TECHNICAL SPECIFICATIONS
FOR

NEW BRAUNFELS ETJ
FLYING W TRACT LIFT STATION

Prepared for:

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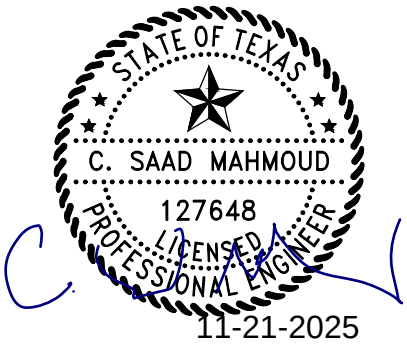

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Section 13400

Measurement and Control Instrumentation

PART 1. GENERAL

1.01 SUMMARY

A. This specification is confidentially issued for this specific project only

B. Contractor shall be responsible for reading all specifications from all disciplines prior to bid

C. This section covers field transmitters for instrumentation and control systems. Refer to complete plans and project manual for additional information on all transmitters described to be provided and installed

1.02 SUBMITTALS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

1.03 QUALITY ASSURANCE

A. All equipment shown to be provided and installed shall be coordinated with each manufacturer for accuracy and relevance. Manufacturer shall be included in all testing, calibration, and substantial walkthrough prior to engineer final walkthrough

PART 2. PRODUCTS

2.01 FLOAT SWITCH

A. Wastewater / Non-Potable Use:

1. Manufacturers:
    a. Anchor Scientific
    b. Pre-approved equal
2. Construction:
    a. Direct acting
    b. Polyprosylene body
    c. Form C type contact mercury switch
    d. 10 amps at 230 VAC maximum

B. Float switches for control of indicated equipment shall consist of plastic encased ball-type float switch with weighted neck and three conductor plastic sheathed cord. Float switches shall be furnished with form C contacts.

C. Furnish Flygt, Anchor-Scientific, or approved equal float switches.

2.02 SUBMERSIBLE LEVEL TRANSDUCER

A. Non-Potable Water Application:

1. Manufacturer:

a. Dwyer

b. Pre-approved equal

B. Model: PBLTX

C. Power: 10 - 30 VDC

D. Output: 4-20 mA

E. Accuracy: plus/minus 0.1 percent of calibrated span, minimum

F. Range: 0.2 to 100 meters of H_2O, minimum

G. Sensor: Flush mounted ceramic

H. Heavy stainless-steel body

I. Cable: Heavy duty, submersible rated with strain relief device

J. Cable Length: Wet well depth plus length to terminal box with 10 feet slack coiled in terminal box (not in wet wells)

K. Kellum grip with protective bushing. Suspend on stainless steel cable clear of pump and 4 inches above intake. Clamp transducer cable to stainless steel cable with suitable stainless-steel clamps at 24-inch intervals

L. Provide epoxy coated lead weight at end of stainless-steel cable. Provide stainless steel cable strain relief device at transducer that fits threaded connection at transducer, and that has ring for support by stainless steel cable

PART 3. EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's written instructions and approved submittals.

B. Set-up and calibration of equipment shall only be performed by a Factory Technician.

3.02 ADJUSTEMENT/CALIBRATION

A. Provide services of a Factory Technician for calibration and programming of transmitters for range of variable with 4/20 mA representing 0 to 125 percent of maximum range. Allow for field adjustments during testing of installation

3.03 MAINTENANCE/WARRANTY

A. Contractor shall provide full 3-year service warranty on the overall installation and shall include all labor and materials required to repair or replace equipment and/or components that are defective or malfunctioning

B. All critical warranted repairs shall be made within 24 hours of receipt of required parts from Manufacturer with reasonable delivery time of overnight shipping. Any repairs not completed within 5 working days from date of notice are subject to Owner making other arrangements for repair and back charging Contractor. This requirement is a condition of this contract.

C. Where equipment or instrument problems remain unresolved by Contractor beyond a reasonable time, a Factory Technician shall be provided on-site to take any corrective actions necessary to put equipment or instruments in operating order. Owner and Engineer reserve the right to determine a reasonable time for corrective action by Contractor.

D. Any failed equipment may not be repaired and returned to service prior to final acceptance. Only new equipment is allowed.

END OF SECTION

Section 16004

Electrical Systems Testing and Startup

PART 1. GENERAL

1.01 SUMMARY

A. This specification is confidentially issued for this specific project only

B. Contractor shall be responsible for reading all specifications from all disciplines prior to bid

C. Requirements for electrical system testing and startup are included in this section.

1.02 REFERENCES

A. National Electrical Codes (NEC): NEC Article 110 - Requirements for Electrical Installations.

B. International Electrical Testing Association (NETA): “NETA Acceptance Testing Specifications.”

1.03 SUBMITTALS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

B. The name, address, and telephone number of the proposed testing company to be engaged for testing the electrical system, together with their references and samples of recent test results and reports

C. The Contractor shall submit for approval a complete list, including catalog data and descriptive matter, of all products and equipment the Contractor proposes to furnish, and details as may be required by the Engineer to review proposed testing methods. At a minimum, the following are required.

1. Samples of proposed test report forms for the various types of tests indicated herein prior to commencement of field testing.
2. Test reports shall include but not be limited to the following: date, testing personnel names, temperature and humidity, description of item tested, type of tests performed, equipment used for testing, and test results.

PART 2. PRODUCTS

2.01 MATERIALS, EQUIPMENT, AND PERSONNEL

A. The Contractor shall provide the following:

1. Qualified personnel to conduct all testing.
2. Labor, temporary power, lighting, wiring, and materials required for testing.

3. Submit nameplates and label legends as required in Section 16075 - Electrical Identification. All abbreviations and titles shall be checked for clarity.

B. Test Equipment: The third party testing agency shall furnish all test equipment, which shall include but not be limited to the following:

1. Wet and dry bulb thermometer.
2. Meggers by James G. Biddle Co., or Associated Research, Inc., or approved substitution, suitable for 120, 208, 240, and 480 volt and systems testing. Use instruments rated at voltages recommended by Material and Equipment Manufacturers.
3. Portable radios.
4. A Simpson Model 260 Volt-Ohm-Millimeter, or approved substitution.
5. A phase sequence and rotation meters rated at 600 volts, 30-60 hertz, by Knopp, Inc., or approved substitution for the 120, 208, 240, and 480-volt systems.
6. A commercial model, three point, ground test by James G. Biddle Co., a "Vibroground" tester by Associated Research, Inc., or approved substitution.

C. The Contractor shall furnish and use safety devices such as rubber gloves and blankets, protective screens and barriers, danger signs, etc., to adequately protect and warn all personnel in the vicinity of the tests.

D. Test equipment, material, and labor for electrical system testing execution. Test shall be by the outside testing agency engaged for this purpose.

PART 3. EXECUTION

3.01 GENERAL

A. All testing to be performed in compliance with NETA Acceptance Testing Specifications. All submitted test results must include statement indicating compliance.

B. Prior to start of field testing the installation shall be completed, punch listed and inspected by the Engineer and/or Owner’s Representative for satisfactory completion of work.

C. Testing may be witnessed by the Engineer or Owner’s Representative. Provide 1 week advanced notice accordingly.

D. Where hard copy reports are generated, provide all original reports bound in a three (3) ring binder and assembled in a professional format. All reports shall be submitted to Engineer for review. Upon approval, any hard copies shall be left on site or turned over to Owner’s Representative.

3.02 TESTING

A. Molded Case Breaker Tests: The tests shall include the following:

1. Check adjustable magnetic trip settings against nominal values.
2. Megger each pole for freedom from grounds.
3. Check connections and tighten as required.

B. Tests on Motor Starters and Contactors: Tests shall include the following:

1. Check equipment grounding to assure continuity of connections.
2. Remove any blocking used for shipment.
3. Check overload relays for proper current range with motor nameplate full load amperes. Adjust relays for manual or automatic reset.
4. Check each magnet coil for proper operating voltage.
5. Check auxiliary contacts for correct arrangement with coil de-energized; i.e.; normally open or normally closed.
6. Megger each pole of the starter or contractor for freedom from grounds.
7. Check fuses and/or circuit breakers for proper ratings as prescribed by the manufacturer for the actual motor supplied.
8. Check overload heater relays or other overload protection for proper ratings as prescribed by the manufacturer.
9. Check wiring connections and tighten as required
10. Check secondary fuses for proper ratings for motor starter control power transformers.

C. Inspection of Disconnect Switches:

1. Inspect contacts, clean as required.
2. Inspect arc chutes.
3. Inspect fuses for proper rating, type, and size.

D. Lighting System Tests:

1. Test lighting systems for proper operation, for conformance with indicated switch control on the Drawings, for dimming, etc.
2. Set time clocks with astronomical dials to turn "ON" at sunset and "OFF" at sunrise and test operation.

E. 600-Volt Wire and Cable Tests:

1. 600-volt wire shall be meggered with a 500-volt megger for one minute, and values must be approximately as listed as follows:

Conductor Capacity	Resistance
Amperes	Ohms
0 - 24	1,000,000
25 - 50	250,000
51 - 100	100,000
101 - 200	50,000
201 - 400	25,000
501 - 800	12,000
Over - 800	5,000

2. The above values shall be determined with switchboards, panel boards, fuse holders, switches, and over current devices in place. Devices containing semi-conductors, such as diodes, transistors, and other devices, which can be damaged by the megger shall not be connected during meggering. Motors and transformers shall not be connected during meggering. Wire and cable shall be meggered after installation, not on the reel.

3. Wiring to be meggered shall be limited to feeder wiring between main distribution equipment and power panels, branch circuit panels, motor control centers, individual pieces of mechanical equipment and other similar equipment. Wiring for mechanical equipment connected to branch circuit panels shall also be meggered. Branch circuit wiring for lighting and receptacles shall not be meggered.

4. The Contractor shall perform all phasing tests and shall make changes necessary to assure proper rotation of all motors, the correct phasing and phase sequence of all circuits susceptible of being paralleled, the proper polarity on all instrument transformer wiring, and such other phasing tests and changes as may be required for the equipment being connected under this Contract.

F. Panelboards:

1. Test breaker ON/OFF operation.

2. Test voltages between phase and phase to ground at:

   a. Before incoming breaker.

   b. After the incoming breaker at the bus.

   c. At all feeder breaking.

3. Record all test results.

G. Miscellaneous Equipment Tests: Test all miscellaneous equipment for proper operation in accordance with equipment manufacturer’s instructions.

3.03 SYSTEM STARTUP

A. Testing and Startup:

1. All elements of each electrical control system shall be confirmed to demonstrate that the total system satisfies all of the requirements of this Specification. The Contractor shall coordinate and schedule all of his testing and startup work with the Owner and Systems Integration Engineer.
2. Factory Tests: The electrical controls and all other associated hardware shall be tested via a full simulation at the factory, prior to shipment, to demonstrate that each component is operational and meets the requirements of these specifications. Manufacturer shall provide test routine program for shop testing of I/O wiring. Test results shall be certified, with written documentation provided to the Engineer upon test completion. Factory testing may be witnessed by the Engineer.
3. Field Tests: All electrical control system components shall be checked to verify that they have been installed properly and that all terminations have been made correctly. Witnessed field tests shall be performed on the complete system. Contractor shall provide a checklist for all electrical, control and instrumentation functions and send to Engineer for approval. Each function shall be demonstrated to the satisfaction of the Owner and Engineer on a item-by-item basis. Each test shall be witnessed and signed off by the Contractor and the Engineer upon satisfactory completion. The Contractor shall notify the Owner at least 2 weeks prior to the commencement date of the field tests. After tests are completed and with system fully operational, system shall run continuously for a period of 10 days without failure. Any failures shall be repaired and 10 day test shall start over again.
4. Start-up Testing will require a minimum of 10 working days after work is substantially complete, including loading of programs to local PLC. Provide 4 weeks' notice for program downloading by Programmer. This shall be accounted for in project schedule.
5. Prior to testing system, any PLC programs or HMI programs provided by other than the Systems Integration Engineer shall be furnished on CD for review by Engineer. Provide any special software necessary to run and test complete program.

END OF SECTION

Section 16050

Basic Electrical Materials and Methods

PART 1. GENERAL

1.01 SUMMARY

A. This specification is confidentially issued for this specific project only

B. Contractor shall be responsible for reading all specifications from all disciplines prior to bid

C. The electrical drawings and specifications under this section shall be made a part of the full contract documents. The drawings and technical specifications of this contract, supplemental information issued thereto, information to bidders and pertinent documents issued by the owner's representative are part of the overall construction documents. All constructions documents shall be complied with by general contractor

D. The requirements herein are base requirements for all specifications. Other specifications will refer to this section for detailed requirements. No one specification will have all details. Specifications shall be reviewed as a complete package. Coordinate as needed

E. All the above documents will be on file at the office of the owner's representative and shall be examined by all bidders prior to bid. Failure to examine all construction documents shall not relieve the responsibility of a fully functional system as described

F. The documents shall not be used as a basis for additional compensation due to omission of details of other sections, specifications, documents, and drawings

G. Furnish all work, labor, tools, staff, material, equipment, and operations necessary to provide and install a complete and functioning electrical system as defined in construction documents

H. The contractor shall be responsible for visiting the project site prior to bid submission to verify existing conditions for relevant modifications to final bid

I. It is the intent of the contract document that upon completion of the scope of work, the entire system shall be a finished/workable condition

J. Secure all permits, licenses, easements, and inspections as required by all authorities having jurisdiction. Give all notices and comply with laws, ordinances, rules, regulations, and contract requirements

K. Contractor shall determine the exact requirements for the utility service connections and metering facilities as set forth by the utilities that will serve the project. Contractor shall pay for and perform all work as required by those utilities. Refer to section 1.02 (A) for allowance requirements

L. This specification section is an inherent part of all work performed on this project and its contents shall apply for any and all electrical, controls, instrumentation, and communication related work

M. This specification covers all electrical equipment materials and methods required for a fully functional electrical system. This specification holds as a foundational document for electrical items stated in specifications under the same division

N. Relocations and adjustments up to 50 feet are required per this contract as requested by owner or engineer at no additional cost to owner. Include cost in bid

O. Contractor shall provide the equipment necessary for locating all underground pipes, conduits, and structures before digging. All locations of intersection shall be properly staked and identified. Locating all underground utilities is the sole responsibility of the contractor at no additional cost to owner

P. Where obstructions are present in existing spare underground conduits to be used in this project, use video camera to determine cause of obstruction. Coordinate with engineer

Q. Provide arc flash warning tags on all electrical equipment where required by NFPA 70E. Submit arc flash analysis for engineer's review

R. Major scope of work:

1. Provide and install lighting system as described in construction drawings, and technical specifications.
2. Provide and install fully operational lift station control panel operating off primary pressure transducer with backup float relay system. Control panel shall contain built in overcurrent protection system for electrical service and per pump, surge protection system, and emergency power connection transfer system with overcurrent protection
3. Provide grounding system per NEC Article 250, construction drawings, and technical specifications
4. Provide and install terminal boxes for float switches and pump cables
5. Provide and install underground and above ground conduit/ductbank system as described in construction drawings and technical specifications
6. Provide and install electrical shelter as described in construction drawings and technical specifications

S. High level system requirements:

1. The electrical and control system shall include, but shall not be limited to, all circuit breakers, motor starters, alternator, contactors, indicating lights, selector switches, surge protector, phase failure, heaters, instruments, relays, programmable controllers, alarm light, push buttons, control transformers, electronic devices, sensors, interlock wiring, nameplates, and all other associated items required
2. Provide all heaters and equipment to motors per associated references and manufacturer's instructions

1.02 REFERENCES

A. Installations shall conform to all appropriate articles/sections of latest standards, codes, local codes, and ordinances of the owner, authority having jurisdiction, and all entities involved. Contractor shall be responsible for verifying relevance of each reference requirement per the project scope, appropriateness, owner input, and historical requirements. Contractor may submit questions on code requirements where legitimate conflict exists. Relevant references may include all shown below:

1. National Electrical Code (NEC)
2. Underwriters Laboratories (UL)
3. National Electrical Manufacturers Association (NEMA)
4. Insulated Power Cable Engineers Association (ICEA)
5. International Building Code (IBC)
6. National Fire Protection Association (NFPA) 70E – "Standards for safety in the workplace"
7. American National Standard Institute (ANSI)
8. Institute of Electrical and Electronic Engineers (IEEE)
9. International Energy Conservation Code (IECC)
10. Texas Center for Environmental Quality (TCEQ)

B. Where contract documents indicate requirements, which are in excess of minimum requirements stated in section 1.03 (A), the most stringent requirements shall be met. Should there be any conflicts between the contract documents and section 1.03 (A), submit RFI's prior to bid

C. Codes and ordinances having jurisdiction and specified codes shall serve as minimum requirements. Where the Contract Documents indicate requirements which are in excess of those minimum requirements then the requirements of the Contract Documents shall be followed. Should there be any conflicts between the Contract Documents and codes, or any ordinances, report these with bid

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination

1. Contractor is bound to coordinate all equipment and scope of work with engineers and sub-contractors under this contract. Coordination of various equipment installations and operations is required as not to delay scheduled installation and startup
2. Refer to contractor responsibilities section of this document for further coordination items

B. Preinstallation meetings

1. Should contractor require a pre-installation meeting for any equipment with engineer, contractor shall provide ample time to schedule all required parties

C. Scheduling

1. Provide schedule of construction to engineer for review on a monthly basis. Refer to submittal section for further requirements

D. Change orders

1. Change orders and RFI's shall be submitted with full technical explanation of request and shall contain statement confirming contractor has reviewed all construction documents
2. Confirm all work has been coordinated with all other trades prior to submitting change order

1.04 SUBMITTALS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

1.05 RECORD DRAWINGS

A. At the start and during the progress of the job, keep one separate set of blue-line prints for making construction notes and mark-ups

B. Show conduit routing and wiring runs as constructed and identify each

C. Record all deviations from the contract documents

D. Submit set of marked-up drawings for review

1.06 QUALITY ASSURANCE

A. All manufacturers named are a basis of design for standard and quality expected. Substitutions of any equal product will be considered for acceptance. The judgement of equality of product substitution shall be made by the engineer and owner

B. UL Compliance: Materials manufactured within scope of Underwriters Laboratories shall conform to UL standards and have an applied UL listed mark

C. Materials and equipment shall be new, free from defects. Any and all equipment deemed defective by engineer shall be replaced at no additional cost to owner

D. All materials and equipment, of the same class, shall be supplied by the same manufacturer unless specified otherwise in construction documents

E. Contractor shall consider all degrees of uncertainty for all existing, hidden or unknown conditions. Bid shall cover all reasonable unknown conditions not evident in pre-bid site visit for additions and modifications to existing facilities

F. Any change orders or additional work beyond the scope of this project as bid shall be approved by engineer. Any unapproved work performed is at contractors' risk

G. Installation shall conform to engineering drawings and described in specifications. Any variation shall be pre-approved in writing by engineer before work begins. Any unauthorized work may be requested for removal at contractors' expense with no delay to construction schedule and at no additional cost to owner

H. Prior to bidding and during construction, contractor shall coordinate with equipment vendors/suppliers and determine requirements for power, control, and interconnection wiring. Provide conduits and conductors accordingly for complete operating system

1.07 PROJECT SAFETY:

A. Electrical system for this project has lethal voltages present. Contractor shall have qualified personnel perform installations by, or under direct on-site supervision of, a licensed master electrician

B. Contractor shall not work on energized equipment except when necessary and with all appropriate protective clothing, tools, and qualified staff required to perform tasks

C. Submit “Job Safety Plan & Electrical Work Permit” per NFPA 70E to engineer

D. Do not install fuel tanks within 50-feet of habitable building where prohibited by local codes. Field verify site with construction documents and notify engineer of any conflicts. Failure to do so is at contractors

1.08 CONTRACTOR QUALIFICATIONS

A. All prequalification’s under this contract shall be submitted prior to bid date

B. All electrical work shall be performed by a Texas State Licensed Electrical Contractor

C. Contractor and their subcontractors shall be experienced with electrical systems covered under this contract

D. Contractor firm, project supervisors, and electrical labor workers without recent experience in similar projects shall not be utilized to perform work under this contract. Projects older than 5-years are not considered recent

E. Electrical contractors, electricians, inspectors, installers, and programmers assigned to this project shall be full-time qualified employees

F. Contract employees shall not be utilized unless approved by engineer

G. Contractor shall be required to furnish proof of experience and employment where requested by owner, engineer, or their representatives

H. Maintain safety training program throughout project timeline. Program may be requested for review by owner, engineer, or their representatives

I. Pre-qualified electrical contractors are shown below:

1. Alterman
2. Big State
3. CC Electric BCS
4. Clarion Electrical, LLC
5. McDonald Electric

6. Pfeiffer & Son, Ltd.
7. RESCO Electric
8. SECO
9. W.W. Payton
10. Or as pre-approved in writing via email, not less than seven (7) days before bid date

1.09 CONTRACTOR RESPONSIBILITIES

A. Contractor is bound to coordinate all equipment and scope of work with engineers and sub consultants under this contract. Coordination of various equipment installations and operations is required as not to delay scheduled installation and startup

B. Any and all delegation of construction of sub-contractors shall be coordinated prior submittal review and meetings with owner, owners' representatives, and engineering team

C. Scope of work in each specification and discipline drawings are ultimately the sole responsibility of the general contractor under this contract

D. Contractor shall verify all product materials and drawings prior to bidding

E. Plans and diagrams are illustrative and may not contain all devices, wiring point-to-point diagrams, and controls required to perform the intended function in construction documents. Not all required equipment quantities required for a fully functional system may be documented in drawings or specifications. Location and alignments for equipment shown on plans may require adjustment. Contractor is responsible for providing all appurtenances required for each stand-alone system and overall project system

F. Vendor furnished systems shall be coordinated prior to submittal to meet all required expectations in construction documents. All additional fees for testing, commissioning, and warranties shall be included in bid for all equipment/installation

G. Contractor to provide full contact list of all sub-contractors and vendors under this contract to engineer upon notice to proceed. Contact information shall include: Person's name, title, direct telephone number, address, and email information

H. All correspondence, RFI's, and submittals concerning electrical, controls, and related work shall be from general contractor. General contractor shall provide statement on all correspondence, RFI's, and submittals stating contractor has verified information and validity of the correspondence in reference to full construction documents from all disciplines. Any documents received not having this statement may be rejected without review

I. Contractor shall reach out to engineer for coordination of construction methods, plans, and specifications should they deem beneficial

J. Coordinate and pay all electrical power, natural gas, hardline telephone, cellular telephone, or special purpose utility installation. Contractor shall coordinate with owner for account setup or transfer ownership at substantial completion, method of choice is contractor's responsibility

K. Maintain documentation and notify owner of all utility coordination and requirements for new/modified services

1.10 COORDINATION

A. Coordinate installation of lightning protection with installation of other building systems and components including:

1. Electrical wiring
2. Supporting structures
3. Building materials
4. Metal bodies requiring bonding to lightning protection components
5. Building finishes

B. Coordinate installation of air terminals attached to single-membrane roof system with roofing manufacturer and installer

1.11 SPARE PARTS

A. Spare parts shall be hand delivered to operations team at 75% completion of project completion to operations team

B. Furnish, tag, and box all spare parts in an organized manner. Provide detailed bill of materials of all items included in box

C. Provide transmittal form documenting individuals delivering and receiving spare parts with date, signature, printed name, and title. Provide scanned copy to engineer for record keeping. Include documents in O&M manual

D. Provide the following spare parts:

1. Fuses (0 – 600V): Six of each type and each current rating installed as part of this project unless otherwise specified

1.12 EMERGENCY POWER

A. Where required by drawings, provide any and all provisions for continuous electrical service thru contractor furnished standby generator power. Contractor shall not utilize an existing standby generator on the facility unless given permission by owner and engineer. Include all provisions in bid

B. Where power outage is required, coordinate with owner and engineer. Outage length shall be coordinated and approved by owner and engineer. Where outage exceeds approved timeframe, contractor shall provide equipment as required to maintain electrical power

1.13 PROGRAMMING RELATED ITEMS

A. Contractor shall comply with programming allowances designated in bid sheet for this project to be paid to Heirholzer upon completion of shop test (50%) and substantial programming completion (100%)

B. Refer to all sections of this specification and specifications from all disciplines for additional requirements under this contract

C. General contractor and sub-contractors are not responsible for contents of program where Heirholzer perform the programming

D. Warranty for operation of program is solely the responsibility of the programming firm, Heirholzer

E. There are to be no contractual agreements between the contractor and/or his sub-contractors and the programming firm, Heirholzer

F. Contractor is required to provide all software required for development and operation of Programmable Logic Controller (PLC) automation logic, Human Machine Interface (HMI), communication system, Distributed Control Systems (DCS), Industrial Control System (ICS), Supervisory Control and Data Acquisition System (SCADA), network equipment, alarm system, and all other systems required for this project to programming firm, Heirholzer. Software shall remain unopened and include all relevant manuals

G. Where modifications are performed on existing facilities where a new SCADA system is installed, route all existing alarms to auto dialer, alarm panel, and PLC. Install all conduit and wiring as required regardless if shown on construction drawings

H. PLC program shall not be uploaded until an inspection by engineer has been performed. Any discrepancies to construction documents shall be corrected

PART 2. PRODUCTS

2.01 GENERAL

A. Products shown are not intended to discriminate against a product of similar quality and purpose by another manufacturer

B. Provide coordination with manufacturer’s representative for exact model, options, configurations, and services included in bid. Where construction documents do not match manufacturer’s representative equipment list, contact engineer prior to ordering and installing

C. Substitution items may be acceptable where deemed so by engineer and or owner’s representative

D. All equipment and materials shall be rated for harsh industrial environments.

E. Equipment ratings shown on construction documents are minimum requirements and contractor may be required to provider the next size greater

F. Door mounted rotating operating mechanisms for circuit breakers are not permitted

G. All equipment installed on this project shall incorporate the installation of all devices and features to protect their respective equipment from the influence of other equipment, voltage irregularities, phase irregularities, power surges, harmonics, and other disturbances that may prevent proper and safe operation

H. All equipment shall be NEMA rated, IEC components are prohibited

I. Where model numbers are shown on drawings or specifications, provide current most up to date available model

PART 3. EXECUTION

3.01 GENERAL

A. Where required by drawings, provide any and all provisions for continuous electrical service thru contractor furnished standby generator power. Contractor shall not utilize an existing standby generator on the facility unless given permission by owner and engineer. Include all provisions in bid

B. Where power outage is required, coordinate with owner and engineer. Outage length shall be coordinated and approved by owner and engineer. Where outage exceeds approved timeframe, contractor shall provide equipment as required to maintain electrical power

C. All construction and equipment fabrication shall be of highest quality and installed in a workmanlike manner

3.02 TESTING

A. All equipment shall put through a trial run-in test to ascertain the performance complies with the intent of the specifications. All-in tests shall be made in the presence of the Engineer and owner's representatives. Control system shall be setup, calibrated, and tested by manufacturer's technician.

B. Contractor shall startup entire system prior to engineer present inspections. All troubleshooting and issues shall be corrected prior to scheduling owner/engineer inspections

C. All special testing of materials and equipment shall be provided by the contractor

D. Contractor shall coordinate and schedule testing and startup work with the owner and engineer

E. Provide full documentation for factor test and field tests

F. Where facility is located more than 100 miles from the project site, supplier shall provide accommodations for overnight stay for engineering team

G. All cables shall have an insulation test performed using 1000-volt megger that has been calibrated within the last twelve months

H. Cables installed with an insulation reading less than 500 megohms shall be removed and new cable installed and retested at no additional cost to the owner.

I. Cables installed with an unacceptable insulation reading shall be removed and new cable installed and retested at no additional cost to the owner. Submit cable megger test report to owner's representative and engineer for review. Include test results in O&M's.

J. The grounding system shall be tested in the presence of the owner's representative using the fall of potential method and shall provide a grounding system resulting in an ohmic value of five (5) ohms or less at no additional cost to the owner. The contractor shall submit test report to owner's representative. Test equipment must be calibrated within the previous 12 months. Provide dated calibration results along with submittal.

K. All controls shall be fully tested prior to shipment and installation at project facility

L. Contractor shall fully inspect all controls, wiring devices, conduit, and other items before starting work, ordering materials, or submitting shop drawings for discrepancies to construction documents. Inform engineer of any discrepancies. Failure to do so may result in contractor's responsibility for any required changes at no additional cost to owner

3.03 TRAINING

A. Contractor shall provide two (2) 8-hour classes covering all equipment installed from a systematic level to general maintenance, operation, and troubleshooting. Provide all training manuals prior to start of class to operations, owner, and engineer for review

B. Engineer or owner may attend training where requested

C. Contractor shall provide adequate classroom environment or coordinate for on site facility to cover training

D. Training agenda and outline of training course shall be forwarded to engineer for review

E. Coordinate with any and all manufacturers required for adequate training

F. Document all attendees and acquire signatures upon completion of training program

G. Owner/Engineer shall sign a document provided by contractor indicating installation has formally been accepted

H. Inform engineer where training does not require two (2) full 8-hour classes

I. Schedule with owner minimum two (2) weeks in advance

3.04 INSTALLATION

A. All slabs around electrical equipment shall be constructed and sloped to avoid any standing water

B. Do not overfill raceways. Provide additional conduit where cables purchased exceed standard cable fill calculations

C. Provide minimum 48 inches of workspace in front of electrical equipment

D. Provide a minimum of 8 inches between wall or rack mounted enclosures/ equipment. Do not extend past building wall and maintain 6 inches from edge of wall

3.05 REPAIR/RESTORATION

A. Where any equipment performance does not conform to specifications or parameters are out of tolerance, per engineers or owner's opinion, contractor shall remove and replace equipment at no additional cost to owner

B. Where contractor damages existing facilities, damaged equipment shall be replaced with equal or better at no additional cost to owner. Contractor shall take photos of facility prior to starting work to dispute any discrepancies. Where photos are not taken, damaged equipment shall be replaced at owner's request

C. Any damage to underground utilities is the responsibility of the contractor for repair and restoration

D. Where equipment fails or gets damaged, contractor shall replace with new. Repair is not permitted unless specifically approved by owner, owner's representative, or engineer

3.06 SYSTEM STARTUP

A. Upon successful testing, contractor shall provide full system startup in presence of authority, owner's representative, and engineer presenting fully functional gate operating system with all respective capabilities.

B. Contractor is responsible for coordinating with all parties required for system startup including manufacturer's prior to system startup. Ample time is required for coordination.

C. System will be not be accepted by owner until all systems are started and presented to authority, owner's representative, and engineer without issues or pending punch list items.

3.07 ADJUSTEMENT/CALIBRATION

A. Should initial testing or system startup not present an acceptable functioning system, adjustment/calibration shall be performed as necessary at no additional cost to owner.

B. All equipment shall put through a trial run-in test to ascertain the performance complies with the intent of the specifications. All-in tests shall be made in the presence of the Engineer and owner's representative.

3.08 CLEANING

A. Remove all temporary labels, dirt, paint, grease and stains from all exposed equipment. Upon completion of work, clean equipment and entire installation site in a workmanlike manner. No loose parts or scraps or equipment shall be left on the premises. Site shall not be accepted by owner where site is not suitably cleaned to engineer or owner's representative preference.

B. Equipment paint scars shall be repaired with paint kits supplied by the equipment manufacturer, or with an approved paint.

C. Clean interiors of each item of electrical equipment. At completion of work all equipment interiors shall be free from dust, dirt, and debris.

D. Concrete spoils shall not be dumped on site without approval by engineer or owner

3.09 CLOSEOUT

A. System acceptance upon substantial completion shall occur only when the below items have been submitted, accepted, and approved.

1. Submittals
2. O&M Manuals
3. Contractor testing
4. Inspections
5. Operations team training
6. Warranty certificates
7. Shop testing
8. Record drawings
9. Spare parts

3.10 MAINTENANCE/WARRANTY

A. Provide extended warranty certificates with contact information to operations and include in Operations & Maintenance manual.

B. Contractor shall provide full system wide warranty on all equipment for 3-year. Warranty shall include all labor and materials required to repair or replace equipment defective or malfunctioning at no additional cost to owner

C. Provide any and all testing equipment required to verify equipment malfunction (i.e. power monitor, etc.)

D. Warranty shall include, but not limited to; equipment, devices, hardware, and software

E. Warranty begins at time of written acceptance of substantial completion

F. Provide warranty certificates for electrical installation and consolidate warranty certificates from sub consultants with contact information for repairs

G. General contractor is ultimately responsible for all warranty items and requests

H. All repairs shall be made within 24 hours of receipt of required parts from manufacturer with minimum priority shipping. Any repairs not completed within five (5) working days from date of notice are subject to owner hiring separate integrator to perform services. Services shall be invoiced to general contractor

END OF SECTION

Section 16051

Basic Electrical Submittal and O&M Requirements

PART 1. GENERAL

1.01 SUMMARY

A. This specification is confidentially issued for this specific project only

B. Requirements described in this specification are in addition to any submittal requirements of other specifications

1.02 SUBMITTALS

A. Submit all submittals within sixty (60) days of notice to proceed.

B. Review of submittals shall not remove sole responsibility of contractor for furnishing materials or equipment of proper dimension, quantity, quality, or rating; nor will such review remove the responsibility for errors in the submittals.

C. Each submittal shall be submitted as a single pdf per specification with all related equipment.

D. Include catalog cuts, general descriptive information, catalog numbers, and manufactures name

E. Shop drawings shall include detailed drawings with dimensions, schedules, weights, capacities, installation details, and all pertinent information for a complete and fully functional equipment installation.

F. Failure to process submittals on any item(s) specified shall be at risk of contractor to replace any and all unreviewed items as directed by engineer, authority, or owner.

G. Contractor shall assume all costs and liabilities which may result ordering and installing any equipment/material prior to review of the submittals. No work shall be done prior to review of all submittals. In case of corrections required, rejection and resubmit required; resubmit submittals until owner's representative and or engineer review updated submittals. This process shall not label as cause of any delays in construction.

H. Contractor shall have two (2) submittal reviews after which contract may be charged by owner and or engineer at firm hourly rates to review additional submittals. After final reviews, provide final copies in printed/PDF O&M Manuals.

I. Submittals shall be compiled from the manufacturer's latest product data. Provide most update product where product specified has been replaced, recalled, discontinued, or newer product exists. Provide description on submittal stating reason for not providing product specified in construction documents.

J. Contractor shall clearly indicate on submittal which items and options are proposed. Submittal may be marked rejected-resubmit where if specific items and

options proposed are not clearly marked. Submittal may be rejected where transmittal cover page and required information in this section is not provided.

