SECTION 15102

POWER-ACTUATING DEVICES FOR VALVES

PART 1 GENERAL

1.01 DESCRIPTION OF WORK

A. This Section includes furnishing and installing power-actuating devices that are externally mounted on valves as shown on the Drawings and as specified herein. Actuator types included are electric-motor type producing a multi-turn rotary motion.

B. Related Work specified elsewhere:

1. Division 13 - Instrumentation and Controls
2. Section 15100 - Valves and Appurtenances
3. Division 16 - Electrical Work

1.02 SUBMITTALS

A. Coordinate with Instrumentation and Valve suppliers. Check installation arrangements to prevent conflicts with piping and other equipment. Provide three sets of final Shop Drawings to Engineer for use in observing installation and for record purposes.

B. All submittals shall be in accordance with Section 01340 - Shop Drawings, Project Data and Samples.

C. Submit certificates from manufacturer showing compliance with specified requirements and standards.

1.03 QUALITY ASSURANCE

A. Power-actuating devices shall conform to the requirements of ANSI/AWWA C540 except as modified in this Section.

B. Actuators shall be assembled to new valves at the valve manufacturer's factory, bench tested for alignment, and shipped to the job site as a complete assembly.

1.04 ACCEPTABLE MANUFACTURERS

A. Subject to complying with specified requirements, manufacturers offering actuators which are acceptable for use on this project are limited to the following:

1. Limitorque L120 Series

2. Or approved equal

1.05 OPERATION AND MAINTENANCE MANUALS

A. Operations and Maintenance manuals shall be submitted as outlined in Specification 01730 - Operation and Maintenance Data.

1.06 WARRANTY

A. Per General Condition Article 9, the Contractor shall provide a 3 year warranty from substantial completion.

PART 2 PRODUCTS

2.01 GENERAL

A. Actuators shall be sized for the required operational characteristics of the valves as listed in the Valve Actuator Data Sheet and for the required torque or thrust, shaft diameter, thread characteristics and keyway dimensions of the valve actually furnished.

B. Actuators shall be designed for indoor and outdoor service and shall be capable of mounting in any position.

C. Torque capacity of the actuators shall be sufficient to operate the valves with the maximum pressure differential, as indicated in the Valve Schedule, with a safety factor of 1.5. Actuators in modulating service will be selected such that the required dynamic valve torque is no more than 60% of the electric actuator's maximum rated breakaway of torque.

D. Operating time for full limits of travel shall be not more than 2 seconds per inch diameter of the valve, +/- 50 percent through 20 inches; +/- 30 percent for valves 24 inches and larger. Operating time shall not be less than 30 seconds for all modulating valves.

E. Actuators shall be capable of operating in ambient temperatures ranging from 0 degrees F to 160 degrees F.

F. For open/close (non-modulating) actuators, the gearing, motor and contactor shall be capable of up to 60 starts per hour without overheating.

G. For modulating actuators, the gearing, motor and contactor shall be capable of up to 1200 starts per hour without overheating. This includes both discrete and analog setpoint modulation.

H. The actuators shall include, in one integral housing, individual compartments for the motor, gearing, wiring terminals, and control circuits. The terminal compartment shall be separated from the inner electrical components of the actuator by means of a watertight seal. The inner seal shall protect the motor and all other internal electrical elements of the actuator from entrance of moisture and dust when the terminal cover is removed. Double cartridge shaft seals shall be provided on the hand wheel and output shafts for weatherproof protection. All external fasteners shall be stainless steel. Compartments shall be provided with moisture and dust-proof rigid cast covers meeting NEMA 6, certified to submergence in 6 ft of water for 30 minutes. Actuators located in classified areas shall be suitable for use in Class 1, Division 1, Group D environments.

I. Gearing shall consist of a worm shaft and worm gear pinion operating in an oil bath. All gearing shall be hardened alloy steel or bronze. The worm gear pinion shall be alloy bronze. Gears shall be rated at twice the output torque of the operator and shall be designed to withstand the stall torque of the motor without failure. Worm gear drive shall be self-locking to prevent creeping of the valve disc in an intermediate position. Heavy-duty grease shall protect gearing and sealed ball bearings of the main shaft for five years without changing. The gearing shall be designed to allow field repair and change in gear ratio. Overtravel of the operator shall be prevented by internal mechanical stops cast into the actuator.

J. A mechanical dial position indicator shall be furnished to continuously indicate the position of the valve at and between the fully open and fully closed positions. The indicator shall be driven by gearing driven off of the main worm gear pinion and shall operate when the actuator is in either the electrical mode or manual mode.

K. A handwheel shall be permanently attached for manual operation. A planetary gear assembly shall be provided between the handwheel and the worm shaft if required to reduce the force necessary to operate the handwheel to less than 40 pounds. A positive declutch mechanism

shall engage the handwheel when required. When the actuator is set in the declutched position for handwheel operation, it shall return automatically to electric operation when the actuator motor is energized. The handwheel shall not rotate during electric operation nor shall a fused motor prevent handwheel operation.

2.02 ACTUATOR ELECTRIC MOTOR AND ACCESSORIES

A. The drive motor shall be specifically designed for actuator service and shall be characterized by high starting torque and low inertia.

B. Motors shall be 460 volts, three phase, 60 Hz AC reversible squirrel cage induction type motors and shall be specifically designed for modulating service where indicated on the Valve Schedule.

C. Motors shall be totally enclosed, non-ventilated, with NEMA Class H insulation minimum and a maximum continuous temperature rating of 120 degree C (rise plus ambient). A 120 VAC space heater shall be provided in the motor compartment.

D. The electric motor shall have a time rating of at least 15 minutes at 104°F (40°C) or twice the valve stroking time, whichever is longer, at an average load of at least 33% of maximum valve torque.

E. Motor bearings shall be permanently lubricated by premium lubricant. The motor shall have plug and socket electrical connection to facilitate easy removal and replacement.

F. The actuator shall include a device to ensure that the motor runs with the correct rotation for the required direction of valve travel with either phase sequence of the three-phase power supply connected to the actuator.

G. The motor shall include single phase protection. A suitable thermal protection device shall be incorporated in the motor or motor starter circuits, connected to a tripping device. Fast acting fuses shall be provided to protect solid state components.

H. The motor shall be capable of starting against the rated load in either the open or close direction when voltage to the motor terminals is plus or minus ten (10) percent of nameplate rating.

I. Open/Close actuators shall be furnished with electro-mechanical reversing starters. Modulating actuators shall be furnished with solid state reversing starters utilizing thyristors.

J. Leads from the motor shall be brought to the control circuit (limit switch) compartment without external piping or conduit box. An adequately sized space heater shall be installed in the control circuit compartment to aid in the prevention of damage resulting in from condensation. The following items shall be located in the control circuit compartment.

K. Torque limit switches shall be provided to de-energize the motor control circuit in the event of a stall when attempting to unseat a jammed valve and when torque is exceeded during valve travel. Each actuator shall have an open direction torque switch and a close direction torque switch. The torque switches shall be mechanically operated and able to be set in torque units. Torque switches shall be calibrated prior to the actuator's assembly to the valve.

L. Travel limit switches shall be provided to de-energize the motor control circuit when the actuator reaches the limits of travel in the open and close directions. The limit switch drive shall be of the counter gear type and "in step'" with the actuator output drive at all times in either the electrical or manual mode of operation. A minimum of eight (8) contacts, four (4) normally open and four (4) normally closed, shall be supplied at each end of valve travel (total of 16 contacts). Limit switches shall be fully adjustable when power is applied to the actuator.

M. The electrical terminals shall be housed in a double sealed terminal compartment isolated from the rest of the actuator components. All control terminations shall have plug and socket connections such that removal of the terminal compartment cover simultaneously disconnects all wiring in the compartment. The actuators shall be designed to operate from a single 480VAC, 3-phase source. The actuators shall be furnished with fuses inside the terminal compartment. A quantity of two - ¾ inch NPT conduit entries shall be furnished.

N. Motor enclosures shall be as listed in the Valve Actuator Data Sheet.

2.03 ACTUATOR CONTROLS

A. Modulating actuators shall have a position feedback potentiometer mounted directly to the valve actuator gearing inside the gearing compartment. The potentiometer shall provide a 4-20 mA signal corresponding to valve position. Modulating valve actuators shall be designed to respond to either a 4-20 mA DC analog signal or a digital pulse signal as specified herein or as required to coordinate with the requirements of Section 13100.

B. Modulating valve actuators designed to respond to a 4-20 mA DC signal shall be provided with a valve positioner, which shall position the valve proportional to an externally generated 4-20mADC signal. The valve positioning control circuitry shall position the valve by comparing the command signal with the present valve position as indicated by the feedback potentiometer. The positioner shall be field adjustable to fail to the "open," "closed," or "last" position on loss of 4-20 mA DC command signal.

C. Modulating valve actuators designed to respond to "pulse" open/close signals shall operate the valve during the time the open or close pulse signal is high. Modulating actuators designed to respond to "pulse" open/close signals shall have the latching circuitry described for open/close actuators disabled.

D. Actuators shall contain wiring and terminals for the following control functions. All dry contacts shall be rated for 5A at 250VAC.

1. Open, Close, and Stop commands from external dry contacts (utilizing internal 24VDC power supply) and/or from an external signal of 12V to 120V. The inputs for the open, close, stop signals shall be field selectable to be respond to either maintained or momentary remote signals. In momentary mode, the actuator shall have internal latching circuitry that causes the operator to drive the valve to its limit of travel upon receipt of the momentary contact signal unless a stop signal is received.

2. Remote Local-Off-Remote selector switch, Open/Close pushbuttons, and Open/Closed pilot lights for a remote manual control station (see below). The remote Local-Off-Remote selector switch and Open/Close pushbuttons shall be a dry

contact input to the actuator control circuitry. The Open/Closed pilot lights shall be powered from the valve actuator control power.

3. Four (4) unpowered contacts shall be provided which can be selected to indicate valve "Opened" and "Closed" position, "Remote" status of the actuator, and fail status of the actuator. The fail status contacts shall activate upon motor overtemperature and actuator overtorque as a minimum.

4. Terminals for 4-20mADC position command and 4-20mADC position feedback as described above for modulating actuators.

E. Local Controls

1. Actuators shall be furnished with a Local-Off-Remote selector switch; Open, Close, and Stop pushbuttons for local control; a red lamp indicating closed and a green lamp indicating open. L-O-R switch shall be padlockable in any of the three positions.

2. When the LOR is in the "Local" position, open/close control shall be by the open and close pushbuttons on the actuator. The stop push button shall stop the actuator travel.

   a) When the LOR is in the "Off" position, the actuator shall not operate.

   b) When the LOR is in the "Remote" position, the actuator shall be controlled by remote inputs from the PLC or from the remote manual controls station.

3. The local controls shall be arranged so that the direction of travel can be reversed without the necessity of stopping the actuator.

F. Remote Manual Control Station

1. Where indicated in the Valve Schedule, manual actuator controls shall be furnished in a separate NEMA 4X stainless steel enclosure (NEMA 7 if located in a classified area). Manual control station controls shall include Hand-Off-Auto Selector switch; Open, Stop, and Close

pushbuttons; a red lamp indicating closed and a green lamp indicating open.

a) When the HOA is in the "Hand" position, open/close control shall be by the open and close pushbuttons on the remote manual control station. The stop push button shall stop actuator travel.

b) When the HOA is in the "Off" position, the actuator shall not operate.

c) When the HOA is in the "Auto" position, the actuator shall be controlled by remote inputs to the valve actuator from the PLC.

2.04 PAINTING AND COATINGS

A. Actuators shall be painted in accordance with the requirements of the specified Standard with finish coats and colors conforming to the requirements of Section 09900 – Painting and Coatings.

PART 3 EXECUTION

3.01 SHIPPING, HANDLING AND STORAGE

A. Assembled actuators and valves shall be packaged, shipped and stored in accordance with the requirements of the specified Standard.

3.02 INSTALLATION

A. Install new actuators and valves as specified for valve installations. Make necessary piping, electrical and instrumentation connections.

3.03 TESTING

A. After installation, test valves and actuators in accordance with the requirements of Section 15100 – Valves and Appurtenances.

VALVE ACTUATOR DATA SHEET

DATA SHEET NOTES

1. Quantity of valves on this project shown underneath.

2. Status of valve:
   Relocate = existing valve with existing actuator to another location.
   Replace = Replace valve with another valve. Use the existing actuator.
   New = Provide and install new valve with new actuator.

3. Nominal diameter of valve.

4. Type of valve: Gate, Ball, Plug, Butterfly, Motorized Check, V-port Ball.

5. Maximum differential pressure across closed valve at time of actuation.

6. Stroking time: Time for full travel operation of valve.

7. Available Voltage.

8. Maximum flow rate through the fully open valve at time of actuation.

9. Type of valve operation required: Open-Close; Throttle; Modulate.

10. Electric enclosure required: NEMA 4 (Water-tight); NEMA 6 (Submersible); NEMA 7 (Hazardous).

Valve No.	Valve Qty	Valve Diam	Valve Type	Max Diff Pres	Stroking Time	Voltage	Max Flow Rate	Type of Oper	Elec Enc.
SWWRF									
MOV-100	1	30"	BFV	150 psi	90 sec	480 volt 3 Phase	17,500 GPM	Modulate	NEMA 4
MOV-103	1	12"	BFV	150 psi	90 sec	480 volt 3 Phase	2,800 GPM	Modulate	NEMA 4
SEWRF									
MOV 100	1	30"	BFV	150 psi	90 sec	480 volt 3 Phase	17,500 GPM	Modulate	NEMA 4
MOV 101	1	24"	BFV	150 psi	90 sec	480 volt 3 Phase	11,000 GPM	Modulate	NEMA 4
MOV 102	1	24"	BFV	150 psi	90 sec	480 volt 3 Phase	11,000 GPM	Modulate	NEMA 4
MOV 104	1	16"	BFV	150 psi	90 sec	480 volt 3 Phase	5,000 GPM	Modulate	NEMA 4
MOV 105	1	16"	BFV	150 psi	90 sec	480 volt 3 Phase	5,000 GPM	Modulate	NEMA 4
MOV 115	1	30"	BFV	150 psi	90 sec	480 volt 3 Phase	17,500 GPM	Modulate	NEMA 4
MOV 116	1	12"	BFV	150 psi	90 sec	480 volt 3 Phase	2,800 GPM	Modulate	NEMA 4

END OF SECTION

SECTION 16010

ELECTRICAL BASIC REQUIREMENTS

PART 1 GENERAL

1.01 THE REQUIREMENT

A. Furnish all labor, materials, equipment and incidentals required for a complete electrical installation for the Work associated with the Contract Documents, as hereinafter specified and shown on the Contract Drawings.

B. Provide functioning systems in compliance with manufacturer's instructions, performance requirements specified or shown on the Contract Drawings and modifications resulting from reviewed shop drawings and field coordinated drawings.

C. The work, apparatus and materials which shall be furnished under these Specifications and accompanying Contract Drawings shall include all items listed hereinafter and/or shown on the Contract Drawings. Certain equipment will be furnished as specified in other sections of these Specifications which will require wiring thereto and/or complete installation as indicated. All materials necessary for the complete installation shall be furnished and installed by the Contractor to provide complete power, lighting, communication systems, instrumentation, wiring, and control systems as indicated on the Contract Drawings and/or as specified herein.

D. Provide complete bonding and/or grounding systems for all equipment as specified herein, shown on the contract documents, and as required for specific pieces of equipment per manufacturer.

E. The Contractor shall furnish and install the necessary cables, transformers, motor control centers, protective devices, conductors, exterior electrical system, etc., to serve motor loads, lighting loads and miscellaneous electrical loads as indicated on the Contract Drawings and/or as specified hereinafter.

F. The work shall include complete testing of all equipment and wiring at the completion of the work and making any connection changes or adjustments necessary for the proper functioning of the system and equipment.

G. Mount and wire control panels and process instruments furnished under other Divisions of these Specifications unless specifically stated otherwise. Mount and make all field connections to process instrument panels and other control panels furnished under other Divisions of these Specifications. For process instrumentation, furnish and install all conduit, wire and interconnections between primary elements, transmitters, local indicators, surge protection devices and receivers.

H. Mount and wire isolation transformers, operator's stations, and power conversion equipment for all variable speed drive systems furnished under other Divisions of these specifications.

I. Install and wire all thermostats, aqua-stats and other devices furnished under other Divisions of this Specification directly controlling HVAC equipment or fan motors.

J. Mount and wire electric heaters, and heat tracing furnished under other Divisions of this Specification.

K. The scheduling and duration of any power or control interruption for the removal of existing equipment or the installation of new equipment shall be coordinated in advance with the Owner.

L. It is the intent of these Specifications that the electrical system shall be suitable in every way for the service required. All material and all work which may be reasonably implied as being incidental to the work of this Section shall be furnished at no extra cost.

M. Provide all temporary power as required to facilitate the Contract phased construction plan.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Related Sections include but are not necessarily limited to:

1. Division 1 - General Requirements
2. Section 03300 - Cast-in-Place Concrete
3. Division 11 - Equipment
4. Division 13 Special Construction

1.03 AREA CLASSIFICATIONS

A. Outdoor locations may contain wet, corrosive and hazardous areas.

1. Corrosive and hazardous areas are identified on the Contract Drawings. Areas not identified as such shall be considered wet.

B. Indoor locations may contain unclassified, damp, wet, corrosive and hazardous areas.

1. Damp, wet, corrosive and hazardous areas are identified on the Contract Drawings. Areas not identified as such, but provided with heating shall be considered unclassified. Areas not identified as such, but provided without heating shall be considered damp.

C. Hazardous Locations

1. Hazardous locations shall be as defined in NFPA 70 NEC, NFPA 820 Standard for Fire Protection in Wastewater Treatment and Collection Facilities, and other applicable standards or codes governing the classification of a particular type of facility or location. In addition, areas are classified as shown on Contract Drawings and as follows:

a) Class I Division 1
b) Class I Division 2
c) Class II Division 1
d) Class II Division 2

1.04 DEFINITIONS

A. Outdoor Areas

1. Those locations on the Project site where the equipment is normally exposed to wind, dust, rain, etc. Outdoor areas include areas protected by a roof or rain/sun shields but not enclosed within a structure.

B. Indoor Areas

1. Those locations on the Project site where the equipment is normally protected from wind, dust, rain, etc.

1.05 QUALITY ASSURANCE

A. Referenced Standards

1. American Iron and Steel Institute (AISI)

2. American National Standards Institute (ANSI)

   a) C2, National Electrical Safety Code.

3. American Society for Testing and Materials (ASTM)

4. Factory Mutual System (FM)

   a) A Guide to Equipment, Materials and Services.

5. Institute of Electrical and Electronics Engineers (IEEE)

   a) 141, Recommended Practice for Electrical Power Distribution for Industrial Plants.

   b) 242, Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.

6. National Electrical Contractors Association (NECA)

   a) NECA 1, Good Workmanship in Electrical Construction

   b) NECA 200, Recommended Practice for Installing and Maintaining Temporary Electrical Power at Construction Sites.

7. National Electrical Manufacturers Association (NEMA)

   a) 250, Enclosures for Electrical Equipment (1000 V Maximum)

   b) ICS 6, Enclosures for Industrial Control and Systems

8. National Fire Protection Association (NFPA)

   a) 70, National Electrical Code (NEC).

   b) 70E, Standard for Electric Safety in the Workplace

   c) 79, Electrical Standard for Industrial Machiner

   d) 820, Standard for Fire Protection in Wastewater Treatment and Collection Facilities

9. Underwriters Laboratories, Inc (UL)

   a) 508, Industrial Control Equipment

   b) 508A, Industrial Control

   c) 698, Industrial Control Equipment for Use in Hazardous Locations.

B. When a specific code or standard has not been cited, the applicable codes and standards of the following code-making authorities and standards organizations shall apply.

1. American Association of State Highway and Transportation Officials (AASHTO)

2. American Iron and Steel Institute (AISI).

3. American National Standard Institute (ANSI).

4. American Society for Testing and Materials (ASTM).

5. ETL Testing Laboratories, Inc (ETL).

6. Insulated Cable Engineers Association (ICEA).

7. Institute of Electrical and Electronic Engineers (IEEE).

8. Illuminating Engineering Society of North America (IES).

9. Instrument Society of America (ISA).

10. Lightning Protection Institute (LPI).

11. National Electrical Manufacturers Association (NEMA).

12. National Fire Protection Association (NFPA).

13. Occupational, Health and Safety Administration (OSHA).

14. Underwriters Laboratories Inc (UL).

C. In case of conflict or disagreement between codes, standards, laws, ordinances, rules, regulations, drawings

and specifications, or within either document itself, the more stringent condition shall govern.

1.06 SUBMITTALS

A. Shop Drawings - All submittals shall be in accordance with Specification 01340 - Sop Drawings, Project Data and Samples.

1. Shop drawings shall be arranged and labeled according to specification section and Contract Drawing.

2. Submit shop drawings prior to purchase or fabrication of equipment. See individual Division 16 sections for additional specific requirements.

3. Prior to submittals of shop drawings, coordinate electrical equipment, particularly motor control equipment, control panels, and instrumentation, with all applicable equipment and systems interfacing with that equipment.

