMA design "B" rating or better with moisture-resistant Class "F" insulation rated for 180°C and a locked rotor starting current rating of code "H" maximum. Ensure motor bearings are of the anti-friction, permanently lubricated type having a B-10 life of 40,000 hours. Use a special submersible service type of motor cable with a Hypalon jacket sized per NFPA 70, National Electrical Code. Motors must be suitable for across the line starting and starting via a reduced voltage solid-state soft-starter. Provide for the cable to enter the motor through a separate entry compartment, with an external mechanical clamp and a separate internal compartment sealed from above and below to prevent migration of moisture and gas through the conductors. Fit the motor with a stator high temperature sensor with an automatic reset connected to stop the motor and with an oil chamber moisture sensor wired to the alarm light at pump control panel. The conductors for these functions are routed in the same overall cable jacket as the motor power phase conductors.

Provide submersible pump overtemp and moisture detection relays to pump control cabinet manufacturer for installation in their control cabinet.

Verify the cable lengths. Size each stormwater pump to deliver 4,264 GPM at a total dynamic head (TDH) of 18.50 ft. and design it to operate at maximum efficiency without cavitation or vibration between a maximum TDH of 27.50 ft. and a minimum of 18.50 ft. The pump motor minimum power factor is 0.85 at any load and must never exceed unity. The power may be corrected by using power factor correction capacitors connected on the line side of the motor starter as far upstream as possible.

Construct the pump as follows:

- Provide a casing made of fine grain cast iron with smooth surface; ASTM A 48 Class 35B minimum.
- Provide casing seals designed for continuous submergence at a depth of 60 ft.
- Provide a wear ring that provides a seal between the impeller and the volute.
- Use a shaft seal that is a tandem mechanical rotating type, running in an oil bath that hydrodynamically lubricates the lapped seal faces at a constant rate. Use seal wear rings having the characteristics of tungsten carbide.
- Provide seals capable of sealing pressure equal to 65 ft. of head.
- Furnish a pump capable of being run dry without damage. Provide a drop-in type pump, that when removed from the surface, leaves the column in place.
- Ensure the pump manufacturer submits for approval, certified test results stating that the pumps will operate as required, in the columns supplied and installed.

Incorporate a Pump Retrieval System into the pump design. Furnish a pump capable of being removed through the use of a single Type 304 stainless steel wire rope and lifted easily, securely, and safely in one continuous motion. Provide properly sized stainless-steel thimble eyes and shackles. Provide a wire rope assembly with a minimum safety factor of 3:1 based on the breaking strength of the wire rope and the weight of the pump. Submit the lifting technique for approval. Use stainless steel hardware.

For the Stormwater Pump Discharge Line, provide the following components:

- Pump Column and Discharge Pipe. Use steel pipe per ASTM A 53 Type E, Grade A or B, API-5L, or ASTM A36 rolled and seam welded plate, sized as shown on plans.
- Weld Flanges. Supply 125 lb., flat face, slip-on registered machined steel in conformance with AWWA C207, Class B. Use full face flange gaskets made of neoprene rubber.
- Gaskets. Provide 125 lb., full face, neoprene rubber gaskets.
- Bolts. Use ASTM A193-B7 hex head bolts with ASTM A194-2H nuts, hot dip galvanized.
- Adapter Flange. Use mechanical joint type adapter flanges, manufactured from ductile iron, ASTM A 536 Grade 65-45-12, Class 125, Series 400 Uni-Flange with set screws and SBR (Buna-S) gasket. Use a galvanized flange.
- T-bolt Hinged Closure. To be made of carbon steel and have a semi-ellipsoidal head hinged to a matching hub prepared for welding to the pipe column, with a self-energizing Buna-N O-ring and a suitable number of T-bolts to effect and maintain a tight seal and is rated at 90 psi min. at 250°F. Ensure it is quickly and easily opened with the cover swung back on its hinges to allow complete and unrestricted access. Supply T-bolts with attached break-over wrenches. Provide a hot dip galvanized closure with proper size pipe couplings for pump cables welded in place.

Submit certified performance curves for pumps, complete electrical characteristics of motors and installation details.

4.3.1 Design Requirements:

Maximum Design Flow 47.0 CFS

4.4 Pump Access Panels.

Provide floor style access doors. Fabricate the frame from 1/4 in. extruded aluminum incorporating a continuous concrete anchor. Fabricate the door leaf from 1/4 in. aluminum diamond tread plate reinforced with aluminum stiffeners designed to withstand a live load of 300 lbs. per square ft. Provide a door capable of opening to 90° and locking automatically in that position with a stainless-steel hold open arm. Incorporate an enclosed stainless-steel compression spring assist into the hold open arm. Provide a stainless-steel slam lock with a removable handle for securing the door. Provide a vinyl grip handle to release the cover for closing. Provide an aluminum mill finish, with a bituminous coating applied to exterior of the frame where it will come into contact with concrete. Supply a stainless-steel lifting handle, hinges, and fastening hardware. Install as shown on the plans. Warranty the doors against defects in material and workmanship for a period of 5 years and supply a copy of the warranty to the Department. Provide manufacturer's brochures and specifications.

4.5 Wet Well Roof Access Hatch.

Provide as shown on plans. Provide manufacturer's brochures and specifications for Pump Station Structural Details. Provide for separate areas requiring galvanized steel grates per ASTM A1011C Type B of size shown on plans. Grates must resist uniform load of 100 PSF with deflection not to exceed 0.25 inch. Provide documentation certifying sufficient capacity for loading and deflection prior to installation.

4.6 Control System.

Control switches, relays, and alarm panels.

4.6.1 References.

- National Electrical Manufacturers Association (NEMA).
  - NEMA ICS 1 - General Standards for Industrial Control and Systems.
  - NEMA ICS 2 - Standards for Industrial Control Devices, Controllers and Assemblies.
  - NEMA ICS 3 - Industrial Systems.
  - NEMA ICS 6 - Enclosures for Industrial Controls and Systems.
  - NEMA ST 1 - Standard for Specialty Transformers (Except General Purpose Type).
- Instrument Society of America (ISA).
- Underwriters Laboratories, Inc. (UL).
- Factory Mutual (FM).
- Institute of Electrical and Electronic Engineers (IEEE).
- National Fire Protection Association (NFPA). ANSI/NFPA 70 - National Electrical Code (NEC).
- Joint Industrial Council (JIC).
- American National Standards Institute (ANSI).

4.6.2 Submittals.

Submit product data, shop drawings and samples (if samples are requested by the Engineer) under provisions of this Section.

- Submit in complete packages grouped together to allow review of related items as outlined in these specifications.
- Bind submittals in three-ring binders with complete indexing and tab dividers. Completely tag and label equipment information to correspond with Shop Drawings.
- Review of Submittals will be for conformance to Contract Documents and for application to

specified functions.

4.6.3 Product Data.
Submit descriptive product literature including manufacturer's specifications for each component specified.

4.6.4 Shop Drawings.
Indicate layout and mounting of completed assemblies and systems, interconnecting piping and cabling, dimensions, weights, external power and communication connections and programming information.

4.6.4.1 Panel and Cabinet Information.
Layout plans, including the following:

- Front, rear, end and plan views to scale.
- Dimensional information.
- Tag numbers and functional names of components mounted in and on panels, consoles or cabinets.
- Product information on panel components.
- Nameplate locations and legends, including text, letter sizes and colors to be used.
- Location of anchoring connections and holes.
- Location of external wiring and piping connections.
- Mounting and installation details.
- Proposed layouts and sizes of graphic display panels.

4.6.4.2 Wiring Diagrams.
Include the following:

- Name of panel or cabinet.
- Wiring sizes and types.
- Terminal strip numbers.
- Color coding for each wire and color-coding legend.
- Functional name and manufacturer's designation of components to which wiring is connected.

4.6.4.3 Electrical control schematics in accordance with JIC standards.

4.6.4.4 Plan showing equipment layout in each area.

4.6.4.5. Field Wiring Diagrams

- Wiring and piping/tubing sizes and types.
- Terminal strip, device terminal and wire numbers.
- Color coding.
- Designation of conduits in which wiring is to be located.
- Location, functional name and manufacturer's designation of items to which wiring is connected.
- Point-to-point wiring diagrams identifying every termination point and connection.

4.6.4.6. Instrumentation Diagrams.
Prepare instrument loop diagrams for analog and digital displays, and control and I/O loop diagrams, using ISA standard symbols in accordance with ISA Standard S5.4.
Provide plans that follow the format in Attachment C and include the following:

- Instrument tag numbers.
- Functional name, manufacturer's name, product name and model or catalog number of each item.
- Location of each item.
- Submit loop diagrams, wiring diagrams, and control schematics on USB Flashdrive, formatted as MicroStation files using the latest release of MicroStation current and available on bid date, or any subsequent version. Identify diagrams, schematics and other files with computer printed labels affixed to each diskette. Leave at least 200,000 bytes free space available on each USB Flashdrive.
- In addition, submit such diagrams and schematics laser-printed on 8.5-in. x 11-in. paper. Use lettering and numerals of at least 1/16-in. nominal height.

4.6.5. Quality Control Submittals.

4.6.5.1. Factory Test Reports. If specified, submit 6 copies.

4.6.5.2. Testing Procedures. Submit testing procedures proposed to verify input, output, loop, and operations system logic verification. Testing procedures are to detail, as a minimum, verification of required functions as follows:

- Verification of pump start, pump stop, and well level alarm outputs by simulation of discrete level switch signals representing wet well sump level.
- Verification of each discrete input via external manually-operated switch.
- Verification of communications system by hardwire connection via modem and wiring to a similar unit.
- Demonstrate operation and status monitoring of each register specified for external monitoring.
- Test and verify system with external devices required to simulate field connections connected simultaneously for a full system test. Reconnecting external devices to verify portions of the systems at a time is not acceptable.

4.6.5.3. Certificates. Submit manufacturers' certificates that equipment and systems meet or exceed specified requirements.

4.6.5.4. Instructions. Submit manufacturer's installation instructions for each component specified.

4.6.5.5. Field Reports. Submit 6 copies of Manufacturer's Installation Inspection, Field Calibration and Field-Testing Reports.

4.6.5.6. Site Acceptance.

4.6.5.7 Operations and Maintenance (O&M) Data. Submit operation and maintenance data notebook in accordance with this section and as requested by the Engineer.

Information and plans submitted must reflect the final installed condition. Revise documents requiring updates following testing and start-up.

In addition to the content specified in this section, provide the following information:

- Name, address and telephone number of the control system supplier's local service representative.
- Complete list of supplied system hardware parts with full model numbers referred to system part designations, including spare parts and test equipment provided.

- Copy of approved submittal information and system shop drawings as specified in Section 1.6.2 “Submittals,” with corrections made to reflect actual system as tested, delivered and installed at the site. Provide half-size blackline reproductions of shop drawings larger than 11 in. x 17 in.
- Control system description and system operation sequence instructions.
- For each major system/subsystem, in separate binders, submit ladder logic control schematics,
- I/O schematics, control and loop diagrams, electrical plans, system description, operation instructions and files on a USB Flashdrive.

4.6.7. Project Record Documents. Submit record documents under provisions of this section or as requested by the Engineer.

Revise system shop drawings, software documentation and other submittals to reflect system as installed. Accurately record locations of controller cabinets and input and output devices connected to system. Include interconnection wiring and cabling information and terminal block layouts on Rite in the Rain All Weather Writing Paper Model 8511 in a suitable drawing pocket installed inside the controller cabinet door.

Insert half-size blackline prints of wiring diagrams applicable to each control panel in a clear plastic envelope and store in a suitable print pocket or holder inside each control panel.

4.6.8. Quality Assurance.

4.6.8.1. Manufacturer’s Qualifications. Employ a manufacturer specializing in manufacturing products specified in this Section, having proven compatibility with the Department’s existing facilities and at least 3 years of documented experience.

4.6.9. Delivery, Storage, and Handling. Deliver products to site in factory-sealed containers. Store and protect products under provisions of this Section or as specified by the Engineer. Check for damage upon receiving products on site. Store products in a clean, dry area; maintain temperature in accordance with NEMA ICS 1.

4.6.10. Environmental Requirements. Maintain temperature above 32° F and below 104° F during and after installation of products. Maintain area free of dirt and dust during and after installation of products. Provide temporary heating and air conditioning units and equipment required to maintain environmental conditions specified for all control panels.

4.6.11. Maintenance Service. Provide manufacturer’s maintenance services for programmable logic controllers for one year from Date of Substantial Completion without additional cost to the Department.

4.6.12. Communication Interfaces for Remote Lift Station.

4.6.13. Control Switches and Indicator Lights.

4.6.13.1. Manufacturers.

- Cutler Hammer.
- General Electric Company.
- Square D Company.
- Allen Bradley.
- Siemens.

- Or approved equal.

4.6.13.2. Substitutions. Comply with Article 5., "Product Substitution Procedures."

4.6.13.3. Control Switches.

- Contacts: NEMA ICS 2; at least two Form C contact sets.
- Contact Ratings: NEMA ICS 2; 120V, 10 ampere inductive.
- Selector Switch Operators: NEMA ICS 2; heavy-duty, oil-tight, NEMA 4 multi-position rotary selector switch.
- Push-button Operator: NEMA ICS 2; heavy-duty oil-tight NEMA 4X unguarded and lockable type; black for start, red for stop.

4.6.13.4. Indicator Lights. Red for run, amber or yellow for alarm, green for control mode; LED, oil-tight, 100,000-hour rated life expectancy; rated voltage approximately 125 percent of nominal 120 VAC operating voltage, to be push-to-test type.

4.6.14. Control Relays.

- Contacts: Three Form C contact sets (3PDT)
- Rating: 120-volt, 10 ampere inductive.
- Coil Voltage: 120-volt, 60 Hz AC.
- Socket: DIN Rail, Include hold-down clip.
- Features: 11-pin tube socket relay base, external color-coded test button, mechanical and electrical status indications, impact-resistant thermoplastic case.
- Manufacturer: Turck, GE, Allen-Bradley, Eaton, Square D, IDEC, Siemens, or approved equal.
- Spare Units: In addition to units installed, furnish 2 spare units.

4.6.15. Time Delay Relays.

- Contacts: Three Form C contact sets (3PDT).
- Contact Ratings: DPDT Class; 120-volt 10 ampere inductive.
- Coil Voltage: 120-volt 60 Hz AC.
- Socket: Turck S3B with coding system, label and label holder (11-pin).
- Description: Control relay as specified above in Paragraph 2.04, with added Time Cube Module as manufactured by Turck, Inc.; series CT3, with on or off delay, as indicated, Square D, Allen-Bradley, Eaton, GE, Siemens or IDEC
- Features: DIP switch-selectable timing ranges of 0.2 to 3 seconds, 0.8 to 12 seconds, 0.1 to 1.5 minutes and 0.8 to 12 minutes; externally-adjustable graduated time dial; solid-state digital timing system.
- Spare Units: In addition to units installed, furnish 2 spare units.

4.6.16. System Description.

4.6.16.1. Level Measurement System. Equip pump station will have level switches for pump control and alarm functions as indicated on the plans.

4.6.16.2. Primary Pump Control.

The level switches are to monitor the primary level measurement system and control the pumps as indicated on the plans.

The primary control system is to monitor a NO contact which closes when the pump is running and will totalize pump running time.

The PLC is to provide first-on first-off alternate sequencing of pump starts.

Provide a numerical sequencer to sequence available pumps (when HAND-OFF-AUTO switches are set in AUTO position). When three pumps are available (switches are in AUTO), ensure the Local Pump Controller (LPC) selects Pump No. 1 as lead pump, Pump No. 2 as lag pump, and

Pump No. 3 as lag 2 pump.

Stagger start times by 10 seconds between pump lead/lag stages to prevent pumps starting at the same time. If responses to a pump signal to run command are not confirmed within 20 seconds, then the next pump available to start should automatically start. Refer to pump control logic in plans for more information.

Phase failure, high temperature, and seal leak alarms must cause a pump to stop when operating in either Primary or Back-up mode. Alarm conditions must keep the pump out of service and may only be reset through the control panel push-button switch. In a power failure condition, control is to automatically operate pumps in primary or back up mode when power is restored without local or remote alarm reset.

If a period of 8 hr. expires with no pump sequence rotation (one pump running and more than one pump available), the control must stop the lead pump and rotate the sequence.

Provide remote start, stop, and alarm reset capabilities. Low level alarm must cut all pumps off.

4.6.16.3. Secondary Pump Control.

Accomplish via back up pump controller logic shown in the plans. Pump controls and alternations will be performed by back up pump control.

Provide hardware timer for backup control system to stagger pump starts (add time cubes to pump start relays).

4.6.16.4. Pump Status and Alarm Monitoring. The pump control panel is to monitor NO contacts which close to indicate the following:

- Pump run status for each pump.
- Auto status for each pump.
- Alarm for each pump.
- Station undervoltage/phase failure alarm.

4.6.16.5 Pump Controls. The hard wire relay logic in the pump control panel is to provide a NO contact which closes and provides 120VAC to drive the following discrete pump control outputs:

- Start/stop Pump No. 1.
- Reset Pump No. 1.
- Pump No.1 Fault
- Start/stop Pump No. 2.
- Reset Pump No. 2.
- Pump No.2 Fault
- Start/stop Pump No. 3.

- Reset Pump No. 3.
- Pump No.3 Fault
- High level alarms.

4.6.17. Installation.

Install in accordance with manufacturer's instructions and plans. Provide sufficient clearance for calibration and maintenance access.

Do not install products until major construction is complete and building interior is enclosed and heated. Connect input and output devices as shown on the plans.

Provide complete programming, testing and verification of the programmable controller and associated inputs and outputs, including work required to interface with the existing Department's system.

4.6.18. Manufacturer's Field Services.

Prepare and start systems under provisions of Article 7, "Starting Systems."

4.6.19. Demonstration.

Provide systems demonstration under provisions of these specifications and as required by the Engineer.

Demonstrate operation and programming of controller. Provide 2 sessions of 4 hr. of instruction each for 4 persons, to be conducted at project site with manufacturer's representative.

Include the following in the system demonstration:

- Complete verification of field wiring.
- Complete verification of system software.
- Demonstration of functionality of each discrete input and output by simulation of actual field device action.
- Complete demonstration of each alarm by simulation of actual field device action.

4.6.20. Training (Operational Personnel Only).

Provide training on operations of control panel as specified below. This training must be performed by fully-qualified and manufacturer-certified training personnel who can clearly illustrate experience in teaching previous courses. Obtain approval from the Department/Engineer course outline before scheduling training. Schedule classes at the Department's convenience. The supplier should not assume that the Department's personnel will attend these courses in a continuous and sequential manner.

4.6.21. Field Acceptance Functional Test.

Must be completed before performance and reliability testing.
Field Acceptance Functional Test Submittals will include:

- Field Acceptance Functional Test Plan Submittal.
- Description of plan for testing field devices.

- Description of plan for function test and system integration of each subsystem.
- Field Acceptance Functional Test Schedule to be submitted after the acceptance of the test plan submittal.
- Field Acceptance Functional Test Plan Completion Report.

4.7. Primary Instrumentation Devices.

4.7.1. Section Includes. Pump controllers, level switches, power meter, control power transformers, phase/voltage monitor relay, terminal blocks, surge protections, and accessories for use with lift station instrumentation.

4.7.2. References and Standards.

- NEMA ICS 1 - General Standards for Industrial Controls and Systems.
- NEMA ICS 2 - Standards for Industrial Control Devices, Controllers and Assemblies.
- NEMA ICS 3 - Industrial Systems.
- NEMA ICS 6 - Enclosures for Industrial Controls and Systems.
- NFPA 70 - National Electrical Code (NEC).
- Underwriters Laboratories, Inc. (UL).
- ANSI B40.1 - Gauges, Pressure Indicating Dial Type Elastic Element.

4.7.3. Submittals.

Comply with this Section and as required by the Engineer.

Submit shop drawings indicating layout of completed assemblies, interconnecting cabling, dimensions, weights and external power requirements.

Submit product data for each component specified.

Submit manufacturer's certificate that the equipment meets or exceeds specified requirements. Submit manufacturer's installation instructions.

4.7.4. Project Record Documents.

Submit record documents.

Accurately record actual locations of controller cabinets and input and output devices connected to system. Include interconnection piping, wiring and cabling information, and terminal block layouts in controller cabinets.

During drawing submittal phase, submit detailed programming information consisting of ladder logic and line code of proposed program, and complete input, output, relay, register and controller identification labels.

Submit factory testing procedures proposed to verify input, output, loop and register operations, system logic verification, and spare memory capacity.

4.7.5. Operation and Maintenance Data. Submit operation manuals in accordance with Article 3., "Operations and Maintenance Manuals."

4.7.6. Regulatory Requirements.

Conform to requirements of ANSI/NFPA 70 (NEC).

Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for the purpose specified and shown; install in accordance with UL requirements.

4.7.7. Delivery, Storage, and Handling.

Deliver products in factory-sealed containers. Store, handle and protect products under provisions of Article 6. "Basic Product Requirements."

Upon delivery, inspect products for damage.

Store products in clean, dry area; maintain temperature in compliance with NEMA ICS 1.

4.7.8. Environmental Requirements.

Maintain temperature above 32° F and below 104° F during and after installation of products. Maintain area free of dirt and dust during and after installation of products.

All equipment must be suitable for continuous operation in a 122° F environment.

4.7.9. Pump Controls.

Pump Controls will be achieved via hard wired relay logic as shown in the pump control schematic in the plans.

4.7.10. Level (Float) Switches.

- Manufacturer:
    - Contegra.
    - Magnetrol.
    - Blue Ribbon: Model Birdcage GP: 50 (15, 30 psi).
    - AMETEK: Model 575P.
    - Dwyer: PPBL2 series.
    - Or approved equal.
- Suitable for operating in hazardous environments.
- Provide cable lengths as required.

4.7.11. Control Power Transformers.

- Transformer: NEMA ST 1 machine tool transformer with isolated secondary winding.
- Power Rating: 250 VA or 200 percent power requirement, whichever is greater.
- Voltage Rating: 480/240-volt primary, 120-volt secondary, single phase.

