SECTION 16000
ELECTRICAL POWER AND SYSTEMS

PART 1 - GENERAL

1.01 SCOPE

A. Work described in this Section includes furnishing all labor, materials, equipment, tools and incidentals required for a complete installation of all electrical power and systems. All equipment shall be installed, adjusted, tested and placed in operation in accordance with these Specifications, the manufacturer's recommendations and as shown on the Drawings.

B. Contract drawings show only functional features and some of the required external connections. They do not show all components required for a complete installation nor exact dimensions particular to any manufacturer's equipment. Contractor shall supply all parts, devices and equipment necessary to meet the requirements of the Contract Documents and shall make all dimensional adjustments particular to the equipment being furnished. All costs associated with such changes and adjustments shall be considered as being included in the price bid for the Work shown and specified.

1.02 DEFINITIONS

A. Provide: Furnish, install, and connect.

B. Product Data: Catalog cuts and descriptive literature.

C. Shop Drawings: Factory prepared specific to the installation.

D. Indicated: Shown on the Contract Drawings.

E. Noted: Indicated or specified elsewhere.

F. Control Diagram: A control diagram shows by means of graphic symbols, the electric connections and functions of a specific circuit arrangement. The control diagram facilitates tracing the circuit and its functions without regard to the actual physical size, shape, or location of the component devices or parts.

G. One-Line Diagram: A one-line diagram shows by means of single lines and graphic symbols the course of an electric circuit or system of circuits and the components, devices, or parts used therein. Physical relationships are usually disregarded.

H. Block Diagram: A block diagram is a diagram of a system, instrument, computer, or program which selected portions are represented by annotated boxes and interconnecting lines.

I. Wiring Diagram: A wiring or connection diagram includes all the devices in a system and shows their physical relationship to each other including terminals and interconnecting wiring in an assembly. This diagram shall be a) in a form showing interconnecting wiring only by terminal designation (wireless diagram), or b) a panel layout drawing showing the physical location of devices plus the control diagram.

J. Interconnection Diagram: Interconnection diagrams shall show all external connections between terminals of equipment and outside points, such as motors and auxiliary devices. References shall be shown to all connection diagrams, which interface to the interconnection diagram. Interconnection diagrams shall be of the continuous line type. Bundled wires shall be shown as a single line with the direction of entry/exit of the individual wires clearly shown. Wireless diagrams and wire lists are not acceptable. Each wire identification as actually installed shall be shown. The wire identification for each end of the same wire shall be identical. All devices and equipment shall be identified. Terminal blocks shall be shown as actually installed and identified. All jumpers, shielding and grounding terminations not shown elsewhere shall be shown here. Signal and DC circuit polarities shall be shown. Spare wires shall be shown.

K. Arrangement, Layout, or Outline Drawings: An arrangement, layout, or outline drawing is one, which shows the physical space and mounting requirements of a piece of equipment. It may also indicate ventilation requirements or the location to which connections are to be made.

1.03 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions of the Contract Documents. In addition, the following specific information shall be provided:

1. Information required "for reference" such as product samples, similar unit test reports, and time current curves is for the purpose of determining the suitability of a product, selecting breaker settings, etc. This information is to be submitted at the same time as approval data; however, this information will not be returned and stamped approval is not required prior to installation.
2. Except as noted, installation instructions are not required to be submitted. However, it is the Contractor's responsibility to obtain installation information from the manufacturer for all equipment prior to installing the equipment.
3. Interconnecting diagrams depicting all cable requirements together with actual terminations as specified under paragraph 16000-1.02J.

1.04 QUALITY ASSURANCE

A. Provide complete electrical installation in accordance with the National Electrical Code (NFPA 70), Life Safety Code (NFPA 101), and in accordance with applicable local codes. Obtain all necessary permits and have all work inspected by appropriate authorities.

B. All products shall be designed, manufactured, and tested in accordance with industry standards. Where applicable, products shall be labeled or listed by third party certification agencies.

C. Industry Standards: Standards organizations and their abbreviations, as used herein, are as follows. Applicable date for industry standards is that in effect on the date of advertisement of the project.

1. American National Standards Institute (ANSI).
2. American Society for Testing and Materials (ASTM).
3. Federal Specifications (FS).
4. Institute of Electrical and Electronics Engineers (IEEE).

5. Insulated Cable Engineers Association (ICEA).
6. National Electrical Manufacturers Association (NEMA).
7. National Fire Protection Association (NFPA).
8. Underwriters Laboratories, Inc. (UL).
9. National Electrical Testing Association (NETA).

1.05 WORK INCLUDED IN DIVISION 16, ELECTRICAL

A. Electrical power and systems.

B. Basic materials and methods.

C. Raceway Systems.

D. Wire and Cable.

E. Boxes.

F. Wiring devices.

G. Electric motors.

H. Cabinets and enclosure.

I. Instrument transformers and meters.

J. Liquid filled secondary substation transformers.

K. Primary power switchgear.

L. Low voltage switchgear.

M. Surge arrestors.

N. Protective relays.

O. Disconnect switches.

P. Grounding.

Q. Dry type transformers.

R. Panelboards.

S. Low voltage motor control center.

T. Large variable frequency drives.

U. Lighting fixtures.

V. Lightning protection.

W. Neutral grounding resistors.

X. Fire alarm system.

Y. Telephone system.

Z. Acceptance testing and calibration.

AA. Access system.

BB. Short circuit and coordination studies.

1.06 MATERIALS AND EQUIPMENT FURNISHED AND INSTALLED UNDER OTHER DIVISIONS WITH RACEWAY AND ELECTRICAL CONDUCTORS FURNISHED, INSTALLED, AND CONNECTED UNDER DIVISION 16, ELECTRICAL

A. Equipment, Instrumentation and control system components indicated on the Drawings by filled circumscribed diamond symbol.

1.07 INTENT OF DRAWINGS

A. Electrical plan drawings show only general locations of equipment, devices, and raceway, unless specifically dimensioned. The Contractor shall be responsible for proper routing of raceway, subject to the approval of Engineer.

1.08 PROTECTIVE COORDINATION STUDY

A. The Contractor shall provide phase and ground fault coordination study to show that the following conditions are met:

1. Utilization equipment and conductor systems are protected from thermal damage.
2. An overload or short circuit will cause operation of the next upstream device and no others.
3. Device operation will not occur on steady state or inrush conditions.

B. Provide five brochures in hard cover 3-ring binders, each including complete protective device coordination study complete with device coordination time-current curves for the medium and low voltage distribution system.

C. After award of the Contract, the Engineer will give the Contractor a list of available 3-phase symmetrical short circuit current at important points throughout the plant and a computer generated list of circuit conductor characteristics (number of phases, number of wires, wire size, number of paralleled conductors, raceway type, circuit length), motor fault contributions, utility fault contribution and circuit topology. Before starting the protective device coordination study the Contractor shall confirm this information and inform the Engineer in writing if any substantial discrepancies are found. The Engineer's corrected fault current list will be the, basis for the coordination study. Values supplied by the Engineer are to be used solely for determination of device settings equipment ratings are as elsewhere noted.

D. In the protective device coordination study, provide time-current curves graphically indicating the coordination proposed for the system, on conventional, full-size, log-log forms, K&E 48-5257, or equal. Include with each curve sheet a complete title and one-line diagram with legend identifying the specific portion the system covered by that particular curve sheet. Include a detailed description of each protective device identifying its type function, manufacturer, and time-current characteristics. Tabulate recommended device tap, time dial, pickup, instantaneous, and delay settings. Show settings so that they read directly in the unit marked on the adjustment knob; for instance, if a setting is to be 5 times current-tap, the adjustment knob has settings A-F, and setting C corresponds to 5 times, note that setting is "5 X current tap = adjustment knob mark C."

E. Include-on the curve sheets power company relay and fuse characteristics, system medium voltage equipment relay and fuse characteristics, low voltage equipment circuit breaker trip device characteristics, pertinent transformer characteristics, pertinent motor characteristics, and characteristics of other system load protective devices. Include at least all devices down to largest branch circuit and largest feeder circuit breaker in each motor control center and 480-volt panelboard. Include all adjustable setting ground fault protective devices. Include manufacturing tolerance and damage bands in plotted fuse characteristics. For transformers use the manufacturer's thermal three-phase and thermal stress line-to-ground damage curves per ANSI C57.109. Terminate device characteristic curves at a point reflecting the maximum symmetrical or asymmetrical fault current to which the device is exposed.

F. Select each primary protective device required for a delta-wye connected transformer so that its characteristic or operating band is within the transformer characteristics, including a point equal to 58 percent of the ANSI withstand point to provide secondary line-to-ground fault protection. Where the primary device characteristic is not within the transformer characteristics, show a transformer damage curve. Separate transformer primary protective device characteristic curves from associated secondary device characteristics by a 16 percent current margin to provide proper coordination and protection in the event of secondary line-to-line faults. Separate medium voltage relay characteristic curves from curves for other devices by at least a 0.4-second time margin.

G. In each binder, include complete sets of individual protective device time-current characteristics on transparencies.

H. Protective device study may be prepared with a network analyzer, digital computer, or by written computations.

I. Provide protective device coordination study carried out by a professional electrical engineer registered in the State of Georgia who is not employed by the Contractor or by an electrical equipment manufacturer. Provide studies prepared by persons experienced in the work. Submit a draft study to Engineer for review. Make all additions or changes as required by the reviewer.

J. Use new equipment load data for the study from Contract Documents, including Contract Addenda issued prior to bid opening. Verification of existing equipment data shall be by Contractor.

1.09 ELECTRICAL NUMBERING SYSTEM

A. Raceway Numbers:

1. Raceways shall be tagged at all terminations where raceway numbers have not been assigned, Contractor shall assign raceway numbers in accordance with the following system:

Raceway Prefix	Type of Function
C	Control and/or 120V or less power
H	Power above 600V
N	Pneumatic tubing
P	Power 208V to 600V
S	Low level signal (less than 90 volt communication or less than 30 volt instrumentation)
X	Spare

2. Prefixes shall be followed by a 5-digit equipment number. Where there is more than one raceway to particular equipment, a letter suffix is added to distinguish the raceways.

3. Example:

Raceway number = P31109A

31109 = unique 5-digit equipment number

A=Letter to distinguish from other raceways to same equipment

B. Conductor Numbers:

1. Conductors shall be identified with numbers at both ends. Conductor tag numbers shall consist of the 5-digit equipment number followed by a dash followed by the conductor number specified on the control diagram.

2. Example:

Tag number = 19000-L1

Where:

19000 = Cable number

L1 = Conductor number

3. Conductors which are in parallel or in series between equipment shall have the same conductor number. Neutral conductors shall have the same conductor number wherever possible, the conductor shall be the same as the terminal to which it connects.

4. When factory-wired equipment has terminal numbers different than the conductor number shown on the control diagram, both shall be shown on the interconnection diagram, and a copy of the interconnection diagram shall be fastened to the inside of the equipment cabinet.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Ship products to the job site in their original packaging. Receive and store products in a suitable manner to prevent damage or deterioration. Keep equipment upright at all times.

B. Investigate the spaces through which equipment must pass to reach its final destination. Coordinate with the manufacturer to arrange delivery at the proper stage of construction and to provide shipping splits where necessary.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Provide only new products of the manufacturer's latest design.

B. Equipment shall be applied only within its rating. Equipment ratings shown are minimums. Voltage and current ratings shall be as required to adequately power the connected equipment. Fault current ratings shall be as shown for the particular item or for the next upstream device that has a fault current rating shown.

C. The following areas are classified hazardous:

1. Pumping station wet well.
2. All underground vaults.

D. The following areas are classified as corrosive:

1. Valve Vaults.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Maintain continuity of electric service to all portions of the process or buildings at all times. Temporary outages will be permitted during cutover work at such times and places as can be prearranged with Engineer and the electric utility company providing service to the facility. Such outages shall be kept to a minimum number and minimum length of time. Make no outages without prior written authorization of the Engineer. Include all costs for temporary wiring and overtime work required in the Contract price. Remove all temporary wiring at the completion of the work.

B. Wherever the requirements of the Specifications or Drawings exceed those of the above items, the requirements of the Specifications or Drawings govern. Code compliance is mandatory. Construe nothing in the Contract Documents as permitting work not in compliance with these codes.

C. Unless otherwise indicated, all material required to be removed and salvaged shall become the property of the City.

D. Carefully modify existing electrical equipment, as necessary to carry out proposed changes. Rehabilitate and relocate items of equipment as required and as indicated or specified.

3.02 CERTIFICATION AND TESTS

A. Prior to request for final review, test all systems and repair or replace all defective work. Submit, with request for final review, written certification that all electrical systems are complete and operational.

B. At the time of final review of electrical work, demonstrate the operation of electrical systems. Furnish labor, apparatus and equipment for systems' demonstration.

C. After final review and acceptance, turn over to the Engineer all keys for electrical equipment locks. Present to the City's designated representatives, demonstrations and oral instructions for proper operation and maintenance of the electrical equipment and systems.

D. Provide motors and heater tabulation as requested in Section 01005.

FORM 16000 A
INSTALLED WIRE AND CABLE RESISTANCE TEST DATA FORM

Project _____
Date: _____

Site Conditions: _____

Time: _____

Circuits or Items being tested:

_____

_____

Wire or Cable No.: _____ Temperature, oF: _____

	Location of Test	From	To	Insulation, Resistance, megohms
1.				
2.				
3.				
4.				
5.				
6.				
7.				

Comments:

_____

_____

_____

CERTIFIED _____ _____
Contractor's Representative Date

WITNESSED _____ _____
City's Representative Date

FORM B
INSTALLED MOTOR TEST FORM (PRE-OPERATIONAL CHECK/TEST)

Motor Equipment Number _____ Date of test _____
Equipment Driven _____ Ambient temp _____oF
MCC Location _____

Resistance:

Insulation resistance phase-to-ground megohms:

Phase A _____ , Phase B _____, Phase C _____

Current at Full Load:

Phase Current, amps _____

Phase Current, amps _____

Phase Current, amps _____

Thermal Overload Device: Manufacturer/catalog # _____ Amperes _____

Circuit breaker (MCP) setting: _____

Motor Nameplate Markings:

Mfr _____ Mfr type _____ Frame_____ HP _____
Volts _____ Phase _____ RPM _____ **Service factor _____
Amps _____ Freq _____ Ambient temp rating _____ oC

Time rating _____ **Design letter _____
(NEMA 1-10.35) (NEMA MG-1.16)

Code letter_____ Insulation class_____

**Required for 3-phase squirrel cage induction motors only.

CERTIFIED _____ _____
Contractor's Representative Date

WITNESSED _____ _____
City's Representative Date

END OF SECTION 16000

SECTION 16010
BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS AND DEFINITIONS

A. Drawings, Specifications and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this and the other sections of Division 16.

B. "Drawings" or "Contract Drawings", as used herein, refer to the Project Contract Drawings.

C. "Specifications" or "Contract Specifications", as used herein, refer to the Project Contract Specifications.

D. "Documents" or "Contract Documents", as used herein, refer to the Project Contract Drawings, Specifications, and general conditions and requirements.

E. "Division 16", as used herein, refers to the Project Division of Work and Scope (also referred to as the Electrical Division), comprising the Project requirements intended for the Electrical Contractor's completion. Included are all Electrical Division Drawings and Electrical Division Specifications (16XXX).

F. "Contractor", as used herein, refers to the Electrical Contractor (including his sub-contractors and his electrical / etc., equipment manufacturers and suppliers who provide his equipment), who has responsibility to furnish and install the "Scope of Work", as described herein and per the Contract Documents.

G. "Owner", as used herein, refers to the property owner, proprietor, administrator or agent as defined in the project contractual agreements.

H. "Code", as used herein, refers to all of the applicable regulatory and advisory standards listed herein.

I. "Authority Having Jurisdiction (AHJ)" is defined in the National Electrical Code as "An organization, office or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure".

J. The requirements of this Section apply to the entire Scope of Work including that shown on the Drawings, in the Division 16 Section Specifications, in the General and Supplementary Conditions, and in the Division 1 and other related Specifications.

1.02 SUMMARY

A. This Section includes general, administrative and procedural requirements for electrical installations. The following general, administrative and procedural requirements are included in this Section to expand the requirements specified elsewhere in general Project Specifications and in Division 1:

1. Scope of work.
2. Applicable standards / Quality assurance.
3. Interpretation of Drawings.
4. Priority of contract documents.
5. Submittals.
6. Co-ordination drawings.
7. Record documents.
8. Operation and Maintenance manuals.
9. Materials.
10. Codes, inspections and fees.
11. Delivery, storage and handling.
12. Tests and settings.
13. Manufacturers' services.
14. Size of equipment.
15. Enclosure types.
16. Hazardous areas.
17. Electrical protective device coordination, short circuit and other studies.
18. Warranty.

B. Related Sections: All Division 16 Section Specifications.

1.03 SCOPE OF WORK

A. Furnish all labor, supervision, materials, equipment and incidentals required to make ready for use complete functional electrical systems as shown on the Drawings and specified herein.

B. The work shall include furnishing, installing, interconnecting and testing the equipment and materials specified in all other Sections of the Division 16 Specifications and shown on the Drawings.

C. The work shall include furnishing, coordinating, and installing the following:

1. It is intended that Contractor coordinate with the Electrical Utility Company, to the extent necessary, so that an appropriate, complete and reliable electrical service or supply is provided for this Project. Electrical Utility Company cost charges, for modification and extension of all on-site, Project-related but Utility-required infrastructure installations, materials, improvements, etc, which benefit the project, shall ultimately be borne by Owner. Projects warranting Electrical Utility Company cost charges for off-site Utility infrastructure improvements or modifications shall likewise have such costs ultimately borne by Owner, when required by Utility. However, unless otherwise indicated or negotiated with the Owner, Contractor shall include in his project scope and pricing and bear responsibility for coordination and completion of all requisite work as required by Utility including the following:

a. Project service transformer pad, vault, and / or work to enable / facilitate Utility interface or "point-of-tie-in" interface.

b. Determination and implementation of Utility requirements and details and locations of major equipment, including project service transformer(s).

c. Empty conduit with pull wire or conduit sleeves between project service transformer(s) and Utility primary voltage point-of tie-in, as per Utility.

d. Utility requirements for metering and installation.

e. Complete conduit and wiring and termination of secondary voltage conductors between the project service transformer(s) and the project service entrance equipment.

f. Concrete encasement of primary conductors when required by Utility and / or called for on the Contract Drawings.

g. Concrete encasement of project service transformer(s) secondary, where required and /or called for on the Contract Drawings.

h. Utility required fencing, bollards, grounding, signage and all miscellaneous appurtenances.

i. Contractor shall include all costs for items tabulated above and appurtenant items related to Electric Utility Company service or supply, in his scope, cost estimates, bids, etc. Intent is that these costs, to the extent applicable, be passed from Utility, through Contractor (as project costs), to Owner as part of the electrical subcontract bid price and subsequent payment requests.

    i) Unless specified otherwise, complete, functional, fully installed, interconnected and tested systems for power, control, lighting, grounding, telephone, data, fire alarm, communications, signaling, security, lightning protection, electrical heat tracing of piping, etc. as indicated in other Sections of Division 16 and as shown on the Drawings are included in Division 16 scope.

    ii) Conduit, wire, field connections and installation for all motors, motor controllers, control devices, control panels, and "packaged" equipment furnished under other Divisions of these Specifications are included in Division 16 scope.

    iii) Installation, mounting and field wiring for all field-mounted devices and instruments, furnished under other Divisions and / or Sections of these Specifications, which require on-site electrical and / or electronic wiring supply / terminations. All conduit, wire, and interconnections between devices, primary elements, transducers, transmitters, relays, transformers, indicators, sensors, switches, alarms, control panels, etc. are included in Division 16.

    iv) A complete raceway system for all special and / or system cables furnished by electronic system suppliers, process instrumentation suppliers and process control system suppliers. Review the raceway layout with Supplier and the cable manufacturer, prior to installation, to insure raceway compatibility with the systems and materials being furnished.

    v) Installation of all control panels, controllers, etc. furnished under other Divisions and / or Sections of these Specifications.

    vi) Nominal 110-120 volt or greater power service, power supply, power wiring and appropriate conduit or raceway for all equipment and devices utilizing or requiring such power including power for heating, ventilating, air conditioning, (HVAC), mechanical and/or plumbing equipment and appurtenances furnished under other Divisions of these Specifications. Include power wiring for all air handlers, fans, condensing units, heat pumps, heaters, heat tracing, unit heaters, pumps, powered

induction units (PIUs), terminal units, fan coil units, variable air volume units (VAVs), dampers, louvers, motorized operators, valves and any and all other similar HVAC, mechanical and/or plumbing equipment. Include power wiring for all such equipment covered by the Division 15 Drawings and /or Specifications. Provide power wiring and conduit from power source to equipment physical locations and provide wiring terminations as required. Unless noted otherwise, excluded from Division 16 responsibility are conduit and wiring for Division 15 furnished or other similar "HVAC Controls", "Building Management Systems (BMS)" and "Sequence of Operations" controls and systems that require / operate at only "low" voltage (below 110-120 volt nominal) and that do not require 110 - 120 volt or greater power service. See applicable Sections of Division 15 or for reference.

vii) A complete conduit or raceway system with nominal 110-120 volt or greater power wiring for all electronic/ technology and similar system devices and units requiring such supply power from the building infrastructure. Such electronic/ technology systems will be furnished under separate Divisions of the Specifications, unless noted otherwise.

viii) A complete empty raceway system with pull wire for power-limited / low voltage (12V, 24V, 48V, etc.) control, signaling, data highways, fiber-optic systems, etc., related to all electronic / technology and similar systems and devices, shall be furnished and installed by Div.16. The supply, installation and termination of such systems and devices and their required wiring shall be under separate Divisions of these Specifications, unless noted otherwise. Review the raceway layout with Supplier and the cable manufacturer, prior to installation, to insure raceway compatibility with the systems and materials being furnished.

ix) Contractor shall review the submittal / shop drawings for all electrically operated and electrically connected equipment being furnished under all other divisions of these specifications. Unless specified otherwise, Contractor shall provide raceway, wire and interconnection for all materials, devices, components, systems and packages requiring "field wiring", to the extent clarified in the preceding paragraphs. Where applicable, Contractor shall make electrical interconnections per manufacturer's requirements. This includes, but is not limited to, devices that are parts of "packages" but which are shipped separately and require field inter-connection. Also, Contractor shall identify terminals and prepare drawings or wiring tables to extent necessary to enable interconnections.

x) Electrical power utility, conduit, wiring, and wiring termination for all special equipment furnished under other Divisions. Included in Division 16 are electrical supply pumps, site utilities, grounds maintenance equipment, and similar equipment.

xi) Demolition, where / as required.