K. Where requested, furnish samples of materials for acceptance review. If a sample has been reviewed and accepted, equipment installed shall maintain equal quality to sample provided. Should engineer deem installed equipment does not match quality of sample provided, item shall be replaced at engineer's discretion at no additional cost to owner

L. Submittals shall be provided one section at a time. All related submittals are to be provided at one time

M. Hard copies are not required for submittal review. Where required by owner, or general conditions, hard copies of any and all documentation shall be under the contractor's responsibilities

N. Provide a schedule describing estimated start dates, completion dates, shop test dates, and field test dates. Contractor shall provide updated schedules to our office in a regular schedule upon any changes

O. Contractor shall provide submittal log showing status of submittal approved, rejected, and pending with each submittal

P. Contractor shall review all voltages, horsepower, current, phase, and starter size requirements for all equipment prior to providing submittals to engineer for review. Shop drawing review by engineer does not remove this responsibility. Incorrect submittal information shall be at risk of contractor and at no additional cost to owner

Q. Data sheets shall have model numbers that correctly identify equipment and accessories as described in construction documents highlighted or boxed

R. Submittals shall require a minimum of two (2) weeks for review from time of receipt by engineer. Contractor shall provide submittals with sufficient time for review as to no impede construction schedule. Lack of required coordination shall not be acceptable for construction schedule extension

S. All submittals for control panels, control sections of MCC, controllers, and vendor furnished panels shall contain statement of U.L. certification and identifying name and number of U.L. certification for fabrication shop. All submittals without this information shall be marked rejected. Any panels installed without U.L. listing, and where not acceptable by engineer or owner, shall be replaced at no additional cost to owner

T. Any and all equipment installed without approval not matching construction documents shall be replaced at no additional cost to owner

U. General contractor shall route all vendor submittals with electrical requirements to electrical contractor who shall review and coordinate all power and control items. Any variation to construction documents shall be noted accordingly on submittal

V. All resubmittals shall indicate modifications due to original submittal comments from engineer

W. Include all relevant technical specifications with each submittal. Mark each section as “comply”, “non-compliant”, and “substitution”

X. Provide transmittal cover page on all submittals with the following information:

1. General contractor company name
2. General contractor project manager name and contact information
3. Sub-contractor company name
4. Sub-contractor project manager name and contact information

1.03 ACCEPTANCE AND SUBSTITUTIONS

A. All manufacturers named are a basis as a standard of quality and substitutions of any equal product will be considered for acceptance. The judgment of equality of product substitution shall be made by the Engineer and owner’s representative

B. Substitutions for equipment specified or shown on plans as “Or pre-approved equal” shall be submitted for approval prior to bid. Failure to submit RFI for pre-approval may lead to rejection of substitution for higher cost equipment originally specified in construction documents.

C. Substitutions after award of contract shall be made only within sixty (60) days after notice to proceed. Furnish all required supporting data. The submittal of substitutions for review shall not be cause for time delay of construction.

D. Where substitutions are offered, the substituted product shall meet the product performance as set forth in the specified manufacturer’s current catalog literature, as well as meeting the details of the construction documents.

E. The details on the drawings and the requirements of the specifications are based on the first listed item of material or equipment; if any other than the first listed materials or equipment is furnished, then assume responsibility for the correct function, operation, and accommodation of the substituted item. In the event of misfits or changes in work required, either in this Section or other Sections of the Contract, or in both; bear all costs in connection with all changes arising out of the use of other than the first listed item specified

1.04 REQUIRED SUBMITTALS FOR REVIEW:

1. Power quality monitors
2. Wiring devices
3. Wire
4. Conduit and fittings
5. Automatic transfer switch
6. SCADA system
7. Main service disconnect/circuit breaker
8. Enclosed circuit breakers

9. Mini-power zones
10. Surge protection devices
11. Wet well j-box
12. All relays & terminals
13. Grounding
14. Junction boxes and pull boxes
15. Terminal junction boxes
16. Panelboards and circuit breaker data
17. Fuses
18. Contactors
19. Transformers
20. Lighting fixtures and poles
21. Control cabinet enclosures
22. Control cabinet wiring and terminal blocks
23. Control cabinet devices and nameplates
24. Control panels
25. Vendor furnished equipment
26. Project schedule on a monthly basis
27. Warranty certificates
28. Testing reports

1.05 OPERATIONS & MAINTENANCE MANUALS

A. Hardcopies provided to owner, once approved, are to be professionally assembled with tabs and coversheets

1. Wiring diagrams shall be on same size pages (8.5 x 11 or 11 x 17 pullout sheets) as used in O&M's and shall be placed in a separate section of the manuals identified "Wiring Diagrams"

a. Each O&M manual hard copy shall include USB jump drive containing complete and organized in PDF format inserted in pocket of binder

b. All O&M manuals shall be written in a professional manner and bound in high quality latching vinyl binder. Loose page three ring binders shall not be used for hard copy O&M manual

B. Provide diagrams of all control panels in clear plastic laminated pages. One (1) hard copy and one (1) copy in pocket affixed to inside of cabinet door

C. Six (6) weeks prior to the completion of the project, compile an operations and maintenance manual for each item of equipment. These manuals shall include

detailed instructions and maintenance, warranty certificates, vendor contact information, and spare parts lists

D. O&M manuals shall be reviewed by engineer and owner's representative prior to printing and delivering hard copy to operations

E. In addition to record drawings, submittals, manufacturer's operational instructions, and maintenance instructions, O&M's shall include sufficient literature to detail operation, removal, installation, configuration, adjustment, calibration, and testing of equipment by operations

F. All related submittals are to be provided at one time as follows:

1. Contact information for all contractors and vendors
2. System hardware/installation
3. System software (where applicable)
4. Operation of equipment
5. Electrical and Control wiring diagrams
6. Maintenance and Troubleshooting
7. Warranty Certificates
8. Point-To-Point wiring diagrams for each circuit installed

G. O&M manuals should be complete and approved prior to any scheduled training

1.06 RECORD DRAWINGS

A. At the start and during the progress of the job, keep one separate set of blue line prints for making construction notes and mark-ups

B. Show conduit routing and wiring runs as constructed and identify each. Record all deviations from the Contract Documents

C. Submit set of marked up drawings for review

D. The Contractor is always required to keep up to date blue lines and may be reviewed during construction at any time by the Engineer. Record Drawings that are found to be inaccurate are the responsibility of the Contractor

E. Provide Record Drawing that clearly show any work that varies from the Contract Drawings. Remove any lines or text from drawings that no longer apply as a result of as installed variations. "Record Drawing" Drawings shall be on backgrounds that are furnished by the Engineer. Submit Record Drawing Drawings electronically for review

F. Show accurate dimensioned layout of conduits under or encased in building slabs

G. Show accurate dimensioned location of all conduits and ductbanks on site and on structures that are installed or modified under this contract. Identify conduits by tag number

H. Record Drawing construction drawings shall be provided on full size plan sheets for Owner and furnished electronically in AutoCAD format for Owner and

Electrical Engineers files. Provide hard copy quantities specified in this specification or in General Conditions Specifications, whichever is more stringent

END OF SECTION

Section 16052

Electrical Identification

PART 1. GENERAL

1.01 SUMMARY

A. This specification is confidentially issued for this specific project only

B. Contractor shall be responsible for reading all specifications from all disciplines prior to bid

C. Identification of electrical materials, equipment, and installations

D. Nameplate identification on MCC's and control panels

E. Arc Flash Warning Signs

F. Equipment and High Voltage Warning Signs

G. Identification of conduit and conductors

1.02 REFERENCES

A. National Electrical Code: Components and installation shall comply with NFPA 70

B. Comply with ANSI C2

1.03 SUBMITTALS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

1.04 RECORD DRAWINGS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

1.05 OPERATIONS & MAINTENANCE MANUALS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

PART 2. PRODUCTS

2.01 RACEWAY AND CABLE LABELS

A. Label wiring with yellow heat shrink type markers with black machine printing. Labels shall be Raychem or Panduit

B. Buried conduit marking tape for marking path of buried conduits shall be a six (6") inch and red color nominal width strip of polyethylene with highly visible and foil backed, repetitive marking "BURIED CONDUIT", or similar language, along its length

C. Nameplates shall be micarta lamicoid material, 1/8" thick, black background with white 3/8 IN. block lettering engraving. Attachment means shall be made with a minimum of two aluminum rivets. All instruments shall have round shaped black phenolic tags with white 1/4 IN. block lettering, attach with 316 SS cable

D. Manufacturer's Standard Products: Where more than one type is listed for specified application, selection is Installer's option, but provide single type for each application category. Use colors prescribed by ANSI A13.1, NFPA 70, or as specified elsewhere

E. Conform to ANSI A13.1, Table 3, for minimum size of letters for legend and minimum length of color field for each raceway or cable size

1. Color: Black legend on orange field
2. Legend: Indicates voltage

F. Pre-tensioned, Wraparound Plastic Sleeves: Flexible, preprinted, color coded, acrylic bands sized to suit diameter of line it identifies and arranged to stay in place by pre-tensioned gripping action when placed in position

1. Provide identification wire marker for all power and control conductors.

G. Colored Adhesive Tape: Self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 in. wide for phase and ground conductor identification

H. Underground Line Warning Tape: Permanent, bright colored, continuous printed, vinyl tape with following features:

1. Size: Not less than 6 in. wide by 4 mils thick.
2. Compounded for permanent direct burial service.
3. Embedded continuous metallic strip or core.
4. Printed Legend: Indicates type of underground line.

I. Tape Markers: Vinyl or vinyl cloth, self-adhesive, wraparound type with preprinted numbers and letters. Limited use for indoor control cabinets

J. Aluminum, Wraparound Marker Bands: Bands cut from 0.014 in. (0.4 mm) thick aluminum sheet, with stamped or embossed legend, and fitted with slots or ears for permanently securing around wire or cable jacket or around groups of conductors

K. Plasticized Card Stock Tags: Vinyl cloth with preprinted and field printed legends. Orange background, except as otherwise indicated, with eyelet for fastener

L. Aluminum Faced Card Stock Tags: Wear resistant, 18-point minimum card stock faced on both sides with embossable aluminum sheet, 0.002 in. (0.05 mm) thick, laminated with moisture resistant acrylic adhesive, and punched for fastener. Preprinted legends suit each application

M. Brass or Aluminum Tags: Metal tags with stamped legend, punched for fastener. Dimensions: 2 by 2 in. by 0.05 in. for conduit and power conductor identification. Attached with stainless steel bands

2.02 ENGRAVED NAMEPLATES AND SIGNS

A. Manufacturer's Standard Products: Where more than one type is listed for specified application, selection is Installer's option, but provide single type for each application category. Use colors prescribed by ANSI A13.1, NFPA 70, or as specified elsewhere

B. Engraving stock, melamine plastic laminate, 1/16 in. (1.6 mm) minimum thick for signs up to 20 sq. in. (129 sq. cm), 1/8 in. (3.2 mm) thick for larger sizes.

1. Engraved Legend: Black letters on white face.
2. Punched for mechanical fasteners or stainless-steel screws.
3. Use in control panels, MCC's, device housings, boxes, and similar locations.

C. Baked Enamel Signs for Interior Use: Preprinted aluminum signs, punched for fasteners, with colors, legend, and size as indicated or as otherwise required for application. 1/4 in. (6.4 mm) grommets in corners for mounting

D. Exterior, Metal Backed, Butyrate Signs: Wear resistant, non-fading, preprinted, cellulose acetate butyrate signs with 0.0396 in. (1 mm), galvanized steel backing, with colors, legend, and size appropriate to application. 1/4 in. (6.4 mm) grommets in corners for mounting

E. Fasteners for Plastic Laminated and Metal Signs: Self-tapping stainless-steel screws or No. 10/32 stainless steel machine screws with nuts, flat washers and lock washers

F. Exterior, Painted Aluminum, Warning Signs: Wear resistant, non-fading, pre-printed aluminum with glossy finish with colors, and size appropriate to applications, ¼ inch grommets in corners for mounting. Provide per standards ANSI 2535 and OSHA 1910.145

2.03 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungusinert, self-extinguishing, 1 piece, self-locking, Type 6/6 nylon cable ties with following features:

1. Minimum Width: 3/16 inch
2. Tensile Strength: 50-pound minimum.
3. Temperature Range: -40°F to 185°F
4. Color: As indicated where used for color coding

B. Paint: Alkyd-urethane enamel. Primer as recommended by enamel manufacturer

2.04 MCC AND CONTROL PANELS

A. Wire Markers: Provide wire markers on all power and wiring in MCC's and panels of all types. Identify wire at points of termination at devices and at terminal strips

B. Provide nameplates on body or housing of all pressure switches, transmitters, and other devices

C. Provide engraved nameplates near base of all relays and similar devices. Adhesive materials not allowed

PART 3. EXECUTION

3.01 INSTALLATION

A. Disconnecting Means/Circuit Breakers

1. All disconnecting means shall include the identification of the circuit source that supplies the disconnecting means and be legibly marked, with durable label, to indicate its purpose.

B. Install identification devices according to manufacturer's written instructions.

C. Install labels where indicated and at locations for best convenience of viewing without interference with operation and maintenance of equipment

D. Lettering, Colors, and Graphics: Coordinate names, abbreviations, colors, and or designations used for electrical identification with corresponding designations used in Contract Documents or required by codes and standards. Use consistent designations throughout Project

E. Sequence of Work: Where identification is to be applied to surfaces that require finish, install identification after completion of finish work

F. Self-Adhesive Identification Products: Not allowed. Use stainless steel screws.

G. Identify feeders over 600 V with "DANGER HIGH VOLTAGE"; in black letters 2 in. (51 mm) high, stenciled with paint at 10 ft (3 m) intervals over continuous, painted orange background. Identify following:

1. Entire floor area directly above conduits running beneath and within 12 in. (305 mm) of basement or ground floor that is in contact with earth or is framed above un-excavated space
2. Wall surfaces directly external to conduits concealed within wall
3. All accessible surfaces of concrete envelope around conduits in vertical shafts, exposed in building, or concealed above suspended ceilings
4. Entire surface of exposed conduits

H. Install painted identification as follows:

1. Clean surfaces of dust, loose material, and oily films before painting
2. Prime Surfaces: For galvanized metal, use single component, acrylic vehicle coating formulated for galvanized surfaces. For concrete masonry units, use heavy duty, acrylic resin block filler. For concrete surfaces, use clear, alkali resistant, alkyd binder type sealer
3. Apply one intermediate and one finish coat of silicone alkyd enamel
4. Apply primer and finish materials according to manufacturer's instructions

I. Identify Raceways and Exposed Cables of Certain Systems with Color Banding: Band exposed and accessible raceways of systems listed below for identification

1. Bands: Pre-tensioned, snap around, colored plastic sleeves; colored adhesive tape; or combination of both. Make each color band 2 in. (51 mm) wide, completely encircling conduit, and place adjacent bands of 2 color markings in contact, side by side
2. Locate bands at changes in direction, at penetrations of walls and floors, at 50 ft maximum intervals in straight runs, and at 25 ft (7.6 m) in congested areas
3. Colors: As follows:
    a. Fire Alarm System: Red
    b. Fire Suppression Supervisory and Control System: Red and yellow
    c. Combined Fire Alarm and Security System: Red and blue
    d. Security System: Blue and yellow
    e. Mechanical and Electrical Supervisory System: Green and blue
    f. Telecommunications System: Green and yellow

J. Install Caution Signs for Enclosures: Use label indicating system voltage in black, preprinted on orange field. Install on exterior of door or cover with stainless screws

K. Install Circuit Identification Labels on Boxes: Label externally as follows:

1. Exposed Boxes: Plastic label on cover
2. Concealed Boxes: Plasticized card stock tags
3. Labeling Legend: Permanent, waterproof listing of panel and circuit number or equivalent

L. Identify Paths of Underground Electrical Lines: During trench backfilling, for exterior underground power, control, signal, and communications lines, install continuous underground plastic line marker located directly above line at 6 to 8 in. (150 to 200 mm) below finished grade. Where multiple lines installed in common trench or concrete envelope do not exceed an overall width of 16 in. (400 mm), use single line marker

1. Install line marker for underground wiring, both direct buried and in raceway

M. Color Code Conductors: Secondary service, feeder, and branch circuit conductors throughout secondary electrical system

1. Field applied; color coding methods may be used in lieu of factory coded wire for sizes larger than No. 10 AWG
    a. Colored, pressure sensitive plastic tape in half lapped turns for distance of 6 in. (150 mm) from terminal points and in boxes where splices or taps are made. Apply last 2 turns of tape with no tension to prevent possible unwinding. Use 1 in. (25 mm) wide tape in colors as specified. Adjust tape bands to avoid obscuring cable identification markings

b. Colored cable ties applied in groups of three (3) ties of specified color to each wire at each terminal or splice point starting 3 in. (76 mm) from terminal and spaced 3 in. (76 mm) apart. Apply with special tool or pliers, tighten to snug fit, and cut off excess length

System Voltage	A	B	C	Neutral
120/240 Volt 1Ph/3w	Black	Red		White
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		

N. Power Circuit Identification: Use metal tags or aluminum wraparound marker bands for cables, feeders, and power circuits in vaults, pull boxes, junction boxes, manholes, and switchboard rooms

1. Legend: 1/4 in. (6.4 mm) steel letter and number stamping or embossing with legend corresponding to indicated circuit designations
2. Fasten tags with nylon cable ties; fasten bands using integral ears

O. Conduit Identification: Use aluminum tags with SS bands at termination points such as MCC, light fixtures, control panels, receptacles and junction boxes. Tag is to include conduit tag and panel circuit number (where applicable.)

P. Apply identification to conductors as follows:

1. Conductors to Be Extended in Future: Indicate source and circuit numbers.
2. Multiple Power or Lighting Circuits in Same Enclosure: Identify each conductor with source, voltage, circuit number, and phase. Use color coding for voltage and phase indication of secondary circuit
3. Multiple Control and Communications Circuits in Same Enclosure: Identify each conductor by its system and circuit designation. Use consistent system of tags, color coding, or cable marking tape

Q. Apply warning, caution, and instruction signs and stencils as follows:

1. Install warning, caution, and instruction signs where indicated or required to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved, plastic laminated instruction signs with approved legend where instructions or explanations are needed for system or equipment operation. Install butyrate signs with metal backing for outdoor items
2. Install warning signs on the following equipment as a minimum requirement

a. MCC Main Breaker
b. Main Service Breaker
c. Transfer Switch
d. Where exposed bus bars inside.
e. Automatic Power Factor Correction Units
f. VFD's and Solid-state Starters
g. Other locations described in No. 1 above.

3. Emergency Operating Signs: Install engraved laminate signs with white legend on red background with minimum 3/8-inch-high lettering for emergency instructions on power transfer, load shedding, and/or emergency operations

R. Install identification as follows:

1. Apply equipment identification labels of engraved plastic laminate on each major unit of equipment, including central or master unit of each system. This includes communication, signal control, and alarm systems, unless units are specified with their own self-explanatory identification

2. Except as otherwise indicated, provide single line of text with ½ inch high lettering on 1 ½ inch high label; where two (2) lines of text are required, use ½ inch lettering on 2-inch-high label. For small control panels a smaller text may be used but shall be clearly readable. Use black lettering on white field. Use red lettering on white field where shown on plans or as requested by Engineer or Owner. Apply labels with stainless screws for each unit of following categories of equipment.

a. Panelboards, electrical cabinets, and enclosures.
b. Access doors and panels for concealed electrical items
c. Electrical switchgear and switchboards
d. Electrical substations
e. Motor control centers and control panels
f. Motor starters
g. Push button stations
h. Power transfer equipment
i. Contactors
j. Remote controlled switches
k. Dimmers
l. Control devices
m. Transformers
n. Inverters
o. Rectifiers
p. Frequency converters
q. Battery racks
r. Power generating units

s. Telephone equipment
t. Conduits at manholes, at junction boxes, and pull boxes

3. Apply designation labels of engraved plastic laminate for disconnect switches, breakers, push buttons, pilot lights, motor control centers, and similar items for power distribution and control components above, except panelboards and alarm/signal components where labeling is specified elsewhere. For panelboards, provide framed, typed circuit schedules with explicit description and identification of items controlled by each individual breaker
4. For control panels the nameplate designation shall be according to the control, alarm or status function indicated on the control diagrams, one-line diagrams, details as required in other applicable specifications for this project
5. Provide nameplate designations list and nameplate and text size for Engineer and/or Owner's approval as required by 1.02 of this specification

S. Labeling

1. In addition to requirements for labeling as specified throughout this section, install as follows:
   a. Phase color insulation is required for all conductors, no exceptions
   b. Apply numbered wire marking labels to control wires; power wiring in panelboards, pull and junction boxes, and at outlets to identify circuit numbers. Each control wire shall be labeled at each connection. Labels shall heat shrink type
   c. Apply Phenolic labels with engraved identification to wiring sets in each hand-hole to identify function. Use waterproof labels
   d. Apply write-on identification labels to empty conduits to identify each with information as to terminus of other end and also trade size of conduit.
   e. Install micarta nameplates with engraving to identify function and/or load served for the following:
      i. Panelboards
      ii. Overcurrent Devices
      iii. Power Quality Monitor
      iv. Control Panels
      v. Automatic Transfer Switch
      vi. Wet Well Junction Box
      vii. All components in control panel and SCADA panel
   f. Micarta nameplates shall be attached with aluminum rivets, use two (2) per each nameplate
   g. Submit for review a schedule for engraving along with size for each proposed micarta nameplate. Do not fabricate nameplate until review has been completed

h. Type circuit directory information on circuit directory cards on all panelboards and laminate

T. Wiring

1. Heat shrink type labels shall be installed to identify circuit numbers from panel boards. Install labels on each wire in each panelboard, junction, and pullbox, and device connection
2. Label each wiring run with heat shrink type labels inside each motor control center and in-service switchboard. Install write-on label ties around wire group at conduit entrance and write-on label the wire size, and service
3. Install numbered marking on each control wiring termination at each terminal strip and at each device. Do this in motor control center, terminal cabinets, safety switches, remote controllers, pilot operators, and instrumentation equipment. Number selected shall correspond to number on terminal strip

END OF SECTION

Section 16060

Grounding and Bonding

PART 1. GENERAL

1.01 SUMMARY

A. This specification is confidentially issued for this specific project only.

B. Contractor shall be responsible for reading all specifications from all disciplines prior to bid.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. B3 - Standard Specification for Soft or Annealed Copper Wire
2. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
3. B33 - Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes
4. E699 - Standard Criteria for Evaluation of Agencies Involved in Testing, Quality Assurance, and Evaluating Building Components

B. National Fire Protection Association (NFPA): NFPA 780 – Standard for the Installation of Lightning Protection Systems

C. Underwriter’s Laboratories (UL): 467 UL Standard for Safety Grounding and Bonding Equipment

1.03 SUBMITTALS, RECORD DRAWINGS, AND O&M MANUALS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

B. Test Results: Report of field tests and observations certified by contractor

PART 2. PRODUCTS

2.01 GROUDNING DEVICES

A. Exothermally welded joints shall be made with Enrico "cadweld"

B. Ground bus connectors shall be Square D type "LU", OZ Type "XLH", or equal

C. Products: Of types indicated and of sizes and ratings to comply with current NEC. Where types, sizes, ratings, and quantities indicated are in excess of current NEC requirements, more stringent requirements and greater size, rating, and quantity indications govern

D. Conductor Materials: Copper

2.02 WIRE AND CABLE CONDUCTORS

A. Conform to NEC Table 8, except as otherwise indicated, for conductor properties, including stranding

B. Equipment Grounding Conductor: Green insulated

C. Grounding Electrode Conductor: Stranded cable

D. Bare Copper Conductors:

1. Solid Conductors: ASTM B3

2. Assembly of Stranded Conductors: ASTM B8

3. Tinned Conductors: ASTM B33

2.03 MISCELLANEOUS CONDUCTORS

A. Ground Bus: Bare annealed copper bars of rectangular cross section

B. Braided Bonding Jumpers: Copper tape, braided No. 30 gage bare copper wire, terminated with copper ferrules

C. Bonding Strap Conductor/Connectors: Soft copper, 0.05-inch-thick and 2 inch wide, except as indicated

2.04 CONNECTOR PRODUCTS

A. General: Listed and labeled as grounding connectors for materials used.

B. Pressure Connectors: High conductivity plated units

C. Bolted Clamps: Heavy duty units listed for application

D. Exothermic Welded Connections: Provide in kit form and select for specific types, sizes, and combinations of conductors and other items to be connected

2.05 GROUNDING ELECTRODES

A. Ground Rods: Copper clad steel with high strength steel core and electrolytic grade copper outer sheath, molten welded to core

1. Size: 3/4 inch by 10 feet unless otherwise indicated.

B. Plate Electrodes: Copper plates, minimum 0.10 in. thick, size as indicated.

PART 3. EXECUTION

3.01 PREPERATION

A. Equipment Grounding Conductor Application: Comply with NEC Article 250 for sizes and quantities of equipment grounding conductors, except where larger sizes or more conductors are indicated

1. Install separate insulated equipment grounding conductors with circuit conductors
    a. Raceway may be used as equipment ground conductor where feasible in non-hazardous areas and permitted by current NEC for lighting circuits and receptacle circuits
    b. Install insulated equipment ground conductor in nonmetallic raceways unless designated for telephone or data cables

B. Underground Conductors: Bare, tinned, stranded copper except as otherwise indicted

C. Signal and Communications: For telephone, alarm, instrumentation and communication systems, provide #4 AWG minimum green insulated copper conductor in raceway from grounding electrode system to each terminal cabinet or central equipment location

D. Ground separately derived systems required by NEC to be grounded in accordance with NEC Paragraph 25030.

E. Metal Poles Supporting Outdoor Lighting Fixtures: Ground pole to grounding electrode as indicated in addition to separate equipment grounding conductor run with supply branch circuit

F. Connections to Lightning Protection System: Bond grounding conductors or grounding conductor conduits to lightning protection down conductors or grounding conductors in compliance with NFPA 780

G. Common Ground Bonding with Lightning Protection System:

1. Bond electric power system ground directly to lightning protection system grounding conductor at closest point to electric service grounding electrode, using exothermic welded connection

2. Use bonding conductor sized same as system ground conductor and installed in conduit

H. At all water, wastewater and industrial facilities, install UFER grounding per Item 3.02 – “Installation” at all equipment structures and buildings unless specifically deleted

I. Bond all metallic fences, gates, posts, steel structural columns, and other exposed steel structures

J. Install ground rod at all outdoor control panel, service rack, equipment racks, radio tower, steel canopy structures, and other steel structures where electrical equipment is installed

3.02 INSTALLATION

A. Each item of equipment shall be adequately and thoroughly grounded. Comply with Article 250 of N.E.C., except where higher standards of grounding have been specified

B. Equipment grounding conductors (EGC) shall be installed where indicated. These wires shall be green colored for all sizes

C. EGC runs into equipment and shall be grounded to equipment bus where available, or to equipment ground lugs

D. Where grounding type myers hub are installed, bond EGC thereto and furthermore ground each myers hub lug to equipment ground bus or ground lug, or ground rod

E. In each motor terminal box, install equipment ground lug and connect EGC thereto

F. In each floodlight pole, install ground connector to pole and bond to conduit bushing and to EGC in branch circuit

G. Install grounding conductor in all raceways and ground at both ends

H. General: Ground electrical systems and equipment in accordance with current NEC requirements except where Drawings or Specifications exceed NEC requirements

I. Ground Rods:

1. Locate minimum of one rod length from each other and at least same distance from any other grounding electrode
2. Interconnect ground rods with bare conductors buried at least 24 in. below grade
3. Connect barecable ground conductors to ground rods by means of exothermic welds
4. Make connections without damaging copper coating or exposing steel
5. Use 3/4inch by 10ft. ground rods except as otherwise indicated.
6. Drive rods until tops are 6 inches below finished floor or final grade except as otherwise indicated

J. Metallic Water Service Pipe:

1. Provide insulated copper ground conductors, sized as indicated, in conduit from building main service equipment, or ground bus, to main metallic water service entrances to building
2. Connect ground conductors to street side of main metallic water service pipes by means of ground clamps
3. Bond ground conductor conduit to conductor at each end

K. Braided Type Bonding Jumpers: Use elsewhere for flexible bonding and grounding connections

L. Route grounding conductors along shortest and straightest paths possible without obstructing access or placing conductors where they may be subjected to strain, impact, or damage, except as indicated

M. Test Wells: Locate as indicated, and fabricate in accordance with details indicated

N. UFER Ground:

1. Fabricate with 20 feet of bare 2/0 (minimum) copper conductor laid lengthwise in excavation for foundation or footings
2. Install so conductor is within 2 in. of bottom of concrete
3. Where base of foundation is less than 20 feet in length, coil excess conductor at base of foundation
4. Bond conductor to reinforcing steel at four locations, minimum. Bond to all electrical equipment
5. Extend conductor below grade and connect to building grounding grid or grounding electrode
6. Extend to all steel support columns for buildings, equipment structures or roof columns
7. Alternate UFER Grounding: Install 2/0 (minimum) bare copper conductor in 24” deep trench around perimeter of structures, buildings, slabs, and foundations where electrical or mechanical equipment is located. Install 4 ft. from edge of structure. Bond to all steel structure and equipment and to grounding system, using exothermic welded connections
8. Do not install ground grid conductors in or under existing concrete adjacent to generators electrical equipment without written approval from Engineer

3.03 CONNECTIONS

A. General: Make connections to minimize possibility of galvanic action or electrolysis. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible

1. Use electroplated or hot tin coated materials to assure high conductivity and make contact points closer in order of galvanic series
2. Make connections with clean bare metal at points of contact
3. Aluminum to steel connections: stainless steel separators and mechanical clamps
4. Aluminum to galvanized steel connections: tinplated copper jumpers and mechanical clamps
5. Coat and seal connections involving dissimilar metals with inert material such as red paint to prevent future penetration of moisture to contact surfaces

B. Exothermic Welded Connections:

1. Use for connections to structural steel, water tanks, equipment, generators and enclosures, and for underground connections
2. Install at connections to ground rods and plate electrodes.
3. Comply with manufacturer’s written recommendations. Use CAD-Weld or approved equal

4. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable

C. Terminations:

1. Terminate insulated equipment grounding conductors for feeders and branch circuits with pressure type grounding lugs
2. Where metallic raceways terminate at metallic housings without mechanical and electrical connection to housing, terminate each conduit with grounding bushing
3. Connect grounding bushings with bare grounding conductor to ground bus in housing
4. Bond electrically non-continuous conduits at both entrances and exits with grounding bushings and bare grounding conductors

D. Tighten grounding and bonding connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values for connectors and bolts. Where manufacturer's torqueing requirements are not indicated, tighten connections to comply with torque tightening values specified in UL 486A-486B

E. Connections at Test Wells: Refer to details for connections between conductors and ground rods

F. Compression Type Connections: Where compression type connections are specifically called for on plans, use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by manufacturer of connectors. Provide embossing die code or other standard method to make visible indication that connector has been adequately compressed on ground conductor

G. Moisture Protection: Where insulated ground conductors are connected to ground rods or ground buses, insulate entire area of connection and seal against moisture penetration of insulation and cable

3.04 OVERHEAD LINE GROUNDING

A. General: Comply with ANSI C2, "National Electrical Safety Code"; for "Single Grounded Systems"; using two electrodes in parallel if single electrode resistance to ground exceeds 25 ohms

B. Ground Rod Connections: Use exothermic welds for underground connections and connections to rods.

C. Lightning Arresters: Separate arrester grounds from other ground conductors.

D. Secondary Neutral and Tank of Transformer: Interconnect and connect to ground.

E. Grounding Conductor Protection: Protect grounding conductors running on surface of wood poles with molding of a type manufactured for this purpose. Extend from grade level up to and through communications and transformer spaces

3.05 UNDERGROUND DISTRIBUTION SYSTEM GROUNDING

A. Manholes and Handholes:

1. Install 3/4inch by 10ft. driven ground rod in corner close to wall and set rod depth such that 4 inches will extend above finished floor
2. Where necessary, install ground rod before manhole is placed and provide No. 1/0 bare tinned copper conductor from ground rod into manhole through waterproof sleeve in manhole wall
3. Protect ground rods passing through concrete floor with double wrapping of pressure sensitive tape or heat shrunk insulating sleeve from 2 in. above to 6 in. below concrete
4. Seal floor opening with waterproof non-shrink grout.

B. Connections at Manholes:

1. Connect exposed metal parts, such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole to ground rod or ground conductor
2. Make connections with minimum No. 4 AWG stranded hard drawn copper wire
3. Train conductors' plumb or level around corners and fasten to manhole walls.
4. Connect to cable armor and cable shields by means of tinned terminals soldered to armor or shield, or as recommended by manufacturer of splicing and termination kits

C. Grounding System: Ground noncurrent carrying metallic items associated with manholes, substations, and pad mounted equipment by connecting them to bare underground cable and grounding electrodes arranged as indicated.

3.06 SITE QUALITY CONTROL

A. Test:

1. Subject completed grounding system to megger test at each location where maximum ground resistance level is specified, at service disconnect enclosure ground terminal, and at ground test wells
2. Measure ground resistance without soil being moistened by any means other than natural precipitation or natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance
3. Perform tests by 2point method in accordance with Section 9.03 of IEEE 81, "Guide for Measuring Earth Resistivity, Ground Impedance and Earth Surface Potentials of a Grounding System"

B. Ground/resistance maximum values shall be as follows:

1. Equipment rated 500 kVA and less: 10 Ohms.
2. Equipment rated 500 kVA to 1000 kVA: 5 Ohms.

3. Equipment rated over 1000 kVA: 3 Ohms.
4. Unfenced substations and pad mounted equipment: 5 Ohms.
5. Manhole grounds: 10 Ohms.