4.7.12. Phase/Voltage Monitor Relay.

- Manufacturer, Product: Diversified Electronics Inc.; Model PBD Series
- Description: All three phases monitored individually for preselected under and over voltage limit phase loss, phase unbalance, phase reversal, frequency shift and phase shift. Automatic reset after adjustable release delay when line conditions return to normal.
- Indicators: LED indicators for under and over voltage limit.
- Output Rating: DPDT, 3 amps resistive at 600 VAC.
- Phase Sequence: ABC.
- Sampling Time: 2 seconds.

- Spare Unit: In addition to the unit installed, furnish one spare phase/voltage monitor relay.

4.7.13. Terminal Blocks.

- Manufacturers.
  - Bussmann.
  - Phoenix Contact.
  - General Electric Company.
  - Weidmuller.
  - Allen Bradley.
  - Or approved equal.
- Substitutions: Comply with Article 5., "Product Substitution Procedures."
- Terminal Blocks: Provide isolated fused snap-on type terminal blocks.
- Power Terminals: Unit construction type with closed back and tubular pressure screw connectors, rated 600 volts.
- Signal and Control Terminals: Modular construction type suitable for channel mounting with tubular pressure screw connectors; 600-volt rating.
- Provide color-coded (green/yellow) ground bus terminal block, with each connector bonded to enclosure.

4.7.14. Surge Protection and Suppression Devices.

4.7.15. Definitions.

- TVSS: Transient Voltage Surge Suppressor.
- SPD: Surge Protection Devices.

4.7.15.1 Codes and Reference Standards.

The SPD must comply with the following standards:

- UL Listed or recognized to UL 1449, 2nd edition.
- Application Guide A and IEEE C62.41.1-2002 Category C area.
- IEC 61024/ Application Guide A.
- National Electrical Code.
- IEC 61643-1.

4.7.15.2 General.

The SPD is to be available in a non-enclosed Din rail mounted version or mounted in a suitable enclosure.

The SPD components can be either a self-contained wired in unit or a modular unit with field replacement capability
without the removal of any wires.

The SPD is to be capable of supporting local and or remote alarming for failure notification.

4.7.15.3. Main Power Panel Requirements.

Facility incoming voltage of 3 phase 480Y/277 AC will require SPD protection with the following requirements:

- 50 KA per IEC 61024 or 100 KA each phase per ANSI/IEEE C62.41.
- MOV, Arc Chute or Hybrid technology is acceptable.
- Response time: 1< nanosecond or di/dt rise for lighting strikes.

- Din Rail mounted or suitable enclosure.
- Multi-modes of protection (minimum L, N, and G).

Manufacturers.
- Surge Suppression Incorporated, Advantage SHDLA-3Y2.
- Dehn, Dehnguard P-R Series.
- Phoenix Contact, Combo Trab SYS FT+CT-VAL 480,277 rail kit.
- Or approved equal.

4.7.15.4. Secondary Power Panel Requirements.

Secondary power panels supplying power to single phase 120/ 240 VAC or 120 VAC systems will require SPD protection with the following requirements:
- 40 KA each leg per ANSI/ IEEE.
- MOV or Hybrid technology is acceptable.
- Response time: <1 nanosecond.
- Din Rail mounted or suitable enclosure.

Manufacturer:
- Surge Suppression Incorporated, Advantage SKLA-1S1.
- Dehn, Dehnguard Series.
- Square D
- Phoenix Contact, Plugtrab PT2-PE/S 120AC-ST with PT-BE/FM base.
- Or approved equal.

4.7.15.5. Testing Requirement.

Vendor is to provide verifiable third-party test results of the stated specification of SPD.

4.7.15.6. Warranty.

5-year unlimited, free replacement unit or replacement parts for all Malfunctioning SPD devices.

4.7.15.7. Listed manufacturers or approved equal.
- Dehn.
- Phoenix Contact.
- Square D.
- Surge Suppression Inc.

4.7.16. Accessories.
- Plastic Raceway: Plastic slotted wireway with snap on locking covers.
- Manufacturers:
  - Anixter Bros., Inc.
  - Delaware Industries, Inc.
  - Panduit Corp.
  - Iboco.

4.7.17. Installation.

Furnish complete enclosure, factory tested and ready for installation and field termination. Terminate wiring with spade lugs at terminal strips corresponding to designations on plans.

When not installed in plastic wireways, such as along back of door, neatly bundle and support air tubing and internal panel wiring with self-adhesive nylon clips. Provide adequate slack for proper door operation without damage to wiring or tubing.

Identification: Identify system components in accordance with Section 4.19., "Electrical Identification."

- Identify conductors and termination points (device and relay terminals).
- Identify transmitters, switches and devices with stainless steel tags.
- Provide nameplates for panel-mounted devices and instruments as shown on plans.

4.7.18. System Testing. Perform system testing as required by individual component Sections. Calibrate and adjust components for proper operation. Submit six (6) copies of Manufacturer's Installation Inspection, Field Calibration and Field-Testing Reports. Replace components found to be defective.

4.8. Control Cabinet Enclosures.

4.8.1. Section Includes. Outdoor control cabinets for instrumentation.

4.8.2. References.

- NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
- ANSI/NFPA 70 - National Electrical Code (NEC).
- Underwriters Laboratories, Inc. (UL).
- Factory Mutual (FM).
- Occupational Safety and Health Administration (OSHA).
- American National Standards Institute (ANSI).

4.8.3. Submittals.

Conform to this Section or as required by the Engineer.

Product Data: Provide manufacturer's product literature and specifications.

Manufacturer's Instructions: Indicate application conditions and limitations of use. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

4.8.4. Regulatory Requirements.

Conform to requirements of ANSI/NFPA 70 (NEC).

Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and shown; install in accordance with UL requirements.

4.8.5. Extra Materials.

Provide two keys for each cabinet; key locks as directed by the Engineer to operate in current master keying system.

Insert half-size blackline prints on rite in the rain all weather writing paper model 8511 of the complete wiring diagrams, schematics, and loop diagrams applicable to each control panel in a clear plastic envelope and store in a suitable print pocket or holder inside each control panel.

4.8.6. Manufacturers.

- Acceptable Manufacturers:
  - Rittal.
  - Hennessey Products, Inc.
  - Hoffman Engineering.
  - Hammond Manufacturing.
  - The EMF Company.
  - Rose Enclosure.
  - Weigman Company.
  - N.E.M.A. Enclosure Mfg. Co.
  - Or approved equal
- Substitutions: Comply with Article 5., "Product Substitution Procedures."

4.8.7. Outdoor Control Cabinets.

Enclosures: NEMA 3R type 5052-H32 aluminum with 0.125 in. thickness 5052-H32 aluminum back panel for mounting components as shown on the plans. Obtain inspection and approval by Underwriters Laboratory, Inc., after installation of control system in cabinet.

Enclosure Size: As required to accommodate equipment and as indicated in UL standards.

Material: Exterior and interior enclosure doors, shelves and component enclosures: Fabricate of 14-gauge type 316 stainless steel or 0.125 in. thick type 5052-H32 aluminum.

Doors: Aluminum pan-type construction, with full-length stainless-steel piano hinge (for stainless steel or aluminum). Equip exterior door with padlock, heavy-duty locking pistol-grip handles and 3-point latching mechanism of the draw roller type (0.750 in. minimum diameter rollers). Provide handles of 3/4 in. minimum diameter stainless steel. Equip interior doors with flush quarter-turn closure devices. Equip interior and exterior doors with neoprene gaskets.

Provide aluminum canopy structure as indicated on the plans.

Nameplates: On the outside of each cabinet's inner door, provide motor data nameplate information for each pump motor; copy the information exactly as shown on each motor nameplate. Provide engraved laminated plastic nameplates; black letters with white background; fasten to outside of cabinet door of each motor starter section with stainless steel screws.

Provide nameplates for all devices within panel.

In each cabinet section, provide a 120V convenience outlet and a switched LED light fixture, with 0°F LED driver in each section.

Ensure the inside and outside of the cabinet is smooth and free from burrs.

If aluminum cabinet, provide hinges 0.090 in. thick minimum, aluminum, with a 0.250 in. diameter stainless steel hinge pin. Hinge leaves must not be exposed externally when the door is closed.

Add a divider of same material and thickness as the cabinet to divide electrical components and wiring from instrumentation and pneumatic components and wiring.

4.8.8. Examination. Verify that surface and job conditions are ready for construction; report unsatisfactory conditions to the Engineer. Do not proceed with work until unsatisfactory conditions have been corrected

4.8.9. Installation.

Transport, handle and install products in accordance with manufacturer's instructions.

Install on prepared pads. Anchor securely at each corner. Shim and grout as required forming a watertight seal. Install cabinet fronts plumb.

Field-cut bottom conduit entrance openings for outdoor cabinets. Seal removable plates with silicone sealant. Install ground rod and equipment ground conductor.

Install separate instrument ground lug and ground conductor; connect to common station ground grid.

Mount devices to allow removal and reinstallation without backboard removal. Use stainless steel mounting hardware.

Except for nameplate fasteners do not allow mounting or other hardware to penetrate the panel exterior.

Exterior panels: Mount with stainless steel anchor bolts and ground to the station ground field. Install and test ground field to provide maximum 5-ohm resistance to ground in accordance with Section 4.18., "Grounding and Bonding."

Provide door restraints for outer and inner doors to positive lock and hold doors open at 115 degrees minimum. Label the wires with heat shrink markers per Section 4.19., Electrical Identification."

4.9. Basic Electrical Requirements.

4.9.1. Section Includes. Basic requirements specifically applicable to the work of Sections 4.10. through 4.26., "Electrical Requirements." Furnish equipment, materials, and labor for assembly and installation plus check-out and start-up of the complete electrical system as shown on the plans and stipulated in the Specifications.

4.9.2. References.

As a minimum requirement, construct the electrical system in accordance with:

- American National Standards Institute/National Fire Protection Association (ANSI/NFPA), No. 70 – National Electrical Code (NEC).
- City of El Paso Building Code.

- Other applicable Codes and Standards as referenced in other Master Specifications.

Comply with local, county, state and federal regulations and codes in effect as of date of purchase.

Equipment of foreign manufacture must meet U.S. codes and standards.

Provide equipment and materials conforming to requirements of specification and to the criteria provided in data sheets for the project.

4.9.3 Quality Assurance.

4.9.3.1. Product Conformance Certificate and Quality Assurance Release. Submit an overall conformance certificate for electrical components signed by the person responsible for product quality. Specifically identify the purchased material or equipment by project name and location, purchase order number, supplements, and item number where applicable, including materials and services provided by others. Indicate that all requirements have been met and identify any approved deviations.

4.9.3.2. Field Inspection.

- Electrical work must be inspected and approved by the Engineer before starting the 7-day test or scheduling training.
- Notify inspectors a minimum of two days before the installation is ready for inspection and give two days' notice to the Engineer.
- Concealed work must be inspected and approved by the Engineer before it is covered:
  - Conduit with stub-ups, underground in duct banks before concrete is poured.
  - Conduit in slabs, walls and ceilings, complete with boxes.
- The Engineer is to inspect electrical equipment and materials upon arrival for compliance with specifications.

4.9.4 Component Design. Use components in the construction of the material or equipment of the latest proven design, new and in current production. Do not use obsolete components or components to be phased out of production.

4.9.5. Factory Inspection. Provide free access with prior notice for the Engineer at all times to the shop where the material or equipment is being fabricated or tested. Provide reasonable facilities for inspection, witnessing tests, and examining records. Give 7-days' notice before starting tests which are scheduled for factory inspection.

4.9.6. Preparation. Verify dimensions and ratings of equipment and materials to ensure proper fit and performance.

4.9.7. Installation. Install equipment and materials in accordance with the plans and manufacturer's written instructions. If field conditions necessitate changes in electrical installation, obtain approval from the Engineer.

Conductor voltage drop must not exceed 2 percent for feeders and 3 percent for branch circuits.

4.9.8 Demonstration.

. Test the electrical system to specification requirements and to demonstrate correct installation and operation of equipment. Furnish O&M Manual before testing for reference during testing and corrections for final O&M.

Before 7-days test, demonstrate the system to the wastewater inspectors and the Engineer. Show the system to be fully operational. Alarms, safeties, and communication points to central and locally must operate in both full-automatic and back-up modes. Use fresh water in the test medium.

. Operate the system continuously for a period of 7 days in fully automatic, without failure, to qualify as acceptable. "Failure" is considered any problem that requires correction by maintenance personnel, such as: high or low water level, any motor alarm, power failure, or phase failure. This would exclude conditions not under the control of Contractor, such as: evident lightning strikes, 25-year rains, local power utility power failure.

Failures due to uncontrollable situations would allow the 7-day test to continue, as soon as test conditions are restored, and the Engineer is notified.

The existing station will remain in service during this test.

4.10. Conduit, Fittings, and Bodies.

4.10.1. Section Includes. Conduit, fittings, and bodies.

4.10.2. References.

- American National Standards Institute (ANSI):
  - ANSI C 80.1 - Rigid Steel Conduit - Zinc Coated.
  - ANSI C 80.4 - Fittings for Rigid Metal Conduit.
- Federal Specifications:
  - W-C-58 C - Conduit Outlet Boxes, Bodies Aluminum and Malleable Iron.
  - W-C-1094 - Conduit and Conduit Fittings Plastic, Rigid.
  - WW-C-566 C - Flexible Metal Conduit.
  - WW-C-581 D - Coatings on Steel Conduit.
- National Electrical Manufacturers Association (NEMA):
  - NEMA RN 1 - Polyvinyl-Chloride Externally Coated Galvanized Rigid Steel Conduit and Electrical Metallic Tubing.
  - NEMA TC 2 - Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80).
  - NEMA TC 3 - PVC Fittings for Use with Rigid PVC Conduit and Tubing.
- National Fire Protection Association (NFPA), ANSI/NFPA 70 - National Electrical Code (NEC).
- Underwriters' Laboratories (UL):
  - UL 1 - Flexible Metal Electrical Conduit.
  - UL 6 - Rigid Metal Electrical Conduit.
  - UL 514 B - Fittings for Conduit and Outlet Boxes.
  - UL 651 - Schedule 80 Rigid PVC Conduit.
  - UL 651 A - Type EB and A Rigid PVC Conduit and HDPE Conduit.
  - UL 886 - Electrical Outlet Boxes and Fittings for Use in Hazardous Locations.
  - City of EL Paso Electrical Code and any other local ordinances.

4.10.3. Submittals.

Make submittals following this Section and as requested by the Engineer:

- Manufacturer's cut sheets, catalog data.
- Installation, terminating and splicing procedure.

- Instruction for handling and storage.

- Dimensions and weight of products.
- Code compliance certificate.
- Conformance certificate.

4.10.4. Quality Assurance.

Provide rigid aluminum conduit that passes the bending, ductility, and thickness of zinc coating tests described by
ANSI C 80.1.

Provide flexible conduit that passes the tension, flexibility, impact, and zinc coating test described by UL 1.

Provide non-metallic conduit and fittings that pass the test requirements of NEMA TC 2, UL 651 and 651 A and Federal Specification W-C-1094 A.

4.10.5. Delivery Storage and Handling.

Package conduit in 10-ft. bundles maximum with conduit and coupling thread protectors suitable for indoor and outdoor storage. Package fittings in the manufacturer's standard quantities and packaging suitable for indoor storage. Package plastic-coated rigid conduit, fittings, and bodies in such a manner as to protect the coating from damage during shipment and storage.

Store conduit above ground on racks to prevent corrosion and entrance of debris. Protect plastic conduit from sunlight.

4.10.6. Acceptable Manufacturers.

4.10.6.1. Rigid Aluminum Conduit.
- Allied Tube and Conduit.
- Triangle Wire and Cable, Inc.
- Wheatland Tube Company.
- Or approved equal.

4.10.6.2. PVC Coated Aluminum Conduit.
- Occidental Coating Company (O-Cal Blue).
- Robroy Industries, Inc.
- Rob-Roy Red.
- Plasti-Bond Red.
- Perma-Cote Green.
- Or Approved Equal.

4.10.6.3. PVC Rigid Conduit.
- Cantex.
- Carlon Industries, Inc.
- Or approved equal.

4.10.6.4. Conduit Fittings and Bodies.

- Appleton Electric.
- Crouse-Hinds.
- Killark Electric Manufacturing Company.
- O-Z/Gedney.
- Or approved equal.

4.10.6.5. Liquidtight Flexible Conduit.

- Anamet, Inc.
- Electriflex Company.
- Triangle Wire and Cable, Inc.
- Or approved equal.

4.10.6.6. Materials and Equipment.

4.10.6.6.1. Design Conditions. Use electrical conduit, fittings, and bodies designed for service in areas as specified in Section 4.9., "Basic Electrical Requirements," and this section to form a continuous support system for power, control, and instrument cables or any combination thereof.

4.10.6.6.2. Conduit and Fittings.

Rigid Aluminum Conduit and Fittings.

- Rigid aluminum conduit and rigid aluminum conduit bends, nipples, and bodies are to comply with the latest ANSI C 80.1, UL 6, Federal Specification WW-C- 581 D, and NEC Article 34bas6-15.
- Use mild aluminum l tubing for conduit, nipples, and couplings, and that is free of defects on both the inner and outer surfaces.
- For fittings and bodies and covers for rigid steel conduit, use aluminum that complies with ANSI C 80.4, UL 514 B, and Federal Specification W-C-58C.
- PVC-Coated Rigid Aluminum Conduit and Fittings.
- PVC-coated conduit, fittings, bodies, and covers must conform to NEMA RN 1 (Type A). Rigid steel galvanized conduit and fittings must conform to Federal Specifications WW-C-581 D and ANSI C 80.1. PVC-coated rigid aluminum conduit must be UL listed with PVC as the primary corrosion protection. Conduit bodies must conform to UL 514 B and Federal Specification W-C-58 C. PVC-coated fittings for general service locations must be UL listed with the PVC as the primary corrosion protection. Provide sufficient coating for touch-up after installation.
- Use PVC-coated couplings of the ribbed type.
- Provide condulet covers with encapsulated stainless-steel thumb screws.
- Provide condulets and covers that are of malleable iron or ferroalloy material before coating.
- Ensure the urethane coating is a minimum of 2 mil thickness on the interior of the conduit and the interior of fittings, condulets, covers, and bodies.

Liquidtight Flexible Metal Conduit and Fittings.

- Use liquidtight flexible metal conduit manufactured in accordance with UL 1 and Federal specification WW-C-566 C.
- For fittings used with liquidtight flexible metal conduit, use the PVC-coated type. Thoroughly ground the conduit to the fittings and through the fittings to the box or enclosure to which it is attached.
- Couplings and fittings for use in hazardous areas must comply with UL 886, NEC Article 501-4 (a&b), and Federal Specification W-C-586 C.

PVC Conduit and Fittings.

- Use PVC conduit, bends, and fittings, which comply with NEMA TC 2, W-C-A, and NBC Article 347-17 for above ground and underground installation. Use Schedule 80 conduit.

4.10.7. Preparation.

Ensure that the conduit system to be installed is sized properly for the cable and wire requirements.

Verify the actual physical conduit route from the conduit plan plans and prepare the conduit support system.

Verify the equipment locations to which the conduit will be connected and determine detail requirements for connections.

4.10.8. Installation.

Install PVC-coated conduits in outdoor locations, inside valve vaults and wet wells, lift station drypits, areas that are not air-conditioned, and in other corrosive and wet environments. Install PVC-coated conduit in strict accordance with manufacturer's instructions. Use installers certified by the manufacturer.

Install rigid galvanized steel (RGS) conduits in dry, inside, air-conditioned locations only.

Install PVC conduits in reinforced duct banks or encased in concrete slabs. For stub-ups, use PVC coated rigid aluminum elbows as required in Section 4.20, "Underground Duct Banks."

Run exposed conduit parallel or perpendicular to walls, ceilings or main structural members. Group multiple conduits together where possible. Ensure conduit does not interfere with the use of passageways, doorways, overhead cranes, monorails, equipment removal areas or working areas. Do not allow conduit routing to present a safety hazard, trip hazard, or interfere with normal plant operating and maintenance procedures. Maintain a minimum overhead clearance of 8 ft. For conduits installed across walkways, install concrete or aluminum trip plates.

Ensure installation and support of conduit is from steel or concrete structures in accordance with the standard detail plans. Furnish necessary conduit straps, clamps, fittings and support for the conduit in accordance with the standard details.

Identify conduit at termination points like MCC, light fixtures, control panels, receptacles, panels, and junction boxes.

Not more than 3 equivalent 90-degree bends will be permitted between outlets. Provide bonded expansion fittings at building expansion joints.

Install conduit runs so that they are mechanically secure, mechanically protected from physical harm, electrically continuous, and neat in appearance. Ensure interiors of conduit provide clean, smooth raceways through which conductors may be drawn without damage to the insulation. Make threaded connections wrench tight.

Cut conduit square with a power saw or a rotary type conduit cutter designed to leave a flat face. Do not use plumbing pipe cutters for cutting conduit. Ream the cut ends of conduit with a reamer, designed for the purpose to eliminate rough edges and burrs. Cut threads with standard conduit dies providing 3/4-in. taper per ft., allowing the proper length so that joints and terminals may be

made up tight and the ends of the conduit not deformed. Keep dies sharp and use a good quality threading oil continuously during the threading operation.

Remove metal cuttings and oil from the conduit ends after the threads are cut and paint threads before connections are made. Use non-corrosive Carbozinc No. 11 as manufactured by the Carboline Company, coal tar enamel or zinc rich epoxy primer on the threads of steel conduit before connections are made.

Use strap wrenches only to tighten joints in plastic coated rigid steel conduit. Replace conduit and fittings with damage to the plastic coating, such as cuts, nicks and threader chuck jaw marks. Use a solvent, or the same patching material to seal around the edges of conduit fitting covers.

Make changes in direction of conduit using elbows or fittings. Do not use pull boxes to make direction changes unless specifically designated otherwise.

Make field fabricated bends that are free of indentations or elliptical sections. The minimum radius of the bend is 6 times the smallest diameter of the raceway.