D. 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 or other applicable sections shall be furnished at no extra cost.

E. Where applicable, the Contractor or his authorized representatives shall, before preparing his proposal, visit all areas of the existing site, buildings and structures in which work under this section is to be performed and inspect carefully the present installation. The submission of the proposal by this Contractor shall be considered evidence that he or his representative has visited

the buildings and noted the locations and conditions under which the work will be performed and that he takes full responsibility for a complete knowledge of all factors governing his work.

F. Where applicable, all power interruptions to existing equipment shall be at the Owner's convenience with 72 hours (minimum) notice. Each interruption shall have prior approval.

G. Where applicable, the Contractor shall maintain the existing facility in operation at all times.

H. Temporary power connections as required shall be provided by the Contractor at no additional expense to the Owner. All temporary wiring shall be in accordance with the NEC. All temporary equipment wiring shall be installed in conduit. The Contractor shall provide to the Engineer details, methods, materials, etc. prior to making temporary connections. Furnish and install all equipment and materials including control equipment, motor starters, branch and feeder circuit breakers, panelboards, transformers, etc., for temporary power. Remove temporary installations prior to / at job completion.

I. The work shall include complete testing of all equipment and wiring at the completion of work and making any minor correction changes or adjustments necessary for the proper functioning of the system and equipment. All workmanship shall be of the highest quality; substandard work will be rejected.

J. Where applicable, identify and verify field conditions of all existing underground structures and utilities, including electrical and mechanical piping.

K. The Contractor shall have the Manufacturer of the major electrical components (per Paragraph 2.01) provide a coordination and short circuit study as specified herein. Contractor shall set all protective devices and relays as specified in Paragraph 1.19.

L. Where applicable, provide all electrical work associated with the relocation of equipment for the existing and new facilities, including disconnection of all existing wiring and conduits and provision of new wiring from the point of electrical supply and conduit to the relocated equipment.

M. Excavation and backfilling, including gravel or sand bedding for underground electrical work is included in Division 16.

N. Concrete work, including concrete electrical duct encasement and electrical equipment and light pole foundations and pads, is included in Division 16.

O. Contractor shall provide all work for duct banks, including but no limited to excavation, concrete, conduit, reinforcement, backfilling, grading and seeding. All work shall be in accordance with Divisions 2 and 3 of these specifications.

P. Complete coordination with other contractors. Div. 16 Contractor shall coordinate with other contractors regarding each-others equipment and equipment submittals and shall obtain all relevant submittals.

Q. Complete electrical heat tracing system for all piping which is indicated as electrically traced on the project Piping & Instrumentation Diagrams and/or Project Mechanical Drawings / Specifications. Contractor shall employ the services of an approved heat-tracing product manufacturer to design the system, using a certified manufacturer developed electronic based

program. System shall protect piping and appurtenances against freezing, or shall maintain temperatures, as required. System shall include code-compliant, environmentally suitable and properly sized self-regulating heat tracing cables, and all related requisite power source and control equipment, panels, transformers, circuitry, contactors, controls, etc. necessary for a complete and functional heat tracing system. Installation shall be by Contractor.

R. Complete coordination with the Electrical Utility Company. Contractor shall complete applicable Utility forms and comply with and respond to Utility requests for information. Such are as related to, but not limited to, sizes and types of new electrical loads, existing loads to remain, existing loads to be deleted, anticipated load diversity/ demand, generators, and size, rating and characteristics of Owner's new and existing electrical equipment, etc., to the extent required by the Utility Company. Intent is that Utility Company will, from such coordination with Contractor, be able to finalize Utility's incoming electrical service ratings and details, service transformer(s) ratings and details, and proper interconnection with Owner's equipment.

S. Seismic Requirements:

1. Conform to the requirements indicated on the structural and other Contract Documents, where applicable.
2. It shall be the responsibility of the equipment manufacturers and suppliers along with the Contractor to conform to the seismic design requirements based on the Project's seismic classification and/or the Contract Documents.
3. All electrical raceways and equipment shall utilize earthquake resistant supporting systems as required by the Project's seismic classification and/or the Contract Documents.
4. Electrical distribution and power control equipment shall be labeled by the equipment manufacturer as "seismic qualified". This labeling shall be indicative that representative samples of the same equipment have been tested and found to meet or exceed the seismic requirements of the I.B.C., U.B.C. and C.B.C. codes and relevant parts of the NFPA codes for the applicable project seismic classification. Contractor shall install such equipment in accordance with these codes and the manufacturer's recommendations. Equipment seismic labeling applies to panelboards, switchboards, motor control centers, busway, transfer switches, switchgear, network protectors, transformers, power centers, metal enclosed switchgear, metal clad switchgear, loadcenters, safety switches, enclosed control assemblies, and generators and generator fuel delivery and storage systems.

T. Interface with the services provided by the Telephone, Data and other Systems Utility Companies / Service Providers. Unless indicated otherwise, furnish and install 4 foot x 8 foot x ¾ inch painted plywood backboard at designated location within the site and two- 4 inch underground non-metallic conduits with pull-wire between the backboard and each point of interface as directed by the applicable Telephone or other Systems' Utilities.

U. Complete testing, as specified.

1.04 APPLICABLE STANDARDS / QUALITY ASSURANCE

A. All electric equipment, materials, and installation shall be in accordance with the National Electrical Code (NEC) and with the latest edition, adopted by the Authorities Having Jurisdiction, of all codes and standards of the following organizations:

1. National Fire Protection Association (NFPA), including (but not limited to):
   a. National Electrical Code (NEC), NFPA 70
   b.
   c. National Fire Alarm Code, NFPA 72
   d.
   e. Life Safety Code, NFPA 101
   f.
   g. Emergency and Standby Power Systems, NFPA 110
2. American National Standards Institute (ANSI), including (but not limited to):
   a. National Electrical Safety Code, ANSI C2
3. Occupational Safety and Health Act (OSHA)
4. Federal Communication Commission (FCC)
5. National Electrical Manufacturers Association (NEMA)
6. Insulated Cable Engineers Association (ICEA)
7. Institute of Electrical and Electronics Engineers (IEEE)
8. National Electrical Testing Association (NETA)
9. American Society of Testing and Materials (ASTM)
10. Illumination Engineering Society of North America (IESNA)
11. Anti-Friction Bearing Manufacturers Association (AFBMA)
12. Building Officials and Code Administrators International, Inc. (BOCA)
13. International Code Council (ICC):
    a. International Building Code (IBC)
14. Uniform Building Code (UBC)
15. International Conference of Building Officials (ICBO)
16. International Energy Conservation Code (IECC), endorsed by the U.S. Department of Energy (DOE)
17. Combined ANSI / ASHRAE / IESNA Standard 90.1- 2010 "Energy Standard for Buildings Except Low-Rise Residential Buildings".
18. National Electrical Contractors Association Installation Standards (NECA)
19. All applicable state and local codes, amendments, regulations and practices

20. All applicable regulatory requirements and advisory practices of appropriate Authorities Having Jurisdiction (AHJs). Note that projects in the state of Georgia are subject to the following:
    a. Georgia Amendments to the IBC and IECC.
    b. Georgia Amendments to the NEC.
    c. Georgia State Minimum Fire Safety Standard Document 120-3-3.
21. All applicable standards, regulations and practices of the Owner.

B. Where codes and/or standards conflict, the most conservative document shall be followed.

C. OSHA Statute Part 29 CFR1926.403(a) requires that "All electrical conductors and equipment shall be approved". Acceptable evidence includes approval or listing by a qualified testing agency. Accordingly, all electrical conductors and equipment shall bear the appropriate Underwriter's Laboratories Inc. (UL), or other Nationally Recognized Testing Laboratory (NRTL) listing mark or classification marking. Equipment, materials, etc. not bearing a supplier provided UL or NRTL certification shall be field certified by UL or NRTL (or by other method satisfactory to the AHJ) prior to equipment acceptance and use.

D. The portion of work requiring interface with any and all utility companies, service providers, etc. shall be in accordance with their codes, regulations, requirements, etc.

E. Projects including wastewater treatment and / or collection are subject to the latest applicable revision of NFPA 820, Standard for Fire Protection in Wastewater Treatment and Collection Facilities.

F. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 INTERPRETATION OF DRAWINGS

A. Electrical loads (KVA, KW, Horsepower, Amperes, etc.) and wiring requirements indicated on the electrical Drawings are estimates representative of standard mechanical and building equipment. Electrical equipment ratings, bus ratings, circuit wire sizes, circuit wire quantities, conduit sizes, conduit quantities and overcurrent protection device ratings indicated on the Drawings are based on such equipment. Contractor is advised that prior to installation he must compare indicated electrical equipment ratings, wire sizes and quantities, conduit sizes and quantities and overcurrent protective device ratings versus approved shop drawings of actual equipment being furnished. Contractor shall provide electrical materials conforming to the requirements of the actual equipment being furnished, reflecting increased ratings, wire sizes and quantities, conduit sizes and quantities and overcurrent protective device ratings where required to match shop drawings. Overcurrent protective device ratings shall be decreased if required to match actual equipment requirements and/or manufacturer's recommendation. Other electrical ratings, wire sizes and quantities and conduit sizes and quantities shall not be decreased to less than that indicated on the electrical Drawings.

B. Equipment short circuit interrupting and/or withstand ratings are indicated on the Drawings and/or Specifications. These ratings equal or exceed design Engineer's determination of approximate short circuit levels based on standard data available at the time of design. Such determinations often assume "worst condition" situations and allow for unknown / unavailable / unreliable data at time of design. Such data typically includes Utility Company available fault

levels, service transformer ratings, type, location, etc. Also note that Engineer's design may indicate equipment with higher ratings than required by specific application, in cases where there is a desire for standardization of equipment throughout the Project. Contractor shall furnish equipment meeting these indicated ratings or shall furnish higher rated equipment if and when required based on the results of the Short Circuit Study (see Section 1.19). Advise Engineer and request clarification in such situations. In no case, shall equipment with ratings lower than those indicated on the Drawings and/or specified (per design Engineer's determined values) be permitted.

C. Unless otherwise approved by the Engineer, conduit shown or specified exposed shall be installed exposed; conduit shown or specified concealed shall be installed concealed.

D. Where circuits are shown as "home-runs", all necessary fittings and boxes shall be provided for a complete raceway installation.

E. Verify with the Engineer the exact locations and mounting heights of lighting fixtures, switches and receptacles prior to installation.

F. Any work installed contrary to or without approval by the Engineer shall be subject to change as directed by the Engineer, and no extra compensation will be allowed for making these changes.

G. The Drawings are not intended to show exact locations of equipment or conduit runs. The locations of equipment, fixtures, outlets, and similar devices shown on the Drawings are approximate only. Exact locations shall be as determined in field by Contractor, during construction, after coordination with the Owner and /or his designated representative and approval by the Engineer. Obtain in the field all information relevant to the placing of electrical work, and in case of any interference with other work, proceed as directed by the Engineer and furnish all labor and materials necessary to complete the work in an approved manner.

H. Surface mounted panel boxes, junction boxes, conduit, etc., shall be supported by spacers (minimum 1/2 inch) to provide a clearance between wall and equipment.

I. Circuit layouts are not intended to show the number of fittings, or other installation details. Furnish all labor and materials necessary to install and place in satisfactory operation all power, lighting, and other electrical systems shown. Additional circuits shall be installed wherever needed to conform to the specific requirements of equipment.

J. All connections to equipment shall be made as required, and in accordance with the approved shop and setting drawings.

K. Redesign of electrical or mechanical work, which is required due to the Contractor's use of an alternate item, arrangement of equipment, and/or layout other than specified herein, shall be done by the Contractor at his own expense. Redesign and detailed plans shall be submitted to the Engineer for approval. No additional compensation will be provided for changes in the work, either his own or others, caused by such redesign.

L. The Contractor shall coordinate his work with the work of the different trades so that interferences between conduits, piping, equipment, architectural and structural work will be avoided. All necessary offsets shall be furnished so as to take up a minimum space and all such offsets, fittings, etc., required to accomplish this shall be furnished and installed by the Contractor

without additional expense to the Owner. In case interference develops, the Engineer is to decide which equipment, piping, etc., must be relocated, regardless of which was installed first.

M. Where installation of new, active, conduit runs are called for or indicated in the Contract Documents, in locations which will become "inaccessible" after installation is complete, (such as underground, or in concrete encasement, or in concrete slabs, or similar application), Contractor shall furnish and install spare conduits of similar type and size, for the entire "inaccessible" part of such conduit runs. The quantity of additional spare conduits shall be such that the number of additional spare conduits (or, with Engineer's approval, the cumulative cross sectional area) shall be equivalent to 20% or more of the active conduits. Such spare conduits will generally not appear on the Drawings, but shall be included.

N. Conduits and cables called for or indicated per the Contract Documents as having 8 or more installed control wires, shall be supplemented by Contractor to include 20% additional spare control wires. Where such additional wires require increase in conduit size, Contractor shall furnish and install larger conduit. Such spare wires will generally not appear on the Drawings, but shall be included.

O. Dimensions indicated on the Drawings related to electrical equipment locations and /or clearances (relative to walls, column lines, other equipment, etc) are generally minimum clear dimensions to be maintained as per Code, AHJ, Project and / or operating requirements. Such dimensions shall be maintained or exceeded, but not reduced, regardless of actual equipment sizes which will only be determined after approval of project specific manufacturer's drawings. Concrete pads, vaults, structures, etc for electrical equipment, where dimensioned on the Drawings, are estimated dimensions based on typical catalog sizes of electrical equipment on which the design is based. Such dimensions shall be adjusted by Contractor if / as necessary based upon project specific approved manufacturer's drawings.

P. Conduit and wiring between electrical "field" utilization equipment, loads, motors, instrumentation, etc. and their respective "source" switchgear, motor control center, panelboard, PLC, termination cabinet, etc. are generally shown on the Drawings as "homeruns". Similarly, conduit and wiring between panels are shown as "homeruns". Contractor's scope, under this Section, shall include determination of the most suitable physical routing of such "homeruns", considering Owner preferences, building layouts, existing conditions, ease of installation, interferences, etc. Where multiple "homeruns" of instrumentation "digital control (120 VAC)" or "analog control (4-20 mA DC)" wiring run from the same "field" location or from the same panel to the same "source" location, Contractor may combine multiple wiring circuits into larger (common) conduits so as to provide an economical and practical installation. However, "digital" and "analog" wiring shall not share the same (common) conduits with each other. Contractor shall not combine power wiring into larger (common) conduits except in limited situations as specifically allowed by the Contract Documents. Contractor shall prepare Coordination Drawings (per this Spec.) clearly indicating "homerun" routing and combining of multiple wiring into common conduits, as permitted, for Approval before execution of the installation.

Q. Overall underground electrical ductbanks are generally shown on the electrical site plans. Final stub-up locations (entry/exit) into equipment inside electrical rooms and at each site area shall be field coordinated and determined by Contractor.

R. Equipment drawings shall be used to determine where embedded conduits may be stubbed- up at or beneath equipment. For all embedded conduits, Contractor shall determine routing of conduit based on site conditions.

S. Conduits embedded in concrete slab shall not interfere with equipment or building structures. Interferences with embedded conduits stubbed-up up at or beneath equipment shall also consider accessibility at such equipment. Interferences with embedded conduits shall be the Contractor's responsibility and cost to remedy.

T. Spare empty conduits shall be installed embedded in slabs as required, and as part of underground ductbanks according to Division 16 specifications.

1.06 PRIORITY OF THE CONTRACT DOCUMENTS

A. If during the performance of the work, the Contractor finds a conflict, error or discrepancy between or among one or more of the Sections or between or among one or more Sections and Drawings, furnish the higher performance requirements. The higher performance requirements shall be considered the equipment, material, device or installation method that represents the most stringent option, the highest quality, or the largest quantity.

B. In all cases, figured dimensions shall govern over scaled dimensions, but work not dimensioned shall be as directed by the Engineer and work not particularly shown, identified, sized, or located shall be the same as similar work that is shown or specified.

C. Detailed drawings shall govern over general drawings; larger scale drawings take precedence over smaller scale drawings; change order drawings shall govern over Contract Drawings. Contract Drawings shall govern over shop drawings. Once submittal / shop drawings have cleared the submittal review process, they shall be used as documents complementary to and supportive of the Contract Drawings. Should a shop drawing that has been through the submittal review process contain a conflict, omission and / or error, contrary to the Contract Drawings and / or Contract Documents, so as to void or diminish the original intent of the Contract Drawings and /or Contract Documents, the Contract Drawings and / or Contract Documents shall govern.

D. If the issue of priority is due to a conflict or discrepancy between the provisions of the Contract Documents and any referenced standard, or code of any technical society, organization or association, the provision of the Contract Documents will take precedence if they are more stringent or cause a higher level of performance. If there is any conflict or discrepancy between standard specifications, or codes of any technical society, organization or association, or between laws and regulations, the higher performance requirements shall be binding on the Contractor, unless otherwise directed by the Engineer.

E. In accordance with the intent of the Contract Documents, the Contractor accepts the fact that compliance with the priority order specified shall not justify an increase in Contract Price or an extension in Contract Time, nor limit in any way the Contractor's responsibility to comply with all Laws and Regulations at all times.

1.07 SUBMITTALS

A. Submit, in accordance with the General Conditions, and the Special Conditions, copies of all materials required to establish compliance with the Contract Documents. Submittals shall include at least the following:

1. Switchgear.
2. Switchboards and Panelboards.

3. Medium Voltage Motor Control Centers.
4. Low Voltage Motor Control Centers.
5. Variable Frequency Drives
6. Transformers.
7. Reduced Voltage Starters.
8. Lighting Fixtures and Lamps.
9. Manholes, Pullboxes and Handholes, Frames and Covers.
10. Grounding Hardware and Connections.
11. Raceways, Boxes, Fittings and Hangers.
12. Wires and Cable.
13. Switches, Receptacles and Covers.
14. Lightning Protection System.
15. Fire Alarm System.
16. Acceptance Testing Plan.
17. The Manufacturer's name and product designation, catalog number and serial number shall be submitted for all electrical and grounding testing equipment utilized.

B. When a resubmittal is required the Contractor shall submit all previously accepted material in addition to the corrected or added information. It is intended that each resubmittal be a complete and stand- alone document.