C. Deficiencies: Where ground resistances exceed specified values, notify Engineer, and if directed by Engineer, modify grounding system to reduce resistance values. Where measures are directed that exceed those indicated, provisions of Contract covering changes will apply

D. Report: Prepare test reports, certified by testing organization, of ground resistance at each test location. Include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results

3.07 RESTORATION

A. Restore surface features at areas disturbed by excavation and reestablish original grades except as otherwise indicated

B. Where sod has been removed, replace it as soon as possible after backfilling is completed

C. Restore areas disturbed by trenching, storing of dirt, cable laying, and other Work to their original condition

D. Include necessary top soiling, fertilizing, liming, seeding, sodding, sprigging, or mulching

E. Restore disturbed paving as indicated

END OF SECTION

Section 16121

Low-voltage Conductors and Cables

PART 1. GENERAL

1.01 SUMMARY

A. This specification is confidentially issued for this specific project only

B. Contractor shall be responsible for reading all specifications from all disciplines prior to bid

1.02 REFERENCES

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

1. Article 310 - Conductors for General Wiring
2. Article 200 – Use and Identification of Grounded Conductors

B. EPA, 40CFR, Part 261.24 Toxicity Characteristic

C. CSA FT-4 Vertical Cable Tray Flame Tests

D. Underwriter's Laboratories (UL)

1. UL 44: Rubber Insulated Wires and Cables
2. UL 83: Thermoplastic Insulated Wires and Cables
3. UL 514 B: UL Standard for Safety Conduit, Tubing, and Cable Fittings
4. UL 1063: Machine Tool Wires and Cables
5. UL 1277: Standard for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members
6. UL 1581: Reference Standard for Electrical Wires, Cables, and Flexible Cords

E. American Society for Testing and Materials (ASTM)

1. ASTM B3: Soft or Annealed Copper Wires
2. ASTM B8: Concentric-Lay-Stranded Copper Conductors, Hard, Medium Hard, Soft
3. ASTM B33: Tinned soft or annealed copper wire for electrical purposes

F. 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

G. IEEE 383: Vertical Wire Flame Test

H. IEEE 1202: Flame testing of cables for use in cable tray

I. Insulated Cable Engineers Association (ICEA)

1. ICEA S-61-402: Thermoplastic- Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (NEMA WC5)
2. ICEA S-66-524: Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (NEMA WC-7)
3. ICEA S-68-516: Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (NEMA WC-8)
4. ICEA S-95-658 Non-shielded Power Cable Rated 2000 Volts or Less
5. ICEA T-29-520 Flame Test

1.03 SUBMITTALS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

1.04 RECORD DRAWINGS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

1.05 OPERATIONS & MAINTENANCE MANUALS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

1.06 QUALITY ASSURANCE

A. Tests:
1. Cable shall meet all the requirements of Part 6 of ICEA S-61-402
2. Cable shall be tested at the factory to confirm that the cable complies with requirements of ICEA Section 7.7.9 of S-66-524 or 7.5.9 of S-68-516
3. Where applicable, the cable shall meet the requirements of the vertical tray flame test as described in IEEE 383-2.5

PART 2. PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Belden
B. Cerrowire
C. General Cable
D. Okonite Company
E. Service Wire Drive VFD Cable
F. Southwire
G. Or approved equal

2.02 MATERIALS AND EQUIPMENT

A. Design:

1. Provide cable designated as THWN/THHN or XHHW 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 while installed in underground duct, conduit or in control panels (MTW). Use XHHW, 90° rated conductors for main service or feeders
2. Provide cable with the following design characteristics. The cable shall consist of multiple conductors. The cable assembly shall be UL listed, flame, oil, and sunlight resistant, and certified for continuous operation at the temperature specified in wet or dry locations while installed in underground duct, conduit, or cable tray. The number and size of conductors supplied in each cable shall correspond to the quantities specified. Each conductor shall be individually insulated. Pairs and triads shall have conductors, which are twisted together with a drain wire, shielded, and covered with a jacket. Multi-pair/triad cables shall consist of the required number of electrically isolated, shielded pairs or triads, which are bundled together and covered by an overall jacket as specified

B. Conductors:

1. Provide conductors, which are Class B, concentric stranded, annealed un-coated copper with physical and electrical properties complying with ASTM B3 and B8 and Part 2 of ICEA S-61-402, S-66-524, or S-68-516, unless otherwise specified

C. Insulation:

1. Each conductor shall be PVC insulated and nylon jacketed to meet the requirements of Part 3 of ICEA S-61-402. The insulation thickness shall match the dimensions listed in NEC Table 310-13 for type THHN and THWN wire
2. Each conductor shall be insulated as specified in compliance the requirements of Part 3 of ICEA S-61-402, S-66-524, or S68-516. The average insulation thickness shall not be less than the dimensions shown in Table 7-32 or 7.5.1 of ICEA S-66-524 or S-68-516 for 600-volt insulation unless otherwise specified. The minimum insulation thickness shall not be less than 90 percent of the value given in the table

D. Shielding:

1. Provide shielding consisting of laminated, non-burning, mylar-backed aluminum tape applied helically around a twisted pair or triad with the aluminum side in continuous contact with the drain wire unless otherwise specified. Wrap the tape around each twisted pair or triad with a 25 percent minimum overlap unless otherwise specified

E. Drain Wire:

1. Provide drain wire, which is Class B, seven-stranded, tin-coated copper in accordance with ASTM B3, B8, or B33 and as specified. The drain wire shall not be less than two AWG sizes smaller than the insulated conductor's size, except for multiple pair triad drain wires, which shall not be less than the insulated conductor size

F. Jacket:

1. The physical and electrical properties of the jacket used to cover single or multipair or triad cables shall meet the requirements of section 7.7.7 or ICEA S-66-524 or section 7.5.6 of ICEA S-68-516. Jacket material as specified. The jacket thickness shall be equal to the dimensions shown in Table 7-33 or 7.5.2 of ICEA S-66-524 or S-68-516

G. Armor:

1. Where requested, use instrumentation cables protected by an interlocked metal tape armor coating made of galvanized steel, which meets the requirements of paragraph 4.5 of ICEA S-68-516 or S-66-524, unless otherwise specified

H. Wire Marking:

1. Wire marking shall be in accordance with NEC Article 310-11 and shall be printed on the wire insulation at 2-foot intervals
2. The printing method used shall be permanent and the color shall sharply contrast with the jacket color
3. Use individual conductors in single-pair and single-triad cables, which are, color coded black and white; and black, white and red, respectively. Multi-pairtriad cables shall have one conductor in each pair or triad colored white, and all other conductors are color coded in sequence according to Table L-2 of Appendix 2 of ICEA S66-524, and as specified
4. Print cable marking information on the jacket of each cable at 2-foot intervals. Use a permanent printing method with color sharply contrasting the jacket color

I. The single conductor color coding shall be as follows:

System Voltage	A	B	C	Neutral
120/240 Volt 1Ph/3w	Black	Red		White
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	

J. VFD cables are to be selected and provided for AC motor drive duty and shall be rated at voltage listed in VFD Manufacturer's data sheets

K. All service and feeder conductors to be XHHW-2

L. All conductors shall be soft-drawn, stranded annealed copper that meets ANSI 44, ASTM B3-74/38-72

M. Insulation for all 480Vconductors, insulated equipment grounding conductors and control conductors shall be type XHHW-2 For dry and wet locations; maximum operating temperature shall be 90°C. Meet UL 44 and Federal Spec A-A-59544

N. All power conductor cables shall have phase colored insulation

O. Insulation for all 120/240V conductors, insulated equipment grounding conductors and control conductors shall be type XHHW-2 For dry and wet locations; maximum operating temperature shall be 90°C. Meet UL 44 and Federal Spec A-A-59544

P. Multiconductor shielded cables shall be polyethylene insulated tinned copper conductors within an aluminum-polyester shield tinned copper drain wire and a chrome PVC jacket. Shield shall provide 100% coverage. Cables shall be UL style 2092 and shall be Beldon Beldfoil #8760 or equal, with number of conductors shown. Minimum conductor size shall be #18AWG

Q. Multiconductor signal cables shall consist of twisted pairs of insulated copper conductors, size and number of pairs as indicated, with a petroleum-polyethylene compound which fills all cable interstices, a non-hygroscopic core tape, .005" copper shield and a polyethylene jacket. Cable shall be manufactured to REA Specification PE-39 for REA designation BJCF cables and shall be Okonite type KTC-F or equal

R. All control panel wiring shall be tinned stranded #14 AWG minimum size conductors for controls with type SIS insulation

S. Ethernet cable to be CAT6

2.03 INSULATING PRODUCTS

A. Tape products shall be furnished as hereinafter specified and shall be Plymouth, Okonite, F.E., 3M, or equal

B. General purpose electrical tape shall be 7 mil thick stretchable vinyl plastic, pressure adhesive type, "slipknot Grey", 3M Scotch 33+, or equal

C. Insulating void-filling tape and high voltage bedding tape shall be stretchable ethylene propylene rubber with high-tack and fast fusing surfaces. Tape shall be rated for 90 degrees Celsius continuous, 130 degrees Celsius overload, and shall be moisture-proof void filling tape shall be "plysafe", 3M Scotch 23, or equal

D. High temperature protective tape shall be rated 180 degrees Celsius continuous indoor/outdoor, stretchable, self-bonding silicone rubber. High temperature tape shall be "Plysil #3445", 3M Scotch 70, or equal

E. Insulation putty filler-tape shall be Plymouth #2074, 3M, or equal

2.04 WIRING DEVICES

A. All wiring devices shall be specification grade and shall meet NEMA WD 1-1971 requirements. Furnish following types unless otherwise indicated

B. GFI receptacles shall be 20A duplex receptacle in a duplex body containing reset and test pushbuttons. Furnish Square D "GFCI-WR", or equal

C. Single-pole, single throw, 20A toggle switch shall be Arrow-Hart #1791, Hubbell #1221, or equal

D. Door switch, single-throw pressure sensitive shall be Pass & Seymour #1205, or equal

E. Wiring devices are to be ivory in color

2.05 MISCELLANEOUS MATERIAL

A. Cable grips shall be 316 stainless steel, grip-type wire mesh with machined metal support. Furnish Kellems, Appleton, or equal products

B. Conduit pull-cords for use in empty raceways shall be glass-fiber reinforced tape with foot-marked along its length. Furnish Thomas, Greenlee, or equal products

C. Conduit thread coating compound shall be conductive, non-galling, and corrosion-inhibiting and applied to all threads. Furnish Crouse-Hinds type "STL", Appleton type "ST", Noalox, Penetrox or equal

D. Wire pulling compound shall be non-injurious to insulation and to conduit and shall be lubricating, non-crumbling, and non-combustible. Furnish clear wire pulling compound

E. Plastic compound for field-coating of ferrous material products shall be PVC in liquid form that sets-up semi-hard upon curing. Furnishing Rob Roy "rob Kote", Sedco "Patch Coat", or equal

F. Zinc spray for coating electrogalvanized steel products shall be Research Laboratory type "LPS", Mobil "Zinc-spray", or equal

G. Splicing kit shall be provided with insulating and sealing compound to provide a moisture-tight splice. Provide Scotchcast Series 82 or equal splicing kit

2.06 CONNECTORS

A. Power connectors shall be insulated tap connectors. Furnish NSI Polaris connectors with no equals

B. Insulated silicone filled spring-wire connectors, "wire-nuts", for small building wire taps and splices shall be plated spring steel with thermoplastic jacket. Connector shall be rated at 150 degrees Celsius continuous. Furnish 3M "or equal

C. Insulated set-screw connectors shall consist of copper body with flame-retardant plastic insulated shield. Furnish Ideal, T&B, or equal

D. Connectors for control conductor connections to screw terminals shall be crimp-type with vinyl insulated barrel and tin-plated copper ring-tongue style connector. Furnish T&B "Sta-kon", 3M "Scothlok", or equal

PART 3. EXECUTION

3.01 TESTING

A. Tests:

1. In general, test insulation integrity of the wiring system before terminating
2. Make sure to disconnect sensitive electronic equipment before testing insulation
3. Use a 500 VDC megohmmeter and perform the wire system insulation test in accordance with the operating instructions
4. Before connecting the cables, test insulation integrity and conductor continuity
5. All cables shall have an insulation test performed using 1000-volt megger that has been calibrated within the last twelve months.
6. Cables installed with an insulation reading less than 500 megohms shall be removed and new cable installed and retested at no additional cost to the owner.
7. Cables installed with an unacceptable insulation reading shall be removed and new cable installed and retested at no additional cost to the owner. Submit cable megger test report to owner’s representative.
8. The grounding system shall be be tested in the presence of the owner’s representative using the fall of potential method and shall provide a grounding system resulting in an ohmic value of five (5) ohms or less at no additional cost to the owner. The contractor shall submit test report to owner’s representative. Test equipment must be calibrated within the previous 12 months. Provide dated calibration results along with submittal.

3.02 PREPERATION

A. Ship wire and cable on manufacturer’s standard reel sizes unless otherwise specified. Where cut lengths are specified, mark reel footage accordingly. Each reel shall 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

B. Complete the cable raceway systems and underground duct banks before installing cables

C. Verify sizing of raceways and pull boxes to ensure proper accommodation for the cables

D. Check the length of the cable raceway system against the length of cable on the selected reel

E. Clean conduits of foreign matter before cables are pulled

F. Preparation for termination:

1. Make 600-volt power cable terminations and splices with heat shrinkable sleeves and seals
2. Terminal lugs and connectors for all sizes of conductors shall be crimp-on type
3. For size 1/0 AWG and larger, crimp-on lugs shall have the long barrel with 2-hole tongues except in places where termination space is limited

G. Do not install or work on PVC insulated or jacketed cables in temperatures below 32-degrees F

H. Provide at least 30 percent spare conductors or pairs

3.03 INSTALLATION

A. Wiring Methods

1. Use wiring methods indicated on the Drawings
2. In general, use THHN/THWN or XHHW building wire for lighting, power and control wiring where conductors are enclosed in raceways such as above ground conduit system, underground duct banks, or inside control panels. Use XHHW, 90° rated conductors for main service or power and motor feeders
3. Do not use solid conductors
4. Use conductors no smaller than No. 12 AWG stranded for lighting circuits indoors and not smaller than No. 10 AWG stranded for outdoors. Use No. 10 AWG (minimum) for outdoor receptacles on structures or poles
5. Use conductors no smaller than No. 14 AWG for control circuits, except when part of a multi-conductor cable or internal panel wiring
6. In general, do not splice conductors. All conductors must be one continuous length from starting point to end point without splices, unless prior written approval by Engineer
7. Splices associated with taps for lighting and control circuits are allowed without approval
8. Make splices in accessible junction boxes located above ground. Do not splice power and control conductors in underground pull boxes or manholes, unless specifically allowed. Any slices allowed in underground boxes shall be made using 3M liquid tight kits specifically made to withstand submergence in water. Any conductors allowed to be spliced in underground boxes shall have conductors elevated to near top of wall
9. Wire nuts with insulated caps may be used for lighting wiring splices located in wall boxes, switch boxes, and receptacle boxes, but not in control panels,

MCC's or underground boxes. Splice control circuit with insulated crimp connectors

10. All conductors routed in manholes, electrical vaults and underground pull boxes shall be routed around walls and supported by nonmetallic fiberglass strut that is bolted vertically to walls at intervals not less than two per wall. Do not use horizontal arms unless specifically called for. Support conductors with stainless steel bands made for the purpose of supporting conductors, or with large wide nylon Ty-Wraps. Under no conditions shall conductors be routed directly across length of box. Any conductors routed otherwise shall be removed and replaced at Contractors expense. Splicing in UG pull boxes, manholes or vaults is prohibited without written approval by Engineer

B. Single Conductor in Conduit and Ductbank

1. Install cables in accordance with the manufacturer's instructions and NEC Chapter 3 - Wiring Methods and Materials. Do not exceed maximum wire tension, maximum insulation pressure and minimum bending radius
2. Pull cables into conduits using adequate lubrication to reduce friction. Lubricants must not be harmful to the conductor insulation
3. Splices are not allowed in manholes

C. Single Conductor in Cable Tray:

1. Do not install single conductor building wire and cable in cable tray. All conductors to be tray rated composite cable type

D. Multi-Conductor Shielded VFD Rated Cable:

1. Install cables in accordance with the manufacturer's instructions
2. Pull cables into conduits using adequate lubrication to reduce friction. Lubricants must not be harmful to the conductor insulation
3. Do not splice cables unless specifically shown on plans. Provide as one continuous length. Where splicing is shown on plans or approved, use mechanical compressing tools and splice barrels only, and tape connections
4. All cables and conductors routed thru UG pull boxes or manholes shall be routed around walls and secured on racks. See plans for details

E. Termination:

1. After the 600-volt wiring system has been tested with satisfactory results, reconnect wire
2. Do not splice conductors. For termination use crimp-on type ring tongue non-insulated tin-plated copper lugs
3. For shielded control cable, terminate the shield and ground it at one end only, preferably at the control panel end for instrument and communication cable and at the supply end for electronic power cables

4. If splicing is required, maintain shield continuity by jumpering the ground shield across connection point where it is broken at junction boxes, or other splice points. Insulate these points from ground
5. 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 or base of the terminal

F. Conductors shall be sized as shown and where no size is indicated, the conductor size shall be size #12 AWG

G. Insulation for all conductors, insulated equipment grounding conductors and control conductors shall be stranded copper type XHHW-2 for dry and wet locations; maximum operating temperature shall be 90°C (XHHW-2). UL listed as gasoline and oil resistant. PVC insulation with nylon outer jacket. Meet UL 83 and Federal Spec J-C-30B

H. Branch circuits may be spliced for receptacle and lighting loads inside appropriate junction boxes. All control and power cables shall be run continuous without splices except where approved by the engineer

I. Except as otherwise specified, taps and splices for receptacles and lighting shall be made with silicone filled spring wire connectors

J. Motor connections and all taps and splices other than for receptacle and lighting shall be made with the appropriate NSI Polaris series connectors

K. Control wiring connections to stud type and screw type terminals shall be made with ring-tongue type crimp connectors. Label each terminal jacket with wire marking label at each connection

L. Each wire connection shall be made up tightly so that resistance of connection is as low as equivalent length of associated conductor resistance

M. All wiring inside enclosures will be neatly trained and laced with nylon tie-wraps

N. All wiring shall be installed in raceways except inside the wet well; however, no wire shall be drawn into a conduit until all work of a nature which may cause injury is completed. Do not exceed wire and cable manufacturer's recommended pulling tensions. A cable pulling compound shall be used as a lubricant and its composition shall not affect the conductor or its insulation

O. Install wiring devices where indicated. Wiring devices shall be type as indicated

P. Each wiring device shall be set with axis plumb and installed with yoke screw so as to adequately support device yokes to the box. Install ground prong pointed up

Q. Device boxes shall be type FS or FD cast aluminum

R. Use aluminum ganged boxes for ganged devices. “Type FD sand cast aluminum boxes are required

S. Each device box shall be equipped with specified aluminum cover and 316 S.S. hardware

3.04 REPAIR/RESTORATION

A. Inspection of Conductors

B. All conductors shall be inspected for damage after pulled in conduit. Where damage is deemed excessive by Engineer, conductors shall be replaced for entire length of run

C. Where damage is due to condition of conduits, Contractor may be requested to provide a televised inspection of conduits at no additional cost to Owner and where deemed necessary by Engineer, any damaged conduits shall be replaced at no additional cost to Owner

END OF SECTION

Section 16131

Raceways and Boxes

PART 1. GENERAL

1.01 SUMMARY

A. This specification is confidentially issued for this specific project only

B. Contractor shall be responsible for reading all specifications from all disciplines prior to bid

C. This specification will cover device boxes, pull boxes, junction boxes, and raceways not covered in other sections

1.02 REFERENCES

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

1. FB1 - Fittings and Support for Conduits and Cable Assemblies
2. 250 - Enclosures for Electrical Equipment (1000 volts maximum)

B. 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

C. Underwriters Laboratories (UL):

1. 50 - Safety Cabinets and Boxes
2. 508 - Safety Industrial Control Equipment
3. 514B - Safety Fittings for Conduit and Outlet Boxes
4. 886 - Safety Outlet Boxes and Fittings for Use in Hazardous Areas.

1.03 SUBMITTALS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

B. Installation instructions

C. Dimensions and weights

1.04 RECORD DRAWINGS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

1.05 OPERATIONS & MAINTENANCE MANUALS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

PART 2. PRODUCTS

2.01 ACCEPTABLE MANUFACTURER'S

A. Sheet Metal Boxes
   1. Hoffman Industrial Products
   2. Robroy
   3. Eaton/Crouse-Hinds
   4. Rittal

B. Cast Device Boxes
   1. Appleton Electric Company
   2. Eaton/Crouse-Hinds
   3. Hubbel/Killark

C. Pull box
   1. Oldcastle
   2. Cesco
   3. Rexel USA
   4. Or approved equal

2.02 MATERIALS AND EQUIPMENT

A. Sheet metal boxes
   1. Provide UL-approved junction boxes and pull boxes manufactured from stainless steel sheet metal and meeting requirements of NEMA 4X for corrosive and wet areas, NEMA 250 and NEC Article 314. Enclosures located outdoors or in environmentally harsh or wet locations shall be NEMA 4X 316 stainless steel
   2. Provide boxes with a stainless-steel continuous hinge, closure hasps and all stainless-steel hardware
   3. Furnish the door with neoprene gasket and provision for padlock

B. Device boxes
   1. 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
   2. Supply boxes that are hot dip galvanized on cast iron suitable for corrosive and wet atmosphere
   3. All boxes located in environmentally harsh or wet or outdoor locations shall be NEMA 4X 316 stainless steel

4. All boxes located in chemical rooms shall be H.D. PVC only
5. Where unprotected service conductors are routed through a pull box with other conductors a divider wall shall be provided in the pull box for separation as required by the NEC

C. Hardware

1. Mounting Hardware: Stainless steel
2. Conduit Connectors: Watertight as manufactured by Myers Hubs, or equal

D. Pull Box

1. Minimum size 24” x 24”
2. Pull box shall be traffic rated
3. Pull box shall be aircraft rated where shown on plans
4. Modular construction
5. Base/bottom section
6. Lockable cover

PART 3. EXECUTION

3.01 PREPERATION

A. Pack and crate boxes to permit ease of handling and to provide protection from damage during shipping, handling, and storage

B. Review the drawings and determine how many boxes of each kind are required and check if supplied quantity is sufficient

3.02 INSTALLATION

A. Boxes described in this specification shall be used both in dry and wet, corrosive areas, both inside and outside locations

B. B. Install boxes in accordance with NEC Article 314 in locations indicated on the Drawings

C. Install junction and pull boxes in readily accessible places to facilitate wire pulls, maintenance, and repair

D. Plug unused conduit openings

E. Make conduit connections to sheet metal boxes with watertight conduit connectors

F. Size underground pull boxes and manholes large enough to allow cables and conductors to be routed around walls and supported on wall racks. See plans for details. Do not use arms on mounted racks, except for MV cables or large multiple 600 Volt cables. Do not cross and occupy middle of pull box or manhole with cables or conductors

END OF SECTION

Section 16132

Conduit, Fittings, and Bodies

PART 1. GENERAL

1.01 SUMMARY

A. This specification is confidentially issued for this specific project only

B. Contractor shall be responsible for reading all specifications from all disciplines prior to bid

C. This specification covers all requirements for conduits, fittings, and bodies for various service and electrical equipment

D. All equipment described herein shall be submitted, and factory installed, as an integral part of equipment specified in overall construction documents

1.02 PRICE AND PAYMENT PROCEDURES

A. No separate payment for work performed under this section. Include cost for conduits, fittings, and bodies in overall electrical equipment

1.03 REFERENCES

A. American National Standards Institute (ANSI)

1. ANSI C80.1: Rigid Steel Conduit - Zinc Coated
2. ANSI C80.4: Fittings for Rigid Metal Conduit

B. Federal Specifications

1. W-C-58C: Conduit Outlet Boxes, Bodies Aluminum, and Malleable Iron
2. W-C-1094A: Conduit and Conduit Fittings Plastic, Rigid
3. WW-C-566C: Flexible Metal Conduit
4. WW-C-581E: Coatings on Steel Conduit

C. National Electrical Manufacturers Association (NEMA)

1. NEMA RN1: Polyvinyl Chloride Externally Coated Galvanized Rigid Steel Conduit and Electrical Metallic Tubing
2. NEMA TC2: Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80)
3. NEMA TC3: PVC Fittings for Use with Rigid PVC Conduit and Tubing

D. National Fire Protection Association (NFPA), ANSI/NFPA 70 - National Electrical Code (NEC)

E. Underwriters' Laboratories (UL)

1. UL 1: Flexible Metal Electrical Conduit

2. UL 6: Rigid Metal Electrical Conduit
3. UL 514B: Fittings for Conduit and Outlet Boxes
4. UL 651: Schedule 40 and 80 Rigid PVC Conduit
5. UL 651A: Type EB and A Rigid PVC Conduit and HDPE Conduit
6. UL 886: Electrical Outlet Boxes and Fittings for Use in Hazardous Locations

F. ETL verified PVC-001 for PVC coated rigid steel conduit

1.04 SUBMITTALS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

1.05 RECORD DRAWINGS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

1.06 OPERATIONS & MAINTENANCE MANUALS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

1.07 QUALITY ASSURANCE

A. Tests:

1. Rigid steel conduit shall pass the bending, ductility, and thickness of zinc coating tests described by ANSI C80.1
2. Flexible conduit shall pass the tension, flexibility, impact, and zinc coating test described by UL 1
3. Nonmetallic conduit and fittings shall pass the test requirements of NEMA TC2, UL 651 and 651A and Federal Specification W-C-1094A

PART 2. PRODUCTS

2.01 RACEWAYS

A. Acceptable manufacturer’s

1. Cantex
2. Wheatland Tube
3. ABB - Ocal
4. Champion Fiberglass
5. NEC Inc., - Black Guard
6. Atkore - Heritage Plastics
7. Allied Tube & Conduit

8. Prime Conduit
9. Emerson - O-Z/Gedney
10. Eaton/Crouse-Hinds
11. Western Tube and Conduit
12. Robroy – Plasti-Bond
13. Or equal

B. Materials and equipment

1. Design Conditions. Use electrical conduit, fittings, and bodies designed for service in areas as specified within this section to form a continuous support system for power, control, and instrument cables
   a. Use PVC coated steel conduits and hardware for Wastewater Facilities or corrosive environments
   b. Use rigid galvanized steel conduits for Water Facilities
2. Conduit and Fittings
   a. Fiberglass Conduit – Above Ground
      i. Listing: UL 2515 Above Ground Standard
      ii. RTRC (Thermosetting Resin Conduit) manufactured by single circuit filament winding process. The resin shall be epoxy based, with no fillers.
      iii. Manufacturer shall have a current ISO 9001 Quality Management System Certificate
      iv. Toxicity: The conduit shall not contain any compounds that can release halogens (chlorine, bromine, flour, and iodine) in more than trace amounts when burning.
   b. Fiber Glass conduit – XW Conduit
      i. RTRC (Thermosetting Resin Conduit) manufactured by single circuit filament winding process. The resin shall be epoxy based, with no fillers.
      ii. Manufacturer shall have a current ISO 9001 Quality Management System Certificate
      iii. Toxicity: The conduit shall not contain any compounds that can release halogens (chlorine, bromine, flour, and iodine) in more than trace amounts when burning.
      iv. Wall thickness: Minimum of .25”
   c. PVC-Coated Rigid Steel Conduit and Fittings.
      i. PVC-coated conduit, fittings, bodies, and covers shall conform to NEMA RN1 (Type A). Rigid steel galvanized conduit and fittings before coating shall conform to Federal Specification WW-C-581E, ANSI C80.1, and UL 6. Conduit bodies shall conform to UL 514B

and Federal Specification W-C-58C. Provide sufficient coating for touch up after installation

ii. PVC-coated couplings shall be of the ribbed type

iii. Condulet covers shall have encapsulated stainless steel thumbscrews

iv. Condulets and covers shall be of malleable iron or feraloy material before coating

v. PVC coating shall be a minimum of 2-mil thickness on the interior of the conduit and the interior of fittings, condulets, covers, and bodies

vi. Conduit clamps, strut, and devices shall be PVC coated when used with PVC-coated conduit

d. Flexible and Liquid tight Flexible Metal Conduit and Fittings

i. Use liquid tight flexible metal conduit manufactured in accordance with UL 1 and Federal Specification WW-C-566C

ii. Fittings used with liquid tight flexible metal conduit shall be the PVC- coated type and of such design as to thoroughly ground the conduit to the fittings and through it to the box or enclosure to which it is attached

iii. Liquid tight flexible couplings and fittings for use in hazardous areas shall comply with UL 886, NEC Article 501-10 (A&B), and Federal Specification W-C-586C

iv. Do not use flexible metal conduit or liquid tight flexible metal conduit for light fixtures or receptacles unless shown on plans or approved by Engineer

e. PVC Conduit and Fittings. Use PVC conduit, bends, and fittings, which comply with NEMA TC2, W-C-1094A, and NEC Article 352-III for above ground and underground installation. Conduit shall be Schedule 80, unless shown or noted otherwise on drawings or in other specifications

f. Use PVC Schedule 80 conduits, fittings, and boxes for all chemical areas and provide conduit seals per NEC

g. Aluminum RMC conduit may be used only where shown on plans

h. Do not use liquid tight flexible metallic conduit to connect rigid conduit to fixed or wall mounted enclosures or panels

i. Do not run liquid tight flexible metallic conduit directly thru walls, ceilings, or floors.

j. Do not attach liquid tight flexible metallic conduit with nylon or plastic tie- wraps on straps. Use aluminum straps made for that purpose, except where approved by Engineer.

C. Use UNY or UNF aluminum unions

D. Conduit entrances into equipment shall be carefully planned. Cutting away of enclosure structure, torching out sill or braces, and removal of enclosure structural members, will not be acceptable

E. Below-grade to above-grade upturns in non-metallic runs shall be made with ETL-PVC-001 compliant PVC coated rigid metallic conduit including 90-degree bends

F. Above ground conduit shall be pvc coated rigid galvanized steel 1 in. minimum and shall comply with Article 346 of NEC and U.L. standard UL-6.

G. Below grade conduit shall be non-metallic rigid PVC Schedule 80 1 in. minimum, rated 90 degrees Celsius and conform to NEMA TC-2 and UL-651 Standards, transitions to above ground to be made with PVC coated hot dipped rigid steel conduit that is ETL-PVC-001 compliant.

H. Limited use of flexible conduit may be allowed if approved by the inspector. Use type LFNC flexible seal tight for 3/4 in. minimum thru 2 in. sizes, connectors shall be UL listed. Use aluminum core liquid tight flexible metal conduit for sizes 2 1/2 in. and larger, connectors shall be aluminum. All conduit shall be mounted on strut

2.02 CONDUIT FITTINGS

A. Field applied hubs for all enclosure type entries shall be aluminum with grounding type lock ring, nylon throat, threaded NPT insert and shall be MYERS "SCRU-TITE", or equal

B. Rigid metallic conduit chase nipples, slip fittings, unions, reducers shall be aluminum

C. Limited use of flexible conduit may be allowed if approved by the inspector. Use type LFNC flexible seal tight for 3/4 in. minimum thru 2 in. sizes, connectors shall be UL listed. Use aluminum core liquid tight flexible metal conduit for sizes 2 1/2 in. and larger, connectors shall be aluminum. All conduit shall be mounted on strut

2.03 BODIES AND BOXES

A. Conduit bodies such as "C", "LB", "T" and the like pulling fittings shall be sand-cast copper free steel. Covers shall be gasketed 316 stainless steel cover screws and clamp style attachment. Furnish Crouse-Hinds Form 7, or equal

B. Cast metal outlet boxes, pull boxes, and junction boxes whose volume is smaller than 100 cubic inches, and cast metal device boxes, shall be sand-cast copper free. All boxes shall have threaded hubs. Furnish Crouse-Hinds "FD" style Condulets, Appleton "FD" style Unilets, or equal

C. Covers for cast aluminum boxes shall be gasketed aluminum covers with 316 stainless steel screws. Furnish Pass & Seymor series WIUCast for receptacle covers and Cantex single gang toggle switch covers for light switches

PART 3. EXECUTION

3.01 PREPERATION

A. Package conduit in 10-foot bundles maximum with conduit and coupling thread protectors suitable for indoor and outdoor storage. Package fittings in 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

B. Store conduit above ground on racks to prevent corrosion and entrance of debris

C. Protect plastic conduit from sunlight

D. Confirm submittal of shop drawing with conduit and conduit fitting, sizes, types, and routing shown

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

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

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

H. Submit layout of all conduit stub-ups for Engineers review before installing conduits. Do not install conduit to equipment, electrical panels or devices until enclosure locations and sizes have been determined and verified by Supplier.

3.02 INSTALLATION

A. Conduit bodies such as "LB", "T", etc., shall be installed in exposed runs of conduit wherever indicated and where required to overcome obstructions and to provide pulling access to wiring. Covers for such fittings shall be accessible and unobstructed by the adjacent construction. All conduit fittings shall be form 7 sand cast aluminum with aluminum covers and 316 S.S. hardware

B. Covers for conduit bodies installed shall match the conduit material being installed

C. No more than 270 degrees of bends shall be used in conduit runs

D. Empty conduits shall have pull-tape installed. Identify each terminus as to location of other end. Use blank plastic waterproof write-on label and write information on each label with waterproof ink. Cap exposed ends of empty conduit with threaded plastic caps

E. Conduit runs into boxes, cabinets, and enclosures shall be set in a neat manner. Vertical runs shall be set plumb. Conduits set cocked or out of plumb will not be acceptable. Use aluminum grounding type myers hubs with insulated throats for all enclosure entries

F. All raceways shall be swabbed clean after installation. There shall be no debris left inside. All interior surfaces shall be smooth and free from burrs and defects that would injure wire insulation. All conduits shall be sealed after cable installation with electrical insulation putty

G. Each flex connector shall be made-up tightly so that the minimum pull-out resistance is at least 150 lbs.

H. Rigid metallic conduit runs shall have their couplings and connections made with screwed fittings and shall be made up wrench tight. Check all threaded conduit joints prior to wire pull

I. All conduit runs shall be watertight over their lengths of run except where drain fittings are indicated. In which cases, install specified breather-drain fittings. Use aluminum seal-off fittings where required by NEC. Seal with 3M-2123 re-enterable sealing compound

J. LFNC conduit shall be used to connect wiring to limit switches, bearing thermostats, and other devices that may have to be removed for servicing. Unless otherwise indicated, maximum lengths of flex shall be six (6') feet

K. Install the conduit system to provide the facility with the utmost degree of reliability and maintenance free operation. The conduit system shall have the appearance of having been installed by competent workmen. Kinked conduit, conduit inadequately supported or carelessly installed, do not give such reliability and maintenance free operation and will not be accepted

L. Raceways shall be installed for all wiring runs

M. Conduit sizes, where not indicated, shall be N.E.C. code-sized to accommodate the number and diameter of wires to be pulled into the conduit. 3/4" trade-size shall be minimum size conduit except for conduits installed in duct banks which shall be a minimum 1” trade-size

N. Unless otherwise noted, conduit runs shall be installed exposed. Such runs shall be made parallel to the lines of the structure. Aluminum rigid conduit shall not come in contact with concrete

O. All raceway systems shall be adequately and safely supported. Loose, sloppy and inadequately supported raceways will not be acceptable. Supports shall be installed at intervals not greater than those set forth under Article 300 of N.E.C., unless shorter intervals are otherwise indicated, or unless conditions require shorter intervals of supports

P. Surface mounted runs of conduit on concrete or masonry surfaces shall be supported off the surface by means of 316 stainless steel slotted channels and conduit clamps. Attach each slotted channel support to concrete surface by means of two (2) 1/4" diameter 316 stainless steel bolts into drilled expansion shields

Q. Conduit runs that are installed along metallic structures shall be supported by means of 316 S.S. beam clamps or other methods as may be indicated

R. Below-grade conduits shall be supported with plastic saddles

S. Install PVC-coated conduits in all locations at wastewater facilities, inside valve vaults, in wet well slabs, in corrosive and wet environments, in chemical rooms (Schedule 80 required) and, where specifically noted on drawings. Aluminum PVC- coated conduit may be used where specifically shown on plans, where specifically noted in specifications or where approved in writing. Install PVC coated conduits in Water Facilities where wet locations, inside valve vaults, or where specifically shown on Plans or noted in other Specifications

T. Install rigid galvanized steel (RGS) conduits in dry inside locations and in all outdoor locations for water facilities and, where specifically noted otherwise on drawings. Aluminum RMC may be used where specifically shown on plans, where

specifically noted in specifications or where approved in writing. Where aluminum conduit is approved, use all aluminum condulets and fittings

U. Install PVC conduits in duct banks. For stub-ups and directional turn elbows, use PVC-coated rigid steel elbows or rigid steel elbows as applicable in A and B above and other specifically noted locations on drawings. Rigid steel stub-up shall have minimum three (3) layers of mylar tape up to 1" above slab where conduit is in contact with concrete. Stub-ups inside MCC's, panels, equipment and/or enclosures shall have threads with grounding bushings installed. Stub up all conduits entering MCC's, and other equipment enclosures from the bottom into each respective starter, feeder breaker or control section per equipment manufacturers conduit layout detail. Coordinate with equipment manufacture data sheets before starting any underground or below slab conduit installations

V. Run exposed conduit parallel or perpendicular to walls, ceilings, or main structural members. Group multiple conduits together where possible. Do not install conduit where it interferes with the use of passageways, doorways, overhead cranes, monorails, equipment removal areas or working areas. In no case shall conduit routing present a safety hazard or interfere with normal plant operating and maintenance procedures. Maintain a minimum overhead clearance of 8'0" in passageways. Except where absolutely impossible, all conduits are to be installed in or under concrete slab, in walls and ceilings. Any exposed conduit installed otherwise may be relocated at Contractor's expense where directed by Engineer or Owner. Exceptions, where specifically noted otherwise on plans

W. Installation and support of conduit shall be from steel or concrete structures in accordance with the standard detail drawings. Furnish necessary conduit straps, clamps, fittings and support for the conduit in accordance with the standard details and consistent with the grade and type of conduit being installed

X. Identify conduit at termination points like MCC, light fixtures, control panels, receptacles, and junction boxes. Tag all conduits per Section 16052 – "Electrical Identification."