Protect conduit terminations from mechanical injury. Prevent the entry of moisture and foreign matter into the conduit system by properly capping terminations.

Avoid trapped runs of conduit, if possible. When they are necessary, provide drainage using a "tee" condulet equipped with a drain. Conduit is likely to pass through areas with a temperature differential of 20 °F or more. Seal penetrations with a proper seal fitting at the wall or barrier between such areas. For conduit passing through walls separating pressurized areas from non-pressurized areas, install sealing fittings at the wall on the non-pressurized side.

Fit conduit crossing building or structure expansion joints with approved expansion fittings, except that fittings will not be required when conduit crossing an expansion joint is supported on trapeze hangers in such a way that at no time will the conduit be under stress due to expansion. Unless otherwise indicated on plans, install expansion fittings every 300 ft. within a straight conduit run and where conduit crosses building expansion joints, using bonding straps to ensure ground continuity. Protect bonding strap connections by minimum 40 mils of PVC coating.

Where rigid galvanized conduit terminates in sheet metal enclosures, fit the conduit with double locknuts and bushings. Furnish sheet metal enclosures made of stainless steel or aluminum located outside or in any other wet, damp, or corrosive areas, with PVC-coated threaded hubs. Restrict side penetrations to the lower one third of the enclosure.
Where PVC-coated rigid conduit is used, PVC-coated rigid threaded hubs will be used.

Provide flexible Liquid tight metallic conduit where necessary to allow for movement or to localize sound or vibration, at transformers, at motors and any other rotating equipment. Use flexible metal conduit as fixture whips only.

Seal openings or holes where conduits pass through walls or floors. When passing through a firewall or floor, use a fire-rated seal per the typical detail included in the plans. Certain walls, as indicated on the plans, require environmental
(air-tight) seals; seal as indicated on the plans.

Install explosion-proof seals in conduit runs crossing or entering a hazardous classified area (as shown on plans). Install type CSBE removable sealing fittings to seal pump cables between wet well and first junction box. If a junction box is not used, install the CSBE seals at the wet well and

the control panel.

Effect transitions in PVC-coated conduit size with PVC-coated RECs or manufactured reducing condulets. Do not use RE bushings.

Parallel runs of conduit may be supported by structural steel racks. When two or more racks are arranged one above the other, provide vertical separation of not less than 12 in. between racks, unless otherwise indicated on plans. Space conduits on the racks at least enough to provide 1/4-in. clearance between hubs on adjacent conduits at terminations and to allow room for fittings.

Fill conduit racks no more than 75 percent of their capacity, providing usable space for future conduit. To ensure this, offset conduits leaving the rack horizontally up or down so that future conduits may be installed in the space remaining. Construct conduit racks to permit access for wire or cable pulling at pull points, even when future conduits are added to fill the racks.

Where conduit racks are supported on rods from beam clamps or by some other non-rigid suspension system, install rigid supports at no more than 50-ft. intervals to give lateral stability to the rack.

Conduit racks or hangers must in no way interfere with machinery (or its operation), piping, structural members, process equipment, or access to anticipated future equipment. Refer to structural, equipment layout and piping plans to ensure that this requirement is met. Label high voltage conduit with the circuit phase-to-phase voltage by means of a firmly attached tag or label of approved design at each conduit termination, on each side of walls or barriers pierced and at intervals not exceeding 200 ft. along the entire length of the conduit.

Support conduit sizes 2 in. and larger at spacings not exceeding 10 ft. and conduit sizes 1-1/2 in. and smaller at spacings not exceeding 8 ft.

The allowable means of fastening conduit to supports are: by one-hole malleable iron conduit straps secured by wood screws to wood and by bolts with expansion anchors to concrete or masonry; by “Korn” clamps or U-bolts to other surfaces. Use “clamp backs” when strapping conduits to walls, column faces, or other such surfaces.

Support conduit runs with conduit clamps, hangers, straps and metal framing channel attached to structural steel members. Conduits of 1-1/2 in. size or less may be supported by one-hole conduit straps on concrete, tile or steel work, but for larger size conduit, use 2-hole straps. Use clamps of galvanized malleable iron for rigid galvanized conduit and stainless steel for PVC-coated conduit. Use Type 316 stainless steel for metal framing channel straps for PVC-coated conduit.

Install conduits supported form building walls with at least 1/4-in. clearance from the wall to prevent the accumulation of dirt and moisture behind conduit.

For conduits embedded in the concrete lift station deck, use PVC-coated rigid.

4.11. 600-Volt Building Wire and Cable

4.11.1. Section Includes. Specifications for 600-volt building wire and cable.

4.11.2 References.

- American National Standards Institute/National Fire Protection Association (ANSI/NFPA),

- Underwriter's Laboratories (UL):
  - UL 83: Thermoplastic Insulated Wires and Cables.
  - UL 1063: Machine Tool Wires and Cables.
- American Society for Testing and Materials (ASTM):
  - ASTM B 3: Soft or Annealed Copper Wires.
  - ASTM B 8: Concentric-Lay-Stranded Copper Conductors, Hard, Medium Hard, Soft.
- Insulated Cable Engineers Association (ICEA), ICEA S-61-402: Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (NEMA WC-5).

4.11.3. Submittals.

Make submittals following this Section and as requested by the Engineer.

- Manufacturer's cut sheets, catalog data.
- Instruction for handling and storage.
- Dimensions and weight.
- Conformance Certificate.

4.11.4. Quality Assurance.

4.11.4.1. Tests. Ensure cable meets the requirements of Part 6 of ICEA S-61-402.

4.11.4.2. Conformance Certificate and Quality Assurance Release. Submit a conformance certificate signed by the person responsible for product quality. The certificate must specifically identify the purchased material or equipment; such as by the project name and location, purchase order number, supplements, and item number where applicable, including materials and services provided by others. The certificate must indicate that requirements have been met and identify any approved deviations.

4.11.5. Delivery, Storage and Handling. Ship wire and cable on manufacturer's standard reel sizes unless otherwise specified. Where cut lengths are specified, mark reel footage accordingly. Each reel is to contain one continuous length of cable. Provide impact protection by wood lagging or suitable barrier across the traverse of the reel. Provide moisture protection by using manufacturer's standard procedure or heat shrinkable self-sealing end caps applied to both ends of the cable.

4.11.6. Acceptable Manufacturers.

- Southwire.
- Encore
- General Cable Company.
- Okonite Company.
- Or approved equal.

4.11.7. Materials and Equipment.

4.11.7.1. Design. Provide cable designated as XHHW/XHWNN stranded single conductor type and UL 83 and UL 1063 listed, rated 600 volts and certified for continuous operation at maximum conductor temperature of 90 C in dry locations and 75 C in wet locations in conduit. MTW stranded will be used in control panels.

4.11.7.2. Conductors. Provide conductors which are Class B, concentric stranded, annealed uncoated copper with physical and electrical properties complying with ASTM B 3 and ASTM B 8 and Part 2 of ICEA S-61-402.

4.11.7.3. Insulation. Ensure each conductor is PVC insulated and nylon jacketed to meet the requirements of Part 3 of ICEA S-61-402. For the insulation thickness, match the dimensions listed in Table 310-13 of the National Electrical Code (NEC) for type THHN and THWN wire.

4.11.7.4. Wire Marking. Provide wire marking in accordance with National Electrical Code (NEC) Article 310-11 and printed on the wire insulation at 2-ft. intervals. Use a permanent type printing method and color which sharply contrasts with the jacket color.

4.11.7.5. Color Code the Single Conductor as follows:

System Voltage	A	B	C	Neutral
120/208 Volt 3Ph/4w	Black	Red	Blue	White
120/240 Volt 3Ph/4w	Black	Orange	Blue	White
277/480 Volt 3Ph/4w	Brown	Purple	Yellow	Grey

Motor Control	1	Black
	2	Red
	3	Blue
Ground		Green

4.11.8. Preparation.

Complete the cable raceway systems and underground duct banks before installing cables. Verify sizing of raceways and pullboxes to ensure proper accommodation for the cables.

Check the length of the cable raceway system against the length of cable on the selected reel. Clean conduits of foreign matter before cables are pulled.

4.11.9. Installation.

4.11.9.1. Wiring Methods.

Use wiring methods indicated on plans.

In general, use XHHW/XHWN stranded building wire for lighting, power and control wiring where conductors are enclosed in raceways like in above ground conduit system or in underground duct banks, or inside control panels.

Do not use solid conductors.

Use conductors not smaller than No. 12 AWG stranded for general lighting circuits.

Use conductors not smaller than No. 14 AWG stranded for control circuits, except when part of a multi-conductor cable or internal panel wiring.

In general, do not splice conductors unless approved by the Engineer.

Splices associated with taps for lighting and control circuits are allowed without approval. Make splices in accessible junction boxes.

4.11.9.2. Single Conductor in Conduit and Duct Bank.

Install cables in accordance with the manufacturer's instructions and the National Electrical Code (NEC), Chapter 3, "Wiring Methods and Materials." Do not exceed maximum wire tension, maximum insulation pressure and minimum bending radius.

Pull cables into conduits using wire pulling compounds approved by cable manufacturers to reduce friction. Lubricants must not be harmful to the conductor insulation. Do not use mixtures containing soap or detergent.

4.11.9.3. Preparation for Termination.

Make 600-volt power cable terminations and splices with heat shrinkable sleeves and seals. For terminal lugs and connectors for all sizes of conductors, use crimp-on type.

For size 1/0 AWG and larger, use crimp-on lugs that have the long barrel with 2-hole tongues except in places where termination space is limited.

4.11.9.4. Tests.

In general, test insulation integrity of the wiring system before terminating.

Make sure to disconnect sensitive electronic equipment before testing insulation.

Use a 500 VDC megohmmeter and perform the wire system insulation test in accordance with the operating instructions.

4.11.9.5. Termination. After the 600-volt wiring system has been tested with satisfactory results, reconnect wire.

4.12. 600-Volt Control Cable.

4.12.1. Section Includes. 600-volt control cable.

4.12.2. References.

- American Society for Testing and Materials (ASTM).
  - ASTM B 3 - Soft or Annealed Copper Wires.
  - ASTM B 8 - Concentric-Lay-Stranded Copper Conductors, Hard, Medium Hard, Soft.
  - ASTM B 33 – Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes.
  - ASTM B 174 - Bunch-stranded Copper Conductors for Electrical Conductors.
- Institute of Electrical & Electronics Engineers (IEEE), IEEE 383-2.5.
  - IEEE Standard for Type Test of Class IE Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations.
- Insulated Cable Engineers Association (ICEA).
  - ICEA S-61-402 - Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (NEMA WC-5).
  - ICEA S-66-524 - Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (NEMA WC-7).
  - ICEA S-68-516 - Ethylene-Propylene-Rubber-Insulated Wire and Cable for the

Transmission and Distribution of Electrical Energy (NEMA WC-8).

- Underwriter's Laboratories (UL).
  - UL 44 - Rubber Insulated Wires and Cables.
  - UL 83 - Thermoplastic Insulated Wire and Cables.
- American National Standards Institute/National Fire Protection.
  - Association (ANSI/NFPA), No. 70 - National Electrical Code (NEC) , Chapter No.3 - Wiring Methods and Materials, Article 725 - Class 1, Class 2, and Class 3 Remote Control, Signaling, and Power-Limited Circuits.

4.12.3. Submittals.

Make submittals following this Section and as requested by the Engineer.

- Completed engineer's data sheets.
- Completed manufacturer's data sheets.
- Manufacturer's cut sheets, catalog data.
- Installation, terminating and splicing procedure.
- Instruction for handling and storage.
- Dimensions and weight.
- Conformance certificate.

4.12.4. Quality Assurance.

- Ensure cable is tested at the factory to confirm that the cable complies with requirements of Part 6 of ICEA S-61-402,
  S-66-524 or S-68-516. Refer to data sheet for additional test requirements.
- Where applicable, use cable that meets the requirements of the vertical tray flame test as described in IEEE 383-2.5.

4.12.5. Delivery Storage and Handling.

Ship cable on manufacturer's standard reel sizes, unless otherwise specified. Where cut lengths are specified, mark reel footage accordingly. Each reel is to contain one continuous length of cable. Reels must be of the type specified on the data sheets. Provide impact protection by wood lagging or suitable barrier across the traverse of the reel. Provide moisture protection by manufacturer's standard procedure or heat shrinkable self-sealing end caps applied to both ends of the cable.

4.12.6. Acceptable Manufacturers.

- Alpha Wire Corporation.
- Belden Division, Cooper Industries, Inc.
- Southwire General Cable Company.
- Okonite Company.
- Or approved equal.

4.12.7. Materials and Equipment.

4.12.7.1. Design. Provide cable with the following design characteristics: The cable consists of multiple conductors. The cable assembly is UL listed, flame, oil and sunlight resistant, and certified for continuous operation at the temperature specified on the 600-Volt Control Cable Data Sheets in wet or dry locations while installed in underground duct, conduit, or cable tray. The number and

size of conductors supplied in each cable is to correspond to the quantities specified on the 600-Volt Control Cable Data Sheets.

4.12.7.2. Conductors. Provide conductors which are concentric or bunch-stranded, annealed tinned copper with physical and electrical properties conforming to ASTM B 3, ASTM B 8 or ASTM B 33 or ASTM B 174 and Part 3 of ICEA S-61-402, S-66-524, or S-68-516 unless otherwise specified on the 600-Volt Control Cable Data Sheets.

4.12.7.3. Insulation. Provide insulation for each conductor as specified on the 600-Volt Control Cable Data Sheets complying with the requirements of Part 3 of ICEA S-61-402, S-66-524 or S-68-516. The average insulation thickness must not be less than the dimensions shown in Section 3.2, Table 3-1 of ICEA S-61-402, S-66-524 or S-68-516 for 600-volt insulation unless otherwise specified on the 600-Volt Control Cable Data Sheets. The minimum insulation thickness is 90 percent of the value given in the table.

4.12.7.4. Drain Wire. Provide drain wire Class B, seven-stranded, tin-coated copper in accordance with ASTM B 3, ASTM B 8, or ASTM B 33 and as specified on the 600-Volt Control Cable Data Sheets.

4.12.7.5. Shielding. Cable shielding consists of laminated, nonburning, mylar-backed aluminum tape applied helically around conductors with the aluminum side in continuous contact with the drain wire unless otherwise specified on the 600-Volt Control Cable Data Sheet. Wrap the tape around the conductors with a 25 percent minimum overlap unless otherwise specified on the 600-Volt Control Cable Data Sheets.

4.12.7.6. Jacket. When control cables are to be enclosed in conduit, ducts or in other raceway systems, use cables of the non-metallic type and cover them by an overall nonmetallic jacket, as specified on the 600-Volt Control Cable Data Sheets, which complies with the requirements of Section 4.4 of ICEA S-66-524 or S-68-516, Section 4.3 of ICEA S-61-402, or Table 21-5 of Part 21 of UL 83.

For multi-conductor cables, provide a jacket thickness which complies with Table 4-7 of Part 4 of ICEA S-66-524, Table 4-5 of Part 4 of ICEA S-68-524, or Table 4-6 of Part 4 of ICEA S-61-402 unless otherwise specified on the 600-Volt Control Cable Data Sheets.

4.12.7.7. Conductor Identification. Identify individual conductors by method as specified on the 600-Volt Control Cable Data Sheets in conformance with Appendix L of ICEA S-66-524, Part 5 of ICEA S-68-516, or Appendix I of ICEA S-61-402.

4.12.7.8. Cable Marking. Print cable marking information on the jacket of each cable at 2-ft. intervals. Use a permanent printing method with a color sharply contrasting the jacket color. See the 600-Volt Control Cable Data Sheets for the minimum information required.

4.12.8. Preparation. When control wiring requires installation in a cable tray and other cable support systems, use the 600-Volt Multi-conductor Control Cable. Complete cable raceway systems underground duct banks, and cable support systems before installing cables. Verify sizing of raceways and pull boxes to ensure proper accommodation for the cables. Check the length of the cable raceway system against the length of cable on the selected reel. Do not install or work on PVC insulated or jacketed cables in temperatures below 32°F. Clean conduits of foreign matter before cables are pulled in. Provide at least 30 percent spare conductors.

4.12.9. Installation.

4.12.9.1. Cable in Conduit and Ductbank. Install cables in accordance with the manufacturer's instructions and the National Electrical Code (NEC), Article 725 - Class 1, Class 2, and Class 3 Remote

Control, Signaling and Power Limited Circuits. Do not exceed maximum wire tension, maximum insulation pressure, and minimum bending radius.

Pull cables into conduits using wire pulling compounds approved by cable manufacturers to reduce friction. Lubricants must not be harmful to the conductor insulation or cable jacket. Do not use mixtures containing soap or detergent.

4.12.9.2. Termination. Do not splice conductors unless approved by the Engineer. For termination use crimp-on type, ring tongue, non-insulated, tin-plated copper lugs. Mark wiring on both ends with circuit numbers or loop tag numbers. Heat shrink wire markers after the ring tongue terminal has been installed. Extend the marker over the crimp-on base of the terminal.

4.12.9.3. Tests. Test insulation integrity and conductor continuity before connecting the cables. Use a 500 VDC megohmmeter and perform the cable insulation test in accordance with the operating instructions.

4.12.9.4. Termination. After the 600-volt control cable has been tested with satisfactory results, terminate the cable at both ends to designated terminal points.

4.13. 600-Volt Power Cable.

4.13.1. Section Includes. 600-volt power cable.

4.13.2. References.

- American Society for Testing and Materials (ASTM).
  - ASTM B 3: Soft or Annealed Copper Wires.
  - ASTM B 8: Concentric-Lay-Stranded Copper Conductors, Hard, Medium Hard, Soft.
  - ASTM B 33: Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes.
- Institute of Electrical and Electronics Engineers (IEEE), IEEE 383-2.5.
  - IEEE Standard for Type Test of Class IE Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations.
- Insulated Cable Engineers Association (ICEA).
  - ICEA S-61-402: Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (NEMA WC-5).
  - ICEA S-66-524: Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (NEMA WC-7).
  - ICEA S-68-516: Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (NEMA WC-8).
- Underwriter's Laboratories (UL).
  - UL 44: Rubber Insulated Wires and Cables.
  - UL 83: Thermoplastic Insulated Wire and Cables.
- National Fire Protection Association (NFPA), No. 70 - National Electrical Code (NEC), Chapter No.3 - Wiring Methods and Materials.

4.13.3. Submittals.

Make submittals following this Section and as requested by the Engineer:

- Completed Engineer's data sheets.
- Completed manufacturer's data sheets.

- Manufacturer's cut sheets, catalog data.
- Installation, terminating and splicing procedure.
- Instruction for handling and storage.
- Dimensions and weight.
- Conformance certificate.

4.13.4. Quality Assurance Test.

Ensure cable is tested at the factory to confirm that the cable complies with requirements of Part 6 of ICEA S-61-402, S-66-524 or S-68-516. Refer to data sheet for additional test requirements. Where applicable, use cable that meets the requirements of the vertical tray flame test as described in IEEE 383-2.5.

4.13.5. Delivery Storage, and Handling.

Ship cable on manufacturer's standard reel sizes unless otherwise specified. Where cut lengths are specified, mark reel footage accordingly. Each reel is to contain one continuous length of cable. Reels must be of the type specified on the data sheets. Provide impact protection by wood lagging or suitable barrier across the traverse of the reel. Provide moisture protection by manufacturer's standard procedure or heat shrinkable self-sealing end caps applied to both ends of the cable.

4.13.6. Acceptable Manufacturers.

- Southwire Encore General Cable Company.
- Okonite Company.

4.13.7. Materials and Equipment.

4.13.7.1. Design. Provide cable with the following design characteristics: Cable is UL 44 or UL 83 listed, rated 600 volts and certified for continuous operation at the temperature as specified on the 600 Volt Power Cable Data Sheets while installed in underground duct, conduit, or cable tray. Provide single-conductor or multi-conductor cables (with ground) as specified on the data sheets.

4.13.7.2. Conductors. Provide conductors which are Class B, concentric stranded, annealed copper coated, unless otherwise specified on the data sheets, with physical and electrical properties conforming to ASTM B 3, ASTM B 8 or ASTM B 33 and Part 2 of ICEA S-61-402, S-66-524, or S-68-516. The number and size of conductors supplied in each cable must correspond to the quantities specified on the data sheets.

4.13.7.3 Insulation. Insulate each conductor as specified on the 600 Volt Power Cable Data Sheets to meet the requirements of Part 3 of ICEA S-61-402, S-66-524 or S-68-516. For the insulation thickness, match the dimensions listed in Section 3.2, Table 3-1 of ICEA S-61-402, S-66-524 or S-68-516, as specified on the data sheets.

4.13.7.4. Jacket. When power cables are to be enclosed in conduit, ducts or in other raceway systems, use multi-conductor power cables of the non-metallic type and covered by an overall nonmetallic jacket as specified on the Data Sheets, which complies with the requirements of Section 4.4 of ICEA S-66-524 or S-68-516, Section 4.3 of ICEA S-61-402, or Table 21-5 of Part 21 of UL 83.

Use single-conductor cables that have a jacket thickness meeting the requirements of Table 4-4 of Part 4 of ICEA S-66-524, Table 4-2 of Part 4 of ICEA S-68-516, or Table 4-2 or 4-6 of Part 4 of ICEA S-61-402. Use multi-conductor cables that have a jacket thickness which complies with Table 4-7 of Part 4 of ICEA S-66-524, Table 4-2 of Part 4 of ICEA S-68-516, Table 4-5 of Part 4 of ICEA S-68-516, or Table 4-6 of Part 4 of ICEA S-61-402, unless otherwise specified on the data sheets.

4.13.7.5. Cable Marking. Print cable marking information on the overall cable jacket at 2-ft. intervals. Use a permanent printing method and color sharply contrasting with the jacket color. Identify individual conductors as specified on the data sheets in conformance with Part 5 of ICEA S-61-402, S-66-524, and S-68-516.