C. Prior to submittal, all Submittal shop drawings shall be checked for accuracy and Contract requirement conformance. Submittal shop drawings shall bear the date checked. In addition each Submittal shall include a copy of the applicable specification section, including addendum updates, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and, therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. The submittal shall be accompanied by a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justifications for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

D. Upon receipt of a Submittal, a review will be conducted. This review will be limited to general assessment of Submittal's conformance to the Project's design intent and general compliance with the Contract Specifications and Drawings. The review will not change the requirements of the Contract Documents, nor shall this review relieve the Contractor of responsibility for non-conformances or errors in the Submittal. The responsibility of, or the necessity of, furnishing materials and workmanship required by the Specifications and Drawings, which may not be indicated in the shop drawings, is included as work under this Section. In no case will the Submittal review process include review of submitted fixture / outlet / fittings and similar commodity quantities nor wire / raceway and similar material lengths, etc.

E. The responsibility for all dimensions to be confirmed and correlated at the job site and for coordination of this work with the work of all other trades is also included under the work of this Section.

F. No material shall be ordered or shop work started until approval of shop drawings has been given.

G. In addition to Manufacturer's equipment shop drawings, the Contractor shall submit for review electrical coordination/installation working drawings. See Paragraph 1.08

H. Submit Record Documents. See Paragraph 1.09

I. Submit Operation and Maintenance Manuals. See Paragraph 1.10

1.08 COORDINATION DRAWINGS

A. Prepare electrical coordination/installation working drawings to scale of 1/4" = 1'-0" or larger, detailing major elements, components, and systems of electrical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access, and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:

1. Indicate the proposed locations of all raceway systems, equipment, and materials. Include the following:
   a. Size of equipment and clearances for servicing equipment, including space for equipment disassembly required for periodic maintenance.
   b. Exterior wall and foundation penetrations.
   c. Fire-rated wall and floor penetrations.
   d. Equipment connections and support details.
   e. Sizes and location of required concrete pads and bases.
   f. Sizes and locations of man-holes, hand-holes, pull boxes, etc.
2. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
3. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings, and their relationship to other penetrations and installations.
4. Particular attention shall be directed toward concealed and buried conduit layouts. The drawings shall be prepared based on approved equipment shop drawings and shall accurately locate and dimension all conduit stub-ups. Contractor shall assure that no concrete floors or walls are poured until such layouts are approved.
5. Prepare reflected ceiling plans to coordinate and integrate installations, air outlets and inlets, light fixtures, communications systems components, and other ceiling-mounted devices.

B. These coordination drawings shall be prepared by Contractor and submitted by Contractor for conceptual review by Engineer prior to installation by Contractor. Contractor shall be responsible for accuracy of the coordination drawings.

1.09 RECORD DOCUMENTS

A. Contractor shall maintain one set of Contract Drawings in the field, which shall be marked as "Record Drawings". This set of Drawings shall be edited / red-lined by Contractor on a regular basis to indicate all modifications. This set of Drawings shall be available for review by Owner, Engineer, etc.

B. At milestone of substantial project completion, or at alternate date as directed, prepare record documents, using original Contract Drawings in electronic version as a template, to indicate installed modifications for:

1. Major raceway systems, size and location, for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; and fuse and circuit breaker size and arrangements.
2. Equipment locations (exposed and concealed) dimensioned from prominent building lines.
3. Approved substitutions, contract modifications, and actual equipment and materials installed.
4. Record power one line diagrams, panel schedules, control diagram and fire alarm riser diagrams.
5. Unless otherwise noted, Contractor shall provide such Drawings, completely drafted in electronic format, with all installed modifications made clearly distinguishable from original design. This shall be done by use of "clouding" and "numbered triangles" for drafted revisions.

1.10 OPERATION AND MAINTENANCE MANUALS

A. Prepare operation and maintenance manuals include the following information for equipment items:

1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
4. Servicing instructions and lubrication charts and schedules.

B. Operation and Maintenance Data

1. Submit complete operations and maintenance data for all equipment furnished under this Division. The manuals shall be prepared specifically for the installation and shall include all required cuts, drawings, equipment lists, descriptions, complete parts list, etc, that are required to instruct operating and maintenance personnel unfamiliar with such equipment.

1.11 MATERIALS

A. The materials used in all systems shall be new, unused and as hereinafter specified. All materials where not specified shall be of the very best of their respective kinds. Sample of materials or Manufacturers shall be submitted for approval as required by the Engineer.

B. All current carrying cables, wires, buses, terminals, windings, parts, etc. shall be copper.

C. Equipment shall be suitable in all ways for the intended application. Ratings shall match or exceed the requirements of the indicated Reference Standards, Drawings and Specifications. Electrical short circuit interrupting ratings shall meet the requirements of NEC Article 110. Additionally, electrical equipment shall have fully rated interrupting ratings; equipment having certified "series" rated interrupting capabilities from the manufacturer shall not be considered as acceptable, unless prior written approval is received from the Engineer.

D. Electrical equipment shall at all times during construction be adequately protected against mechanical damage, water damage, corrosion, dirt, dust and foreign material. Equipment equipped with internal electrical heaters shall have them energized to keep the equipment dry. Doors to cabinets, panelboards, motor control centers, switchgear, control panels and other similar equipment shall be kept closed at all times when work on them is not being done. Switchgear, motor control center, panelboards and similar Electrical equipment shall not be stored out-of-doors. Such Electrical equipment shall be stored in dry permanent shelters. If any apparatus has been subject to possible injury by water, it shall be replaced at no additional cost to the Owner, the damaged units or systems shall remain on site and returned to the manufacturer after the replacement units or systems have been delivered to the site. Under no circumstances will electrical equipment damaged by water be rehabilitated or repaired, new equipment shall be supplied, and all costs associated with replacement shall be borne by the Contractor.

E. Any damage to factory applied paint finish shall be repaired using touch-up paint furnished by the equipment manufacturer. The entire damaged panel or section shall be repainted per the field painting specification, at no additional cost to the Owner.

1.12 CODES, INSPECTIONS AND FEES

A. All equipment, materials, procedures and installation shall be in accordance with the requirements of all Authorities Having Jurisdiction, including federal, state and local Authorities and Owner-representative Authorities Having Jurisdiction.

B. Contractor shall obtain all necessary forms, permits, inspections, certificates of acceptance, certificates of occupancy, etc. Contractor shall complete all forms and pay all fees related to these items. Contractor shall submit to the appropriate Authority Having Jurisdiction all necessary documentation, including Drawings, calculations, load summaries, safety plans, work execution plans, schedules, etc., all in the format and quantity as required by the governing Authority Having Jurisdiction. These permits, inspections, and certificates shall cover all aspects of the electrical systems, including the fire alarm system. The permits, inspections and certificates shall be obtained by Contractor from the appropriate Authority Having Jurisdiction including, but not limited to, building departments, inspection authorities, plan review examiners, fire marshals, insurers, utility suppliers, etc.

C. Obtain required inspection stickers indicating installation suitability from appropriate Authorities Having Jurisdiction. Install as directed by Authorities Having Jurisdiction.

1.13 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

B. Inspect products for completeness and conditions; if it is to be stored, reseal for protection; unpack and handle equipment in accordance with manufacturer's recommendations.

C. Store products in dry spaces, free from corrosives. Heat storage areas to prevent condensation, and dust free. Keep equipment clean by covering or by other measures as necessary. Store shipping sections on level surfaces.

D. Store equipment and material under cover, and off the ground or floors exposed to rain.

E. For outdoor storage, protection covers of 10 mil thick black sheet plastic shall be fitted. Covers shall be reinforced to withstand wind and precipitation. Set materials on skid or platforms of height to avoid damage or deterioration from spattering and ground waste.

1.14 TESTS AND SETTINGS

A. Test all systems furnished under Division 16 and repair or replace all defective work. Make all necessary adjustments to the systems and instruct the Owner's personnel in the proper operation of the systems.

B. Complete all work as detailed in project Specification "Acceptance Testing and Calibration".

C. Make the following minimum field tests and checks. Where possible, make tests and checks prior to energizing electrical equipment. Tests shall be in accordance with manufacturer's requirements and suggestions, industry standards (NETA, or other standard referenced) and with the requirements outlined in the specific Sections of these Specifications:

1. Mechanical inspection, testing and setting of all circuit breakers, disconnect switches, motor starters, control equipment, etc. for proper operation.
2. Test grounding system.
3. Test switchgear and switchboards.
4. Test fire alarm system.
5. Test motor control centers.
6. Test transformers.
7. Test wires and cables.
8. Test substations and protective relaying.
9. Test variable frequency drives / controllers
10. Check all wire and cable terminations. Verify to the Engineer connections meet the equipment's torque requirements. Verify control wire continuity via bell / buzzer test. Megger all power wire and cable. Record all results.
11. Field set all transformers taps as required in order to obtain the proper secondary voltage.

12. Check motor nameplates for correct phase and voltage. Check bearings for proper lubrication.

13. Check the ampere rating of all thermal overloads for motors and submit a typed record to the Engineer of same, as well as locations and designations, listing the nameplate service factor, horsepower, and full load current. If inconsistencies are found, new thermal elements shall be supplied and installed by this Contractor.

14. Check rotation of all motors, obtain permission from the Engineer to start the motors, and proceed to check it for proper rotation. If it rotates in the wrong direction, correct the rotation at the motor. Take all necessary precautions not to damage any equipment.

15. Carefully check interlocking, control and instrument wiring for each system, and/or part of a system to ascertain that the system will function properly and as indicated by schematic and wiring diagrams where applicable.

16. Provide all instruments, personnel and equipment required for the tests specified herein.

D. All testing shall be scheduled and coordinated by the Contractor. Notify the Owner at least two (2) weeks in advance of conducting tests. The Contractor shall have qualified personnel present during all testing.

E. The following additional tests and checks shall be made prior to the energizing of electrical equipment. Contractor shall engage the services of an independent testing firm. Tests shall be conducted by the independent testing firm, and a certified test report shall be submitted stating that the equipment meets and operates in accordance with the manufacturers and job specifications, and that equipment and installation conforms to all applicable standards and specifications:

1. Testing of protective relays for calibration and proper operation.

2. Over potential, high potential, insulation resistance, and shield continuity tests for cables.

3. Mechanical inspection of switches and circuit breakers to assure proper operation.

F. Three (3) copies of certified test reports shall be furnished to the Engineer for all tests.

G. Contractor shall be responsible for supply of all electrical equipment, components, systems, and qualified manpower, as applicable, to provide for and execute complete electrical testing, system testing and acceptance testing and calibration as specified in the Contract Documents and / or as required. Include testing submittal preparation, testing plan, scheduling, start-up procedures, functional testing, attendance at meetings, testing results recording and documentation, demonstration and training, operations and maintenance manuals, and project close out data (bonds, warranties, spare parts, record documents and maintenance service agreements).

H. Set all relays, protective devices, breakers, etc. in accordance with findings and recommendations of the Electrical Protective Device Coordination Study and of the equipment manufacturer.

I. Infra-red hot spot inspection shall be made of all switchgear, switches, power and control panels. This shall be done under representative load conditions before the equipment is used by the Owner and again three (3) months before expiration of the one (1) year warranty period.

1.15 MANUFACTURER'S SERVICES

A. Provide Manufacturer's services for testing and start-up of the following equipment:

1.	Main MV Switchgear	Minimum three (3) days, two (2) trips.
2.	Unit Substations	Minimum three (3) days, two (2) trips.
3.	Low Voltage Motor Control Centers	Minimum three (3) days, two (2) trips.
4.	MV Load Interrupter Switchgear	Minimum two (2) days, two (2) trips.
5.	VFDs	Minimum one (1) day, one (1) trip.
6.	Reduced Voltage Solid State Starters	Minimum one (1) day, one (1) trip.
7.	Transformers	Minimum one (1) day, one (1) trip.
8.	Switchboards	Minimum one (1) day, one (1) trip.
9.	Fire Alarm Systems	Minimum two (2) days, two (2) trips.
10.	Generators and Transfer Switches	Minimum one (1) day, one (1) trip.

B. The Manufacturers of the above listed equipment shall provide an experienced Field Service Engineer to accomplish the following tasks:

1. The equipment shall be visually inspected upon completion of installation and prior to energization to assure that wiring is correct, interconnection complete and the installation is in compliance with the Manufacturer's criteria. Documentation shall be reviewed to assure that all Drawings, operation and maintenance manuals, parts list and other data required to check out and sustain equipment operation is available on-site. Documentation shall be red-lined to reflect any changes or modifications made during the installation to assure correct type and quantity.
2. The Field Service Engineer shall provide engineering support during the energization and check-out of each major assembly. They shall perform any calibration or adjustment required for the equipment to meet the Manufacturer's performance specifications.
3. Upon satisfactory completion of equipment test, they shall provide engineering support of system tests to be performed in accordance with Manufacturer's test specifications.
4. Three (3) four (4) hour training sessions (one for each system) on operation, and three (3) four (4) hour training sessions (one for each system) on maintenance and trouble-shooting procedures shall be provided for the Owner's maintenance personnel. All training shall be conducted at a facility provided by the Owner. The maintenance and trouble-shooting sessions shall be conducted with record "as-built" electrical drawings sufficient for a class of eight (8) personnel.
5. A final report shall be written and submitted by Contractor to the Engineer within fourteen (14) days from completion of final system testing. The report shall document the inspection and test activities, define any open problems and recommend remedial action.
6. A certificate of proper installation shall be issued by the manufacturer of the following equipment:
   a. Switchgear.
   b. Switchboards.
   c. Motor control centers.

d. Transformers.

e. Variable speed drives / controllers

f. Fire alarm system.

g. Any other equipment as required by the Engineer.

1.16 SIZE OF EQUIPMENT

A. Investigate each space in the structure through which equipment must pass to reach its final location. If necessary, the manufacturer shall be required to ship his material in sections sized to permit passing through such restricted areas in the structure.

B. The equipment shall be kept upright at all times. When equipment has to be tilted for ease of passing through such restricted areas during transportation, the manufacturer shall be required to brace the equipment suitably, to insure that the tilting does not impair the functional integrity of the equipment.

1.17 ENCLOSURE TYPES

A. Unless otherwise specified herein or shown on the Drawings, electrical enclosures shall have the following ratings.

1. NEMA 1 for dry, non-process indoor locations.
2. NEMA 12 for locations subject to "DUST".
3. NEMA 4X for outdoor locations, rooms below grade (including basements and buried vaults), "DAMP" and "WET" locations. Enclosure material shall be stainless steel or carbon steel with baked or electrostatically applied enamel finish. NEMA 3R may be substituted outdoors only where specifically indicated on the Drawings.
4. NEMA 4X for "CORROSIVE" locations. Enclosure material shall be stainless steel or fiberglass reinforced polyester.
5. NEMA 7 (and listed for use in the area classifications shown) for "Class I, Division 1" and "Class I, Division 2" Hazardous Locations. Enclosure material shall be cast malleable iron.

1.18 HAZARDOUS AREAS

A. All equipment, materials, and installation techniques used in areas designated as hazardous in the Specification Sections, or on the Contract Drawings shall be in strict accordance with National Electrical Code Articles 500, 501, 502 and 503.

B. All equipment and materials used in hazardous areas shall be UL listed for the appropriate hazardous area classification.

1.19 COORDINATION, SHORT CIRCUIT AND OTHER STUDIES

A. General:

1. The Contractor shall engage the services of a professional electrical engineer, currently registered in the applicable state, to provide an Electrical Protective Device Coordination Study, an Electrical Short Circuit Study (for the power distribution and motor control equipment), and other Studies as defined herein. The Studies shall bear the engineer's seal,

license number and signature. The professional electrical engineer shall work with the approved switchgear manufacturer to provide these Studies for projects that have new switchgear. The Studies shall cover Coordination, Short Circuit, Harmonic Analyses and Arc-Flash as outlined herein.

2. Prior to major electrical equipment order placement, a preliminary short circuit calculation / study shall be prepared by Contractor and submitted for review. The study shall verify the adequacy of the Contract Documents-indicated or specified short circuit and related ratings for all new equipment as well as that of existing affected equipment, to the extent applicable. In the unlikely case that the study calculations indicate available short circuit or related values exceeding indicated or specified ratings for new equipment, or exceeding existing equipment ratings, Contractor shall inform Engineer, request clarification, and await instruction prior to further action. In no case, in accordance with NEC, shall equipment with ratings below calculated values be applied. After review and acceptance of the preliminary calculation / study, Contractor shall use it as a basis for preparation and submittal for review of a complete, thorough and detailed study, as specified herein.

3. The study shall also include the utility company's protective devices, all switchgear, all feeders, all switchboards, all MCCs and all panelboards. Every overcurrent and protective device shall be included in the study. The study shall include all electrical systems including those utility powered, on-site powered, generator powered, or other source powered. Include all "emergency systems", "legally required standby systems", "optional standby systems" and COPS systems as defined in NEC. All devices shall be evaluated for short circuit capabilities and shall be electrically coordinated as required by code and to the extent practical. Graphic indication of coordination shall be furnished in the form of a clearly labeled and identified composite drawing showing time-current curves of system protective devices. Time-current curves of each device shall also be furnished. Results and recommended settings shall be summarized in a clear and concise tabulation.

4. The Contractor shall be responsible for obtaining and verifying with the Electric Utility Provider all information needed to conduct this study. This includes, but is not limited to, actual service transformer KVA rating, impedence and available fault current.

5. The Contractor shall set all protective devices and relays based on this coordination study to provide coordinated, selective protection for all equipment supplied or affected by the installation under this Contract.

6. The Contractor shall provide data necessary to perform the study. This includes feeder cable sizes, approximate feeder length, motor data, switchgear data, existing protective relay settings and any other information relevant to the study.

7. A summary of the short circuit analysis shall be provided by the Contractor at the time shop drawings for all of the new equipment is submitted for approval.

8. Where applicable, for projects that expand existing facilities, the Contractor shall investigate the existing distribution system and prepare an up-to-date single line diagram for the existing system. The Contractor shall provide necessary information to clearly represent an existing single line diagram as required in order to perform the coordination and short-circuit study.

B. Scope:

1. The short circuit study shall be in accordance with ANSI Standard C37.010 and C37.13, shall be performed to check the adequacy, and to verify the correct application of circuit protective devices and other system components specified. Where applicable, the study shall address the case when the system is being powered from the normal source as well as from

the alternate source. Minimum as well as maximum possible fault conditions shall be adequately covered in the study.

2. Fault contribution of all motors shall be considered. The Contractor shall be responsible for obtaining all required data of equipment. All back-up calculations shall become part of the final report. The calculations shall be in sufficient detail to allow easy review.

C. Contents:

1. The study shall include representation of the power company's systems, the base quantities selected, impedance source data, calculation methods and tabulations, one-line and impedance diagrams, conclusions and recommendations. Short circuit momentary duties, shall be calculated on the basis of an assumed bolted three-phase short circuit at each medium voltage bus, low voltage switchboard bus, switchboards, motor control centers, distribution panelboards, pertinent branch circuit panelboards, and other significant locations through the systems. The short-circuit tabulations shall include significant X to R ratios, asymmetry factors, KVA, and symmetrical fault current.

2. A protective device time current coordination study shall be included with coordination plots of key and/or limiting protective devices, tabulated data, rating, and/or settings selected. The study shall present an engineering balance between the competing objectives of protection and continuity of service for the system specified, taking into account the basic factors of sensitivity, selectivity and speed. In addition to including all facility "normal" utility powered and / or generator powered electrical power systems, the coordination study shall include all protective devices utilized in emergency systems, legally required standby systems and elevator systems in order to confirm selective coordination to the extent required by the NEC.

3. Separate plots shall be provided for each mode of "normal" and "alternate" operation. Maximum fault values shall be shown in each case. Both power sources shown in one plot will not be accepted.

4. Where applicable, existing protective device settings shall be reviewed to ensure selectivity under the new conditions. Recommended changes shall be indicated in the report.

5. Required settings for breakers and relays shall be maximized to provide the most effective protection possible whether the system is fed from the normal or emergency source, where applicable.

6. Tabulations indicating recommended set points for all protective devices shall be provided. This shall include the normal as well as the alternate source.

D. Motor Current-Time Characteristic Curves:

1. A complete independent set of current-time characteristic curves for all medium voltage motor drives indicating coordination between the protective relays and the thermal characteristics of the motor shall be provided.

2. The Contractor shall obtain the necessary information to perform the study from the motor suppliers.

E. Motor Starting Study:

1. A motor starting study for all large electric drives (100 horsepower and above) to determine voltage dip or power inrush limitations at selected locations due to starting of motors shall be provided. This applies to both the normal and the alternate mode.