4. Submittals shall be made in the following combinations:

a) Conduits, raceways, cable trays, ductbank details, wire and cable 600V and below, medium voltage cable, boxes and fittings.

b) Medium voltage switchgear, medium voltage motor starters, distribution transformers and secondary substations.

c) Motor control centers and control equipment, low voltage switchboards, safety switches, dry-type (specialty) transformers, panelboards, power factor correction capacitors, grounding.

d) Lamps, interior lighting, exterior building lighting, site lighting.

e) Wiring devices.

f) Alarm systems, communication systems and telephone systems.

g) Provide a wire or cable identification schedule for all power, control, signal, process and protective circuits. The schedule

shall be submitted in an electronic spreadsheet type Excel compatible file format and include the following information:

(1) Wire or Cable tag number.
(2) Number of conductors.
(3) Conductor size and type.
(4) Wire or Cable usage description.
(5) Conduit tag number
(6) Conduit routing (to and from).
(7) Conduit size and type.
(8) Additional notes

5. For each product, clearly identify manufacturer by name. When general data sheets are provided as part of the submittal, specifically identify the products to be used on this Project. Provide manufacturer's technical information on products to be used, including:

a) Product descriptive bulletin.

b) Electrical data pertinent to the Project and necessary to assure compliance with Specifications and Contract Drawings.

c) Equipment dimensions, where applicable.

d) Evidence that the products submitted meet the requirements of the standards referenced.

e) Specify part number with explanation of options selected.

6. Ensure that all submittals clearly indicate the equipment is UL or ETL listed.

7. For all equipment, provide manufacturer's installation instructions.

B. When a quality standard has been established by identification of a specific manufacturer or catalog number, submittals for proposed alternates and substitutions shall include:

1. Alternate and substitute equipment cross-referenced to the equipment it is replacing. Submittal shall be marked to show how differences will be accommodated.

2. Calculations and other detail data to allow determination of alternate and substitute equipment equivalency to the equipment it is replacing. Data supplied shall allow detailed comparison of all significant characteristics upon which the design equipment is based.

3. Dimensioned drawings, of the same or larger scale as the Contract Drawings, for all alternate and substitute equipment, which differs in size, configuration, service accessibility or in any significant way from the equipment it is replacing.

   a) Complete system layout, except that portion which is identical to the Contract Drawings.

   b) Redesign and modifications to all work required by the alternate or substitute equipment.

C. Operation and Maintenance Manuals.

1.07 DELIVERY, STORAGE, AND HANDLING

A. The Contractor shall unload and handle materials using methods, rigging, and equipment that will prevent damage to the materials. Care shall be used to prevent damage to painted and galvanized surfaces.

1. Bare wire rope slings shall not be used for unloading and handling materials and equipment, except with the specific written permission of the Engineer.

B. Equipment and materials, in accordance with the manufacturer's recommendations, shall be stored, supported and protected to prevent damage.

1. Stored materials and equipment shall not be allowed to contact the ground.

2. Equipment and materials which incorporate electrical equipment or which have finished painted surfaces, and other items which would be damaged by outdoor exposure, shall be stored indoors.

   a) Provide covering and shielding for all equipment to protect from damage.

b) When such storage would present an unreasonable building space or volume requirement, the equipment or materials may, when acceptable to the Engineer, be stored under weatherproof coverings on shoring or platforms.

3. All small loose items that could be easily lost, stolen, broken, or misused shall not be stored on open platforms or shoring.

4. All storage methods and schedules shall be acceptable to the Engineer.

C. Ensure that equipment is not used as steps, ladders, scaffolds, platforms, or for storage-either inside or on top of enclosures.

D. Protect nameplates on electrical equipment to prevent defacing.

E. Repair, restore or replace damaged, corroded and rejected items at no additional cost to the Owner.

F. Record Drawings

1. The Contractor shall maintain a marked up set of Document Drawings showing actual installed circuit numbers, conduit sizes, cable tray routing, number of conductors, conductor sizes (other than #12AWG) and all other deviations from the design drawings.

2. All underground conduit and concealed items shall be dimensioned on the Document Drawings from permanent, visible, building features. Depths to the top of ductbanks shall be recorded.

3. Provide actual motor size, starter size, and heater size, along with all other protective equipment for all motor circuits as part of the one-line record drawings.

4. Revise all wire/cable identification schedules to indicate as installed conditions.

5. Revise all panelboard schedules to indicate as installed conditions.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Refer to related Division 16 sections. All equipment of a similar type shall be by one manufacturer unless otherwise noted in the Specifications.

2.02 MATERIALS

A. Trade names and catalog numbers may be used in the Contract Drawings or Specifications to establish quality standards and basics of design.

1. Other listed manufacturers in the applicable specification sections with equal equipment may be acceptable.

2. If no other manufacturer is listed then any manufacturer of equal equipment may be acceptable.

B. Listed: Where UL test procedures have been established for the product type, electrical equipment shall be approved by UL or ETL and shall be provided with the UL or ETL label.

2.03 FABRICATION

A. When equipment is shop fabricated for the Project, the electrical devices and enclosures utilized shall be UL or ETL listed and labeled or shall be UL recognized.

B. Shop or Factory Finishes: Interiors of other painted equipment shall be white.

PART 3 EXECUTION

3.01 INSTALLATION

A. Equipment shall be installed in accordance with the requirements of the NEC.

B. Enclosures for use with electrical equipment unless specifically shown or specified elsewhere in the Contract Documents:

1. NEMA 1/12

a) Acceptable in unclassified indoor locations.

2. NEMA 3/3R
   a) Acceptable in damp or wet indoor/outdoor non-corrosive locations

3. NEMA 4X

   a) Use in wet indoor/outdoor corrosive locations.

   b) Enclosures shall be 304-Stainless-Steel minimum. Enclosures constructed of 316-Stainless Steel may be required in extremely corrosive areas as shown on the Contract Drawings

   c) Nonmetallic enclosures shall not be used in areas subject to physical damage or sunlight. Nonmetallic enclosures may be used in interior locations.

4. NEMA 6P

   a) Use in "Accidental Submergence" locations.

5. NEMA 7

   a) Use in all Class I, Division 1, 2, Group A, B, C, D locations.

   b) Unless other enclosures are approved and UL listed for the application.

6. NEMA 9

   a) Use in all Class II, Division 1, 2, Group E, F, G and Class III, Division 1, 2 locations.

   b) Unless other enclosures are approved and UL listed for the application.

7. Exceptions

   a) As modified in other Division 16 sections.

   b) As otherwise indicated on the Contract Drawings.

C. Coordinate the installation of electrical equipment with other trades.

1. Arrange for the building in of equipment during structure construction.

2. Where equipment cannot be built-in during construction, arrange for sleeves, box-outs, openings, etc., as required to allow installation of equipment after structure construction is complete.

D. Verify that equipment will fit support layouts indicated.

E. Equipment Dimensions and Clearances

1. Equipment shall fit in the locations shown on the Contract Drawings.

2. Do not use equipment or arrangements of equipment that reduce required clearances or exceed the space allocation.

F. Install equipment in accordance with the manufacturer's instructions.

G. Equipment Access

1. Install equipment so it is readily accessible for operation and maintenance.

2. Equipment shall not be blocked or concealed.

3. Do not install electrical equipment such that it interferes with normal maintenance requirements of other equipment.

H. Equipment shall be installed plumbed, square and true with the building construction and shall be securely fastened.

I. Outdoor wall-mounted equipment and indoor equipment mounted on earth or water bearing walls shall be provided with corrosion-resistant spacers to maintain 1/4 IN separation between the equipment and the wall.

J. Screen or seal all openings into outdoor equipment to prevent the entrance of rodents and insects.

K. Equipment fabricated from aluminum shall not be placed in direct contact with earth or concrete.

L. Provide all necessary anchoring devices and supports.

1. Use supports as detailed on the Drawings and as specified. Where not detailed on the Drawings or specified, use supports and anchoring devices rated for the equipment load and as recommended by the manufacturer.

2. Supports and anchoring devices shall be rated and sized based on dimensions and weights verified from approved equipment submittals.

3. Hardware shall be malleable type, corrosion resistant and shall be supported by heavily plated machine screws or brass, bronze or stainless steel bolts.

4. Do not cut, weld to, or modify building structural members without written approval by the Engineer of record.

5. Do not mount safety switches and external equipment to other equipment enclosures, unless enclosure-mounting surface is properly braced to accept mounting of external equipment.

M. Contractor shall verify exact rough-in location and dimensions for connection to electrical items to be installed under this Contract.

1. Shop drawings shall be secured from those furnishing the equipment.

2. Proceeding without proper information may require the Contractor to remove and replace work that does not meet the conditions imposed by the equipment supplied.

3. Provide sleeves wherever openings are required through new concrete or masonry members. Place sleeves accurately and coordinate locations with the Engineer.

4. Should any cutting and patching be required on account of failure of the Contractor to coordinate penetrations, such cutting and patching shall be done at the expense of the Contractor.

a) Contractor shall not endanger the stability of any structural member by cutting, digging, chasing, or drilling and shall not, at any time, cut or alter the work without the Engineer's written consent.

1) Provide additional reinforcing if required.

2) Cutting shall be done neatly using proper tools and methods.

b) Subsequent patching to restore walls, ceilings, or floors to their original condition shall be done by workmen skilled in their particular field.

N. Provide concrete foundations or pads required for electrical equipment as indicated or specified.

1. Floor-mounted equipment shall be mounted on a 4IN high concrete housekeeping pad. Pad shall be poured on top of the finished floor or slab.

O. Material that may cause rusting or streaking on a building surface shall not be used.

P. Perform excavation and backfill in accordance with Section 02200 - Earthwork.

Q. Contractor shall coordinate the installation of the conduit and wire associated with the HVAC equipment supplied under this Contract.

R. Enclosed electronic equipment located outdoors shall be provided with sun/rain shields and oriented to minimize sun exposure.

S. Device Mounting

1. Dimensions are to top of item unless otherwise indicated.

2. Mounting heights as indicated below unless otherwise indicated on the Contract Drawings

a) Light switch: 48IN.

b) Receptacle in offices and other finished areas: 16IN.

c) Receptacle in all other locations: 48IN.

d) Telephone outlet for desk-mounted phone: 16IN.

e) Telephone outlet for wall-mounted phone: 64IN.

f) Bracket light above lavatory: 80IN to bottom of fixture.

g) Disconnect / Safety-Switch: 64IN to top of enclosure.

h) Panelboard: 72IN to top of enclosure.

i) Motor starter: 64IN to top of enclosure.

j) Pushbutton motor control station: 48IN to top of enclosure.

3.02 IDENTIFICATION

A. Identify all major items of equipment including controls, panels, switches, contactors, motor starters/controllers, junction boxes and metering by permanent nameplates, with wording approved by the Engineer. Secure nameplates to equipment with stainless-steel screws or rivets. Adhesives may be used in conjunction with mechanical fasteners.

B. Nameplates after installation shall be easily visible and shall bear notations corresponding to those shown on the Record Drawings.

C. All conduits shall be identified with a stamped stainless-steel tag system. Conduit tags shall be permanently attached to each exposed end of conduit runs such as in manholes, pull boxes, panels, motor control centers, junction boxes, etc., and at each point of entry into a structure or building. Each tag shall be stamped with the appropriate conduit number per the conduit and cable schedules.

D. Each instrument shall be identified with a stamped stainless-steel tag system. Instrument tags shall be permanently attached to each individual instrument and stamped with the appropriate tag number per the instrument specification section.

E. Each cable shall be identified with a heat-shrinkable polyolefin label printing system. Instrumentation cables

shall be labeled with the appropriate instrument tag (Example: FIT-200-1). Multiplex cables, power and control cables shall be labeled with the appropriate cable tag number per the equipment tag number (Example: PP1-CKT-9).

F. All motor control centers, power panels, lighting panels, control panels, control cabinets, etc., shall be identified with permanently mounted nameplates.

G. All power and lighting panels shall have matte-finish plastic laminated typed schedules mounted on panel doors.

H. Identification Types

1. Equipment Nameplates

a) Phenolic Resin or Thermoplastic Elastomer

1) Thickness: 3/32IN minimum.
2) Size: As required by text.
3) Letters: White letters on Black background.
4) Mount with stainless-steel screws.

2. Wire and Cable Labels

a) Heat shrinkable Polyolefin
1) Size: As required by wire or cable.
2) Letters: Black letters on White background.
3) Heat-shrink after termination.
4) Replace damaged or illegible labels.

3. Raceway Tags

a) Material: Stainless-Steel
b) Size: As required by text.
c) Attach with stainless-steel wire and permanent crimp sleeve

4. Instrument Tags

a) Material: Stainless-Steel
b) Size: As required by text.
c) Attach with stainless-steel wire and permanent crimp sleeve

5. UNDERGROUND WARNING TAPE

a) Manufacturers: Brady Company, Seton or as approved.
b) Description: 2-inch wide plastic tape, detectable type, colored red with suitable warning legend describing buried electrical lines.

3.03 FIELD QUALITY CONTROL

A. Do not remove or damage fireproofing materials.
1. Install hangers, inserts, supports, and anchors prior to installation of fireproofing.

2. Repair or replace fireproofing removed or damaged.

B. Make all penetrations through roofs prior to installation of roofing.

C. All penetrations required after installation of roofing, shall be completed by an authorized roofer to maintain the roof warranty.

D. Make all penetrations of electrical work through walls water and weather-tight.

E. Equipment furnished under this Contract for use on future work and all concealed equipment, including conduits, shall be dimensioned, on the Record Drawings, from visible and permanent building features.

F. After installation, all equipment shall be tested as recommended by the manufacturer.

G. Verify all components are operational.

H. Perform ground-fault performance testing as required by NEC Article 230-95(c).

I. Test Equipment Interface

1. Verify systems coordination and operation.

J. Set all adjustable trip protective devices as required for system protection and coordination.

K. Verify all system and equipment ground continuity.

L. Adjust installed equipment for proper operation of all electrical and mechanical components.

M. Replace equipment and systems found inoperative or defective and re-test.

1. If equipment or system fails re-test, replace it with products that conform to Contract Documents.

2. Continue remedial measures and re-tests until satisfactory results are obtained.

3. Remedial measures and re-tests will be done at no cost to the Owner.

N. The Engineer shall be notified of tests and Engineer may witness individual tests.

O. Required certificates of testing and test reports shall be presented to the Engineer upon completion of the tests.

P. At Completion of Installation

1. Test to ensure all equipment is free of short circuits and improper grounds.

2. Test to ensure all equipment is operational.

3.04 CLEANING

A. Clean dirt and debris from all interior and exterior surfaces.

B. Apply touch-up paint as required to repair scratches, etc.

C. Replace nameplates or wire and cable markers damaged during installation.

D. Thoroughly vacuum the interior of all enclosures to remove dirt and debris. Do NOT use pressurized air systems to blow out dirt and debris.

3.05 DEMONSTRATION

A. Demonstrate equipment in accordance with Contract Requirements.

END OF SECTION

SECTION 16050

MATERIALS AND METHODS

PART 1 GENERAL

1.01 RELATED WORK SPECIFIED ELSEWHERE

A. In addition to the requirements specified in this section, the requirements of specification Section 16010 - Electrical, Basic Requirements and the sections referenced therein shall be applied.

B. Specification Section 03300 - Cast-in-Place Concrete

C. Specification Section 09900 - Painting and Coatings

1.02 SUBMITTALS

A. All submittals shall be in accordance with Specification 01340 - Shop Drawings, Project Data and Samples.

B. In accordance with the procedures and requirements set forth in the Contract requirements, the Contractor shall obtain from the equipment manufacturer and submit shop drawings. Each submittal shall be identified by the applicable Specification Section.

C. Shop drawings shall include but not be limited to:

1. Equipment specifications and product data sheets identifying all materials used and methods of fabrication.

2. Complete assembly, layout, installation, and foundation drawings with clearly marked dimensions.

1.03 QUALITY ASSURANCE

A. Manufacturers: Firms regularly engaged in manufacture of products for electrical related work of sizes, types, ratings, and materials required, whose products have been in satisfactory use in similar service for not less than three (3) years.

1.04 PROJECT CONDITIONS

A. Protect property from any and all damage that might result from excavating and backfilling.

B. Protect persons from injury at excavations, by barricades, warnings and illumination.

C. Coordinate excavations with weather conditions, to minimize possibility of washouts, settlements and other damages and hazards.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXCAVATING FOR ELECTRICAL WORK

A. General: Do not excavate for electrical work until the work is ready to proceed without delay, so that total time lapse from excavation to completion of backfilling will be minimized.

B. Excavate with vertical-sided excavations to greatest extent possible, except where otherwise indicated. Where necessary, provide sheeting and cross-bracing to sustain sides of excavations. Remove sheeting and cross-bracing during backfilling wherever such removal would not endanger the work or other property. Where not removed, cut sheeting off at sufficient distance below finished grade to not interfere with other work.

C. Depth for sub-base Support: Unless otherwise noted, provide installation of sub-base material(s). Excavate for installation of sub-base material in depth indicated or, if not otherwise indicated, 6IN below bottom of work to be supported.

D. Shoring and Bracing: Provide materials for shoring and bracing, such as sheet piling, uprights, stringers and cross-braces, in good serviceable condition.

1. Establish requirements for trench shoring and bracing to comply with local codes and authorities having jurisdiction.

2. Maintain shoring and bracing in excavations regardless of time period excavations will be open. Carry down shoring and bracing as excavation progresses.

E. Excavate trenches to the uniform dimensions required for the particular item(s) to be installed and provide sufficient working clearances. Dig trenches to

approximate depth and hand grade bottom to accurate elevation as required.

F. Where rock is encountered, carry excavation 6IN below required elevation and backfill with a 6IN layer of sand prior to installation of conduit.

G. Where soil conditions at bottom of indicated excavation are unsatisfactory, excavate additional depth as directed to reach satisfactory soil-bearing condition. Backfill with sub-base material compacted as directed, to indicated excavation depth.

H. Unless otherwise noted in the Contract Drawings, store excavated material (temporarily) near excavation, in manner that will not interfere with or damage excavation or other work. Do not store under trees (within drip-line).

I. Retain excavated material that complies with requirements for backfill material.

J. Dispose of excess or unsatisfactory excavated material(s) as directed by the Contract requirements and site conditions.

K. Refer to the Contract requirements and site conditions for removal of large subsurface materials.

3.02 DEWATERING

A. Prevent surface water and subsurface or ground water from flowing into excavations and from flooding project site and surrounding area.

B. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey rain water and water removed from excavations to collecting or run-off areas. Do not use trench excavations as temporary drainage ditches.

C. Maintain dry excavations for electrical work, by removing water. Protect excavations from inflow of surface water. Pump minor inflow of ground water from excavations; protect excavations from major inflow of ground water, by installing temporary sheeting and waterproofing. Provide adequate barriers that will protect other excavations and below-grade property from being damaged by water, sediment or erosion from or through electrical work excavations.

3.03 BASE PREPARATION

A. Install subbase material to receive electrical work, and compact by tamping to form a firm base for the work.

B. Provide finely-graded subbase material for equipment to be buried.

C. Tamp fill to uniform compacted density.

D. Where conduit crosses over areas which have been previously excavated to depths greater than required for conduit installation, provide suitable support that comply with details shown and Contract requirements.

3.04 BACKFILLING

A. Backfill with approved backfill materials.

B. Backfill with finely-graded subbase material to 6IN above equipment to be buried. Backfill materials shall be soil materials free of clay, rock or gravel larger than 3/4IN, debris, waste, frozen materials, vegetation and other deleterious matter.

C. Condition backfill material by either drying or adding water uniformly, to whatever extent may be necessary to facilitate compaction to required densities. Do not backfill with frozen soil materials.

D. Backfill simultaneously on opposite sides of electrical work, and compact simultaneously; do not dislocate the work from installed positions.

E. Backfill excavations in 8IN high courses of backfill material, uniformly compacted to the following densities (% of maximum density, ASTM D 1557), using power-driven hand-operated compaction equipment.

F. When backfilling excavations for electrical work, backfill to elevations matching finished grades.

G. Backfill trenches with concrete where trench excavations pass within 18IN of column or wall footings and which are carried below bottom of such footings, or which pass under wall footings. Place concrete to level of bottom of adjacent footing.

H. Do not backfill trenches until tests and inspections have

been made and backfilling authorized by the Engineer. Use care in backfilling to avoid damage or displacement of conduit systems.

3.05 INSTALLATION OF CONCRETE WORK

A. Refer to Specification Section 03300 - Cast-in-Place Concrete

B. Miscellaneous Concrete Work

1. Concrete Grouting: Grout openings and recesses as indicated on the Contract Drawings and around all electrical work and other work that penetrates or adjoins all concrete work. Provide formwork where required, and tamp, screed and trowel surfaces. Cure grout as specified for concrete work.

2. Refer to Specification Sections for grouting of equipment base plates on foundations (with high-strength, non-shrinking grout), and similar grouting requirements not defined herein.

C. Clean-Up: Upon completion of work, clean excess concrete and grout from adjacent areas and surfaces. Remove excess concrete and grout by proper methods of removal, using care not to scratch or otherwise damage finished surfaces.