4.13.8. Preparation. Complete cable raceway systems, underground duct banks, and cable support systems before installing cables. Verify sizing of raceways and pull boxes to ensure proper accommodation for the cables. Check the length of the cable raceway system against the length of cable on the selected reel. Do not install or work on PVC insulated or jacketed cables in temperatures below 32°F.

4.13.9. Installation.

4.13.9.1. Cable in Conduit and Ductbank.

- Clean conduits of foreign matter before cables are pulled.
- Install cables in accordance with the manufacturer's instructions and the National Electrical Code (NEC), Chapter 3 - Wiring Methods and Materials. Do not exceed maximum wire tension, maximum insulation pressure and minimum bending radius.
- Pull cables into conduits using wire pulling compounds approved by cable manufacturers to reduce friction.
- Lubricants must not be harmful to the conductor insulation. Do not use mixtures containing soap or detergent.

4.13.9.2. Cable in Tray.

- Install medium voltage (5 KV and 15 KV) and 600V cables in separate trays or separated cables by a barrier in a single tray in accordance with NEC 318-6(f).
- Install cables in trays in a neat and orderly manner. Tie cables to the tray rungs at approximate 15-ft. intervals by use of cable ties.
- Only one layer of 3-conductor No. 4/0 AWG and larger 600-volt power cables are allowed in a cable tray per NEC 318-9(a).
- Using cable ties, make a triplex of single conductors used for 3-phase systems. Install in cable tray in accordance with NEC 318-10.

4.13.9.3. Preparation for Termination.

- Make up 600-volt power cable terminations and splices with heat shrinkable sleeves and seals.
- Use crimp-on terminal lugs and connectors for all sizes of conductors.
- Use crimp-on lugs with long barrel and 2-hole tongues, except in places where terminations space is limited.

4.13.9.4. Tests.

- Before connecting the cables, test insulation integrity.
- Use a 500 VDC megohmmeter and perform the cable insulation test in accordance with the operating instructions.

4.13.9.5. Termination.

- After the 600-volt cable has been tested with satisfactory results, terminate the cable at both ends to designated terminal points.
- Tighten connection bolts with a torque wrench to specified torque levels.

4.14. Device, Pull, and Junction Boxes.

4.14.1 Section Includes. Specifications for device, pull, and junction boxes.

4.14.2 References.

- American National Standards Institute/National Electrical Manufacturers Association (ANSI/NEMA).
  - FB1 - Fittings and Support for Conduits and Cable Assemblies
  - 250 - Enclosures for Electrical Equipment (1000 volts maximum)
- American National Standards Institute/National Fire Protection Association (ANSI/NFPA), NFPA70 - National Electrical Code (NEC) - Article 314 - Outlet Device, Pull and Junction Boxes, Conduit Bodies and Fittings.
- Underwriters Laboratories (UL).
  - 50 - Enclosures for Electrical Equipment.
  - 508 - Industrial Control Equipment.
  - 514B - Safety Fittings for Conduit and Outlet Boxes.
  - 886 - Outlet Boxes and Fittings for Use in Hazardous Areas.

4.14.3. Submittals.

Submit the following under provisions of this Section and as requested by the Engineer:

- Manufacturer's cut sheets, catalog data.
- Instruction for handling and storage.
- Installation instructions.
- Dimensions and weights.

4.14.4. Delivery, Storage, and Handling. Pack and crate boxes to permit ease of handling and to provide protection from damage during shipping, handling and storage.

4.14.5. Acceptable Manufacturers.

4.14.5.1. Sheet Metal Boxes.

- Hoffman Industrial Products.
- Pauluhn Electric Manufacturing Company.
- Hennessy.
- Tanco.
- Tejas.
- Circle A.W.

4.14.5.2. Cast Device Boxes.

- Appleton Electric Company.
- Crouse-Hinds, Division of Cooper Industries.
- Killark Electric Manufacturing Company.

4.14.6. Materials and Equipment.

4.14.6.1. Sheet Metal Boxes.

- Provide UL-approved junction boxes and pull boxes manufactured from stainless-steel sheet

metal and meeting requirements of NEMA 4X stainless steel for corrosive and wet area, NEMA 250 & NEC Article 314.

- Provide boxes with a stainless-steel continuous hinge, closure hasps and all stainless-steel hardware.
- Mount junction boxes so the door opens to the right or to the left.
- Furnish the door with neoprene gasket and provision for padlock.

4.14.6.2. Device Boxes.

- Provide UL-approved boxes designed and manufactured to house electrical devices like receptacles and switches, and in conformance with NEMA FB1 and NEC Article 314.
- Supply boxes that are hot-dip galvanized on cast iron suitable for corrosive and wet atmosphere.
- Hardware.
- Mounting Hardware: Stainless steel.
- Conduit Connectors: Watertight as manufactured by Myers Hubs, or equal.

4.14.7. Preparation. Review the plans and determine how many boxes of each kind are required and check if supplied quantity is sufficient.

4.14.8. Installation. Use boxes described in this specification both in dry and wet, corrosive areas, both inside and outside locations. Install boxes in accordance with NEC Article 314 in locations indicated on the plans. Mount junction boxes so the door opens to the right or to the left. Install junction and pull boxes in readily accessible places to facilitate wire pulls, maintenance and repair. Size junction boxes for the number and size of conduits that enter the junction box. Plug unused conduit openings. Make conduit connections to sheet metal boxes with watertight conduit connectors. Label boxes with phenolic nameplates as required in Section 4.19., “Electrical Identification.” Boxes must be bottom or side entry. No top entry allowed.

4.15. Wiring Devices.

4.15.1. Section Includes.

Specifications for wiring devices including:

- Receptacles.
- Wall switches.
- Wall plates and cover plates.

4.15.2. References.

- Federal Specifications (WC-596F).
- American National Standards Institute/National Electrical Manufacturers Association (ANSI/NEMA).NEMA WD1 - General Purpose Wiring Devices.
- NEMA WD6 - Dimensional Requirements.
- American National Standards Institute/National Fire Protection Association (NFPA).
- NFPA No. 70 - National Electrical Code (NEC), Articles 210 Branch Circuits, 250 Grounding and 410, Paragraphs 56, 57 and 58.

4.15.3 Submittals.

Submit the following under provisions of this Section and as requested by the Engineer:

- Product Data: Manufacturer’s product literature and specifications including dimensions, weights, certifications and instructions for handling, storage and installation.

4.15.4. Delivery, Storage, and Handling.

Pack and crate devices to permit ease of handling and protect from damage during shipping, handling and storage.

4.15.5 Acceptable Manufacturers.

- Bryant Electric.
- Crouse-Hinds, Arrow Hart Division.
- Hubbel Inc. Wiring Devices Division.
- Leviton Manufacturing Company.
- Pass & Seymour/Legrand.

4.15.6. Materials and Equipment.

Standards: Conform to NEMA WD1 for general requirements and NEMA WD6 for dimensional requirements.

Manufacture devices to heavy-duty industrial specification grade with brown nylon bodies (orange for isolated-ground receptacles) back and side wiring provisions and green-colored grounding screws.

Receptacles:

- Duplex-type receptacles: Rated 20 amps at 120 volts.
- Contacts: Brass or phosphor bronze.
- Receptacle grounding system: Extend to the mounting strap unless isolated ground is indicated or required.
- GFI or GFCI (ground fault circuit interrupter) receptacles: Provide feed-through type with test and reset button.

Wall Switches:

- Toggle switches: Rated 20 amps at 120/277 volts AC rated for both resistive and inductive loads.
- Contacts: Silver cadmium oxide construction to prevent sticking, welding and excessive pitting.

Cover Plates:

- In outdoor, corrosive and wet areas, provide cover plates of heavy duty plastic, gasketed with hinged covers that remain waterproof while still in use and stainless-steel hardware.
- All other plates: Type 302 stainless-steel.

4.15.7. Preparation. Verify that device boxes are correctly placed. Verify that the correct quantity, size and type of wires are pulled to each device box. Verify that wiring has been checked at both ends. Prepare wire ends for connection to devices. Inspect each wiring device for defects.

4.15.8. Installation. Install products in accordance with manufacturer's instructions. Install devices plumb and level. Install switches with OFF position down. Install receptacles with grounding pole on top. Connect wiring device grounding terminal to outlet box with bonding jumper. Connect wiring devices by wrapping conductors clockwise around screw terminals. Install cover plates on switch, receptacle and blank outlets in finished areas. Energize and test devices for proper operation.

4.16. Cabinets and Enclosures.

4.16.1. Section Includes. Specifications for cabinets and enclosures for housing of control panels and motor controls. Refer to details on plans for more information.

4.16.2. References.

- National Electrical Manufacturers Association (NEMA).
    - 250 - Enclosures for Electrical Equipment (1000 volts maximum).
      (3) NEMA R - Enclosures for outdoor use primarily to provide a degree of protection against wind-blown dust, rain, and sleet; undamaged by formation of ice on the enclosure.
- American National Standards Institute/National Fire Protection Association (ANSI/NFPA), NFPA 70 - National Electrical Code (NEC), Article 312 - Cabinets, Cutout Box, and Meter Socket Enclosures.
- Underwriters Laboratories (UL), UL 50 - Safety for Cabinets and Boxes.

4.16.3. Submittals.

Submit the following under provisions of this Section and as requested by the Engineer:

- Manufacturer's cut sheets and catalog data.
- Instruction for handling and storage.
- Installation instructions.
- Dimensions and weights.

4.16.4. Delivery, Storage, and Handling. Have cabinets and enclosures packed and crated to permit ease of handling and to provide protection from damage during shipping, handling and storage.

4.16.5 Acceptable Manufacturers.

- The EMF Company.
- Hennessey Products, Inc.
- Hoffman Industrial Products.
- Pauluhn Electric Manufacturing Company.
- Weigman Company.
- Rose Enclosure.
- N.E.M.A. Enclosure Mfg. Co.
- Rittal.

4.16.6. Materials and Equipment.

4.16.6.1. Sheet Metal Boxes.

Provide enclosures manufactured in accordance with NEMA 250 and NEC Article 312. Fabricate outdoor NEMA R panels from 0.125- in. thick type 5052 H32 aluminum or 14-gauge, 304 stainless-steel for installation in areas that are not air conditioned.

Boxes must be sized per the National Electrical Code.

Construct outdoor enclosures with continuously welded seams ground smooth.

Additional material thickness and bracing requirements are to be determined by the manufacturer to provide the strength required by the standard listed. Provide the bracing in such a way as to minimize the protrusion into the wiring and the equipment spaces.

Install the door with a stainless-steel continuous hinge, stainless steel padlock handle with gasket and stainless-steel hardware. Mount junction boxes so the door opens to the right or to the left.

Furnish the door with oil-resistant neoprene gasket attached with oil-resistant adhesive and held in place with aluminum retaining strips.

Use a single, 3/4-in. minimum, door handle that provides a 3-point latching through latch rods with rollers. Provide rollers with at least 3/4-in. diameter.

Gasketed overlapping doors may be used instead of a center post. Provide heavy duty lifting eyes of suitable material.

Fabricate the enclosure with a stud-mounted panel inside. Make panels from 12-gauge steel painted with white enamel finish.

Equip both NEMA 12 and NEMA 3 enclosures with thermostatically controlled space heaters and corrosion inhibitors. Provide heaters rated for 240V for 120V operation.

Weld mounting feet to the enclosure if called for on the Drawing. Include a high impact plastic data pocket in the enclosure.

Provide ground connections on the enclosures to enable grounding of the enclosure with a No. 2 AWG conductor.

Equip free-standing outdoor cabinets with inner and outer door restraint bars to prevent door swing during windy conditions.

Supply indoor enclosures with filtered passive air intake and exhaust openings, 4-in. square in the side near the top and near the bottom of the adjacent side panel.

4.16.6.2. Hardware.

Mounting Hardware: Stainless steel.

Conduit Connectors: Watertight as manufactured by Myers Hubs, or approved equal that meets the City of Houston requirements.

4.16.7. Testing. Test cabinets and enclosures in accordance with UL 50 so unit qualifies for a UL label.

4.16.8. Preparation. Review plans and determine how many enclosures of each kind are required and check if supplied quantity is sufficient. Check the mounting pads or foundations for proper mounting dimensions and features, including grounding conductor stub-up.

4.16.9. Installation. Use enclosures described in this specification only above grade. Install enclosures in accordance with NEC Article 312 in locations as indicated on the plans. Install enclosures in readily accessible locations to facilitate general operations, wire pulls, maintenance and repair. Plug unused conduit openings. Make conduit connections to the enclosures with watertight conduit connectors. Identify components in cabinets with phenolic nameplates as required in Section 4.26. Use pre-printed tubular heat-shrink type wire and cable markers to label each end of all conductors.

4.17. Disconnect Switches.

4.17.1. Section Includes.

Specifications for disconnect switches including:

- Fusible disconnect switches.
- Non-fusible disconnect switches.
- Circuit breaker type disconnect switches.
- Fuses.
- Circuit breakers.

4.17.2. References.

- American National Standards Institute/National Electrical Manufacturers Association (ANSI/NEMA).
  - NEMA AB1: Molded Case Circuit Breakers.
  - NEMA KS1: Enclosed Switches.
- Underwriters Laboratories (UL).
  - UL 98: Standard for safety enclosed switches and Dead Front Switches.
  - UL 198C: High Interrupting Capacity Fuses, Current Limiting type.
  - UL 198E: Class R Fuses.
- American National Standards Institute/National Fire Protection Association (ANSI/NFPA), NFPA No. 70 - National Electrical Code (NEC), Chapter 4.

4.17.3. Submittals.

Submit the following under provisions of this Section and requested by the Engineer:

- Manufacturer's cut sheets and catalog data.
- Switch internal arrangement.

- Breaker or fuse characteristic curves.
- Instructions for handling and storage.
- Installation instructions.
- Dimensions and weights.

4.17.4. Delivery, Storage, and Handling. Have disconnect switches packed and crated to permit ease of handling and to provide protection from damage during shipping, handling and storage.

4.17.5. Acceptable Manufacturers.

4.17.5.1. Disconnect Switches and Circuit Breakers.

- Cutler-Hammer Products.
- General Electric.
- Siemens Energy and Automation.
- Square D Company.

4.17.5.2. Fuses.

- Bussman Division, Cooper Industries.
- Mersen.
- Littelfuse Incorporated.

4.17.6. Materials and Equipment.

4.17.6.1. Disconnect Switches.

Characteristics: Horsepower rated, 600-volt, heavy-duty type with an interlocked door, positive quick-make, quick-break mechanism and visible blades.

Use switches and components designed, manufactured and tested in accordance with NEMA AB1, NEMA KS1, UL 98, and NEC Chapter 4.

NEMA 4X (Type 316 stainless steel) in outdoor locations, non-air-conditioned areas, or other wet or corrosive areas.

Provide switches with provisions for padlocking the operating lever in OFF position and door in closed position.

Select switches having the number of poles and general size conforming to the plans.

Conform to fusible, non-fusible or circuit breaker type switch requirements as shown on plans and required by the NEC, or one-line diagrams.

4.17.7. Preparation. Review the plans and verify that the disconnect switches are correct for the applications. Make sure that the correct fuses or breakers are being used regarding size and short circuit interrupting capability. Prepare adhesive labels on the inside door of each switch indicating UL fuse class and size or breaker type and size for replacement.

4.17.8. Installation.

Install the disconnect switches in accordance with and NEC Chapter 4. Mount disconnect switches in sight of or within 25 ft. of motors and rotating equipment.

Mount switches 6 ft.- 6 in. (to top of cabinet) above finished floor or grade.

In wet and corrosive areas, including outdoor locations, install switches on spacers to provide a space of approximate 1/4-in. between the back of cabinet and the mounting surface.

In wet and corrosive areas, including outdoor locations, connect conduit to the bottom of enclosure and to the lower 30 percent of the sides using watertight connectors.

Label disconnect as required in Section 4.19., “Electrical Identification.”

4.18. Grounding and Bonding.

4.18.1. Section Includes.

- Grounding electrodes and conductors.
- Equipment grounding conductors.
- Bonding.
- Power system grounding.
- Communication system grounding.
- Electrical equipment and raceway grounding and bonding.
- Control equipment grounding.

4.18.2. References.

- American Society for Testing and Materials (ASTM).
  - ASTM B3: Soft or Annealed Copper Wires.
  - ASTM B8: Concentric-Lay-Stranded Copper Conductors, Hard, Medium Hard, Soft.
  - ASTM B33: Tinned Soft or Annealed Copper Wire for Electrical Purposes.
- Institute of Electrical and Electronics Engineers (IEEE).
  - IEEE 142-82: Recommended Practice for Grounding of Industrial and Commercial Power Systems.
  - IEEE 383-2.5: IEEE Standard for Type Test of Class IE Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations.
- Underwriter's Laboratories (UL).
  - UL 83: Thermoplastic Insulated Wire and Cables.
  - UL 467: Grounding and Bonding Equipment.
- National Fire Protection Association (NFPA), NFPA No. 70 - National Electrical Code (NEC), Article No. 250 - Grounding.

4.18.3. Submittals.

Submit the following under the provisions of this Section and as requested by the Engineer:

- Manufacturer's cut sheets and catalog data.
- Installation, terminating and splicing procedure.
- Instruction for handling and storage.
- Dimensions and weight.

4.18.4. Quality Assurance.

Tests.

- Use insulated cable conforming to requirements of the vertical tray flame test as described in IEEE 383-2.5.
- Test grounding system in the field in accordance with procedures outlined in Part 3 - Execution.

4.18.5. Delivery, Storage, and Handling. Ship grounding cable on manufacturer's standard reel sizes unless otherwise specified. Where cut lengths are specified, mark reel footage accordingly. Ensure each reel contains one continuous length of cable. Provide impact protection by wood lagging or suitable barrier across the traverse of the reel. Pack and crate other materials specified to withstand normal abuse during Shipping, handling and storage.

4.18.6. Acceptable Manufacturers.

4.18.6.1. Cable.

- Southwire.
- General Cable.
- General Cable Company.
- Okonite Company.

4.18.6.2. Ground Rods and Connectors.

- Blackburn.
- Copperweld.
- Thomas & Betts.

4.18.6.3. Exothermic Connections.

- Burndy Corporation (Therm-O-Weld).
- Erico Products (Cadweld).

4.18.6.4. Grounding Connectors.

- Burndy Corporation.
- O.Z. Gedney.
- Thomas & Betts.

4.18.7. Materials and Equipment.

4.18.7.1. Design. Provide grounding cable and materials with the following characteristics: Use a grounding system designed in accordance with NEC Article No. 250 - Grounding, and the IEEE 142-82 - Recommended Practice for Grounding of Industrial and Commercial Power Systems.

4.18.7.2. Materials.

Use grounding conductors, bare or insulated, which are manufactured and tested in accordance with applicable standards ASTM B3, ASTM B8 and ASTM B33.

Provide a main ground loop of No. 4/0 AWG, Class C stranded, bare copper cable. Small groups of isolated equipment may be grounded by a No. 2 AWG minimum insulated conductor connected to the main loop. In general, size taps as follows:

Main ground loop or grid	#4/0
Switchgear, motor control centers and power transformers	#4/0
Motors 200 hp and above	#4/0
Power panels - AC and DC	#4/0
Control panels and consoles	#4/0
Building columns	#4/0
Fencing posts	#2/0

Where single conductor insulated grounding conductors are called for, use 600-volt insulation. Use ground conductors identified with green insulation or green tape marking.

Supply identifying ribbon which is PVC tape, 3 in. wide, red color, permanently imprinted with "CAUTION BURIED ELECTRIC LINE BELOW" in black letters as specified in Section 4.19., “Electrical Identification.”

Utilize flexible copper braid across hinged chain link or fence gates to bond the movable portion to the grounded fence post.

4.18.8. Preparation. Complete site preparation and soil compaction before trenching and driving ground rods for the underground grid. Verify from plans the exact location of stub-up points for grounding of equipment, fences and building or steel structures.

4.18.9. Construction Criteria. The main ground loop at a depth of at least 30 in. below earth surface. Connect the ground loop to ground rods and to tap connections to form a complete system as indicated on the electrical plans. Pay special attention to the grounding of service equipment, structures and fences to comply with the NEC, local authorities and the serving utility company.

Ground electrical equipment, buildings, tanks, and other structures and equipment as indicated on the plans. Where ground rods are required, ensure the rods are 10 ft. long, 3/4 in. diameter, copper-clad steel ground rods. Drive the rods vertically so that the tops of the rods are a minimum of 18 in. below finished grade, or as specified on the plans. Ground wells will be provided for the driven rods.

Ground local pushbutton and selector switch stations, two-wire control devices, disconnect switches, lighting transformers, panelboards, operator panels, benchboards, and the enclosures of other electrical apparatus through and run the equipment grounding conductor with the power supply or control circuit conductors, or ground as shown on the plans.

Ground medium voltage motors, in addition to the grounding conductors in the motor feeder cable, with a separate No. 4/0 AWG cable to motor frame.

Ground motors having power supplied by multi-conductor cable by using a separate grounding conductor in the cable, and where supplied by single conductor cable in conduit by using a grounding conductor pulled in the conduit. Connect ground conductors to the ground bus in the motor control center and to the ground terminal provided in the motor conduit box.

Do not ground the insulated bearing pedestals of large motors.
Install a warning ribbon approximately 12 in. below finished grade directly above the ground grid.

Connect fence posts of chain link and metal fences to the main ground loop at least every 50 ft. Install bonding straps to gates.

4.18.10. Installation.

4.18.10.1. Equipment Grounding.

Make grounding connections to surfaces which are dry and cleaned of paint, rust, oxides, scales, grease and dirt to ensure good conductivity. Clean copper and galvanized steel to remove oxide before making welds or connections.

Use the exothermic welding process for below-grade grounding connections, except at ground rods. Use mechanical connectors or thermal connections for above-grade grounding connections as shown on the plans.

Make grounding connections to electrical equipment, vessels, mechanical equipment and ground rods in accordance with the plans.

Ground tanks and vessels by making connections to integral structural supports or to existing grounding lugs or pads, and not to the body of the tank or vessel.