F. General Information for Time-Current Curves Presentations:

1. The coordination plots shall include complete titles, representative one-line diagrams, legends, associated power company's relay or system characteristics, significant motor starting characteristics, complete parameters for power, and substation transformers, and complete operating brands for low-voltage circuit breaker trip devices.
2. The coordination plots shall define the types of protective devices selected, together with the proposed coil taps, time-dial settings and pick-up settings required.
3. The short-time region shall indicate the medium voltage relay instantaneous elements, the magnetizing in-rush, and ANSI withstand transformer parameters, the low-voltage circuit breaker instantaneous trip devices, fuse manufacturing to tolerance bands, and significant symmetrical and asymmetrical fault currents.
4. Each primary protective device required for a delta-to-wye connected transformer shall be selected so that the characteristic or operating band is within the transformer parameters; which, where feasible, shall include a parameter equivalent to 58 percent of the ANSI withstand point to afford protection for secondary line-to-ground faults.
5. Low-voltage power circuit breakers shall be separated from each other and the associated primary protective device, where feasible, by a 16 percent current margin for coordination and protection in the event of secondary line-to-line faults.
6. Protective relays shall be separated, where feasible, by a 0.3 second time margin when the maximum three-phase fault flows, to assure proper selectivity.

G. Harmonic Analysis:

1. As part of the study, a harmonic analysis shall be performed. The study shall utilize approved computer software and shall follow industry approved procedures in concurrence with IEEE recommended methodology. The effects of variable speed drives and other non-linear system components on the power system including harmonic distortion to power, current and voltage shall be included.
2. Where such analysis indicates power system calculated harmonic content exceeding recommended interference limitations per IEEE 519-1992, or other industry recommendations, the study shall identify possible mitigating solutions including, but not limited to, additional filters, isolators, reactors, etc. The study shall identify the recommended type of mitigating device(s), ratings, recommended system point(s) of application and calculated harmonic improvement.

H. Arc-Flash Analysis:

1. A complete arc-flash analysis for the entire new and modified (as applicable) electrical system shall be prepared and submitted by Contractor. It shall be based on NFPA 70E and IEEE 1548. It shall be comprehensive and include all assumptions, data, calculations and recommendations. Such analysis shall determine arc-flash hazard at all operator access

points and provide recommendations for operator safety and precaution including protective clothing, danger / warning / hazard signs, safe work practices, clearances, floor markings of flash hazard boundaries, etc. All signs and floor markings shall be furnished and installed by Contractor in accordance with the study results and in accordance with Code. See NEC 110.16.

I. The coordination study shall be bound in a standard 8-1/2 inch X 11 inch size report and submitted in triplicate to the Engineer. The final selection of all protective devices shall be based on a preliminary draft of the coordination study that shall be submitted with the equipment shop drawings for review. The completed study shall be submitted to and approved by the Engineer before any of the equipment is shipped. All protective devices shall be adjusted, tested, and calibrated in the field, prior to energizing the equipment, per the settings listed in the study. This work shall be performed by the Manufacturer as described in this section and prior to final acceptance by the Owner.

J. Unless indicated otherwise, all new and existing protective devices shall be calibrated and tested by an approved independent testing firm. Testing shall be in accordance with industry standards and as recommended by the equipment manufacturer. This work shall be provided and accomplished under Section 16010.

1.20 WARRANTY

A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

B. Provide a warranty for all electrical equipment in accordance with the general requirements of specification. Unless specified more stringently elsewhere in the general requirements, the components of the electrical system shall be warranted for a period of one (1) year from the date of final acceptance, against defective materials, design and workmanship.

PART 2 - PRODUCTS

A. Materials of the same type shall be the product of one (1) manufacturer. In addition, major electrical items including switchgear, substations, switchboards, motor control centers, and power transformers shall be the product of one (1) manufacturer.

PART 3 - EXECUTION (SEE APPLICABLE DIVISION 16 SECTIONS)

END OF SECTION 16010

SECTION 16050
BASIC ELECTRICAL MATERIAL AND METHODS

PART 1 - GENERAL

1.01 SCOPE

A. This Section covers basic materials and methods not included in other Sections of Division 16.

1.02 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions of the Contract Documents.

PART 2 - PRODUCTS

2.01 INDIVIDUAL MOTOR STARTERS

A. Manual Starters: NEMA ICS-2; general purpose type; trip-free mechanism; with overload relays. Provide pushbutton operation for integral horsepower sizes, and toggle switch for fractional sizes.

B. Magnetic Starters: NEMA ICS-2 Type A; NEMA size 1 minimum; magnetically held contactor with field replaceable coil and contacts; bimetallic or melting alloy overload relay, manually reset. Starters shall be rated and sized in accordance with NEMA size designations; fractional sizes and ratings per IEC recommendations are not acceptable.

C. Magnetic Starter Controls: All controls, unless otherwise noted or shown, shall be 120 volts. Equip each starter with a control power transformer fused on the primary and secondary. Provide starter and overload relay auxiliary contacts for red run light, green stop light and amber overload light on the enclosure door. Provide one (1) spare normally open starter auxiliary contact, and door mounted start-stop pushbuttons or hand-off-auto selector switch and other controls as indicated.

D. Combination Starters: Molded case circuit breaker rated 42,000 amps.

E. Acceptable Manufacturers: General Electric, Square D, Allen Bradley, Siemens, Cutler-Hammer or equal.

2.02 FUSES

A. Fuses: Current limiting, non-renewable type, rated 200,000 AIC, with rejection feature; Class RK-5 for motors and transformers for ratings 600 amp and below and Class L for feeders rated 601 amp and above.

B. Acceptable Manufacturers: Bussmann, Brush, Littelfuse or equal.

2.03 TERMINAL JUNCTION BOXES (TJB)

A. Provide hinged-cover terminal junction boxes of the required type and size where indicated. Utilize enclosures as required in 16000-2.01. Provide terminal blocks with a separate connection point for each conductor entering or leaving the box. Provide metal back plate for mounted

terminal blocks. Provide 20 percent spare terminal points. Paint interior surfaces with white enamel or lacquer.

2.04 PUSHBUTTONS, INDICATING LIGHTS, AND SELECTOR SWITCHES

A. For nonhazardous, indoor, dry locations, including motor control centers, control panels, and individual stations, provide heavy-duty, oiltight type pushbuttons, indicating lights, selector switches, and stations for these devices. Utilize General Electric Type CR 104P, or equivalent by Square D, Cutler-Hammer, or equal.

B. For nonhazardous, outdoor, or normally wet locations, or where otherwise indicated, provide heavy-duty corrosion resistant, watertight type pushbuttons, indicating lights, or selector switches mounted in NEMA 4X stainless steel (316) enclosures. Provide special gasketing required to make complete station watertight. Utilize Square D Type SK, General Electric, Cutler-Hammer, or equal.

C. Provide devices meeting the requirements of NEMA ICS 2, and having individual, extra large nameplates indicating their specific function. Provide pushbutton stations with laminated plastic nameplates indicating the drive they control. Provide contacts with NEMA designation rating A600.

D. Utilize selector switches having standard operating levers. Make all indicating lights push-to-test type. Provide ON or START pushbuttons colored black. Provide OFF or STOP pushbuttons colored red.

2.05 TERMINAL BLOCKS 0 TO 600 VOLTS

A. Provide 600-volt terminal blocks for termination of all control circuits entering or leaving equipment, panels, or boxes. Provide screw clamp compression, dead front barrier type terminal blocks with current bar providing direct contact with wire between the compression screw and yoke. Provide yoke, current bar, and clamping screws constructed of high strength and high conductivity metal. Utilize yoke that guides all strands of wire into the terminal. Utilize current bar providing dependable vibration-proof connection. Supply terminals constructed to allow connection of wire without any special preparation other than stripping. Rail mount individual terminals to create a complete assembly and provide terminals constructed such that jumpers can be installed with no loss of space on terminal or rail.

B. Size all terminal block components to allow insertion of all necessary wire sizes and types. Supply terminal blocks with marking system allowing the use of preprinted or field-marked tags. Supply CSA certified and UL approved terminal blocks manufactured by Weidmuller, Ideal, Electrovert, or equal.

2.06 CONTROL RELAYS

A. Provide magnetic control relays, NEMA Class A600 (600 volts, 10 amps continuous, 7,200VA make, 720VA break), industrial control type with field convertible contacts, and meeting the requirements of NEMA ICS 2. Provide General Electric Type CR120B, Cutler-Hammer Type M-600, or equal.

B. Where time delay relays are specified or required, unless otherwise noted, provide magnetic control relays with a timer attachment adjustable from 0.2 to 60 seconds (minimum) and field convertible from ON delay to OFF delay and vice-versa.

C. Where latching (mechanically held) relays or motor thermal detector relays are specified, provide magnetic control relays with mechanical latch attachment with unlatching coil and coil clearing contacts. Utilize an attachment allowing 01 easy manual latching and unlatching.

2.07 ELAPSED TIME METERS

A. Provide synchronous-motor-driven, elapsed time meters, to 99,999.9 hours range, nonreset type, suitable for semiflush, panel mounting. Provide General Electric Type 240, 2-½-inch Big Look unit, Eagle Signal Bulletin 705 unit, or equal.

2.08 CIRCUIT BREAKERS, INDIVIDUAL, 0 TO 600 VOLTS

A. Mount individual circuit breakers complying with requirements for circuit breakers in this section in enclosure required for the location, unless otherwise indicated. Provide circuit breakers with handles that can be locked in the OFF position. Interlock enclosure and circuit breaker to prevent opening the cover with the circuit breaker in the ON position.

2.09 CIRCUIT BREAKERS, 0 TO 600 VOLTS

A. General: Provide circuit breakers of the indicating type showing ON/OFF and TRIPPED positions of the operating handle. Do not use single-pole circuit breakers with handle ties where multipole circuit breakers are indicated. Utilize multipole circuit breakers designed so that an overload on one pole automatically causes all poles to open. Provide circuit breakers meeting the requirements of NEMA AB 1. Circuit breakers shall have a minimum interrupting rating equal to the maximum fault current available at the point of application or they shall be part of an assembly with an integrated equipment short circuit rating at least as great as the fault current available at the point of application. Where circuit breakers are used as service entrance equipment, provide units UL labeled for that use. Provide circuit breakers suitable for use with 75 degrees C wire at full NEC 75 degrees C ampacity.

B. Inverse Time Type:

1. Provide thermal-magnetic circuit breaker, unless otherwise shown, for one- and two-pole breakers, breakers operating- at 240V or less, and three-pole branch circuit breakers operating at 480V.

2. Provide solid state trip circuit breakers with an adjustable short-time function, unless another type breaker is required for coordination, or otherwise indicated on the Drawings, for three-pole, 480V feeder circuit breakers with not more than one downstream, 480V, overcurrent protective device, excluding protective devices provided as part of a process equipment package. Such breakers shall be Cutler-Hammer Seltronic Circuit Breakers, Square D, Type ME or PE Circuit Breakers, or equal.

3. Provide solid-state trip circuit breakers with at least the following adjustment: long time pickup, long time delay, short time pickup, short time delay, I-squared t, for circuit breakers not covered by either of the above cases. Such breakers shall be General Electrical Circuit Breakers with Microversatrip; Cutler-Hammer Circuit Breakers with Digitrip; or equal.

C. Instantaneous Only Type: Instantaneous only circuit breakers shall have only an instantaneous trip element. The breakers shall be used only as part of a listed combination motor starter. Instantaneous only breakers shall be sized with a continuous rating of at least 115 percent of the full-load current of the motor served. The trip setting shall be continuously adjustable from a lowest setting of not more than 700 percent to a highest setting of not less than 1,300 percent of the motor full-load current. Instantaneous only breakers shall be General Electric Mag-Break; Westinghouse MCP; Square D Mag-Guard; or equal.

2.10 SUPPORTING DEVICES

A. Support Channel: Fiberglass, according to 16000-2.01

B. Hardware: Stainless steel, according to 16000-2.01.

2.11 ELECTRICAL IDENTIFICATION

A. Nameplates: Engraved three-layer laminated plastic, black letters on white background.

B. Wire and Cable Markers: Plastic, split sleeve or tubing type.

2.12 PLYWOOD BACKBOARDS

A. Backboards: Grade BC plywood, ¾-inch thick. Paint with two coats of flat black paint.

PART 3 - EXECUTION

3.01 INDIVIDUAL MOTOR STARTERS

A. Select and install heater elements in motor starters to match installed motor characteristics. Do not use NEC motor full load ampere data for heater selection.

B. Provide a typed label inside each motor starter enclosure door identifying the motor served and listing the motor nameplate data. Provide an engraved nameplate on the exterior of the enclosure door identifying the motor served, the horsepower, voltage, and phase rating.

C. Enclosure type, unless otherwise indicated, enclosures shall be according to Section 16000-2.01.

D. Install starters so they are rigidly supported and readily accessible. Where mounted on stud walls, provide a non-flammable backboard secured to the studs with the starter secured to the backboard. Provide stainless steel mounting channel or phenolic spacers to give nominal ½ inch separation from concrete walls in wet or damp locations.

3.02 FUSES

A. Equip all fusible devices with fuses. Replace all blown fuses up to final acceptance of the Project. At the completion of the Project, turn over to the City spare fuses for each type and size installed; six each for ratings 60 amps and below, and three each for ratings above 60 amps.

3.03 TERMINAL JUNCTION BOXES (TJB)

A. Install in accordance with all the requirements detailed under Section 16130, Boxes. Label each block and terminal with a permanently attached, nondestructible tag.

3.04 SUPPORTING DEVICES

A. Fasten hanger rods, support stands, conduit clamps, etc. to building structure using approved material.

B. Do not fasten supports to piping, ductwork, mechanical equipment, or conduit. Do not use powder actuated fastening devices. Do not drill structural steel members.

3.05 ELECTRICAL IDENTIFICATION

A. Provide nameplates for all switchboards, panelboards, transformers, disconnect switches, individual motor starters, and other items of electrical distribution equipment. Engrave with the equipment identification as indicated, and the voltage rating. Attach nameplates with screws or rivets; adhesives are not acceptable.

END OF SECTION 16050

SECTION 16111
CONDUIT RACEWAY SYSTEMS

PART 1 - GENERAL

1.01 SCOPE

A. Work described in this Section includes furnishing all labor, materials, equipment, tools and incidentals required for a complete and operable installation of raceways, including metallic conduit and fittings, non-metallic conduit and fittings, flexible metal conduit (Greenfield) and fittings, liquid tight flexible non-metallic conduit and fittings, explosion proof flexible conduit, cable tray, wire trough, manholes, handholes and ductbanks. All raceways shall be installed, adjusted, tested and placed in operation in accordance with these Specifications, the manufacturer's recommendations and as shown on the Drawings.

B. Contract drawings show only functional features and some of the required external connections. They do not show all components required for a complete installation nor exact dimensions particular to any manufacturer's equipment. Contractor shall supply all parts, devices and equipment necessary to meet the requirements of the Contract Documents and shall make all dimensional adjustments particular to the equipment being furnished. All costs associated with such changes and adjustments shall be considered as being included in the price bid for the work shown and specified.

C. Minimum conduit size shall be 3/4" for all wiring unless shown otherwise on the Contract Drawings. All conduit sizes if not specifically shown on the Drawings shall be in accordance with Chapter 9, NEC. All boxes and fittings shall be of the same material or have the same surface treatment or coating as the conduit serving same.

D. All wiring shall be enclosed in raceways unless otherwise indicated. All raceways shall be as indicated on the Contract Drawings and as noted below:

1. Rigid galvanized steel conduit.
2. Electrical metallic tubing conduit.
3. Polyvinyl chloride (PVC) conduit.
4. Polyvinyl chloride coated metallic conduit.
5. Flexible metal conduit (Greenfield) may be used in final connections from ceiling outlet box to light fixtures above hung ceilings or in joist spaces, or for other work in existing buildings, as approved by the Engineer. Maximum length 6'-0" unless otherwise approved by Engineer.
6. Liquid tight flexible conduit shall be used for final connections to motors, vibrating or moving equipment in non-explosion-proof areas. Make connection with a 360o loop with a minimum radius of 10 times the conduit size.
7. Auxiliary gutters and wireways shall be used for grouped circuits adjacent to grouped panels or switchgear, and at the Contractor's option for other grouped circuits as approved by the Engineer.

1.02 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions of the Contract Documents. In addition, the following specific information shall be provided:

1. Equipment data specified in this Section.
2. Catalog cuts.

1.03 QUALITY ASSURANCE

A. Reference Standards. Comply with all Federal and State laws or ordinances, as well as all applicable codes, standards, regulations and/or regulatory agency requirements including the partial listing below:

1. ANSI C80.1.
2. ASTM F 512.
3. Fed Spec WW-C-581E.
4. Fed Spec WW-C-1094A.
5. NEMA TC2.
6. NEMA TC6.
7. NFPA 70.
8. UL 1.
9. UL 6.
10. UL 360.
11. UL 651.

1.04 QUALITY STANDARDS

A. All products covered by these specifications shall be in conformance with NEMA standards, and shall be UL approved.

B. Manufacturers offering products that comply with these specifications include:

1. Conduit: Allied, Republic, Triangle, Wheatland, or equal.
2. PVC Coated Conduit: Permacote, Robroy, or equal.
3. PVC Conduit: Amoco, Carlon, Certainteed, or equal.
4. Flexible Conduit: Anamet, Columbia, Electrilex, or equal.
5. Fittings: Appleton, Crouse-Hinds, Thomas & Betts, or equal.

PART 2 - PRODUCTS

2.01 GENERAL

A. The type and size of raceway shall be as specified on the Drawings or schedules. Lighting, receptacle and other raceways are not scheduled and shall be sized by the Contractor in accordance with the NEC. Minimum size shall be ¾-inch for exposed and 1-inch for embedded raceway. The number and size of communication and security raceways shall be as required for the particular equipment provided, subject to the minimum sizes specified above.

2.02 METALLIC CONDUIT AND FITTINGS

A. Rigid Steel Conduit: UL 6; ANSI C80.1; Federal Specification WCC-581; hot dip galvanized. Minimum size 3/4-inch, exposed, 1-inch embedded or inaccessible.

B. PVC Coated Conduit: NEMA RN-1; galvanized rigid steel conduit with factory applied external 40 mil PVC coating and 2 mil urethane interior coating. Prior to coating, treat conduit with a heat polymerizing adhesive so the bond between metal and coating is greater than the tensile strength of the coating. All fittings, boxes and conduit accessories shall be coated and of the same manufacture to assure an extremely corrosion resistant raceway system. Minimum size ¾-inch.

C. Electrical metallic tubing conduit shall be UL labeled and shall conform with UL 1243 and Federal Specification WWC-581, hot dipped galvanized.

D. Metallic auxiliary gutters or wireways shall be formed heavy gage sheet steel, hinged and screw attached steel covers, bonderized with baked enamel finish.

E. Rigid Aluminum Conduit: UL6; ANSI C80.5; Alloy 6063; Temper T-1. Minimum size ¾-inch.

F. Fittings and Conduit Bodies: NEMA FB-I; zinc coated; taper-threaded type, material to match threaded metallic conduit. Where PVC coated conduits are indicated all couplings, fittings, conduit bodies, pipe straps, U bolts, beam clamps, and other accessories are to be PVC coated.

2.03 FLEXIBLE METAL CONDUIT AND FITTINGS

A. Conduit: UL 1; FS WW-C-566; single steel continuous strip with galvanized coating. Minimum size ½-inch.

B. Fittings and Conduit Bodies: NEMA FB-1; malleable iron squeeze type.

2.04 LIQUIDTIGHT FLEXIBLE CONDUIT AND FITTINGS

A. Conduit: UL listed liquid tight, non-metallic, sunlight and corrosion resistant, extruded thermoplastic. Minimum size ¾-inch. Metallic liquid tight flexible conduit is not acceptable.

B. Fittings and Conduit Bodies: NEMA FB-1; non-metallic compression type with O-ring.

2.05 RIGID NONMETALLIC CONDUIT AND FITTINGS

A. Conduit: Rigid polyvinyl chloride (PVC), UL listed for concrete-encased, underground direct burial, concealed and direct sunlight exposed use, and UL listed and marked for use with conductors having 90 degrees C insulation. Use conduits, couplings, bushings, elbows, nipples, and other fittings meeting the requirements of NEMA TC 2 and TC 3, Federal Specification W-C-1094, UL-651, NEC, and ASTM specified tests for the intended use. Use only conduit with a factory formed bell on one end. Conduit that requires the use of couplings for straight runs will not be acceptable. Use Schedule 40 for concrete encased conduit. Use Schedule 80 elsewhere. Minimum size ¾-inch exposed, 1-inch embedded or encased.