Y. Not more than three (3) equivalent 90-degree bends will be permitted between pull boxes, or between pull boxes and equipment. Provide bonded expansion fittings at building expansion joints. Where pull boxes are located such the three 90-degree bend rule is not exceeded without the pull box, the box may be deleted where approved by Engineer in writing

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

AA. 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-inch taper per foot, 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 zinc rich, brush-on compound on the threads of steel conduit before connections are made. Use only tools specifically made for bending and installing PVC-coated or PVC conduit when installing these materials

BB. Use strap wrenches only to tighten joints in plastic coated rigid steel conduit. Replace all conduit and fittings with damage to the plastic coating, such as cuts, nicks and threader chuck jaw marks

CC. Make up changes in direction of exposed conduit using elbows or fittings. Do not use pull boxes to make direction changes unless specifically designated otherwise. Do not use elbow bends for change in direction of exposed conduit

DD. Field fabricated bends shall be free of indentations or elliptical sections. The radius of the bend shall not be less than 6 times the smallest diameter of the raceway

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

FF. 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 degrees 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

GG. 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. Install bonding jumpers around expansion joint fittings

HH. Where conduit terminates in sheet metal enclosures, threaded hubs are required. Conduit entries with double locknuts and bushings are prohibited. Sheet metal enclosures located outside or in any other wet, damp, or corrosive areas shall be furnished with threaded hubs. Restrict side penetrations to the lower one third of the enclosure

II. Provide liquid tight flexible metallic conduit only where necessary to allow for movement or to localize sound or vibration, at transformers, at motors, solenoid valves, motor operated valves, generators, and any other rotating equipment unless shown otherwise on Drawings. Do not make rigid connections of conduit to vibrating equipment housing or frame. Limit length to less than 2 feet. Do not use flexible metallic conduit for light fixture circuits or similar devices and do not use as a substitute for rigid conduit

JJ. Seal openings or holes where conduits pass through walls or floors. When conduits are passing through a firewall or fire-rated floor into different rooms, cabinets, or enclosures, use a fire-rated seal as shown in the typical detail included in the drawings. Certain walls, where indicated on the Drawings, require environmental (airtight) seals; seal as shown

KK. Install explosion-proof seals in conduit runs crossing or entering a hazardous classified area, where shown on Drawings. Install type CSBE removable sealing fittings to seal pump cables in the wet well and at the first junction box outside the well. Install EYS seals in all conduits leaving chemical rooms or chemical storage spaces. There shall be no unions, couplings, boxes, or fittings in conduit run between seal and point at which conduit leaves the room

LL. Unless otherwise indicated on the Drawings, install expansion fittings every 300 feet within a straight conduit run and where conduit crosses building expansion joints, using bonding straps to ensure ground continuity

MM. 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 inches between racks, unless otherwise indicated on the Drawings. Space conduits on the racks at least enough to provide 1/4-inch clearance between hubs on adjacent conduits at terminations and to allow room for fittings

NN. Fill conduit racks no more than 75 percent of their capacity, providing usable space for future conduit. To ensure this, conduits leaving the rack horizontally shall be offset 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 all pull points, even when future conduits are added to fill the racks

OO. 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-foot intervals to give lateral stability to the rack

PP. 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 architectural, structural, equipment layout and piping drawings to ensure that this requirement is met

QQ. 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 feet along the entire length of the conduit

RR. Support conduit sizes 2 inches and larger at spacings not exceeding 10 feet and conduit sizes 1-1/2 inches and smaller at spacings not exceeding 8 feet

SS. The means of fastening conduit to supports shall be 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

TT. Support conduit runs with conduit clamps, hangers, straps, and metal framing channel attached to structural steel members. Conduits of 1-1/2-inch 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 PVC-coated or stainless steel for PVC-coated conduit. Metal framing channel straps used for PVC-coated conduit shall be Type 316 stainless steel

UU. Install conduits supported from building walls with at least 1/4-inch clearance from the wall to prevent the accumulation of dirt and moisture behind conduit. All conduits shall be routed below concrete floor slabs on grade and shall have sand fill and cover. Set depth to account for radius of turn-up to prevent exposure of elbow bend

VV. Where specifically shown on plans, size and space embedded conduits in structural slabs in accordance with the Uniform Building Code. Conduits should occupy no more than one-third the thickness of the slab and should not be closer than 3 times the largest diameter on center without additional reinforcement

WW. Do not cut paved driveways, sidewalks, concrete foundations, etc. to install conduits unless specifically noted on plans. Bore under such construction and maintain a minimum of 24 inches below underside of paving or concrete. Repair any cutting or damage to original condition and to satisfaction of Engineer and Owner

XX. All conduits for fiber optic cables are to have wide tube radius compatible with cable manufacturer's requirements

YY. Damaged conduits shall be replaced at no additional cost to Owner where Engineer deems necessary because of extent of damage or, where conductors are damaged by defective conduit installation

ZZ. Seal all conduits entering motor control centers, control panels, equipment, enclosures, valve actuators, etc. with CSBE seals or, install EYS at locations permissible. Sealing glands shall be selected specifically for each conduit and conductor. Install seals at all equipment located at elevation lower than U.G. conduit route

AAA. Conduits penetrating underground pull boxes shall be sealed with CSBE seals where larger than 1 ¼-inch diameter and with RTV silicon-based sealant where smaller than 1 ¼-inch diameter

BBB. Conduits penetrating structural walls of lower levels shall be sealed with CSBE seals where larger than 1 ¼-inch diameter and with RTV silicon-based sealant where smaller than 1 ¼-inch diameter

CCC. All conduit duct banks penetrating lower level structures and penetrating underground pull boxes shall be sealed watertight between conduit and wall of structure or pull box

DDD. Where conduits are stubbed out from building for future use, extend conduits 5 feet past building wall or past edge of pavement, whichever is applicable. Do not leave under pavement. Cap ends of conduits

EEE. All conduits shown entering outside walls of buildings shall stub-up immediately adjacent to wall and penetrate low on wall. Where not shown entering wall, all conduits shall be routed up through building floor by excavating below foundation, core drill through floor, and stub-up conduits then backfill with cement stabilized sand, compacted in place

FFF. Apply a conductive coating to field-cut threads of aluminum conduits to ensure continuity and ease of joining. Noalox and Kopr-Shield are acceptable coatings

GGG. Avoid excessive force when tightening threaded fittings for aluminum conduit, both between conduits and at threaded box entries. Generally, the correct force is hand-tight plus one full turn with a wrench. At least three (3) full threads should be engaged

HHH. Do not use conduit bushings to secure threaded aluminum RMC to a box or enclosure. Install a locknut between a conduit bushing and the inside of the box or enclosure

III. Threadless fittings shall not be used with threaded aluminum conduit

JJJ. Install expansion fittings in outdoor runs of aluminum RMC

KKK. Do not install aluminum conduit in concrete or underground

LLL. Use special tools for installing aluminum conduit. All damaged conduits shall be replaced

MMM. In chemical rooms, enclosures, and portable/prefab buildings used for chemical storage or chemical equipment operation, use Schedule 80 PVC conduit and fittings only, except where specifically noted on Plans, use PVC coated steel conduit. Use PVC boxes and enclosures. There are no exceptions to this requirement unless specifically noted on drawings as an exception to this section

NNN. Do not route conduit on outside walls of buildings or structures unless specifically shown on Plans, route from floor slab. Do not route conduit on building interiors, MCC rooms or equipment rooms unless shown on Plans, or approved in writing. Exception: conduits to light fixtures on ceilings. Paint to match. Where shown on Plans or where approved, conduits shall be painted to match surface on which installed. Submit drawings or sketches of any conduit routing that varies from Plans or Specifications.

OOO. Provide steel conduit for all security, fire, TV, and access control system circuits. Coordinate circuits and conduit requirements within respective vendors

PPP. Paint all exposed conduit threads to prevent corrosion. Match color of conduit

QQQ. Paint all exposed rigid steel surface mounted conduits in MCC rooms. Match wall and ceiling color

RRR. Where RGS conduit is installed on interior or exterior building walls (or ceilings), paint conduit, supports and clamps to match wall color

SSS. Contact Engineer for inspection of conduit stub-ups and U.G. ductbanks before concrete pour

TTT. Where RGS conduit is installed on interior or exterior building walls (or ceilings), paint conduit, supports and clamps to match wall color

UUU. For conduits that will contain coaxial cable or other wide radius band cables, provide wide sweep conduit elbows on bands that will accommodate pulling such cables thru 3 90 degree turns without exceeding band radius limitations.

END OF SECTION

Section 16133

Underground Ductbank

PART 1. GENERAL

1.01 SUMMARY

A. This specification is confidentially issued for this specific project only.

B. Contractor shall be responsible for reading all specifications from all disciplines prior to bid.

1.02 REFERENCES

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

1.03 SUBMITTALS, RECORD DRAWINGS, AND O&M MANUALS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

PART 2. PRODUCTS

2.01 ACCEPTABLE MANUFACTURER'S

A. Thomas and Betts

B. Underground Devices Inc.

C. Walker Division, Butler Manufacturing Company.

D. Carlon

E. Or approved equal

2.02 MATERIALS AND EQUPMENT

A. Conduit: Construct ducts using schedule 80 rigid PVC conduit

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

C. Concrete: Use steel reinforced, red concrete as duct encasement. Provide Class F concrete in non-truck traffic areas. Provide Class C concrete under gravel or asphalt driveways subject to heavy traffic

D. Where unprotected service conductors are routed through a pull box with other conductors a divider wall shall be provided in the pull box for separation as required by the NEC

PART 3. EXECUTION

3.01 PREPERATION

A. Have duct spacers and associated hardware packed and crated to avoid damage during shipment and handling

B. Clearly mark packages or crates stating that the material is for electrical duct banks only

C. Verify from Drawings and field survey that the location of ductbanks does not interfere with any existing or new underground facilities

D. Verify that materials are on site in proper condition and that sufficient quantity is on hand for the work

E. Verify that trenches are in the correct places and prepared with sufficient depth and width to accommodate the duct banks, reinforcing rod, and concrete

F. Be prepared for inspection of the duct banks before reinforcing rod is installed

G. 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

H. Provide 24-hour notice to Engineer and the Local Code Inspector for cover-up inspection before pouring electrical conduit ductbanks

3.02 INSTALLATION

A. Conduit runs installed below-grade in earth shall be Sch 80 PVC. Use manufacturer's approved cement for joining couplings and adapters. Runs shall be installed so that top of concrete ductbank is a MINIMUM OF TWENTYFOUR (24") INCHES BELOW FINISHED GRADE. Support conduit runs on plastic spacers and encase conduits with 3000 PSI reinforced concrete dyed with red concrete dye at a rate of 12 pounds of dye per cubic yard of concrete. Provide clearances as shown on detail drawings. Cover top of concrete to finished grade with selected soil that is free from clods, debris, rocks and the like. Pneumatically tamp backfill in six (6") inches to eight (8") inches below finished grade, install continuous run of "BURIED ELECTRIC" marking tape and complete backfill to finished grade. Contractor’s means and methods shall prevent floating of conduit and rebar during concrete placement. Metal to metal contact between the earth and rebar cage is not allowed

3.03 EXCAVATION AND BACKFILLING

A. Do all excavating and backfilling necessary for the installation of the work. This shall include shoring and pumping in ditches to keep them dry until the work in question has been installed. All shoring required to protect the excavation and safeguard employees shall be properly performed

B. All excavations shall be made to the proper depth, with allowances made for floors, forms, beams, piping, finished grades, etc. Ground under conduits shall be well compacted before conduits are installed

C. All backfilling shall be made with selected soil; free of rock and debris and shall be pneumatically tamped in six (6") inch layers to secure a field density ratio of 90%

D. All excavated material not suitable and not used in the backfill shall be removed offsite at the Contractors expense

E. Field check and verify the locations of all underground utilities prior to any excavating. Avoid disturbing these as far as possible. In the event existing utilities are broken into or damaged, they shall be repaired so as to make their operation equal to that before the trenching was started at no additional cost to owner

F. Where the excavation requires the opening of existing walks, drives, or other existing pavement, these facilities shall be cut as required to install new lines and to make connections to existing lines. The sizes of the cut shall be held to a minimum consistent with the work to be installed. After installation of new work is completed and the excavation has been backfilled in accordance with above, repair existing walks, drives or other existing pavement to match existing installation

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

H. Make duct bank installations and penetrations through foundation walls watertight

I. Assemble ductbanks using non-magnetic saddles, spacers, and separators. Position separators to provide 3-inch minimum concrete separation between the outer surfaces of the conduits

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

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

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

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

N. Make bends of 30 degrees or more using rigid galvanized steel

O. Reinforce duct banks throughout, where indicated on the Drawings

1. Unless otherwise noted on the Drawings, reinforce with No. 5 longitudinal steel bars placed at each corner and along each face at a maximum parallel spacing of 12 inches on centers, and No. 5 tie-bars transversely placed at 18-inch maximum longitudinal intervals

2. Maintain a maximum clearance of 3 inches from bars to the edge of the concrete encasement

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

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

R. Install a bare stranded copper duct bank ground on top of duct bank. 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

S. After completion of the duct bank and prior to pulling cable, pull a mandrel, not less than 12 inches long and with a cross section approximately one-fourth inch 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. Re-pull the rag or sponge swab until the swab emerges clean

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

U. Install a warning ribbon approximately 12 inches below finished grade over underground duct banks.

V. For manholes and pull boxes below grade, install racks to support cables properly around the perimeter and keep them dry. Arrange cables in orderly fashion and tie to racks. If metallic racks are used, provide grounding per NEC

W. For manholes and pull boxes below grade, construct a french drain, or other drainage as detailed on the Drawings

X. All manhole and U.G. pull boxes used for electrical construction are to have the work “Electrical” permanently embossed on cover

Y. Conduits penetrating underground pull boxes shall be sealed with CSBE seals where larger than 1 ¼-inch diameter and with RTV silicon-based sealant where smaller than 1 ½-inch diameter

Z. Conduits penetrating structural walls of lower levels shall be sealed with CSBE seals where larger than 1 ¼-inch diameter and with RTV silicon-based sealant where smaller than 1 ½-inch diameter

AA. All conduit duct banks penetrating lower level structures and penetrating underground pull boxes shall be sealed watertight between conduit and wall of structure or pull box

BB. Install identification tags on all conduits at manholes, pull boxes, and junction boxes

CC. Conduits shall be separated by means of manufactured interlocking “chairs” spaced at no more than 5 feet apart along the length of the ductbank. Spacing between conduits shall not be less than 3 inches

DD. Every effort shall be made to minimize the number of bends in all ductbank systems. Field bends shall be made using a “hot box” designed for the size of PVC used. Care shall be given to ductbank routing so that very large radius sweeping turns are designed into the route as opposed to factory made 45° and 90° bends. When factory 90° bends are used, they shall be a minimum of 36-inch radius for 4 inch and 48-inch radius for 5 inches. Factory 90° bends used in ductbank construction shall be rigid metal conduit (ferrous) only. These factory-made bends shall be protected by corrosion tape such as 3M Scotchrap 50 or approved equal prior to the concrete pour

EE. The ductbank support “chairs” shall be spaced up from the bottom of the trench using cement brick to ensure that the proper amount of concrete is poured under the conduits. Sides of the trench may be used as the form if the width does not exceed 1 ½ times the recommended dimension of the ductbank (width.)

FF. The Electrician shall vacuum, swab, and install pull strings in every conduit of the completed ductbank. The pull string shall be permanently marked in 1-foot increments to aid in wire estimation on future projects. Use Greenlee #435 pull string or approved equal

GG. Route all electrical ductbanks and conduits below water lines. Maintain minimum of 24 inches between bottom of water line and top of ductbank

HH. Electrical ductbanks are not required below concrete floors of buildings or below process equipment slabs, at which locations conduits shall be encased in minimum 3 inches of stabilized sand. Where ductbanks are shown on plans to be routed under existing concrete slabs or pavements, install per plan details. Do not cut rebar in existing conduit except where approved by Engineer. Repair any cut or damaged rebar by welding back together after conduits are installed. Submit detail of intent for cutting or removal of existing concrete for ductbank installation to Engineer for approval

END OF SECTION

Section 16211

Electrical Utility Service

PART 1. GENERAL

1.01 SUMMARY

A. This specification is confidentially issued for this specific project only

B. Contractor shall be responsible for reading all specifications from all disciplines prior to bid

C. Electric Utility Charges: Electric Utility charges for extension of distribution system to point of service termination and meters will be paid by Owner, except where bid allowance is indicated, or where specifically noted otherwise on plans or in other specifications

D. Temporary service disconnects at existing installations shall be paid for by Contractor. Prompt connection or reconnection of service shall be coordinated by Contractor. All temporary disconnection and reconnection costs are to be paid for by Contractor

E. Determine the exact requirements for the utility service connections and metering facilities as set forth by the utilities that will serve the project, and pay for and perform all work as required by those utilities

1.02 PRICE AND PAYMENT PROCEDURES

A. The Contractor shall request and pay for the service installation as part of this Contract and maintain the electrical service until the facility is fully installed and accepted by the Engineer and Owner

B. Allowance may be shown on bid sheet. Where not shown, contractor shall include all costs required for new service or modification to existing service

1.03 REFERENCES

A. National Fire Protection Association (NFPA): NFPA No. 7093 National Electrical Code (NEC)

B. Installation shall strictly comply with current Power Company standards. Where plans conflict with Power Company standards, contact Engineer for directions before starting work. Failure to do so is at Contractor’s risk

1.04 ADMINISTRATIVE REQUIREMENTS

A. The Contractor shall be required to transfer ownership of the electric service to the Owner. Documentation of the transfer of ownership shall be submitted to the Owner prior to Contract Closeout. Final payment will not be released until transfer of ownership documents have been submitted to the Owner

PART 2. PRODUCTS

2.01 ELECTRIC SERVICE

A. Electric Service Characteristics:

1. As indicated on Drawings and provided by Electric Utility. Standard voltage is as follows:
    a. 480/277-volt, 3 phase, 4 wire
    b. 120/240-volt, 3 phase 4 wire
    c. 120/240-volt, single phase, 3 wire
    d. Or as shown otherwise
2. Where 480-volt delta service is specifically shown on plans, adjust electrical wiring and select all devices to accommodate that type service. Where 12,470-volt primary service is provided, select all devices to accommodate that type service
3. All 480/277-volt service 200 amps and under, where the service conductors' feeds through the meter shall have a disconnect switch installed upstream of the meter per Power Company standards. This requirement is essential and may be shown on plans. CT cans are required for service above 200 amp
4. Allow for aerial or underground service equipment in bid as determined by Power Company. Most stringent requirements shall be provided at no additional cost to Owner
5. Do not route aerial service drop across site. Contact Engineer if problem.

B. Service Pole Location: Locate service pole based on "Outlet Location Data Statement" and drawing from Power Company. Do not install service pole or service equipment without this data statement and without confirming location with Power Company and Engineer. Contact Engineer prior to construction. Provide submittal with layout of Power Company's pole, Owner's service pole or rack, control panel or MCC or control building for review by owner, Engineer and Power Company before starting construction. Send copy of Power Company "Outlet Location Data Statement" to Engineer for review. Any construction performed without Engineer's review is at Contractor's risk and expense

C. All bus weatherhead installations shall have approved insulated split closure plate around entering conductors from Power Company drop to prevent entry of birds or animals into bus weather head assembly. Install EYS seals in conduits from weather head above to equipment below.

D. Provide pad mounted transformer service equipment, conduits and devices where only U.G. or pad mounted transformer service is available from Power Company

PART 3. EXECUTION

3.01 PREPERATION

A. Confirmation of Electric Service:

1. Consult with Electric Utility to verify service information specified and shown on Drawings. Failure to do so may result in removal and replacement of service equipment at Contractor's cost. Do not start service installation work until "Outlet Location Data Statement" has been received from Power Company and has been reviewed and approved in writing by the Engineer

B. Include deviations required by Electric Utility from contract documents to comply with Electric Utility standards and requirements. Send drawing of final service arrangement for engineer's review. Do not install service equipment until approved by Power Company in writing

C. Relocate service pole, transformer pad or structure up to (10) ten feet to maintain clearance required by Electric Utility Company or to maintain other clearances. Coordinate exact point of service with Power Company and locate customer service pole within distance of Power Company pole as per Power Company Standards. Failure to coordinate location is at expense of Contractor and at no additional cost to Owner

D. Metering:

1. Consult with Electric Utility regarding service entrance requirements and metering equipment. Conform strictly to Utility Company standards

2. Install metering equipment and empty conduit for metering conductors to meet standards and requirements of Electric Utility

3. Consult with electric utility regarding arrangement of disconnect switch in relation to meter, meter can, or other service equipment

4. Where 480 voltmeters is used and a manual transfer switch is used, install one (1) disconnect switch above meter and one (1) below meter per Power Company requirements

E. Application for Electric Service.

1. Obtain required forms from Electric Utility.

2. Assist Owner in completion of forms and deliver completed forms to Electric Utility. Advise Owner of exact voltage and phase requirements

3. Coordinate schedule for installation of electric service with Electric Utility.

4. Notify utility company in writing, within 30 days of project start date that permanent service will be required for this project. Specify date required and location of project

5. Notify Owner and Engineer, in writing of date service applied for, date to be installed, Power Company contact name and telephone number and copy of "Outlet Location Data" report as this information become available. Do not

start construction of service without this report and without confirming service location with Engineer

6. Notify Power Company when old abandoned service is to be disconnected. Coordinate with Owner
7. Contractor is responsible to see that service is connected according to the Power Company standards. Final permanent service connection by Power Company is required before project is considered complete, before final acceptance, and before final payment is made

END OF SECTION

Section 16212

Short Circuit Coordination Study – Arc Flash Hazard Analysis

PART 1. GENERAL

1.01 SUMMARY

A. This specification is confidentially issued for this specific project only

B. Contractor shall be responsible for reading all specifications from all disciplines prior to bid

C. The contractor shall furnish short-circuit and protective device coordination studies as prepared by the electrical equipment manufacturer or an approved engineering firm

D. The contractor shall furnish an Arc Flash Hazard Analysis Study per the requirements set forth in NFPA 70E – Standard for Electrical Safety in the Workplace. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E-2004, Annex D

E. The scope of the studies shall include all new distribution equipment supplied by the equipment Manufacturer under this contract

1.02 REFERENCES

A. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

1. IEEE 141 – Recommended Practice for Electrical Power Distribution and Coordination of Industrial and Commercial Power Systems
2. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
3. IEEE 399 – Recommended Practice for Industrial and Commercial Power System Analysis
4. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings
5. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems
6. IEEE 1584 – Guide for Performing Arc-Flash Hazard Calculations

B. American National Standards Institute (ANSI):

1. ANSI C57.12.00 – Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
2. ANSI C37.13 – Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures

3. ANSI C37.010 – Standard Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
4. ANSI C37.41 – Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories

C. The National Fire Protection Association (NFPA)

1. NFPA 70 – National Electrical Code, latest edition
2. NFPA 70E – Standard for Electrical Safety in the Workplace

1.03 SUBMITTALS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

B. The short-circuit and protective device coordination studies shall be submitted to the design engineer prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment drawings for manufacturing. If formal completion of the studies may cause delay in equipment manufacturing, approval from the engineer may be obtained for preliminary submittal of sufficient study data to ensure that the selection of device and characteristics will be satisfactory

C. The results of the short-circuit, protective device coordination and arc flash hazard analysis studies shall be summarized in a final report. No more than five (5) bound copies of the complete final report shall be submitted. For large system studies, submittals requiring more than five (5) copies of the report will be provided without the section containing the computer printout of the short-circuit input and output data. Additional copies of the short-circuit input and output data, where required, shall be provided on CD in PDF format

D. The report shall include the following sections:

1. Executive Summary
2. Descriptions, purpose, basis and scope of the study
3. Tabulations of circuit breaker, fuse and other protective device ratings versus calculated short circuit duties
4. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip unit settings, fuse selection
5. Fault current calculations including a definition of terms and guide for interpretation of the computer printout
6. Details of the incident energy and flash protection boundary calculations
7. Recommendations for system improvements, where needed
8. One-line diagram

E. Arc flash labels shall be provided in hard copy only at least 30 days prior to energizing the electrical equipment

PART 2. PRODUCTS

2.01 STUDIES

A. Contractor to furnish short-circuit and protective device coordination studies as prepared by equipment manufacturer or an approved engineering firm

B. The contractor shall furnish an Arc Flash Hazard Analysis Study per NFPA 70E – Standard for Electrical Safety in the Workplace, reference Article 130.3 and Annex D

2.02 COMPUTER ANALYSIS SOFTWARE

A. The studies shall be performed using the latest revision of the SKM Systems Analysis Power* Tools for Windows (PTW) software program

2.03 DATA COLLECTION

A. A Contractor shall furnish all data as required by the power system studies. The Engineer performing the short-circuit, protective device coordination and arch flash hazard analysis studies shall furnish the Contractor with a listing of required data immediately after award of the contract. The Contractor shall expedite collection of the data to assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to the release of the equipment for manufacturing.

B. Source combination may include present and future motors and generators

C. Load data utilized may include existing and proposed loads obtained from Contract Documents provided by Owner, or Contractor

D. If applicable, include fault contribution of existing motors in the study. The Contractor shall obtain required existing equipment data, if necessary, to satisfy the study requirements

2.04 SHORT-CIRCUIT AND PROTECTIVE DEVICE EVALUATION STUDY

A. Use actual conductor impedances if known. If unknown, use typical conductor impedances base on IEEE Standard 141-1993

B. Transformer design impedances shall be used when test impedances are not available

C. Provide the following:

1. Calculation methods and assumptions
2. Selected base per unit quantities
3. One-line diagram of the system being evaluated
4. Source impedance data, including electric utility system and motor fault contribution characteristics

5. Tabulations of calculated quantities
6. Results, conclusions and recommendations

D. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each:
1. Electric utility's supply termination point
2. Incoming switchgear
3. Unit substation primary and secondary terminals
4. Low voltage switchgear
5. Motor control centers
6. Standby generators and automatic transfer switches
7. Branch circuit panelboards
8. Other significant locations throughout the system

E. For grounded systems, provide a bolted line-to-ground fault current study for areas as defined for the three-phase bolted fault short-circuit study

F. Protective Device Evaluation:
1. Evaluate equipment and protective devices and compare to short circuit ratings
2. Adequacy of switchgear, motor control centers, and panelboard bus bars to withstand short-circuit stresses
3. Notify Owner in writing, of existing, circuit protective devices improperly rated for the calculated available fault current

2.05 PROTECTIVE DEVICE COORDINATION STUDY

A. Proposed protective device coordination time-current curves (TCC) shall be displayed on log-log scale graphs

B. Include on each TCC graph, a complete title and one-line diagram with legend identifying the specific portion of the system covered

C. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed

D. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended

E. Plot the following characteristics on the TCC graphs, where applicable:
1. Electric utility's overcurrent protective device
2. Medium voltage equipment overcurrent relays
3. Medium and low voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands
4. Low voltage equipment circuit breaker trip devices, including manufacturer's tolerance bands

5. Transformer full-load current, magnetizing inrush current and ANSI through-fault protection curves
6. Conductor damage curves
7. Ground fault protective devices, as applicable
8. Pertinent motor starting characteristics and motor damage points, where applicable
9. Pertinent generator short-circuit breaker in each motor control center and applicable panelboard

F. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection

2.06 ARC FLASH HAZARD ANALYSIS

A. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E-2004, Annex D

B. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchboards, switchgear, motor-control centers, panelboards, busway and splitters) where work could be performed on energized parts

C. The Arc-Flash Hazard Analysis shall include all significant locations in 240 volt and 208 volt systems fed from transformers equal to or greater than 125 kVA where work could be performed on energized parts

D. Safe working distances shall be based upon the calculated arc flash boundary considering an incident energy o 1.2 cal/cm^2

E. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Ground overcurrent relays should not be taken into consideration when determining the clearing item when performing incident energy calculations

F. The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios must be compared and the greatest incident energy must be uniquely reported for each equipment location. Calculations must be performed to represent the maximum and minimum contributions of fault current magnitude for all normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum and will assume a minimum motor contribution (all motors off). Conversely, the maximum calculation will assume a maximum contribution from the utility and will assume the maximum amount of motors to be operating. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable

G. The incident energy calculation must consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions, as

the sources are interrupted or decremented with time. Fault contribution from motors and generators should be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond 3-5 cycles.
2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g. contributions from permanent magnet generators will typically decay from 10 per unit to 3 per unit after 10 cycles).

H. For each equipment location with a separately enclosed main device (where there is adequate separation between the lines side terminals of the main protective device and the work location), calculations for incident energy and flash protection boundary shall include both the line and load side of the main breaker

I. When performing incident energy calculation on the line side of a main breaker (as required per above), the line side and load side contributions must be included in the fault calculation

J. Mis-coordination should be checked amongst all devices within the branch containing the immediate protective device upstream of the calculation location and the calculation should utilize the fastest device to compute the incident energy for the corresponding location

K. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584-2018 section B.1.2. Where it is not physically possible to move outside the flash protections boundary in less than 2 seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized

2.07 REPORT SECTIONS

A. Input data shall include, but not be limited to the following:

1. Feeder input data including feeder type (cable or bus), size, length, number per phase, conduit type (magnetic or non-magnetic) and conductor material (copper or aluminum)
2. Transformer input data, including winding connections, secondary neutral-ground connection, primary and secondary voltage ratings, kVA rating, impedance, % taps and phase shift
3. Reactor data, including voltage rating, and impedance
4. Generation contribution data, (synchronous generators and Utility), including short-circuit reactance (X'd), rated MVA, rated voltage, three-phase and single line-ground contribution (for Utility sources) and X/R ratio
5. Motor contribution data (inductin motors and synchronous motors), including short-circuit reactance, rated horsepower or kVA, rated voltage, and X/R ratio

B. Short-Circuit Output Data shall include, but not be limited to the following reports:

1. Low Voltage Fault Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:
    a. Voltage
    b. Calculated fault current magnitude and angle
    c. Fault point X/R ratio
    d. Equivalent impedance
2. Momentary Duty Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:
    a. Voltage
    b. Calculated symmetrical fault current magnitude and angle
    c. Fault point X/R ratio
    d. Calculated asymmetrical fault currents
        i. Based on fault point X/R ratio
        ii. Based on calculated symmetrical value multiplied by 1.6
        iii. Based on calculated symmetrical value multiplied by 2.7
    e. Equivalent impedance
3. Interrupting Duty Report shall include a section for three-phase and unbalanced built calculations and shall show the following information for each applicable location:
    a. Voltage
    b. Calculated symmetrical fault current magnitude and angle
    c. Fault point X/R ratio
    d. No AC Decrement (NACD) ratio
    e. Equivalent impedance
    f. Multiplying factors for 2, 3, 5 and 8 cycle circuit breakers rated on a symmetrical basis
    g. Multiplying factors for 2, 3, 5 and 8 cycle circuit breakers rated on a total basis

C. Recommended Protective Device Settings:

1. Phase and Ground Relays:
    a. Current transformer ratio
    b. Current setting
    c. Time setting
    d. Instantaneous setting
    e. Recommendations on improved relaying systems, if applicable

2. Circuit Breakers:
    a. Adjustable pickups and time delays (long time, short time, ground)
    b. Adjustable time-current characteristic
    c. Adjustable instantaneous pickup
    d. Recommendations on improved trip systems, if applicable

D. Incident energy and flash protection boundary calculations
1. Arcing fault magnitude
2. Protective device clearing item
3. Duration of arc
4. Arc flash boundary
5. Working distance
6. Incident energy
7. Hazard Risk Category
8. Recommendations for arc flash energy reduction

PART 3. EXECUTION

3.01 QUALIFIED ELECTRICAL CONTRACTORS

A. The short-circuit, protective device coordination and arc flash hazard analysis studies shall be conducted under the supervision and approval of a Registered Professional Electrical Engineer skilled in performing and interpreting the power system studies

B. The Registered Professional Electrical Engineer shall be a full-time employee of the equipment manufacturer or an approved engineering firm

C. The Registered Professional Electrical Engineer shall have a minimum of five (5) years of experience in performing power system studies

D. The equipment manufacturer or approved engineering firm shall demonstrate experience with Arc Flash Hazard Analysis by submitting names of at least ten actual arc flash hazard analysis it has performed in the past year

3.02 ARC FLASH WARNING LABELS

A. The contractor of the Arc Flash Hazard Analysis shall provide a 3.5 in. x 5 in. thermal transfer type label of high adhesion polyester for each work location analyzed

B. All labels will be based on recommended overcurrent device settings and will be provided after the results of the analysis have been presented to the owner and after any system changes, upgrades or modifications have been incorporated in the system

C. The label shall include the following information, at a minimum:

1. Location designation
2. Nominal voltage
3. Flash protection boundary
4. Hazard risk category
5. Incident energy
6. Working distance
7. Engineering report number, revision number and issue date

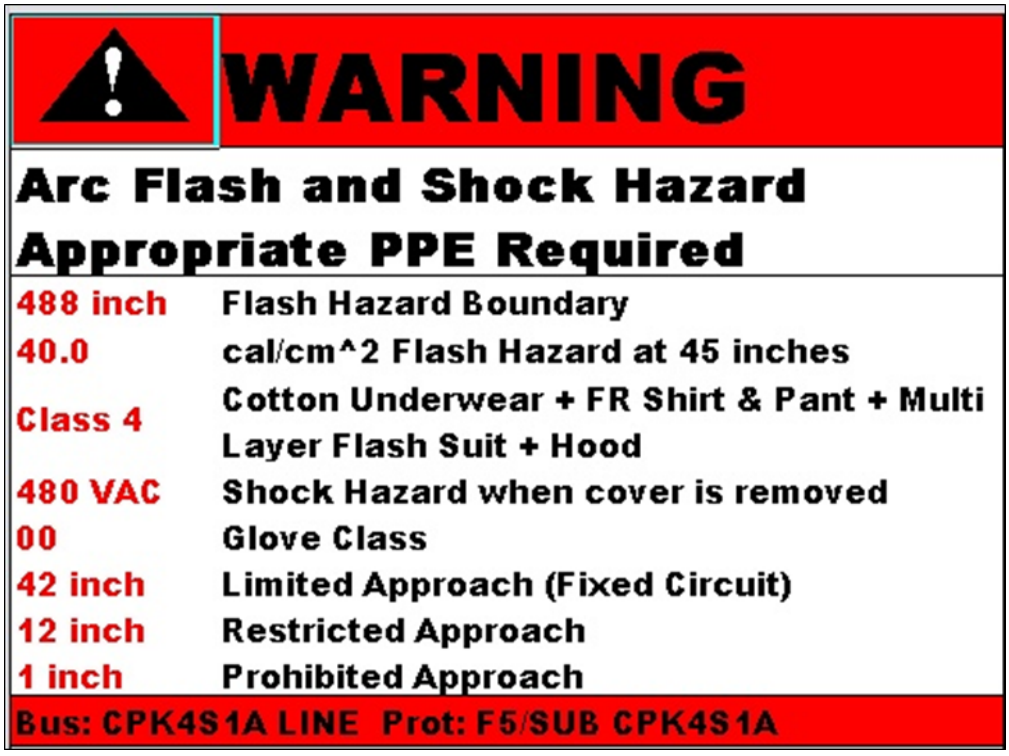
D. Labels shall be machine printed, with no field markings

E. Arc flash labels shall be provided in the following manner and all labels shall be based on recommended overcurrent device settings

1. For each 480 and applicable 208-volt panelboard, one arc flash label shall be provided
2. For each motor control center, one arc flash label shall be provided
3. For each low voltage switchboard, one arc flash label shall be provided
4. For each switchgear, one flash label shall be provided
5. For medium voltage switches one arc flash label shall be provided.