Leave ground connections to equipment visible for inspection. Protect them with PVC non-metallic conduit as indicated on the plans.

Make connections to motor frames and ground buses with lugs attached to the equipment by means of bolts. Do not use motor anchor bolts or equipment housing for fastening lugs of grounding cable.

Where the wiring for lighting systems consists of single conductor cables in conduit, provide each conduit with an equipment grounding conductor. Use a grounding conductor with green colored insulation and ground equipment in the lighting system.

4.18.10.2. Raceway and Support Systems Grounding.

Install raceway, cable rack or tray and conduit so that it is bonded together and permanently grounded to the equipment ground bus, according to the plans. Connection to conduit may be grounding bushing or ground clamp.

Install raceway at low voltage motor control centers or other low voltage control equipment so that it is bonded and grounded, except that any conduit which is effectively grounded to the sheet metal enclosure by bonding bushing or hubs need not be otherwise bonded.

Where a grounding conductor is run in or on a cable tray, bond the grounding conductor to each section of cable tray with a cable tray ground clamp.

Where only grounding conductor is installed in a metal conduit, bond both ends of the conduit to the grounding conductor.

Provide flexible "jumpers" around raceway expansion joints. Use copper bonding straps for steel conduit. Install jumpers across cable tray joints which have been parted to allow for expansion and any hinged cable tray connections.

4.18.10.3. Fences and Gates. Ground fences, fence posts and gates to the underground grid as shown on the plans.

4.18.10.4. Power System Grounding. Solidly ground the secondary neutral of the main power supply transformer either to the ground grid or through an impedance. See plans for details. Solidly ground the neutral of lighting, instrument and control transformers.

4.18.10.5. Test Wells.

Provide access (test wells) for testing the ground grid system at one or several ground rod locations. Make test wells of a pipe surrounding the rod and connections with a cover placed on top at grade level. See plans or details. Install a test well at the service entrance pole to serve as the service entrance grounding electrode. Test wells and covers will have an ASHTO HS-20 rating.

4.18.10.6 Test.

Perform ground resistance tests after underground installation and connections to building steel are complete, unless otherwise noted on applicable plans.

Make tests at each ground test well using a "fall of potential" test method. The maximum allowable resistance for each ground test well is 5 ohms. Where measured values exceed this figure, install additional ground rods as required to reduce the resistance to the specified limit.

4.18.10.7 Inspection. Inspection of the grounding system by the Engineer and the local Code Inspector must take place before the grid trenches are backfilled.

4.19. Electrical Identification.

4.19.1. Section Includes. Specification for electrical identification including:

- Nameplates and labels.
- Wire and cable markers.

- Conduit markers.
- Cable tray markers.
- Underground warning tape.
- Warning labels.

4.19.2. References.

- American National Standards Institute/National Fire Protection Association (ANSI/NFPA).
  - No. 70 - National Electrical Code (NEC).
    (1) Article 110 - Requirements for Electrical Installation.
    (2) Article 430 - Transformers and Transformer Vaults.
- Other applicable Codes and Standards: As referenced in other Sections.
- Underwriters Laboratories: U.L. Standards No. 224 - Extruded Insulated Tubing.

4.19.3. Submittals.

Submit the following under the provisions of this Section and as requested by the Engineer:

- Manufacturer's cut sheets and catalog data.
- Description of materials used.
- Label or nameplate dimensions.
- Engraving or imprint legends.
- Instruction for handling and storage.
- Installation instructions.

4.19.4. Delivery, Storage, and Handling. Pack materials to permit ease of handling and to provide protection from damage during shipping, handling and storage.

4.19.5. Acceptable Manufacturers.

- Almetek Industries Incorporated.
- Brady U.S.A. Incorporated.
- Ideal Electric Company.
- Raychem Corporation.
- 3M Electrical Products Division.
- Thomas & Bett.
- Tyton Corporation.

4.19.6. Materials and Equipment.

4.19.6.1. Nameplates and Labels.

Provide an identification tag for each item of electrical and instrumentation equipment showing its item number and service or application. Use the description shown on the electrical plans.

For nameplates, use 3-ply phenolic material engraved to show black lettering on a white background. Size the nameplates approximately 1 in. wide and 3 in. long for 3 lines of 3/16 in. - 16 letters with a 0.8 condensed factor.

Generally, provide large pieces of equipment with engraved nameplates; provide additional nameplates at pushbuttons and other local devices; as detailed. Provide identification for other electrical and instrumentation equipment, devices, or enclosures, such as Motor Control Centers (MCC's), panelboards, disconnect switches, capacitors, relays, and dedicated receptacles not furnished with readily noticeable tag, nameplates, or other means of identification. Install nameplates on the front cover of transformers stating the transformer service location number or identification

number, the panelboard

or device served, and main breaker feeding the transformer (MCC No. and compartment), and the drawing number on which the transformer schematic is shown.

Furnish equipment, such as motor starters, safety switches, welding receptacles and circuit breakers, with 1 in. x 3 in. plastic nameplates stating description of item served.

Provide nameplates for motors giving the driven equipment description, the service location number, and the MCC number with compartment number when applicable. Nameplates will normally be mounted adjacent to the motor at the motor pushbutton when one is furnished.

Install nameplates on the outside and inside of doors to circuit breaker panelboards (i.e., lighting, instrument or receptacle panels). State the panelboard name, the drawing number on which the panelboard schedule shows, and the main breaker feeding the panel (MCC No. and compartment).

Type panelboard directories and insert them inside the panelboard doors.

Place a large nameplate no less than 3 in. x 5 in. on control panels, relay panels, junction boxes, or enclosures with electrical devices mounted inside or on the outside of the enclosure indicating the purpose of the cabinet.

Provide a nameplate on MCC motor starter doors duplicating motor nameplate data.

4.19.6.2. Wire and Cable Markers.

Use pre-printed tubular heat-shrink type wire and cable markers at each end of all conductors.

Select markers manufactured so that the heat-shrink process makes the imprint permanent and solvent- resistant.

Use markers that are self-extinguishing, conforming to U.L. Standard No. 224 for print performance, heat shock, and flammability.

Provide marker material that is flexible, radiation cross-linked polyolefin with 3 to 1 shrink ratio, rated 600 volts, and white in color.

4.19.6.3. Conduit Markers.

Provide conduit markers made of stainless steel tags approximately 2 in. x 1 in. x 19 gage. Stamp the caption on the tag and have it black filled.

Punch tags for tie fasteners. Fasten tags to the conduits with stainless steel braided wire.

4.19.6.4 Cable Tray Markers.

For high visibility and contrast, use cable tray markers that are yellow with black legend.

Use markers made of vinyl impregnated cloth, suitable for exposure to corrosive, wet, and abrasive environment.

Make markers of pre-cut individual letters or numbers with pressure sensitive adhesive backing.

Size legend characters to 4 in. high on a total marker height of approximately 5 in., suitable for applying to 6-in. side rails of a cable tray.

4.19.6.5. Underground Warning Tape.

Provide warning tape made of 4 mil thick polyolefin film, 3 in. wide, suitable for direct burial and resistant to alkalis, acids, and other common soil substances.

Use red tape with black legend printed in permanent ink.

4.19.6.6. Warning Labels.

Place OSHA safety labels on enclosures and boxes 100 cubic in. or more containing electrical equipment or terminations.

Provide OSHA color codes for the labels. Use labels made from 4 mil vinyl with pressure sensitive adhesive backing.

The warning label caption is DANGER - 480 VOLTS or as indicated on the plans. Size labels either 5 in. x 3-1/2 in. or 10 in. x 7 in., as indicated on the plans.

4.19.7. Preparation. Degrease and clean surfaces where adhesive labels will be applied. Drill holes for nameplates to be fastened with stainless screws. Prepare the cable ends for termination and conductor markings. Identify conduits at terminating points and select tags accordingly.

4.19.8. Installation.

Install nameplates and labels in accordance with the manufacturer's instructions and the plans.

Apply wire and cable markers in accordance with manufacturer's instructions using a heat gun with properly sized nozzle for the application. Tag the wires at both ends with the same notation.

Tag conduits at junction boxes, pull boxes, and at other termination points.

Identify cable trays at the time of installation with the alphanumeric number shown on the plans. Label cable trays on the outside rail. Place the tray identifier at each point where the tray designation changes and at 200 ft. intervals in between, but not less than two per run.

Identify underground conduits, cables, or duct banks using the underground warning tape. The underground grounding grid, including the laterals. Also use underground warning tape. Install one tape per trench at 12 in. below grade or as indicated on the plans. For wide trenches or duct banks, install one warning tape per 24 in. width.

Apply the 5 in. by 3-1/2 in. warning labels to disconnect switches, panelboards, terminal boxes, and similar devices in accordance with manufacturer's instruction and the plans. Apply the 10 in. x 7 in. warning labels to larger control panel enclosures, motor control centers, and to entrance doors to buildings containing electrical power and control equipment.

4.20. Underground Duct Banks.

4.20.1. Section Includes. Underground electrical duct banks.

4.20.2. References. National Fire Protection Association (NFPA): No. 70 - National Electrical Code (NEC) Appendix B.

4.20.3. Submittals. Catalog cut sheets of the ducts and spacers.

4.20.4. Delivery, Storage, and Handling. Have duct spacers and associated hardware packed and crated to avoid damage during shipment and handling. Clearly mark packages or crates stating that the material is for electrical duct banks only.

4.20.5. Acceptable Manufacturers.

- Thomas and Betts.
- Underground Devices Inc.
- Walker Division, Butler Manufacturing Company.

4.20.6. Materials and Equipment.

4.20.6.1. Conduit. Construct ducts using Schedule 80 rigid PVC conduit. Refer to Section 4.15., "Conduit, Fittings and Bodies."

4.20.6.2. Spacers. Secure conduit with non-magnetic, universal, interlocking-type spacers for both horizontal and vertical duct arrangements.

4.20.6.3. Concrete. Use steel reinforced, red concrete as duct encasement. Refer to Section 4.1., "Concrete."

4.20.7. Preparation. Verify from plans and field survey that the location of duct banks does not interfere with any existing or new underground facilities. Verify that materials are on site in proper condition and that sufficient quantity is on hand for the work. Verify that trenches are in the correct places and prepared with sufficient depth and width to accommodate the duct banks, reinforcing rod, and Concrete. Be prepared for inspection of the duct banks before reinforcing rod is installed. Before pouring concrete, verify that the ducts are free of debris and properly installed in the support and spacer systems and that the ducts are properly fitted together and firmly held in place by the hold down hardware. Provide 24-hr. notice to Engineer, Wastewater Inspectors and the Local Code Inspector for cover-up inspection before pouring electrical conduit duct banks.

4.20.8 Installation.

Use the size and types of conduit as indicated on the plans for the various duct banks required for the project.

Make duct bank installations and penetrations through foundation walls watertight.

Assemble duct banks using non-magnetic saddles, spacers and separators. Position separators to provide 2-in. minimum concrete separation between the outer surfaces of the conduits.

Provide a 3-in. minimum concrete covering on both sides, top and bottom of concrete envelopes around conduits. Add red dye at the rate of 10 lbs. per cubic yard to concrete used for envelopes for easy identification during subsequent excavation.

Firmly fix ducts in place during pouring of concrete. Carefully spade and vibrate the concrete to ensure filling of spaces between ducts.

Make bends with sweeps of radius not less than 6 times the smallest diameter of the raceway.

Make a transition from non-metallic to PVC-coated aluminum rigid conduit where duct banks enter structures or turn upward for continuation above grade.

Make bends of 30 degrees or more using rigid galvanized aluminum factory coated elbows.
Reinforce duct banks throughout, where indicated on the plans.

- Unless otherwise noted on the plans, reinforce with No. 5 longitudinal steel bars placed at each corner and along each face at a maximum parallel spacing of 12 in. on centers, and No. 5 tie-bars transversely placed at 18-in. maximum longitudinal intervals.
- Maintain a maximum clearance of 2 in. from bars to the edge of the concrete encasement.

Where ducts enter structures such as handholes, manholes, pullboxes, or buildings, terminate the ducts in suitable end bells, insulated L-bushings, Meyers hubs or couplings on steel conduits. Tag conduit entering pull boxes with stamped, stainless steel tags. Identify as designated in cable and conduit schedule.

Do not backfill with material containing large rock, paving materials, cinders, large or sharply angular substances, corrosive material, or other materials which can damage or contribute to corrosion of ducts or prevent adequate compaction of fill.

Install a bare stranded copper duct bank ground in each duct bank envelope. Make ground electrically continuous throughout the entire duct bank system. Connect ground to switchgear and MCC ground buses and to steel conduit extensions of the underground duct system.

After completion of the duct bank and before pulling cable, pull a mandrel, not less than 12 in. long and with a cross section approximately 1/4 in. less than the inside cross section of the duct, through each duct. Then pull a rag swab or sponge through to remove any particles of earth, sand or gravel that may have been left in the duct. Repull the rag or sponge swab until the swab emerges clean.

Use hemp rope to pull conductors into PVC conduit. Do not use nylon or wire cable for this purpose.

Install a warning ribbon approximately 12 in. below finished grade over underground duct banks. Refer to Section 4.19., “Electrical Identification.”

For manholes and pull boxes below grade, install wire racks to support cables properly around the perimeter and keep them dry.

For manholes and pull boxes below grade, construct a French drain, or other drainage as detailed on the plans.

4.21. Dry-Type Transformers

4.21.1. Section Includes.

Specifications for dry-type transformers for the following applications:

- Shielded isolation.
- Non-linear loads.
- General purpose.

4.21.2. References.

- American National Standards Institute/National Electrical Manufacturers Association (ANSI/NEMA).

  - ANSI No. C89.2: Transformers.
  - NEMA ST 1: Specialty Transformers.
  - NEMA ST-20: Dry-Type Transformers for General Applications.
- Underwriters Laboratories (UL). UL 506 - Standard for Safety Specialty Transformers.
- American National Standards Institute/National Fire Protection Association ANSI/NFPA). NFPA No. 70 -National Electrical Code (NEC); Article 450 - Transformers and Transformer Vaults.

4.21.3. Submittals.

Submit the following under provisions of this Section and as requested by the Engineer:

- Outline dimensions, support points and unit weight.
- Electrical characteristics, including impedance and tap configuration. Insulation type, rated temperature rise, and total insulation system.
- Test reports, for transformers 300 KVA and above, indicating losses at 25, 50, 75 and 100 percent rated load and sound levels.
- Connection diagrams.
- Catalog data.
- Operation and maintenance data.

4.21.4. Quality Assurance Tests. Run manufacturer's test on transformers in accordance with Underwriters Laboratories (U.L.) Standard No. UL-506.

4.21.5 Delivery, Storage, and Handling. Have transformers individually packed and crated to permit ease of handling and to provide protection from damage during shipping, handling and storage.

4.21.6. Acceptable Manufacturers.

- Cutler-Hammer.
- General Electric.
- Square D Company.
- Or approved equal.

4.21.7. Materials and Equipment.

Use dry-type transformers for lighting system or other general-purpose applications, shielded isolation and non-linear load requirements.

Provide transformers with copper windings.

Select transformers designed and constructed in accordance with NEMA ST-1, NEMA ST-20 and the NEC Article 450.

For applications up to 30 KVA, use transformers that are encapsulated, non-ventilated type with 115 °C temperature rise and 185 °C insulation class.

Provide transformers with full capacity winding taps a minimum of two 2-1/2 percent above and two 2-1/2 percent below normal voltage.

For applications of 30KVA and above use transformers that are the drip-proof ventilated type for indoor mounting only.

Use transformers with sound levels in accordance with NEMA ST-20.

Basic impulse level (BIL) is 10KV for transformers less than 300 KVA, 30KV for transformers 300KVA and larger.

Ground core and coil assembly to enclosure by means of a visible flexible copper strap. Provide transformers with lifting eye bolts or brackets.

Provide transformer nameplates of stainless steel, marked in accordance with NEC Article 450-14. Fasten nameplate to the transformers with stainless steel screws or rivets.

Refer to the one-line diagram or the plans for transformer size, volt and wire configuration. Provide special purpose transformers as follows:

- Design non-linear transformers to withstand the heating effects caused by harmonics resulting from non-linear, non-sinusoidal loads. Use K-rated transformers for non-linear loads.

4.21.8. Preparation. Verify dimensions of housekeeping pads or other support structures to ensure proper fit. Verify raceway and wiring plans that are prepared for the transformers and check them against the manufacturer's information. Verify that the protective devices planned for the transformers are in accordance with NEC Article 450.

4.21.9. Installation.

Install transformers plumb and level and in accordance with manufacturer's instructions and the NEC Article 450.

Use flexible conduit for connection to transformer case. Make conduit connections to side panel of enclosure.

Mount transformers on isolation pads as required to isolate transformer noise from the buildings structure.

Wire transformer primary and secondary in accordance with the nameplate instructions and the designated voltages as shown on the one-line diagram.

4.22. Motor Starters.

4.22.1. Section Includes. Specification for low voltage starters in pump control panel.

4.22.2. References.

- American National Standards Institute/National Electrical Manufacturers Association (ANSI/NEMA).
  - ICS 1: General Standards for Industrial Control and Systems.
  - ICS 2: Industrial Control Devices, Controllers and Assemblies.
  - ICS 4: Terminal Blocks for Industrial Use.
- American National Standards Institute/Underwriters Laboratories, Inc. (ANSI/UL).
  - 467: UL Standard for Safety, Grounding and Bonding Equipment.
  - 489: UL Standard for Safety, Molded-Case Circuit Breakers and Circuit-Breaker Enclosures.

- 506: UL Standard for Safety, Specialty Transformers.
- 845: UL Standard for Safety, Motor Control Centers.

- American National Standards Institute/National Fire Protection Association (ANSI/NFPA). 70 National Electrical Code (NEC).

4.22.3. Submittals.

Submit the following under the provisions of this Section and as requested by the Engineer:

- Outline plans with elevations.
- Equipment arrangement plans.
- Anchor bolt location plans.
- Electrical schematics and wiring diagrams.
- Current, potential, and power transformer curves.
- Electrical fuse/circuit breaker characteristic.
- Equipment performance curves and data.
- Bill of installation/assembly materials.
- Equipment weights.
- Completed manufacturer's data sheets.
- Catalog data.
- Assembly/disassembly sizes and weights.
- Nameplate data.
- Performance/acceptance test report.
- Operation and maintenance data.

4.22.4. Quality Assurance.

Tests. Perform tests in accordance with ANSI/NEMA ICS 2-322.22. Make available upon request certified temperature and short-circuit test data, and a certificate of circuit breaker conformance with ANSI C37.16. Have tests and inspections performed and evaluated by qualified personnel. Document and correct deficiencies observed during the testing process before shipment.

4.22.5. Delivery, Storage, and Handling. Upon completion of the manufacture and assembly of the starter and before crating for shipment, have parts that are disassembled match marked to facilitate field. Installation in the Pack and crate parts in such a way to permit ease of handling.

4.22.6. Acceptable Manufacturers.

- Allen-Bradley.
- Cutler-Hammer/Westinghouse.
- General Electric.
- Siemens Energy and Automation, Inc.
- Square D Company.

4.22.7. Materials and Equipment.

4.22.7.1. Design. Provide an MCC with the following design characteristics:

Ensure the starter construction and wiring is NEMA Class I, Type B as specified in ANSI/NEMA ICS-2-322.08 and ICS-2-322.10. Provide starter designed for 3-phase, 60 Hz, 480-Volt service.

Furnish starters designed to operate in service conditions described in NEMA ICS 1 and as shown on the one-line diagram.

Supply motor starters suitable for full voltage starting unless otherwise noted on the one-line diagram.

Provide motor control units of the combination type, consisting of a motor circuit protector (MCP), a magnetic starter and a control power transformer. Size the MCP and starter in accordance with manufacturer's recommendation for the starter and motor size indicated on the one-line diagram.

Manufacture main breaker (if used) and feeder breakers of the molded case, thermal-magnetic type to be mounted and wired in accordance with ANSI/UL 489.

4.22.7.2. Construction. Construct the starter section for mounting of motor circuit breakers and necessary accessories including bus bars, control transformers, control switches, ground bus, and control as wiring, specified in this section and shown on the one-line diagram.

4.22.7.3. Enclosures.

Starters to be housed in pump control cabinet as shown on the plans.

Provide enclosures of suitable size for reduced voltage starting auto transformers and associated wiring, if required.

4.22.7.4. Combination Starter Unit.

Provide a standard combination motor starter unit which consists of a Motor Circuit Protector (MCP), a magnetic motor starter, and an overload relay. Install starter and circuit protective device and control power transformer in a plug-in unit. The ratings of the components are shown on the one-line diagram.

Provide motor starters conforming to NEMA standards for the horsepower of the motors with which they are to be used and which are suitable for full voltage, across-the-line starting. Select starters with pickup and dropout voltages of not greater than 85 percent and 60 percent of rated voltage, respectively. Do not use a starter smaller than NEMA Size 1.

For NEMA size 4 and larger, provide vacuum-type contactors.

Select overload relays designed so that any attempt for reset immediately after operation cannot result in damage to the unit. Provide running protection for the motor and other series components, based upon the tripping characteristics of the overload relay.

Utilize motor overload relays of the solid-state type with adjustable overload, phase unbalance and phase failure sensitivity.

Furnish starters with a minimum of one NC and one NO auxiliary contacts in addition to the seal-in contact.

Provide an MCP of the magnetic type with a fault interrupting capability suitable for the complete starter unit.

Provide each combination starter unit with its own control power transformer with Class B insulation and 120 volt secondary.

Place fuses on the secondary side of control power transformers with one dual element fuse. Have control transformers separately fused on the primary side with two dual element fuses.

Unless otherwise called for on the one-line diagram, the minimum rating of the control power transformer, for the various sizes of starters, is as follows:

- NEMA Size 1 75
- NEMA Size 2 150
- NEMA Size 3 250
- NEMA Size 4 500

VA

Connect the control power transformer so that it is de-energized when the circuit breaker is opened.

4.22.7.5. Reduced Voltage Starters.

If reduced voltage starters are specified, provide the solid-state reduced voltage starter type.