B. Fittings for PVC conduit shall comply with Standard for PVC Fittings for use with Rigid Conduit and Tubing, NEMA TC3, and shall be NEMA Type IV.

C. PVC auxiliary gutters or wireways shall be high-impact resistant, nonmetallic, corrosion resistant PVC with clip-on covers.

2.06 EXPLOSION PROOF FLEXIBLE STEEL CONDUIT

A. Conduit shall be suitable for use in Class 1, Division 1, Groups C and D hazardous areas as specified in NEC and shall be watertight. Flexible conduit shall be used for final connections to motors and other equipment subject to vibration or adjustment in Class 1, Division 1 hazardous areas. Minimum size ½-inch.

2.07 PRECAST HANDHOLES AND MANHOLES

A. Install handholes and manholes with 28-day, 2,500 psi minimum compressive strength concrete and designed for AASHTO H-20 loading. Minimum dimensions for handholes and manholes are shown on the Drawings. Increase these as required by use of extension sections to accommodate the several raceway entrances at their required elevations.

B. Slope floors toward drain points, leaving no pockets or other nondraining areas. Provide a drainage outlet at the low point of the floor constructed with a heavy, cast iron, slotted or perforated hinged cover, and 4-inch minimum outlet and outlet pipe.

C. Provide raceway entrances on all four sides. For raceways installed under this Contract, knockout panels or precast individual raceway openings may be used. On sides where no raceways are installed under this Contract, provide 12-inch high by 24-inch wide (minimum) knockout panels for future raceway installation.

D. For manholes, utilize heavy-duty type frames and covers made of stainless steel, suitable for H-20 loading, and having machined bearing surfaces. Provide indented type covers, solid top design, with two drop handles each. On the upper side of each cover, cast or burn by welder, in integral letters not less than 2 inches high appropriate titles, ELECTRIC-HV (for above 600 volts), ELECTRIC-LV (for 600 volts and below), or COMMUNICATION. Field stamp covers with handhold and manhole numbers indicated on the Drawings.

E. For handholes, frames and covers shall conform to ASTM A48-83 and shall be slab type with letters as indicated above.

F. Provide heavy weight cable racks with adjustable arms and acceptable insulators for all cables in each handhold and manhole. Set adjustable inserts in the concrete walls for the attachment of racks. Do not use bolts or studs embedded in concrete for attaching racks. Set racks and inserts on not greater than 3-foot centers around the entire inside perimeter of the manhole, arranged so that all spare conduit ends are clear for future cable installation. Provide stainless steel racks with a sufficient number of arms and insulators to accommodate cables for each conduit entering or leaving the handhold, including spares.

G. Provide pulling irons. Utilize ¾-inch round stock securely fastened to the overall steel reinforcement before concrete is poured.

H. Utilize handhole and manhole hardware of stainless steel construction only after fabrication.

I. Manufacturers: Brooks Products, Inc.; Penn-Cast Products, Inc.; Concrete Conduit Company; Associated Concrete Products, Inc, or equal.

2.08 WARNING TAPE

A. Provide heavy-gauge, yellow plastic tape of 6-inch minimum width for use in trenches containing electric circuits. Utilize tape made of material resistant to corrosive soil. Use tape with printed warning that an electric circuit is located below the tape. Manufacturers and types: Equal to: ITT Blackburn Type YT or RT; Griffolyn Co. Terra-Tape.

2.09 RACEWAY IDENTIFICATION

A. Raceways number tags shall be brass with stainless steel attachment wire. Raceway number shall be embossed on to the tag with ¼-inch letters.

PART 3 - EXECUTION

3.01 CONDUIT SCHEDULE

A. Use RGS or EMT steel conduits for indoor clean area or as indicated on the Drawings.

B. Use liquid tight flexible non-metallic conduit for connections to motors, transformers, and other vibrating equipment.

C. Non-jacketed flexible steel conduit may be used for connections to large transformers and motors or lighting fixtures in suspended ceilings.

D. Use PVC coated conduits where conduits are in direct contact with earth or where conduits are installed in corrosive areas.

E. Use PVC conduits where conduits are embedded in concrete structures, encased in concrete duct bank or concealed in concrete block CMU.

F. Where PVC conduit is indicated, make a transition to PVC coated rigid steel below grade or slab and continue above with PVC coated rigid steel conduit.

G. Exception: PVC may enter switchboards, motor control centers or other floor standing electrical equipment enclosures.

3.02 CONDUIT ARRANGEMENT AND SUPPORT

A. Arrange conduit to maintain headroom and present a neat appearance. Run exposed conduits parallel or perpendicular to building surfaces and adjacent piping. Group conduit in parallel runs where practical and provide rack space for 25 percent additional conduits.

B. Avoid sources of heat when possible. Where unavoidable, maintain 6-inch clearance when crossing hot pipes and 12-inch clearance between parallel hot pipes, flues, heating appliances, and other heat sources.

C. Support conduits to prevent distortion of alignment by wire pulling operations. Fasten single conduits with one hole malleable iron straps. For multiple runs use galvanized steel channel and clamps. Wire, perforated pipe straps and the like are not acceptable support means.

D. Support conduit at a maximum of 7 feet on center and within 3 feet of each box, cabinet, or fitting. Hang trapeze assemblies with threaded rods not less than 3/8-inch diameter. Remove all temporary supports prior to pulling conductors.

3.03 CONDUIT INSTALLATION

A. Raceways shall be installed between equipment essentially as shown. Raceway systems shall be electrically and mechanically complete before conductors are installed. Bends and offsets shall be smooth and symmetrical, and shall be accomplished with tools designed for this purpose. Factory elbows shall be utilized wherever possible.

B. Where raceway routings are designated on plan views, the Contractor shall follow those routings to the extent possible.

C. Where raceways are designated, but not shown, such as home runs or on conduit block diagrams and schedules, raceway routings shall be at the Contractor's discretion, in strict accordance with the N.E.C., customary installation practice, and/or as designated, i.e., encased, exposed, under floor, etc.

D. Routings shall be adjusted to avoid obstructions. Coordinate with all other trades prior to installation of raceways. Lack of such coordination shall not be an excuse for extra compensation, and removal and reinstallation shall be at no extra cost to the OWNER.

E. Cut conduit square using a saw or pipe cutter and de-burr and ream cut ends. Paint all threads with zinc compound. Bring conduit to the shoulder of fittings and couplings and fasten securely. All connections are to be wrench tightened and electrically continuous. No running threads are permitted.

F. Use conduit hubs for fastening conduit to boxes. Use conduit bodies to make sharp changes in direction. For sizes 2-inches and larger, use "LD", Mogul, or similar fittings to permit a straight pull from either direction.

G. The maximum length between pull points is 400 feet. This length shall be reduced by 100 foot for each 90 degree of bend.

H. Use hydraulic one-shot shoe bender or factory elbows for bends in conduit larger than 2-inch size. Crushed or deformed conduits may not be installed.

I. Avoid moisture traps where possible; where unavoidable, provide junction box with drain fitting at conduit low point.

J. Use suitable conduit caps to protect installed conduit against entrance of dirt and moisture. Install threaded PVC end caps on conduits stubbed up for future use.

K. Unless otherwise specified, conduit entering field equipment enclosures shall enter the bottom or side of the box.

L. Provide a 200 pound tensile strength polyolefin line pulled through and tied off at each end of all empty conduits.

M. Install expansion joints where conduit crosses building expansions joints and for straight runs in excess of 100 feet.

N. Where conduit penetrates fire-rated walls and floors, provide mechanical fire-stop fittings with UL listed fire rating equal to wall or floor rating.

O. Provide watertight conduit seals, equal to OZ type WSK or FSK, where conduit penetrates exterior walls below grade.

P. Provide watertight cable seals, equal to OZ type CRC or CRN for conduit that penetrates exterior walls below grade or for conduit that passes between spaces normally at different temperatures.

Q. All exposed raceways shall be installed at least one-half (1/2) inch from walls or ceilings except that at locations above finished grade where damp conditions do not prevail, exposed raceways shall be installed one-quarter (1/4) inch minimum distant from the face of walls or ceilings by the use of clamp backs and/or struts.

R. Wherever contact with concrete or dissimilar metals can produce galvanic corrosion of equipment, suitable insulating means shall be provided to prevent such corrosion.

S. Route conduits in slabs above the bottom reinforcing and below the top reinforcing. Maximum size for conduits in slabs above grade is 1-inch. Route so conduits in slabs above grade do not cross.

T. PVC conduit bends: Use PVC-coated rigid steel factory elbows.

U. PVC coated conduit: Exercise care not to damage the coating during cutting, threading, bending, and assembly. Follow the manufacturer's installation instructions. Use vise jaws, bending equipment, strap wrenches, and other tools, which are specifically designed for coated conduits. Do not use chain vise, pipe wrench, channel locks or the like.

V. Provide sealing compound equal to Chico A or Chico B where conduit passes from hazardous or corrosive area in to a non-classified area.

W. Each conduit shall be provided with a number tag at each termination.

X. Contractor will provide chases, recesses, and wall pockets in new construction as specified or shown on Contract Drawings. Check architectural and structural design and shop drawings to

verify correct size and location for all openings in general construction work. Supply information in ample time, giving size and exact locations, furnishing templates if required.

Y. Provide all required sleeves and inserts of material and type specified. Set sleeves and inserts in place ahead of new construction, securely fastened during pouring. Correct, by drilling, all omitted or improperly located sleeves. Plug all abandoned sleeves as directed.

Z. Provide pipe sleeves for all conduit passing through masonry walls above grade or concrete floors. Sleeves shall be 1/2" larger than conduit and adequately calked watertight and finished with escutcheon plates. Floor sleeves shall extend 3 inches above the floor elevation and shall be encased in a minimum of 2 inches of concrete around each sleeve.

AA. Provide roof flashings for all conduits passing through roofs compatible with the type of roof construction. All installations shall be watertight.

BB. After installing conductors, seal inside of conduits where passing through walls containing vapor seals or where reduction of sound transmission is required. Sealing may be accomplished by locating junction box or approved fitting at wall and filling with an approved compound.

3.04 UNDERGROUND DUCT BANK INSTALLATION

A. Install top of duct bank minimum 24-inches below finished grade with plastic warning tape 12-inches below finished grade.

B. Install conduit with minimum grade of 4-inches per 100 feet.

C. Terminate conduit in end bell at manhole entries.

D. Provide minimum 3-inch concrete cover at bottom, top, and sides of duct bank. Use suitable separators and chairs installed not greater than 4 feet on centers to provide conduit spacing as indicated. Securely anchor conduit to prevent movement during concrete placement. Stagger conduit joints in concrete encasement 6-inches minimum.

E. All underground electrical duct bank encasements shall be reinforced. Reinforcing shall consist of steel rods to prevent shearing and/or cracking of the concrete envelopes. Provide #4 rebars at corners on top and bottom. Longitudinally, provide #4 rebars at 8-inch centers; 4 bars minimum. Transversely, provide #4 u-shaped rebars at 12-inch centers with vertical legs lapping a minimum of 6-inches. Provide 3-inch, minimum concrete cover all around the reinforcing rods. Concrete shall be F'c = 3 KSI, Fy = 60 KSI with Schofield Red Dye throughout the encasement applied at 10 lbs per cubic yard to the concrete mix.

F. Where duct bank passes beneath footings or slabs resting on grade excavate to provide a minimum of 6-inch clearance between the ductbank and the structure.

G. Utilize only long radius (minimum 36 inch) elbows and bends where conduit duct bank changes direction or conduit stubs up.

H. Thoroughly swab inside of conduits upon completion of pouring concrete. Before backfilling, a mandrel, ½-inch smaller than the conduit diameter, shall be pulled through each conduit.

3.05 HANDHOLES AND MANHOLES

A. Install handholes and manholes where shown on the Drawings. Provide excavation, shoring, bracing, backfilling, grading, etc., in accordance with requirements specified in Division 2 of these Contract Documents.

B. Do not install handholes or manholes until final conduit grading, including field changes necessitated by underground interferences, has been determined. Set frames to final grades as required.

C. Install one ground rod in each handhold and/or manhole. Connect all non-current carrying metal parts in the manhole or hand hole and any metallic raceway grounding bushings to this ground rod with No. 6 AWG (minimum) copper conductor.

END OF SECTION 16111

SECTION 16119
UNDERGROUND DUCTS AND UTILITY STRUCTURES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This section includes:

1. Underground conduits.
2. Ducts, and duct banks.
3. Pull boxes.
4. Handholes, and manholes.
5. Other underground utility structures.

B. Products furnished and installed under this Section include pulling eyes, cable stanchions, cable arms, and insulators.

1.03 REFERENCED DOCUMENTS

A. Industry Standards:

1. American National Standards Institute, Inc. (ANSI):
   a. C2 National Electrical Safety Code
   b. C80.1 Rigid Steel Conduit
2. National Electrical Manufacturers Association, Inc. (NEMA):
   a. TC-2 Rigid Nonmetallic Conduit
   b. TC-3 PVC Conduit and Tubing Fittings
3. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC)

B. Government Standards:

1. U.S. Department of Labor, Occupational Safety and Health Administration (OSHA): Code of Federal Regulations, Title 29, Chapter XVII:
   a. Part 1910, Subpart S, Electrical, Revised by CFR 4056, January 16, 1981.
   b. Part 1926, Subpart K, Electrical, Revised by 51 CFR 25318, July 11, 1986

1.04 SUBMITTALS

A. General: Submit the following according to the General Conditions of the Contract and Division 1 Specification Sections.

B. Product data for metal accessories for manholes and handholes, conduit and duct, duct bank materials, and miscellaneous components.

C. Field test reports indication and interpreting test results relative to compliance with performance requirements of "Field Quality Control" Article in Part 3 of this Section.

D. Record Documents: Show dimensioned locations of underground ducts.

1.05 QUALITY ASSURANCE

A. Comply with NFPA 70 and ANSI C2 for components and installation.

B. Listing and Labeling: Provide products that are listed and labeled for their applications and installation conditions and for the environments in which installed.

1. The Terms "Listed" and "Labeled": As defined in the "National Electrical Code", Article 100.

2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

C. Coordinate layout and installation of ducts, manholes and handholes with final arrangement of other utilities as determined in the field.

D. Coordinate elevations of duct and duct bank entrances into manholes and handholes with final profiles of conduits as determined by coordination with other utilities and underground obstructions. Revise locations and elevations from those indicated as required to suit field conditions and ensure duct runs drain to manholes and handholes and as approved by the Architect.

1.06 DEFINITIONS

A. Duct: PVC conduit used underground, embedded in concrete (concrete with rebar reinforcement).

B. Duct Bank: 2 or more PVC conduits installed underground in the same concrete envelope (concrete with rebar reinforcement).

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver ducts to site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.

1.08 EXTRA MATERIALS

A. Furnish extra materials matching products installed, packaged with protective covering for storage and with identification labels clearly describing contents.

B. Furnish cable stanchions, support arms, insulators, and associated fasteners each in quantities equal to 5 percent of quantities installed.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering the specified products that may be incorporated in the Work include, but are not limited to, the following:

1. Nonmetallic Ducts:
   a. CANTEX, Inc.
   b. Carlon; Lamson & Sessions Company.
   c. Pipe & Plastic Group; Certainteed Products Corp.

2.02 CONDUIT AND DUCT

A. Rigid Steel Conduit: ANSI C80.1, galvanized.

B. Rigid Plastic Conduit: NEMA TC 2, Schedule 40 PVC, rated for use with 90 deg C conductors under all installation conditions. Suitable for above ground, direct burial, concrete encased and direct sunlight applications. ASTM class DB (suitable for direct burial without concrete encasement). Where subject to damage, use Schedule 80 PVC.

C. PVC Conduit and Tubing Fittings: NEMA TC3.

2.03 ACCESSORIES

A. Duct Supports: Rigid PVC spacers selected to provide minimum duct spacing and concrete cover depths indicated, while supporting ducts during covering.

B. Duct Sealing Compound: Non-hardening, safe for human skin contact, not deleterious to cable insulation, workable at temperatures as low as 35 degree F (1 degree C), withstands temperature of 300 degree F (149 degree C) without slump, and adheres to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheathes, cable jackets, insulation materials, and the common metals.

2.04 CONSTRUCTION MATERIALS

A. Concrete: Where applicable, conform to Division 3 Section "Cast-In-Place Concrete" for concrete and reinforcing.

1. Strength: 3,000 psi (20.7 Mpa) minimum 28 day compressive strength.
2. Aggregate for Duct Encasement: 3/8 inch (10mm) maximum size.

B. Concrete: Where applicable, conform to Division 3 Section "Pre-Cast Concrete".

C. Concrete Reinforcement: All underground structures, including duct banks, shall utilize concrete reinforced with rebar. Intent is for rebar details to be in accordance with Division 3 requirements and / or Division 16 details as shown on the Drawings. In the absence of Division 3 or Division 16 Drawing details, structure and duct bank rebar shall be #4 steel rebar. Install rebars in a continuous horizontal manner, arranged in parallel for the entire duct bank length, along all the structure's or duct bank's top and bottom corners. Provide additional intermediate #4 rebars

parallel to these and arranged such that 18 inches maximum spacing between horizontal rebars is maintained for the entire duct bank length. Also, duct banks shall have #4 rebar ties every 18 inches on center for the entire length of the duct bank; these placed across and perpendicular to the bank horizontal axis and encompassing the top, sides and bottom of the bank. Overlap the ends of the rebar ties.

2.05 MANHOLES AND HANDHOLES

A. Cable racks, supports, pulling-in-irons, manhole steps and hardware shall be hot dipped galvanized steel as manufactured by Line Materials Co. or equal.

B. Precast concrete manholes and handholes shall be heavy duty type, designed for a Class H20 wheel load. Precast manholes and handholes shall be as manufactured by Brooks Products Co.

C. Manhole frames and covers shall be cast iron heavy duty type for class H-20 wheel loading, and shall be as manufactured by Neenah, or equal. Manhole covers shall be marked Electrical Medium Voltage or Electric Low Voltage as applicable, in addition stamp the manhole covers with minimum 1-1/2 inch high letters and numbers for manhole identification. Provide gasketed covers with stainless steel non-standard bolt head configuration security bolts. Provide two (2) special 1/2 inch drive sockets to fit the security bolts supplied. Apply anti-siege compound to the security bolts prior to installation.

D. Handhole covers and frames shall be hot dipped galvanized and designed for a Class H-20 wheel load. Handhole covers and hatches shall have 316 stainless steel security bolts. Handhole covers shall be marked Electric Medium Voltage or Electric Low Voltage as applicable, in addition stamp the handhole covers with minimum 1-1/2 inch high letters and numbers for handhole identification. Provide gasketed covers with stainless steel non-standard bolt head configuration security bolts. Provide two (2) special 1/2 inch drive sockets to fit the security bolts supplied. Apply anti-siege compound to the security bolts prior to installation.

E. Manholes and Handholes shall be installed with features to permit passive drainage as detailed on the Drawings. In the absence of such detail, provide 3" PVC sleeve at low point of structure extending to a depth approximately 12" below the bottom surface of the structure. Provide a finely crushed and packed stone base below the structure to a total depth of approximately 24" to permit structure drainage. Provide drain cover.

F. Bell ends and plastic duct spacers shall be as manufactured by Carlon or equal.

PART 3 - EXECUTION

3.01 APPLICATION

A. Underground Ducts for Electrical Utility Service: Plastic conduit encased in concrete.

B. Underground Ducts for Electrical Feeders: Plastic conduit encased in concrete.

C. Underground Ducts for Telephone Utility Service: Plastic conduit encased in concrete.

D. Underground Ducts for Communication Circuits: Plastic conduit encased in concrete.

3.02 EXAMINATION

A. Examine site to receive ducts and manholes for compliance with installation tolerances and other conditions affecting performance of the underground ducts and manholes. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.03 EARTHWORK

A. Excavation and Backfill: Conform to Division 2 Section "Earthwork", but do not use heavy-duty, hydraulic-operated compaction equipment.

B. Restore surface features at areas disturbed by excavation, and reestablish original grades except as otherwise indicated. Replace removed sod as soon as possible after backfilling is completed. Restore all areas disturbed by trenching, storing or dirt, cable lay, and other work. Restore vegetation and include necessary topsoil, fertilizing, liming, seeding, sod, sprigging, or mulching.