F. Labels shall be field installed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion

G. Example of Arc Flash Warning Label:



3.03 ADJUSTEMENT/CALIBRATION

A. Adjust relay and protective device settings according to the recommended settings table provided by the coordination study. Field adjustments to be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion

B. Make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies

C. Notify Owner in writing of any required major equipment modifications

3.04 TRAINING

A. The contractor of the Arc Flash Hazard Analysis shall train the owner's qualified electrical personnel of the potential arc flash hazards associated with working on energized equipment (minimum 4 hours). The training shall be certified for continuing education units (CEU's) by the International Association for Continuing Education Training (IACET) or equivalent

END OF SECTION

Section 16230

Emergency Generator

PART 1. GENERAL

1.01 SUMMARY

A. This specification is confidentially issued for this specific project only

B. Contractor shall be responsible for reading all specifications from all disciplines prior to bid

C. A complete generating system and all related equipment, including cooling system, coolant pumps, expansion tanks, valves, piping lubricating systems, fuel system components, miscellaneous devices and all required appurtenances shall be built, tested, furnished, installed, and site tested by the generator Manufacturers Supplier and/or Local Representative. It is the Generator Suppliers responsibility that any and all electrical and mechanical parts of the complete generator system that Supplier sub-assigns for installation by another Contractor be accounted for, approved and coordinated by said Generator Supplier. Any additional electrical and/or mechanical equipment or devices required for the specific generating system for this project shall be accounted for in Supplier and Contractor's bid where or not shown in plan and specifications details for this project

D. Listing of acceptable Equipment Manufacturers does not limit or remove the intent of these specification requirements

E. Any and all exceptions to the published specifications shall be subject to the approval of the engineer

F. The equipment shall be produced by a manufacturer who has produced this type of equipment for a period of at least 10 years and who maintains a service organization available twenty-four hours a day throughout the year.

G. The equipment shall be supported by a local distributor who has had local facilities for at least 5 years and who maintains a local service organization available twenty-four hours a day throughout the year.

1.02 SCOPE OF WORK

A. The generator for this specific project is to be provided by owner and installed by contractor. Contractor shall ensure testing for functional operation of existing generator prior to taking ownership. Upon acceptance testing, contractor takes full responsibility of generator functionality until lift station site handover. Where generator experiences failure after handover to contractor, contractor shall be solely responsible to repair/replace at no additional cost to owner.

1.03 REFERENCES

A. All material and equipment supplied under this specification shall be designed, assembled, tested, and conform in full compliance with the latest edition of the following codes and standards:

1. UL – Underwriters' Laboratories
2. NEMA - National Electronic Manufacturers Association
3. ASA - American Standards Association
4. ANSI - American National Standards Institute
5. CSA C22.2, No. 14-M91 Industrial Control Equipment.
6. EN50082-2, Electromagnetic Compatibility-Generic Immunity Requirements, Part 2: Industrial.
7. EN55011, Limits and Methods of Measurement of Radio Interference Characteristics of Industrial, Scientific and Medical Equipment.
8. IEC8528 part 4, Control Systems for Generator Sets.
9. IEC Std 61000-2 and 61000-3 for susceptibility, 61000-6 radiated and conducted electromagnetic emissions.
10. IEEE446 Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications.
11. NFPA 70, National Electrical Code, Equipment shall be suitable for use in systems in compliance to Article 700, 701, and 702.
12. NFPA 99, Essential Electrical Systems for Health Care Facilities.
13. NFPA 110, Emergency and Standby Power Systems. The generator set shall meet all requirements for Level 1 systems. Level 1 prototype tests required by this standard shall have been performed on a complete and functional unit. Component level type tests will not substitute for this requirement.

B. The generator set shall be ETL certified to UL 2200 standards or submitted to an independent third-party certification process to verify compliance as installed.

C. Generator system shall comply with all EPA, state and local requirements. Where generator size shown on plans is not properly rated, the next size up shall be supplied

1.04 SUBMITTALS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

B. The following items are required of the successful bidder prior to manufacture:

1. Bill of material describing all components and recommended spare parts with pricing and delivery
2. Schematic and wiring diagrams of the electrical system showing all factory wiring and clearly indicating wiring and voltage of any electrical strip heaters.

Also, submit fully detailed inter-connection drawings indicating each individual connection to any remote equipment, including a separate connection drawing to show point-to-point electrical wiring connections

3. Drawings and/or literature describing auxiliary equipment to be furnished.
4. Foundation design for each location

PART 2. PRODUCTS

2.01 ENGINE START/STOP CONTROLS

A. The engine controls shall be provided with bypassing of the low oil pressure shutdown circuitry during start-up.

B. If unit fails to start in an appropriate time (normally 30 seconds), the starting circuit shall shut down for an appropriate time (approximate 10 seconds) and then repeat the start cycle. If the unit still fails to start after approximately four start attempts, the over crank alarm shall activate, and the starting circuit shall shut down.

C. The engine start/stop control shall be static solid state.

2.02 GENERATOR CONCRETE FOUNDATION

A. Provide concrete pad as shown on plans. Use 3000-psi concrete with #5 rebar 12” O.C. Coordinate pad construction with generator drawings and weight

2.03 GENERATOR ACCESS

A. Where generator controls or enclosure step-up height is greater than 18 inches above grade, Contractor shall provide concrete or galvanized steel steps for access to controls or to enclosure

2.04 GENERATOR MONITORING SYSTEM

A. Provide interface to the generator solidstate controller and route data signal (ModBus TCP) to data switch as shown on plans.

B. Provide all software, programming, and devices required for monitoring trouble status, run status, alternator loading, fuel tank level, and all other available status signals. Provide HMI templates for display on SCADA HMI. Route data cable to monitoring station PLC via Ethernet switch as shown on plans. Assist in setting up system during construction, testing, demonstrations to Owner, and final inspection

C. Provide all addressing information needed to display all alarm, function, and status information at PLC HMI. Send information on CD or via e-mail to Engineer

D. Provide and install separate conduit with control and wire integrity monitoring wire from main power conductors. Where not shown on drawings, contractor shall provide and install separate conduit per this specification and latest requirements of NEC.

2.05 GENERATOR INSTALLATION

A. Contractor shall consult with Generator Manufacturer on all aspects of generator installation to assure all work is proper and professional

2.06 STORAGE

A. Where generator is stored on site prior to installation, provide any heating or other measures required to prevent moisture accumulation in high humidity areas. Consult Manufacturer for requirements

2.07 INHIBIT RELAYS

A. Where generator is not designed to carry full load of motors, provide inhibit relay for each motor starter over 5 horsepower to inhibit motor starter operation when generator runs. Relay is to be energized by generator run signal from ATS or generator. Provide bypass switch across the inhibit relay contacts to allow selected motors to run on generator power

2.08 GENERATOR ACCESSORIES AND MISCELLANEOUS EQUIPMENT

A. Contractor shall provide power, control, and instrument circuits as well as all fuel source piping and devices, cooling equipment, pumps, and related appurtenances, and all accessory equipment that is standard factory component supplied by the generator manufacturer.as part of this installation. Contractor shall coordinate all requirements with generator vendor and include all materials and design in bid cost

2.09 SIGNAGE

A. Provide all signage shown on drawings and required per NEC.

2.10 ACCESSORIES

A. Remote Annunciator. Flush Mount Remote Annunciator meeting NFPA-110 requirements.

B. Remote Emergency Stop Switch. Break-Glass Type

PART 3. EXECUTION

3.01 TESTING

A. Prior to acceptance of the installation, the equipment shall be subjected to an onsite cold start block test at 100% load followed by 4-hour resistive load bank test with a minimum of 2 hours at 100% load. All consumables necessary for this test operation shall be furnished by the contractor. Any defects which become evident during this test shall be corrected by the contractor at this own expense. All testing shall be performed by the contractor and witnessed by owner. Test equipment must be calibrated within the previous 12 months

B. Perform startup test to ensure all systems work properly together to include transfer switches, annunciator panel and other associated accessories

C. The manufacturer's distribution representative shall perform an installation check, startup, and 4-hour full load test utilizing a resistive type load bank. The engineer, regular operators, and the maintenance staff shall be notified of the time and date of the site test. The tests shall include:

1. Utilizing a resistive load bank, load test the generator set as follows:
    a. Load should be applied as 50% of the generator name plate output for the first 30 minutes, 75% of the generator name plate output for the next 30 minutes, 100% of the generator name plate output for the next 60 minutes, for a total run time of least 2 hours
    b. Fuel, lubricating oil, and antifreeze shall be checked for conformity to the manufacturer's recommendations, under the environmental conditions present and expected.
    c. Accessories that normally function while the set is standing by shall be checked prior to cranking the engine. These shall include block heaters, battery chargers, alternator strip heaters, remote annunciators, etc.
    d. Generator set startup under test mode to check for exhaust leaks, path of exhaust gases outside the building, cooling air flow, movement during starting and stopping, vibration during operation, normal and emergency line-to-line voltage and frequency, and phase rotation.
    e. Automatic start by means of a simulated power outage to test remote-automatic starting, transfer of the load, and automatic shutdown. Prior to this test, all transfer switch timers shall be adjusted for proper system coordination. Engine coolant temperature, oil pressure, and battery charge level along with generator set voltage, amperes, and frequency shall be monitored throughout the test.
    f. At a minimum, record the following at least every 15 minutes during the test:
        i. Time
        ii. Frequency (Hz)
        iii. Battery voltage (DC)
        iv. Voltage (AC-L1, L2, L3)
        v. Coolant Temperature
        vi. Power Factor (1.0)
        vii. Ambient temperature
        viii. KW
        ix. Exhaust temperature
        x. Load percentage

D. Field Tests

1. Units shall be factory tested under design conditions. Purchaser, at his option, may witness test. Vendor shall give one (1) week notice before test is made
2. Perform field tests at the site after installation is complete and in the presence of the Owner's representative to verify that unit meets start up sequences listed
3. Manufacturer's Representative shall conduct field tests after electrical installation is completed and shall provide a certified report of these tests for the Owner and Engineer. The tests shall include sequential stating of all motor loads and recording the voltage dip as each motor starts. This report shall be sent to Engineer no less than 10 working days prior to "Final Acceptance" testing. Operation of system shall be demonstrated to Owner and Engineer by the Representative during setup tests and at final inspection and testing
4. Load testing shall be performed using a reactive load bank sized to simulate all loads running with largest load then applied. Provide written report of tests for Engineer's review
5. The following minimum work shall be performed by the Contractor and Manufacturer's Representative under the technical direction of the manufacturer's service representative. Allow for a minimum of twelve (12) days for factory technician including all expenses for the following services:
   a. Inspection and final adjustments for startup, and acceptance testing.
   b. Operational and functional test of controllers.
   c. Participation in commissioning services. Technical representative shall be present for duration of commissioning test related to vendor equipment
6. The contractor shall provide three (3) copies of the manufacturer's field start-up report before final payment is made

3.02 LOAD LIMITING

A. Where generator is not sized to carry all motor loads simultaneously, Contractor shall provide inhibit relays and bypass switches to prevent operation of selected loads when on standby power

3.03 INSTALLATION

A. Installation of generator shall be according to Manufacturer's instructions and shall be witnessed and inspected by Manufacturer's Representative

B. Do not install vibration isolation rubber pads at random locations under skids. Place continuous pad, that is width of skids or, do not place at all. Manufacturer is to advise on this requirement.

C. Install on concrete pad that is sloped to avoid any standing water under generator or skids. Standing water test will be conducted and where water stands, the concrete slab shall be reworked to provide satisfactory installation.

D. Generator frame is to be bonded to ground grid via exothermic welded connection with 2/0 bare cu conductor (minimum)

E. Fuel source piping shall be stubbed up in PVC sleeve and routed under generator pad to proper location. Confirm exact location of stub-up in generator with manufacturer

F. Refer to grounding specification for additional requirements.

3.04 FIRE EXTINGUISHER

A. Provide two (2) high quality portable fire extinguishers noted for diesel fuel fire suppression. Provide mounting brackets and install on both sides of the enclosure doors located in the electrical control panel area. Coordinate location with Owner.

3.05 EAR PROTECTION

A. Provide dispenser with disposable ear protection devices on inside of generator enclosure near entry at controls section

3.06 FUEL REQUIREMENTS

A. Contractor shall provide all fuel required for use during the construction phase. Fuel tank shall be full when the facility is turned over to the Owner after final acceptance

END OF SECTION

Section 16261

Automatic Transfer Switch

PART 1. GENERAL

1.01 SUMMARY

A. This specification is confidentially issued for this specific project only

B. Contractor shall be responsible for reading all specifications from all disciplines prior to bid

C. Contractor shall contact local Factory Representative to verify all equipment purchased conforms to the requirements of this project. Failure to do so may result in equipment removal and replacement at Contractor's expense

D. Under no conditions shall transfer switch ampacity be rated less than main service breaker ampacity

E. Transfer switches with cable linkage when in manual mode are not accepted. Coordinate power and controls with Generator Manufacturer where generator is shown on Plans

F. All equipment, instruments and devices provided for this project shall have means of protection from power line conditions such as surge, phase fail, or other line conditions that may damage equipment, instruments or devices furnished. It is vendors and manufacturers' responsibility to provide protective devices as required for maintaining warranty of furnished items and to assure no damage occurs from power line conditions

1.02 SCOPE OF WORK

A. An automatic transfer switch shall be installed and rated at 480 Volts and 60 HZ and be mechanically held and electrically operated by a single solenoid mechanism energized from the source to which the load is to be transferred and capable of manual operation by one person. The switch shall be mechanically and electrically interlocked to ensure one of the two positions - normal or emergency. The switch shall be applicable to 50 Hz or 60 Hz and suitable for all common voltages from 110 to 600. Switch shall be service entrance rated and housed in a NEMA 4X 316 stainless steel enclosure and shall conform with the provisions of underwriter's Laboratories 1008 Standards and meet the National Electric Code (NEC) requirements for critical applications.

B. Accessories- Transfer switches shall be equipped with the following accessories:

C. Time delay to retransfer to normal power source: Time delay to be provided for retransfer from emergency power to normal power (if restored and within acceptable operating parameters). This time delay is to be automatically bypassed in the event the emergency source fails and normal power is available. Retransfer time delay to be field adjustable from 0-30 minutes.

D. Unit to be shipped with the initial transfer to normal power source time delay set at 5 minutes.

E. Time delay on engine cooling, (fixed, non-adjustable 5 minutes, -1 to +2 minutes tolerance)

F. Time delay on engine starting, (adjustable 0.5 to 60 seconds)

G. A test switch to simulate a normal power source failure

H. Pilot contact to initiate engine starting control.

I. Pilot lights to visually indicate the transfer switch position

J. Relay contacts as required plus one spare set of normally open and normally closed relay contacts

K. Provide solid state exerciser clock to set the day, time, and duration of generator set exercise/test period. Provide a with/without load selector switch for the exercise period.

1.03 REFERENCES

A. National Fire Protection Association (NFPA): NFPA 70 - National Electrical Code (NEC)

B. National Electrical Manufacturers Association (NEMA): NEMA ICS 2-447- AC Automatic Transfer Switches

C. Underwriters Laboratories (UL): UL 1008 - Standard for Automatic Transfer Switches

1.04 SUBMITTALS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

B. Submit all products covered under this specification for engineer’s approval. Contractor shall submit transfer switch data to power company for approval prior to submitting to engineer

C. Manufacturer shall submit shop drawings for review, which shall include the following, as a minimum:

1. Descriptive literature
2. Plan, elevation, side, and front view arrangement drawings, including overall dimension, weights and clearances, as well as mounting or anchoring requirements and conduit entrance locations.
3. Installation exhibit showing dimension and spacing between existing equipment
4. Schematic diagrams
5. Wiring diagrams
6. Accessory list

7. Training outline
8. Manufacturers testing reports as requested

PART 2. PRODUCTS

2.01 MANUFACTURER'S

A. ASCO

B. Cummins

C. Eaton

D. Five Star Electric

E. Lexington Zenith

F. Russelectric

G. Generator manufacturer provided ATS, or equal, as pre-approved in writing. No substitutions allowed except where pre-approved in writing by Engineer

H. Listing of acceptable Manufacturers does not relieve obligation of conditions described in this Specification Section

2.02 CONSTRUCTION

A. General:

1. The delayed transition automatic transfer switch shall be furnished as shown on the drawings. Voltage and continuous current ratings and number of poles shall be as shown. Switches shall be UL listed in accordance with UL-1008

Where transfer switch is shown on one-line diagram or on details as installed directly after service head and, where no overcurrent protection precedes the transfer switch, a service rated, breaker type switch shall be provided

Ampacity of transfer switch contacts shall be rated equal or greater than ampacity of main service breaker. No exceptions

2. On 3 phase, 4 wire systems, utilizing ground fault protection downstream of the transfer switch, a true 4-pole switch shall be supplied with all four poles mounted on a common shaft. The continuous current rating and the closing and withstand rating of the fourth pole shall be identical to the rating of the main poles and shall have quick-break contacts. See plans for 4 pole requirements. This requirement does not apply for water and wastewater facility installation

3. The transfer switch shall be mounted in a NEMA 4X 316 S.S. for outdoors, unless otherwise indicated. Indoor enclosures shall be fabricated from 12-gauge steel. The enclosure shall be sized to exceed minimum wire bending space required by UL 1008. Outdoor enclosures shall have no exposed controls. Fabricated covers over exposed controls are not allowed. Controls shall be located on inner door of automatic transfer switch. Enclosure shall

have three (3) point latching handle with locking hasp. Where shown on plans in MCC, transfer switch enclosure shall match MCC enclosure

4. The transfer switch shall be equipped with an internal welded steel pocket, housing an operations and maintenance manual
5. The transfer switch shall be top and bottom accessible
6. The main contacts shall be capable of being replaced without removing the main power cables, or removing incoming normal power from service rated transfer switches
7. The main contacts shall be visible for inspection without any major disassembly of the transfer switch
8. All bolted bus connections shall have Belleville compression type washers
9. When a solid neutral is required, a fully rated bus bar with required AL-CU neutral lugs shall be provided. All grounding and neutral conductors shall be terminated and labeled per article 250 of latest edition of National Electrical Code
10. Control components and wiring shall be front accessible. All control wires shall be multi-conductor 18-gauge 600-volt SIS switchboard type point-to-point harness. All control wire terminations shall be identified with tubular sleeve-type markers
11. The switch shall be equipped with 90 degrees C rated copper/aluminum solderless mechanical type lugs
12. The complete transfer switch assembly shall be factory tested to ensure proper operation and compliance with the specification requirements. A copy of the factory test report shall be available to engineer with ATS submittal upon request
13. Transfer time shall be of sufficient duration to allow motor run controls to drop out or, Contractor shall provide additional time delay controls in the neutral position, both directions of transfer to accomplish this function
14. Provide 480: 120/240-volt, single phase transformer and all required circuit breakers to provide low voltage power to all generator heaters, controls, etc. Feed from load motor control center or, from side of ATS where shown on plans
15. All power and control circuits to have circuit breakers for overcurrent protection. Fuses are not acceptable. No Exceptions
16. All doors on outdoor enclosures shall have door restraints, 3-point latching handle and locking hasp. Keyed handles are not acceptable
17. No devices or controls are to be installed on outer door of outdoor enclosures or where NEMA 4X rated
18. Provide generator status annunciator with voltage, current, and phase indicators and run time (non-resettable) elapse time meter in panel (door) of indoor transfer switch. Provide nameplate. Flush mount annunciator. Where

ATS is located outdoors or in NEMA 4 X enclosure, mount status annunciator in inner door panel. Installation to be completed by ATS Factory Technician

19. Install Generator Manufacturer furnished alarm annunciator panel on wall near ATS or as shown on plans
20. All circuit breakers shall be covered. No exposed circuit breakers. No exceptions
21. Provide heater with thermostat control in all enclosures. Route 120 VAC circuit from LVP. Provide circuit breaker
22. Provide all power supplies required to operate transfer switch
23. Where transfer switch contains two circuit breakers, and where service breaker serves as main breaker, the transfer switch shall be UL listed, “Service Rated,” and acceptable to Power Company

B. Automatic Transfer Switch:

1. The transfer switch shall be double throw, actuated by two electric operators momentarily energized, and connected to the transfer mechanism by a simple over center type linkage. Cable linkage mechanism is not acceptable
2. The normal and emergency contacts shall be positively interlocked mechanically and electrically to prevent simultaneous closing. Main contacts shall be mechanically locked in both the normal and emergency positions without the use of hooks, latches, magnets, or springs, and shall be silver-tungsten alloy. Separate arcing contacts with magnetic blowouts shall be provided on all transfer switches. Interlocked, molded case circuit breakers or contactors are not acceptable unless specifically shown on Plans, or pre-approved in writing
3. The transfer switch shall be equipped with a safe external manual operator, designed to prevent injury to operating personnel. The manual operator shall be front accessible and shall provide “quick make-quick break” operation, offering the same contact-to-contact transfer speed as the electrical operator to prevent switching the main contacts slowly. The external manual operator shall be UL listed for operation, under load, from the outside of the transfer switch while the door is closed. Door shall have 3-point latching handle. No automatic transfer switch enclosure shall be installed without door; Exerciser timer shall be readily accessible to operator
4. Circuit breakers used for service rated transfer switches shall be mechanically or electrically interlocked in a manner acceptable to the local Power Company
5. Provide all AC and/or DC power supplies required for transfer switch operation. Provide separate batteries and charger where operation requires separate power source independent of normal or generator power sources

C. Automatic Transfer Switch Controls:

1. The transfer switch shall be equipped with a microprocessor-based control system, to provide all the operational functions of the automatic transfer switch. The controller shall have two asynchronous serial ports. The controller shall have a real-time clock with battery backup
2. The CPU shall be equipped with self-diagnostics, which perform periodic checks of the memory I/O, and communication circuits, with a watchdog/power fail circuit
3. The controller shall have industry standard ethernet port connections for communicating with future industrial control system controller via a ethernet data switch
4. The Ethernet communication port shall allow interface to the Manufacturers and/or the Owner's furnished remote supervisory control. Provide all software, programming, testing, and cables and hardware for a complete operating system. Coordinate with SCADA Provider and Programmer and assist in setting up system. Provide all addresses, HMI templates, and function descriptions for Programmer's use. Functions shall include status of all operating time settings such as transfer time, transition delays, etc.
5. The controller shall have password protection required to limit access to qualified and authorized personnel
6. The controller shall include human machine interface with keypad allowing access to the system for generator exercising and time delay modifications
7. The controller shall include three phase over/under voltage, over/under frequency, phase sequence detection and phase differential monitoring on both normal and emergency sources
8. The controller shall store the following records in memory for access either locally or remotely:

   Number of hours transfer switch is in the emergency position

   Number of hours emergency power is available

   Total transfer in either direction

   Date, time, and description of the last four source failures

   Date of the last exercise period

   Date of record reset (where applicable)

D. Sequence of Operation:

1. When the voltage on any phase of the normal source drops below 80% or increases to 120%, or frequency drops below 90%, or increase to 110%, or 20% voltage differential between phases occurs, after a programmable time delay period of 0-300 seconds factory set at 3 seconds to allow for momentary dips, the engine starting contacts shall close to start the generating plant
2. The transfer switch shall transfer to emergency when the generating plant has reached specified voltage and frequency on all phases

3. After restoration of normal power on all phases to a preset value of at least 90% to 110% of rated voltage, and at least 95% to 105% of rated frequency, and voltage differential is below 20%, an adjustable time delay period of 0-3600 seconds (factory set at 300 seconds) shall delay retransfer to allow stabilization of normal power. If the emergency power source should fail during this time delay period, the switch shall automatically return to the normal source
4. After retransfer to normal, the engine generator shall be allowed to operate at no load for a programmable period of 0-3600 seconds, factory set at 300 seconds

E. Automatic Transfer Switch Accessories:

1. Programmable three phase sensing of the normal source set to pick up at 90% and dropout at 80% of rated voltage and overvoltage to pick up at 120% and dropout out at 110% of rated voltage. Programmable frequency pickup at 95% and dropout at 90% and over frequency to pick up at 110% and dropout at 105% of rated frequency. Programmable voltage differential between phases, set at 20%, and phase sequence monitoring
2. Time delay for override of momentary normal source power outages (delays engine start signals and transfer switch operation). Programmable 0-300 seconds. Factory set at 3 seconds, if not otherwise specified
3. Time delay to control contact transition time on transfer to either source. Programmable 0-120 seconds, factory set at 10 seconds
4. Time delay on retransfer to normal, programmable 0-3600 seconds, factory set at 300 seconds if not otherwise specified, with overrun to provide programmable 03600 second time delay, factory set at 300 seconds, unloaded engine operation after retransfer to normal. Time delay in neutral position of switch shall be adjustable 0-300 seconds
5. Time delay on transfer to emergency, programmable 0-300 seconds, factory set at 1 second.
6. A maintained type load test switch shall be included to simulate a normal power failure, keypad initiated.
7. A remote type load test switch shall be included to simulate a normal power failure, remote switch initiated.
8. A time delay bypass on retransfer to normal shall be included. Keypad initiated.
9. Contact rated 10 Amps 30 volts DC, to close on failure of normal source to initiate engine starting.
10. Contact rated 10 Amps 30 volts DC, to open on failure of normal source for customer functions
11. Light emitting diodes shall be mounted on the microprocessor panel to indicate switch is in normal position, switch is in emergency position, and controller is running

12. A plant exerciser shall be provided with ten (10) 7-day events, programmable for any day of the week and (24) calendar events, programmable for any month/day, to automatically exercise generating plant programmable in one-minute increments. Also include selection of either "no load" (switch will not transfer) or "load" (switch will transfer) exercise period. Keypad initiated with password. Provide means to observe and adjust settings locally and via data link to plant PLC controller
13. Provision to select either "no commit" or "commit" to transfer operation in the event of a normal power failure shall be included. In the "no commit position," the load will transfer to the emergency position unless normal power returns before the emergency source has reach 90% of its rated values (switch will remain in normal). In the "commit position", the load will transfer to the emergency position after any normal power failure. Keypad initiated
14. Two auxiliary contacts rated 10 Amp, 120 volts AC (for switches 100 to 800 amps) 15-amp, 120 volts AC (for switches 1000 to 4000 amps), shall be mounted on the main shaft, one closed on normal, the other closed on emergency. Both contacts will be wired to a terminal strip for ease of customer connections
15. A three-phase voltage readout, with 1% accuracy shall display all three phase-to-phase voltages simultaneously, for both the normal and emergency source
16. A frequency readout with 1% accuracy shall display frequency for both normal and emergency source
17. A readout shall display normal source and emergency source availability
18. Signal before transfer contacts.
19. Selector switch to allow transfer by manual push button or switch movement
20. Maintenance Selector Switch: For service rated transfer switches provide means to deactivate switch in "Normal," "Open," or "Emergency" positions when servicing internal parts of switch assembly. Provide means for locking out in any position
21. Provide means to temporarily switch off "All" control voltages that are tapped on the incoming power side of the Normal circuit break for maintenance purposes. This is to remove all live voltages during service of transfer switches
22. Provide all available "Options" for transfer switch

F. Ratings:

1. Delayed transition automatic transfer switches shall have the following 3-cycle short circuit closing and withstand as follows:

   a. RMS Symmetrical Amperes 480 VAC

Amperes	Closing and Withstand	Current Limiting Fuse Rating
100-400	42,000	200,000
600	50,000	200,000
800	65,000	200,000

1000-1200	85,000	200,000
1600-4000	100,000	200,000

2. During the 3-cycle closing and withstand tests, there shall be no contact welding or damage. The 3-cycle tests shall be performed without the use of current limiting fuses. The test shall verify that contacts separation has not occurred, and there is contact continuity across all phases. Test procedures shall be in accordance with UL-1008, and testing shall be certified by Underwriters' Laboratories, Inc
3. When conducting temperature rise tests to UL-1008, the manufacture shall include post-endurance temperature rise tests to verify the ability of the transfer switch to carry full rated current after completing the overload and endurance tests
4. The microprocessor controller shall meet the following requirements:
    a. Storage conditions - 25 degrees C to 85 degrees C
    b. Operation conditions - 20 degrees C to 70 degrees C ambient
    c. Humidity 0 to 99% relative humidity, non-condensing
    d. Capable of withstanding infinite power interruptions
    e. Surge withstand per ANSI/IEEE C-37.90A-1978
5. Manufacturer shall provide copies of test reports upon request

G. Provide means to remotely monitor switch positions via a data network. See electrical plans for additional requirements. Provide all programming, software and devices. Provide on CD all addressing information for starter, alarm, and functions available for display at future PLC HMI. Manufacturer’s Representative shall provide setup assistance during construction. Coordinate with Generator and Data Monitoring Systems Vendors to assure a unified power system

H. Manufacturer:

1. The transfer switch manufacturer shall employ a nationwide factory-direct, field service organization, available on a 24-hour a day, 365 days a year, call basis
2. The Manufacturer shall include an 800-telephone number, for field service contact, affixed to each enclosure
3. The manufacturer shall maintain records of each transfer switch, by serial number, for a minimum 20 years

I. Warranty: Provide Manufacturer’s standard full 5-year comprehensive extended coverage service. Warranty shall be “on site” and warranty service shall be available by the factory service department on an emergency basis if required. Depot or non-site warranties are not acceptable

J. Load Bank Controls:

1. Where load bank is required, provide all controls, contactors, and devices needed to exercise generator on load bank. Normal plant loads shall not be on generator during load bank operation of generator

2. Coordinate with Generator Vendor
3. Submit load bank controls data

K. Provide fiber optic connector interface where indicated on plans

L. Where transfer switches are used ahead of main breaker or include main breaker, unit shall be “service rated” and shall have normal service breaker rated for service ampacity

2.03 PROTECTION

A. All equipment installed on this project shall incorporate all devices and features to protect that equipment from the influence of other equipment, line voltage and phase irregularities, harmonics and other disturbances that may affect the proper and safe operation of that equipment whether these required features are a standard component of that equipment as an off-the-line product. No equipment shall be installed without these features

PART 3. EXECUTION

3.01 INSTALLATION

A. Automatic Transfer Switches shall be provided with adequate lifting means for ease of installation of wall or floor mounted enclosures

B. Provide access and working space as indicated or as required per latest edition of National Electrical Code

C. Where Contractor fails to protect automatic transfer switches before and after installation on site and where excessive dust is observed inside the enclosure, the Contractor shall have a factory warranty service technician clean, inspect and test unit, after which the factory shall issue a written and signed statement that full factory is in effect. There are no exceptions to this requirement except to replace entire unit at Engineer’s request

3.02 ADJUSTMENTS

A. Tighten assembled bolted connections with appropriate tools to manufacturer's torque recommendations prior to first energization

3.03 START-UP AND TESTING

A. Provide the services of a Factory Technician to checkout, adjust, set-up, test, and start-up the automatic transfer switch in conjunction with the standby generator. Fully function test the automatic transfer switch to verify proper operation

B. A Factory Technician shall be present for final acceptance testing and shall demonstrate unit operation to Engineer and Owner’s Representative

C. Factory Representative shall demonstrate operation of system to Owner and Engineer

D. Where items are not functional at time of generator start-up, generator manufacturer shall return for additional start-up and testing as required for a complete and thorough demonstration

3.04 TRAINING

A. Provide two (2) 4-hour training courses conducted by Manufacturer's Representative at a time approved by Owner and Engineer. Engineer may be present. Training shall include operation and required owner service and preventative maintenance. Operation and Maintenance Manuals shall be used during training for reference

3.05 WARRANTY

A. Contractor shall provide the Manufacturer's full 5-year comprehensive extended coverage service warranty on the generator installation and shall include all labor and materials required to repair or replace equipment and/or components that are defective or malfunctioning. Included under this warranty shall be all equipment, devices, hardware, and software

B. This warranty shall begin on date of written "Final Acceptance" of the electrical systems and to be executed as required at no additional cost to the Owner. Contractor's warranty shall also guarantee 24-hour service response time and shall provide labor, work, or materials as necessary to maintain plant operation when replacement parts are on order. In no case shall plant electrical systems be out of service for more than 24 hours from time Owner calls for warranty service

C. This shall be provided at no additional cost to the Owner. All equipment and materials installed shall have full warranty from Manufacturer that guarantees equipment is rated for harsh industrial electrical/mechanical environment in which it is installed. Where Manufacturer's products fail prematurely, Manufacturer shall be fully responsible for new replacement and shall not have the option of declaring that failures were caused by environmental conditions and its effect on the product

D. Contractor is fully responsible for assuring that Product Manufacturers are aware of this condition and that warranty statement is included in shop drawing submittals. Failure to do so will be at the Contractor's expense and at no additional cost to the Owner

E. All critical warranted repairs shall be made within 24 hours of receipt of required parts from Manufacturer with reasonable delivery time of overnight shipping. Any repairs not completed within 5 working days from date of notice are subject to Owner making other arrangements for repair and back charging Contractor. This requirement is a condition of this contract

F. Where equipment or instrument problems remain unresolved by Contractor beyond a reasonable time, a Factory Technician shall be provided on-site to take any corrective actions necessary to put equipment or instruments in operating order.