Construct each reduced voltage starter unit with a molded-case circuit breaker in combination with a reduced voltage starter. Equip the starter with three phase overload relays and ensure it is ambient temperature compensated with manual reset. Include a thermal switch wired to protect the auto-transformer from overheating.

4.22.7.6. Terminal Blocks.

Provide terminal blocks conforming to NEMA/ANSI ICS 4 type rated 600 volts, with screw type terminals to accommodate non-insulated ring tongue wire lugs for No. 18 through No. 10 size wire for field connection.

Use a sufficient number of terminal blocks so circuits for 480-volt and 120-volt service can be wired to a separate group of terminal blocks, making power and control circuit readily identified for safety during maintenance.

4.22.7.7. Auxiliary Contacts. Wire auxiliary contacts to terminal blocks.

4.22.7.8. Control Devices.

Provide pushbuttons, selector switches and indicating lights which are of the oil tight, heavy duty type with industrial application quality.

Provide indicating lights which are push-to-test LED type with transformer and 100,000-hour lamp life.

4.22.7.9. Space Heaters. Install thermostat controlled electric space heaters to prevent condensation of moisture in the control cabinet. Ensure the rated voltage of these heaters is double the voltage

applied. Make thermostats adjustable and set to cut out when the temperature rises to an ambient of 30 ° C (240 volt rated space heaters operated on 120 volt which power is derived from a local panel board).

4.22.7.10. Nameplates.

Use engraved phenolic with black lettering and white background for nameplates on individual units as well as the main nameplate for the assembly.

4.22.8. Installation.

Install the starter in accordance with the manufacturer's published instructions.

Adjust the magnetic setting on motor circuit protectors in accordance with motor inrush currents (nameplate data).

Select and install motor starter overload relay heater coils based on motor nameplate data.

4.23. Lighting Fixtures.

4.23.1. Section Includes. Lighting specific to those specified under canopy structure protecting electrical equipment. Pole light shown on plans is specified in different section. Specification for:

- LED.

4.23.2. References.

- American National Standards Institute/National Fire Protection Association (ANSI/NFPA).
  - No. 70 - National Electrical Code (NEC) No. 70 - National Electrical Code (NEC).
    (1) Article 410 - Lighting Fixtures, Lampholders, Lamps and Receptacles.
    (2) Article 700 – Emergency Systems.
  - No. 101 - Life Safety Code.
- American National Standards Institute (ANSI).
  - C78.379 - Electric Lamps - Incandescent and High Intensity discharge Reflector Lamps - Classification of Beam Patterns.
  - C82.1 - Ballasts for Fluorescent Lamps - Specifications.
  - C82.4 - Ballasts for High-Intensity-Discharge and Low-Pressure Sodium Lamps (Multiple- Supply Type).
- American National Standards Institute/Illuminating Engineering Society (ANSI/IES). Use the IES Handbook as a basis for design and construction of lighting systems.
- American Society of Heating, Refrigeration and Air-Conditioning Engineers, Inc./Illuminating Engineering Society (ASHRAE/IES). ASHRAE/IES 90.1 - 1989 - Energy Efficient Design of new Buildings Except Low-Rise Residential Buildings.
- American National Standards Institute/Underwriters Laboratories (ANSI/UL).
  - UL1570 - Fluorescent Lighting Fixtures.
  - UL1571 - Incandescent Lighting Fixtures.
  - UL1572 - High Intensity Discharge Lighting Fixtures.
  - UL844 - Fixtures for Hazardous Areas.

4.23.3. Submittals.

Submit the following under the provisions of this Section and as requested by the Engineer:

- Outline dimensions, support points and unit weight.
- Operation and maintenance data.
- Complete test report with photometric curves.
- Storage, handling, and installation recommendation.
- Connection diagrams.
- Catalog data.

4.23.4. Quality Assurance.

Tests. Run manufacturer's tests on lighting fixtures in accordance with applicable Underwriters Laboratories (U. L.) Standards 1570, 1571 and 1572.

4.23.5. Delivery, Storage, and Handling. Have lighting fixtures individually packed to permit ease of handling and to provide protection from damage during shipping, handling, and storage.

4.23.6. Acceptable Manufacturers.

- G.E. Lighting System.
- Holophane Company, Inc.
- Hubbell Lighting, Inc.
- Lithonia Lighting.
- Dual-Lite Company.
- Or approved equal.

4.23.7. Requirements. Provide lighting fixtures in accordance with the lighting plan plans, Lighting Fixture Schedules and this specification.

4.23.8. Preparation. Check the types and quantity of fixtures to be mounted in the area to be illuminated and verify that materials are on hand. Pick out the necessary accessories and mounting hardware.

4.23.9. Installation.

Install fixtures in accordance with manufacturer's instructions, NEC Articles 410, 500 and 700 as applicable, and the plans.

Wire up fixtures in accordance with the plans and ensure proper switching, circuiting and balanced loads. Make sure proper grounding and bonding are provided for fixtures and raceways. Install specified lamps in each fixture.

When applicable, aim and adjust fixtures in accordance with directions as indicated on the plans. Energize and test fixtures for proper operation.

Check the illumination level with a light meter and ensure that sufficient light is reaching areas where tasks are performed and that egress paths are properly illuminated during emergency situations.

4.24. 480 Volt Automatic Transfer Switch.

4.24.1. Description – Scope. Furnish labor, materials, equipment, and incidentals required to provide open transition automatic transfer switches as an integral part of the motor control centers as shown and as specified.

4.24.2. References. Comply with applicable provisions and recommendations of the following except where otherwise shown or specified:

- UL Standard 1008.
- NEMA ICS2-447.
- National Electrical Code.

4.24.3. Submittals.

Submit for review and approval a complete set of manufacturer's technical information for the proposed automatic transfer switch. Include in the submittal the following:

- Dimensional outline and installation plans including both interior and exterior views.
- Unit elementary wiring diagrams showing numbered terminal points and interconnections to other units.
- Complete technical description of the proposed automatic transfer switch.
- A full listing, with address and telephone numbers, of the local Houston based service and parts source for the ATS unit proposed.
- Two (2) copies of a complete installation, operation and maintenance manuals with specific delineation of the information pertinent to the unit proposed.

4.24.4. Materials.

The open transition Automatic Transfer Switch (ATS) consists of a power transfer module and a control module, interconnected to provide complete automatic operation. Ensure the automatic transfer switch is mechanically held, and electrically operated by dual solenoid mechanisms energized from the source to which the load is to be transferred. Use a switch rated for continuous duty and that is inherently double throw. Provide a mechanically interlocked switch to ensure only one of two possible energized positions - normal or emergency. Furnish an automatic transfer switch suitable for use with emergency sources such as a diesel engine powered generator. Furnish a switch that provides for a time adjustable pause in a neutral, disconnected, position in both directions of travel.

ATS must be mounted in a NEMA 4X stainless steel enclosure, refer to plans for more information on ATS requirements.

Ensure main contacts are of silver composition, protected by arching contacts, of the blow-on configuration, and of segmented construction. The maximum allowable operating transfer time in either direction is one-sixth (1/6) of a second.

Equip the control module with a protective cover and mount the module separately from the transfer switch for ease of maintenance. Include in the interconnecting wiring harness, a disconnect plug to disconnect all wires including both sources of control power for routine maintenance. Provide solid state sensing and control logic mounted on plug-in printed circuit boards. Ensure printed circuit boards are keyed to prevent incorrect installation. Provide interfacing relays that area industrial control grade plug-in type with dust covers.

Ensure inspection of contacts (movable and stationary) is possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. Provide a manual operating handle for maintenance purposes. The handle must permit the operator to stop the contacts at any point throughout the entire travel to properly inspect and service the contacts when required.

Automatic transfer switches utilizing components of molded-case circuit breakers, contactors, or parts thereof which have not been intended for continuous duty or repetitive load transfer switching are not acceptable.

Provide at a minimum, an automatic transfer switch that conforms to the requirements of the NEMA and UL standards noted above.

- Provide an ATS rated in amperes for total system transfer including control of motors, electric-discharge lamps, electric-heating and tungsten-filament lamp loads as referred to in paragraph 30.9 of UL 1008.

Provide a complete set of terminal lugs for connection of power cables, both the normal, emergency and common sides.

4.24.5. Tests.

4.24.5.1. Provide certified laboratory test data on a switch of the same design and rating to confirm the following switching abilities:

- Overload and endurance at 480 volts AC per Tables 21.2, 23.1, and 23.2 of UL 1008.
- Temperature rise tests after the overload and endurance tests to confirm the ability of the ATS to carry their rated current within the allowable temperature limits of the insulation in contact with current-carrying parts.
- Withstand current tests. No welding of contacts. Transfer switch is operable to alternate source after the withstand current tests.
- Dielectric tests at 1960 volts, rms, minimum after the withstand current test.

4.24.5.2. Subject production units to the following factory tests:

- Test the complete ATS as to ensure proper operation of the individual components and correct overall sequence of operation and to ensure that the operating transfer time voltage, frequency and time delay settings are in compliance with the specification requirements.
- Subject the switch to a dielectric strength test per NEMA Standard ICS 1-109.21.
- Ensure the control panel meets or exceeds the voltage surge withstand capability in accordance with the latest version of IEEE Standard 472 (ANSI C37.90a) and the impulse withstand voltage test in accordance with NEMA Standard ICS 1-109.

4.24.6 Operation.

Provide an ATS control panel that utilizes solid state sensing on normal and emergency for automatic, positive operation consisting of the following:

- Monitoring of all phases of the normal source, line-to line. Provide close differential voltage sensing on all phases. Ensure the pickup voltage is adjustable from 85% to 100% of nominal and the dropout voltage is adjustable from 75% to 98% of the pickup value. The transfer to emergency will be initiated upon reduction of normal source to 85% of nominal voltage and retransfer to normal will occur when normal source restores to 90% of nominal.
- Extended time delay to override momentary normal source outages and to delay all transfer switch and engine starting signals. The time delay is to be field adjustable from 0 to 5 minutes and factory set at 5 minutes.
- A time delay on retransfer to normal source. The time delay will be automatically bypassed if the emergency source fails and normal source is available. The time delay is to be field adjustable from 0 to 30 minutes and factory set at 15 minutes.
- A time delay on transfer to emergency. Initially set at zero but field adjustable up to 1 minute for controlled timing of load transfer to emergency.
- Independent phase voltage and frequency sensing of the emergency source. The pickup voltage is to be adjustable from 85% to 100% of nominal. Pickup frequency is to be adjustable from 90% to 100% of nominal. Transfer to emergency upon normal source failure when emergency source voltage is 90% or more of nominal and frequency is 95% or more of nominal.

- A contact that closes when normal source fails for initiating engine starting, rated 10 amperes, 32 VDC. Use gold plated contacts.
- A contact that opens when normal source fails for initiating engine starting, rated 10 amperes, 32 VDC. Use gold plated contacts.
- A green signal light to indicate when the automatic transfer switch is connected to the normal source. A red signal light to indicate when the automatic transfer switch is connected to the emergency source.
- One auxiliary contact that is closed when ATS is connected to normal and one auxiliary contact that is closed when ATS is connected to emergency. Use contacts rated 10 amps, 480 volts, 60 Hz AC.
- A test switch that momentarily stimulates normal source failure.
- Reset switch to manually bypass time delay on retransfer to normal. Gold plated low voltage contacts.
- The transfer switch controls are to provide for a programmable pause in the neutral position.

4.24.7. Approved Manufacturers. Provide an automatic transfer switch complying with these specifications as manufactured by one of the following:

- ASCO,
- Onan
- Caterpillar
- GE Zenith

4.24.8. Installation. The supplier of the transfer switches is to furnish a manufacturer certified field installation and service technician to inspect and formally certify the proper installation of the automatic transfer switch. Operational functions of the switch must be illustrated to the Engineer or his designated representative. Coordinate operation of ATS with generator supplier.

4.25. Emergency Engine Generator Set.

4.25.1. Scope.

Provide one (1) complete factory assembled and field installed natural gas generator set complete with digital electronic controls, weatherproof enclosures, factory and field testing, etc.

Provide field installation coordination and startup by a supplier authorized by the manufacturer.

The generator set manufacturer must warrant the equipment provided under this section, whether or not is manufactured by the generator set manufacturer, so that there is one source for warranty and product service. Technicians specifically trained and certified by the manufacturer to support the product and employed by the generator set supplier must service the generator sets.

4.25.2. Codes and Standards.

4.25.2.1. Provide a generator set installation and on-site testing that conforms to the requirements of the following codes and standards, as applicable. Include with the generator set necessary features to meet the requirements of these standards.

- CSA 282, 1989 Emergency Electrical Power Supply for Buildings.
- IEEE446 B Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications.
- NFPA37.
- NFPA70 B National Electrical Code. Provide equipment suitable for use in systems in

compliance to Article 700, 701, and 702.

- NFPA99 B Essential Electrical Systems for Health Care Facilities.
- NFPA110 B Emergency and Standby Power Systems. Provide a generator set that meets the requirements for Level 1 systems. Level 1 prototype tests required by this standard must have been performed on a complete and functional unit, component level type tests will not substitute for this requirement.
- EPA and TCEQ requirements relative to NOx and non-methane hydrocarbon emissions.

4.25.2.2. Provide a generator set and supplied accessories that meet the requirements of the following standards:

- NEMA MG1-1998 part 32. Alternator must comply with the requirements of this standard.
- UL1236 B Battery Chargers.
- UL 2200 – Stationary Engine Generator Assemblies.

4.25.2.3 Provide a control system for the generator set that complies with the following requirements:

- CSA C22.2, No. 14 B M91 Industrial Control Equipment.
- EN50082-2, Electromagnetic Compatibility B Generic Immunity Requirements, Part 2: Industrial.
- EN55011, Limits and Methods of Measurement of Radio Interference Characteristics of Industrial, Scientific and Medical Equipment.
- FCC Part 15, Subpart B.
- IEC8528 part 4. Control Systems for Generator Sets.
- IEC Std 801.2, 801.3, and 801.5 for susceptibility, conducted, and radiated electromagnetic emissions.
- UL508. The entire control system of the generator set must be UL508 listed and labeled.
- UL1236 Battery Chargers.

4.25.3. Acceptable Manufacturers/Suppliers.

The manufacturer is to be the authorized distributor of the engine in the area of the project. The generator and the associated generator monitoring equipment are to be manufactured by one of the following approved manufacturers:

- Cummins Power Generation.
- Caterpillar.
- Kohler
- Generac

Provide equipment manufactured by a single source of supply and supplied by a manufacturer who has been continuously engaged in the manufacture of industrial grade emergency power system products for a minimum of 25 years. The manufacturer must have test facilities available in the State of Texas to test the proposed equipment and demonstrate the equipment will meet the project specifications.

If a manufacturer other than an approved manufacturer is proposed, then provide the following additional services:

- Pay all costs, including travel and lodging expenses to the test facility for the Department's representatives (3 people) to witness the test.
- Provide the name, address, and telephone number of at least five (5) comparable installations which can prove the proposed equipment has operated satisfactorily for no less than three (3) years.
- Pay all costs, including travel and lodging expenses for the Department's representatives (3 people) to inspect two of the above referenced installations.

Ensure the equipment is supplied by an authorized distributor of the manufacturer who has been continuously engaged in the distribution of industrial grade power system products for a minimum of fifteen (15) years. The supplier is to provide initial start-up services, conduct field acceptance testing, and warranty service. The supplier must be authorized to perform warranty service on the products provided.

The supplier is to provide qualified field technicians and properly supply spare parts for the supplied equipment, a shop with overhaul capabilities.

4.25.4. Gas Generator Set.

4.25.4.1. Rating.

The natural gas fueled generator set is to operate at 1800 RPM and at a voltage of 480/277 Volts AC, three phase, 60 hertz. Size of generator shown on plans is for information only and is minimum size allowed. Generator manufacturer will perform sizing analysis based on actual loads and submit to the Engineer for review and approval prior to purchasing. This rating is to be based on operating at an altitude of 100 ft. and an ambient temperature of 104° F (40° C).

4.25.4.2. Performance.

- Ensure voltage regulation is plus or minus 0.5 percent for any constant load between no load and rated load for both parallel and non-parallel applications. Random voltage variation with any steady load from no load to full load must not exceed plus or minus 0.5 percent.
- Ensure frequency regulation is isochronous from steady state no load to steady state rated load. Random frequency variation with any steady load from no load to full load must not exceed plus or minus 0.25%.
- Provide an engine-generator set capable of a single step load pick up of 100% nameplate kW and power factor, less applicable derating factors, with the engine-generator set at operating temperature with a voltage drop of no more than 15 percent and a frequency drop of no more than 5 percent. This performance must be formally shop tested using formally calibrated test equipment capable of monitoring very fast and short duration changes. Provide certified test reports to substantiate the generator set is capable of sustaining a minimum of 90% of rated no load voltage with the specified kW load at near zero power factor applied to the generator set.
- Provide alternators that produce a clean AC voltage waveform, with not more than 5% total harmonic distortion at full linear load, when measured from line to neutral, and with not more than 3% in any single harmonic. Telephone influence factor must be less than 40.

4.25.4.3. Construction.

- Mount the engine-generator set on a heavy-duty steel base to maintain alignment between components.
- Incorporate in the base a vibration isolated battery tray with hold-down clamps within the rails.
- Provide switches, lamps, and meters in the control system that are oil-tight and dust-tight and ensure the enclosure doors are gasketed. Do not allow any exposed points in the control system (with the door open) to operate in excess of 50 volts.

4.25.4.4 Connections.

- For the generator set load connections, use silver or tin-plated copper bus bars, drilled to accept mechanical or compression terminations of the number and type as shown on the plans. Provide sufficient lug space for use with cables of the number and size as shown on the plans.

- Make power connections to auxiliary devices at the devices, with required protection located at a wall-mounted common distribution panel.
- Make generator set control interfaces to other system components on a common, permanently labeled terminal block assembly.

4.25.5. Engine and Engine Equipment.

Provide engines that are natural gas fueled and radiator/fan cooled. Ensure the horsepower rating of the engines at their minimum tolerance level is sufficient to drive the alternators and the connected accessories. Include the following engine accessories and features:

- Complete engine fuel systems, including pressure regulators, isolation valving, strainers, solenoid valves and flexible fuel lines. Plumb and mount fuel system components to the generator set skid for ease of connections at the site of the natural gas service from the utility as illustrated on the plans.
- Provide flexible stainless-steel mesh protected lines for both the supply and engine sides of the regulator to isolate vibration. Provide a control system that actively controls the fuel rate and excitation as appropriate to the state of the generator set. Ensure the fuel rate is regulated as a function of starting, accelerating to start disconnect speed, and accelerating to rated speed. Include in the governing system a programmable warm up at idle and cool down at idle function.
- While operating in idle state, ensure the control system disables the alternator excitation system. Furnish an electronic governor that provides automatic isochronous frequency regulation. Provide the governing system dynamic capabilities that are controlled as a function of engine coolant temperature to provide fast, stable operation at varying engine operating temperature conditions. Provide control systems that actively control the fuel rate and excitation as appropriate to the state of the generator set. Ensure fuel rate is regulated as a function of starting, accelerating to start disconnect speed, accelerating to rated speed, and operating in various isochronous or parallel states.
- Skid-mounted radiator and cooling systems rated for full load operation in 104° F (40° C) ambient as measured at the generator enclosure air inlet and based on 0.5 in H_2O external static head. Size radiators based on a core temperature that is 20° F higher than the rated operating temperature, or prototype test the exact radiator proposed to verify cooling performance of the engine/radiator/fan operation in a controlled environment. Provide radiators with a minimum 14-gauge galvanized steel sheet metal duct adapter flange to the radiator and the enclosure. Equip this flange adapter with a flexible vibration isolation section that is continuous around the adapter flange. The equipment manufacturer is to fill the cooling system with a 50/50-ethylene glycol/water mixture. Provide guards for rotating parts against accidental contact.
- Furnish an electric starter capable of three sequential and complete cranking cycles without overheating.
- For oil pumps, use positive displacement, mechanical, full pressure type.
- Full flow lubrication oil filters with replaceable spin-on canister elements and dipstick oil level indicator. Provide three complete sets of filters as spares.
- Replaceable heavy dry element air cleaner with restriction indicator. Provide one filter element mounted along with three spare units.
- Flexible fuel lines.
- Coolant heater.
    - Engine mounted, thermostatically controlled coolant heater rated at 120 volts. Provide a coolant heater that is UL499 listed and labeled.
    - Install the coolant heater on the engine with silicone hose connections. Use steel tubing for connections into the engine coolant system wherever the length of pipe run exceeds 12 in. Specifically design the coolant heater installation to provide proper venting of the

system. Install the coolant heater using quick disconnect couplers to isolate the heater for replacement of the heater element. Provide quick disconnect/automatic sealing couplers that allow the heater element to be replaced without draining the engine cooling system or significant coolant loss.

- Equip the coolant heater with a 12 or 24 VDC thermostat, installed at the engine thermostat housing. Provide an AC power connection box for a single AC power connection to the coolant heater system.

- Provide vibration isolators, spring/pad type or as recommended by the manufacturer, quantity as recommended by the generator set manufacturer. Isolators must include seismic restraints.
- Provide starting and control batteries that are lead acid type, 12-volt DC, sized as recommended by the engine manufacturer, complete with battery cables and connectors.
- Exhaust System: Provide a 304 stainless steel exhaust system with critical grade silencers providing a minimum 32 to 40 dB(A) noise attenuation. Mount this silencer inside of the enclosure. Include 304 stainless steel flexible exhaust assemblies for mounting between the engine and muffler. Furnish exhaust components that are 304 stainless steel. Provide an exterior outlet end of the exhaust piping that runs horizontally with a stainless-steel bird screen. Insulate the mufflers, outlet elbows, piping and flanges inside the enclosure with borosilicate insulation blankets.
- Provide a UL listed/CSA certified minimum 10-amp voltage regulated battery charger for each engine-generator set. Locate the charger in the generator enclosure. The charger must be either rated as weatherproof or sufficiently shielded from rainfall so as to not sustain damage. Ensure the input AC voltage and DC output voltage is indicated. Equip chargers with float, taper, and equalize charge settings. Supply operational monitors that provide visual output along with individual form C contacts rated at 4 amps, 120 VAC, 30VDC for remote indication of:
    - Loss of AC power - red light.
    - Low battery voltage - red light.
    - High battery voltage - red light.
    - Power ON - green light (no relay contact).