3.06 SUPPORT AND FASTENERS

A. The Contractor shall furnish and install structural supports and fasteners for mounting and installing all electrical, lighting, alarm systems, instrumentation, communications and other equipment furnished under this Contract.

B. Where the weight of equipment exceeds 75LBS and is supported from walls, ceilings, columns and/or beams, such structural supports, methods, and locations shall be approved in writing by a professional engineer currently registered in the State of the projects location.

C. Concrete or Masonry Inserts

1. The Contractor shall be responsible for the furnishing and installation of all conduit sleeves, anchor bolts, masonry inserts, and similar devices required for installation of equipment furnished under this Contract.

2. The Contractor shall furnish leveling channels for all switchgear, switchboards, motor control centers, and similar equipment spanning 60IN, in any direction, along the floor. The leveling channels shall be provided for installation into the equipment supporting pads. Coordination of the installation of these channels within the concrete pad is essential and required. Pad height shall be as required to maintain coverage of the reinforcement bars while not exceeding the maximum mounting heights requirements of the NEC.

D. Support Fastening and Locations

1. All equipment fastened to structural steel; columns, beams, and trusses shall be made by approved clamps or welded. No holes shall be drilled in structural steel.

2. Where supports or hangers are required for heavy electrical equipment units exceeding 75LBS, the structural engineer of record shall check the structural members. Where required, additional sections shall be provided for a safe installation.

3. All holes in hung ceilings for support rods, conduits, and other equipment shall be made adjacent to ceiling supports where possible, to facilitate removal of ceiling panels.

4. For interior dry areas, a bracket and channel type support of galvanized steel construction shall be provided wherever required for the support of starters, switches, panels, and miscellaneous equipment.

5. For outdoor service or in indoor damp/wet process areas, the support system shall be made of either stainless steel, PVC coated rigid galvanized steel, aluminum or as indicated on the Contract Drawings.

6. All fastening hardware (bolts, nuts, washers, etc.) shall be approved stainless steel materials or as indicated on the Contract Drawings.

7. All supports shall be rigidly bolted together and braced to make a substantial supporting framework. Where possible, control equipment shall be grouped together and mounted on a single framework.

Wherever this occurs, a provision shall be made for ready access to the wiring for connections to the equipment by means of boxes with screw covers.

8. Aluminum support members shall not be installed in direct contact with concrete. Stainless steel or non-metallic "spacers" shall be used to prevent contact of aluminum with concrete.

9. The Contractor is responsible for the design of supporting structures and shall submit design details to the Engineer for acceptance before proceeding with the fabrication and installation.

10. Wherever dissimilar metals come into contact, the Contractor shall isolate these metals as required with nylon washers, 9MIL polyethylene tape, or gaskets.

END OF SECTION

SECTION 16111

CONDUIT AND RACEWAY

PART 1 GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish all labor, materials, tools and equipment necessary for furnishing, installing, connecting, testing and placing into service all raceway to include all conduits, conduit fittings, wireway, supports, etc. as required for a complete electric installation as specified herein and indicated on the Contract Drawings.

1. Conduit home runs for lighting, receptacle and other misc. circuits are not necessarily indicated on the Contract Drawings; however, the circuit numbers are shown. Conduit shall be furnished and installed for these circuits.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. In addition to the requirements specified in this section, the requirements of specification Section 16010 - Electrical Basic Requirements, and the sections referenced therein shall be applied.

1. Additional raceway from what is shown on the Contract Drawings may be required. Coordinate with the requirements of equipment provided under other Divisions of the specifications.

1.03 CODES AND STANDARDS

A. Raceway shall comply with the following applicable codes and standards as well as any others within the specifications and drawings. In the event of any conflict between these codes, regulations, standards, and Contract Documents, the most restrictive shall apply.

1. American National Standards Institute (ANSI)

a) C80.4 Fittings for Rigid Metal Conduit and Electrical Metallic Tubing.

b) C80.5 Electrical Rigid Aluminum Conduit.

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

   a) A36, Standard Specification for Structural Steel.

   b) A153, Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

   c) A307,Carbon Steel Externally Threaded Standard Fasteners.

   d) A563, Standard Specification for Carbon Steel Nuts.

   e) A569, Steel Carbon, Hot-Rolled Sheet and Strip, Commercial Quality.

   f) A570, Hot-Rolled Sheet and Strip, Structural Quality.

   g) A575, Merchant Quality Hot-Rolled Carbon Steel Bars.

   h) A635, Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Carbon, Hot-Rolled.

   i) D1784, Standard Specification for Rigid Poly (Vinyl Chloride)(PVC)Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.

   j) D1788, Standard Specification for Rigid Acrylonitrile-Butadiene-Styrene(ABS) Plastics.

   k) D2564, Solvent Cements for (PVC) Plastic Pipe, Tubing, and Fittings.

   l) F512, Standard Specification for Smooth-Wall Poly (Vinyl Chloride) (PVC) Conduit and Fittings for Underground Installation.

3. ETL Testing Laboratories, Inc (ETL).

4. National Electric Manufacturers Association (NEMA):

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

   b) TC-2, Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80).

c) TC-6, PVC and ABS Plastic Utilities Duct for Underground Installation.

5. National Electric Contractors Association

a) NECA 1: Standard Practices for Good Workmanship in Electrical Construction

6. National Fire Protection Association (NFPA)

a) 70, National Electric Code (NEC)

b) 79, Electrical Standard for Industrial Machinery

7. Underwriters Laboratories Inc (UL)

a) 1, Flexible Metal Conduit

b) 6A, Electrical Rigid Metal Conduit - Aluminum

c) 209, Cellular Metal Floor Raceways and Fittings

d) 360, Liquid-Tight Flexible Steel Conduit

e) 467, Grounding and Bonding Equipment

f) 514, Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers

g) 514B, Conduit, Tubing and Cable Fittings

h) 651, Schedule 40 and 80 Rigid PVC Conduit

i) 870, Wireways, Auxiliary Gutters, and Associated Fittings

j) 886, Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations

k) 1242, Intermediate Metal Conduit

l) 1660, Liquid-Tight Flexible Non-Metallic Conduit

1.04 SUBMITTALS

A. Shop Drawings - All submittals shall be in accordance with Specification 01340 - Shop Drawings, Project Data and Samples.

1. Proposed routing of all site conduits including direct buried, concrete encased, and long run above ground conduits.

2. Proposed routing of conduits buried under floor slabs.

3. Proposed routing and details of construction, including conduit and rebar, of conduits embedded in floor slabs, columns, etc.

4. Operation and Maintenance Manuals shall be submitted as outlined in Specification 01730 - Operation and Maintenance Data.

1.05 WARRANTY

A. Per General Condition Article 9, the Contractor shall provide a 3 year warranty from substantial completion.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

A. The material covered by this Specification is intended to be standard material of proven performance as manufactured by reputable firms. Raceways and appurtenances shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

B. All equipment shall be UL listed and labeled for its intended service.

C. Subject to compliance with the Contract Documents, the listed manufacturers are acceptable.

2.02 RIGID ALUMINUM CONDUIT (RAC)

A. Acceptable Manufacturers

1. Allied Tube and Conduit Corporation

2. Western Tube and Conduit Corporation

3. Wheatland Tube Company

B. RAC and associated fittings shall be manufactured from 6063 aluminum alloy in temper designation T-1.

C. RAC shall be installed for all above ground conduit installations indoor or outdoor unless otherwise noted on the contract drawings.

D. Standards

1. ANSI C80.5

2.03 PVC-COATED RIGID GALVANIZED STEEL CONDUIT (PVC-RGS)

A. Acceptable Manufacturers

1. Thomas & Betts

2. Perma-Cote

3. Rob-Roy Ind.

B. PVC-RGS shall have a minimum 40MIL polyvinyl chloride exterior coating. The coating shall be bonded to hot-dipped galvanized rigid steel conduit conforming to ANSI C80.1. The bond between the polyvinyl chloride coating and the conduit surface shall be greater than the tensile strength of the coating. PVC-RGS shall have a nominal 2MIL, minimum, urethane interior coating and a urethane coating on threads. The PVC-RGS conduit shall have an epoxy prime coating prior to application of polyvinyl chloride and urethane coatings.

C. Female ends shall have a plastic sleeve extending a minimum of 1 pipe diameter or 2 inch, whichever is less beyond the opening. The inside diameter of the sleeve shall be the same as the outside diameter of the conduit to be used with it.

D. Standards

1. ANSI C80.1

2. NEMA RN-1

2.04 RIGID POLYVINYL CHLORIDE CONDUIT (PVC)

A. Acceptable Manufacturers

1. Allied Tube and Conduit Corporation

2. Carlon

3. Cantex

B. PVC shall be either Schedule 40 or Schedule-80. The polyvinyl-chloride plastic compound shall meet, as a minimum, ASTM D1784 cell classification PVC 12233-A, B, or C. PVC shall be rated for direct sunlight exposure, 90°C wire, and fire retardant with low smoke emission.

C. Schedule 40 PVC conduit shall be installed in concrete encased underground conduit installations. Schedule 80 PVC conduit shall be installed in direct buried installations.

D. Standards

1. ANSI C33.91

2. NEMA TC-2

3. UL 651

2.05 LIQUID-TIGHT FLEXIBLE METAL CONDUIT (LFMC)

A. Acceptable Manufacturers

1. Anamet, Inc.

2. Electri-Flex Company

3. International Metal Hose Company

B. LFMC shall have a core formed of continuous, spiral wound, hot-dip galvanized steel strip with successive convolutions securely interlocked, contain an interwoven copper strip suitable as a grounding means, and have an extruded vapor and liquid tight polyvinyl chloride outer jacket positively locked to the steel core.

C. Standard

1. UL 360

2.06 WIREWAY

A. Acceptable Manufacturers

1. E.M. Wiegmann and Company, Inc.

2. Hoffman Engineering Company

3. Stahlin

4. Square D

B. Wireway shall have a minimum wall thickness of 0.040 inch, be furnished without knockouts, be designed for continuous grounding, and suitable for lay-in conductors. Provide Solid and non-removable covers when passing through partitions and solid hinged covers with captive screw fasteners when accessible.

C. Wireway shall not be smaller than 4-inch x 4-inch unless otherwise indicated on the Contract Drawings.

D. Types

1. NEMA-1: Wireway shall be steel, finished with rust inhibiting phosphatizing coating and gray baked enamel finish on interior and exterior surfaces.

2. NEMA-3/3R/12: Wireway shall be steel, finished with rust inhibiting phosphatizing coating and gray baked enamel finish on interior and exterior surfaces. Cover shall be fully gasketed and provided with captive clamp type latches.

3. NEMA- 4/4X: Wireway shall be type 304 stainless steel for interior or exterior corrosive areas. Cover shall be fully gasketed and provided with captive external screw type clamps.

4. NEMA- 4/4X: Fiberglass or PVC may be utilized for interior corrosive areas only where specifically shown on the Contract Drawings.

E. Standards

1. NFPA 79

2. UL 870

2.07 CONDUIT FITTINGS AND ACCESSORIES

A. Acceptable Manufacturers

1. Appleton
2. Carlon
3. Crouse-Hinds
4. Killark
5. OZ Gedney Company
6. Perma-Cote
7. RACO
8. Rob-Roy Ind.
9. Steel City
10. Thomas and Betts
11. Western Plastics Company

B. Fittings for Use with RAC

1. Materials: Following minimum requirements unless otherwise noted.

   a) Body: Copper-free aluminum with aluminum lacquer or aluminum enamel finish.

   b) Covers: Copper-free aluminum and gasketed.

   c) Gaskets: Neoprene or PVC.

   d) Insulators-phenolic, thermosetting: minimum 105 Deg C UL rating.

   e) Grounding saddles tin-plated copper or bronze suitable for use with copper and aluminum conductors.

   f) Bonding jumpers: Tinned copper flexible braid.

   g) Locknuts: Malleable iron, zinc plated.

2. All fittings: Threaded unless otherwise noted.

3. Conduit Hubs shall be cast aluminum with insulated throat.

4. Straight couplings: Same material and finish as the conduit with which they are used.

5. Mogul pulling elbows and tees:

   a) Die cast copper free aluminum

   b) Rain tight

6. Conduit seals

   a) Drain and breather: Stainless steel or brass

   b) Fiber and sealing compound: UL listed for use with the sealing fitting

7. Standards

   a) UL 467

   b) UL 514B

C. Fittings for Use with PVC

1. Fittings shall be of the same material, thickness, and construction as the conduits with which they are used.

   a) Standards

      1) UL 651

      2) NEMA TC-2-1978

2. Solvent cement for welding fittings shall be supplied by the same manufacturer as the conduit and fittings.

   a) Shall not be more than 1 year past date of manufacture.

   b) Standard: ASTM D2564

D. Fittings for Use with LFMC

1. Fittings shall meet the following minimum requirements unless otherwise noted:

a) Body: Malleable iron, zinc-plated

b) Ferrule: Steel, zinc-plated

c) Locknuts and compression nuts: Malleable iron, zinc-plated

d) Sealing ring: Neoprene

2. Fittings shall be compression type

3. Standard: UL 514

2.08 STRUT CHANNEL SUPPORT SYSTEMS

A. Acceptable manufacturers:

1. Allied Power-Strut Products

2. B-Line Systems

3. Rob-Roy Industries

4. Thomas & Betts

5. Unistrut Building Systems

B. All strut-channel, clamps, fittings and fastener materials shall conform to the following unless otherwise noted on the Contract Drawings.

1. Indoor Wet/Dry Areas:

a) Aluminum 6063-T6

2. Indoor Corrosive Areas:

a) Fiberglass (ASTM D-4385)

b) Stainless Steel Type-316 (ASTM A240)

c) PVC Coated Hot-Dipped Galvanized Steel (ASTM D1151, D2247)

3. Outdoor Wet Areas:

a) Stainless Steel Type-304 (ASTM A240)

b) Aluminum 6063-T6

4. Outdoor Corrosive Areas:

a) Stainless Steel Type-316 (ASTM A240)

b) PVC Coated Hot-Dipped Galvanized Steel (ASTM D1151, D2247)

C. Strut-channel shall not be bent, drilled, cut or otherwise modified to produce fittings, braces or brackets for conduit and equipment supports.

D. Manufactured strut-channel braces, brackets, fittings and post-bases shall be provided and installed with associated hardware and fasteners as a complete system for conduit and equipment supports.

PART 3 EXECUTION

3.01 DELIVERY, STORAGE, AND HANDLING

A. All conduit, raceway, wireway and associated fittings shall be stored in accordance with the manufacturer recommendations and shall not be stored exposed to sunlight or other UV rays.

3.02 INSTALLATION

A. The Contractor shall plan the layout of conduit and raceway systems so that when the work is complete it will exhibit good workmanship practices in accordance with NECA-1.

B. Routing of Conduits and Raceways

1. Conduit and Raceway runs, where shown, indicate the preferred location. Site conditions may affect actual routing. Contractor shall coordinate routing and measurement with other trades and with equipment suppliers.

2. Shall not interfere with, or prevent access to, piping, valves, ductwork, or other equipment for operation, maintenance and repair.

3. Wherever possible avoid routing conduits and raceways through areas of high ambient temperature or radiant heat.

C. Size of Conduits and Raceways

1. The size of conduits and raceways are normally shown on the Contract Drawings. If a size is not shown on the Contract Drawings, or if a minimum size is not stated in the Specifications, then the size of conduits and raceways shall be in accordance with the NEC.

2. Conduits shall not be smaller than 1 inch for underground installations and 3/4 inch elsewhere, unless otherwise shown on the Contract Drawings.

D. Types of Conduits and Raceways

1. Shall be installed as defined in the Contract Drawings.

2. As required by NFPA.

3. Flexible Conduit

a) Install as the final conduit to motors, electrically operated valves, primary elements (instrumentation), and electrical equipment that is liable to vibrate.

b) Shall not be used as a conduit run:

c) Maximum length shall not exceed:

(1) 36 inch to motors.

(2) 24 inch to all other equipment.

4. PVC-RGS

a) Contractor shall use tools, clamps, dies, equipment, etc. designed specifically for the cutting, bending and threading of PVC-RGS.

b) Contractor shall follow the recommendations and methods of the manufacturer for installing PVC-RGS.

E. Provide openings in walls, floors, and ceilings for all required raceway penetrations.

1. Sleeves and block outs: Set in masonry walls during erection.

2. Sleeves and block outs: Set in concrete during forming.

a) Material: Not harmful to the concrete.

b) Not considered to replace structurally the displaced concrete.

F. Conduit Runs

1. All conduits within a structure shall be installed concealed unless otherwise noted on the Contract Drawings.

2. Total of Bends in a Conduit Run

a) Less than 270 degrees.

b) Provide pull boxes, conduits, or pulling elbows or tees as needed.

3. Run in straight lines parallel to or at right angles to structural members or building lines.

4. Maintain minimum 2-inch separation between all conduits.

5. Maintain minimum 6-inch separation between instrumentation and power conduits.

6. Maintain minimum 12-inch separation from process, gas, air and water pipes.

7. Conduits and accessories embedded in concrete:

a) Shall not be larger in outside diameter than one-third the thickness of the slab, column or beam.

b) Place conduit and accessories after reinforcing steel has been laid.

c) Shall not displace the reinforcement steel.

d) Provide a minimum of 1-1/2 inches of concrete cover around conduit.

e) Do not run against reinforcing steel.

f) Provide 2 inch minimum of spacing between conduits.

g) Install expansion/deflection fittings wherever conduit spans structural or expansion joint.

G. Field Bending of Conduits

1. Utilize tools, equipment, methods and recommendations by the manufacturer to make all field bends.

2. The internal diameter of conduit shall not be reduced or distorted.

H. Field Cutting and Threading Conduits

1. Utilize tools, equipment, methods and recommendations by the manufacturer to field cut and thread conduit.

2. All field cut conduit shall be smooth and evenly chamfered on the inside.

3. All field threaded conduit shall be clean and degreased before applying a zinc rich paint.

I. Terminating Conduits

1. NEMA 1 enclosures

a) Top: Locknuts and insulated bushings.

b) Side: Locknuts and insulated bushings.

c) Bottom: Locknuts and insulated bushings.

2. NEMA 2/12/12K enclosures

a) Top: Sealing locknuts and insulated bushings.

b) Side: Locknuts and insulated bushings.

c) Bottom: Locknuts and insulated bushings.

3. NEMA 3/3R/3S/13 enclosures

a) Top: Threaded conduit hubs with insulated throats.

b) Side: Sealing locknuts and insulated bushings.

c) Bottom: Locknuts and insulated bushings.

4. NEMA 4/4X enclosures

a) Top: Threaded conduit hubs with insulated throats or approved cable gland fittings.

b) Side: Threaded conduit hubs with insulated throats or approved cable gland fittings.

c) Bottom: Threaded conduit hubs with insulated throats or approved cable gland fittings.

5. NEMA 5 enclosures

a) Top: Sealing locknuts with insulated throats.

b) Side: Sealing locknuts and insulated bushings.

c) Bottom: Locknuts and insulated bushings.

6. NEMA 6/6P enclosures

a) Top: Threaded conduit hubs with insulated throats or approved cable gland fittings.

b) Side: Threaded conduit hubs with insulated throats or approved cable gland fittings.

c) Bottom: Threaded conduit hubs with insulated throats or approved cable gland fittings.

7. NEMA 7/8/9 enclosures

a) Enclosures shall be provided with integral conduit hubs

J. Conduit Seal Installation

1. In each conduit entering or leaving a Class I area.

2. In each conduit in a Class I Division 1 area entering or leaving an enclosure containing switches, circuit breakers, fuses, relays, resistors or other apparatus which may produce arcs, sparks or high temperature.

3. In each conduit 2-inch or larger in a Class I Division 1 area entering or leaving an enclosure containing terminals, splices and taps.

4. In each conduit in a Class I Division 2 area entering or leaving an enclosure required to be approved for use in Class I environments.

5. In each conduit in a Class II location between an enclosure required to be dust ignition-proof and an enclosure that is not required to be dust ignition-proof.

6. In each conduit in a corrosive area entering or leaving that area and entering or leaving an electrical equipment enclosure in that area.

7. So that the filler plug and drain is accessible.

8. Complete with approved sealing fiber and compound.

K. Conduit Moisture Sealing

1. All conduits terminated into enclosures located outdoors or routed from interior to exterior locations shall have non-hardening conduit sealing putty packed into and around conductors within each conduit opening.

L. Conduit Coatings

1. The protective coating of metallic conduits, fittings, and accessories shall be maintained.

   a) Repair PVC-RGS utilizing a patching compound, of the same material as the coating, provided by the manufacturer of the conduit.

      (1) The total nominal thickness: 40 MIL.

   b) Repair surfaces that will be inaccessible after installation prior to installation.

2. All metallic raceways installed in direct contact with concrete, masonry or soils shall be:

   a) PVC-RGS

   b) Installed with 40 MIL minimum coating of cured coal-tar bitumastic paint.

3. All metallic raceway transitions through concrete, masonry or soils shall be:

   a) PVC-RGS

   b) Installed with heavy-wall heat-shrink polyolefin tubing extending 6-inch minimum on each side of transition.

c) Installed with 40 MIL minimum coating of cured coal-tar bitumastic paint.