END OF SECTION

Section 16410

Enclosed Switches and Circuit Breakers

PART 1. GENERAL

1.01 SUMMARY

A. This specification is confidentially issued for this specific project only

B. Contractor shall be responsible for reading all specifications from all disciplines prior to bid

C. This section covers service disconnects, feeder disconnects, equipment disconnects, and enclosed circuit breakers

1.02 SUBMITTALS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

B. Product Data:

1. Submit for switches, circuit breakers, and accessories
2. Descriptive data and time current curves for protective devices and let through current curves for those devices with current limiting characteristics. Include coordination charts and tables, and related data

1.03 RECORD DRAWINGS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

1.04 OPERATIONS & MAINTENANCE MANUALS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

1.05 QUALITY ASSURANCE

A. Coordination: Contractor shall determine size, horsepower, voltage, and phase of all equipment to provide/adjust breaker and fused switch size accordingly. Failure to do so will be at expense of contractor at no additional cost to owner

PART 2. PRODUCTS

2.01 MANUFACTURER'S

A. Fusible Switches:

1. Eaton
2. Or approved equal

B. Fused Power Circuit Devices:
   1. Eaton
   2. Or approved equal
C. Boltswitch
D. Molded Case Circuit Breakers:
   1. Eaton
   2. Or approved equal
E. Combination Circuit Breaker and Ground Fault Trip:
   1. Eaton
F. Molded Case Current Limiting Circuit Breakers:
   1. Eaton

2.02 ENCLOSED SWITCHES

A. Enclosed Non-fusible Switch: NEMA KS 1, Type HD handle lockable with 2 padlocks
B. Enclosed Fusible Switch, 800 Amperes and Smaller: NEMA KS 1, Type HD, clips to accommodate specified fuses, enclosure consistent with environment where located, handle lockable with two (2) padlocks, and interlocked with cover in CLOSED position
C. Enclosed Fusible Switch Larger Than 800 Amperes: Bolted pressure or high-pressure contact switch, bus drilled to accommodate specified fuses, enclosure consistent with environment where located
   1. Minimum Fault Current Rating: 100,000 symmetrical rms amperes.
D. All enclosures located outdoors or where subject to wet or environmentally harsh locations shall be NEMA 4X 316 stainless steel
E. All switches shall be rated at 600 volts minimum.
F. Handle operator mechanisms shall be on side of enclosure and not on front. Keyed mechanisms that separate handle from breaker mechanism when door is opened are not acceptable

2.03 ENCLOSED CIRCUIT BREAKERS

A. Enclosed Molded Case Circuit Breaker: NEMA AB 1, handle lockable with 2 padlocks
B. Characteristics:
   1. Frame size, trip rating, number of poles, and auxiliary devices as indicated
   2. Interrupting capacity rating to meet available fault current, 10,000 symmetrical rms amperes minimum

3. Appropriate application listing when used for switching fluorescent lighting loads or heating, air conditioning, and refrigeration equipment

C. All enclosures located outdoors or where subject to wet or environmentally harsh locations shall be NEMA 4X 316 stainless steel

2.04 ACCESSORIES

A. Solid state breaker requiring programming unit for settings adjustment

1. Provide new programming unit and all accessories for Owner and Engineers use. Turn over to Engineer for review and testing

B. Original set-up and adjustments shall be performed by the Circuit Breaker Manufacturers Factory Representative

2.05 TRIP UNITS

A. All service and feeder breakers shall have replaceable trip plugs, adjustable, or electric type with adjustable trips

PART 3. EXECUTION

3.01 INSTALLATION

A. Install enclosed switches and circuit breakers in locations as indicated, according to Manufacturer's written instructions

B. Install enclosed switches and circuit breakers level and plumb

C. Install wiring between enclosed switches and circuit breakers and control/indication devices

D. Connect enclosed switches and circuit breakers and components to wiring system and to ground as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts according to equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torqueing requirements are not indicated, tighten connectors and terminals according to tightening torques specified in UL Standard 486A

3.02 ADJUSTEMENT/CALIBRATION

A. Set field adjustable enclosed equipment trip ranges as recommended by manufacturer

END OF SECTION

Section 16415

Surge Suppression

PART 1. GENERAL

1.01 SUMMARY

A. This specification is confidentially issued for this specific project only

B. Contractor shall be responsible for reading all specifications from all disciplines prior to bid

C. This section describes the requirements for low-voltage AC surge protective devices (SPD's) for various service and electrical equipment

D. All equipment described herein shall be submitted, and factory installed, as an integral part of equipment specified in overall construction documents

1.02 PRICE AND PAYMENT PROCEDURES

A. No separate payment for work performed under this section. Include cost for surge suppression in overall electrical equipment

1.03 REFERENCES

A. This specification references the following publications in their current editions. The publications are referred to in the text by basic designation only

1. DLA MIL-STD-220C: Method of Insertion Loss Measurement
2. IEEE C37.90.1: Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
3. IEEE C62.41.2: Recommended Practice on Characterization of Surges in Low Voltage (1,000 V and Less) AC Power Circuits
4. IEEE C62.45: Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1,000 V and Less) AC Power Circuits
5. NFPA 70: National Electrical Code (NEC) - Article 285 UL 67: UL Standard for Safety Panelboards
6. UL 845: UL Standard for Safety Motor Control Centers UL 891: UL Standard for Safety Switchboards
7. UL 1283: UL Standard for Safety Electromagnetic Interference Filters
8. UL 1449: UL Standard for Safety Surge Protective Devices
9. UL 1558: UL Standard for Safety Metal-Enclosed Low Voltage Power Circuit Breaker Switchgear
10. UL 67: UL Standard for Safety Panelboards
11. UL 845: UL Standard for Safety Motor Control Centers

12. UL 891: UL Standard for Safety Switchboards
13. UL 1558: UL Standard for Safety Metal-Enclosed Low Voltage Power Circuit Breaker Switchgear
14. All SPDs and their installation shall comply with the requirements of the National Electric Code and Underwriters Laboratories (UL) where applicable
15. Each specified device shall also conform to the standards and codes listed in overall construction documents
16. Refer to general work and all relevant specifications in construction documents for additional requirements and coordination
17. Refer to submittal requirements in other specifications for full requirements
18. Refer to O&M manual requirements in other specifications for full requirements

1.04 SUBMITTALS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

B. Submit catalog data for all items supplied from this section as applicable. Submittal shall include at minimum:

1. Cut sheets
2. Functions
3. Ratings
4. Inputs
5. Outputs
6. Displays
7. Dimensional drawings of each SPD type
8. UL 1449 documentation
9. Compliance documentation with Nationally Recognized Testing Laboratory (NRTL)
10. UL 1283 documentation
11. IEEE C62.41.2 and IEEE C62.45, Category C3 (20kV-1.2/50, 10kA-8/20µs waveform) clamping voltage test results
12. All other information required to confirm SPD conforms to all requirements

1.05 OPERATIONS & MAINTENANCE MANUALS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

1.06 QUALITY ASSURANCE

A. The manufacturer of this equipment shall have produced similar equipment for a minimum of five (5) years. Engineer may request a list of installations with similar equipment demonstrating qualifications

B. The manufacturer shall be the same manufacturer providing service entrance and distribution equipment where SPD's are to be installed

C. Equipment shall comply and be tested under the UL standards stated in reference section of this specification

D. Manufacturer shall be ISO 9001 or 9002 certified

1.07 SPARE PARTS

A. Provide one surge protective device per installed equipment on project

B. Deliver spare parts to operations and provide signed transmittal form to engineer

C. Lack of transmittal form may require providing additional equipment at no additional cost to owner where supply chain is broken

PART 2. PRODUCTS

2.01 APPROVED SPD TYPE 1 AND TYPE 2 MANUFACTURER'S

A. Eaton

B. General Electric

C. Schneider Electric

D. Allen Bradley

E. Citel

F. Or approved equal

2.02 APPROVED SPD TYPE 3 MANUFACTURER'S

A. EDCO SLAC Series

B. Phoenix Contact

C. Citel

D. Siemens

E. Or approved equal

2.03 SERVICE ENTRANCE RATED EQUIPMENT (TYPE 1)

A. This type applies to switchgear, switchboards, panelboards, motor control centers, and other devices installed as service entrance equipment

B. Where a type 1 SPD installed on service entrance equipment, an additional type 2 SPD shall not be installed unless shown on plans

C. The SPD shall be of the same manufacturer as the electrical equipment installed

D. The SPD shall be integral to the equipment as a factory standardized design

2.04 DISTRIBUTION EQUIPMENT APPLICATIONS (TYPE 2)

A. This type applies to switchgear, switchboards, panelboards, motor control centers, and other devices installed as non-service entrance equipment

B. The SPD shall be of the same manufacturer as the electrical equipment installed

C. The SPD shall be integral to the equipment as a factory standardized design

D. The SPD shall be included and mounted within the equipment by the equipment manufacturer

E. The SPD shall be located within the panelboard, unless otherwise noted in plans

2.05 CONSTRUCTION

A. Overcurrent Protection: The unit shall contain thermally protected metal-oxide varistors (MOVs). The thermally protected MOVs shall have a thermal protection element packaged together with the MOV in order to achieve overcurrent protection of the MOV. The thermal protection element shall disconnect the MOVs from the system in a fail-safe manner should a condition occur that would cause them to enter a thermal runaway condition.

B. Maintenance Free Design: The SPD shall be maintenance free and shall not require any user intervention throughout its life. SPDs containing items such as replaceable modules, replaceable fuses, or replaceable batteries are not acceptable. SPDs requiring any maintenance of any sort such as periodic tightening of connections are not acceptable.

C. Balanced Suppression Platform: The surge current shall be equally distributed to all MOV components to ensure equal stressing and maximum performance. The surge suppression platform must provide equal impedance paths to each matched MOV. Designs incorporating replaceable SPD modules are not acceptable.

D. Electrical Noise Filter: Each unit shall include a high-performance EMI/RFI noise rejection filter. Noise attenuation for electric line noise shall be up to 50 dB from 10 kHz to 100 MHz using the DLA MIL-STD-220C insertion loss test method.

E. Local Monitoring: Visible indication of proper SPD connection and operation shall be provided. The indicator lights shall indicate which phase as well as which module is fully operable. The status of each SPD module shall be monitored on the front cover of the enclosure as well as on the module. A push-to-test button shall be provided to test each phase indicator. Push-to-test button shall activate a state change of dry contacts for testing purposes.

F. Surge Counter: The SPD shall indicate user how many surges have occurred at the location. The surge counter shall trigger each time a surge event with a peak

current magnitude of a minimum of 50 ± 20A occurs. A reset pushbutton shall also be standard, allowing the surge counter to be zeroed. The reset button shall contain a mechanism to prevent accidental resetting of the counter via a single, short-duration button press. To prevent accidental resetting, the surge counter reset button shall be depressed for a minimum of 2 seconds in order to clear the surge count total. The ongoing surge count shall be stored in nonvolatile memory or UPS backup.

G. Remote Monitoring: For remote monitoring, the SPDs shall provide the same discrete and analog signal and control functions as specified for local monitoring and the surge counter, to a terminal strip for outgoing connection to a PLC as shown on the Plans. The functions shall be converted as specified for interface to the monitored equipment.

H. The voltage surge suppression system shall incorporate thermally protected metal-oxide varistors (MOVs) as the core surge suppression component for the service entrance and all other distribution levels. The system shall not utilize silicon avalanche diodes, selenium cells, air gaps, or other components that may crowbar the system voltage leading to system upset or create any environmental hazards.

I. SPD shall be listed in accordance with UL 1449 and UL 1283

J. Integrated surge protective devices (SPD) shall be Component Recognized in accordance with UL 1449, Section 37.3.2 and 37.4 at the standard's highest short circuit current rating (SCCR) of 200 kA, including intermediate level of fault current testing.

K. SPD shall be tested with the ANSI/IEEE Category C High exposure waveform (20kV-1.2/50µs, 10kA-8/20µs).

L. SPD shall provide suppression for all modes of protection: L-N, L-G, and N-G in WYE systems (7 Mode).

2.06 RATINGS

A. Unit operating voltage: Refer to plans for operating voltage equipment and unit configuration

B. SPD shall be designed to withstand a maximum continuous operating voltage (MCOV) of not less than 115% of nominal RMS voltage measured on site

C. Minimum surge current rating shall be 240kA per phase (120kA per mode) for service entrance and 120kA per phase (60kA per mode) for distribution applications

D. Pulse life test: Capable of protecting against and surviving 5000 ANSI/IEEE category C high transients without failure or degradation of clamping voltage by more than 10%

E. Minimum UL 1449 withstand nominal discharge current (In) rating to be 20kA per mode

F. UL 1449 clamping voltage must not exceed the following: Voltage Protection Rating (VPR)

Voltage	L-N	L-G	N-G
204/120	1200/800V	800V	800V
208Y/120	800V	800V	800V
480Y/277	1200V	1200V	1200V
600Y/347	1500V	1500V	1500V

PART 3. EXECUTION

3.01 INSTALLATION

A. All equipment specified herein shall be factory installed, field adjusted, tested, and cleaned as an integral part of equipment specified in other equipment specification

B. Type 1 and 2 SPD's shall be grounded and bonded as a part of the individual equipment as specified in the individual equipment specifications

C. Type 3 shall be grounded and bonded in accordance with the SPD manufacturer's instructions

D. All monitoring and diagnostic features shall be visible from the front of the equipment

E. Provide and install a fully integrated component design: All SPD's components and diagnostics shall be contained within one discrete assembly

F. SPD's or individual SPD modules that must be ganged together to achieve higher surge current ratings

G. Furnish nameplates for each SPD as shown on plans

3.02 SERVICE ENTRANCE RATED EQUIPMENT (TYPE 1)

A. Service entrance located SPD's shall be tested and demonstrate suitability for application within IEEE C26.41.2 category C environments

B. Locate the SPD on the load side of the main disconnect device, as close as possible to the phase conductors and the ground/neutral bars

C. The SPD shall be connected through a UL approved disconnecting means. The disconnect shall be located in immediate proximity to the SPD

D. Connection shall be made via electrical bus, conductors, or other connections originating in the SPD and shall be kept as short as possible

3.03 DISTRIBUTION EQUIPMENT APPLICATIONS (TYPE 2)

A. Service entrance located SPD's shall be tested and demonstrate suitability for application within IEEE C26.41.2 category B environments

B. SPD's shall be installed immediately following the load side of the main breaker

C. SPD's installed in main lug only panelboards shall be installed immediately following the incoming main lugs

3.04 INDIVIDUAL EQUIPMENT PROTECTION (TYPE 3)

A. Locate the SPD on the load side of the ground and neutral connections

B. The SPD shall be connected through a UL approved disconnecting means. The disconnect shall be located in immediate proximity to the SPD

3.05 ADJUSTEMENT/CALIBRATION

A. Coordinate stabilized voltage levels within the project boundaries and provide product voltage rated equipment appropriate to avoid overvoltage

3.06 MAINTENANCE/WARRANTY

A. The manufacturer shall warrant the equipment to be free from defects in material and workmanship for ten (10) years from date of substantial completion

B. Within such period of warranty, the manufacturer shall promptly furnish all material and labor necessary to return the equipment to new operating condition

C. Any warranty work requiring shipping or transporting of the equipment shall be performed by the manufacturer at no expense to owner

END OF SECTION

Section 16416

Power Factor Correction

PART 1. GENERAL

1.01 SUMMARY

A. This specification is confidentially issued for this specific project only

B. Contractor shall be responsible for reading all specifications from all disciplines prior to bid

C. Refer to drawing details for mounting requirements

D. Install capacitors on all motors over 5 horsepower. Where motor starter is a solid state or variable frequency drive coordinate with manufacturer for power factor inclusion and sizing. Provide circuit breaker at bus for overcurrent protection

1.02 SUBMITTALS, RECORD DRAWINGS, AND O&M MANUALS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

B. Include calculations or motor data schedules used to determine capacitor size for each motor 5 horsepower and greater. Provide correction to minimum 0.96 and in no case greater than 0.99. Motors less than 25 horsepower with greater than 0.9 power factor and with solid state soft starters do not require correction

1.03 QUALITY ASSURANCE

A. Manufacturer Qualifications: Firms experienced in manufacturing equipment of types and capacities indicated that have record of successful in-service performance.

B. Items provided under this section shall be listed or labeled by UL or other Nationally Recognized Testing Laboratory (NRTL)

1. Term “NRTL” shall be as defined in OSHA Regulation 1910.7

2. Terms “listed” and “labeled” shall be as defined in National Electrical Code, Article 100

C. Regulatory Requirements:

1. National Electrical Code (NEC): Components and installation shall comply with National Fire Protection Association (NFPA) 70

1.04 SPARE PARTS

A. Extra Materials:

1. Furnish extra materials matching products installed, as described below, packaged with protective covering for storage, and identified with labels describing contents. Deliver extra materials to Owner

2. Fuses: Ten (10) of each type and rating
3. Blown Fuse Indicating Lamps: Ten (10) lamps of each type and rating

PART 2. PRODUCTS

2.01 CAPACITORS

A. Manufacturers:

1. Power Factor Correction Capacitors – General Use:
    a. Aerovox.
    b. ARCO Electric Products Corp.
    c. Myron Zucker, Inc.
    d. Square D Co.
    e. Cutler Hammer
    f. Siemens
    g. Or approved equal
2. Power Factor Correction Capacitor – Tray Mount:
    a. Tray mount by Myron Zucker Inc., for specific MCC Manufacturer.
    b. Pre-approved equal.

B. Capacitors: Comply with UL 819 and applicable requirements of NEMA CP1 and IEEE 18

C. Construction: Multiple capacitor cells or elements wired together in 3phase groups and mounted in metal enclosures

D. Capacitor Cells: Dry metalized dielectric, self-healing type. Each cell is encapsulated in thermosetting resin inside plastic container

E. Cell Rupture Protection: Equip each cell with an NRTL recognized pressure sensitive interrupter

F. Fuses for Protection of Capacitor Banks: Current limiting, non-interchangeable type, Factory installed in each phase and located within equipment enclosure. Features include:

1. Interrupting Capacity: 200,000 amperes
2. Fuse Ratings and Characteristics: As recommended by manufacturer for specific capacitor bank protected
3. Blown Fuse Indicator: Neon lamps for each fuse, connected to light when fuse has opened, and visible from outside enclosure

G. Enclosure: Steel or aluminum, arranged to contain fluid leakage from capacitor cells. Factory equip with mounting brackets suitable for type of mounting indicated

1. Indoor Enclosures: Dust tight or as indicated

2. Outdoor Enclosures: Gasketed doors or covers and equipped with watertight conduit connections
3. MCC tray mount in bucket spaces mounting required where MCC is used. Provide additional MCC sections as required

2.02 FIXED CAPACITORS

A. Integrally fused except as indicated, with quantities, ratings, mounting provisions and electrical connections as indicated

B. Discharge Resistors: Factory installed and wired

C. Internal Wiring: Completely factory wired, ready for field connection to external circuits at single set of pressure terminals

2.03 FACTORY FINISH

A. Finish: Manufacturer's standard enamel over corrosion resistant treatment or primer coat.

2.04 SOURCE QUALITY CONTROL

A. Factory test power factor correction equipment prior to shipment. Include following:

B. Routine capacitor production tests, including short time overvoltage test, capacitance test, leak test, and dissipation factor test

PART 3. EXECUTION

3.01 TESTING

A. Testing: Test system functions, operations, and protective features according to manufacturer's written instructions

B. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met

C. Measure power factor with appropriate instruments and provide report to Engineer for evaluation

3.02 INSTALLATION

A. Mount equipment as indicated. Do not mount over top of motor control centers or switchgear

B. Install fixed tray mount style capacitors in MCC bucket space near associated motor starter. Where MCC not used, install wall mount style capacitors with stainless steel brackets

1. Connect online side of motor starter overload elements and switch with motor.

2. Install fuse holders and fuses within capacitor enclosures

C. Maintain minimum working space at live parts according to manufacturer's written instructions

D. Install capacitor one (1) each motor, 5 horsepower and above

E. Provide contactor with circuit protection device, H.O.A. and time delay relay for capacitors connected to main power bus for solid-state starters. Do not connect capacitors directly to motor or on the load side of starter where solid-state or VFD starters are installed. Contractor shall shunt capacitor on MCC bus.

F. Provide drawing and detail of each capacitor installation and submit for Engineers approval of location and method of installation

3.03 CLEANING

A. Upon completion of installation, inspect system components. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish. Clean components internally using methods and materials recommended by manufacturer

END OF SECTION

Section 16420

Motor Controllers

PART 1. GENERAL

1.01 SUMMARY

A. This specification is confidentially issued for this specific project only

B. Contractor shall be responsible for reading all specifications from all disciplines prior to bid

C. This section covers motor controllers including; full voltage non-reversing, and solid state reverse voltage rated 600V and below

D. All motor controller unit manufacturer shall furnish, field test, adjust, calibrate, and certify all installed motor controllers' units for satisfactory operation

1.02 ADMINISTRATIVE REQUIREMENTS

A. Coordinate features of controllers and control devices with pilot devices and control circuits provided under other sections of Specifications covering control systems

B. Coordinate motor controls, starters and overcurrent devices with motor manufacturer's data. Provide motor manufacturer's data sheets to motor control manufacturer at time of order

1.03 REFERENCES

A. ANSI/NFPA 70 - National Electrical Code

B. NEMA ISC 1, Industrial Control Systems: General Requirements

C. NEMA ISC 2, Industrial Control Systems: Contactors and Overload Relays, rated not more than 2000 Volts AC or 750 Volts DC

D. NEMA ICS 6, Industrial Control Systems: Enclosures

E. UL 508 – UL Standard for Safety Industrial Control Equipment

F. UL 845 – UL Standard for Safety for Motor Control Centers

1.04 SUBMITTALS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

B. Product Data: Include dimensions, ratings, and data on features and components

C. Test Results: Certified reports of field tests and observations.

D. Miscellaneous: Load Current and Overload Relay Heater List: Compiled by Contractor after motors have been installed. Arrange list to demonstrate selection of heaters to suit actual motor nameplate full load currents

1.05 RECORD DRAWINGS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

1.06 OPERATIONS & MAINTENANCE MANUALS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

1.07 SPARE PARTS

A. Spare Fuses and Incandescent Indicating Lamps: Furnish one spare for every five (5) installed units, but not less than one set of three (3) of each kind

PART 2. PRODUCTS

2.01 MANUFACTURER'S

A. ABB

B. Eaton

C. SCHNEIDER

D. Or approved equal

2.02 MOTOR CONTROLLERS

A. Coordinate features of each motor controller with ratings and characteristics of supply circuit, motor, required control sequence, duty cycle of motor, drive, and load, and pilot device, and control circuit affecting controller functions. Provide controllers horsepower rated to suit motor controlled

B. NEMA Size 1 minimum

C. Contacts shall open each ungrounded connection to motor

D. Overload Relays:

1. Ambient-compensated type with inverse-time-current characteristic
2. Provide with heaters or sensors in each phase matched to nameplate full load current of specific motor to which connected with appropriate adjustment for duty cycle. Overload devices to require manual reset after tripping occurs
3. Enhanced Protection Overload Relay: Provide overload relays with NEMA Class 10 tripping characteristics for submersible equipment or where indicated. Select to protect motor against voltage unbalance and single phasing

E. Enclosures:

1. For individually mounted motor controllers and control devices, comply with NEMA 250
2. Provide enclosures suitable for environmental conditions at controller location
3. Provide NEMA Type enclosures as indicated or required to suit environment
4. where located
5. All enclosures for motor starters 100 hp and greater shall have forced cooling
6. All enclosures to have 120-volt space heaters
7. Provide door restraints for all inner and outer doors

F. Control Diagrams: Provide complete and accurate control diagrams and one-line diagram laminated in clear plastic and installed in door pockets of motor control center

2.03 MANUAL MOTOR CONTROLLERS

A. Quick-make, quick-break toggle action

B. Double break silver alloy contacts

C. Pilot light

D. Padlocking provision

2.04 MAGNETIC MOTOR CONTROLLERS

A. Full voltage, non-reversing, across-the-line, magnetic controller, except where another type indicated

B. Control Circuit: 120 volts. Control power transformer integral with controller where no other supply of 120-volt control power to controller indicated. Control power transformer with adequate capacity to operate connected pilot, indicating and control devices, plus 100% spare capacity

C. Combination Controller: Switch type; Circuit breaker or non-fused as indicated; quick-make, quick-break switch; factory assembled with controller and arranged to disconnect it. For fused switches, provide rejection type fuse clips and fuses rated as indicated

D. Combination Controller: Motor circuit protector; molded case circuit breaker type with magnetic only trip element calibrated to coordinate with actual locked rotor current of connected motor and controller overload relays. Provide breakers factory- assembled with controller, interlocked with unit cover or door, and arranged to disconnect controller. Provide motor circuit protectors with field-adjustable trip elements

E. Overvoltage/Undervoltage/Phase-Failure Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connection. Provide adjustable undervoltage setting

1. Provide in starter enclosure for Size 2 and larger starters
2. 2. Delay initial motor start
3. 3. Delay motor restart due to starter dropout caused by undervoltage or starter coil circuit interruption for maintained control circuit
4. Adjustable on delay from 0.15 to 30.0 sec set at 10.0 sec
5. Connect control relay in motor starter coil circuit
6. Coordinate control relay selection with motor starter to cause motor starter to drop out at voltage slightly higher than dropout voltage of starter and have dropout time slightly faster than motor starter to ensure if motor starter drops out, relay will drop out

F. For combination starter units provide interlocks so disconnect means must be in "Off" position before door can be opened and so door cannot be closed with disconnect means in "On" position, except by consciously operating permissive release devices. Rotating type operators located outside of door are not acceptable

2.05 SOLID STATE SOFT START

A. Manufacturer
1. Eaton
2. Schneider
3. General Electric
4. Siemens
5. ABB
6. Or approved equal

B. General description
1. Digital alphanumeric display panel mounted as shown on drawings
2. Digital control keypad to program controller and select parameters to view
3. Ethernet connection/calibration capabilities
4. Display basic functions to include starter status functions, motor status functions, and fault status functions.
5. Display running codes
6. Display error codes
7. Molded case circuit breaker for disconnecting means and emergency shunt trip
8. Line input isolation contactor

C. The soft starter shall utilize an SCR bridge consisting of at least two SCR's per phase

D. The soft starter shall be controlled by a microprocessor that continuously monitors the current and controls the phasing of the SCR's

E. A shorting contactor shall be standard, and all protective features and control options shall be available even when the shorting contactor is engaged

F. Construction

1. Units shall be of modular construction so that it is possible to readily interchange units of the same size without modifications to the motor control structure.
2. All conducting parts on the line side of the unit disconnect shall be isolated to prevent accidental contact with those parts.
3. Provisions shall be provided for locking the enclosure with owner's padlock.
4. A shorting contactor shall be supplied in each soft start controller unit to reduce temperature rise within the unit and enclosure. The shorting contactor shall be rated to carry the motor full load current during steady state after full voltage has been applied to the motor by the soft start.

G. Motor Data

1. The soft start controller unit shall be sized to operate the following AC induction motor:
   a. Motor horsepower: As indicated on the contract drawings.
   b. Motor full load ampere: As indicated on the contract drawings.
   c. Motor voltage: 480
   d. Motor service factor: 1.15

H. Environmental Ratings:

1. The soft start controller unit shall be housed in a NEMA Type 1 gasketed indoor motor control center type enclosure. Also reference specification 16482.
2. The soft start controller unit shall be designed to operate while mounted in an enclosure with an ambient temperature from 15 F to 110 F. Provide ventilation fan in MCC bucket.
3. The storage temperature range shall be -13 F to 158 F.
4. The maximum relative humidity shall be 95%, non-condensing.
5. The soft start controller unit shall be rated to operate at altitudes less than or equal to 3,300 ft.

I. Electrical Ratings:

1. The soft start controller unit shall be designed to operate from an input voltage between –10% and +10% of nominal voltage rating.
2. The soft start controller unit shall operate at 60Hz with a tolerance of + / - 5%.
3. The soft start controller shall be capable of supplying starting current of 300% of rated full load current, for minimum of 20 seconds.
4. The SCR's shall have a minimum repetitive peak inverse voltage (P.I.V) rating of 1800 Vac. Lower rated SCR's with MOV protection are not acceptable

J. Protection:

1. A microprocessor-based thermal protection system shall be included which calculates the temperature-rise of the motor and soft starter and provides:
    a. A motor overload pre-alarm that indicates by relay contact or logic output that the motor windings have exceeded 130% of its rated temperature rise. This function shall be for alarm only.
    b. A motor overload fault will stop the motor if the windings have exceeded 140% of temperature-rise.
    c. An electronic circuit with a time-constant adjustable to the motor's thermal cooling time- constant ensuring the memorization of the thermal state even if power is removed from the soft starter.
2. The soft starter shall provide line and motor phase loss, phase reversal, underload, stall, and jam protection.
3. The integral protective features shall be active even when the shorting contactor is used to bypass the SCRs during steady state operation. Shunt trip coil to trip disconnect in the event of a soft starter fault condition including a shorted SCR
4. The integral protective features shall monitor, alarm and trip, the motor based on the motor winding and bearing temperature reading

K. Adjustments & Configurations:

1. Digital indication shall provide, as a minimum, the following conditions:
    a. Soft starter status – ready, starting/stopping, run
    b. Motor status – current, torque, power factor, elapsed time, power in kW
    c. Fault status – Motor thermal overload, soft starter thermal fault, loss of line or motor phase, line frequency fault, low line voltage fault, locked rotor fault, motor underload, maximum start time exceeded, external fault, serial communication fault, line phase reversal fault, motor overcurrent fault
2. Output relays shall be programmed to provide the following status indications:
    a. One Form A (N.O.) minimum for indication of fault
    b. One Form A (N.O.) for indication that acceleration ramp is complete and current is below 130% motor FLA (ramp complete or motor at speed)
    c. One Form A (N.O.) assignable to one of the following functions: motor thermal alarm, motor current level alarm, and motor underload alarm
3. Additional inputs and outputs shall be available to provide the following status indications:
    a. Two assignable control inputs for the following functions: soft stop, pump control, kick start, linear ramp, dual motor or remote control
4. Relay and I/O functions listed above must be isolated with respect to common

5. All programming/configuration devices, display units, and field control wiring terminals shall be accessible on the front of the control module. Circuit boards or electrical power devices shall not be exposed during routine adjustments

L. Control Characteristics:

1. Starting:
   a. (Full load) Motor current: 40 to 100 % rated starter current
   b. Current limit: 300% motor full load current
   c. Linear (torque-controlled) acceleration ramp time: adjustable 0 to 60 seconds, preset to 15 seconds
2. Stopping:
   a. Coasting: Power removed from motor with no soft stop
   b. Brake time by ramp: Soft stop, 1 to 60 seconds, adjustable, independent of starting ramp

2.06 AUXILLARY CONTROL DEVICES

A. General: Furnish auxiliary control device as shown on 1line diagrams, Drawings, or as specified. Factory-install in controller enclosure except as otherwise indicated

B. Run/Stop and HOA Selector Switches and Pilot Lights: Heavy duty type

C. Stop Pushbutton Station: Momentary break pushbutton station with factory-applied has arranged so padlock can be used to lock pushbutton in depressed position with control circuit open. (Only where specifically shown on Plans.)

D. Lockout Pushbutton Station: Maintained contact red mushroom pushbutton station with factory-applied hasp arranged so padlock can be used to lock pushbutton in depressed position with control circuit open. (Only where specifically shown on Plans.)

E. Control Relays: Auxiliary and adjustable time-delay relays

F. Elapsed Time Meters: Heavy duty with digital readout in hrs.

G. Ammeters, Voltmeters, and Frequency Meters: Panel type, 2-inch minimum size with 90- or 120-degree scale, and ±2% accuracy. Where indicated, provide transfer device with off position

H. Current Sensors: Rated to suit application

I. Current-Sensing Phase-Failure Relays: Solid-state sensing circuit with isolated contacts for hard-wired connection. Arranged to operate on phase failure, phase reversal, current unbalance of from 5% to 30%, or loss of supply voltage. Provide adjustable response delay

J. Over temperature sensors are to be installed on transformers in reduced voltage auto-transformer starters. Sensor stall interrupt and lockout starter control circuit. Provide reset switch and alarm light

K. All well and blower motor starters to have start time delay relay

L. Contactor shall include minimum of four single pole, double throw spare auxiliary contacts rated at 10 amperes continuous, for each starter furnished

2.07 EQUIPMENT PROTECTION

A. All equipment, instruments and devices provided for this project shall have means of protection from power line conditions such as surge, phase fail, or other line conditions that may damage equipment, instruments or devices furnished. It is vendors and manufacturers' responsibility to provide protective devices as required for maintaining warranty of furnished items and to assure no damage occurs from power line conditions

PART 3. EXECUTION

3.01 PREPERATION

A. Verify that the location is ready to receive work and the dimensions are as indicated

B. Do not install the soft start controller unit until the enclosure environment can be maintained within the service conditions required by the manufacturer

3.02 QUALITY CONTROL

A. Before and during installation, the motor controller shall be protected from site contaminants

3.03 INSTALLATION

A. General: Install motor controllers and auxiliary motor control devices in accordance with manufacturer's written instructions and approved submittals.

B. Mounting:

1. For control equipment at walls, bolt single units to wall. Mount multiple units on light-weight structural steel channels bolted to wall
2. For controllers not at walls, provide freestanding racks fabricated of structural steel members and lightweight slotted structural steel channels. Use feet consisting of 3/8 in. thick steel plates, 6 in. square, bolted to floor. Use feet for welded attachment of 11/2in. by 11/2in. by 1/4 in. vertical angle posts not over 3 ft oc. Connect posts with horizontal lightweight slotted steel channels and bolt control equipment to channels
3. Unless shown otherwise on plans

C. Cabinet and Enclosures Heights: Cabinet, panel and enclosure heights shall not exceed 6 feet – 6 inches from floor to top fastening devices to allow access by Operator without use of ladders or steps to open enclosure doors

3.04 CONNECTIONS

A. Tighten connectors, terminals, and mountings. Tighten field connected connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values. Where manufacturer's torqueing requirements not indicated, comply with tightening torques specified in UL 486A and 486B

3.05 FIELD QUALITY CONTROL

A. Manufacturer's Field Services: Supplier's or manufacturer's technician for equipment specified herein shall be present at job site or classroom designated by Owner for minimum man days indicated, travel time excluded, for equipment adjustment, and training of Owner's personnel for plant operation. Include minimum of:

1. 2 man-days for Instructional Services.

B. Testing:

1. Reports: Notify Engineer in writing indicating defective materials and workmanship and unsatisfactory test results. Include records of repairs and adjustments made
2. On completing installation of system, perform following tests
    a. Make insulation resistance tests of conducting parts of motor control components; and of connecting supply, feeder, and control circuits. For devices containing solid-state components, use test equipment and methods recommended by manufacturer
    b. Make continuity tests of circuits
    c. Review updating of final system configuration and parameters where they supplement or differ from those indicated in original Contract Documents
    d. Review manufacturer's written instructions for installation and testing of motor control devices
3. Visual and Mechanical Inspection: Include following inspections and related work
    a. Motor Control Device Ratings and Settings: Verify ratings and settings as installed are appropriate for final loads and final system arrangement and parameters. Recommend final protective device ratings and settings where differences found. Use accepted revised ratings or settings to make final system adjustments
    b. Inspect for defects and physical damage and nameplate compliance with Drawings
    c. Exercise and perform operational tests of mechanical components and other operable devices in accordance with manufacturer's written instructions

d. Check tightness of electrical connections of devices with calibrated torque wrench. Use manufacturer's recommended torque values
e. Clean devices using manufacturer's approved methods and materials
f. Verify proper fuse types and ratings in fusible devices.

4. Electrical Tests: Perform following in accordance with manufacturer's written instructions
   a. Insulation resistance test of motor control devices conducting parts to extent permitted by manufacturer's written instructions. Insulation resistance less than 100 megohms not acceptable
   b. Use primary current injection to check performance characteristics of motor circuit protectors and for overload relays of controllers for motors 15 hp and larger. Trip characteristics not within manufacturer's published time-current tolerances not acceptable
   c. Make adjustments for final settings of adjustable trip devices
   d. Test auxiliary protective features such as loss of phase, phase unbalance, and undervoltage to verify operation
   e. Check for improper voltages at terminals in controllers having external control wiring when controller disconnect opened. Voltage over 30 v unacceptable
5. Correct deficiencies and retest motor control devices. Verify by system tests that specified requirements are met

3.06 ADJUSTING

A. Overvoltage/Undervoltage/Phase Failure Control Relay: Adjust control relay to cause motor starter to drop out at voltage slightly higher than dropout voltage of starter and have dropout time slightly faster than motor starter to ensure if motor starter drops out, relay will drop out

3.07 WARRANTY

A. The motor controller unit shall be warranted to be free from defects in materials and workmanship for a period of two (2) years from substantial completion

3.08 CLEANING

A. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish. Clean devices internally using manufacturer's recommended methods and materials

END OF SECTION

Section 16433

Control Panel

PART 1. GENERAL

1.01 SUMMARY

A. This specification is confidentially issued for this specific project only

B. Contractor shall be responsible for reading all specifications from all disciplines prior to bid

C. This section describes the requirements for a quality construction and fabrication of SCADA/Control Panels including power, control, and instrumentation related equipment

D. This section will also describe desired operation of facility

E. All equipment described herein shall be submitted, and factory installed, as an integral part of equipment specified in overall construction documents

F. 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.

1.02 PRICE AND PAYMENT PROCEDURES

A. No separate payment for work performed under this section. Include cost for Control Panels in overall electrical equipment

1.03 REFERENCES

A. NEMA 250 - Enclosures for Electrical Equipment (1000 volts maximum)

B. ANSI/NFPA 70 - National Electrical Code (NEC)

C. Underwriters Laboratories, Inc. (UL)

D. Factory Mutual (FM)

E. Occupational Safety and Health Administration (OSHA)

F. American National Standards Institute (ANSI)

G. NEMA ICS 1 - General Standards for Industrial Control and Systems

H. NEMA ICS 2 - Standards for Industrial Control Devices, Controllers, and Assemblies

I. NEMA ICS 3 - Industrial Systems

J. NEMA ICS 6 - Enclosures for Industrial Controls and Systems

K. NEMA ST 1 - Standard for Specialty Transformers (Except General Purpose Type).

L. ISA - Instrument Society of America

M. FM - Factory Mutual

N. IEEE - Institute of Electrical and Electronic Engineers

O. NFPA - National Fire Protection Association

P. JIC - Joint Industrial Council

1.04 SUBMITTALS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

B. Panels, Consoles, and Cabinets Information:

1. Layout Drawings include the following:
    a. Front, rear, end, and plan views to scale.
    b. Dimensional information.
    c. Tag number and functional name of components mounted in and on panel, console, or cabinet.
    d. Product information on all panel components.
    e. Nameplate location and legend including text, letter size, and colors to be used.
    f. Location of anchoring connections and holes.
    g. Location of external wiring and/or piping connections.
    h. Mounting and installation details.
    i. Proposed layouts and sizes of graphic display panels.
2. Wiring and/or piping diagrams include the following:
    a. Name of panel, console, or cabinet.
    b. Wiring sizes and types.
    c. Piping and tubing sizes and types.
    d. Terminal strip numbers.
    e. Color coding.
    f. Functional name and manufacturer’s designation for components to which wiring, and piping are connected.
3. Plan showing equipment layout in each area.