C. Restore disturbed paving. Refer to "Cutting and Patching" in Division 1.

3.04 CONDUIT AND DUCT INSTALLATION

A. Install Non-metallic conduit and duct as indicated according to manufacturer's written instructions.

B. Slope: Pitch ducts minimum of 4 inches per 100 feet (1:300) to drain toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between 2 manholes to drain in both directions.

C. Curves and Bends: Use manufactured elbows for stub-ups at equipment and at building entrances. Use manufactured long sweep bends with a minimum radius of 25 feet (7.5 m) both horizontally and vertically at other location.

D. Make joints in ducts and fittings watertight according to manufacturer's instructions. Stagger couplings so those of adjacent ducts do not lie in the same plane.

E. Building Entrances: Transition from underground duct to conduit 10 feet (3 m) minimum outside the building wall. Use fittings manufactured for the purpose. Follow appropriate installation instructions below:

1. Concrete-Encased Ducts: Install reinforcing in duct banks. Coordinate duct bank with structural design to support duct bank at wall without reducing structural or watertight integrity of building wall.
2. Waterproofed Wall and Floor Entrances: Install a watertight entrance-sealing device with the sealing gland assembly on the inside. Anchor device into masonry construction with 1 or more integral flanges. Secure membrane waterproofing to the device to make permanently watertight.

F. Concrete-Encased Nonmetallic Ducts: Support on plastic separators coordinated with duct size and require duct spacing, and install according to the following:

1. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, and secure separators to the earth and to ducts to prevent floating during concreting.

Do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.

2. Concreting: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not use power-driven agitating equipment unless specifically designed for duct bank application. Pour each run of envelope between manholes or other terminations in 1 continuous operation. When more than one pour is necessary, terminate each pour in a vertical plane and install 3/4 inch (18mm) reinforcing rod dowels extending 18 inches (450 mm) into the concrete on both sides of joint near the corners of the envelope.

3. Reinforcing: Reinforce duct banks as specified.

4. Forms: Use the walls of the trench to form the side walls of the duct bank where the soil is self-supporting and concrete envelope can be poured without soil inclusions, otherwise, use

5. Minimum Clearances Between Ducts: 3 inches (75 mm) between ducts and exterior envelope wall, 2 inches (50 mm) between ducts for like services, and 4 inches (100mm) between power and signal ducts.

6. Depth: Except as otherwise indicated, install top of duct bank at least 24 inches (600 mm) below finished grade in general areas and at least 30 inches (750 mm) below finished grade in vehicular traffic areas.

7. Install identification marker tape in accordance with section 16195.

G. Stub-Ups: Use rigid steel conduit for stub-ups to equipment. For equipment mounted on outdoor concrete pads, extend steel conduit a minimum of 5 feet (1.5 m) from edge of pad. Install insulated grounding bushings on the terminations. Couple steel conduits to the ducts with adapters designed for the purpose and then encase coupling with 3 inches (75 mm) of concrete.

H. Sealing: Provide temporary closure at terminations of ducts that are wired under this Project. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15 psi (103 Kpa) hydrostatic pressure.

I. Pulling Cord: Install 100 pound test nylon cord in ducts, including spares.

3.05 MANHOLE AND HANDHOLE INSTALLATION

A. Raceway terminations at manholes shall be with end bells for PVC conduit and insulated throat grounding bushings with lay-in type lugs for metal conduit.

B. Install pulling-in irons opposite all raceway entrances to manholes and in the center of the manhole floor. Pulling irons shall be cast into the walls and floor. Bolt on style pulling irons are not acceptable.

C. Cables shall be completely looped within manholes and handholes. Cables shall be trained in manholes and supported on racks and hooks at intervals not greater than 3 feet-0 inches and supports shall be installed on each side of all splices. Furnish cast in place inserts on all manhole walls for mounting future racks as well as racks required for present installation. Branch circuit conductors shall not be run in manholes. Bolt and anchor surface installation is not acceptable.

D. All joints shall be made so as to prevent the passage of concrete inside the conduit to form obstructions or cause cable abrasions.

E. Manhole covers in streets shall finish flush with finished paving and in other areas shall finish 3 inches above crown of adjacent roadway. Floor elevations of manholes shall be so set that the center line of the lowest conduit entering will be not less than 1 foot above the floor and center line of the highest conduit entering will be not less than 1 foot below the roof slab.

F. A 3/4 inch by 10 foot copper clad ground rod shall be driven in the bottom of each manhole. All bond wires, galvanized conduits and metal cable racks shall be bonded to the ground rod.

G. Polyethylene warning tape shall be provided for all underground raceways, duct banks, etc. Tape shall be placed along the raceways entire length and shall be installed 18" above the raceways on compacted backfill material, unless noted otherwise.

H. Raceways installed in the multiple run duct banks shall be installed so that the coupling if adjacent raceways are not in one shear plane.

I. Install a bare copper cable in the concrete encased duct bank. Size shall be as shown on the Drawings. In the absence of cable size being shown on the Drawings, it shall be #1/0. It shall be continuous from one end to the other for the entire length of the ductwork and shall be bonded to building steel on each end and to all manhole-handhole ground loops and associated manhole-handhole ground rods.

J. Install expansion deflection fittings as required by the NEC and duct bank raceway manufacturer.

3.06 FIELD QUALITY CONTROL

A. Testing: Demonstrate capability and compliance with requirements upon completion of installation of underground duct and utility structures.

1. Grounding: Test manhole grounding to ensure electrical continuity of bonding and grounding connections. Measure ground resistance at each ground rod and report results. Use an instrument specifically designed for ground-resistance measurements.
2. Duct Integrity: Rod ducts with a mandrel ¼ inch (6 mm) smaller in diameter than internal diameter of ducts. Where rod indicates obstructions in ducts, remove the obstructions and retest.

B. Correct installations where possible, and retest to demonstrate compliance. Otherwise, remove and replace defective products and retest.

3.07 CLEANING

A. Pull brush through full length of ducts. Use round bristle brush with a diameter 1/2 inch (12.5 mm) greater than internal diameter or duct.

B. Clean internal surfaces of manholes including sump. Remove foreign material.

END OF SECTION 16119

SECTION 16120
WIRE AND CABLE

PART 1 - GENERAL

1.01 SCOPE

A. Work described in this Section includes furnishing all labor, materials, equipment, tools and incidentals required for a complete and operable installation of building wire, cable and wiring connections and terminations. All wire and cable shall be installed, adjusted, tested and placed in operation in accordance with these Specifications, the manufacturer's recommendations and as shown on the Drawings.

B. Minimum size for all power and lighting wiring shall be #12 AWG. Minimum size for control and alarm wiring shall be #14 AWG.

C. All wire shall be soft drawn copper conforming to ASTM Standard B-3. All wire shall be single conductor type unless otherwise indicated. All wire shall be stranded in accordance with ASTM Standard B-8.

1.02 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions of the Contract Documents. In addition, the following specific information shall be provided:

1. Product data.
2. Maximum pulling tension and recommended lubricant for 15kv cables, provide calculations. Pulling tension during installation shall be measured and documented.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Power/Control Conductors: Equal to: Cablec; Collier; Okonite; Pirelli; Southwire; Triangle.

B. Instrumentation Conductors: Equal to: Belden; Dekoron; Penn.

C. Low Voltage Connectors: Equal to: Burndy; Thomas & Betts; Ideal; OZ.

D. Pulling Compounds: Equal to: Ideal Yellow 77; Electro Y-ER-EAS; Minerallac 100; Burndy Slikon.

E. Or equal.

2.02 SINGLE CONDUCTOR 600 VOLT CABLE

A. Power distribution feeder and power/control circuit conductors in sizes 250 KCM and larger or any conductors installed in underground conduit shall be insulated with ethylene propylene rubber and jacketed with Hypalon. The cable shall be rated for 600 volts and 90 degree centigrade conductor temperature in dry or wet locations.

B. Power, lighting, receptacle and other branch circuit conductors in sizes smaller than 250 KCM and installed in dry, interior locations and insulated equipment grounding conductors shall be moisture and heat resistant, thermosetting, crosslink polyethylene type XHHW-2. The cable shall be rated for 600 volts and 90 degree centigrade conductor temperature in dry or wet locations.

2.03 MULTICONDUCTOR TRAY CABLE

A. Multiconductor tray cable shall be stranded coated or uncoated copper conductors with color-coded flame retardant, crosslinked polyethylene insulation. Three (3) or more conductors shall be twisted with suitable nonhydroscopic fillers where necessary to make a round cable. Each cable shall have a heavy duty Hypalon protective jacket applied over the assembly. The cables shall be rated for 90°C conductor temperature in wet or dry locations. Cables shall meet the requirements of ICEA Pub. No. S-66-524, NEMA Pub. No. WC7, ICEA S-19-81 Para. 6.19.6 UL VW-1 and shall be suitable for cable tray installation.

B. Multiconductor tray cable shall be equal to type FR-XLP as manufactured by Rome Cable Corporation.

2.04 INSTRUMENTATION CABLE

A. Electronic transmission shall be via stranded, shielded, twisted conductors of not less than 18 AWG conductor wire. All termination points shall have terminal lugs. Instruments and panels shall be grounded to the nearest plant equipment ground. Shielded cable shall have the shield grounded at one point for each loop; preferably at the point of origin. Signal wires shall not be run in conduit containing wire used for any other purpose.

B. The 4-20 mA, signal cable shall be minimum 18 gauge twisted shielded single pair tinned copper stranded conductors with teflon insulation. The pair shall have a minimum lay of 2 inches per twist. The shield shall be aluminum polyester with a 20 AWG stranded tinned copper drain wire and an overall teflon jacket rated at 300 volts. Color code shall be red and black. Cable shall be suitable for plenum, conduit and submerged service. Cable shall be equal to Belden No. 88760.

PART 3 - EXECUTION

3.01 GENERAL WIRING METHODS

A. Use only stranded conductors.

B. Use 10 AWG conductor for 20 ampere, 120 volt branch circuit home runs longer than 75 feet, and for 20 ampere, 277 volt branch circuit home runs longer than 200 feet.

C. Place an equal number of conductors for each phase of a circuit in same raceway or cable.

D. Identification: All conductors shall be identified throughout the electrical system. For control and signal conductors use wire markers at all terminals and connections. Color code power circuit conductors as follows:

	120/208/240 Volt Systems	277/480 Volt System
Phase A	Black	Brown
Phase B	Red	Orange
Phase C	Blue	Yellow
Neutral	White	Grey
Ground	Green	Green

E. For conductors #8 AWG and larger color coding may be accomplished with 1-inch wide colored tape applied at each end of the conductor or at points where conductor is accessible so as to be visible inside the enclosure.

F. Neatly train and lace wiring inside boxes, equipment, and panelboards. Support to prevent conductor movement under fault conditions.

3.02 WIRING INSTALLATION IN RACEWAYS

A. Unless otherwise indicated, install all conductors in conduit.

B. Pull all conductors into a raceway at the same time. Thoroughly swab raceway system before installing conductors. Use wire pulling lubricate for all pulls. Do not exceed the manufacturers pulling tension.

C. Install wire in raceway after interior of building has been physically protected from the weather and all mechanical work likely to injure conductors has been completed.

D. Empty conduits shall contain a nylon rope with a minimum test strength of 200 pounds, coil 2 feet of rope at each end in panels or pullboxes.

E. Pulling in conduit - Do not install conductors until conduit system is completed. Inside of conduit shall be dry and clean. Use care in pulling wire to avoid damage. Use approved compounds. Do not pull thermoplastic wire at temperatures below 35°F.

F. Pulling in duct banks - Rod all individual conduits mechanically and install a pull line. A wire brush with diameter 1/2" greater than conduit bore diameter shall be drawn through each conduit. If all obstructions cannot be removed by this method, advise Engineer. Leave nylon pull line in each blank conduit.

3.03 WIRING CONNECTIONS AND TERMINATIONS

A. Avoid unnecessary splices. Splice only in accessible junction or outlet boxes.

B. Make connections to circuit breakers, disconnect switches, panel mains, etc. with solderless lugs.

C. Use mechanical connectors for low voltage splices, taps, fixture and motor connections.

D. Use insulated throat, spade type crimp on connectors for strap screw device terminals.

E. Where possible use connectors with integral, insulating covers. Otherwise tape uninsulated conductors and connectors to 150 percent of the insulation value of conductor.

F. Thoroughly clean wires before installing lugs and connectors.

G. Make splices, taps and terminations to carry full ampacity of conductors without perceptible temperature rise.

H. Taps and Lug Connections - Branch taps from mains shall be made with case copper alloy solderless connectors in a phenolic insulating case with at least 2 spring clip fasteners; Equal to: OZ type "PT", "PM" or "T", Burndy Insulated Service. Lug connections in switches and panelboards, etc., shall use 2 bolt or indent compression attachment cast copper clamps.

I. Splices - All splices shall be accessible and covered using pre-molded encasements such as Scotchlok spring type, Ideal wire nuts, or equal. Splices in manholes or underground boxes shall be watertight and made only by workmen experienced in such work. Splices may be made using mechanical connectors and wrapped using plastic tape equal to Scotch #33, Slipknow plastic tape

J. Terminations - All terminations shall be made to approved terminals and terminal blocks suitable for use with the type wire being used. Stranded control wire terminations shall be compression, self-insulated, spade type.

3.04 INSTALLATION OF CABLE OVER 600 VOLTS

A. The maximum allowable tension to be placed on cable during the installation procedure shall not exceed manufacturer's recommendations.

B. An approved pulling compound such as 1/16" layer of Albantonite shall be applied to the cables as they enter the conduit.

C. After the cable has been installed the contractor shall perform, and supply, 3 copies of test reports of a cable hi-pot acceptance test. Each cable shall be tested separately. A certified report of this test is required as is presence of the Engineer.

D. All new cables shall be tested for phase sequence and shall be permanently tagged with approved brass tags in each manhole. Tags shall show feeder designation and phase. After testing, all new cables shall be fire-proofed in every manhole.

E. All new connections, splicing and tapping in manholes shall be done using disconnectible type Elastimold taps and connectors.

F. New racks and insulators shall be provided in all existing manholes wherever existing cables are being replaced. All new racks shall be stainless steel.

G. All new cables in manholes shall be fire-proofed with an approved fireproofing tape. Cables shall be taped with minimum 50% overlap so that at any cross section of the cable there are at least (2) layers of the fireproofing tape.

H. Provide protective (lead) blankets for cover of existing energized feeders that may be present during the construction period.

3.05 FIELD QUALITY CONTROL

A. Inspect wire and cable for physical damage and proper connection.

B. Torque test conductor connections and terminations to manufacturer's recommended values.

C. Continuity Tests: Ring all conductors for continuity and replace any open conductors.

D. Low Voltage Ground Fault Tests: Meggar all feeder circuits for grounds. Compile and submit a list of meggar readings. Replace all conductors measuring less than 2 megohms to ground.

END OF SECTION 16120

SECTION 16130
BOXES

PART 1 - GENERAL

1.01 SCOPE

A. Work described in this Section includes furnishing all labor, materials, equipment, tools and incidentals required for a complete and operable installation of outlet, pull and junction boxes. All boxes shall be installed, adjusted, tested and placed in operation in accordance with these Specifications, the manufacturer's recommendations and as shown on the Drawings.

B. All junction boxes, outlet boxes and pull boxes shall be accessible, either located in accessible spaces such as push up ceiling spaces, behind access panels, or with covers flush with finished surfaces. Where access panels are used, coordinate location with general construction trade. Do not locate covers of junction or pull boxes in finished rooms without review by the Engineer or unless otherwise indicated.

C. Provide a junction box, pull box or pull fitting at no more than 400 foot intervals in all conduit runs regardless of number of bends, and after every three successive 90° bends whether indicated on the Contract Drawings or not.

D. All junction boxes shall include an internal mounting backplate and numbered terminal strip(s) for splicing and/or tapping of conductors. Splicing of conductors in pull boxes is not allowed. Conductors shall be neatly harnessed and adequately supported to the backplate. Numbering and identification of terminals and conductors shall reveal the function of the conductors and shall follow the standard system established for the project. The Contractor shall provide a typewritten schedule identifying the conductor and terminal strip numbers.

E. Boxes and fittings shall be sized in accordance with NFPA 70, NEC, Article 370.

1.02 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions of the Contract Documents.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Boxes: Equal to: Appleton, Crouse Hinds, Raco, Steel City, Thomas & Betts.

2.02 OUTLET BOXES

A. Sheet Metal Outlet Boxes: NEMA OS-1; galvanized steel, with ½-inch male fixture studs where required.

B. Cast Boxes: Cast feralloy with galvanized or corro-free epoxy finish, deep type, gasketed cover, threaded hubs.

2.03 PULLBOXES, TERMINAL AND JUNCTION BOXES

A. Sheet Metal Boxes: NEMA OS-1; galvanized steel. Boxes larger than 12-inches in any dimension shall be hinged.

B. Cast Metal Boxes: NEMA 250; Type 4, galvanized cast iron box and cover, neoprene gasket, stainless steel cover screws, UL listed as raintight. Provide flat-flanged type for surface mounting and outside flange recessed cover type for underground use. Boxes for sidewalk or other traffic areas to have appropriate duty cover with non-skid finish.

C. Corrosion Resistant (NEMA 4X) Boxes: Stainless steel with gasketed screw cover. For boxes larger than 12-inches in any dimension provide hinge on one (1) side and trunk latches on the other three (3) sides. Corrosion resistant boxes may be non-metallic (polyvinyl chloride (PVC) or fiberglass reinforced polyester (FRP) where indicated on the drawings.

D. PVC coated rigid steel boxes: Galvanized rigid steel with factory applied external 40 mil PVC coating and urethane interior coating.

E. Terminal blocks strips for terminal boxes shall be as specified in this Division.

2.04 HAZARDOUS AREAS - OUTLET, PULLBOXES, TERMINAL AND JUNCTION BOXES

A. Boxes in hazardous areas shall be cast iron with galvanized or corrofree epoxy finish, threaded hubs and cover, and shall comply with UL 886, ANSI C 33.27 and with NEC Class I, Div. I, Group D hazardous locations.

B. Terminal block strips for terminal boxes shall be as specified in this Division.

PART 3 - EXECUTION

3.01 COORDINATION OF BOX LOCATIONS

A. Provide boxes as shown on Drawings, and as required for splices, taps, wire pulling, and equipment connections.

B. Box locations shown on the Drawings are approximate unless dimensioned. Verify box locations prior to rough-in. Locate outlet boxes to permit handicap access per ANSI A117.1. Any outlet may be relocated by up to 10 feet before it is permanently installed without incurring additional cost.

3.02 INSTALLATION

A. Support boxes independently of conduit.

B. Boxes and all other wall mounted devices shall be solidly attached to structural members prior to installation of conduit. These devices shall be set true and plumb and installed with the use of stainless steel anchors and bolts. Wooden plugs are not permitted for securing equipment or conduit to concrete. All hardware items installed shall be stainless steel.

C. Conduit attachment to all electrical boxes and equipment shall be via threaded hubs in all areas. Double steel locknuts may be utilized in dry NEMA Type 1 or 12. Insulated-throat grounding

bushings shall be used on the end of each conduit termination. Grounding bushings shall be bonded to a ground bus or lug within the enclosure.

D. Fittings and boxes shall be provided with breather and drain fittings where indicated on the Contract Drawings or where required to facilitate draining.

E. Use multiple-gang boxes where more than one (1) device is mounted together; do not use sectional boxes. Provide barriers to separate wiring of different voltage systems.

F. Align wall-mounted outlet boxes for switches, thermostats, and similar devices. Align adjacent devices at different elevations in one (1) vertical line. Set floor boxes level and flush with finish flooring material.

G. Provide cast outlet boxes in exposed, exterior, hazardous and wet locations.

H. Use PVC coated rigid steel boxes wherever PVC coated rigid steel conduit is indicated.

I. Box covers shall be of the same material and construction as the box.

END OF SECTION 16130

SECTION 16141
WIRING DEVICES

PART 1 - GENERAL

1.01 SCOPE

A. Work described in this Section includes furnishing all labor, materials, equipment, tools and incidentals required for a complete and operable installation of wall switches, receptacles, device plates and box covers. All equipment shall be installed, adjusted, tested and placed in operation in accordance with these Specifications, the manufacturer's recommendations and as shown on the Drawings.

B. Contract drawings show only functional features and some of the required external connections. They do not show all components required for a complete installation nor exact dimensions particular to any manufacturer's equipment. Contractor shall supply all parts, devices and equipment necessary to meet the requirements of the Contract Documents and shall make all dimensional adjustments particular to the equipment being furnished. All costs associated with such changes and adjustments shall be considered as being included in the price bid for the work shown and specified.