M. Power Cable Pulling Preparation

1. Remove water and debris from conduit prior to installation of power cables.

2. Pull mandrel with diameter nominally 1/4 inches smaller than the interior of the conduit, to ensure circular cross-section and removal of obstructions.

3. Swab conduit by pulling a clean, tight-fitting rag through the conduit.

4. Tightly plug ends of conduit with manufactured pipe plugs or plastic conduit inserts until power cables are pulled.

5. Only nylon or polyethylene rope shall be used to pull power cables in rigid non-metallic conduit systems.

END OF SECTION

SECTION 16115

UNDERGROUND CONDUIT

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes manholes; handholes; pull-boxes; and underground power, control, and instrumentation conduits and ductbanks.

B. In addition to the requirements specified in this section, the requirements of specification Section 16010 - Electrical, Basic Requirements and the sections referenced therein shall be applied.

1.02 QUALITY ASSURANCE

A. Referenced Standards

1. American Association of State Highway & Transportation Officials (AASHTO).

2. American Society for Testing Materials (ASTM):

a) A536, Standard Specification for Ductile Iron Castings.

3. National Fire Protection Association (NFPA):

a) NFPA 70, National Electrical Code (NEC), 2008 Edition.

B. Miscellaneous

1. Contract Drawings indicate the intended location of manholes, handholes and pull-boxes; and routing of ductbanks and direct buried conduit. Field conditions may affect actual routing.

1.03 DEFINITIONS

A. Direct-buried conduit means individual (single) underground conduits without concrete encasement.

B. Direct-buried ductbank means multiple underground conduits, in a common trench, without concrete encasement.

C. Concrete encased ductbank means any underground conduit or combination of underground conduits encased in a common concrete envelope.

1.04 SUBMITTALS

A. All submittals shall be in accordance with Specification 01340 - Shop Drawings, Project Data and Samples and 16010 - Electrical Basic Requirements.

B. Fabrication and layout drawings

1. Provide cross-sectioned sketch of each ductbank.

a) Dimension spacing between conduits

b) Dimension concrete envelope and reinforcing, where applicable

2. Provide ductbank and direct-buried conduit profile.

a) Dimension from grade to ductbank and direct buried conduit

b) Dimension from ductbank and direct buried conduit to other utilities in the route

3. Certifications

4. Test reports

C. Operation and Maintenance Manuals

1. Operation and Maintenance Manuals shall be submitted as outlined in Specification 01730 - Operating and Maintenance Data.

1.05 WARRANTY

A. Per General Condition Article 9, the Contractor shall provide a 3 year warranty from substantial completion.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Precast manholes, handholes and pull-boxes

a) Hanson Pipe & Products, Inc.

b) Oldcastle Precast
c) Utility Vault Co.

2. Manhole and handhole covers

a) Neenah
b) Utility Vault Co.

3. Cable racks

a) Unistrut
b) B-Line
c) Condux International, Inc.
d) Underground Devices, Inc.

4. Cable pulling irons

a) Condux International, Inc.

5. Ground rods and grounding equipment

a) See Section 16450 - Grounding and Bonding

6. Ground wire

a) See Section 16450 - Grounding and Bonding

7. Duct terminators

a) Carlon
b) Condux International, Inc.

8. Conduit

a) See Section 16111 - Conduit and Raceway

9. Duct spacers

a) Underground Devices, Inc.
b) Condux International, Inc.

10. Warning Tape

a) W. H. Brady Company
b) Seton Nameplate Company

2.02 MATERIALS

A. Handholes and Pull-Boxes

1. Pre-Cast steel reinforced concrete

a) Boxes are required to meet ASTM C 858 with 4,000 PSI minimum compressive strength concrete and designed for AASHTO H-20 loading unless otherwise noted on the Contract Drawings.

b) Tongue-and-grove double sealed joints on mating edges of pre-cast components. The joints shall firmly interlock adjoining components and provide waterproof junctions and adequate shear transfer. Joints shall be sealed with approved watertight joint sealant as prescribed in the manufacturer's installation specifications and conforming to AASHTO M198, Type B. Sealing material shall be installed in strict accordance with manufacturer's printed instructions.

c) Knockout panels or pre-cast individual conduit openings may be used. Blockout panels are not acceptable.

d) Cover

(1) Heavy-duty type frames and covers made of cast iron, suitable for H-20 loading, and having machined bearing surfaces shall be used.

(2) The covers shall be of indented type with solid top design.

(3) The upper side of each cover shall have the letters "Electrical", "Control", or "Communication" cast in integral letters no less than 2-inches high as indicated on the Contract Drawings.

2. Cast-In-Place

a) Comply with Section 03300 - Cast-In-Place Concrete unless otherwise specified herein.

b) Constructed as detailed on the Contract Drawings.

c) Cover

(1) Heavy-duty type frames and covers made of cast iron, suitable for H-20 loading, and

having machined bearing surfaces shall be used.

(2) The covers shall be of indented type with solid top design.

(3) The upper side of each cover shall have the letters "Electrical", "Control", or "Communication" cast in integral letters no less than 2-inches high as indicated on the Contract Drawings.

d) Shall have an AASHTO live load rating of H-20, unless otherwise noted in the Contract Drawings or Specifications.

B. Manholes

1. Pre-Cast Steel Reinforced Concrete

a) Boxes are required to meet ASTM C 858 with 4,000 PSI minimum compressive strength concrete and designed for AASHTO H-20 loading unless otherwise noted on the Contract Drawings.

b) Tongue-and-grove double sealed joints on mating edges of pre-cast components. The joints shall firmly interlock adjoining components and provide waterproof junctions and adequate shear transfer. Joints shall be sealed with approved watertight joint sealant as prescribed in the manufacturer's installation specifications and conforming to AASHTO M198, Type B. Sealing material shall be installed in strict accordance with manufacturer's printed instructions.

c) Knockout panels or pre-cast individual conduit openings may be used. Blockout panels are not acceptable.

d) Minimum interior dimensions shall be 4 feet wide x 4 feet long x 6 feet tall

e) Cover

(1) Minimum access opening dimensions

(a) Rectangular 26-inch x 22-inch

(b) Round 26-inch Diameter

(2) Heavy-duty type frames and covers made of cast iron, suitable for H-20 loading, and having machined bearing surfaces shall be used.

(3) The covers shall be of indented type with solid top design.

(4) The upper side of each cover shall have the letters "Electrical", "Control", or "Communication" cast in integral letters no less than 2-inch high as indicated on the Contract Drawings.

2. Cast-In-Place

a) Comply with Section 03300 - Cast-In-Place Concrete unless otherwise specified herein.

b) Constructed as detailed on the Contract Drawings.

c) Shall have an AASHTO live load rating of H-20, unless otherwise noted on the Drawings.

d) Minimum interior dimensions shall be 4-feet wide x 4-feet long x 6-feet tall.

e) Cover

(1) Minimum access opening dimensions

(a) Rectangular 26-inch x 22-inch

(b) Round 26-inch Diameter

(2) Heavy-duty type frames and covers made of cast iron, suitable for H-20 loading, and having machined bearing surfaces shall be used.

(3) The covers shall be of indented type with solid top design.

(4) The upper side of each cover shall have the letters "Electrical", "Control", or "Communication" cast in integral letters no less than 2-inches high as indicated on the Contract Drawings.

f) Cable Racks

(1) Hot-dipped galvanized hot-rolled steel; or Lexan.

(2) 120 Lbs. minimum loading capacity.

(3) Three-point locking to resist twisting.

g) Cable Pulling Irons

(1) Hot-dipped galvanized steel

(2) 6,000 Lbs. minimum pulling load

h) Ground Rods and Grounding Equipment

(1) See Section 16450 - Grounding and Bonding

i) Ground Wire

(1) See Section 16120 - Wire and Cable: 600 Volt and Below

j) Duct Terminators

(1) Window type

(2) ABS plastic

(3) Provide for conduit entrance

(4) Designed for installation into manhole, handhole or pull-box walls for a watertight seal.

(5) Sufficient space between terminator walls to allow for placement of rebar and concrete.

k) Conduit

(1) See Section 16111 - Conduit and Raceway

l) Duct Spacers

(1) High density polyethylene or high impact polystyrene.

(2) Interlocking

(3) Provide 2-inch minimum spacing between conduits.

m) Warning Tape

(1) Material: Polyethylene

(2) Thickness: 3.5 MIL

(3) Tensile strength: 1,750 PSI

(4) Size: 6-inches wide (minimum)

(5) Legend: Preprinted and permanently imbedded:

(a) Message continuously printed.

PART 3 EXECUTION

3.01 INSTALLATION

A. General

1. Install products in accordance with manufacturer's instructions.

2. Comply with Section 16050 - Materials and Methods for trenching, backfilling and compacting.

3. Buried conductor warning tape

a) See Section 16010 - Electrical Basic Requirements.

B. Manholes, Handholes and Pull-Boxes

1. Shape: Manholes, handholes and pull-boxes may be either square or rectangular.

2. Size

a) Manholes shall have minimum interior dimensions of 48-inch x 48-inch with a minimum interior height of 72-inches unless other dimensions are detailed on the Contract Drawings.

b) Handholds shall be sized for the number of conduits entering unless other dimensions are detailed on the Contract Drawings.

(1) Minimum interior dimensions shall be 24-inch x 17-inch with a minimum depth of 36-inches.

c) Pull-Boxes shall be sized for the number of conduits entering unless other dimensions are detailed on the Contract Drawings.

3. Precast or Cast-In-Place

a) Optional unless otherwise noted in the Contract Drawings or Specifications.

4. Precast manholes, handholes and pull-boxes shall be installed in accordance with the manufacturer's instructions for "subject to occasional heavy vehicles."

5. For cast-in-place construction, comply with Section 03300-Cast-In-Place Concrete.

6. Provide minimum 12-inches of tamped crushed rock or gravel prior to setting manhole, handhole or pull box.

7. Construct manholes, handholes and pull-boxes approximately where shown on the Contract Drawings. Determine the exact locations after careful consideration has been given to location of other utilities, grading, and paving.

a) Locations are to be approved by the Engineer prior to excavation and construction of manholes, handholes and pull-boxes.

8. Grout or seal all joints

a) For precast construction, comply with the manufacturer's instructions.

b) For cast-in-place construction, comply with Section 03300 - Cast-In-Place Concrete.

9. Set frames and covers

a) For manholes, handholes and pull-boxes located in roadways, paint with two coats asphaltic paint before setting and set top of covers flush with finished surface of paving.

b) For manholes, handholes and pull-boxes not located in roadways, set top of covers

2-inches above finished grade. Slope surrounding grade away from edge to insure water drains away from opening.

c) Install sufficient number of concrete extensions between top of manhole, handhole or pull-box frame as required to elevate cover to existing grade level.

10. Support cables on walls by cable racks

a) Equip cable racks with adjustable hooks

(1) Quantity of hooks as required by the number of conductors

(2) Minimum of two (2) cable hooks per rack

b) Install a minimum of two (2) racks on each wall in each manhole, handhole and pull-box.

c) Space cable racks so that both ends of cable splices will be supported horizontally.

d) In manholes, install one (1) spare hook on each rack.

e) Install a cable-pulling iron in each wall opposite each ductbank entrance.

11. Grounding: In each manhole, drive copper ground rod into the earth and extend ground rod approximately 6-inches above finished floor.

a) In precast structures, drill openings in floor for ground rod.

b) Connect all metallic conduits, racks, and other metallic components to ground rod by means of #8AWG minimum tinned copper wire and approved grounding clamps.

12. Provide an 18-inch diameter sump in the bottom of each manhole and handhole.

13. After installation is complete, backfill and compact soil around manholes and handholes.

C. Underground Conduits

1. Concrete encased ductbank

a) Provide electrical duct system consisting of conduits completely encased in a minimum of 2-inches of concrete.

b) For circuits 600V and below, install so that top of concrete encased duct, at any point, is not less than the minimum depths established by the NEC (Table 300-5 and exceptions):

(1) RGS conduit: 24-inch

(2) PVC sch-40 conduit: 24-inch

(3) Under areas subject to vehicular traffic

(a) All applications: 24-inch

(4) Unless a greater depth is detailed on the Contract Drawings.

c) Under traffic areas (roadways, parking lots, etc.) and for a distance 10 feet either side of the traffic area, and elsewhere as defined on the Contract Drawings or specified, the concrete shall be reinforced in accordance with Section 03300-Cast-In-Place Concrete.

2. Direct-buried ductbank

a) Provide electrical duct system consisting of conduits directly buried in earth.

(1) Lay conduits on minimum 2-inch sand base completely encased by 2-inch of selected backfill containing no stones or other hard material larger than 1/2-inch diameter.

b) For circuits 600V and below, install so that the top selected backfill at any point, is not less than the minimum depths established by the NEC (Table 300-5 and exceptions).

(1) RGS conduit: 24-inch

(2) PVC sch-80 conduit: 24-inch

(3) Under areas subject to vehicular traffic

(a) All applications: 24-inch

(4) Unless a greater depth is detailed on the Contract Drawings.

3. Direct-buried conduit

a) Provide electrical duct system consisting of conduits directly buried in earth.

(1) Lay conduit on minimum 2-inch sand base completely encased by 2-inches of selected backfill containing no stones or other hard material larger than 1/2-inch diameter.

b) For circuits 600V and below, install so that top of the selective backfill, at any point, is not less than the minimum depths established by the NEC (Table 300-5 and exceptions).

(1) RGS conduit: 24-inch

(2) PVC sch-80 conduit: 24-inch

(3) Under areas subject to vehicular traffic

(a) All applications: 24-inch

(4) Unless a greater depth is detailed on the Contract Drawings.

4. Underground conduits and ductbanks shall comply with the following:

a) Minimum grade shall be 4-inches per 100 feet or as detailed on the Contract Drawings.

(1) Low point shall be at one end of the conduit run.

b) During construction and after conduit installation is complete; plug the ends of all conduits.

c) Provide conduit supports and separators of concrete, plastic, or other suitable nonmetallic, non-decaying material designed for that purpose.

(1) Concrete encasement supports shall provide a uniform minimum clearance of

2 inches between the bottom of the trench and the bottom row of conduit.

(2) Separators shall provide a uniform minimum clearance of 2-inches between conduits.

(3) Place supports and separators for PVC conduit on maximum centers as indicated for the following trade sizes:

(a) 1 inches and less: 2 feet

(b) 1-1/4 to 3 inches: 4 feet

(c) 3-1/2 to 6 inches: 6 feet

(4) Place supports and separators for RGS conduit on maximum centers as indicated for the following trade sizes:

(a) 1-inch and less: 8 feet

(b) 1-1/4 to 2-1/2 inches: 10 feet

(c) 3-inches and larger: 12 feet

(5) Securely anchor conduits to supports and separators to prevent movement during placement of concrete or soil.

(6) Do not place concrete or soil until conduits have been observed by the Engineer.

d) Stagger conduit joints at intervals of 6-inches horizontally.

e) Make conduit joints watertight and in accordance with manufacturer's recommendations.

(1) Make plastic conduit joints by uniformly brushing a plastic solvent cement on inside of plastic coupling fitting and outside of conduit ends. Slip conduit and fitting together with a quick one-quarter turn twist to set joint tightly.

(2) Accomplish changes in direction of runs exceeding a total of 5 degrees by long

sweep bends having a minimum radius of 25-inches.

(3) Sweep bends shall be made up of one curved section.

f) Furnish manufactured bends at end of runs.

(1) Minimum radius of 18-inches for conduits less than 3-inch trade size and 36-inches for conduits 3-inch trade size and larger.

g) After the conduit run has been completed, pull a standard flexible mandrel having a length of not less than 12-inches and a diameter approximately 1/4-inch less than the inside diameter of the conduit through each conduit. Then pull a brush with stiff bristles through each conduit to remove any foreign material left in conduit.

h) Pneumatic rodding may be used to draw in pull-cords.

(1) Install a 1/8-inch polypropylene pull-cord free of kinks and splices in all unused new ducts.

(2) Extend pull-cord 3-feet beyond ends of conduit and fasten to prevent loss of pull-cord in conduits.

i) Transition from PVC to RGS conduit with a minimum of 3-feet prior to entering a structure or going above ground.

(1) Unless otherwise indicated on the Contract Drawings.

(2) PVC conduit may be extended directly to pull, junction and transformer boxes; manholes and handholes.

j) Where conduits enter transformer boxes; manholes and handholes:

(1) Terminate PVC conduits in end bells.

(2) Terminate RGS conduits in insulated bushings.

B. Warning Tape

1. Place warning tape in trench directly over ductbanks, direct-buried conduit, and direct-buried wire and cable.

   a) 6-inches below finished grade where conduit or ductbank is 12-inches or more below finished grade.

   b) 3-inches below finished grade where conduit or ductbank is less than 12-inches below finished grade.

2. Provide warning tape as follows:

   a) Electrical trenches and ductbanks or directly buried conduit

      (1) Legend: "CAUTION CAUTION CAUTION" (1st line), "BURIED ELECTRIC LINE" (2nd line).

      (2) Letters: 1-1/4-inch minimum

      (3) Interval: Continuous

      (4) Color: Red and black letters.

   b) Trenches and direct-buried or conduit encased telephone lines:

      (1) Legend: "CAUTION CAUTION CAUTION" (1st line), "BURIED TELEPHONE LINE" (2nd line).

      (2) Letters: 1-1/4-inch minimum

      (3) Interval: Continuous

      (4) Color: Orange with black letters

   c) Trenches with direct-buried or conduit encased computer or SCADA system communications lines:

      (1) Legend: "CAUTION CAUTION CAUTION" (1st line), "BURIED COMPUTER LINE" (2nd line).

      (2) Letters: 1-1/4-inch minimum

      (3) Interval: Continuous

      (4) Color: Orange with black letters

3.02 MAINTENANCE

A. Provide the Owner with two (2) sets of manhole cover, underground pull-box cover or precast cable trench cover removal tools.

END OF SECTION

SECTION 16120

WIRE AND CABLE: 600 VOLT AND BELOW

PART 1 GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, install, connect, test, and place in satisfactory operating condition, ready for service, all cables and wires indicated on the Contract Drawings and as specified herein or required for proper operation of the installation, with the exception of internal wiring provided by electrical equipment manufacturers. The work of connecting cables to equipment, machinery, and devices shall be considered a part of this Section. All hardware, junction boxes, bolts, clamps, insulators, and fittings required for the installation of cable and wires system shall be furnished and installed by the Contractor

B. The Contractor shall submit Shop Drawings and other material required to substantiate conformance with the requirements set forth on the Contract Drawings and in Section 16010 - Electrical Basic Requirements, and Section 01340 - Shop Drawings, Project Data and Samples. Shop drawings shall include, but not be limited to, detailed specifications and product data sheets for the power, control, and instrumentation cable required for this project.

C. The wire and cable to be furnished and installed for this project shall be the product of manufacturers who have been in the business of manufacturing wire and cable for a minimum of ten (10) years.

D. Reference Section 16010 - Electrical Basic Requirements.

1.02 SUBMITTALS

A. All submittals shall be in accordance with Specification 01340 - Shop Drawings, Project Data and Samples, the Contractor shall obtain from the wire and cable manufacturer and submit the following:

1. Shop Drawings

2. Reports of Certified Shop and Field Tests

3. Wiring Identification Methods.

Each submittal shall be identified by the applicable specification section.

1.03 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed material's compliance with the Contract Documents.

B. Partial, incomplete, or illegible Submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Material specifications and product data sheets identifying all materials used and methods of fabrication

2. Cable and wire identification methods and materials

1.04 IDENTIFICATION

A. Each cable or wire shall be identified as specified in Section 16010 - Electrical Basic Requirements.

PART 2 PRODUCTS

2.01 600V POWER WIRE AND CABLE

A. All 600V rated power wire and cable shall consist of stranded, copper conductor with insulation type XHHW-2, 90°C.

B. Circuits within the interior spaces of buildings may utilize 600V rated insulation, type THHN/THWN, 75°C.

C. Conductors shall be stranded copper per ASTM-B8, B-33 and B-189, Class B or C stranding contingent on the size unless otherwise specified. Minimum size wire shall be #12AWG.

D. 600V rated individual or multi-conductor power wire and cable shall be manufactured by the Okonite Company, BICC Industrial Cable Company or approved equal.

2.02 600V CONTROL CABLE

A. All 600V rated control cable shall consist of stranded, copper conductor with insulation type XHHW-2, 90°C.

B. Control circuits within the interior spaces of buildings may utilize 600V rated insulation, type THHN/THWN, 75°C.

C. The individual conductors of the multiple conductor cable shall be color coded for proper identification. Color coding shall be equal to ICEA S-68-514, Table K-1. Cables shall meet requirements of IEEE-383.

D. Conductors shall be stranded copper per ASTM B-8, B-33 and B-189, Class B or C stranding contingent on the size unless otherwise specified. Minimum wire size shall be #14AWG.

E. 600V rated individual or multi-conductor control wire shall be manufactured by the Okonite Company, BICC Industrial Cable Company or approved equal.

2.03 600V SHIELDED MOTOR POWER CABLE FOR VARIABLE FREQUENCY DRIVES

A. Where indicated on the Contract Drawings, the power connection between the variable frequency drive (VFD) and the associated motor shall utilize a shielded three-conductor plus ground conductor VFD output cable.