C. Field wiring and piping/tubing diagrams, include the following:

1. Wiring and piping/tubing sizes and types.
2. Terminal strip numbers.
3. Color coding.
4. Conduits in which wiring is to be located.
5. Location, functional name and manufacturer’s designation of items to which wiring and/or piping are connected.

6. Point-to-point wiring diagrams

1.05 RECORD DRAWINGS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

1.06 OPERATIONS & MAINTENANCE MANUALS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

B. Accurately record actual locations of control cabinets and input and output devices connected to system. Include interconnection wiring and cabling information and terminal block layouts in control cabinets, inserted in an aluminum drawing pocket on inside of door.

C. During drawing submittal phase, submit detailed information consisting of ladder logic and line code, complete input, output, relay and controls identification labels and written description of program operation. Ladder logic diagrams submitted shall contain a written descriptive note for each line, describing the function and logic of that line. Submit all documents in hard copy and on CD.

D. Submit factory-testing procedures proposed to verify all input, output, loop operation, and system logic verification. Testing procedures submitted shall detail, as a minimum, verification of the following required minimum functions:

1. Verify motor start, motor stop, and level or pressure alarm outputs by simulating signals representing levels or pressures.
2. Verification of each discrete input via external manually operated connection.
3. The system shall be tested and verified with all external devices required to simulate field connections connected simultaneously for a full system test.

1.07 QUALITY ASSURANCE

A. Any manufacturer that cannot meet the requirements of this specification will not be considered

PART 2. PRODUCTS

2.01 MANUFACTURERS

A. Rittal

B. Hoffman Enclosures

C. NEMA Enclosure Manufacturing Co.

D. Approved equal quality

2.02 WIRING METHOD

A. Install wiring in open-slot plastic wiring duct or Panduit wireways

B. Where wireways are used, they shall be properly sized for wiring contained within and shall not be oversized. Wireway fill shall not exceed 75 percent of wireway capacity and shall not be less than 25 percent of wireway capacity. Wireway width to depth ratio shall not be less than 2 to 1

C. Do not use adhesive type cable ties. Attached with stainless steel bolts or welded studs

D. Provide thermostat-controlled strip-type space heater (150 watts maximum), convenience outlets and internal fluorescent lighting (where shown on drawings)

E. Nameplates: On the outside of each cabinet's inner door, provide motor data nameplate information for each pump motor; copy all 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

F. All equipment and devices shall be NEMA rated. IEC rated equipment and devices are not acceptable

G. A divider of same material and thickness as the cabinet shall be added to divide electrical components and wiring from instrumentation and pneumatic components and wiring

H. All interconnect wiring inside panel to be stranded copper conductors intended for panel wire use. Thermoplastic covered wire is not to be used.

I. Cable ties shall be spaced at intervals not to exceed 4 inches. All wiring between device terminals and wireways shall be orderly and tied. Wire markers shall be visible without removing wiring from a wireway

J. All cable ties shall be trimmed, and loose ends shall not exceed 1/8 inch in length after trimming

K. Wiring bundles shall be secured in place with nylon cable clamps that are attached to the mounting plate with stainless steel bolts. Cable bundles attached to the back side of a front plate or cover plate shall be via steel studs welded to the plate before painting. Counter sunk head steel bolts may be used in which case the head finish shall match the panel finish in color so as to provide a neat appearance of the front panel

L. Wire splices inside panels are prohibited. Wire nuts and similar devices are prohibited. Split, bridged, or extended circuits shall be done via use of terminal strips only except where looped grounds or power circuits may be used where wire is not cut and is attached at each device with proper terminal devices. All circuits shall be continuous and unbroken

M. Use wire strippers of proper size to avoid wire nicks or cut strands. Trimming strands to make wire fit a terminal is prohibited. Provide proper sized wire and/or terminal device

2.03 DEVICE MOUNTING

A. All devices mounted on plates or doors shall be installed in holes that are punched with dies that specifically match the device requirements. Holes may be formed with machine tools. No mounting holes are to be cut with saws, nibblers, or similar tools not made for professional panel fabrication. All edges to be smooth and free of burrs

B. Panels that have scratches or are otherwise damaged when mounting devices may be touched up with the same identical paint where dried under the same conditions of heat or drying as the original panel finish. Repairs shall not be detectable

C. All panels to be constructed of 316 stainless steel, 16 gauge painted steel, or 16-gauge aluminum, as noted on plans. All doors to be constructed so as to prevent flexing or twisting movement when opened. This is especially of concern when devices are mounted on door. Lightweight doors are not acceptable. Inner panel is to be aluminum or steel. Plexiglas panel is not acceptable

D. Where panel is provided by an Equipment Manufacturer as part of the specified equipment package, the Equipment Manufacturer shall be held to these same standards and requirements. Providing panels of less quality than these standards will not be acceptable regardless of Equipment Manufacturer's standard panel specification described in equipment data sheets. Other specification sections of lesser quality do not supersede the requirements of this specification section

E. No devices shall be mounted in outer door of panels except where specifically noted on plans. Where instruments are mounted in panel doors or plates, the mounting devices, clips, and brackets shall be type provided by the Instrument Manufacturer or shall be specifically fabricated for the purpose. All panel mounted instruments shall have enclosures that cover any exposed circuit boards or components on the back side of the instrument

F. Components are to be attached with bolts, washers, and nuts properly sized and made for the purpose applied. Screws or self-tapping screws are not acceptable for mounting components, except self-tapping stainless screws shall be used for mounting nameplates

G. Do not mount temperature sensitive devices near heat producing components such as resistors or transformers

H. Arrange all devices for easy identification, removal, and repair. Removal of any device shall not require removal or disturbing other components

I. Wet devices shall be located in lower part of panel or cabinet with metallic spray shield installed above, separating other electrical devices

J. DIN rail mounted devices shall be made for purpose and shall be standard sized components. Micro and miniature type components are not acceptable. Provide additional 8-inch DIN rail for future devices

K. All devices shall be of type that is readily available and not special-order type components that are not standard manufactured units

L. All components, parts, and devices are to be identified at their locations with approved labels or nameplates. Provide 8 ½ x 11-inch laminated parts list in steel or hard plastic door pocket along with the control diagrams

M. All over current devices shall be fast acting circuit breakers. Fuses are not allowed except where specifically called for. Where fuses are specified, provide ten (10) each spare fuses in addition to requirements of other specification sections

N. Fused circuits are not acceptable for power or control devices. Circuit breakers shall be used for all overcurrent protection purposes. Any use of fuses shall be acceptable where specifically approved by Engineer in writing for each specified panel

O. All display screens or readouts shall be mounted in panel at height of 60 inches above level where operator stands. This must be accounted for where panels are installed on concrete pads or other elevated structures

2.04 TERMINALS

A. All terminations for interfacing with external wiring shall be via screw type terminal strips that have numbered markings to identify termination points. All terminals to have compression plates made specifically for the purpose, in addition to the screws. Round washers are not acceptable substitute for the compression plates

B. All terminals or exposed wiring with more than 120 volts to ground or 300 volts between legs are to be shielded with non-metallic, non-conducting insulating material made for the purpose of avoiding accidental contact. Label all shields and devices in a recognizable manner with warning nameplate or sign

C. Locate terminal strips in accessible location in panel to allow easy access when making terminations. Provide nameplate for each terminal strip

2.05 MISCELLANEOUS

A. Door fasteners shall be of highest quality, designed to withstand repeated engagement and disengagement without damage to retaining parts, which shall be firmly attached to the panel frame members. Fasteners shall be properly aligned with retainer parts. Lightweight fasteners are not acceptable. Any fasteners failing before warranty period expires shall be replaced with different type fastener that is acceptable to Owner and Engineer

B. All outdoor panel doors to be NEMA 4X 316 stainless steel unless specifically noted on plans, with three (3) point latching handle and locking hasp. Key type handles are not acceptable. No control devices are allowed on outer door of outdoor enclosures

C. All attachments and studs that are welded to stainless steel panel, enclosure, or plate shall be properly welded in such a manner that does not discolor finish. All welds shall be properly cleaned, buffed, and treated to provide a neat appearing finish. Any discolored plates or enclosures shall be replaced

D. Panel Manufacturer shall send Engineer color photographs or e-mail color photo files of finished panel where shop inspection has not been conducted before shipping. Photos shall be of quality and clarity so as to allow evaluation of finished panel quality. No panels shall be delivered to job site without this review and approval in writing by Engineer and, where delivered without this approval may be rejected by Engineer. Any delay in construction due to failure to satisfy this requirement will be at fault of contractor

E. Relocation of panels up to 40-fet from where shown may be required and shall be included in bid cost

2.06 CLIMATE CONTROLLED CONTROL PANEL

A. Enclosure Type: NEMA 1

2.07 OUTDOOR RATED CONTROL PANEL

A. Enclosure Type: NEMA 4X 316 S.S.

B. Enclosure Size: As indicated on Drawings, or if not indicated, at least 72 inches high by 60 inches wide by 36 inches deep, or larger, as required to accommodate equipment and as indicated in UL standards. Where small motors under quantity of three (3) are served, cabinet may be sized to accommodate components and may be less than 60 inches wide and 36 inches deep. Where on concrete pad higher than 12 inches, the height may be reduced to allow access to top controls

C. Doors: Stainless steel pan-type construction, with full-length stainless-steel piano hinge (for stainless steel or aluminum). Equip exterior doors with padlock, heavy-duty locking pistol-grip handles and 3-point latching mechanism of the draw roller type (0.750-inch minimum diameter rollers). Handles shall be 3/4-inch minimum diameter stainless steel. Equip interior doors with flush quarter-turn closure devices. Equip interior and exterior doors with neoprene gaskets. Provide rear doors for access to power devices in rear and control devices in front where shown on plans

D. Provide rain shield with 1-inch drip lip for outdoor cabinets to protect against direct sun radiation and rainfall where overhead canopy is not shown on construction documents. Design shield to provide 1 foot of cover front and back and 2 inches of cover on the sides. Design shield to provide no more than 1-foot peak height above the top of the panel with 1-inch airflow clearance from the top of the control panel. Shielding material: Type 316 stainless steel. Maintain minimum 7 feet head clearance from finished grade

E. In each cabinet section, provide a 120-volt convenience outlet and a switched LED light fixture

F. Inside and outside of cabinet shall be smooth and free from burns

G. NEMA 4X enclosures shall have all bolt holes gasketed

H. Provide locking hasp on all enclosures unless noted otherwise on plans.

I. Outdoor enclosures shall not have exposed devices or controls mounted on outer door and, no see-through windows or covers are allowed unless specifically shown on plans

PART 3. EXECUTION

3.01 QUALIFIED ELECTRICAL CONTRACTORS

A. Only qualified manufacturers listed may assemble controller panels for this project

B. Manufacturer: Company specializing in manufacturing the assembled control products specified in this specification section with minimum 5 years documented experience, which maintains service facilities within 200 miles of project, and with proven compatibility with owner's existing type facilities. All equipment shall be coordinated with qualified integrators and manufacturers covered in the construction documents prior to bid

C. Control/SCADA panel may be assembled by the following prequalified integrators:

1. Ace Controls
2. Control Panel USA
3. Five Star Electric
4. Heirholzer
5. Systems, Inc.
6. Texas Industrial Control Manufacturing (TICM)
7. Trac N Trol
8. W.W. Payton Corp.
9. Weimar Manufacturing
10. Or as pre-approved by engineer prior to bid

3.02 TESTING

A. All elements of each electrical control system shall be set up, calibrated, and tested by Manufacturer's Technician to demonstrate that the total system satisfies all of the requirements of this Specification. All special testing of materials and equipment shall be provided by the Contractor. The Contractor shall coordinate and schedule all of his testing and startup work with the Owner and Systems Integration Engineer. As a minimum, the testing shall include both a factory test and a field test. Testing requirements are as follows:

1. Factory Tests: The electrical controls and all other associated hardware shall be tested via a full simulation at the factory, prior to shipment, to demonstrate that each component is operational and meets the requirements of these specifications. Manufacturer shall provide test routine program for shop testing of I/O wiring. Where solid-state controller programs are furnished by a

specified Systems Integration Programmer, a copy of the program will be provided for Manufacturer's use in factory testing. Test results shall be certified, with written documentation provided to the Engineer upon test completion. Factory testing may be witnessed by the Engineer and/or Programmer.

2. Field Tests: All electrical control system components shall be checked to verify that they have been installed properly and that all terminations have been made correctly. Witnessed field tests shall be performed on the complete system. Prior to witnessed test, Contractor shall perform a complete test of each and every function, device operation and overall operations of electrical power, control, instrumentation and SCADA system. Prior to loading PLC or SCADA programming and prior to any PLC or SCADA set up by programmer, an inspection shall be conducted by Engineer's Inspector to assure electrical controls are functioning properly. Any discrepancies or problems shall be corrected and then Contractor shall send a written notice that complete electrical control system is installed and operating per the Plans and Specifications. This notice shall be signed by an Officer of the General Contractor's company. Contractor shall provide a checklist for all electrical, control and instrumentation functions and send to Engineer for approval. Each function shall be demonstrated to the satisfaction of the Owner and Engineer on a paragraph-by-paragraph basis. Any equipment, devices or functions that are found not performing properly will be reason for termination of test until repairs are made. Additional testing by Engineer and Owner may be at Contractor's expense for time and travel of Engineer and Owner's staff.

B. A state licensed Electrician shall be present at all scheduled inspections.

C. Controller Program: Remote testing by Engineer will require a minimum of 30 working days after programs are downloaded to the controller. Provide six (6) weeks' notice for program downloading by Programmer. This shall be accounted for in project schedule. Any delay of project completion due to lack of notice is at Contractor's risk and expense

D. Prior to testing system, PLC programs or HMI programs provided by other than the Systems Integration Engineer, programs shall be furnished on CD for review by Engineer. Provide any special software necessary to run and test complete program

E. Modem and/or radio system setup shall be conducted by Manufacturer's Technician before any field-testing by Engineer is performed. Set up per Manufacturer's written instructions. Provide Engineer with checklist and values of all settings and adjustments before requesting field test by Engineer. Indicate impedance of terminal load resister at each end of modem line

3.03 PREPERATION

A. 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

B. Deliver products to site in acceptable condition and in protective wrappings

C. Store and protect products from damage

D. Accept products on site in factory containers and verify damage

E. Store products in clean, dry area; maintain temperature to NEMA ICS 1

F. Maintain temperature above 32°F and below 104°F during and after installation of products

G. Maintain area free of dirt and dust during and after installation of products

H. Provide temporary heating and air conditioning units and equipment required to maintain environmental conditions specified for control panel's

3.04 INSTALLATION

A. Install in accordance with manufacturer's instructions and intent of Contract Drawings. Provide sufficient clearance for calibration and maintenance access

B. Install control panels, instruments, and motor control centers, to allow a minimum of four (4) feet clearance for access to control devices

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

D. Install on prepared pads at minimum height of 12 inches above grade or floor and not less than 18 inches above flood plain elevation. Anchor securely at each corner. Shim and grout as required to form a watertight seal

E. Install cabinet fronts plumb

F. Shop-cut bottom conduit entrance openings for outdoor cabinets. Seal removable plates with silicone sealant. Seal around and beneath perimeter of cabinet with silicone sealant

G. Install ground rod and equipment ground conductor

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

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

J. Except for nameplate fasteners, mounting or other hardware shall not penetrate panel exterior.

K. 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 16452 – "Grounding."

L. Provide door restraints for outer and inner doors to positive lock and hold doors open at 115 degrees minimum.

M. Minimum headroom around control cabinet shall be 78 inches.

N. Label all wires with heat shrink markers per Section 16052 – "Electrical Identification."

3.05 CONTROL LOGIC

A. Lift Station

1. Primary level control shall be a Dwyer Model PBLTX (0-15psi) submersible level transmitter used in conjunction with a Pump Vision PV1200 pump controller by California motor controls mounted on pump control panel dead front. All I/O's shall be landed on terminal strips which shall pump down the wet well level using lead/lag and alternation of the lift pumps.
2. The backup level control shall be one high level float switch and one low level float switch. Both float switches, when either is activated shall disengage the primary level control and provide alarms to the SCADA cabinet and lift pumps control panel alarm horn and alarm lights.

B. Provide a start delay timer for each pump, set at 30, 60, and 90 seconds

C. Each motor controller shall be as follows:

1. Each pump control panel shall be equipped with pull-apart terminal blocks
2. Control wiring and associate control devices in each pump control panel shall be furnished intrinsically safe for operation in its intended environment
3. Provide electronic ambient-compensated overloads for each motor controller. Each overload block shall be wired as indicated. Overload blocks shall be adjustable from 80% to 115% of their nominal value. Where indicated, provide overloads with auxiliary contacts. Selection of overloads shall be determined by the full-load current of motors to be supplied
4. Each motor controller shall be equipped with a copper ground bus
5. All control relays shall be 3-pole ice cube type each with 10-amp, 120V rated contacts. Each contact shall be field convertible. Each relay shall have open-close position indication. Relay coils shall be rated 120V A.C. continuous duty, including the latch type relay coils. Relay to accept #14 AWG conductors
6. Motor branch circuit over current protection shall be motor circuit protectors, unless otherwise indicated. Each "MCP" shall have adjustable current setting pickup. Minimum I.C. of each MCP shall be 22 KA rms symmetrical amps. Motor circuit protectors shall be provided with 120V A.C. shunt trip
7. Controls shall be as indicated on the drawings
8. Remote pilot operators, "RPD" devices, shall be furnished for remote control of indicated motor and other remote-control functions
9. RPD Devices, such as start, stop pushbuttons, pilot lights, and selector switches shall consist of heavy-duty oil-tight operators. Pushbuttons, selector switches, and pilot lights are to be multi-light industrial type. Pilot lights shall be transformer type LED, push to test, complete with LED. Pilot lights shall be equipped with the indicated colored lenses:
    a. Red: Run

b. Green: Stop
c. Amber: Fault
d. White: Power On

10. Each RPD device shall be equipped with engraved plastic surround to identify functions. Legend plates shall be provided for devices mounted on the door. The plates shall be manufacturer's standard with lettering indicated on the plans and of the same manufacture as the respective pushbutton, selected switch, or pilot light. Provide all legend and name plates as per the plans
11. Remote pilot operators shall be Eaton or Schneider
12. Each motor controller shall have phase failure protection. This device shall sense a loss-of-phase, phase unbalance with negative-sequence sensing circuit, under-voltage, and over-voltage, Furnish Square D type DASV. This device shall be furnished with interlocks to motor control circuits
13. Elapsed time meters shall be installed for each motor and shall measure in increments of hours and be non-resettable. Furnish Eagle Signal Controls H Series time totalizer or approved equal
14. Each pump control panel shall be equipped with a lightning arrester complete with an overcurrent protection device. Furnish schneider or approved equal
15. Each motor controller shall be equipped with a fused control power transformer (CPT). VA capacity of CPT shall be sized to handle its controller load plus external connected loads
16. Each pump control panel shall be furnished with one main disconnect circuit breaker that de-energizes all power and controls when the handle is turned to the off position. Main disconnect shall be able to be padlocked in the off position

3.06 SYSTEM STARTUP

A. Provide the services of factory trained personnel to assist in the installation and start- up of the control system

3.07 TRAINING

A. Provide minimum four (4) hours of "hands-on" instruction each for Owner's staff. To be conducted at project site by control systems manufacturer's representative, at no additional cost to Owner. Training is to be conducted after all control systems are fully operational

B. Provide minimum two (2) weeks' notice to Engineer and Owner before conducting training

3.08 MAINTENANCE/WARRANTY

A. Provide manufacturer's maintenance services of control systems for one year from date of substantial completion

B. Contractor shall provide full 1-year service warranty on the overall installation and shall include all labor and materials required to repair or replace equipment and/or components that are defective or malfunctioning. Included under this warranty shall be all equipment, devices, hardware, and software. This warranty shall begin on date of written “Final Acceptance” of the electrical systems to be executed as required at no additional cost to the Owner

C. Contractor’s warranty shall also guarantee 24-hour service response time and shall provide labor, work, or materials as necessary to maintain plant operation when replacement parts are on order. In no case shall plant electrical systems be out of service for more than 24 hours from time Owner calls for warranty service. This shall be provided at no additional cost to the Owner. All equipment and materials installed shall have full warranty from Manufacturer that guarantees equipment is rated for harsh industrial electrical/mechanical environment in which it is installed. Where Manufacturer’s products fail prematurely, Manufacturer shall be fully responsible for new replacement and shall not have the option of declaring that failures were caused by environmental conditions and its effect on the product. Contractor is fully responsible for assuring that Product Manufacturers are aware of this condition and that warranty statement is included in shop drawing submittals. Failure to do so will be at the Contractor’s expense and at no additional cost to the Owner

D. All critical warranted repairs shall be made within 24 hours of receipt of required parts from Manufacturer with reasonable delivery time of overnight shipping. Any repairs not completed within 5 working days from date of notice are subject to Owner making other arrangements for repair and back charging contractor. This requirement is a condition of this contract

E. Where equipment or instrument problems remain unresolved by contractor beyond a reasonable time, a factory technician shall be provided on-site to take any corrective actions necessary to put equipment or instruments in operating order. Owner and engineer reserve the right to determine a reasonable time for corrective action by contractor

END OF SECTION

Section 16438

Panelboards

PART 1. GENERAL

1.01 SUMMARY

A. This specification is confidentially issued for this specific project only

B. Contractor shall be responsible for reading all specifications from all disciplines prior to bid

C. Section Includes: Lighting and power panelboards and associated auxiliary equipment rated 600 V or less

1.02 REFERENCES

A. A. Institute of Electrical and Electronic Engineers (IEEE):

1. IEEE C62.1 - Standard for Gap Silicon-Carbide Surge Arrestors for AC Power Circuits

B. IEEE C62.11 - Standard for Metal-Oxide Surge Arrestors for AC Power Circuits

C. National Electrical Manufacturers Association (NEMA):

1. NEMA PB.1 - Panelboards.
2. NEMA PB1.1 - General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 volts or less

D. Underwriter's Laboratory (UL):

1. UL 486A Wire Connectors and Soldering Lugs for Use with Copper Conductors, 7th Edition
2. UL 870 - Wireways, Auxiliary Gutters, and Associated Fittings, 5th Edition

1.03 SUBMITTALS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

B. Product Data:

1. For each type panelboard, accessory item, and component specified.
2. Identification materials.

C. Shop Drawings:

1. Dimensioned plans, sections, and elevations.
2. Tabulations of installed devices, major features, and voltage rating.
3. Include:
    a. Enclosure type with details for types other than NEMA Type 1

D. b. Bus configuration and current ratings.

E. c. Short circuit current rating of panelboard.

F. d. Features, characteristics, ratings, and factory settings of individual protective devices and auxiliary components

G. Wiring diagrams detailing schematic diagram including control wiring, and differentiating between manufacturer installed and field- installed wiring

H. Report of field tests and observations in accordance with this section

I. Maintenance and Operations Data: Include instructions for testing circuit breakers

PART 2. PRODUCTS

2.01 MANUFACTURER'S

A. Schneider

B. Eaton

C. General Electric

D. Or Equal

2.02 PANELBOARDS

A. Panelboards shall have voltage, overcurrent devices and features as indicated

B. Breakers shall be bolt-in type, trip-free. Multipole breakers shall be provided with a common internal trip which opens all poles simultaneously and with a single operating handle for all poles. Handle ties between breakers are not acceptable

C. Breakers for 480V distribution panels shall be rated at least 14000 amps I.C., and breakers for 120/240V panels shall be rated at least 10,000 amps I.C.

D. Provide copper ground bus inside each cabinet

E. Enclosures shall be NEMA 4X 316 stainless steel surface mounted cabinet with gasketed, hinged door, inside gutter trim and with door mounted directory pocket.

F. Electrical panels shall have tinned or silver-plated copper bus

G. Construction in accordance with NEMA PB1

H. Overcurrent Protective Devices (OCPD's):

1. Provide type, rating, and features as indicated
2. Tandem circuit breakers shall not be used
3. Multi-pole breakers shall have common trip

I. Enclosures: Cabinets, enclosures, and panels, flush or surface mounted as indicated. NEMA Type 12 enclosure shall be use indoors, except where other enclosure requirements are indicated on drawings. All outdoor enclosures shall be

NEMA 4X stainless steel. This includes indoor locations such as wastewater process areas and environmentally harsh locations

J. Front:

1. Secure to box with concealed trim clamps except as indicated
2. Front for surface mounted panels shall be same dimensions as box
3. Fronts for flush panels shall overlap box except as otherwise specified

K. Directory Frame: Metal, mounted inside each panel door

L. Bus: Hard drawn copper of 98 percent conductivity

M. Main and Neutral Lugs: Mechanical type

N. Equipment Ground Bus: Adequate for feeder and branch circuit equipment ground conductors. Bonded to box

O. Service Equipment Approval: Listed for use as service equipment for panelboards having main service disconnect

P. Provision for Future Devices: Equip with mounting brackets, bus connections, and necessary appurtenances, for the OCPD ampere ratings indicated for future installation of devices

Q. Special Features: Provide following features for panelboards as indicated

1. Isolated Equipment Ground Bus: Adequate for branch circuit equipment ground conductors; insulated from box
2. Split Bus: Vertical bus of indicated panels divided into two vertical sections with connections as indicated
3. Extra Gutter Space: Dimensions and arrangement as indicated
4. Auxiliary Gutter: Conform to UL 870
5. Column Type Panelboard Configuration: Narrow cabinet extended as wireway to overhead junction box equipped with ground and neutral terminal buses
6. Sub-feed: OCPD or lug provision as indicated
7. Feed Through Lugs: Sized to accommodate feeders indicated
8. Surge Arresters: For panelboards as indicated on Plans
   a. Comply with IEEE C62.11 or IEEE C62.1
   b. Description: Coordinate impulse sparkover voltage with system circuit voltage and provide factory mounting with UL recognized mounting device

2.03 LOAD CENTERS

A. Provide load center type panelboards only where specifically indicated

B. OCPD’s: Plugin full module (nominal 1in. width) circuit breaker

C. Circuit Breakers for Switching Lights at Panelboards: Indicated type SWD

D. Circuit Breakers for Equipment Marked HCAR Type: Indicated HCAR type

E. Interiors: Provide physical means to prevent installation of more OCPD's than quantity for which enclosure was listed

F. Main, Neutral, and Ground Lugs and Buses: Mechanical connectors for conductors

2.04 LIGHTING AND APPLIANCE BRANCH CIRCUIT PANELBOARDS

A. Branch OCPD's: Bolton circuit breakers, replaceable without disturbing adjacent units

B. Doors: In panel front, with concealed hinges. Secure with flush catch and tumbler lock, all keyed alike

2.05 DISTRIBUTION PANELBOARDS

A. Branch Circuit Breakers: Where OCPD's are indicated to be circuit breakers, use bolt on breakers except circuit breakers 225ampere frame size and greater may be plugin type where individual positive locking device requires mechanical release for removal

B. Doors:

1. In panel front, omit single panelboard door in cabinet front for fusible switch panelboards except as indicated
2. Secure with vault type with tumbler lock, all keyed alike

2.06 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items as required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: Arranged to permit testing of functions of solid-state trip devices without removal from panelboard

C. Spare Fuse Cabinet: Identified, compartmented, lockable steel box or cabinet with compartments suitable for surface mounting on wall

D. All equipment, instruments and devices provided for this project shall have means of protection from power line conditions such as surge, phase fail, or other line conditions that may damage equipment, instruments or devices furnished. It is vendors and manufacturers' responsibility to provide protective devices as required for maintaining warranty of furnished items and to assure no damage occurs from power line conditions

2.07 IDENTIFICATION

A. General: Provide nameplates for all panelboards.

B. Panelboard Nameplates: Engraved laminated plastic for each panelboard.

PART 3. EXECUTION

3.01 TESTING

A. Perform tests on low voltage power panelboards and accessories

B. Upon completing installation of system, perform following tests:

1. Make insulation resistance tests of panelboard buses, components, and connecting supply, feeder, and control circuits
2. Make continuity tests of circuits

C. Quality Control Program

1. Procedures: Make field tests and inspections and prepare panelboard for satisfactory operation in accordance with manufacturer's recommendations and these specifications
2. Notify Engineer at least one week in advance of testing
3. Report Testing:
    a. Report written reports of tests and observations
    b. Report defective materials and workmanship and unsatisfactory test results
    c. Include records of repairs and adjustments made
4. Protective Device Ratings and Settings:
    a. Verify indicated ratings and settings to be appropriate for final system configuration and parameters
    b. Where discrepancies are found, recommend final protective device ratings and settings
    c. Use accepted ratings or settings to make final system adjustments

D. Visual and Mechanical Inspection: Include following inspections and related work:

1. Inspect for defects and physical damage, labeling, and nameplate compliance with requirements of up to date drawings and panelboard schedules
2. Exercise and perform operational tests of all mechanical components and other operable devices in accordance with manufacturer's instruction
3. Check panelboard mounting, area clearances, and alignment and fit of components
4. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values
5. Perform visual and mechanical inspection and related work for overcurrent protective devices as within this section

E. Electrical tests: Include following items performed in accordance with manufacturer's instruction:

1. Insulation resistance test of buses and portions of control wiring that disconnected from solid state devices. Insulation resistance less than 100 megohms is not acceptable
2. Ground resistance test on system and equipment ground connections
3. Test main and sub-feed overcurrent protective devices in accordance within this section

F. Retest: Correct deficiencies identified by tests and observations and provide retesting of panelboards. Verify by system tests that total assembly meets specified requirements

3.02 CLEANING

A. Upon completion of installation, inspect interior and exterior of panelboards

B. Remove paint splatters and other spots, dirt, and debris

C. Touch up scratches and mars of finish to match original finish

D. Clean interior of panelboard

3.03 ADJUSTING

A. Adjust doors and operating mechanisms for free mechanical movement

3.04 COMMISSIONING

A. Balancing Loads: After Substantial Completion, but before Final Acceptance, conduct load balancing measurements and circuit changes as follows:

1. Perform measurements during period of normal working load as advised by Owner
2. Perform load balancing circuit changes outside the normal occupancy/working schedule of the facility. Make special arrangements with Owner to avoid disrupting critical 24hr services such as Fax machines and online data processing, computing, transmitting, and receiving equipment
3. Recheck loads after circuit changes during normal load period. Record load readings before and after changes and submit test records
4. Tolerance: Difference between phase loads exceeding 20 percent at any one panelboard is not acceptable. Re-balance and recheck as required to meet this minimum requirement

3.05 INSTALLATION

A. General: Install panelboards and accessory items in accordance with NEMA PB 1.1, and manufacturers' written installation instructions, and approved submittals

B. Mounting Heights: Top of trim 6 ft 2in. above finished floor, except as indicated

C. Mounting:

1. Plumb and rigid without distortion of box
2. Mount flush panels uniformly flush with wall finish

D. Circuit Directory: Typed and reflective of final circuit changes required to balance panel loads. Obtain approval before installing

E. Install filler plates in unused spaces

F. Provision for Future Circuits at Flush Panelboards:

1. Stub four 1inch empty conduits from panel into accessible ceiling space or space designated to be ceiling space in future
2. Stub four 1inch empty conduits into raised floor space or below slab other than slabs on grade

G. Auxiliary Gutter: Install where a panel is tapped to a riser at an intermediate location

H. Wiring in Panel Gutters: Train conductors neatly in groups, bundle, and wrap with wire ties after completion of load balancing

3.06 GROUNDING

A. Connections: Make equipment grounding connections for panelboards as indicated

B. Provide ground continuity to main electrical ground bus indicated

3.07 CONNECTIONS

A. A. Tighten electrical connectors and terminals, including grounding connections, in

B. accordance with manufacturer’s published torque- tightening values. Where manufacturer’s torque values are not indicated, use those specified in UL 486A.

END OF SECTION

Section 16441

Pilot & Control Devices

PART 1. GENERAL

1.01 SUMMARY

A. This specification is confidentially issued for this specific project only

B. Contractor shall be responsible for reading all specifications from all disciplines prior to bid

C. This section includes pilot and control devices for instrumentation and control system

D. Products listed are applicable where shown on plans or required by other specifications or manufacturer's

1.02 SUBMITTALS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

PART 2. PRODUCTS

2.01 TAGGING

A. Provide Type 316 stainless steel tag on field-mounted units and permanently affix tag to unit

B. Include Engineer's tag number where listed in Control Diagrams

2.02 PUSHBUTTONS/SELECTOR SWITCH/PILOT LIGHTS

A. Manufacturers:

1. Square D Class 9001, Type K
2. Eaton
3. Allen Bradley 800T
4. Or, pre-approved equal

B. Construction:

1. Heavy duty
2. Liquid tight
3. Oil tight
4. Base mounting
5. Flush panel mounting

6. Size to mount in 30.5 mm diameter opening without adapter. Smaller units are not acceptable
7. Padlock attachments, where required, constructed of metal. Plastic material is not acceptable
8. Legend plates, as required, for type of operation or as specified elsewhere

C. Pushbuttons:

1. Flush head unless specified elsewhere.
2. Contact Blocks:
    a. Double break silver contacts
    b. AC Ratings: 7,200 VA make, 720 VA break
    c. Single pole, double throw or double pole, single throw
    d. Up to six (6) tandem blocks
3. Maintained contact unless specified elsewhere
4. Non-illuminated.
5. Legend plates, as required, for type of operation or as specified elsewhere

D. Selector Switches:

1. Maintained position unless specified elsewhere
2. Contact Blocks:
    a. Double break silver contacts
    b. AC Rating: 7,200 VA make, 720 VA break
    c. Single pole, double throw or double pole, single throw
    d. Up to six (6) tandem blocks
3. Operators:
    a. a. Number of positions as specified elsewhere
    b. b. Standard knob type unless specified elsewhere

E. Pilot Lights:

1. LED, high visibility type
2. Colored lenses as specified elsewhere
3. Interchangeable lenses
4. Push to test
5. Legend plates as specified elsewhere

F. Enclosures:

1. Mounted in control or instrument panel as specified elsewhere
2. Control Station:
    a. Environment:

i. NEMA 12 in general areas
ii. NEMA 4X 316 stainless steel in wet locations or outdoors

b. Flush or surface mounted as specified elsewhere.
i. Provide flush mounted pull box.

G. Nameplates:

1. Control Stations:

a. Engraved laminated plastic
b. Letters 3/16 in. high
c. White letters on black background
d. Identify per equipment controlled

2.03 MOTOR STARTER CONTROL RELAYS

A. Manufacturers:

1. Square D
2. Eaton
3. Or pre-approved equal

B. Construction:

1. Industrial type
2. 300 V rated
3. AC operation
4. Pressure wire connectors

C. Operating Data:

1. Pickup Time: 11 ms maximum
2. Dropout Time: 6 ms maximum

D. Coil:

1. Molded construction
2. 120 VAC, 60 Hz
3. Continuous rated
4. Color coded to indicate status
5. Pilot duty
6. 60A make, 6A break, (120 V inductive)

E. Contacts:

1. Double break
2. Silver alloy
3. Convertible

4. Color coded to indicate status
5. Pilot duty
6. 60A make, 6A break, (120V inductive)

F. Track mounting capability

G. Accessories:

1. Add-on pole attachment:
   a. 4 NO and 4 NC contacts
   b. Add-on to 0 to 4 pole relays
2. Latch attachment.
3. Pneumatic Timer Attachment:
   a. Single pole, double throw, double break timed contact
   b. Adjustable 0.2 to 60 sec
   c. Repeat accuracy of + 15 percent
   d. Convertible timing mode
4. Transient Timing Mode: Suppress coil transients to 300 V or less

H. All relays to be 4PDT type

2.04 CONTROL RELAYS

A. Manufacturers:

1. Potter and Brumfield
2. Struthers Dunn
3. Or pre-approved equal

B. B. Operating Data:

1. Pickup Time: 13 ms maximum
2. Dropout Time: 10 ms maximum.
3. Operating Temperature: -45 o C to 70 o C

C. AC Coil:

1. 120 or 240 Va
2. Continuous rated
3. 3.5 VA inrush
4. 1.2 VA sealed
5. 50 to 60 Hz
6. Minimum Dropout Voltage: 10% of coil rated voltage

D. DC Coil:

1. 24 or 120 Vdc
2. Continuous rated
3. Minimum Coil Resistance
    a. 24 Vdc: 450 ohm
    b. 120 Vdc: 9,000 ohm

E. Contacts:
1. Silver cadmium oxide for 1 amp or less resistive load
2. Gold flashed fine silver; gold diffused
3. 4 Form C
4. 120 VAC
5. 20 amp make, 1.5-amp break (inductive)

F. Rated at 10 million operations

G. Plug-in sockets

H. Enclosed and protected by polycarbonate cover

I. Provide relay retaining clips

J. All relays to be 4PDT type

2.05 TIME DELAY RELAY

A. ATC # 319D-016, with 2 SPDT switches rated 5 amps at 120 Volt, contacts and coil, plug in base and socket, 5 ranges, .02 seconds to 30 minutes.