1.02 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions of the Contract Documents. In addition, the following specific information shall be provided:

1. Catalog cuts.

1.03 QUALITY STANDARDS

A. All products covered by these specifications shall be in conformance with NEMA standards and shall be UL approved.

B. Manufacturers include equal to:

1. Arrow Hart.
2. Bryant.
3. GE.
4. Hubbell.
5. Leviton Specmaster.
6. Pass and Seymour.
7. Sierra.
8. Crouse Hinds.
9. Appleton.

1.04 WARRANTY

A. Provide a warranty against defective equipment and workmanship in accordance with the requirements of the General Conditions of the Contract Documents.

PART 2 - PRODUCTS

2.01 SWITCHES

A. General Purpose: NEMA WD-1; FS W-S-896; 20 amp, 120/277 volt, specification grade; horsepower rated; quiet type; back and side wiring provisions; toggle handle.

B. Hazardous Areas: Switches shall consist of a factory assembled and sealed combination general purpose switch in an explosion proof housing. The external operating mechanism shall consist of a wing-type handle having the on-off positions visible from front. The switch shall be rated in accordance with NEC for the area.

C. Corrosive and Outdoor Areas: Switches shall be 20 Amp pressure switch type with weatherproof/corrosion resistant neoprene plate. Switches shall be mounted in "FD" type copper-free aluminum or PVC mounting boxes.

D. Device Colors: Brown or black for specific use devices, otherwise as selected by the Engineer.

2.02 RECEPTACLES

A. General Purpose: Receptacles shall be NEMA WD-1; FS W-C-596, 20 AMP, 125 Volt, specification grade; impact resistant nylon face; back and side wiring provision; grounding screws; duplex.

B. Hazardous Areas: Receptacles shall be rated in accordance with NEC for the area and shall be factory sealed. Receptacle shall be designed so the plug must be inserted and turned before load is energized. Provide mounting box, sealing chamber and compatible plug.

C. Corrosive Areas: Receptacles shall be duplex; 20 Amp, NEMA 5-20R. Receptacle and plug shall be corrosion resistance; marine duty; polycarbonate with weatherproof lift cover.

D. Ground Fault Interrupter (GFI) Receptacles: Provide duplex specification grade GFI receptacles tripping at 5 milliamps; rated 20 amps, 120 volts, NEMA Configuration 5-20R. Use units meeting NEMA WD 1, fitting standard sized outlet boxes having provision for testing, and ivory in color. Use standard model where ground fault protection is needed. Do not use feed-thru model. Acceptable manufacturers: Equal to: Square D, General Electric.

E. Specific Use Receptacles: NEMA WD-1 or WD-5; type as indicated. For branch circuits serving a single device, match device rating to branch circuit rating.

F. Plug Caps: Male plug caps for receptacles shall be of the cord grip armored type with heavy phenolic housing of the same manufacturer as the receptacle.

G. Three Phase Receptacles and Plugs: Receptacles shall be suitable for 480V, 3 phase, 4 wire service with ampere rating as specified. The grounding pole shall be permanently connected to the housing. The grounding pole shall make contact before the line poles are engaged when the

plug is connected to the receptacle housing. The plug sleeve shall also make contact with the receptacle housing before the line and load poles make contact. Receptacles shall be provided complete with cast back box, angle adapter, gaskets, a gasketed screw-type, weathertight cap with chain fastener and one plug.

2.03 WALL PLATES

A. Damp Area Cover Plates: Unbreakable nylon, Lexan, or noryl, smooth finish, color to match devices.

B. Dry Area Device Plates: Type 302 stainless steel, 0.030 inch thick minimum, satin finish.

C. Weatherproof Cover Plate: Gasketed cast metal with hinged, gasketed, spring loaded device covers.

D. Lockable Cover Plate: Equipment local disconnect (power or control circuits) with padlockable, NEMA rated for the location, equal to Appleton FSK-IVS, Carlon E98TSL or Arrow Hart 7949.

2.04 PLUG STRIP

A. Plug strip shall be manufactured of sheet steel with the receptacles mounted on front cover. The front cover shall be removable.

B. Disconnect Switches:

1. The switches shall have switchblades, which are fully visible in the "OFF" position when the switch door is open. All current carrying parts shall be plated to resist corrosion and promote cool operation. Switches shall have removable arc suppressors where necessary to permit easy access to line side lugs. Lugs shall be front removable and UL listed for 60°C or 75°C copper wires.

2. The switches shall be quick-make, quick-break such that, during normal operation of the switch, the operation of the contacts shall not be capable of being restrained by the operating handle after the closing or opening action of the contacts has started. The operating handle shall be an integral part of the box, not the cover. Provisions for padlocking the switch in the "OFF" position with at least three locks shall be provided. Switches shall have a dual cover interlock to prevent unauthorized opening of the switch door when the handle is in the "ON" position, and to prevent closing of the switch mechanism with the door open. The handle position shall indicate whether the switch is "ON" or "OFF".

3. The switches shall be furnished in a NEMA rated enclosure as indicated on the Drawings and/or as required for the specific application and approved by the Engineer.

4. The discónnect switches shall be 600 volt, ampere and horsepower rated, fusible or non-fusible, 3 pole, heavy duty front-operated safety switch with ground lug, and auxiliary electrical contacts, Equal to: Square D, Class 3110, General Electric or Siemens.

5. Ratings shall be as shown on the Contract Drawings.

2.05 ENCLOSED CIRCUIT BREAKERS

A. The breakers shall be thermal-magnetic, molded case circuit breakers with instantaneous pick up adjustment. The circuit breakers shall be UL and CSA listed, IEC 157-1 rated, meet NEMA Standard AB1-1975 and Federal Specification W-C-375B/GEN.

B. The circuit breakers shall have overcenter toggle-type mechanisms, providing quick-make, quick-break action and shall be calibrated for operation in an ambient temperature of 40oC. The circuit breakers shall have trip indication by handle position and shall be trip-free. The circuit breakers shall have a permanent trip unit containing individual thermal and magnetic trip elements in each pole. A push-to-trip button shall be provided on the cover for mechanically tripping the circuit breaker. The circuit breakers shall have reverse connection capability and be suitable for mounting and operating in any position.

C. Lugs shall be UL listed for copper conductors and installation of compression type lugs.

D. NEMA type enclosures shall be furnished fabricated from sheet steel, which conforms to UL 50. The enclosure shall be given an electrodeposited, baked enamel finish. Color shall be selected by the Engineer at the time of shop drawing submittal. Padlocking provisions shall be provided to allow locking the circuit breaker in the "OFF" position. The enclosure and breaker assembly shall be UL listed and service entrance rated as required.

E. Ratings shall be as indicated on the Contract Drawings.

2.06 MANUAL MOTOR STARTERS

A. Manual starters shall be furnished and installed as specified herein, as shown on the Contract Drawings and as required to properly control and protect the motor controller. Motor controllers shall be of the manual type with thermal overload.

B. Manual starters shall be ampere and horsepower rated and shall be either one pole at 115 VAC or 2/3 pole at 230/460 VAC as required or as otherwise acceptable to the Engineer.

C. Provide pilot lights where required and heater elements of rating based on motor nameplate data.

D. Each starter shall be equipped with either a pushbutton or toggle operator and a reset device accessible without opening the enclosure.

E. The starters shall be furnished in a lockable NEMA rated enclosure as indicated on the Drawings and/or as required for the specific application and approved by the Engineer. Provide appropriate wall plate(s) for flush mounted application(s).

F. The manual starters shall be equal to Square D, Class 2510, General Electric or Siemens.

2.07 MAGNETIC MOTOR STARTERS

A. Magnetic starters shall be of the combination circuit breaker type except as shown on the Contract Drawings and in accordance with the following for 600V and below applications.

B. Unless otherwise indicated, the Contractor shall provide non-reversing, full voltage, across-the-line mechanisms, closed by coil action, an opened by gravity. Starters shall be equipped with 120V coils and self-contained control transformer for 480-volt circuits unless otherwise indicated.

C. Each combination starter shall use a thermal-magnetic type molded case circuit breaker as the unit disconnect. Instantaneous trip, magnetic only motor circuit protector type breakers may be utilized as approved by the Engineer. All breakers shall have a short circuit interrupting capacity of 65,000 amps RMS at 480 VAC or as indicated otherwise on the Contract Drawings. All starters shall use NEMA rated contactors (NEMA size 1 minimum).

D. The overload relays shall be solid-state type and provide proper protection for T-frame and U-Frame motors and shall meet NEMA Class 10 tripping characteristics. Overload relays shall be NEMA Class 20 or 30 where indicated or directed by the Engineer. The overload relays shall trip within the NEMA defined timing range under locked rotor condition and shall be designed to provide phase failure, phase unbalance and ground fault protection. They shall be ambient compensated and shall include an isolated Form-C contacts. Overload trip indication shall be provided. The relays shall be factory inspected and calibrated so that a minimum acceptance accuracy level of + 5% is maintained. The relays shall have a field adjustable tripping current range of approximately 3 to 1.

E. When provided, control circuit transformers shall include two primary fuses and one secondary fuse (in the non-grounded secondary conductor). The transformer shall be sized to accommodate the contactor(s) and all connected control circuit loads plus 20% spare burden capacity.

F. When a unit control circuit transformer is not provided, the disconnect will include an electrical interlock for disconnection of externally powered control circuits.

G. Auxiliary control circuit interlocks shall be provided where indicated. Auxiliary interlocks shall be field-convertible to normally open or normally closed operation.

H. The starters shall be furnished in a lockable NEMA rated enclosure as indicated on the Drawings and/or as required for the specific application and approved by the Engineer.

I. The magnetic motor starters shall be equal to Square D, or Cutler-Hammer.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Secure devices to outlet boxes without depending on device plates to pull them tight. Install a bonding jumper between all devices and outlet boxes.

B. Install switches with off position down; and receptacles with grounding pole on bottom.

C. For cord and plug connected equipment, coordinate receptacle configuration with equipment supplied.

D. Install device plates on switch, receptacle, and blank outlets. Use jumbo size plates for devices installed in masonry walls.

E. Mounting heights from the finished floor to the centerline of the various boxes and equipment shall be as follows except as otherwise indicated on the Contract Drawings.

END OF SECTION 16141

SECTION 16150
ELECTRIC MOTORS

PART 1 - GENERAL

1.01 SCOPE

A. Work described in this Section includes furnishing all labor, materials, equipment, tools and incidentals required for a complete and operable installation of all electric motors. All electric motors shall be installed, adjusted, tested and placed in operation in accordance with these Specifications, the manufacturer's recommendations and as shown on the Drawings.

B. Contract drawings show only functional features and some of the required external connections. They do not show all components required for a complete installation nor exact dimensions particular to any manufacturer's equipment. Contractor shall supply all parts, devices and equipment necessary to meet the requirements of the Contract Documents and shall make all dimensional adjustments particular to the equipment being furnished. All costs associated with such changes and adjustments shall be considered as being included in the price bid for the Work shown and specified.

C. Related Work Specified Elsewhere:

1. All motor driven equipment sections except submersible motors and DC motors.

1.02 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions of the Contract Documents. In addition, the following specific information shall be provided:

1. Expected and guaranteed minimum efficiency values and power factor for operation at 100, 75, 50, 25 and 0 percent load.
2. Type of enclosure.
3. Overall dimensions and proposed size and location at terminal junction boxes.
4. Noise level guarantee.
5. Bearing life certificate.
6. Starting characteristics, including torque and lock rotor current.
7. Motor nameplate data.

1.03 QUALITY ASSURANCE

A. Reference Standards: Comply with all Federal and State laws or ordinances, as well as all applicable codes, standards, regulations and/or regulatory agency requirements including the partial listing below:

1. NEMA MG-1.
2. UL 674.
3. UL 1004.

B. Efficiency: High efficiency; guaranteed minimum values determined in accordance with IEEE Standard 112, Test Method B including stray load loss as follows; or as specified in other Divisions:

	------Synchronous RPM------			
HP	3600	1800	1200	900 & less
15 - 49	90%	91%	90%	88%
50 - 99	92	93%	92%	90%
100 & Above	94%	95%	94%	92%

NOTE: Provide the manufacturer's highest available design for motors less than 15 horsepower and for motors specified with special torque (NEMA design C or D) or duty cycle (intermittent operation).

1.04 QUALITY STANDARDS

A. Motors shall be designed, manufactured and tested in accordance with the latest revisions of the following standards:

1. NEMA Standards.
2. IEEE Standards.
3. ANSI Standards.
4. UL Standards.

B. Manufacturers offering products that comply with these Specifications include:

1. General Electric.
2. Reliance.
3. U. S. Motors.
4. Or equal.

1.05 PERFORMANCE

A. Motors shall be adequate for long periods of inactivity and the effects of an atmosphere that is made corrosive by traces of chemicals normally present in a wastewater treatment plant, and environmental conditions existing at the plant site such as high humidity, insects, plant life, fungus, rodents, etc. When motors are to be inactive in excess of 30 days, the Contractor shall maintain the bearings and rotate the shaft twice a month for the duration of the inactive period. The insulation of all drip-proof and weather-protected motors shall be specially designed for use in atmospheres containing moisture and corrosive fumes, which are normally encountered in wastewater treatment plants.

PART 2 - PRODUCTS

2.01 GENERAL

A. Unless otherwise indicated, provide materials and equipment which are the standard products of manufacturers regularly engaged in the production of such materials and equipment. Provide the

manufacturers' latest standard design that conforms to these Specifications, unless otherwise indicated:

B. Unless otherwise specified, all ac motors shall be squirrel cage induction type, rated for continuous duty at service conditions specified herein.

C. The connected load (maximum horsepower required) of each motor shall not exceed its nameplate horsepower rating (exclusive of service factor) under any anticipated operating condition. All motors shall have a service factor of 1.15.

D. Motors with synchronous speeds of 1,800 rpm or higher shall have full load current not exceeding the values in NEC Table 430-150. Motors with synchronous speeds of 1,200 rpm shall have full load current not exceeding 110 percent of the above values.

E. Motors shall be rated for a 40 degrees C ambient temperature unless specifically indicated otherwise.

F. Motors shall have a grounding terminal in the motor terminal junction box. The bolt which attaches the grounding lug to motor terminal junction box shall not be used for any other purpose (such as mounting the box to the motor).

G. Drip-proof and weather protected motors shall have 316 stainless steel screens over all openings.

H. Motors specified as totally enclosed and rated 5 horsepower or less may be either fan ventilated or nonventilated. Motors specified as totally enclosed and rated over 5 horsepower shall be fan ventilated.

2.02 MOTOR CONDUIT BOXES

A. Conduit boxes shall be NEMA 4 made of cast iron and shall be of adequate size to permit terminating leads. It shall be possible to rotate these boxes in steps of 90 degrees. Conduit box shall be of adequate size and shall have a sufficient number of correct size openings to accept all required conduits. (See Electrical Drawings for size and number of conduits).

B. Torque Classification: Motors shall match the torque requirements of the driven equipment.

2.03 MOTOR EFFICIENCY AND POWER FACTOR

A. Motors shall be NEMA Design B, of the energy efficient type unless otherwise noted. The motor guaranteed minimum efficiency at full load shall not be less than the values shown in Table 1, in 1.03 B. For exceptions see 2.06E.

B. The guaranteed minimum efficiency shall be submitted with the shop drawings. Any motor not meeting the minimum efficiency shall be rejected. If the motor is found in the field to be of a lower efficiency than specified, it shall be replaced with a new motor meeting these specification and efficiency requirements.

2.04 MOTORS OPERATED FROM ADJUSTABLE SPEED DRIVE CONTROLLERS

A. Provide motors with sufficient nameplate rated capacity to drive the specified equipment and to provide the specified margin between system capacity and connected load after any motor

derating required to allow for extra heating in the motor due to the harmonic content in the voltage supplied by the controller. The adjustable frequency drive system supplier shall be responsible for a properly sized and completely compatible drive system. For small PWM drives, motor insulation system shall be suitable for volts/per microsecond = 1,200 maximum. For large current source drives, motors shall be compatible with the drive.

2.05 RATING

A. Horsepower (HP): As noted. Where no value is noted, match the requirements of the driven equipment.

B. Phase:

1. Less than ½ HP: Single Phase.
2. ½ HP and Larger: Three-Phase.

C. Voltage:

1. Single Phase Motors: 115/230 volt, 1 phase, 60 Hz.
2. Three-Phase Motors: 460/230 volt, 3 phase, 60 Hz.

D. Speed, Revolutions Per Minute (RPM): As noted. Where no value is noted, match the requirements of the driven equipment.

E. Torque and Starting Current: Exceptions: Provide NEMA design C or D where required by the driven equipment. Unless specifically noted NEMA design A motors are not acceptable.

F. Insulation and Temperature Rise: Except as noted, Class F insulation with temperature rise, measured by resistance, corresponding to the insulation class in accordance with NEMA standards for operation in a 40 degree C ambient. Exception: For motors used with variable frequency drives provide Class F insulation with temperature rise in accordance with Class B limits.

2.06 CONSTRUCTION

A. Enclosure: Totally enclosed fan cooled (TEFC) cast iron frame with stainless steel drain/breather unless otherwise noted.

B. Windings: Copper.

C. Starting: As noted.

D. Multispeed motors: Two winding type unless otherwise noted.

2.07 ACCESSORIES

A. Provide lifting eyes for 182 and larger frame size.

B. Where noted provide normally closed thermostat for winding protection.

C. Where noted provide 120 volt, single phase space heater. Size heater to increase motor temperature approximately 10 degrees C above ambient. Provide power and motor space heaters for all pumps located in damp, wet, or outdoor locations, including but not limited to all submersible pumps located in the diversion pump station and the jet mixing pump station.

D. Provide six 100-ohm platinum RTDs (2 per phase) with the stator windings wired to a separate terminal box for 575 volt motors used with VFDs. Provide a temperature switch in the stator winding for 460 V motors to be used with VFDs or wherever specified in the equipment specifications.

E. Nameplate: Permanently affixed and stamped so as to permit recovery of the nameplate data in the event the nameplate is painted over.

2.08 SEVERE DUTY MOTORS

A. Motor types designated as severe duty shall have the following minimum features as defined by NEMA:

1. Totally enclosed, mill and chemical duty.
2. Cast iron frames and end shields.
3. Stainless steel hardware, drains, breathers and nameplates.
4. Capillary type drains/breathers.
5. Nonsparking, corrosion-resistant fans.
6. Gasketed conduit boxes.
7. Nonhygroscopic epoxy varnish sealed windings.
8. Extra dips and bakes of insulating varnish for moisture protection of windings.

2.09 SEVERE DUTY SUBMERSIBLE MOTORS

A. Motor type designated as severe duty submersible motor shall have the following features:

1. Shell type design housed in an air-filled or oil-filled water tight chamber.
2. UL listed for explosion-proof motors, in accordance with UL 674 for Class I, Group D hazardous atmosphere.

2.10 INVERTER DUTY MOTOR

A. Motors connected to variable frequency drives shall be "Inverter Duty Motor"

2.11 MOTOR TYPES

A. Motor types indicated in the detailed equipment specifications are defined as follows:

1. Type 1: Horizontal, single speed, protected standard duty motor.

Bearing Life	50,000 hours, ABMFA B-10

2. Type 2: Horizontal, single speed, severe duty motor. The motor shall have:

Bearing Lubrication	Grease, positive lubrication system.
Bearing Life	50,000 hours, ABMFA B-10

3. Type 3: Vertical, solid shaft, single speed, severe duty motor. The motor shall have or be suitable for:

Frames and Endshields	Cast iron, NEMA Style P-Base
Motor Modifications	
Bearing Life	25,000 hours

4. Type 4: Horizontal, single speed, severe duty submersible motor. The motor shall have:

Bearing Lubrication	Grease, positive lubrication system.
Factory pre-wired, with thermal detector and moisture detector	
Bearing Life	25,000 hours

5. Type 5: Horizontal, single speed, explosion proof motor for Class I, Group D Hazardous Atmosphere. The motor shall have:

Motor Modifications	Breather/drain device Frame temperature thermostat, normally closed contact

PART 3 - EXECUTION

3.01 GENERAL

A. All motors shall be designed, manufactured, and tested in accordance with the latest edition of NEMA MG 1. All motors shall be able to start, accelerate, and drive the design load of the driven equipment without exceeding any of the specified design requirements.