B. Shielded motor power cables with #2AWG and smaller conductors shall have an overall polyvinyl chloride jacket, utilize XLPE conductor insulation with 100 percent rated ground conductor, overall foil shield, 85% TC braid and drain wire.

C. Shielded motor power cables with #1AWG and larger conductors shall have an overall polyvinyl chloride jacket, utilize XLPE conductor insulation with three-symmetrical BC grounds, two spiral copper tape shields.

D. Shielded Motor cable shall meet the following requirements:

1. Utilize high-strand tined copper conductors

2. Lower capacitance suitable for longer runs

3. Sunlight and oil resistant

4. Suitable for Class I and II; Division 2 hazardous locations

5. Rated for 90°C temperature for wet or dry locations

6. Pass UL 1685 vertical tray flame test

E. All VFD cables shall be terminated with approved VFD cable connectors and/or termination kits.

F. 600V rated shielded motor power cable shall be:

1. Belden: 29500 Series Cable

2. General Cable: CVTC VFD Cable

3. Service Wire Company: ServiceDrive ASD/VFD Cable

4. Southwire Armor-X VFD Cable

5. Approved equal

2.04 LIGHTING AND RECEPTACLE WIRE AND CABLE

A. All exterior lighting and receptacle branch circuit wire and cable shall consist of stranded, copper conductors with 600v rated insulation, type XHHW-2, 90°C.

B. Interior lighting and receptacle branch circuit wire and cable may utilize stranded, copper conductors with 600v rated insulation, type THHN/THWN 75°C.

C. Conductors shall be stranded copper per ASTM-B8, B-33 and B-189, Class B or C stranding contingent on the size unless otherwise specified. Minimum size wire shall be #12AWG.

D. Lighting and receptacle cables and wire shall be manufactured by the General Cable Company, Southwire Cable Company or approved equal.

2.05 INSTRUMENTATION SIGNAL CABLE (STP)

A. The instrumentation cable for analog signals shall be individually shielded twisted pair cable (STP) or individually shielded twisted multi-pair cable (M#STP, where # = number of pairs). Conductors shall be tin or alloy coated, soft, annealed copper, #16AWG minimum with a minimum of 19 strands with 600V rated insulation for 75°C. Pairs shall have 100% coverage foil shields with a

#18AWG tinned copper drain wire. Outer jackets shall be chromed polyvinyl chloride.

B. The instrumentation cable shall be Belden, Okonite or approved equal for single and multiple pair applications or approved equal.

C. Instrumentation cables shown on the Contract Drawings to be direct buried shall be UL labeled for direct buried service.

2.06 TELEPHONE/DATA CABLE (CAT-6)

A. All interior telephone/data cables shall be ANSI/TIA/EIA 568 (Category 6e), #24AWG copper, plenum rated and ETL Type-CMP.

PART 3 EXECUTION

3.01 600V CABLE INSTALLATION

A. The cable and wires shall be installed as specified herein and shown on the Contract Drawings.

B. The cables shall be terminated in accordance with the cable and/or termination product manufacturer's instructions for the particular type of cable.

C. To minimize oxidation and corrosion, wire and cable shall be terminated using an oxide-inhibiting joint compound recommended for "copper-to-copper" connections. The compound shall be Penetrox E as manufactured by Burndy Electrical, or approved equal.

D. Splices are normally not permitted in the underground duct, manhole and handhole systems. If splices are required, the Contractor shall obtain approval in writing from the Engineer prior to splicing.

1. Splicing material shall be a two-part insulating and encapsulating resin.

B. Cable and Wire Sizes

1. The sizes of cable and wire shall be as shown on the Contract Drawings, or if not shown, as approved by the Engineer. If required due to field routing, the size of conductors and respective conduit shall be shall be coordinated with and approved by the Engineer.

2. Minimum wire size within control panels, motor control centers, switchboards and similar equipment shall be #12AWG for power and #14AWG for control.

C. Number of Wires

1. The number of wires indicated on the Contract Drawings for the various control, indication, and metering circuits were determined for general schemes of control and for particular indication and metering systems.

2. The actual number of wires installed for each circuit shall, in no case, be less than the number required; however, the Contractor shall add as many wires as may be required for control and indication of the actual equipment selected for installation at no additional cost to the Owner. The addition of conductors shall be coordinated with and approved by the Engineer.

D. Wiring Identification

1. Wiring Identification shall meet the requirements of Section 16010 - Electrical Basic Requirements.

E. Cable Installation

1. All interior cable not protected by a compartment enclosure shall be run in conduit.

F. Training of Cable

1. The Contractor shall furnish all labor and material required to train cables around cable vaults within buildings and in manholes in the outdoor underground duct system. Sufficient length of cable shall be provided in each manhole and vault so that the cable can be trained and racked in an approved manner. In training or racking, the radius of bend of any cable shall be not less than the manufacturer's recommendation. All manhole cables shall be arc and fire-proofed. The training shall be done in such a manner as to minimize chaffing.

G. Connections at Control Panels, Limit Switches, and Similar Devices

1. Where stranded wires are terminated at panels, and/or devices, connections shall be made by

solderless lug, crimp type ferrule or solder dipped.

2. Where enclosure sizes and sizes of terminals at limit switches, solenoid valves, float switches, pressure switches, temperature switches, and other devices make 7-strand, #12AWG, wire terminations impractical, the Contractor shall terminate external circuits in an adjacent junction box of proper size and shall install #14AWG stranded wires from the device to the junction box in a conduit. The #12 AWG field wiring shall also be terminated in the same junction box to complete the circuit.

H. Pulling Temperature

1. Cable shall not be flexed or pulled when the temperature of the insulation or of the jacket is such that damage will occur due to low temperature embrittlement. When cable will be pulled with an ambient temperature within a three day period prior to pulling of 40°F or lower, cable reels shall be stored during the three day period prior to pulling in a protected storage area with an ambient temperature not lower than 55°F and pulling shall be completed during the work day for which the cable is removed from the protected storage.

I. Color Coding

1. Unless otherwise noted on the Contract Drawings, conductor insulation shall be color coded as follows:

a) 480V AC Power

(1) Phase A - BROWN

(2) Phase B - ORANGE

(3) Phase C - YELLOW

(4) Neutral - GREY

b) 120/208V or 120/240V AC Power

(1) Phase A - BLACK

(2) Phase B - RED

(3) Phase C - BLUE

(4) Neutral - WHITE

c) 120VAC Control

(1) Ungrounded conductors - RED

(2) Ungrounded conductors, foreign source - YELLOW.

d) 24VAC Control

(1) All wiring - ORANGE

e) 24VDC Power

(1) Positive Lead - RED

(2) Negative Lead - BLACK

f) 24VDC Control

(1) Ungrounded conductors - BLUE

(2) Grounded conductors - BLUE w/WHITE stripe

g) Equipment Grounding Conductor:

(1) All wiring - GREEN

2. Conductors #4AWG and smaller shall be factory color coded with a separate color for each phase and neutral, which shall be used consistently throughout the system. Larger cables shall be coded by the use of colored tape.

3.02 INSTRUMENTATION / TELEPHONE / DATA CABLE INSTALLATION

A. Grounding of cable shield shall be accomplished at one end point only.

B. Raceways exceeding 5 feet and containing instrumentation / telephone / data cable shall be installed to provide the following clearances:

1. Raceway installed parallel to raceway conductors energized at 480 through 208V shall be 18 inch and 208/120V shall be 12 inch.

2. Raceway installed at right angles to conductors energized at 480V or 120/208V shall be 6 inch.

C. Where practical, raceways containing instrumentation / telephone / data cable shall cross raceway containing conductors of other systems at right angles.

D. Where instrumentation / telephone / data cables are installed in panels, etc., the Contractor shall arrange wiring to provide maximum clearance between cables and other conductors. Instrumentation / telephone / data cables shall not be installed in same bundle with conductors of other circuits.

E. Additional pullboxes shall be furnished and installed for ease of cable pulling and the cable manufacturer's recommended conduit fill factor shall be followed.

F. All cable, insulation and jacket shall have adequate strength to allow for it to be pulled through the conduit systems. Sufficient conductors shall be installed to provide space and serve future equipment where shown and specified. All conductors shall be color coded and all wires shall be suitably tagged with permanent markers at each end.

3.03 TESTING

A. All testing shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Shop Test

a) Prior to the first shipment of each size of power, control, and telephone / data cable to be furnished and installed under this Contract, samples of each size of cable shall be subjected to complete physical and electrical factory production tests at the manufacturer's plant. Other cable and wiring shall be tested in accordance with the applicable ICEA Standards. Six copies of certified test data sheets shall be submitted to the Engineer for approval prior to installation at the site. Subsequent shipment of each size of wire shall be covered by certificates of compliance which shall list Contractor's name, point of delivery, reel numbers, size of wire, length of wire, and date of shipment. Certificates shall attest the wires and cables comply with specification requirements and that wires and cables are

equal in every respect to wires and cables which have been successfully tested.

b) All test data or certificates shall be notarized and submitted.

2. Field Tests

a) Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and Section 16010-Electrical-Basic Requirements.

b) After installation, all wires and cables shall be tested for insulation levels and continuity. Insulation resistance between conductors of the same circuit and between conductor and ground shall be tested. Testing for insulation levels shall be as follows:

(1) For 600V rated power and control cable, apply 1,000VDC from a Megaohmeter for all 600V wires and cables installed in lighting, control, power, indication, alarm and motor feeder circuits. Testing for continuity shall be "test light" or "buzzer".

(2) 600V rated instrumentation signal cable shall be tested from conductor to conductor, conductor to shield, and conductor to ground using a 260 volt-ohmmeter, or approved equal. The resistance value shall be 200 megaohms or greater.

B. Low voltage wires and cables shall be tested before being connected to motors, devices or terminal blocks. Voltage tests shall be made successively between each conductor of a circuit and all other conductors of the circuit grounded.

C. If tests reveal defects or deficiencies, the Contractor shall make the necessary repairs or shall replace the cable as directed by the Engineer, without additional cost to the Owner.

D. All tests shall be made by and at the expense of the Contractor who shall supply all testing equipment.

END OF SECTION

SECTION 16130

OUTLET PULL AND JUNCTION BOXES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:

1. Outlet pull and junction boxes

B. Related Sections include but are not necessarily limited to:

1. Contract and Bidding Requirements

2. Section 16010 - Electrical Basic Requirements

1.02 QUALITY ASSURANCE

A. Referenced Standards

1. Refer to Section 16010 - Electrical Basic Requirements

1.03 SUBMITTALS

A. All submittals shall be in accordance with Specification 01340 - Shop Drawings, Project Data and Samples, Shop Drawings

B. Operation and Maintenance Manuals shall be submitted as outlined in Specification 01730 - Operation and Maintenance Data.

1.04 DELIVERY, STORAGE, AND HANDLING

A. See Section 16010 - Electrical Basic Requirements

1.05 WARRANTY

A. Per General Condition Article 9, the Contractor shall provide a 3 year warranty from substantial completion.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Galvanized Steel Boxes

   (a) Appleton Electric Co.

   (b) Steel City

   (c) Raco

2. Corrosion-Resistant Boxes

   (a) Hoffman Engineering Co.

   (b) Crouse-Hinds

3. Hazardous Location Boxes (Class I, II & III)

   (a) Appleton Electric Co.

   (b) Crouse-Hinds

   (c) Killark

   (d) O-Z/Gedney

4. Raintight and Watertight Boxes

   (a) Appleton Electric Co.

   (b) Crouse-Hinds

5. Terminal Boxes

   (a) Hoffman Engineering Co.

6. Exposed Switch and Receptacle Boxes

   (a) Appleton Electric Co.

   (b) Crouse-Hinds

   (c) Killark

2.02 MATERIALS

A. Pull and Junction Boxes (smaller than 100 cubic inch)

1. Wet Areas

(a) Material: Malleable-Iron or 14 gage steel with polyester powder coating inside and out over phosphatized surfaces.

(b) 14 gage steel

(1) Continuously welded seams, ground smooth, no conduit punch-outs

(2) Stainless steel clamps on four sides

(3) Flat cover with oil resistant gasket

(4) NEMA 4 classification

(5) UL listed

2. Corrosive Areas:

(a) Material: Nylon, PVC or fiberglass reinforced polyester material.

(1) Neoprene door gasket

(2) Grounding bushing(s)

(3) NEMA 4X classification

(4) UL listed

3. Hazardous Areas

(a) Material: Cast gray iron alloy or copper-free cast aluminum

(b) Drilled and tapped openings or tapered threaded hub equipped

(c) Flat bolted-down or threaded cover with neoprene gasket

(d) Stainless steel hex head screws

(e) Explosion-proof, UL listed for Class 1 Groups C and D

B. Large Pull and Junction Boxes (100CU-IN and larger)

1. Wet and Corrosive areas

(a) NEMA 4X with stainless steel screws

(1) Type 304 L welded stainless steel

(2) Continuously welded seams, ground smooth, no conduit punch-outs

(3) Rolled lip around all sides

(b) Termination Boxes

(1) Galvanized 16 GA steel box provided with plain blank screw cover, subpanel, and terminal points.

(2) Terminal blocks shall be screw-cage barrier-type with white marker strip.

(3) Refer to Contract Drawings for dimensions, number of terminals and ratings.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Use listed and labeled boxes with threaded conduit hubs for use in hazardous areas.

C. Use malleable iron Type FS and FD boxes in wet areas and where exposed rigid steel conduit is required.

D. Use stainless steel, fiberglass, nylon or PVC boxes for corrosive areas.

E. Fill unused punched, tapped, or threaded hub openings with insert plugs of like material to maintain enclosure NEMA rating.

F. Use boxes sized to accommodate the quantity of conductors and devices enclosed.

G. Set all outlet pull and junction boxes plumb and vertical to the finish floor or grade.

H. Provide and install pull boxes or junction boxes in conduit runs as required to facilitate pulling of wires or making connections.

I. Make covers of boxes accessible.

J. Install pull boxes or junction boxes rated for the area classification.

K. Install all conduits squarely into all outlet pull and junction boxes.

L. Terminate all conduits as required in Specification **Section 16111-Conduit and Raceway.**

M. Large pull and junction boxes shall NOT be mounted to hand-rail or safety rail.

N. Do not install "back-to-back" boxes anywhere within this Project.

O. Support outlet boxes for lighting fixtures and other ceiling-mounted devices in lay-in acoustical tile ceilings by bar hangers anchored to ceiling construction members which do not interfere with tile removal.

END OF SECTION

SECTION 16140

WIRING DEVICES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Light switches, receptacles, device plates, dimmers, plug-in strips.

B. Related Sections include but are not necessarily limited to:

1. Division 1 - General Requirements

2. Section 16010 - Electrical Basic Requirements

1.02 QUALITY ASSURANCE

A. Referenced Standards

1. Refer to Section 16010 - Electrical Basic Requirements

1.03 SUBMITTALS

A. Shop Drawings

1. All submittals shall be in accordance with Specification 01340 - Shop Drawings, Project Data and Samples and 16010 - Electrical Basic Requirements.

1.04 WARRANTY

A. Per General Condition Article 9, the Contractor shall provide a 3 year warranty from substantial completion.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Light switches (except explosion-proof)

a) Hubbell

b) Slater

c) P&S

d) Arrow Hart

e) General Electric

f) Leviton

2. Explosion-proof light switches

a) Crouse-Hinds

b) Appleton Electric Co.

c) Killark

3. Door switches

a) General Electric

b) Slater

c) P&S

d) Arrow Hart

e) Micro-switch

4. Receptacles (except explosion-proof)

a) Hubbell

b) Slater

c) P&S

d) Arrow Hart

e) General Electric

f) Leviton

5. Explosion-proof Receptacles

a) Crouse-Hinds

b) Appleton Electric Co.

c) Killark

6. Dimmers

a) Lutron

b) General Electric

c) P&S

7. Plug-in Strip

a) Wiremold

b) Walker

2.02 MATERIALS

A. Light Switches for Unclassified Areas

1. Toggle type, quiet action, and specification grade with grounding terminal

2. Back and side wired

3. Solid silver cadmium oxide contacts

4. One-piece switch arm rated 20A, 120/277VAC

5. UL listed

6. Color: Ivory

7. Wall plate: Type 304 stainless steel

8. Type: As indicated on Contract Drawings

B. Receptacles for Unclassified Areas

1. Straight blade, grounding type, specification grade

2. Back and side wired with Wrap-around Bridge

3. Rated 20A, 125 VAC

4. UL listed

5. Color

a) For use on normal power: IVORY

b) For use on UPS systems: RED

c) For use on isolated ground systems: ORANGE

6. Wall plate: Type 304 stainless steel

7. Type: As indicated on Contract Drawings

C. Light Switches for Wet Areas

1. Press-switch type, quiet action, specification grade, with grounding terminal

2. Back and side wired

3. Solid silver cadmium oxide contacts

4. One-piece switch arm rated 20A, 120/277VAC

5. UL listed

6. Color: IVORY

7. Wall plate: GREY weatherproof press-switch type

8. Type: As indicated on Contract Drawings

D. Receptacles for Outdoor and Wet Areas

1. Straight blade, grounding type, GFIC specification grade

2. Back and side wired with wrap around bridge

3. Rated 20A, 125VAC

4. UL listed

5. Color: IVORY

6. Wall plate: Weatherproof, cast aluminum, UL listed "IN USE" cover

7. Type: As indicated on Contract Drawings

E. Ground Fault Circuit Interrupter (GFCI) Receptacles

1. Straight blade, grounding type, specification grade

2. Rated 20A, 125VAC

3. UL listed

4. Test and reset buttons

5. Wall plate: Indoor or weatherproof "IN USE" as required

6. Feed-thru type

F. Light Switches for Corrosive Areas

1. Corrosion-resistant NEMA 4X enclosure with switch consisting of:

a) Fiberglass reinforced polyester enclosure

b) Fiberglass reinforced polyester gasketed wall plate with built-in toggle lever switch with stainless steel shaft

c) Grounding bushing

d) Rated 20A, 125VAC

e) UL listed

f) Type: As indicated on Contract Drawings

g) Color: YELLOW

2. Optional: Corrosion-resistant enclosure and switch consisting of:

a) Cast copper-free aluminum "FS" or "FD" ridge type hub box

b) Toggle type, quiet action, and specification grade with grounding terminal

c) Rated 20A, 125VAC with solid silver cadmium oxide contacts

d) UL listed

e) Neoprene gasket

f) Cast aluminum cover with stainless steel screws and lever to activate switch

g) Type: As indicated on Contract Drawings

h) Color: YELLOW

G. Receptacles for Corrosive Areas

1. Corrosion-resistant straight blade, grounding type, specification grade

2. Back and side wired with Wrap-around Bridge

3. Rated 20A, 125VAC

4. UL listed

5. Color: YELLOW

6. Box: "FS" or "FD" ridge type cast hub box of copper-free aluminum

7. Gasket: Neoprene

8. Wall plate: Weatherproof, cast aluminum, UL listed "IN USE" cover

9. Type: As indicated on Contract Drawings

H. Explosion-proof Light Switches for Use in Hazardous Areas:

1. Explosion-proof, UL listed for Class I, Division 1 and 2, Groups B, C, and D; and Class II, Division 1 and 2 areas, Groups E, F, and G.

2. EDS factory sealed

3. Malleable iron body and cover

4. Aluminum sealing chamber

5. Front operated handle with stainless steel shaft

6. Rated 20A, 125VAC

7. With grounding screw

8. Type: As indicated on Contract Drawings

I. Explosion-proof Receptacles for Use in Hazardous Areas

1. Explosion-proof, UL listed for Class I, Division 1 and 2, Groups B, C, and D; and Class II, Division 1 and 2, Groups F and G

2. Factory-sealed malleable iron receptacle with spring-loaded cover

3. Malleable iron mounting box

4. Rated 20A, 125VAC

5. "Dead-front" construction requiring plug to be inserted and rotated to activate receptacle

6. Type: As indicated on Contract Drawings

J. Plug-In Strip: Surface steel raceway plug-in strip with single 15A, 125VAC, 3 wire grounding-type receptacles spaced 18 inch on center.

1. Pre-wired with two #12 TW and one #12 TW green insulated ground

2. Minimum 1-1/4 inch wide x 3/4 inch deep

3. Suitable fittings and snap-in cover

4. Finish

a) Stainless steel

5. Receptacle color

a) For use on normal power: Ivory

b) For use on UPS systems: Red

c) For use on isolated ground systems: ORANGE

K. Door Switches

1. Rated 5A, 120VAC

2. Mode of operation: Door open - lights on

3. UL listed

L. Lighting Dimmers

1. Electronic solid state type, rated for load, 120 and 277VAC

2. Circuit design: Silicon symmetrical gate to provide full wave dimming and withstand current and inverse voltage surges

3. Controls: Linear slide with positive off

4. Provide built-in filter to minimize noise interference in nearby audio lines

5. Rated 100°F maximum, ambient

6. UL listed

7. Finish: IVORY or WHITE

M. Pedestal-Type Floor-Mounted or Counter-Mounted Duplex Receptacles

1. Straight blade, grounding type, specification grade

2. Back and side wired with Wrap-around Bridge

3. Rated 15A, 125VAC

4. Horizontal design housing with threaded conduit fittings in base with satin chromium finish

5. Install on adjustable 4-inch flush floor box

6. Color

   a) For use on normal power: IVORY

   b) For use on UPS systems: RED

   c) For use on isolated ground systems: ORANGE

N. Thermostats

1. Contacts close on falling temperature to cycle unit heater on rising temperature to cycle exhaust fan motor

2. Rated 20A, 120VAC

3. Range: 46-84 Degrees F scale.

4. Switch: AUTO/OFF/ON

5. Provide sub-base and mounting plate.

6. Provide standard outlet box for mounting thermostat

PART 3 EXECUTION

A. Installation

1. Install products in accordance with manufacturer's instructions.

2. Mount devices where indicated on the Contract Drawings.

3. Surface-mount receptacles and light switches in concrete construction.

4. In masonry and metal stud construction, recess-mount receptacles and light switches unless device precludes recessed mounting or unless otherwise noted on the Contract Drawings.