B. AGASTAT #7022AC, Instantaneous open on energization, time delay close on de-energization. Time range 1.5 seconds to 15 seconds, 120-volt, 60 Hz

C. ATC Model #319D-134, with 2 S.P.D.T. switches rated 5 Amps at 120 Volt, contacts and coil, plug in base and socket, 3 ranges, .1 to 100 seconds.

D. Macromatic Industrial Controls, Model #TAA1U, with two (2) S.P.D.P. switches rated 3 amps at 250-volt contacts, 24-240VAC/DC coil, plug-in base, six (6) functions, sixteen (16) ranges, 0.5 seconds to 10 hours.

E. Or approved equal

2.06 ELAPSED TIME METER

A. Manufacturers:
1. Cramer #635G/HRS.
2. Digits: Five (5), non-resettable.
3. Power: 120 VAC, 60 Hz.

B. Manufacturers:
1. Cramer #635S surface mounted.

2. Digits: Five (5), non-resettable
3. Power: 120 VAC, 60 Hz

2.07 TIMERS

A. 24 Hour Clock Timer (Repeat Cycle):
1. Manufacturers:
a. Tork Time Controls
b. Intermatic
c. Or pre-approved equal
2. Mounting: Surface
3. Display: 24-hr LCD
4. Contacts: One (1) SPDT rated 20A
5. Set Points: 288 per 24 hr.
6. Skip Feature: 1 to 7-day adjustable
7. Minimum On-Off Time: 5 min.
8. Time cycle programmable by keypad
9. Power: 120 VAC, 60 Hz

B. Interval/Duration Timer:
1. Manufacturers: ATC or equal.
2. Mounting: Plug-in with dust tight cover
3. Type: Integrated circuit
4. Range: As indicated on drawings
5. Contacts: Two (2) DPDT contacts rated 10 amp
6. Power: 120 VAC, 60 Hz

2.08 ALTERNATOR

A. Manufacturers:
1. Diversified Electronics:
a. Two (2) Pump Duplexor:
i. 24 VAC/DC, ARA-24-ABA.
ii. 48 VDC, ARA-48-ABA
iii. 120 VAC/DC, ARA-120-ABA
iv. 208 VAC, ARA-208-ABA
v. 240 VAC, ARA-240-ABA
b. Three (3) Pump Triplexor:

i. 24 V, ARA-24-AFE
ii. 120 V, ARA-120-AFE

c. Four (4) Pump Quadraplexor:
i. 24 V, ARA-24-AGE
ii. 120 V, ARA-120-AGE

d. Two (2)/Three (3) Pump Duplexor/Triplexor: 120 V, ARA-120-AME

e. Three (3)/Four (4) Pump Triplexor/Quadraplexor: 120 V, ARA-120-ANE

f. Five (5)-Pump Pentaplexor: 120 V, ARP-100

g. Six (6)-Pump Hexaplexor: 120 V, ARA-100

2. Time Mark Corporation: 120 V, B 471

3. Macromatic Industrial Controls: Two (2) pump duplexor, 120 volt, ARP120A6, 240 volts, ARP240A6

4. Or approved equal

B. Provide automatic alternation of energizing motor starters

C. Permit operation of units singly or together as called by pilot devices

D. N.O. auxiliary contacts from motor starters required to operate alternator

E. Alternator shall provide for operation of standby or lag unit through second pilot device in event of failure of lead unit or first pilot device or alternator coil

F. With pump selector switch for operation of two (2), three (3), four (4) and five (5) pump systems

2.09 PHASE FAIL RELAY

A. Diversified Electronics #SLD-440-ALE, 480 Volt, 3 Phase

B. Diversified Electronics #SLD-220-ALE, 240 Volt, 3 Phase

C. Macromatic Industrial Controls, #PMDU, 208-480 Volt, 3 Phase

2.10 ROTATED BEACON

A. Manufacturers:

1. Edwards: LED 105XBRM Series XTRA-BRITETM LED – RED 120VAC NEMA 4X

2.11 EXTERIOR MOUNTED ALARM HORN

A. Manufacturers:

1. Edwards

2. Or, pre-approved equal

B. 120 VAC

C. Suitable for use in wet location, gasketed.

D. Cabinet mounted, provide mounting lugs. Body to include outlet box.

E. Aluminum mounting hood.

F. ¾ inch conduit hubs

2.12 SUBMERSIBLE PUMP PROTECTION MODULE

A. Flyght MiniCAS II: Model No. 83 58 57 (24 volt), 40-50 10 98 (120 volt); MiniCAS II/FUS Model No. 14-40 71 13 92 (24 volt)

B. Module shall be capable of monitoring temperature via a thermal switch embedded in motor winding, and capable of detecting leakage via sensor located in pump

C. Temperature detection to operate Form "C" 10-amp contact, such that when wired into pump controls will shut down pump when over-temperature condition is detected

D. Leakage detection to operate Form "C" 10-amp contact, such that when wired into pump controls will initiate alarm

E. 20-30 VAC, 50-60 Hz with 24-volt external power supply, or 120 VAC, 5-60 control power source

F. LED indicators for over-temperature and leak indications.

G. Manual reset pushbutton to interrupt power supply.

H. Model No. 14-50 70 97 Socket

I. Temperature Range: 0-50° C (32-123° F), Max 90% RH

2.13 VOLTAGE TRANSDUCER

A. Manufacturer:

1. Ohio Semitronics, Inc.

2. Or, approved equal

B. A.C. Voltage Transducer Model VT rated per circuit maximum voltage x 1.25. Select version that matches shown on plans

C. Transducer to be rated for 125% of current rating

2.14 UNIVERSAL AC CURRENT SENSOR

A. Manufacturer:

1. Entrelec, SSAC, Inc. – P.O. Box 1000, Baldwin, NY, 13027

2. Or, approved equal

B. TSC, ECS, ECSH, and ECSL Series: Provides relay contact closure when current reaches pre-set level

C. Install per Manufacturer's instructions

D. Sensor to be rated at 125% of current rating

2.15 CURRENT TRANSDUCER

A. A. Manufacturers:

1. HCS
    a. Model: CR4170 Series
    b. Output: 4-20 ma or 0-5 VDC, as required
    c. Three (3) element AC current.
    d. Calibration: True RMS sensing.
    e. Temperature Range: 0 to 50 degrees Celsius.
2. NK Technologies
3. Ohio Semitronics, Inc.
4. Or, approved equal

B. AT Series: Current transformer with signal conditioner. Split or solid core as applicable. 420 model with 4–20 MA output. Self-powered. 0 – 200-amp range. U.L. listed

C. A.C. Current Transformer Model No. MCT5, 005E or 005E2 (as shown on plans) with Manufacturer's recommended CT rated per circuit maximum amps x 1.25

D. AT/ATR Series: 0 – 200-amp range or, as required by motor current rating

E. Transducer to be rated for 125% of voltage rating

F. Size unit to detect peak inrush current of motor

PART 3. EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's written instructions, applicable requirements of NEC, NECA "Standard of Installation," and recognized industry practices.

B. Control Relay:

1. Install panel control relays in I&C panel.
2. Install motor starter control relays in MCC and wherever more rugged type relay required

END OF SECTION

Section 16460

Low-Voltage Transformer

PART 1. GENERAL

1.01 SUMMARY

A. This specification is confidentially issued for this specific project only

B. Contractor shall be responsible for reading all specifications from all disciplines prior to bid

C. General Purpose, Dry Type Transformers.

D. Drive Isolation Transformers.

E. Control and Signal Transformers.

F. Mini Power Zone Packaged Power Supply

1.02 REFERENCES

A. American National Standards Institute, Inc. /Institute of Electrical and Electronics Engineers (ANSI/IEEE):

1. ANSI/IEEE C2 - National Electrical Safety Code
2. ANSI/IEEE C57.12.80 Standard Terminology for Power and Distribution Transformers

B. National Electrical Manufacturers Association (NEMA):

1. NEMA LA 1 - Surge Arresters
2. NEMA ST 1 - Specialty Transformers (Except General-Purpose Type)
3. NEMA ST 20 - Dry-Type Transformers for General Applications

C. Underwriters Laboratories, Inc. (UL):

1. UL 486A- Wire Connectors and Soldering Lugs for Use with Copper Conductors
2. UL 506 – Specialty Transformers

1.03 SUBMITTALS

A. Product Data:

1. Dimensional plans and sections
2. Elevations showing minimum clearances
3. Installed devices
4. Materials list
5. Weights

6. Wiring diagrams
7. Manufacturer's nameplate data and electrical ratings

B. Product Test Reports:

1. Certified copies of manufacturer's design and routine factory tests required by reference standards
2. Submit after manufacture of transformer and before installation

PART 2. PRODUCTS

2.01 MANUFACTURER'S

A. Square D

B. General Electric

C. Or equal

2.02 GENERAL TRANSFORMERS

A. Transformers:

1. Factory-assembled and tested, air-cooled units of types specified, having characteristics and ratings as indicated
2. Design unit for 60 Hz service

B. Cores: Grain-oriented, non-aging silicon steel

C. Coils: Continuous windings without splices, except for taps

D. Internal Coil Connections: Brazed or pressure type

E. Bolt coil/core to bottom of enclosure for transformers larger than 15 kVA

1. Isolated by rubber, vibration-absorbing mounts
2. Metal-to-metal contact between coil/core and enclosure not allowed

F. Provide copper windings.

G. Nameplates: Provide metal nameplate listing manufacturer's name, serial number, type, class, kVA voltage, frequency, and showing internal wiring diagram.

H. Sound Level: Minimum 3 dB less than sound levels for transformer type and size indicated when factory-tested in accordance with NEMA ST 20

I. Enclosures at wastewater treatment plant outdoor or chemical area locations to be NEMA 4X stainless steel

2.03 DRY-TYPE TRANSFORMERS

A. Dry-type transformers shall have continuous KVA and voltage characteristics as shown

B. Enclosures shall be 316 stainless steel

C. Copper coils shall be provided with NEMA standard taps in high voltage windings

D. Furnish Square D or equal dry-type transformers

E. Comply with NEMA ST 20.

F. Windings: 2-winding type. 3-phase transformers shall use 1 coil/ phase in primary and secondary

G. Transformers shall have following features and ratings.

1. Enclosure: Indoor, ventilated unless otherwise shown on plans, outdoor, weatherproof unless shown otherwise on plans
2. Insulation Class: 185 o C or 220 o C class for transformers 15 kVA or smaller; 220 o C class for transformers larger than 15 kVA
3. Insulation Temperature Rise: 80 o C maximum rise above 40 o C for 15 kVA and larger; 115 o C maximum rise above 40 o C below 15 kVA
4. Taps: For transformers 3 kVA and larger, full capacity taps in high voltage winding as follows
   a. 3 through 10 kVA: Two 5% taps below rated high voltage.
   b. 15 through 500 kVA: Six 2-1/2% taps, 2 above and 4 below rated high voltage
   c. 750 through 1,000 kVA: Four 2-1/2% taps, 2 above and 2 below rated high voltage

H. Accessories: Following accessory items are required where shown on Drawings

1. Surge Arresters: Low voltage type, factory-installed and connected to high voltage terminals; complying with NEMA LA 1
2. Wall Mounting Brackets: Manufacturer's standard brackets for transformers sized up to 75 kVA where wall mounting indicated
3. Electrostatic Shielding: Insulated metallic shield between primary and secondary windings. Connect to terminal marked shield" for grounding connection, where applicable

2.04 DRIVE ISOLATION TRANSFORMERS

A. Comply with requirements of NEMA ST 1 and UL 506, except as specified below

B. Ratings:

1. As indicated and continuous duty
2. Minimum kVA: 130% of motor nameplate hp

C. Type:

1. Self-cooled, 2-winding, dry type especially designed for application, with special coil bracing to withstand electro-mechanical forces involved
2. 3-ph transformers shall use 1 coil/phase in primary and secondary

D. Transformers shall have following features and ratings

1. Enclosure: Indoor, ventilated unless otherwise shown on Drawings
2. Insulation Class: 220 o C class
3. Insulation Temperature Rise: 115 o C at 115% of rating
4. Taps: Two 5% full capacity taps, 1 above and 1 below rated high voltage
5. Temperature Sensing Device: Thermistor embedded in coil with leads brought out to terminal board

2.05 CONTROL AND SIGNAL TRANSFORMERS

A. Comply with NEMA ST 1 and UL 506

B. Ratings:

1. As indicated and for continuous duty
2. Where rating not indicated, provide 250 percent of load

C. Type: Self-cooled, 2-winding dry type

D. Enclosure: Indoor, except as indicated

2.06 MINI POWER ZONE PACKAGED POWER SUPPLY

A. Provide with primary breaker, transformer, secondary breaker, and circuit breaker panel as indicated on plans

B. Enclosure shall be NEMA 4X for outdoor and wet area indoor use, NEMA 3R for dry outdoor use, NEMA 1 for dry indoor use, and NEMA 12 for dusty indoor use. Provide stainless steel enclosure where shown on plans

C. Unit shall be rated for maximum full load temperature rise of 115°C

PART 3. EXECUTION

3.01 PREPERATION

A. Temporary Heating: Comply with manufacturer's written recommendations within enclosure of each transformer throughout periods during which equipment is not in a space continuously under normal control of temperature and humidity

3.02 INSTALLATION

A. Arrange equipment to provide adequate spacing for cooling air circulation

B. Tighten electrical connectors and terminals in accordance with manufacturer's published torque-tightening values. Where manufacturer's torque values not indicated, use those specified in UL 486A and 486B

C. Install wall-mounted transformers on prefabricated brackets designed for purpose

D. Install floor-mounted transformers on 4-in. concrete housekeeping pad

E. Touch up scratched or marred surfaces to match original finish

F. Identify transformers as specified herein.

G. Install lightning arresters as shown on Drawings.

3.03 GROUNDING

A. Ground in accordance with Section 16452 – "Grounding."

B. Ground secondary transformers with separate driven ground rod.

3.04 FIELD QUALITY CONTROL

A. Test and permanently record as follows.

1. Prior to energization of transformers, test phase-to-phase and phase-to-ground insulation resistance levels

2. Test transformers for continuity of circuits and short-circuits

3.05 ADJUSTING

A. Adjust transformer taps to provide optimum voltage conditions at utilization equipment

3.06 CLEANING

A. Upon completion of installation, inspect interiors and exteriors of accessible components

1. Remove paint splatters and other spots, dirt, and construction debris

2. Touch up scratches and mars of finish to match original

END OF SECTION

Section 16774

Automatic Dialer System

PART 1. GENERAL

1.01 SUMMARY

A. This specification is confidentially issued for this specific project only

B. Contractor shall be responsible for reading all specifications from all disciplines prior to bid

C. This section covers automatic dialer systems for alarm notification

D. Electronic system shall interface plant alarms via cellular telephone systems on pre-selected basis

1.02 SUBMITTALS, RECORD DRAWINGS, OWNERS & OPERATION MANUALS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

B. Provide list of discrete alarm inputs

C. Provide wiring diagrams for all connections into auto dialer

D. Provide warranty certificates

E. Provide complete operations manual and technical support information

1.03 SPARE PARTS

A. Provide additional two (2) 16 - dry contact expansion cards than what is required per construction documents

PART 2. PRODUCTS

2.01 DESCRIPTION AND PHONE NUMBER DIALING

A. The dialer shall be a solid-state component capable of dialing up to 16 telephone numbers, each up to 60 digits in length. Phone numbers and Standard pulse dialing or Touch Tone® DTMF dialing are user programmable via the system's keyboard or remotely via Touch Tone telephone. In addition, the dialer shall:

1. Group Alarm Calls - On alarm, system shall selectively call the correct phone number according to the specific alarm(s)
2. Detect Telephone Line Fault and indicate condition with Front Panel LED.
3. Automatically select Tone versus Pulse Dialing.
4. Monitor Call Progress - Detect Busy and Ringing Signals, Abandon Call if Busy, wait until phone is answered to Annunciate Voice Reports.
5. Provide Numeric Pager Support

6. Provide PBX Support

B. The autodialer shall be capable of connecting, via a single serial interface cable, to a variety of Programmable Logic Controllers (PLCs), Distributed Control Systems (DCSs) and SCADA systems.

2.02 VOICE MESSAGING RECORDING AND PLAYBACK

A. The unit shall have two different categories of speech message capability, all implemented with permanent non-volatile solid-state circuitry with no mechanical mechanisms. The unit shall allow for message recording from a remote telephone as well as from the front panel

1. Permanent Resident Non-Recorded Messages

a. Permanent built-in messages shall be included to support user programming operations, to provide supplemental warning messages such as advising that the alarms have been disabled, and to allow the unit to be fully functional even when the installer has not recorded any messages of his own

2. User field recorded messages:

a. The user may record and re-record voice messages for each input channel and for the Station ID.

i. There shall be no limit on the length of any message within the overall available message recording time, which shall be 409 seconds for 36 total channel units and 651 seconds for 57 total or more channel units

ii. The unit shall allow selective recording of both Normal and Alarm advisory messages for each input channel

iii. The unit shall provide for automatic setting of the optimum speech recording rate for the total set of messages recorder, in order to achieve optimum recording sound quality

iv. Circuit board switches or jumper straps shall not be an acceptable means of manipulating message length or recording rates

2.03 MANUFACTURER'S

A. Verbatim – Raco

B. Raco – AA – 102 AlarmAgent.com WRTU with NEMA 1 enclosure with 2 year monitoring subscription.

C. Antx

2.04 INPUT MONITORING FUNCTION

A. The basic unit shall continuously monitor the presence of AC power and the status of four (4) contact closure inputs. AC power failure, or violation of the alarm

criteria at any input shall cause the unit to go into alarm status and begin dial-outs. The unit shall, upon a single program entry, automatically accept all input states as the normal non-alarm state, eliminating possible confusion about Normal Open versus Normally Closed inputs. Further, as a diagnostic aid, unit shall have the capability of directly announcing the state of any given input as currently "Closed Circuit" or "Open Circuit" without disturbing any message programming. Each input channel shall also be independently programmable, without the need to manipulate circuit board switches or jumpers, to any of the following:

1. Normally Open, Normally Closed, or for No Alarm (Status Only)
2. Run Time Meter - Any dry contact input can be programmed to accumulate and report the number of hours their respective input circuits have been closed. Any such channels will never cause an alarm, but on inquiry will recite the channel's message according to the status of the input and then report the closed-circuit time to the tenth of an hour. The input will accumulate and report in tenths of hours up to a total accumulated running time of 99,999.9 hours. The initial value of the Run Time Meter shall be programmable in order to agree with existing electromechanical Run Time Meters. Up to a total of eight Run Time Meters may be programmed
3. Pulse Totalizer - Any dry contact input can be programmed to accumulate the number of pulses (momentary contact closures) occurring at the input. The maximum input pulse rate must not exceed 100 pulses per second, and if the rate is over 50 pulses per second, the pulses must have a 50% duty cycle. The user shall be able to program an initial starting value and a scale factor for each pulse totalizer input. The pulse totalizer input shall cause an alarm call upon reaching a user defined alarm setpoint

2.05 INPUT/OUTPUT EXPANSION CABILITY

A. The standard unit shall be modular in design, permitting it to accept "plug in" expansion circuit boards to incorporate any of the following:

1. Contact Closure Expansion Capability to a total of 8, 16, 24, or 32 total dry contact inputs
2. Analog Input Capability to a total of 1, 4, 8, or 16 total analog inputs
3. Remote Supervisory Control Outputs to manipulate 4 or 8 output relays

2.06 RACO ALARM AGENT

A. Wireless, web-based alarm detection and notification system from RACO designed specifically for water and wastewater applications.

B. Provide two year monitoring subscription with product.

C. <u>Input Monitoring Function:</u>

1. The basic unit shall continuously monitor the presence of AC power the status of (8) contact closure inputs and (2) universal inputs. AC power failure or

violation of the alarm criteria at any input shall cause the unit to go into alarm status.

2. The unit shall, upon a single program entry, automatically accept all input states as the normal non-alarm state, eliminating possible confusion about Normal Open versus Normally Closed inputs. Each input channel shall also be independently programmable, without the need to manipulate circuit board switches or jumpers.

D. Alarm Trip Delay: All alarm inputs, power failure alarms shall have individually assigned alarm trip delay settings. The range shall be 2 seconds – 1 hour.

E. Eight Digital Inputs: Eight (8) digital inputs monitoring dry (unpowered) contacts. These inputs shall be opto-isolated and surge protected, and shall also be drivable by five volt logic outputs. Open circuit voltage shall be 3.0 V; closed circuit current shall be 1.0 mA. All digital inputs shall use a single common return. Digital inputs may be programmed for the following functions:

1. Normally Open, Normally Closed, or for No Alarm (Status Only).

2. Run Time Meter — to accumulate and report the number of hours a particular input circuit has been closed. Any channel so configured will never cause an alarm call; it will report the closed circuit time to the tenth of an hour. The input will accumulate and report in tenths of hours up to a total accumulated running time of 999,999,999,999 hours. The initial value of the Run Time Meter shall be programmable in order to agree with existing electromechanical Run Time Meters. Up to a total of three Run Time Meters may be programmed.

3. Pulse Totalizer — to count the accumulated number of pulses (momentary contact closures) occurring at the input so programmed. Up to three input channels may be programmed for a Totalizer Function. Maximum Input pulse rate is 10 Hz, with a 50% Duty Cycle. The scaled value will not “rollover” to zero until a value of 4,294,967,294 has been exceeded.

F. Two Universal Analog / Digital Inputs: Two (2) analog 4-20 mA inputs shall be provided, with 10 bit resolution (0.125%), single ended and surge protected. Absolute accuracy shall be 0.5%. Loop resistance shall be nominally 250 ohm. Universal Analog / Digital inputs may be programmed for the following functions:

1. Independent High and Low set points shall be provided for each analog input.

2. The two analog inputs shall be combinable to allow High–High and Low–Low set point alarm notifications from a single sensor.

3. The two analog inputs shall be user-configurable to serve as additional digital inputs in lieu of analog, without need for physical settings at the WRTU.

4. Analog Input Report Scaling shall be configurable at the website. Scaling shall use any of these five different methods:

   a. Percentage (0 100%)
   b. Raw converter counts (0 1023)
   c. Milliampere reading (4 20 mA)

d. Custom scaling by entry of gain and offset values
e. Custom scaling by entry of two known pairs of signal level and reading values

G. Relay Contact Outputs: 2 Normally Open Output relays shall be provided.

1. Contacts shall be rated ½ A @ 120 VAC. These outputs shall be operable as follows:

a. On an occasional basis from the website, in either momentary or maintained mode.
b. Or, if configured, these relays can control local action at the WRTU site to react to local alarm conditions and activate lights, or buzzers, or engage external relays to turn local pumps or machines one or off. These actions can take place automatically based on unacknowledged alarms.

2. WRTU shall provide the ability to automatically open and close one or both unit relays on a scheduled basis. The Relay Schedule feature shall allow one transition to open and one transition to close per day. The WRTU shall report the completion of the Relay Schedule Event to the website. If, for any reason, the WRTU unit is unable to report this event, the AlarmAgent.com website shall display the missed event on the System Dashboard. Relay Schedules shall not affect the ability to manually transition the unit relays.

2.07 MODBUS COMMUNICATION

A. The unit shall include expansion card which enables it to communicate directly with devices utilizing Modbus RTU Protocol. A unit so configured shall be capable of “reading” and “writing” to 32, 64, or 96 data registers via Touch Tone Telephone. No modem or host computer shall be required. Interface shall consist of a single RS-232

2.08 COMMUNICATION PROTOCAL

A. The unit shall interface to standard networks commonly used in industrial installations. Additional communications protocols shall be supplied from the factory upon request.

2.09 CELLULAR COMMUNICATIONS

A. Where cellular phone communication is required, provide CDMA 800+ 1900 MHz cell phone with battery back-up or provide GSM factory installed quad-band GSM cell phone with battery back-up. (Verify telephone service provider with Owner.)

B. Provide EXTANKIT external omni-directional antenna kit with antenna cables, surge suppressor, and 10 – 20-foot, 2-inch aluminum mast attached to structure

2.10 ALARM AND INQUIRY MESSAGES

A. Upon initiating an alarm call, the system is to “speak” only those channels which are currently in “alarm status.”

2.11 ACKNOWLEDGEMENT

A. Alarms are acknowledged either by pressing a Touch Tone “9” as the call is being received, or by calling the unit back after having received an alarm call

2.12 NONVOLATILE PROGRAM MEMORY RETENTION:

A. User-entered programming and voice messages shall be kept intact, even during power failures or when all power has been removed, for up to ten (10) years

2.13 LOCAL AND REMOTE PROGRAMMING CAPABILITIES:

A. The user may optionally elect to alter the following parameters from their standard normal default values via keyboard entry or remotely from any Touch Tone telephone

1. Alarm Call Grouping: On alarm, system shall selectively call the correct phone numbers according to the current alarm(s)
2. Alarm Response Delay: 0.1 to 999.9 seconds, with different delays being assignable to different alarms
3. Delay Between Alarm Callouts: 0.1 to 99.9 minutes
4. Alarm Reset Time: 0.1 to 99 hours, or “No Reset”
5. Incoming Ring Response (Answer) Delay: 1 to 20 Rings
6. Number of Message Repetitions: 1 to 20 Repetitions
7. Auto call Test: When enabled, the unit shall place a single round of test calls, both at the time this function is enabled, and also at regular subsequent intervals until this function is disabled
8. Run Time Meter: Selected physical channel inputs shall accumulate and report the number of hours that its input contacts have been closed
9. Remote System Microphone Activation
10. Remote Arming and Disarming of System
11. Pulse totalizer function: selected physical input channels shall be capable of counting pulses of up to 100Hz at 50% duty cycle

2.14 SPEAKERPHONE

A. The unit shall be capable of dialing any phone number on command and functioning as a speakerphone

2.15 REAL TIME CLOCK:

A. The unit shall be equipped with a real time clock thereby making the following possible:

1. Alarm Ready Schedule - The dialer shall be user programmable to follow a specific schedule of operations. This shall include the flexibility to set a weekday, weekend, and holiday schedule. With this feature the dialer shall arm and disarm itself according to the schedule programmed
2. In the event any of the printer configurations outlined in Section 6 are utilized, all alarm reports will be time and date stamped. Routine scheduled status reports can also be programmed

2.16 POWER/BATTERY BACKUP:

A. Normal power shall be 105-135 VAC, 15 watts nominal. The product is to contain its own gel cell rechargeable battery which is automatically kept charged when AC power is present. The system shall operate on battery power for a minimum of 20 continuous hours in the event of AC power failure. A shorter backup time shall not be acceptable. The built-m charger shall be precision voltage controlled, not a “trickle charger”, in order to minimize recharge time and to maximize battery life available

2.17 INTEGRAL SURGE PROTECTION:

A. All power, phone line. dry contact. and analog signal inputs shall be protected at the circuit board to IEEE Standard 587. category B (6,000 volts open circuit/3,000 amps closed circuit). Gas tubes followed by solid state protectors shall be integral to the circuit board for each line

2.18 MISCELLANEOUS

A. All keyboard and front panel switches shall be sealed to prevent contamination. Front panel LED’s shall indicate: Normal Operation, Program Mode, Call-in Progress, Status for each Channel, AC Power present, AC Power failure, and Low, Discharging, or Recharging Battery. On any inquiry telephone call, or On-Site status check, the voice shall provide specific warning if no dial out phone numbers are entered, or if the unit is in “alarm disabled “mode, or if AC power is off or has been off since last reset. A built-in microphone shall allow anyone at a remote site to listen to local sounds and to have a two-way conversation with personnel at the dialer

B. Unit shall have cellular modem communication system

C. Radio communications interface

D. Thermostatically controlled heater

E. UL approved power supply

F. Operating temperature: 32 F to 160 F

G. Operating Humidity: 0% - 90%

H. 20-hour battery UPS

I. Vendors for equipment with solid-state controller shall include provisions for both hardwired and data path status, command and alarm functions included under contract without additional cost to Owner, Programmer, or Engineer

2.19 ENCLOSURE

A. Indoor: NEMA 12

B. Outdoor: NEMA 4X

PART 3. EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's written instructions and approved submittals

B. Wire each device, program test, and utility unit to be suitable for operation.

C. Contractor shall provide fail and problem alarms for all devices, equipment, controls, and generator and route to autodialer. Provide expansion modules and programming as required

D. Route all critical alarms to autodialer via relay contact direct from devices at MCC and/or control panel

E. Manufacturer’s Representative is to program unit per Operator’s instructions. Coordinate with solid state controllers where RS485/RS232/RJ-45 interface

F. Vendors for equipment with solid-state controller shall include provisions for both hardwired and data path status, command and alarm functions included under contract without additional cost to Owner, Programmer, or Engineer

END OF SECTION

Section 16911

Power Monitor

PART 1. GENERAL

1.01 SUMMARY

A. This specification is confidentially issued for this specific project only

B. Contractor shall be responsible for reading all specifications from all disciplines prior to bid

C. Contractor shall contact local Factory Representative to verify all equipment purchased conforms to the requirements of this project. Failure to do so may result in equipment removal and replacement at Contractor's expense

D. The Contractor shall furnish and install the Power Monitor equipment having the electrical characteristics, ratings, and modifications as specified herein and as shown on the contract drawings

1.02 REFERENCES

A. General: The latest edition of the following standards and publications shall comply with the work of this section:

1. ANSI/IEEE C12.20
2. National Fire Protection Association, NFPA 70 - National Electrical Code
3. National Electrical Manufacturer's Association
4. ISO 9001, Quality Management Requirements

1.03 SUBMITTALS

A. Refer to specification for Basic Submittal and O&M Requirements 16051

B. Data for each type indicating conductor sizes, conductor types, and connection configuration and lead lengths

C. Manufacturer's certified test data indicating the ability of the product to meet or exceed requirements of this specification

D. Drawings, with dimensions, indicating surge protection device mounting arrangement and lead length configuration, and mounting arrangement of any optional remote diagnostic equipment and assemblies

E. List and detail all protection systems such as fuses, disconnecting means and protective materials

F. Include installation details demonstrating mechanical and electrical connections to equipment to be monitored.

G. For side mount mounting applications (device mounted external to electrical assembly), Electrical/Mechanical drawings showing unit dimensions, weights, installation instruction details, and wiring configuration.

1.04 QUALITY ASSURANCE

A. Manufacturers qualifications

1. Eaton/Cutler Hammer shall be the basis of design. All products submitted shall comply with, meet, or exceed the specifications of the Eaton model type specified herein.
2. Equal products manufactured by Square D Company are acceptable. Equal products as pre-approved are acceptable.
3. The Manufacturer of the assembly shall be the Manufacturer of the major components within the assembly.
4. For the equipment specified herein, the Manufacturer shall be ISO 9001 or 9002 certified.
5. The Manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of 5 years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

2.01 MANUFACTURER'S

A. Shark Power Meter

B. Pre-approved equal

2.02 POWER MONITOR

A. Electrical Requirements:

1. Unit Operating Voltage – Refer to drawings for operating voltage and unit

B. Power Monitor Requirements

1. The device shall be capable of monitoring the following with a minimum accuracy of 0.5% of reading:
   a. Voltage (L-L and L-N)
   b. Amperes (all phases)
   c. Watts,Vars,VA
   d. Power Factor
   e. Frequency
   f. Var-Hours, VA-Hours
   g. Ampere-demand, Watt-demand, VAR-demand, VA-Demand
2. The device shall be capable of monitoring the following advanced parameters with all readings having a minimum accuracy of +/- 0.2%:

a. Individual Harmonics to the 40th harmonic
b. Total Harmonic Distortion (Voltage/Current)
c. Capable of trend logging and analysis up to 100,000 events with timestamp
d. The device shall be capable of recording the waveform with a minimum of 512 samples per cycle.
e. The device shall have a current range of at minimum .1-200% of nominal.
f. The device at a minimum shall have a display capable of 3 lines with 4 characters each, with indication of parameter being displayed.
g. The device shall be capable of communicating via TCP/IP Ethernet (RJ-45). Route data cable to Ethernet switch. Provide network expansion card as required

3.01 TESTING

A. Standard factory tests shall be performed on the equipment under this section. All tests shall be in accordance with the latest version of NEMA and UL standards

3.02 PREPERATION

A. Equipment shall be handled and stored in accordance with Manufacturer's instructions. One (1) copy of Manufacturer's instructions shall be included with the equipment at time of shipment

3.03 INSTALLATION

A. The Manufacturer shall submit a written statement indicating that a factory technician has inspected the installation. The installing contractor shall submit a checkout memorandum to the manufacturer. The memorandum shall indicate the date the equipment is placed into service and the actual method of installation. Submit three copies to the specifying engineer.

B. The installation of devices within or on electrical distribution equipment shall in no way compromise or violate equipment listing, labeling, or warranty of the distribution equipment.

C. The contractor shall follow the Device Manufacturer's recommended installation practice as found in the equipment installation instructions.

D. The installation shall adhere to all applicable codes.

E. The Contractor shall install all equipment per the Manufacturer's recommendations and the contract drawings.

3.04 MAINTENANCE/WARRANTY

A. Contractor shall provide full 5-year service warranty on the overall installation and shall include all labor and materials required to repair or replace equipment and/or components that are defective or malfunctioning.

B. Included under this warranty shall be all equipment, devices, hardware, and software. This warranty shall begin on date of written "Final Acceptance" of the electrical systems and to be executed as required at no additional cost to the Owner. Contractor's warranty shall also guarantee 24-hour service response time and shall provide labor, work, or materials as necessary to maintain plant operation when replacement parts are on order. In no case shall plant electrical systems be out of service for more than 24 hours from time Owner calls for warranty service. This shall be provided at no additional cost to the Owner. All equipment and materials installed shall have full warranty from Manufacturer that guarantees equipment is rated for harsh industrial electrical/mechanical environment in which it is installed. Where Manufacturer's products fail prematurely, Manufacturer shall be fully responsible for new replacement and shall not have the option of declaring that failures were caused by environmental conditions and its effect on the product.

C. Contractor is fully responsible for assuring that Product Manufacturers are aware of this condition and that warranty statement is included in shop drawing submittals. Failure to do so will be at the Contractor's expense and at no additional cost to the Owner.

D. All critical warranted repairs shall be made within 24 hours of receipt of required parts from Manufacturer with reasonable delivery time of overnight shipping. Any repairs not completed within 5 working days from date of notice are subject to Owner making other arrangements for repair and back charging Contractor. This requirement is a condition of this contract.

E. Where equipment or instrument problems remain unresolved by Contractor beyond a reasonable time, a Factory Technician shall be provided on-site to take any corrective actions necessary to put equipment or instruments in operating order. Owner and Engineer reserve the right to determine a reasonable time for corrective action by Contractor.

END OF SECTION