Provide a charger that includes an analog DC voltmeter and ammeter, 12 hour equalize charge timer, and AC and DC fuses.

4.25.6. AC Alternator.

Provide an AC generator that is; synchronous, four pole, 2/3 pitch, revolving field, drip-proof construction, single pre-lubricated sealed bearing, air cooled by a direct drive centrifugal blower fan, and directly connected to the engine with flexible drive disc. Provide insulation system components that meet NEMA MG1 temperature limits for Class H insulation system. The maximum allowable actual temperature rise measured by resistance method at full load is 80° Centigrade.

Provide a generator capable of withstanding a three-phase load of 300% rated current for 10 seconds and sustaining 150% of continuous load current for 2 minutes with field set for normal rated load excitation.

Provide a generator capable of delivering rated output (kVA) at rated frequency and power factor, at any voltage not more than 5 percent above or below rated voltage.

Include a Permanent Magnet Generator (PMG) to provide a reliable source of excitation power for optimum motor starting and short circuit performance.

Ensure the subtransient reactance of the alternator does not exceed 12 percent, based on the standby rating of the generator set.

Provide a 120 VAC, 100-watt anti-condensation heater for the alternator. The manufacturer is to interconnect this heater to a set of normally closed contacts of the control panel to assure that the heater only functions when then generator is not operating.

4.25.7. Generator Set Control.

Provide comprehensive monitoring and control system integral to the generator set control to guard the electrical integrity of the alternator and power system. Provide single and 3-phase fault current regulation, so that downstream protective devices have the maximum current available to quickly clear fault conditions, without subjecting the alternator to potentially catastrophic failure conditions. Include provisions to either prevent over voltage due to single phase faults, or to shut down the generator set if line to neutral voltage on any phase exceeds 115% for more than 0.5 seconds. Acceptable methods are a fully rated (100%) 600-volt circuit breaker, mounted on the generator enclosure, Square D or Cutler-Hammer. Provide submittals that demonstrate that the protective device provides proper protection for the alternator by a comparison of the trip characteristic of the breaker with the thermal damage characteristic of the alternator. Field circuit breakers are not acceptable for generator overcurrent protection.

Mount the control on the generator set. Provide a control that is vibration isolated and prototype tested to verify the durability of its components in the system under the vibration conditions encountered.

Include in the generator set mounted control, the following features and functions:

- Control Switches.
    - Mode Select Switch. The mode select switch initiates the following control modes. When in the RUN or Manual position, the generator set starts, and accelerates to rated speed and voltage as directed by the operator. In the OFF position the generator set immediately stops, bypassing any time delays. In the AUTO position the generator set is ready to accept a signal from a remote device to start and accelerate to rated speed and voltage.
    - Emergency Stop Switch. Provide a switch that is a “Red mushroom-head” push-button. Depressing the emergency stop switch must cause the generator set to immediately shut down and be locked out from automatic restarting.
    - Reset Switch. The Reset switch must be used to clear a fault and allow restarting the generator set after it has shut down for any fault condition.
    - Panel Lamp Switch. Depressing the panel lamp switch causes the entire panel to be lighted with DC control power. The panel lamps will automatically be switched off 10 minutes after the switch is depressed, or after the switch is depressed a second time.
- Generator Set AC Output Metering. Provide the generator set with a metering set including the following features and functions:
    - Analog voltmeter, ammeter, frequency meter, and kilowatt (KW) meter. Voltmeter and ammeter must display all three phases. Ammeter and KW meter scales that are color coded in the following fashion: readings from 0-90% of generator set standby rating: green; readings from 90-100% of standby rating: amber; readings in excess of 100%: red.
    - Digital metering set, 0.5% accuracy, to indicate generator RMS voltage and current, frequency, output current, output KW, KW-hours, and power factor. Ensure the generator output voltage is available in line-to-line and line-to-neutral voltages and displays all three phase voltages (line to neutral or line to line) simultaneously.
    - Both analog and digital metering is required. Provide analog and digital metering equipment driven by a single microprocessor, to provide consistent readings and

performance.

- Generator Set Alarm and Status Display.
  - Provide the generator set with alarm and status indicating lamps to indicate non-automatic generator status, and existing warning and shutdown conditions. For the lamps, use the high-intensity LED type. Ensure the lamp condition is clearly apparent under bright room lighting conditions. Provide generator set control that indicates the existence of the following alarm and shutdown conditions on an alphanumeric digital display panel:
    (1) low oil pressure (alarm).
    (2) low oil pressure (shutdown).
    (3) oil pressure sender failure (alarm).
    (4) low coolant temperature (alarm).
    (5) high coolant temperature (alarm).
    (6) high coolant temperature (shutdown).
    (7) engine temperature sender failure (alarm).

    (8) low coolant level (alarm or shutdown--selectable).
    (9) fail to crank (shutdown).
    (10) fail to start/overcrank (shutdown).
    (11) overspeed (shutdown).
    (12) low DC voltage (alarm).
    (13) high DC voltage (alarm).
    (14) weak battery (alarm).
    (15) high AC voltage (shutdown).
    (16) low AC voltage (shutdown).
    (17) under frequency (shutdown).
    (18) over current (warning).
    (19) over current (shutdown).
    (20) short circuit (shutdown).
    (21) over load (alarm).
    (22) emergency stop (shutdown).
  - Make provisions for indication of four customer-specified alarm or shutdown conditions. Ensure labeling on the customer-specified alarm or shutdown conditions is the same type and quality as for the above specified conditions. The non-automatic indicating lamp must be red and must flash to indicate that the generator set is not able to automatically respond to a command to start from a remote location.

4.25.8. Engine Status Monitoring.

- Make the following information available from a digital status panel on the generator set control:
  - Engine oil pressure (psi or kPA).
  - Engine coolant temperature (°F or °C).
  - Engine oil temperature (°F or °C).
  - Engine speed (RPM).
  - Number of hours of operation (hours).
  - Number of start attempts.
  - Battery voltage (DC volts).
- Incorporate in the control system a data logging and display provision to allow logging of the last 10 warning or shutdown indications on the generator set, as well as total time of operation at

various loads, as a percent of the standby rating of the generator set.

4.25.9. Engine Control Functions.

Provide a control system that includes a cycle cranking system, which allows for user selected crank time, rest time, and number of cycles. Make initial settings for 3 cranking periods of 15 seconds each, with a 15 second rest period between cranking periods.

Include in the control system an idle mode control, which allows the engine to run in idle mode in the RUN position only. In this mode, ensure the alternator excitation system is disabled.

Include in the control system an engine governor control, which functions to provide steady state frequency regulation as noted elsewhere in this specification. Include in the governor control adjustments for gain, damping, and a ramping function to control engine speed and limit exhaust smoke while the unit is starting.

Include in the control system, time delay start (adjustable 0-300 seconds) and time delay stop (adjustable 0-600 seconds) functions.

Include in the control system, sender failure monitoring logic for speed sensing, oil pressure, and engine temperature which is capable of discriminating between failed sender or wiring components, and an actual failure conditions.

4.25.10. Alternator Control Functions.

Include a full wave rectified automatic digital voltage regulation system matched and prototype tested by the engine manufacturer with the governing system provided. Ensure it is immune from miss-operation due to load-induced voltage waveform distortion and provide a pulse width modulated output to the alternator exciter. Ensure the voltage regulation system is equipped with three-phase RMS sensing and controls buildup of AC generator voltage to provide a linear rise and limit overshoot. Include in the system a torque-matching characteristic, which reduces output voltage in proportion to frequency below an adjustable frequency threshold. Ensure the torque matching characteristic is adjustable for roll-off frequency and rate and is capable of being curve-matched to the engine torque curve with adjustments in the field.

Provide controls to monitor the output current of the generator set and initiate an alarm (over current warning) when load current exceeds 110% of the rated current of the generator set on any phase for more than 60 seconds. The controls must shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator. Provide protective functions that are in compliance with the requirements of NFPA70 Article 445.

Provide controls to individually monitor all three phases of the output current for short circuit conditions. The control/protection system is to monitor the current level and voltage. The controls must shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator (short circuit shutdown). Provide protective functions that are in compliance to the requirements of NFPA70 Article 445.

Provide controls to monitor the KW load on the generator set and initiate an alarm condition (over load) when total load on the generator set exceeds the generator set rating for in excess of 5 seconds. Provide controls that include a load shed control, to operate a set of dry contacts (for use in shedding customer load devices) when the generator set is overloaded.

Provide an AC over/under voltage monitoring system that responds only to true RMS voltage

conditions. The system must initiate shutdown of the generator set when alternator output voltage exceeds 110% of the operator-set voltage level for more than 10 seconds, or with no intentional delay when voltage exceeds 130%. Ensure under voltage shutdown occurs when the output voltage of the alternator is less than 85% for more than 10 seconds.

Provide a battery monitoring system which initiates alarms when the DC control and starting voltage is less than 25VDC or more than 32 VDC. During engine starting, ensure the low voltage limit is disabled, and if DC voltage drops to less than 14.4 volts for more than two seconds a "weak battery" alarm must be initiated.

4.25.11. Remote Annunciator. Provide a network ready digital signal remote alarm annunciator with horn for remote mounting. Furnish a remote annunciator that provides the audible and visual alarms called for by NFPA Standard 110 for level 1 systems; and in addition, provides indications for high battery voltage, low battery voltage, loss of normal power to the charger. Supply spare lamps to allow future addition of other alarm and status functions to the annunciator. Make provisions for labeling the annunciator in fashion consistent with the specified functions. Provide alarm silence and lamp test switch(es).Use replaceable LED lamps and indicating lamp color must be capable of changes needed for specific application requirements. Provide a switchable alarm horn for all annunciation points. Provide an alarm horn (when switched on) that sounds for first fault, and for subsequent faults, regardless of whether first fault has been cleared, in compliance with NFPA110 3-5.6.2.

4.25.12. Outdoor Weatherproof Enclosure.

Provide a generator set with a walk-in aluminum sound-attenuated housing which allows the generator set to operate at full rated load in an ambient temperature of up to 104^{O}F. Design the overall acoustic performance of the enclosure to provide a maximum sound pressure of 60dBA at 20 ft. from the generator in every direction. Provide acoustical calculations with the submittal package to substantiate the values listed below. Tests will be performed in the field by the Engineer on the equipment during the full load testing to confirm values are met. Provide the test leads of sufficient length to permit the load bank to be situated on the east side of the generator unit. If the enclosure fails to provide the required attenuation, it is the supplier's responsibility to immediately make the changes necessary to meet the values as specified at no additional cost to the project.

Provide 3 ft. of clearance on each side of the generator set skid and 5 ft. of clearance on the control panel or alternator end of the unit.

Construct the enclosure of minimum 16-gauge aluminum outer skin, internal siffeners and framing and minimum 22-gauge perforated aluminum inner skin. Pack panels with a minimum 4 lbs./cu. ft. density mineral wool acoustical insulation which is protected by a minimum 2 mil mylar liner installed between the perforated inner skin and the insulation material. Provide enclosure framing consisting of A-36 structural steel tubing and channel members.

Provide an enclosure meeting the following fire related parameters, per NFPA No. 255 or ASTM E84. Flame spread = 15, smoke developed = 0 and fuel contributed =0.

Design the generator enclosure to be able to withstand the following loadings; 110 mph winds, 42 lbs./sq. ft. roof loads and zone 1 earthquakes. Submit formal calculations prepared, sealed, and signed by a licensed Texas professional structural engineer for review and approval.

Finish: Clean, prime, and paint enclosure exterior surfaces with three coats of paint. Paint color to be selected by the Department/Engineer.

Provide the enclosure with the following:

- Inlet and discharge weather louvers with birdscreen (Aluminum Construction).
- Inlet and discharge vertical baffle panels (Aluminum Construction).
- A minimum of two access service doors) with one in front of the main circuit breaker.
- Door hardware to be 316 stainless steel including hinges, refrigerator type latches and bolting hardware. Provide hardware of the panic exit type.
- Interior lighting: Two LED lights.
- Two light switches.
- Two 20 Amp GFCI duplex receptacles.

Select an enclosure supplier that has been continuously engaged in the manufacture of sound attenuated enclosures for a minimum of 10 years.

Acceptable Manufacturers:
- Acoustical Control Systems, Inc.
- E&CA.
- Or approved equal.

4.25.13. Installation.

4.25.13.1. Sequence of Operation.

Provide a generator set that starts on receipt of a start signal from remote equipment. The start signal is to be via hardwired connection to the generator set control.

Provide a generator set that completes a time delay start period as programmed into the control.

Ensure the generator set control initiates the starting sequence for the generator set. The starting sequence includes the following functions:
- The control system must verify that the engine is rotating when the fuel system is signaled to operate. If the engine does not rotate after two attempts, the control system must shut down and lock out the generator set and indicate a fail to crank at shutdown.
- The engine is to fire and accelerate as quickly as practical to the start disconnect speed. If the engine does not start, it is to complete a cycle cranking process as described elsewhere in this specification. If the engine has not started by the completion of the cycle cranking sequence, it must be shut down and locked out, and the control system is to indicate a fail to start.
- The engine is to accelerate to rated speed and the alternator to rated voltage. Ensure excitation is disabled until the engine has exceeded the programmed idle speed and regulated to prevent over voltage conditions and oscillation as the engine accelerates and the alternator builds to rated voltage.
- On reaching rated speed and voltage, the generator set is to operate as dictated by the control system in isochronous, synchronize, load share, load demand, or load govern state.
- When the start signals have been removed from the generator set, it must complete a time delay stop sequence. The duration of the time delay stop period is to be adjustable by the operator.
- On completion of the time delay stop period, the generator set control must switch off the excitation system and shut down.
- Any start signal received after the time stop sequence has begun must immediately terminate the stopping sequence and return the generator set to isochronous operation.

4.25.13.2. Other Requirements.

Submittals:

- Manufacturer's product literature and performance data, sufficient to verify compliance to specification requirements.
- A paragraph by paragraph specification compliance statement, describing the differences between the specified and the proposed equipment.
- Manufacturer's certification of prototype testing.
- Manufacturer's published warranty documents.
- Shop drawings showing plan and elevation views with certified overall dimensions, as well as wiring interconnection details.
- Interconnection wiring diagrams showing external connections required; with field wiring terminals marked in a consistent point-to-point manner.
- Manufacturer's installation instructions.

4.25.13.3. Factory Testing.

The generator set supplier is to perform a complete operational test on each of the generator sets before shipping from the factory. Provide a certified test report for each unit. Ensure equipment supplied is fully tested at the factory for function and performance. This testing must be witnessed by one or two representatives of the Department. The costs associated with this factory testing are to be paid by the generator manufacturer. Charges may include travel, lodging, meals, rental cars, etc. The duration of the factory testing is 4 hr. at full load for each unit.

Make the generator monitoring system completely functional, including the loading of operational software, the development of operational graphics, and the integration into the HCTRA system. Illustrate each individual item monitored. Create signals in the field and verify that they are being illustrated as text messages on HCTRA personnel's cell phones.

4.25.13.4. Installation.

The General Contractor to install equipment in accordance with final submittals and contract documents. Comply with applicable state and local codes as required by the authority having jurisdiction. Install equipment in accordance with manufacturer's instructions and instructions included in the listing or labeling of UL listed products.

Perform interconnecting wiring and piping between equipment sections, under the supervision of the equipment supplier.

Install equipment on a concrete housekeeping pad. Permanently fasten equipment to the pad in accordance with the manufacturer's instructions.

Equipment must be initially started and operated by representatives of the manufacturer.

Physically inspect equipment for damage. Repair scratches and other installation damage before final system testing. Thoroughly clean equipment to remove dirt and construction debris before final testing of the system.

4.25.13.5. On-Site Acceptance Test.

The complete installation at each location will be tested for compliance with the specification following completion of all site work. Testing will be conducted by representatives of the manufacturer, with required fuel supplied by Contractor. Notify the Engineer in advance to witness these tests.

Installation acceptance tests to be conducted on-site will include a two-hour full load test. The testing

protocol will be the same as provided for the factory test. Provide a resistive load bank and make temporary connections for this full load test.

Perform a power failure test on the entire installed system. Conduct this test by opening the power supply from the utility service and observing proper operation of the system. Coordinate timing and obtain approval for start of test with site personnel.

4.25.13.6. Training. The equipment supplier is to provide training for the facility operating personnel covering operation and maintenance of the equipment provided. The training program is to be a minimum of 4 hr. in duration and the class size is to be limited to 3 persons. Coordinate the training date with the Department.

4.25.13.7. Service and Support.

The manufacturer of the generator set must maintain service parts inventory at a central location which is accessible to the service location.

Ensure the generator set is serviced by a local service organization that is trained and factory certified in generator set service.

The manufacturer is to maintain model and serial number records of each generator set provided for at least 20 years.

4.25.13.8. Operation and Maintenance Manuals. Provide 4 copies of complete Operation and Maintenance (O&M) manuals for the equipment furnished and installed. Provide bound manuals in three ring binders with clear acetate covers. Include in these manuals complete technical literature on all components along with a material list, wiring schematics, dimensional plans of enclosures (internal and external views), etc.

4.25.13.9. Warranty. Provide a warranty for the generator set and associated equipment furnished under this specification for a minimum period of 5 years from the date of final acceptance of the units against defects in materials and workmanship. Final acceptance will occur after field testing has been completed and approved, punch list items satisfied, and the O&M manuals delivered. This warranty must provide for full parts and labor coverage with no proration for the age of the units.

4.26. Power System Studies.

4.26.1. Description.

4.26.1.1. General: This section specifies that the Contractor prepare a short circuit and protective device coordination study, load flow, motor starting study, and an arc flash hazard analysis for the electrical power system as shown on the plans for the complete electrical system at the pump station.

Short Circuit and Protective Device Coordination Study, Arc Flash Analysis, Load Flow Study, and Motor Starting Study.

The studies should provide an evaluation of the electrical power system and the model numbers and settings of the protective relays or devices and metering or motor monitoring devices for setting by the Contractor.

The Studies must include settings for all protective relays and circuit breakers, including breakers mounted in generator, power meters and electric system monitoring for both devices provided under this contract and for the existing devices. The Contractor will obtain any needed data or

information for the electrical equipment from Contract Documents, various suppliers, and from conducting his own field investigations.

4.26.1.2 Scope: The Contractor is responsible for providing all pertinent information necessary for the successful completion of the Short Circuit and Protective Device Coordination Study, Load Flow and Motor Starting Study, and Arc Flash Analysis. All cable and raceway data, data from all new and existing electrical equipment - Motor control center, transformers, generators, panelboards, and separately mounted fuses, starters or circuit breakers must be obtained by the Contractor. Obtain all existing or new protective device information to include all present settings. The Contractor will obtain any needed data or information from Contract Documents, various suppliers, the Electric Utility and from conducting his own field investigations. The data obtained should be organized and submitted to the Engineer to show that all the necessary data gathering work has been done.

Calculations will utilize actual X/R and three phase short circuit values obtained by the Contractor from the Electric Utility. The use of infinite bus fault current calculation is not acceptable.

The Contractor must redo the Power System Studies if any changes are made during the field-testing checkout and start-up and will re-submit the updated study for engineer approval.

Provide a complete short circuit study. Include three phase and phase-to-ground calculations. Provide an equipment interrupting or withstand evaluation based on the actual equipment and model numbers provided on this project. Generic devices are not acceptable. Normal system operating method, alternate operation, and operations that could result in maximum fault conditions must be thoroughly addressed in the study.

The study will assume all motors operating at rated voltage with the exception that motors identified as "standby" will not be included.

Electrical equipment bus impedance must be assumed zero.

Short circuit momentary duties and interrupting duties will be calculated on the basis of maximum available fault current at the electrical equipment busses.

The Study will be performed using actual available short circuit currents available and system impedances as obtained from the Electric Utility and Generator manufacturer. An assumption of infinite bus for the purposes of the Study is not acceptable.

Study will use actual motor X/R and subtransient reactance data obtained from equipment suppliers. A protective device coordination study must be performed to determine appropriate relay settings. The study will include all electrical equipment provided under this contract and any up-stream equipment that has an impact on the coordination study. The study must show transformer damage curves, cable short circuit withstand curves and motor curves. Include all low voltage distribution switchboards, motor control centers, starters, and panelboards main circuit breakers. Complete the short circuit study down to the main breaker or main lugs on all panelboards. Panelboard branch circuit devices need not be considered. The phase over current and ground-fault protection must be included as well as settings for all other adjustable protective devices. All motor monitoring relays and protective or monitoring devices that are a part of a supplier’s equipment (such as starters, switchgear) must be in included. Include the last protective device in the Electric Utility’s system feeding each facility being considered.

Provide Time-Current Curves on 11X17 log-log paper. Do not put more than one branch of protective devices on any one coordination curve. Include a one-line diagram and the names of each protective device in the branch. Use the names designated in the Contract Documents. Include motor and transformer damage curves, and cable short circuit withstand curves. Coordination study time-current curves (11x17 log-log type) including the instrument transformer ratios, model numbers of the protective relays, and the relay settings associated with each breaker. Organize the curves as specified here in. Ground fault time current curves will be on a separate sheet.

An equipment evaluation study must be performed to determine the adequacy of the fault bracing of all bus from the panelboard level up to the main Switchgear or protective device. Include circuit breakers, controllers, surge arresters, busway, switches, and fuses by tabulating and comparing the short circuit ratings of these devices with the available fault currents.

Provide arc flash hazard analysis in accordance with the applicable NFPA, ANSI, and IEEE standards.

The studies will be performed, sealed and signed by a Registered Professional Engineer licensed in the state of Texas.

Any problem areas or inadequacies in the equipment must be promptly brought to the Engineer's attention.

Use industry standard short circuit software, SKM Captor and Dapper or an equal approved by the Engineer.