5. Where more than one receptacle is installed in a room, they shall be symmetrically arranged.

6. Set all wiring devices including covers plumb and vertical to the floor.

7. Set recess-mounted switches and receptacles flush with face of walls.

8. Do not connect dimmers to loads in excess of 80 percent of the rating of the dimmer.

9. Provide blank plates for empty outlets.

10. Securely attach top to ceiling grid and base to mating surface.

END OF SECTION

SECTION 16450

GROUNDING AND BONDING

PART 1 GENERAL

1.01 THE REQUIREMENTS

A. The Contractor shall furnish and install grounding systems complete in accordance with the minimum requirements established by Article 250 of the NEC. Article 250 of the NEC shall be considered as a minimum requirement for compliance with this Specification.

B. Grounding of all instrumentation and control systems shall be furnished and installed in accordance with the manufacturer/system requirements and IEEE 1100-92, Powering and Grounding of Sensitive Electronic Equipment. Conflicts shall be promptly brought to the attention of the Engineer.

C. In addition to the NEC requirements, building structural steel columns shall be permanently and effectively grounded.

D. Reference Section 16010 - Electrical Basic Requirements.

E. Additional requirements for grounding are shown on the Contract Drawings.

1.02 CODES AND STANDARDS

A. All grounding components and the completed system shall comply with the following codes and standards as well as within the Specifications or as shown on the Contract Drawings:

1. American National Standards Institute (ANSI/IEEE)

   a) C2, National Electrical Safety Code (NESC)

2. Institute of Electrical and Electronic Engineers (IEEE)

   a) IEEE 81, Guide for Measuring Earth Resistivity.

   b) IEEE 142, Recommended Practice for Grounding of Industrial and Commercial Power Systems.

3. National Fire Protection Association (NFPA)

a) NFPA 70, National Electric Code (NEC)

4. Underwriters Laboratories Inc (UL)

a) 588, Grounding Equipment

1.03 SUBMITTALS

A. All submittals shall be in accordance with Specification 01340 - Shop Drawings, Project Data and Samples.

B. In accordance with the procedures and requirements set forth in the General Conditions and Division 1, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings

2. Reports of certified field tests. Each submittal shall be identified by the applicable Specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Equipment specifications and product data sheets identifying all materials used and methods of fabrication.

2. Drawings and written description of how the Contractor intends to furnish and install the grounding system.

1.05 WARRANTY

A. Per General Condition Article 9, the Contractor shall provide a 3 year warranty from substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by these specifications shall be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Contract Drawings.

2.02 GROUNDING CONDUCTOR

A. A green, insulated equipment grounding conductor, which shall be separate from the electrical system neutral conductor, shall be furnished and installed for all circuits. Equipment grounding conductors shall be furnished and installed in all conduits. Use of conduits as the NEC required equipment grounding conductor is not acceptable.

B. Where specified or shown a 3-inch strap shall be furnished and installed as the grounding conductor.

2.03 EQUIPMENT GROUND CONDUCTOR

A. Equipment ground conductors shall be solid and continuous from a connection at earth to all distribution panelboards. Ground connections at panelboards, outlets, equipment, and apparatus shall be made in an approved and permanent manner.

2.04 BONDING FITTINGS

A. Grounding connections to equipment shall be bolted. Cable end connections may be made by use of the crucible weld process or bolted type connectors. Bolted type connectors for this application shall consist of corrosion resistant copper alloy with silicone bronze bolts, nuts and lock-washers which are designed for this purpose.

2.05 GROUND RODS

A. Ground rods shall be rolled to a commercially round shape from copper-clad steel manufactured by the molten-welding process or by the electro-formed process (molecularly bonded). They shall have an ultimate tensile strength of 75,000 PSI and an elastic limit of 49,000 PSI. The rods shall be not less than 3/4-inch diameter by 20 feet in length; and the proportion of copper shall be uniform

throughout the length of the rod. The copper shall have a minimum wall thickness of 0.013 inch at any point on the rod.

B. The maximum resistance to ground of a driven ground rod shall not exceed 10-OHM under normally dry conditions. Where the resistance obtained with one (1) ground rod exceeds 10-OHM, additional ground rods shall be coupled, by exothermic welds. Except where specifically indicated otherwise, all exposed non current-carrying metallic parts of electrical equipment, metallic raceway systems, grounding conductors in nonmetallic raceways and neutral conductors of wiring systems shall be grounded.

The ground connection shall be made at the main service equipment and shall be extended to the point of entrance of the metallic water service. Connection to the water pipe shall be made by a suitable ground clamp or lug connection to a plugged tee. If flanged pipes are encountered, connection shall be made with the lug bolted to the street side of the flanged connection. If there is not suitable metallic water service to the facility, the ground connection shall be made to the driven ground rods on the exterior of the building.

Where ground fault protection is employed, care shall be taken so that the connection of the ground and neutral does not interfere with the correct operation of the ground fault protection system.

2.06 GROUNDING GRID

A grounding grid shall be provided for each structure and interconnected between structures. The grounding grid shall be installed such that the ground resistance does not exceed 5-OHM. The grounding grid shall be interconnected by bare copper conductors sized to the largest service entrance ground, spliced and connected to ground rods by exothermic welds. The grounding conductors shall be installed after the excavations for the building have been completed and prior to the pouring of concrete for the footings, mats, etc. Copper "pigtails" shall be connected to the grounding grid system; shall enter the buildings and structure from the outside; and shall be connected to steel structures and equipment as described in this Section and as shown on the Contract Drawings.

PART 3 EXECUTION

3.01 INSTALLATION

A. Metal surfaces where grounding connections are to be made shall be clean and dry. Steel surfaces shall be ground or filed to remove all scale, rust, grease, and dirt. Copper and galvanized steel shall be cleaned with emery cloth to remove oxide before making connections.

B. Grounding conductors shall be continuous between points of connection; splices shall not be permitted.

C. Where conductors are exposed and subject to damage from personnel, traffic, etc., conductors shall be installed in PVC sch-80 raceway.

D. Mechanical connections shall be permitted to ground rods in "Ground Test Wells" and shall be exposed to permit maintenance and inspection for continuity and effectiveness of grounding system.

E. Where subsurface conditions do not permit use of driven ground rods to obtain proper ground resistance, rods shall be installed in a trench or plate electrodes shall be provided, as applicable and necessary to obtain proper values of resistance.

F. Conduit

1. Conduit that enters equipment such as motor control centers, switchboards, switchgear, variable frequency drives, instrument and control panels, and similar equipment shall be bonded to the ground bus, where provided, and as otherwise required by the NEC.

3.02 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witnessed Shop Tests: None required

2. Field Tests

a) Ground resistance shall be measured with a three-point, fall of potential instrument.

b) All ground rods shall be tested after being driven and prior to connection to the grounding system. Where test results show resistance-to-ground is greater-than 10-OHM, additional ground rods shall be driven by coupling with exothermic welds. The compliance shall be demonstrated by retesting ground rod.

c) Upon completion of installation of the grounding and bonding system, the entire system shall be tested at the ground test well(s), as indicated on the Contract Drawings. The completed system shall have less-than 5-OHM of ground resistance.

3. Documentation

a) All tests shall be completely documented indicating time of day, date, temperature, weather conditions, measuring instrument and all pertinent test information.

b) All required documentation of readings indicating non-compliance, shall be submitted to the Engineer prior to and required for final acceptance of the project.

END OF SECTION

SECTION 16460

DRY TYPE TRANSFORMERS

PART 1 GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, install, and test transformers for power and lighting distribution systems as described herein, as shown on the Contract Drawings, and as required to complete the electrical installations.

B. All equipment specified in this Section shall be furnished by the transformer manufacturer who shall be responsible for the suitability and compatibility of all included equipment.

C. Reference Section 16010 - Electrical Basic Requirements, and Section 09900 - Painting and Coatings.

1.02 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witnessed Shop Tests: None required

2. Certified Shop Tests

a) The transformers shall be given routine factory tests in accordance with the requirements of the ANSI and NEMA standards. Temperature rises may be certified from basic design.

b) As a minimum, the following tests shall be made on all transformers:

(1) Ratio tests on the rated voltage connection and on all tap connections

(2) Polarity and phase-relation tests on the rated voltage connection

(3) Polarity and phase-relation tests on the rated voltage connection

(4) Applied potential tests

(5) Induced potential tests

(6) No-load and excitation current at rated voltage on the rated voltage connection

3. Field Tests

a) Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and Section 16010 - Electrical Basic Requirements.

b) After installation, the transformers shall be subjected to routine insulation resistance tests. The tests shall be made by the Contractor who shall also furnish the required testing equipment.

1.03 SUBMITTALS

A. All submittals shall be in accordance with Specification 01340 - Shop Drawings, Project Data and Samples. The Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings
2. Operation and Maintenance Manuals
3. Spare Parts List
4. Special Tools List
5. Reports of Certified Shop Tests

B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein, and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Equipment specifications and product data sheets identifying all materials used and methods of fabrication

2. Drawings showing clearly marked dimensions for each transformer

3. Sample equipment nameplate diagram

D. The submittal information shall reflect the specific equipment identification number as indicated on the Contract Drawings.

E. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items that the Contractor intends to provide are acceptable and shall be submitted.

1.05 OPERATION AND MAINTENANCE MANUALS

A. Operations and Maintenance Manuals shall be submitted as outlined in Specification 01730 - Operation and Maintenance Data.

1.06 TOOLS, SUPPLIES AND SPARE PARTS

A. The transformers shall be furnished with all special tools necessary to disassemble, service, repair and adjust the equipment. All spare parts as recommended by the equipment manufacturer shall be furnished to the Owner by the Contractor.

B. Spare parts lists, included with the shop drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.

C. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size shall have the same parts number.

1.07 IDENTIFICATION

A. Each transformer shall be identified with the equipment tag number indicated on the Contract Drawings and the accepted shop drawings. A nameplate shall be securely affixed in a conspicuous place on each transformer. Nameplates shall be as specified in Section 16010 - Electrical Basic Requirements.

1.08 WARRANTY

A. Per General Condition Article 9, the Contractor shall provide a 3 year warranty from substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Contract Drawings.

B. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Square-D
2. Cutler-Hammer
3. General Electric
4. Siemens-ITE

2.02 DRY TYPE TRANSFORMERS

A. Furnish and install single-phase and three-phase general purpose, dry-type transformers, as specified herein and indicated on the Contract Drawings. The transformers shall be 60Hz, self-cooled, quiet-design insulated of the two winding type.

B. The transformers shall be Underwriters Laboratories, Inc. listed and shall bear the UL label.

C. The primary windings shall be rated 480VAC for use on 3-phase, 3-wire systems and connected delta unless indicated otherwise on the Contract Drawings. KVA ratings shall be as shown on the Contract Drawings. Furnish taps for transformers as follows:

1. 1 PH, 25 KVA and below: Two 5% FCBN

2. 3 PH, 15 KVA and below: Two 5% FCBN

3. 3 PH, 30 KVA and above: Two 2.5% FCAN and four 2.5% FCBN

D. All taps shall be full capacity rated.

E. The ratings of the secondary windings shall be as indicated on the Contract Drawings.

F. Transformers shall be designed for continuous operation at rated KVA, 24 hours a day, 365 days a year, with normal life expectancy as defined in IEEE 65 and ANSI C57.96. This performance shall be obtainable without exceeding 150 degrees Celsius average temperature rise by resistance or 180 degrees Celsius hot spot temperature rise in a 40 degrees Celsius maximum ambient and 30 degrees Celsius average ambient. The maximum coil hot spot temperature shall not exceed 220 degrees Celsius. All insulating materials shall be flame retardant and shall not support combustion as defined in ASTM Standard Test Method D 635. All insulating materials shall be in accordance with NEMA ST 20 Standard for a 220 degrees Celsius UL component recognized insulation system.

G. Transformer coils shall be of the continuous wound copper construction and shall be impregnated with nonhydroscopic, thermosetting varnish.

H. Transformers shall have copper windings.

I. All cores are to be constructed of high grade, nonaging, grain-oriented silicon steel with high magnetic permeability and low hysteresis and eddy current loses. Magnetic flux densities are to be kept well below the saturation point. The core laminations shall be tightly clamped and compressed with structural steel angles. The completed core and coil shall then be bolted to the base by means of vibration-absorbing mounts to minimize sound transmission. There shall be no metal-to-metal contact between the core and coil assembly and the enclosure.

J. Indoor non-classified enclosures shall be made of heavy gauge steel and shall be degreased, cleaned, primed, and finished with a baked, weather-resistant enamel. See painting requirements specified in this section. Outdoor enclosures or enclosures within a corrosive area shall be constructed of stainless steel and rated NEMA 4X.

K. All transformers shall be equipped with a wiring compartment suitable for conduit entry and large enough to allow convenient wiring. The maximum temperature of the enclosure shall not exceed 90 degrees Celsius. Transformers shall be furnished with lugs of the size and quantity required and suitable for termination of the field wiring.

L. The core of the transformer shall be visibly grounded to the enclosure by means of a flexible grounding conductor sized in accordance with applicable NEMA, IEEE, and ANSI standards.

M. Transformers shall be mounted on neoprene-rubber isolation pads. The transformers shall not exceed the following ANSI sound levels:

1.	0	to	9 kVA	40dB
2.	10	to	50kVA	45dB
3.	51	to	150kVA	50dB
4.	151	to	300kVA	55dB
5.	301	to	500kVA	60dB
6.	501	to	700kVA	62dB
7.	701	to	1000kVA	64dB
8.	1001	to	1.5MVA	65dB

2.03 PAINTING

A. The exteriors of the transformer enclosures shall be painted as follows:

1. Factory painting: Surfaces shall be cleaned carefully and given a priming basic lead chromate. This shall be followed by two coats of an approved paint applied by brushing.

2. Field painting: After delivery and installation, but before transformers are placed in service, all factory-painted surfaces shall be carefully cleaned and all abrasions shall be repaired.

PART 3 EXECUTION

3.01 INSTALLATION

A. The transformers shall be furnished and installed as shown on the Contract Drawings and as recommended by the equipment manufacturer.

B. Conduit routed to and from the transformer shall be arranged for easy removal of the transformer.

END OF SECTION

SECTION 16470

PANELBOARDS

PART 1 GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish and install panelboards of voltage and current ratings as shown on the Contract Drawings. Panelboards shall be furnished with circuit breaker ratings, number of breakers, number of poles, locations and enclosure ratings conforming to the panelboard schedules on the Contract Drawings.

B. Reference Section 16010 - Electrical Basic Requirements.

1.02 STANDARDS

A. Panelboards shall conform to all applicable Federal, UL, and NEMA standards. Materials and components shall be new and conform to grades, qualities and standards as specified herein and shown on the Contract Drawings.

B. Panelboards shall comply with the following industry standards:

1. UL Listing/ Approval

2. Standards

   a) UL 50 - Cabinets and Boxes

   b) UL 67 - Panelboards

   c) NEMA - PB1

   d) NFPA 70 - National Electrical Code

1.03 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witnessed Shop Tests: None Required

2. Field Tests:

   a) Field testing shall be done in accordance with the requirements specified in the General

Conditions, Division 1, and Section 16010 - Electrical Basic Requirements.

1.04 SUBMITTALS

A. All submittals shall be in accordance with Specification 01340-Shop Drawings, Project Data and Samples. The Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings

2. Reports of Certified Shop Tests

3. Spare Parts List

4. Operation and Maintenance Manuals shall be submitted as outlined in Specification 01730 - Operation and Maintenance Data.

B. Each submittal shall be identified by the applicable specification section.

1.05 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Material specifications and product data sheets identifying all materials used and methods of fabrication.

2. Complete assembly, layout, and installation drawings with clearly marked dimensions for each panelboard.

3. Complete panelboard schedules indicating circuit designations and connected loads as shown on the Contract Drawings for each panelboard.

D. The submittal information shall reflect the specific equipment identification as indicated on the Contract Drawings.

1.06 TOOLS, SUPPLIES AND SPARE PARTS

A. The panelboards and accessories shall be furnished with all special tools necessary to disassemble, service, repair, and adjust the equipment. For each panelboard, the Contractor shall furnish to the Owner all spare parts as recommended by the equipment manufacturer including two (2) molded case circuit breakers of each type, size, and rating used.

B. Spare parts lists, included with the shop drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.

C. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size shall have the same parts number.

1.07 IDENTIFICATION

A. Each panelboard shall be identified with the identification tag number indicated on the Contract Drawings and the accepted shop drawings. A nameplate shall be securely affixed in a conspicuous place on each panelboard.

1.08 WARRANTY

A. Per General Condition Article 9, the Contractor shall provide a 3 year warranty from substantial completion.

PART 2 PRODUCTS

2.01 GENERAL

A. The Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Contract Drawings.

2.02 CONDUCTORS (MAIN BUS AND BRANCH CONNECTORS)

A. All main bus shall be copper sized in accordance with UL standards to limit the temperature rise on any current

carrying part to a maximum of 50 degrees C above a maximum ambient temperature of 40 degrees C.

B.

2.03 LIGHTING PANELBOARDS

A. General

1. The Lighting Panelboards, as defined by NEC or noted on the Contract Drawings, shall be dead-front type with automatic trip-free, non-adjustable, thermal-overload, branch circuit breakers. Panelboards shall be of the configuration and rating as specified herein and indicated on the Contract Drawings. Panelboards shall be listed and labeled by Underwriter's Laboratories, Inc.

2. The Lighting Panelboards shall be equipped with a main breaker or main lugs complete with branch circuit breakers, as shown on the Contract Drawings. The panelboards shall be enclosed in a cabinet suitable for flush or surface mounting. Some panelboards shall be furnished and installed within motor control center structures as shown on the Contract Drawings.

3. Lighting Panelboards shall be fully rated and shall have a short circuit rating of 22kA symmetrical, minimum. In the event the results of the Contractor's short circuit fault analysis, as accepted by the Engineer, indicate that a higher short circuit rating of the panelboards is required, furnish complete panelboards with that higher rating.

4. Lighting Panelboards shall be furnished with transient voltage surge suppression (TVSS) and filtering equipment as required in Specification Section 16671-Transient voltage Surge Suppression and indicated on the Contract Drawings. The TVSS devices shall be UL labeled.

5. Subject to compliance with specifications Lighting Panelboards shall be:

   a) Square-D Company

   b) Eaton/Cutler-Hammer Electric Corporation

   c) General Electric

d) Approved equal

B. Cabinets

1. Except for lighting panelboards installed in motor control centers, the cabinet shall be NEMA 12 (minimum) constructed of #12 U.S.S. code gauge galvanized steel. The door shall be fastened to the cabinet with concealed brass hinges and shall be equipped with flush-type catches and locks. All locks shall be keyed alike. The cabinet shall have wiring gutters on sides and shall be at least 20-inches wide and 5-3/4-inches deep. The Contractor shall provide an engraved nameplate for the panelboard. The nameplate shall include the panelboard designation, voltage, phase, wires, and bus rating.

2. Panelboards shall be provided with Stainless steel cabinets meeting NEMA 4X requirements where indicated on the drawings and schedules.

3. An Underwriter's Laboratories, Inc. inspection label shall appear on the interior of the cabinet.

C. Bus Work

1. Main bus bars shall be of ample size so that a current density of not more than 1000A per square inch of cross section will be attained. This current density shall be based on the application of the full load connected to the panel plus approximately 25% of the full load for spare capacity. The main bus shall be full capacity as based on the preceding for the entire length of the panel so as to provide full flexibility of circuit arrangement.

2. Solid neutral bus bars are required. Ratings shall be in accordance with applicable standards.

3. A separate ground bus shall be provided with lugs for termination of equipment grounding conductors.

4. Branch bus work shall be rated to match the maximum branch circuit breaker which may be installed in the standard space.

5. All bus shall be plated copper.

D. Circuit Breakers

1. Circuit breakers shall be bolt-on, molded-case type conforming to NEMA Standard AB 1. Trip elements of circuit breakers shall be 20A unless otherwise shown on the Contract Drawings. Minimum branch circuit breaker shall be 100A frame for 60A and above except where shown otherwise on the Drawings or where a larger frame size is standard for the continuous current rating required. Breakers shall have an interrupting rating of 22kA symmetrical at 240VAC, minimum. All breakers shall have quick-make, quick-break, toggle mechanism for manual as well as automatic operation. Tandem or half-size breakers are not acceptable.

2. Where indicated, or where required by Code, circuit breakers for receptacle circuits shall be equipped with integrally mounted ground fault interrupters complete with "TEST" push button and shall be of a type which fit standard panelboard spaces for the breaker continuous current rating required.

3. Instrument power panel branch circuit breakers set for control instrumentation, telephone, data, fire alarm or auxiliary equipment circuits requiring continuous operation shall be provided with a lock-on device.

4. Circuit breakers used for fluorescent lighting circuit switching shall be approved for the purpose and shall be marked "SWD". Circuit breakers used for high intensity discharge lighting circuit switching shall be approved for the purpose and shall be marked "HID". Where required by Article 440 of the NEC, circuit breakers installed for air conditioning units shall be HACR type.

E. Directories

1. Approved directories with glass or noncombustible plastic cover and with typewritten designations of each branch circuit, shall be furnished and installed in each panelboard. The Contractor shall maintain in each panel, during the duration of the Contract, a handwritten directory clearly indicating the circuit breakers in service. This directory shall be updated as work progresses, and final, typewritten directories, as specified above, shall be installed at the end of the project. Designations and circuit locations shall conform to the panelboard schedules on the Contract Drawings, except as otherwise authorized by the Engineer.

2. The Contractor shall provide directories identifying panelboards and indicating the size of the feeder (cable and conduit) serving the panel, circuit numbers, and a description of associated branch circuits including branch circuit trip and connected load for each circuit.

2.04 POWER DISTRIBUTION PANELBOARDS

A. General

1. The Power Distribution Panelboards, as defined by NEC or noted on drawings, shall be of the configuration and rated as shown on the Contract Drawings. The panelboards shall be dead-front type with automatic trip-free, non-adjustable, thermal overload branch circuit breakers. Circuit breakers shall be bolt-on molded case type conforming to NEMA Standard AB1. Trip elements of the circuit breakers shall be rated 20A unless otherwise shown on the Contract Drawings. The bus ratings shall be as shown on the Contract Drawings. Panelboards shall be listed and labeled by Underwriter's Laboratories, Inc.

2. Power distribution panelboards shall be fully rated and shall have a short circuit rating of 25kA symmetrical, minimum. In the event the results of the Contractor's short circuit fault analysis, as accepted by the Engineer, indicate that a higher short circuit rating of the panelboards is required, furnish complete panelboards with that higher rating.

3. Power Distribution Panelboards shall be furnished with transient voltage surge suppression (TVSS) and filtering equipment as required in Section 16671 - Transient Voltage Surge Suppression (TVSS) 1kV or Less, and as indicated on the Contract Drawings. The TVSS devices shall be UL labeled.

4. Subject to compliance with specifications Power Distribution Panelboards shall be:

   a) Square-D Company

   b) Eaton/Cutler-Hammer Electric Corp.

   c) General Electric

   d) Approved equal

B. Cabinets

1. Except for power panelboards installed in motor control centers, the cabinets shall be NEMA 12 (minimum) constructed of #12 U.S.S. code gauge galvanized steel. The door shall be fastened to the cabinet with concealed brass hinges and shall be equipped with flush-type catches and locks. All locks shall be keyed alike. The cabinet shall have wiring gutters on sides and shall be at least 20-inch wide and 5-3/4-inches deep. The Contractor shall provide nameplates for each panelboard. The nameplate shall include the panelboard designation, voltage, phase, wires, and bus rating.

2. An Underwriter's Laboratories, Inc. inspection label shall appear on the interior of the cabinet.

C. Bus Work

1. Main bus bars shall be of ample size so that a current density of not more than 1,000A per square inch of cross section will be attained. This current density shall be based on the application of the full load connected to the panel plus approximately 25% of the full load for spare capacity. The main bus shall be full capacity as based on the preceding for the entire length of the panel so as to provide full flexibility of circuit arrangement.

2. Solid neutral bus bars, where required, shall be provided. Ratings shall be in accordance with applicable standards.

3. A separate ground bus shall be provided with lugs for termination of equipment grounding conductors.

4. Branch bus work shall be rated to match the maximum branch circuit breaker which may be installed in the standard space.

5. All bus shall be plated copper.

D. Circuit Breakers

1. Circuit breakers shall be bolt-on, molded-case type conforming to NEMA Standard AB 1. Trip elements of circuit breakers shall be 20A unless otherwise shown on the Contract Drawings. Minimum branch circuit breaker shall be 100A frame for 60A and

above except where shown otherwise on the Contract Drawings or where a larger frame size is standard for the continuous current rating required. Breakers shall have an interrupting rating of 25kA symmetrical at 480VAC, minimum. All breakers shall have quick-make, quick-break, toggle mechanism for manual as well as automatic operation. Tandem or half-size breakers are not acceptable.

E. Directories

1. Approved directories with glass or noncombustible plastic cover, and with typewritten designations of each branch circuit, shall be provided in each panel. The Contractor shall maintain in each panel, during the duration of the Contract, a handwritten directory clearly indicating the circuit breakers in service. This directory shall be updated as work progresses, and final, typewritten directories, as specified above, shall be installed at the end of the project. Designations and circuit locations shall conform to the panelboard schedules on the Contract Drawings, except as otherwise authorized by the Engineer.

2. The Contractor shall provide directories identifying panelboards and indicating the size of the feeder (cable and conduit) serving the panel, circuit numbers, and a description of associated branch circuits including branch circuit trip and connected load for each circuit.

2.05 PAINTING

A. All metal surfaces of the panelboard enclosures shall be thoroughly cleaned and given one prime of zinc chromate primer. All interior surfaces shall then be given one shop finishing coat of a lacquer of the nitro-cellulose enamel variety. All exterior surfaces shall be given three coats of the same lacquer. The color of finishing coats shall be light gray ANSI #61.

B. Prior to final completion of the work, all metal surfaces of the equipment shall be cleaned thoroughly, and all scratches and abrasions shall be retouched with the same lacquer as used for shop finishing coats.

PART 3 EXECUTION

3.01 MOUNTING

A. The lighting panelboards, power distribution panelboards, and combination power units shall be furnished and installed as shown on the Contract Drawings and as recommended by the equipment manufacturer.

B. Panelboards shall be set true and plumb in all locations as shown on the Contract Drawings. The top of panelboard enclosure shall not exceed 6 feet above finished floor elevation.

C. Panelboards installed outdoors shall NOT be mounted to hand-rail or safety rail.

D. Enclosures shall not be fastened to concrete or masonry surfaces with wooden plugs, conical plastic anchors. Appropriate cadmium plated or galvanized steel bolts shall be used with expansion shields or other metallic type concrete insert for mounting on concrete or solid masonry walls. Cadmium plated or galvanized steel toggle bolts shall be used for mounting on concrete block or other hollow masonry walls. Bolt diameter shall be as required considering the size and weight of the completed panelboard and enclosure to provide adequate structural support.

E. The Contractor shall not use factory furnished knockouts with surface back boxes. The Contractor shall punch or drill required openings during installation and shall equip flush back boxes with manufacturer's standard pattern of knockouts. The Contractor shall equip cabinet doors exceeding 40-inches height with vertical bolt three point locking mechanism.

F. The Contractor shall install cabinets (and other enclosure products) in plumb with the building construction. Flush enclosures shall be installed so that the trim will rest against the surrounding surface material and around the entire perimeter of the enclosure.

END OF SECTION

SECTION 16475

SAFETY DISCONNECT SWITCHES

PART 1 GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish and install separately mounted, individual disconnect switches as specified herein and indicated on the Contract Drawings.

B. 16010 - Electrical Basic Requirements.

C. 16111 - Conduit and Raceway

1.02 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witnessed Shop Tests: None required.

2. Field Tests: Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and Section 16010 - Electrical Basic Requirements.

1.03 SUBMITTALS

A. All submittals shall be in accordance with Specification 01340 - Shop Drawings, Project Data and Samples and the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings

2. Spare Parts List

B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Equipment specifications and product data sheets identifying all materials used and methods of fabrication.

2. Complete layout and installation drawings with clearly marked dimensions for each type/size/rating of disconnect switch.

3. Assembled weight of each unit.

D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items that the Contractor intends to provide are acceptable and shall be submitted.

1.05 TOOLS, SUPPLIES, AND SPARE PARTS

A. The equipment shall be furnished with all special tools necessary to disassemble, service, repair, and adjust the equipment, and with all spare parts as recommended by the equipment manufacturer.

B. One complete set of spare fuses for each ampere rating installed shall be furnished and delivered to the Owner at the time of final inspection.

C. Spare parts lists, included with the shop drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.

D. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size shall have the same parts number.

1.06 IDENTIFICATION

A. Each equipment item shall be identified with a nameplate. The nameplate shall be engraved indicating the operating voltage, panel and circuit number of the power source and the equipment name with which it is associated.

1.07 OPERATIONS AND MAINTENANCE MANUALS

A. Operation and Maintenance Manuals shall be submitted as outlined in Specification 01730 - Operation and Maintenance Data.

1.08 WARRANTY

A. Per General Condition Article 9, the Contractor shall provide a 3 year warranty from substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Contract Drawings.

B. Disconnect switches shall be manufactured by:

1. Square-D
2. Eaton/Cutler-Hammer
3. General Electric
4. Allen-Bradley
5. Siemens
6. Approved equal

2.02 DISCONNECT SWITCHES

A. Disconnect switches shall be heavy-duty type and/or as specified in these Specifications. Switches shall be furnished and installed as shown on the Contract Drawings and as required by the NEC. Handles shall be lockable.

B. Disconnect switches shall be NEMA Type HD, single throw, externally operated, non-fused, fused or provided with circuit breakers as required. Disconnect switches shall have the poles, voltage, and ampere ratings as shown on the Contract Drawings.

C. Disconnect Switches shall be provided in NEMA 4X stainless steel enclosures.

D. Disconnect switches shall be quick-make, quick-break and with an interlocked cover which cannot be opened when switch is in the "ON" position and capable of being locked in the "OPEN" position.

E. Disconnect switches shall be quick-make, quick-break and with an interlocked cover which cannot be opened when switch is in the "ON" position and capable of being locked in the "OPEN" position.

F. A complete set of fuses for all switches shall be furnished and installed as required. Time-current characteristic curves of fuses serving motors or connected in series with circuit breakers shall be coordinated for proper operation. Fuses shall have voltage rating not less than the circuit voltage.

PART 3 EXECUTION

3.01 INSTALLATION

A. All disconnect switches to be mounted 60-inches above the floor, at the equipment height where appropriate, or as shown on the Contract Drawings.

B. Disconnect switches shall NOT be mounted to any hand-rail or safety rail.

C. The Contractor shall furnish and install fuses or circuit breakers as required or shown on the Contract Drawings.

END OF SECTION

SECTION 16483

VARIABLE FREQUENCY DRIVES

PART 1 GENERAL

1.01 SCOPE OF WORK

A. This section provides specification requirements for adjustable frequency drives, variable speed drives or herein identified as AC Drives for use with NEMA B design AC motors.

B. The AC Drive manufacturer shall furnish, field test, adjust and certify all installed AC Drives for satisfactory operation.

C. Any exceptions/deviations to this specification shall be indicated in writing to the specifying engineer in the submittal documentation.

D. AC Drives shall fit in locations as shown in the contract documents.

E. AC Drives shall operate auxiliary equipment such as seal water valves, motor space heaters, and include safety and equipment protection interlocks as shown in the contract documents.

F. The AC Drive manufacturer shall be responsible for providing all equipment specified under this section, and furnishing the equipment to the Contractor for installation.

1.02 REFERENCES

A. NFPA-70 "National Electric Code (NEC)"

B. ANSI C84.1 "Electric Power Systems and Equipment - Voltage Ratings (60Hz)"

C. CSA® C22.2 No.14-95 "Industrial Control Equipment"

D. UL508A "Standard for Safety for Industrial Control Panels"

E. UL508C "Standard for Safety for Power Conversion Equipment"

F. NFPA 79 "Electrical Equipment of Industrial Machines/Industrial Machinery

G. NEMA ICS7 "Industrial Control and Systems: Adjustable Speed Drives

H. NEMA ICS7.1 "Safety Standards for Construction and Guide for Selection, Installation, and Operation of Adjustable Speed Drive Systems

I. NEMA 250 "Enclosures for Electrical Equipment (1000V maximum

J. IEC 61800-2 "Adjustable speed electrical power drive systems - Part 2: General requirements - rating specifications for low voltage adjustable frequency AC power drive systems"

K. IEC 61800-3 "Adjustable speed electrical power drive systems - Part 3: EMC product standard including specific test methods"

L. IEC 61800-5-1 "Adjustable speed electrical power drive systems - Part 5-1: Safety requirements - Electrical, thermal and energy

M. IEC 61800-6 "Adjustable speed electrical power drive systems - Part 6: Guide for determination of types of load duty and corresponding current ratings."

N. EGSA 101P "Engine Driven Generator Sets - Performance Standard"

O. IEEE 519 "Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems"

1.03 SUBMITTALS

A. All submittals shall be in accordance with Specification 01340 - Shop Drawings, Project Data and Samples.

B. Approval drawings shall be furnished for Engineer's approval prior to factory assembly of the AC Drives. These drawings shall consist of elementary power and control wiring diagrams and enclosure outline drawings. The enclosure drawings shall include front and side views of the enclosures with overall

dimensions and weights shown, conduit entrance locations and nameplate legend details.

C. Standard catalog sheets showing voltage, horsepower, maximum current ratings and recommended replacement parts with part numbers shall be furnished for each different horsepower rated AC Drive provided.

1.04 WARRANTY

A. The equipment manufacturer shall provide a two (2) year warranty beginning from substantial completion of the project, and shall guarantee that the equipment furnished is suitable for the purpose intended and free from defects of design, material and workmanship. In the event the equipment fails to perform as specified, the equipment manufacturer shall promptly repair or replace the defective equipment without any cost to the Owner (including handling, shipment, labor, travel time and expense costs).

1.05 QUALITY ASSURANCE

A. The manufacturer of the AC Drive shall be a certified ISO 9001 facility.

B. The AC Drive and all associated optional equipment shall be UL LISTED according to UL508C Power Conversion Equipment. A UL label shall be attached inside each enclosure as verification.

C. The AC Drive shall be designed constructed and tested in accordance with NEMA, NEC, VDE, IEC standards.

D. Every power converter shall be tested with an actual ac induction motor, 100% load and temperature cycled within an environmental chamber at 104°F. Documentation shall be furnished to verify successful completion at the request of the engineer.

E. All Drive door mounted pilot devices shall be tested to verify successful operation. Documentation shall be furnished upon written request of the engineer.

F. The AC Drive shall undergo QA test procedures and be submitted to a hi-pot test with all enclosed devices mounted and wired, prior to shipment.

1.06 OPERATIONS AND MAINTENANCE MANUALS

A. Operations and maintenance Manuals shall be submitted as outlined in Specification 01730 - Operation and Maintenance Data.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The AC Drive shall be provided by ABB, or approved equal.

B. AC drive shall be ABB ACS 800 series, direct torque controls, including the following features: ACS800-CC-0300-5+B055+F267+G390+P902, Soft Start Bypass starter with service Switch, NEMA 12 enclosure, Input Circuit Breaker, 480 volt with factory authorized start-up.

C. Drive output rating shall be a minimum of 361 Amps at 480 Volts and shall be suitable for operation with 300 HP, 1200 RPM Vertical Turbine Pump Motors.

D. Drive shall include control interfaces as shown on the drawings and as specified

E. Drive enclosure shall be a standard manufactured assembly by the drive manufacture with dimensions of 84"H X 72"W x 30"D, NEMA 12 with front ventilation. Drives assembled into an enclosure by an OEM are not acceptable. There shall be no restriction on space requirements between the sides and rear of the floor mounted enclosures.

F. Alternate control techniques other than pulse width modulated (PWM) are not acceptable.

2.02 GENERAL DESCRIPTION

A. The Drive shall be solid state, with a Pulse Width Modulated (PWM) output. The drive shall be a Direct Torque Control (DTC) AC to AC converter utilizing the latest isolated gate bipolar transistor (IGBT) technology. The Drive shall employ Direct Torque Control (DTC) inner loop torque control strategy that mathematically determines motor torque and flux every 25 microseconds (μs) (40,000 times per second). The

drive must also provide an optional operational mode for scalar or V/Hz operation.

B. Ratings

1. The Drive shall be rated to operate from 3-phase power at 230VAC to 500VAC +10/-10%, 48Hz to 63Hz. The Drive shall employ a full wave rectifier to prevent input line notching and operate at a fundamental (displacement) input power factor of 0.97 at all speeds and loads. The Drive efficiency shall be 98% or better at full speed and load. An internally mounted AC line reactor or DC choke shall be provided to reduce input current harmonic content, provide protection from power line transients such as utility power factor correction capacitor switching transients and reduce RFI emissions.

2. The overvoltage trip level shall be a minimum of 30% over nominal, and the undervoltage trip level shall be a minimum 35% under the nominal voltage.

3. Output voltage and current ratings shall match the adjustable frequency operating requirements of standard 460VAC, 3ph, 60Hz, NEMA design A or NEMA design B motors. The overload current capacity shall be 110% of rated current for one (1) minute out of five (5). Output frequency shall be adjustable between 0Hz and 300Hz. Operation above motor nameplate shall require programming changes to prevent inadvertent high-speed operation. The drive's switching pattern shall be continually adjusted to provide optimum motor flux and avoid the high-pitched audible noise produced by motors energized by conventional PWM drives. The drive shall be furnished in a UL Type 1 listed enclosure rated for operation at ambient temperatures between 0° and 40°C at an altitude not exceeding 3300 feet, with relative humidity less than 95% and no condensation allowed. The drive shall be protected from atmospheric contamination by chemical gasses and solid particles pre IEC 721-3-3, classes 3C2 and 3S2. The drive shall be protected from vibration per IEC 68-2-6 (max. sinusoidal displacement 1 mm, 5Hz to 13.2Hz and max. acceleration $7m/s^2$, 13.2Hz to 100Hz).

C. Control Functions and Adjustments

1. An intelligent start-up assistant shall be provided as standard. The Start-up assistant will guide the user through all necessary adjustments to optimize operation and will include "plug and produce" operation, which recognizes the addition of options/fieldbus adapters and provides the necessary adjustment assistance.
2. Start-up data entries shall include motor nameplate power, speed, voltage, frequency and current.
3. A motor parameter ID function shall automatically define the motor equivalent circuit used by the sensorless vector torque controller.
4. A PID speed/torque loop regulator shall be provided with an autotune function as well as manual adjustments.
5. A selection of six (6) preprogrammed application macro parameter sets shall be provided to minimize the number of different parameters to be set during start-up. Macros included as standard are as follows: Factory Default, Hand/Auto, PID Control, Sequential Control, and Torque Control. A selection of two (2) user defined macros shall are also be available.
6. Start/Stop control functions shall include two (2) or three-(3) wire start/stop, coast/ramp stop selections, optional dynamic braking and flux braking.
7. The AFD shall be capable of starting into a rotating load (forward or reverse) and accelerate or decelerate to reference without safety tripping or component damage (flying start). The AFD shall also be capable of flux braking at start to stop a reverse spinning motor prior to ramp.
8. The AFD shall have the ability to automatically restart after an overcurrent, overvoltage, undervoltage, or loss of input signal protective trip. The number of restart attempts, trial time, and time between reset attempts shall be programmable.
9. Accel/Decel control functions shall include two (2) sets of ramp time adjustments with linear and three (3) s-curve ramp selections.
10. Speed/Torque control functions shall include:

a) Adjustable min./max. speed and/or torque limits

b) Selection of up to 15 preset speed settings or external speed control

c) Three (3) sets of critical speed lockout adjustments.

d) A built-in PID controller to control a process variable such as pressure, flow or fluid level.

e) Reference signal processing shall include increase/decrease floating point control and control of both speed/torque and direction using a "joystick" reference signal. Two (2) analog inputs shall be programmable to form a reference by addition, subtraction, multiplication, minimum selection or maximum selection.

11. Output control functions shall include:

a) Flux optimization to limit the audible noise produced by the motor and to maximize efficiency by providing the optimum magnetic flux for any given speed/torque operating point.

b) Current and torque limit adjustments to limit the maximum Drive output current and the maximum torque produced by the motor. These limits shall govern the inner loop torque regulator to provide tight conformance with the limits with minimum overshoot.

c) A torque regulated operating mode with adjustable torque ramp up/down and speed/torque limits.

12. The Drive shall be capable of sensing a loss of load (broken belt / broken coupling) and signal the loss of load condition. The drive shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communications bus. Relay output shall include programmable time delays that will allow for drive acceleration from zero speed without signaling a false underload condition.

13. The Drive shall have programmable "Sleep" and "Wake up" functions to allow the drive to be started and stopped from the level of a process feedback signal.

14. Two (3) programmable critical frequency lockout ranges to prevent the AFD from operating the load continuously at an unstable speed.

D. Static and Dynamic Performance

1. Open loop static speed regulation shall be 0.1% to 0.3% (10% of motor slip). When motor speed feedback is provided from a suitable encoder, closed loop speed regulation shall be 0.01% or better. Dynamic speed accuracy shall be 0.3-0.4 %-sec or better open loop and 0.1-0.2 %-sec or better-closed loop.
2. Torque response time shall be 5ms or less. In the torque regulating mode, torque regulating accuracy shall be 4% or better.