The report will include a comparison of short circuit duties of each bus to the interrupting capacity of the equipment that is protecting that bus.

The report will include all data that was used as input to the report. This data will include cable impedance, conduit type, source impedance, equipment ratings, motor X/R and subtransient reactance data, etc.

Provide and program all settings for all power meters, motor protection relays, feeder protection relays, etc.

The Contractor must coordinate with the Utility, El Paso Electric for electrical required for the studies.

4.26.1.3 References.

This Section contains references to the following documents. They are a part of this Section as specified and modified. In case of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section will prevail.

Reference	Title
IEEE 141	Recommended Practice for Electric Power Distribution for Industrial Plants
IEEE 242	Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
NFPA 70E	Handbook for Electrical Safety in the Workplace
IEEE 1584	IEEE Guide for Performing Arc-Flash Hazard Calculations
NEC	National Electrical Code

4.26.1.4 Schedule.

The report will be provided to the Engineer no later than two weeks before the equipment is delivered to the Work site.

4.26.1.5 Submittal Procedures. Submittal Procedures must be in accordance with Section 01 30 00, "Submittal Procedures" and must include:

- Shop Drawings.
- Short Circuit and Protective Device Coordination Study. Time current curves will be on 11x17 log type paper. The 11x17 paper with the TCC must also include a one-line diagram for the branch that the TCC on that sheet corresponds with. The Contractor can provide time current curves on 8 ½ x 11 log-log type paper as a supplement but not as a replacement. Provide a list of all recommended settings for all power meters, motor protection relays, feeder protection relays, circuit breakers, etc.
- Load Flow Study.
- Motor Starting Study. Contractor will coordinate with the starter manufacturers for all data required to perform the motor starting analysis. The preliminary starting analysis will determine the maximum inrush allowed when starting the motor to not drop out the loads under the worst operating conditions.
- Arc Flash Hazard Analysis. Provide a color copy of project specific Arc Flash labels for each Motor Control Center, and starters.
- Provide a copy of the one-line diagram color-coded to show the incident ranges at each bus. The one-line will be on 11x17 paper.
- The Contractor must redo the Power System Studies if any changes are made during the field-testing checkout and start-up. The Contractor will re-submit the Power System Studies for Engineer Approval. The Studies must include an updated copy of the color copy Arc Flash Labels.
- A CD with all SKM input files and a PDF of all output files is required for both the preliminary and final power system studies Submittal Procedures.
- Two Software copies of actual power systems computer program project data files burned in on a CD. The Contractor will provide an electronic copy on a CD-ROM of all files used to develop the electrical system model in the power system analysis program and all files for the written study analysis and summary data tables. For instance, if SKM software is used for the power system studies, then the SKM files will be burned in on a CD-ROM and provided to the Department/Engineer. This will include any library files used for circuit breakers, fuses, etc. for the power system analysis.

4.26.1.6. Execution.

General.
Provide a short-circuit and protective device coordination study load flow study, and arc flash hazard analysis on the electrical power distribution system, as specified. The studies must be performed in accordance with IEEE Standards 141 and 242, IEEE 1584, ANSI, and the NEC and will utilize the ANSI method of short circuit analysis in accordance with ANSI C37.010. The studies must be performed using actual equipment data for all equipment. The coordination studies will use the data from the manufacturer of protective devices.

Qualifications.
The studies must be performed by a consultant who is regularly engaged in power system studies. A Licensed Professional Engineer with proficiency in electrical power engineering will conduct the studies and will seal and sign the studies. The Professional Engineer must be licensed to practice engineering in the State of Texas. A study submitted without a Professional Engineer's seal will not be reviewed and returned Not Approved, Revise & Resubmit. Equipment manufacturers must not

be allowed to perform the studies, no exceptions.

Short Circuit Study.
The Contractor will be responsible for obtaining and verifying all data needed to perform the study. As a minimum, each short circuit study must include the following:

- One-Line Diagram:
    - Location and function of each protective device in the system, such as relays, direct-acting trips, fuses, etc.
    - Type designation, current rating, range or adjustment, manufacturer's style and catalog number for all protective devices.
    - Power and voltage ratings, impedance, primary and secondary connections of all transformers. Use the ratings (i.e. Impedence, X/R, etc.) of the actual transformers being provided where available.
    - Type, manufacturer, and ratio of all instrument transformers energizing each relay.
    - Nameplate ratings of all motors and generators with their subtransient reactances. Transient reactances of synchronous motors and generators and synchronous reactances of all generators. Obtain data on the actual equipment being provided. Generic or average data numbers are not acceptable.
    - Sources of short circuit currents such as utility ties, generators, synchronous motors, and induction motors.
    - Provide short circuit studies using each source of power separately. The study will determine if there is sufficient short circuit current to adequately cause interruption of a protective device using the weaker power source (typically local generation) and will determine if the equipment can safely interrupt the fault if the greater power source is connected. Additional short circuit calculations should include emergency as well as normal switching conditions as well as normal and emergency power sources described here in.
    - Show short circuit calculations listing short circuit levels at each bus. Provide the same data in tabular from.
    - All significant circuit elements such as transformers, cables, breakers, fuses, reactors, etc. must be included.
    - The time-current setting of existing adjustable relays and direct-acting trips, if applicable.
    - One-Line showing available fault current at each bus all the way down to the 120/240V and 208Y/120V panelboards.
- Impedance Diagram:
    - Available MVA or impedance from the utility company.
    - Local generated capacity impedance.
    - Bus impedance.
    - Transformer and reactor impedances.
    - Cable impedances.
    - Equipment impedances.
    - System voltages.
    - Grounding scheme (resistance grounding, solidly grounding, or no grounding).
    - Motor contribution assuming the new and existing motors as shown on the plans all running at the same time.
- Calculations:
    - Determine the paths and situations where short circuit currents are the greatest. Assume bolted faults and calculate the 3-phase and line-to-ground short circuits of each case.
    - Calculate the maximum and minimum fault currents.
    - A discussion section evaluating the adequacy or inadequacy of the equipment method

of calculation and formulas used such that all calculations can be verified manually by the Engineer, with recommendations as required for improvements to the system.

- Any inadequacies must be called to the attention of the Engineer and recommendation made for improvements.

Protective Device Coordination Study.
As a minimum, the coordination study for the power distribution system must include the following on 5-cycle, log-log graph paper:

- The time-current coordination analysis will be performed with aid of a digital computer.
- Time-current curves for each device must be positioned to provide for maximum selectivity to minimize system disturbances during fault clearing, but still maintain a low incident energy level. Where selectivity cannot be achieved, the Engineer must be notified as to the cause.
- Time-current curves for each device will be positioned to provide for maximum selectivity to minimize system disturbances during fault clearing. Where selectivity cannot be achieved, the Engineer must be notified as to the cause.
- Time-current curves and points for cable and equipment damage.
- Circuit interrupting device operating and interrupting times.
- Indicate maximum fault values on the graph.
- Sketch of bus and breaker arrangement.

ARC Flash Hazard Analysis.
The study must be performed in accordance with the NEC and all applicable OSHA, ANSI, and IEEE standards.

The Contractor will adjust all adjustable time-current devices such that the trip settings lower the arc flash exposure and minimizing the clearing time. However, the Contractor must adjust the time-current devices to avoid nuisance tripping.

The Contractor will utilize fault current values from the short circuit analysis to determine the Incident energy, limited approach boundary, restricted approach boundary, prohibited approach boundary and appropriate PPE required.

The Contractor must provide project specific arc-flash labeling. The arc-flash labeling will be placed on the outside of the cover of the switchgear, motor control centers, combination motor starters, panelboard, switchboard, distribution panel, and all electrical panels, etc. such that it can be read without opening the electrical equipment. Mount arc-flash labels a maximum of 6’-6” AFF, include the housekeeping pad in the mounting height. The Contractor must provide arc-flash labeling on all existing panelboards, switchboards, distribution panel, etc. where breakers are added, or work is performed in or on the electrical equipment.

Arc Flash Labels must be chemical resistant, UV resistant, water resistant, scratch resistant, and made of 3.0 mil vinyl tape as manufactured by DuraLabel, Brady or approved equal. The lettering will be performed by thermal transfer print.

Arc Flash labels and label lettering will be sized large enough to be legible at a distance outside the hazard area.

Arc Flash Labels should be placed on the door(s) of the room if the hazard area reaches or extends beyond the electrical room door(s).

The arc flash label must include a DANGER header when the incident energy is above 40cal/cm^2, and a WARNING header for all other incident energy levels.

To ensure a safe workplace, and that the labeling meets NEC, OSHA, IEEE, and NFPA requirements, use specialized arc flash software to calculate protection boundaries. These protection boundaries must include the Flash Protection Boundary, Limited Approach Boundary, Restricted Approach Boundary and the Prohibited Approach Boundary.

Arc-flash label will be provided all the way down to the 120/240V and 208Y/120V panelboards.

The arc-flash analysis will be based on calculated fault from the Short Circuit Study at each respective bus. The arc-flash software program will be used to calculate the available arcing fault at each bus in the system, the resultant flash protection boundary based on the applicable protective device operating times and the associated incident energy that workers may be exposed to at the specified working distances.

The report will include the following information: Arc-flash evaluation table, arc-flash and shock hazard label definitions, arc-flash evaluation information, arc-flash and shock hazard labels and definitions of terms used in the arc-flash hazard analysis.

Arc Flash labels must be similar to the following example:

WARNING

Arc Flash and Shock Hazard

Appropriate PPE Required

13 inch	Flash Hazard Boundary
0.67	cal/cm^2 Flash Hazard at 18 inches
3	PPE Category
480 VAC	Shock Hazard when cover is removed
0	Glove Class
42 inch	Limited Approach
12 inch	Restricted Approach
10.692 kA	Calculated Available Fault Current

Equip. ID: Panel LP1
Protected By: 125A CB: TX1 (480V MCC1)
Study Date: May 4, 2016
Upstream Protective Device: Panel HP1 Circuit 1,3,5

Load Flow Study.
Scope: Determine the active and reactive power, voltage, current, and power factor throughout the electrical system. Provide an analysis of all possible operating scenarios.

Procedure: The load flow study will be performed in accordance with the recommended practices and procedures set forth in IEEE 399.

Study Report: Results of the load flow study should be summarized in a final report containing the following items:

- Basis, description, purpose, and scope of the study.
- Tabulation of data used to model the system components and a corresponding one-line diagram.
- Description of scenarios evaluated and the basis of each.
- Tabulation of power and current flow versus equipment ratings. The tabulation must identify percentage of rated load and the scenario for which the percentage is based. Overloaded equipment must be clearly noted.
- Tabulation of system voltage versus equipment ratings. The tabulation must identify percentage of rated voltage and the scenario for which the percentage is based. Voltage levels outside the ranges recommended by equipment manufacturers, IEEE C84.1 or other appropriate standards must be clearly noted.
- Tabulation of system real and reactive power losses with area of concern clearly noted.
- Provide One-line showing voltage at major busses down to the 120/240V and 208Y/120V panelboards.
- Conclusions and recommendations.

Motor Starting Study.
The motor starting study will provide an evaluation of the electrical power system when starting the motors for all operating scenarios. The motor starting study must evaluate all different possible operating scenarios under the worst case starting conditions. The Contractor should coordinate with the electrical equipment manufacturers and obtain all information required to perform the motor starting analysis. The preliminary starting analysis will determine the maximum inrush allowed when starting the motors to not drop out the site loads under the worst operating conditions.

Scope:
Contractor must provide a motor starting/load flow study for the work performed at the site. The study must evaluate all possible operating scenarios. See electrical plans for detailed one-line diagram of the electrical distribution system. The study should show at what setting each soft starter should be set so that when the largest HP pump motor is started via the solid-state reduced voltage soft starter under the worst-case conditions meets or exceeds the voltage flicker requirement of IEEE/NEMA standards and does not drop out the site loads. The Contractor will coordinate with the Local Utility and Department for all voltage flicker requirements and is responsible for obtaining all pertinent data from the Local Utility/Department and other equipment manufacturers to perform the study.

Contractor will obtain any information required for the motor starting/load flow study including utility available fault current, utility system impedance, motor data (i.e., sub transient reactance, etc.), transformer data (i.e. impedance, X/R, etc.), cable data, etc.

The study must be submitted to the Engineer and approved prior to final approval of the electrical equipment shop drawings and release of any electrical equipment for manufacturing.

The study must include as a minimum the following:

- Single line diagram showing voltage at all major busses down to the 120/240V panelboards.
- Bus Voltage and power flow.
- Information on the computer program used for the study and also will include a general discussion of the procedure, items, and data considered in preparing the study.
- Description and analysis of all results.
- Suggested changes to the equipment selection that will result in improved system

performance.

- The study must be performed, sealed and signed by a Registered Professional Engineer licensed in the state where the electric equipment is to be installed.

5. PRODUCT SUSBSTITUTION PROCEDURES

Options for making product or process selections. Procedures for proposing equivalent products or processes, including pre-approved, pre-qualified, and approved products or processes.

5.1. Definitions.

Product: Product does not include machinery and equipment used for production, fabrication, conveying, and erection of the Work. Products may also include existing materials or components designated for reuse.

5.2. Process.

Any proprietary system or method for installing system components resulting in an integral, functioning part of the work. For this Section, the word products includes processes.

5.3. Selection Options.

- Pre-approved products: Construction products of certain manufacturers or suppliers designated in Specifications as “pre-approved.” The Department maintains a list of pre-approved products. Pre-approved products for this Project are designated as pre-approved in Specifications. Products of other manufacturers or suppliers are not acceptable for this Project and will not be considered under the submittal process for approving alternate products.
- Pre-qualified products: Construction products of certain manufacturers or suppliers designated in Specifications as “pre-qualified.” Pre-qualified products for this Project are designated as pre-qualified in Specifications. Products of other manufacturers or suppliers are not acceptable for this Project and will not be considered under the submittal process for approving alternate products.
- Approved products: Construction products of certain manufacturers or suppliers designated in Specifications followed by words “or approved equal.” Approval of alternate products not listed in Specifications may be obtained through provisions for product options and substitutions by Engineer and by following submittal procedures. The procedure for approval of alternate products is not applicable to pre-approved or pre-qualified products.
- Product compatibility: To the maximum extent possible, provide products that are of the same type or function from a single manufacturer, make, or source.

Where more than one choice is available, select product that is compatible with other products already selected, specified, or in use by the Department.

5.4. Contractor’s Responsibility.

- Responsibility related to product options and substitutions is defined in these specifications.
- Furnish information the Engineer deems necessary to judge equivalency of alternate product.

- Pay for laboratory testing, as well as any other review or examination costs, needed to establish equivalency between products in order to obtain information upon which the Engineer can base a decision.
- If the Engineer determines alternate product is not equal to that named in the specifications, furnish one of the specified products.

5.5. Department's Review.

- Use alternate products only when approved in writing by the Engineer. The Engineer's determination regarding acceptance of proposed alternate product is final.
- Alternate products may be accepted if the products are judged by the Engineer to be equivalent to specified product or to offer substantial benefit.

5.6. Substitution Procedure.

- Collect and assemble technical information applicable to the proposed product to aid in determining equivalency as related to the approved product specified.
- Submit a written request for a construction product to be considered as an alternate product.
- Submit product information after the effective date of the Contract and within the time period allowed by the Engineer for substitution submittals. After the submittal period has expired, requests for alternate products will be considered only when the specified product becomes unavailable because of conditions beyond the Contractor's control.
- Submit 5 copies of each request for alternate product approval. Include the following information:
    - Complete data substantiating compliance of proposed substitution with the Contract.
    - For Products:
        (1) Product identification, including manufacturer's name and address.
        (2) Manufacturer's literature with product description, performance and test data, and reference standards.
        (3) Samples, as applicable.
        (4) Name and address of similar projects on which product was used and date of installation. Include names of Department, design consultant, and installing contractor.
    - For Construction Methods.
        (1) Detailed description of proposed method.
        (2) Plans illustrating methods.
- Itemized comparison of proposed substitution with product or method specified.
- Data relating to changes in the Construction Schedule.
- Relation to separate contracts, if any.
- Accurate cost data on proposed substitution in comparison with product or method specified.
- Other information requested by the Engineer.

Approved alternate products will be subject to the same review process as the specified product would have been for Shop Drawings, Product Data, and Samples.

6. BASIC PRODUCT REQUIREMENTS

Requirements for transportation, delivery, handling, and storage of products.

6.1. Products. Does not include machinery and equipment used for preparation, fabrication, conveying

and erection of the work. Products may also include existing materials or components designated for reuse.

When contract documents require that installation of work comply with manufacturer's printed Instructions, obtain and distribute copies of such instructions to parties involved in installation, including two copies to the Engineer. Maintain one set of complete instructions at job site during installation until completion.

Provide products from the fewest number of manufacturers as practical, in order to simplify spare parts inventory and to allow for maximum interchangeability of components. For multiple components of the same size, type or application, use the same make and model of component throughout the work.

6.2. Transportation. Make arrangements for transportation, delivery, and handling of products required for timely completion of the work. Transport and handle products in accordance with the manufacturer's instructions. Consign and address shipping documents to proper party giving name of the Project and its complete street address. Shipments are to be delivered to the Contractor.

6.3. Delivery. Arrange deliveries of products to accommodate short-term site completion schedules and in ample time to facilitate inspection before installation. Avoid deliveries that cause lengthy storage or overburden of limited storage space. Coordinate deliveries to avoid conflict with the work and conditions at the site and to accommodate the following:

- Work of other contractors or the Department.
- Limitations of storage space.
- Availability of equipment and personnel for handling products.
- The Department's use of premises.

Have products delivered to the site in the manufacturer's original, unopened, labeled containers. Immediately upon delivery, inspect shipment to assure:

- Product complies with requirements of the Contract.
- Quantities are correct.
- Containers and packages are intact; labels are legible.
- Products are properly protected and undamaged.

6.4. Product Handling. Coordinate off-loading of products delivered to the site. If necessary during construction, move and relocate stored products at no additional cost to the Department. Provide equipment and personnel necessary to handle products, including those provided by the Department, by methods to prevent damage to products or packaging. Provide additional protection during handling as necessary to prevent breaking, scraping, marring, or otherwise damaging products or surrounding areas. Handle products in accordance with manufacturer's recommendations.

6.5. Storage of Products. Store and protect products in accordance with manufacturer's recommendations and requirements of these Specifications.

Make necessary provisions for safe storage of products. Place products so as to prevent damage to any part of the work or existing facilities and to maintain free access at all times to all parts of the work and to utility service company installations in the vicinity of the work. Keep products neatly and compactly stored in locations that will cause minimum inconvenience to other contractors, public travel, adjoining Departments, tenants, and occupants. Arrange storage in a manner so as to provide easy access for inspection.

Provide off-site storage and protection when on-site storage is not adequate. Provide addresses of, and access to, off-site storage locations for inspection by the Engineer.

Do not use lawns, grass plots, or other private property for storage purposes without written permission of Department or other person in possession or control of premises.

Protect stored products against loss or damage.

Neatly, safely, and compactly stack products delivered and stored along the line of the work to avoid inconvenience and damage to property Departments and general public and maintain at least 3 ft. clearance around fire hydrants. Keep public, private driveways, and street crossings open.

Repair or replace damaged lawns, sidewalks, streets, or other improvements to the satisfaction of the Engineer. The total length that products may be distributed along route of construction at one time is 1000 linear ft., unless otherwise approved in writing by the Engineer.

7. STARTING SYSTEMS

This section includes starting systems, demonstration and instructions, and testing, adjusting and balancing.

7.1. Preparation.

- Coordinate schedule for start-up of various equipment and systems.
- Notify Engineer 7 days before start-up of each item.
- Verify that each piece of equipment or system has been checked for proper lubrication, drive rotation, belt tension, control sequence, or other conditions which may cause damage.
- Verify that tests, meter readings, and specified electrical characteristics agree with those required by the equipment or system manufacturer.
- Verify wiring and support components for equipment are complete and tested.
- Execute start-up under the Contractor's supervision in accordance with the manufacturer's instructions.
- When specified in specification sections, require the manufacturer to provide an authorized representative to be present at the site to inspect, check, and approve equipment or the system installation before start-up, and to supervise placing equipment or the system in operation.
- Submit a written report that the equipment or system has been properly installed and is functioning correctly.

7.2. Demonstration and Instructions.

- Demonstrate operation and maintenance of products to the Department/Engineer or their representatives two weeks before Substantial Completion.
- Utilize operation and maintenance manuals as basis for instruction. Review contents of the manual with the Department/Engineer or their representatives in detail to explain all aspects of operation and maintenance.
- Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at agreed-upon times, at the equipment location.
- Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.

7.3. Testing, Adjusting, and Balancing.

The Engineer will appoint, employ, and pay for services of an independent firm to perform testing, adjusting, and balancing.

Reports will be submitted by the independent firm to the Engineer indicating observations and results of tests and indicating compliance or non-compliance with specified requirements and with the requirements of the contract documents.

8. CONSTRUCTION DEWATERING

Any dewatering required during any phase of construction is the responsibility of the Contractor and is subsidiary to this Item. Provide and install temporary pumps for dewatering. Do not use the permanent or existing pumps as called for in this specification for construction dewatering.

9. MEASUREMENT

The operational building, electrical power and controls, electrical pumps, generators, wet wells, and piping satisfactorily completed in accordance with the plans and specifications to form a fully functional automatic pumping station will be measured as a complete unit by the lump sum.

10. PAYMENT

The work performed, and materials furnished in accordance with this Item, and measured as provided under “Measurement” will be paid for at the unit price bid for “Automatic Pumping Station,” at the location specified. This price is full compensation for furnishing and installing a fully operational automatic pumping station and for the equipment required by this Item including building, generators, pumps, discharge pipes, sensors, controls, switchgear, electrical systems, wet well, and for other materials, labor, tools, equipment, accessories, and incidentals. Any costs associated with dewatering, electrical service, and testing are subsidiary to this Item. The work performed, materials furnished equipment, labor, tools, and incidentals for construction of the wet well will not be paid for directly but are subsidiary to this Item.