E. Operator Control Panel (Keypad)

1. Each Drive shall be equipped with a front mounted operator control panel (keypad) consisting of a four- (4-) line by 20-character back-lit alphanumeric display and a keypad with keys for Run/Stop, Local/Remote, Increase/Decrease, reset, menu navigation and parameter select/save.
2. All parameter names, fault messages, warnings and other information shall be displayed in complete English words or standard English abbreviations to allow the user to understand what is being displayed without the use of a manual or cross-reference table.
3. Other languages selectable in addition to American English (Am) shall be as follows: English (European), French, Spanish, Portuguese, German, Italian, Dutch, Danish, Swedish, Finnish, Czech and Polish.
4. The Display shall have contrast adjustment provisions to optimize viewing at any angle.
5. The control panel shall include a feature for uploading parameter settings to control panel memory and downloading from the control panel to the same drive or to another drive.
6. All Drives throughout the entire power range shall have the same customer interface, including digital display, and keypad, regardless of horsepower rating.
7. The keypad is to be used for local control, for setting all parameters, and for stepping through the displays and menus.

8. The keypad shall be removable and insertable under drive power, capable of remote mounting, and shall have it's own non-volatile memory.
9. During normal operation, one (1) line of the control panel shall display the speed reference, and run/stop forward/reverse and local/remote status. The remaining three (3) lines of the display shall be programmable to display the values of any three (3) operating parameters. At least 26 selections shall be available including the following:
   a) Speed/torque in percent (%), RPM or user-scaled units
   b) Output frequency, voltage, current and torque
   c) Input voltage, power and kilowatt hours
   d) Heatsink temperature and DC bus voltage
   e) Status of discrete inputs and outputs
   f) Values of analog input and output signals
   g) Values of PID controller reference, feedback and error signals
   h) Control interface inputs and outputs shall include:

F. I/O Capabilities
1. Six (6) discrete inputs, all independently programmable with at least 25 input function selections. Inputs shall be designed for "dry contact" inputs used with either an internal or external 24 VDC source.
2. A minimum of three (3) form C relay contact outputs, all independently programmable with at least 30 output function selections. Relay contacts shall be rated to switch 2 Amps at 24VDC or 115/230VAC. Function selections shall include indications that the drive is ready, running, reversed and at set speed/torque. General and specific warning and fault indications shall be available. Adjustable supervision limit indications shall be available to indicate programmed values of operating speed, speed reference, current, torque and PID feedback.
3. Three (3) analog inputs, one (1) +/- 0VAC - 10VAC and two (2) 4mA - 20mA, all independently programmable with at least ten (10) input function selections. A differential input isolation amplifier shall be provided for each

input. Analog input signal processing functions shall including scaling adjustments, adjustable filtering and signal inversion. If the input reference (4-20mA or 2-10V) is lost, the AFD shall give the user the option of the following: (1) stopping and displaying a fault, (2) running at a programmable preset speed, (3) hold the AFD speed based on the last good reference received, or (4) cause a warning to be issued, as selected by the user. The drive shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communications bus.

4. Two (2) analog outputs providing 4mA to 20mA signals. Outputs shall be independently programmable to provide signals proportional to at least 12 output function selections including output speed, frequency, voltage, current and power.

G. Serial communications

1. Serial communication interface modules shall be provided for DeviceNet communication protocol. Communications modules shall be connected to the drive by fiber optic cables. I/O shall be accessible through the serial communications adapter.

2. Serial communication capabilities shall include, but not be limited to, run-stop control; speed set adjustment, proportional/integral/derivative PID control adjustments, current limit, and accel/decel time adjustments. The drive shall have the capability of allowing the Distributed Drive Controller (DDC) to monitor feedback such as process variable feedback, output speed/frequency, current (in amps), % torque, power (kW), kilowatt hours (resettable), operating hours (resettable), relay outputs, and diagnostic warning and fault information. Additionally, remote Local Area Network (LAN) VFD fault reset shall be possible. A minimum of 15 field parameters shall be capable of being monitored. The DDC system shall be able to monitor if the motor is running in the AFD mode or bypass mode (if bypass is specified) over serial communications.

3. The AFD shall allow the DDC to control the drive's digital and analog outputs via the serial interface. The serial communications interface

shall allow for Digital Output DO (relay) control and Analog Output (AO) control. This control shall be independent of any AFD function. Examples of possible DO usage are as follows: Opening check valves, opening discharge valves, starting auxiliary equipment, etc. In addition, the status of the DO's is available over the communications link. Examples of possible AO usage are as follows: Controlling a bypass valve position, throttling valve position, etc. In addition, the status of the AO's is available over the communications link.

4. The AFD shall have built-in to its logic fifteen (15) blocks of adaptive programming capable of twenty (20) different functions. These blocks shall be connectable to drive actual signals and functions allowing the user to tailor the drive to the specific application requirements without additional hardware. These blocks shall be programmable through the standard operator panel and through the use of a Drive*AP* Microsoft Windows®-based software.

H. A fiber optic communication port shall also be provided for personal computer interface. Microsoft Windows®-based software shall be provided for drive setup, diagnostic analysis, monitoring and control. The software shall provide real time graphical displays of drive performance.

I. Protective Functions

1. For each programmed warning and fault protection function, the drive shall display a message in complete English words or Standard English abbreviations. The five (5) most recent fault messages and times shall be stored in the drive's fault history.
2. The drive shall include internal MOV's for phase to phase and phase to ground line voltage transient protection.
3. Output short circuit and ground fault protection rated for 65,000 amps shall be provided per UL508C without relying on line fuses. Motor phase loss protection shall be provided.
4. The drive shall provide electronic motor overload protection qualified per UL508C.
5. Protection shall be provided for AC line or DC bus overvoltage at 130% of maximum rated voltage

or undervoltage at 65% of min. rated voltage and input phase loss.

6. A power loss ride through feature will allow the drive to remain fully operational after losing power as long as kinetic energy can be recovered from the rotating mass of the motor and load.
7. Stall protection shall be programmable to provide a warning or stop the drive after the motor has operated above a programmed torque level for a programmed time limit.
8. Underload protection shall be programmable to provide a warning or stop the drive after the motor has operated below a selected underload curve for a programmed time limit.
9. Over-temperature protection shall provide a warning if the power module temperature is less than 5°C below the over-temperature trip level.
10. Input terminals shall be provided for connecting a motor thermistor (PTC type) to the drive's protective monitoring circuitry. An input shall also be programmable to monitor an external relay or switch contact (klixon).

2.03 **OPERATOR CONTROLS**

A. Industrial rated control operators and pilot devices shall be door mounted and used independently of the keypad display control modes of Hand-Off-Auto, VFD-OFF-BYPASS, etc. as required. The Keypad Display shall be mounted on front of the drive cabinet.

Control modes shall function as follows:

1. Hand - The Hand mode shall allow manual operation of start, stop and speed control. The AC drive shall start when the control operator is in the Hand mode and run and at low speed setting of the drive or higher as required by the position of the manual speed potentiometer. This mode shall function as 2-wire control and automatically restart after a power outage or auto restart after fault.

2. Off - The "Off" position of the control operator shall stop the AC drive and prevent it from

restarting while in the "Off" position. This position shall also reset the AC Drive after a fault condition has occurred.

3. Auto - The Automatic mode shall receive an auto start contact to control start and stop of the AC Drive. This contact shall also start and stop bypass (if used) when both the Automatic mode and Bypass modes of operations are selected. In Automatic mode the user shall remotely reset the AC Drive by opening and closing the Auto-start contact. Speed control shall be from a customer supplied 4-20mA signal.

B. The AC Drive shall include door-mounted "VFD Run", "VFD Fault", "External/MOL Fault" and "Bypass Run" pilot lights. All pilot lights shall Utilize LED lamps.

2.04 **SYSTEM CONTROL AND INTERFACE REQUIREMENTS**

A. The following additional controls and interface requirements shall be provided:

1. Seal Water Solenoid - The AC Drive shall proved 120Vac/50VA to operate the seal water solenoid whenever the motor is energized.

2. Check Valve Sequencing - The AC Drive shall provide a circuit that shuts down the drive whenever a user supplied check valve limit switch does not open within a specified time. This circuit shall provide an illuminated reset push button to indicate improper sequence.

3. Provide N.C. Contacts and 120V AC power source for motor winding space heater.

4. Auxiliary Contacts - The AC Drive shall provide the following auxiliary contacts to indicate the following conditions:

1 N.O. contact to indicate DRIVE RUN
1 N.O. contact to indicate VFD FAULT
1 N.O. contact to indicate BYPASS RUN
1 N.O. contact to indicate AUTO MODE
1 N.O. contact to indicate HAND MODE

2.05 EMERGENCY FULL SPEED REQUIREMENTS (BYPASS)

A. The AC Drive shall include fully rated isolation and bypass contactors complete with Class 20 thermal overload relay protection for emergency full speed capability. Bypass and isolation contactor shall be interlocked. Emergency full speed bypass starters for motors larger than 75 HP shall be solid state reduced voltage soft starter. Bypass and isolation contactors shall be integrated construction configuration.

1. Integrated bypass shall consist of integrating bypass and isolation contactors into the same enclosure compartment as the AC drive controller if space permits. One disconnect shall be common to the drive controller and bypass contactor.

B. Manual transfer to bypass function shall be provided in the event of drive fault or failure. This feature shall be enabled or disabled by an internally mounted selector switch. An adjustable timer shall provide control of the delay time between fault and transfer to bypass.

C. The Solid State Softstart bypass shall include a shorting contactor.

2.06 HARMONIC MITIGATION EQUIPMENT REQUIREMENTS

A. The AC Drive shall be provided with a line reactor mounted inside the enclosure.

PART 3 EXECUTION

3.01 INSPECTION

A. Verify that the location is ready to receive work and the dimensions are as indicated.

B. Do not install AC Drive equipment until the building environment can be maintained within the service conditions required by the manufacturer.

3.02 PROTECTION

A. Before and during the installation, the AC Drive equipment shall be protected from site contaminants

and debris in accordance with the manufacturer's recommendations.

3.03 INSTALLATION

A. The Drive manufacturer shall provide adequate drawings and instruction material to facilitate installation of the Drive by the Contractor. Installation shall comply with manufacturer's instructions, drawings and recommendations.

B. The AC Drive manufacturer shall provide a factory certified technical representative to supervise the Contractor's installation, testing and start-up of the AC Drives furnished under this specification as required. The technical representative shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations. A Certified factory start-up shall be provided for each drive by a factory authorized service center. A certified start-up form shall be filled out for each drive with a copy provided to the owner, and a copy kept on file at the manufacturer. A copy of all drive configuration parameters and their associated settings programmed into each VFD shall be provided to the Owner at the completion of start-up and shall be included in the final O&M.

3.04 TRAINING

A. The AC Drive manufacturer shall arrange for an on-site training course of a minimum of 2 training days, provided by a representative of the AC Drive manufacturer plant and/or maintenance personnel.

END OF SECTION

SECTION 16671

TRANSIENT VOLTAGE SURGE SUPPRESSION (TVSS) 1kV OR LESS

PART 1 GENERAL

1.01 THE REQUIRMENT

A. The Contractor shall furnish and install the Transient Voltage Surge Suppression (TVSS) equipment having the electrical characteristics, ratings and modifications as specified herein and as shown on the Contract Drawings.

B. The TVSS equipment shall provide effective high-energy protection against transient surges, temporary over voltages, voltage swells and high-frequency noise attenuation for power, control and telephone/data circuits 1kV or less and as shown on the Contract Drawings.

C. The TVSS units and all components shall be designed, manufactured and tested in accordance with the latest applicable UL standards.

D. The TVSS equipment installation shall conform to local code requirements and the National Electric Code (NEC).

E. All materials and workmanship shall be of the highest quality.

1.02 DEFINITIONS

A. EMI: ElectroMagnetic Interference

B. NTRL: Nationally Recognized Testing Laboratory

C. SCCR: Short Circuit Current Rating

D. SPD: Surge Protection Device

1. Type-I: Permanently connected between the secondary of the utility transformer and the line or load side of the service entrance overcurrent device and intended to be installed without an external overcurrent device.

2. Type-II: Permanently connected to the load side of the service entrance overcurrent device including branch circuit panels.

3. Type-III: Connected from the electrical service panel to the point of utilization with a minimum conductor length of 30 FT.

4. Type-IV: Component and/or component assemblies.

E. SVR: Suppressed Voltage Rating

F. TOV: Temporary Over Voltage

G. TVSS: Transient Voltage Surge Suppressor

1.03 QUALITY ASSURANCE

A. Referenced Standards:

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

a) C62.41, IEEE Guide for Surge Voltages in Low Voltage AC Power Circuits.

b) C62.43, IEEE Certified by NRTL as "Secondary Surge Arrestor"

c) C62.45, IEEE Guide for Surge Testing for Equipment Connected to Low-Voltage AC Power.

2. International Electrotechincal Commission (IEC):

a) 61024, Protection of Structures against Lightning.

3. National Electrical Manufacturers Association (NEMA):

a) LS-1 (1992), Low Voltage Surge Protection Devices

4. National Fire Protection Association (NFPA):

a) NFPA 70, National Electrical Code (NEC) Article 285.

5. Underwriters Laboratories, Inc (UL):

a) 1283, Electromagnetic Interference Filters

b) 1449, Transient Voltage Surge Suppressors

1.04 SUBMITTALS

A. All submittals shall be in accordance with Specification 01340 - Shop Drawings, Project Data and Samples.

B. Product Data: For each type of product indicated, include unit dimensions, weights, installation instructions, wiring details, rated capacities, operating characteristics, furnish specialties and accessories. Include the following documents:

1. Suppressed Voltage Rating

2. Symmetrical Fault Current Withstand Ratings

3. Provide independent third-party testing lab report indicating device is capable of surviving the specified number of 8x20 micro-second waveforms.

4. Spectrum Analysis based on MIL-STD-220A test procedures between 50 kHz and 200 kHz verifying the device noise attenuation equals or exceeds 50 dB at 100 kHz.

5. Survivability of multiple TOV events for Type-I and Type-II devices.

C. Product Certificates: For TVSS/SPD devices, signed by third-party NRTL testing agencies certifying compliance with the following standards:

1. UL 1283

2. UL 1449 Second Edition 2005 Revision

3. IEEE C62.34 Secondary Surge Arrestor

4. NEMA LS-1 (1992) Low Voltage Surge Protective Devices

D. Qualification Data: Third-Party testing lab or U.S. Department of Labor/OSHA approved NRTL.

E. Field Quality-Control test reports, including the following:

1. Test procedures used. Include single impulse testing data that matches label rating, including fuses or upstream breaker.

2. Test results that comply with requirements.

3. Failed test results and corrective actions taken to achieve requirements.

F. Operation and Maintenance Manuals shall be submitted as outlined in Specification 01730 - Operation and Maintenance Data. For each type or series of TVSS/SPD devices to include emergency, operation and maintenance manuals.

G. Warranties: The manufacturer shall provide a full ten (10) year warranty from the date of installation against any TVSS/SPD device part failure when installed in compliance with manufacturer's written instructions and any applicable national or local codes.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following manufacturers:

1. Advanced Protection Technologies Inc.
2. Current Technology
3. Eaton/ Cutler Hammer
4. Innovative Technology
5. General Electric
6. Square-D
7. Approved Equivalent

2.02 SERVICE ENTRANCE SPD (TYPE-I)

A. Surge Protection Device Description: Modular design with field-replaceable module with EMI filtering and the following features:

1. The SPD unit tested at 200kA interrupting capacity (AIC).
2. The SPD unit shall provide overvoltage protection as follows:
   a) >1800 cycles at 180% of rated voltage to 0.7 OHM load
   b) Test Report included

3. Fabrication using bolted compression lugs for internal wiring.

4. Utilizing copper bus bars, wire connections and bolted connections to phase buses, neutral bus and ground bus.

5. Integral disconnect switch capable of passing full rated surge current.

6. Multiple suppression circuits with current sharing.

7. LED indicator lights for power and protection status.

8. Monitoring system capable of the following:

   a) Number of transient surges, overvoltages and undervoltages

   b) Neutral-to-ground voltage and current

   c) EMI filter status

   d) Percentage of protection available

9. Audible alarm with silencing switch to indicate when protection has failed.

10. Dual set of dry contacts rated at 5A and 250VAC for remote monitoring of protection status.

11. Field testable with test data from factory provided comparison.

12. Field replaceable surge protection modules.

B. Peak Single-Impulse Surge Current Rating of 200kA per mode.

C. Connection Means: Permanent

D. Protection modes and UL 1449 SVR for voltages of 480/277V, 3-Phase, 4-Wire, grounded wye circuits shall be as follows:

1. Line to Neutral: 800V

2. Line to Ground: 1000V

3. Neutral to Ground: 900V

E. EMI noise rejection or attenuation values shall be in compliance with test and evaluation procedures outlined in NEMA LS-1 1992.

2.03 MOTOR CONTROL CENTER (MCC) SPD (TYPE-II)

A. Surge Protection Device Description: Modular design with field-replaceable module mounted externally to the MCC with EMI filtering and the following features:

1. Supplied with fuses rated at 200kA interrupting capacity (AIC).

2. Fabrication using bolted compression lugs for internal wiring.

3. Utilizing wire connections to phase buses, neutral bus and ground bus.

4. Multiple suppression circuits with current sharing.

5. LED indicator lights for power and protection status.

6. Monitoring system capable of the following

   a) Number of transient surges, overvoltages and undervoltages

   b) Neutral-to-ground voltage and current

   c) Percentage of protection available

7. Audible alarm with silencing switch to indicate when protection has failed.

8. Dual set of dry contacts rated at 5A and 250VAC for remote monitoring of protection status.

9. Field testable with test data from factory provided comparison.

10. Field replaceable surge protection modules.

B. Peak Single-Impulse Surge Current Rating of 100kA per mode.

C. Connection Means: Permanent

D. Protection modes and UL 1449 SVR for voltages of 480/277V, 3-Phase, 4-Wire, grounded wye circuits shall be as follows:

1. Line to Neutral: 900V

2. Line to Ground: 900V

3. Neutral to Ground: 900V

E. EMI noise rejection or attenuation values shall be in compliance with test and evaluation procedures outlined in NEMA LS-1 1992.

2.04 LIGHTING PANELBOARD SPD (TYPE-II)

A. Surge Protection Device Description: Modular design with field-replaceable module mounted externally to the panelboard with EMI filtering and the following features:

1. Supplied with fuses rated at 200kA interrupting capacity (AIC).

2. Fabrication using bolted compression lugs for internal wiring.

3. Utilizing wire connections to phase buses, neutral bus and ground bus.

4. Multiple suppression circuits with current sharing.

5. LED indicator lights for power and protection status.

6. Monitoring system capable of the following

   a) Number of transient surges, overvoltages and undervoltages

   b) Neutral-to-ground voltage and current

   c) Percentage of protection available

7. Audible alarm with silencing switch to indicate when protection has failed.

8. Field testable with test data from factory provided comparison.

9. Field replaceable surge protection modules.

B. Peak Single-Impulse Surge Current Rating of 80kA per mode.

C. Connection Means: Permanent

D. Protection modes and UL 1449 SVR for voltages of 208/120V, 3-Phase, 4-Wire, grounded wye circuits shall be as follows:

1. Line to Neutral: 400V

2. Line to Ground: 500V

3. Neutral to Ground: 500V

E. EMI noise rejection or attenuation values shall be in compliance with test and evaluation procedures outlined in NEMA LS-1 1992.

PART 3 EXECUTION

3.01 INSTALLATION OF SURGE PROTECTION DEVICE (SPD)

A. For Dual Rated Surge Protection (listed as both Surge Arrestor and SPD) for service entrance, product can be placed on either Line or Load side of the Service Entrance Equipment.

1. Provide and install circuit breakers or fuses as shown on the Contract Drawings.

B. For all remaining SPD devices:

1. Provide and install circuit breakers or fuses as shown on the Contract Drawings.

C. Install SPD devices for panelboards and auxiliary panels with conductors or buses between suppressor and points of attachment as short and straight as possible. Do NOT exceed manufacturer's recommended lead length. Do NOT connect neutral and ground leads together.

D. SPD devices shall NOT be integrated with Switchgear or Panelboards as recommended by IEEE-1100, Section 8.4.2.5.

E. All SPD devices shall have the raceway between the SPD and the switchgear enclosure sealed with approved fire sealant. The sealant shall prevent vapors from entering the switchgear enclosure.

3.02 PLACING EQUIPMENT INTO SERVICE

A. Do not energize or connect service entrance equipment, panelboards, control panels or telephone/data equipment to their sources until surge protection devices are installed and connected.

3.03 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Contractor shall engage a factory-authorized service representative to perform inspections, field tests and adjustments to the equipment including all connections. Service Representative shall report results in writing to the Engineer.

1. Verify that the electrical wiring installation complies with manufacturer's written installation instructions and requirements.

2. After installation of SPD devices but before circuitry has been energized, test for compliance with requirements.

3. Complete installation checks according to manufacturer's written instructions.

4. Remove and replace malfunctioning SPD devices and retest as specified as above.

END OF SECTION

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