B. Finish shall be manufacturer's standard gray or ANSI 61 gray over a primer and rust inhibitor, unless detailed under motor types and in accordance with 09900 Section, Painting.

3.02 INSTALLATION

A. Verify clearances and alignment prior to operation.

B. Lubricate in accordance with the manufacturer's instructions.

C. Check rotation and correct as necessary.

END OF SECTION 16150

SECTION 16160
CABINETS AND ENCLOSURES

PART 1 - GENERAL

1.01 SCOPE

A. Work described in this Section includes furnishing all labor, materials, equipment, tools and incidentals required for a complete and operable installation of hinged cover enclosures, cabinets, terminal blocks and accessories. All equipment shall be installed, adjusted, tested and placed in operation in accordance with these Specifications, the manufacturer's recommendations and as shown on the Drawings.

B. Contract drawings show only functional features and some of the required external connections. They do not show all components required for a complete installation nor exact dimensions particular to any manufacturer's equipment. Contractor shall supply all parts, devices and equipment necessary to meet the requirements of the Contract Documents and shall make all dimensional adjustments particular to the equipment being furnished. All costs associated with such changes and adjustments shall be considered as being included in the price bid for the work shown and specified.

1.02 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions of the Contract Documents. In addition, the following specific information shall be provided:

1. Product data.
2. Drawings for equipment panels including schematic diagram, wiring diagram, outline drawing and construction diagram as described in NEMA ICS-1.

1.03 QUALITY STANDARDS

A. All products covered by these specifications shall be in conformance with the NEMA standards and shall be UL approved.

B. Manufacturers offering products that comply with these specifications include:

1. Crouse-Hinds.
2. Appleton.
3. Hoffman.
4. Weigmann.
5. Or equal.

PART 2 - PRODUCTS

2.01 GENERAL

A. Enclosure type shall be as follows:

1. Indoors, dry location: NEMA 12.
2. Outdoors and corrosive areas: NEMA 4X.
3. Hazardous areas: NEMA 7.

2.02 HINGED COVER ENCLOSURES

A. Construction: Comply with NEMA 250; 12 gauge steel, no knockouts, wall mounted or free standing as indicated. Free standing enclosures are minimum 20-inches deep. Unless otherwise noted, enclosures shall be as required in 16000-2.01.

B. Finish: Baked on enamel over a rust inhibitor for NEMA 1.

C. Covers: Continuous hinge, held closed by hasp and staple for padlock. Furnish three-point latch for free standing enclosures.

D. Panel for Mounting Terminal Blocks or Electrical Components: 14 gauge steel, white enamel finish interior.

2.03 CABINETS

A. Cabinet Boxes: Code gauge galvanized steel.

B. Cabinet Fronts: Steel, surface type with concealed trim clamps, concealed hinge and flush lock keyed to match branch circuit panelboard; finish in gray baked enamel.

2.04 TERMINAL BLOCKS AND ACCESSORIES

A. Terminal Blocks: NEMA ICS-4; UL listed.

B. Power Terminals: One-piece phenolic closed-back type, with binding screw or stud terminal connectors, rated 600 volts, 30 amperes.

C. Signal and Control Terminals: Modular construction type, channel mounted with marking strip; screw terminals, rated 600 volts.

2.05 FABRICATION

A. Shop assemble enclosures and cabinets housing terminal blocks or electrical components in accordance with NEMA ICS-6.

B. Selectors and Indicators: Door mounted for indoor enclosures. For outdoor enclosures provide a separate, hinged, inner door (dead front panel) for device mounting.

C. Lace conductors with plastic ties to present a neat and orderly appearance. Provide nylon wrapping to protect conductors crossing hinges.

D. Provide conduit hubs on enclosures.

E. Provide protective pocket inside front cover with control wiring and panel layout diagrams.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install cabinets and enclosures plumb, anchor securely to wall and structural supports at each corner with top of cabinet 6 ft. 6 inches above finished floor. Install cabinet interior after all conduit connections are completed.

B. Install all surface mounted cabinets at least 1 (one) inch off wall. Install supports in such a manner as to not block vertical flow of air in back of cabinet.

C. Provide accessory feet for free-standing equipment enclosures.

END OF SECTION 16160

SECTION 16175
INSTRUMENT TRANSFORMERS, METERS, SWITCHES AND ACCESSORIES

PART 1 - GENERAL

1.01 SCOPE

A. Work described in this Section includes furnishing all labor, materials, equipment, tools and incidentals required for a complete and operable installation of accessories for low voltage switchgear, 15kV switchgear, low voltage motor control assemblies and switch boards. All equipment shall be installed, adjusted, tested and placed in operation in accordance with these Specifications, the manufacturer's recommendations and as shown on the Drawings.

B. Contract drawings show only functional features and some of the required external connections. They do not show all components required for a complete installation nor exact dimensions particular to any manufacturer's equipment. Contractor shall supply all parts, devices and equipment necessary to meet the requirements of the Contract Documents and shall make all dimensional adjustments particular to the equipment being furnished. All costs associated with such changes and adjustments shall be considered as being included in the price bid for the work shown and specified.

1.02 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions of the Contract Documents. In addition, the following specific information shall be provided:

1. Product data indicating the general features and dimensions of devices.
2. Burden, accuracy class and ratio data for instrument transformers.
3. Operation and maintenance manuals.

1.03 QUALITY ASSURANCE

A. Reference Standards: Comply with all Federal and State laws or ordinances, as well as all applicable codes, standards, regulations and/or regulatory agency requirements including the partial listing below:

1. ANSI C37.20.
2. ANSI C39.1.
3. ANSI C57.13.
4. NEMA STD.11.

PART 2 - PRODUCTS

2.01 INSTRUMENT TRANSFORMERS

A. General:

1. Instrument transformers shall be molded dry-type in accordance with ANSI C57.13. Transformer volt-ampere rating shall be suitable for carrying the specified load without overheating or exceeding the permissible accuracy for the transformer.

B. Potential Transformers:

1. Potential transformers shall have an ANSI accuracy class of 0.3. They shall be equipped with current limiting fuses.

C. Current transformers:

1. Current transformers shall be furnished with the specified ratios. Transformers shall be 5 ampere secondary bar or window type with single secondary winding and secondary shorting device. The accuracies shall conform to ANSI C37.20.

2.02 PANEL METERS

A. All indicating meters shall be 4-½-inch square, semi-flush mounted, dust tight switchboard type. Moving elements provided with zero adjustments and the movement shall be taut-band with an accuracy of plus or minus 1 percent of full scale. The case shall be black. The scale shall be white with black markings. The length of the scale shall be greater than 7 inches over a deflection angle of 250 degrees. The meters shall be manufactured in accordance with applicable requirements of ANSI C39.1

2.03 INSTRUMENT SWITCHES

A. Control and instrument switches shall be heavy-duty oil tight units rated 20 amperes at 600 volts. Instrument switches shall be provided with contact blocks and positions specified. Switches shall be of the rotary-cam type and contacts shall have positive wiping action of silver-to-silver contact buttons, 5,000,000 operation mechanical life. Switches shall be provided with escutcheon plates and pistol-grip handles. Switches shall be General Electric, SBM, Cutler-Hammer, W-2; or equal.

B. Voltmeter and ammeter switches shall have four positions with the escutcheon legend as follows:

Voltmeter	OFF	1-2	2-3	3-1
Ammeter	OFF	Phase A	Phase B	Phase C

2.04 KEY INTERLOCK

A. Where specified, the key interlock shall consist of two or more identically keyed brass bolt locks. The bolt on the lock shall prevent the operation of the electrical equipment. One brass key shall be provided for each group of identical locks. The key shall be held captive when the lock is positioned to allow equipment operation.

2.05 INDICATING LIGHTS

A. Switchboard indicating lights shall be register type of the voltage specified. Bulbs shall be telephone type with a slide base.

2.06 NAMEPLATES

A. Nameplates shall be provided as specified in Section 16050, Paragraph 2.11.

2.07 EXECUTION

A. All accessories and devices shall be installed per the switchgear manufacturer's instructions.

END OF SECTION 16175

SECTION 16195
ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes identification of electrical materials, equipment, and installations.

1.03 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product Data for each type of product specified.

1.04 QUALITY ASSURANCE

A. Comply with NFPA 70.

1.05 SEQUENCING AND SCHEDULING

A. Coordinate installing electrical identification after completion of finishing where identification is applied to field-finished surfaces.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:

1. American Labelmark Co., Labelmaster Subsidiary.
2. Brady USA Inc.; Industrial Products Div.
3. Carlton Industries, Inc.
4. Champion American, Inc.
5. Cole-Flex Corp.
6. Ideal Industries, Inc.
7. Markal Corp.
8. National Band & Tag Co.
9. Panduit Corp.
10. Raychem Co.

11. Seton Name Plate Co.

12. Standard Signs, Inc.

2.02 ENGRAVED NAMEPLATES AND SIGNS

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

B. Engraving stock, melamine Plastic laminate, 1/16 inch (1.6 mm) minimum thickness for signs up

1. Engraved Legend: White letters on black face.

2. Punched for mechanical fasteners.

C. Baked-Enamel Signs for Interior Use: Preprinted aluminum signs, punched for fasteners, with colors, legend, and size as indicated or as otherwise required for the application. ¼-inch (6.4 mm) grommets in corners for mounting.

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

2.03 WIRE MARKERS

A. Each power and control conductor shall be identified at each terminal to which it is connected. Conductors size No. 10 AWG or smaller shall have identification sleeves. The letters and numbers that identify each wire shall be machine printed on sleeves with permanent black ink. The figures shall be 1/8 inch high. Sleeves shall be yellow or white tubing, sized to fit the conductor insulation. The sleeves shall be shrunk to fit the conductor with hot air after installation. They shall be TMS Thermofit Marker System by Raychem Co., sleeve style wire marking system by W. H. Brady Co., or equal. Adhesive strips are not acceptable. Conductors No. 8 AWG and larger shall use cable markers of the locking tab type. Tabs shall be white plastic with conductor identification number permanently embossed.

2.04 RACEWAY MARKERS

A. Raceway markers shall be 0.036 inch minimum thickness, solid metal tags with raceway number stamped in 3/16 inch minimum height characters. Such tags shall be attached to the raceway with heavy duty tie wraps. Alternatively, aluminum wrapped bands, approved for the purpose, may be employed.

PART 3 - EXECUTION

3.01 INSTALLATION

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

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

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

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

E. Self-Adhesive Identification Products: Clean surfaces of dust, loose material and oily films before applying.

F. Install circuit identification labels on faceplates of receptacles, outlet, telephone/data outlets, etc. Use pressure sensitive, self-adhesive plastic labels. Identify supply panel and circuit on the label.

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

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

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

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

1. 208/120 Volt System: As follows:
   a. Phase A: Black.
   b. Phase B: Red.
   c. Phase C: Blue.
   d. Neutral: White.
   e. Ground: Green.
2. 480/277 Volt System: As follows:
   a. Phase A: Yellow.
   b. Phase B: Brown.
   c. Phase C: Orange.
   d. Neutral: Gray.
   e. Ground: Green.
3. Factory-apply color the entire length of the conductors, except the following field-applied, color-coding methods may be used in lieu of factory-colored wire for sizes larger than No. 10 AWG. Colored, pressure-sensitive plastic tape in half-lapped turns for a distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply the last two (2) turns of tape with no tension to prevent possible unwinding. Use 1 inch (25

mm) wide tape in colors as specified. Adjust tape bands to avoid obscuring cable identification markings.

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

1. Legend: 1/4 inch (6.4 mm) steel letter and number stamping or embossing with legend corresponding to indicated circuit designations.
2. Fasten tags with nylon cable ties; fasten bands using integral ears.
3. Apply tags or bands such that all conductors in each circuit are included.

K. Apply identification to conductors as follows:

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

L. Wire and Cable Identification

1. Every power wire, power cable, control wire, control cable, instrumentation wire and cable shall be permanently identified at every termination point with a wire marker.
2. Use wire marker as described in 2.03 above. Mark with circuit wire number, control diagram number, loop number, equipment number, etc. as applicable.

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

1. Install warning, caution, and instruction signs where required by Code or indicated or required to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install arc-flash hazard warning signs per NEC 110.16. Install engraved, plastic-laminated instruction signs with approved legend where instructions or explanations are needed for system or equipment operation. Install butyrate signs with metal backing for outdoor items.
2. Emergency-Operating Signs: Install engraved laminate signs with white legend on red background with minimum 3/8 inch (9 mm) high lettering for emergency instructions on power transfer, load shedding, and other emergency operations.

N. Install identification as follows:

1. Apply equipment identification labels of engraved plastic laminate on each major unit of equipment, including central or master unit of each system. This includes communication, signal, and alarm systems, unless units are specified with their own self-explanatory identification. Except as otherwise indicated, provide a single line of text with 1/2 inch (13 mm) high lettering on 1-1/2 inch (38 mm) high label: where 2 lines of text are required, use

lettering 2 inches (51 mm) high. Use white lettering on black field. Apply labels for each unit of the following categories of equipment.

a. Panelboards, electrical cabinets, and enclosures.
b. Power transfer equipment.
c. Contactors.
d. Transformers.
e. Fire-alarm master station or control panel.
f. Security-monitoring master station or control panel.
g. Telephone Backboard.
h. Data Backboard.
i. Television Master Station.

2. Apply designation labels of engraved plastic laminate for disconnect switches, breakers, push buttons, pilot lights, motor control centers, and similar items for power distribution and control components above, except panelboards and alarm/signal components where labeling is specified elsewhere. For panelboards, provide framed, typed circuit schedules with explicit description and identification of items controlled by each individual breaker.

3. Raceway Numbering Convention

Raceway Prefix	Type of Function
C	Control and/or 120V or less power
H	Power above 600V
N	Pneumatic Tubing
P	Power 208V to 600V
S	Low level signal (less than 90 volts communication or less than 30 volts instrumentation)
X	Spare

a. The Raceway Prefix shall be followed by the panel designation where the raceway originates. Where there is more than one raceway to a particular panel, a number suffix is added to distinguish the raceway.

Example:
C-RIOXXX-1 C=Control RIOXXX= Remote I/O Panel XXX 1= Conduit #1
C-RIOXXX-2 C=Control RIOXXX= Remote I/O Panel XXX 2= Conduit #2
S-RIOXXX-1 S=Signal RIOXXX= Remote I/O Panel XXX 1= Conduit #1
P-LPXXXX-1 P=Power LPXXXX= Lighting Panel XXXX 1= Conduit #1
P-LPXXXX-2 P=Power LPXXXX= Lighting Panel XXXX 2= Conduit #2

b. When multiple raceways exit a pull box, the raceways shall maintain the Numbering Convention assigned to the main raceway entering the pull box.

Example:
C-RIOXXX-1 2" – (32 - #14) (2" Conduit w/ 32 #14 conductors entering the pull box)
C-RIOXXX-1A ¾" –(4 - #14) (3/4" Conduit w/ 4 #14 conductors exiting the pull box to LSL/LSH-XXX-1)
C-RIOXXX-1B ¾" –(4 - #14) (3/4" Conduit w/ 4 #14 conductors exiting the pull box to LSL/LSH-XXX-2)
C-RIOXXX-1C ¾" –(8 - #14) (3/4" Conduit w/ 8 #14 conductors exiting the pull box to Control Panel CP-XXXX)

c. The conductors within a raceway shall be identified with the raceway number followed by the terminal number the conductor is terminated on inside the equipment.

Example:
C-RIOXXX-1-1560 (Wire number C-RIOXXX-1-1560 routed inside raceway (conduit) C-RIOXXX-1, terminated inside Remote I/O Panel XXX on terminal 1560.)
C-RIOXXX-1-1561 (Wire number C-RIOXXX-1-1561 routed inside raceway (conduit) C-RIOXXX-1, terminated inside Remote I/O Panel XXX on terminal 1561.)

END OF SECTION 16195

SECTION 16215
ELECTRICAL POWER MONITORING

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. The Contractor shall furnish, install and test the electrical power monitoring system as shown on the Drawings in accordance with these Specifications.

1.02 SUBMITTALS

A. Submit to the Engineer, in accordance with the General Conditions, the Special Conditions, and Division 1, copies of all materials required to establish compliance with this Section. Submittals shall include at least the following:

1. Equipment outline drawings showing elevation and plan views, dimensions, weight, shipping splits, and metering layouts. Indicate all options, special features, ratings, and deviations from the specifications.
2. Product data sheets and catalog numbers for components. List all options, adjustments, and accessories furnished specifically for this Project.
3. Manufacturers standard wiring diagrams for metering relay, power and control circuits in accordance with the NEMA wiring class specified. Show all field devices, switches, lights, wire, terminal numbers, etc.
4. Instruction and renewal parts books.
5. Itemized list of spare parts furnished specifically for this Project, including quantities, description, and part numbers.
6. Test and inspection reports.
7. Complete bill of materials list.

1.03 REFERENCE STANDARDS

A. Power monitoring system shall be designed, built and tested in accordance with the latest editions and revisions of NEMA Standards and Underwriters' Laboratories Standards. Equipment shall conform to ANSI test standards and the requirements of the National Electrical Code.

1.04 QUALITY ASSURANCE

A. The equipment furnished under this Section shall be the product of a Manufacturer who has produced this same type of equipment for a period of at least ten (10) consecutive years.

B. Power monitoring system shall be designed, assembled, and tested by the Manufacturer of the equipment included in the assembly.

C. All units and sections shall be UL labeled.

PART 2 - PRODUCTS

2.01 RATING

A. Service: 480 Volts, three-phase, three-wire (or four-wire where indicated on the Drawings), 60 Hertz.

B. Power monitoring system, including devices, shall be designed for continuous operation at rated current in a 40 degrees C ambient temperature.

2.02 CONSTRUCTION

A. General:

1. The general arrangement of the power monitoring system is shown on the Drawings. The power monitoring system shall be manufactured by one of the following companies:
   a. Cutler-Hammer/Westinghouse
   b. General Electric
   c. Square D Co.
   d. Siemens.

2.03 COMPONENTS

A. Instrumentation and Metering:

1. Instrument control switches: 600 Volts switchboard type, rated 20 Amperes continuous, with black molded phenolic escutcheon plates, white characters, Square D or equal.

2. Instrumentation transformers: Indoor, 600 Volts, butyl rubber molded, metering class designed in accordance with ANSI and NEMA standards. Window type current transformers, with burden capacity as low as 50 VA, may be used where such capacity is sufficient. Current transformer accuracy ratings shall be at least equal to NEMA standard requirements for the particular applications.

3. Power circuit monitors shall be provided on the main breakers as indicated in the single line diagrams. The power circuit monitors shall replace the standard voltmeters and ammeters and shall be General Electric PQM-II/EPM, Eaton IQ DP-4000, Square D Company's "Power Logic", or equal, with features as specified below.

4. Elapsed time hour meters: Five digit, non-reset type, with 120 Volts synchronous motor.

B. Power Monitors:

1. Microprocessor based metering: At each circuit location shown on the Drawings, furnish a digital microprocessor based metering device capable of monitoring and displaying the functions listed below. The device shall provide the status input functions indicated and the capability to communicate data to a centralized monitoring system via a data highway network. The device shall be UL listed.

2. Metering Functions:
   a. The digital AC Instrumentation Package shall be capable of measuring, calculating and directly displaying on the front panel display the following information:
      i) Volts on each phase plus average of all three phases.
      ii) Current on each phase plus average of all three phases.
      iii) Neutral or ground current.
      iv) Frequency.
      v) Power Factor.
      vi) KVA.
      vii) KVAR.
      viii) KW.
      ix) Total KWH as an accumulating total, providing bi-directional (import/export) indication.
      x) Amps Demand.

3. Monitoring and Control Functions. These monitoring and control functions are required for switchgear applications, but not for switchboard applications:
   a. Provide eight self-powered digital status inputs to monitor the following points:
      i) Circuit breaker OPEN status.
      ii) Circuit breaker CLOSED status.
      iii) Circuit breaker TRIPPED status.
      iv) Circuit breaker OUT OF SERVICE (withdrawn) status.
   b. Provide one auxiliary analog input (selectable 0-20 mA or 4-20 mA), which can be used to measure an external variable such as transformer temperature, air temperature, or battery voltage.
   c. Provide one auxiliary analog output (selectable 0-20ma or 4-20ma) proportional to any measure parameter.
   d. Provide three Form C dry contact control relay outputs rated 277 VAC or 30 VDC at 10 Amp maximum load current, that can each function as:
      i) Setpoint relays that operate as a function of any measured parameter for demand, power factor, or load control. Seventeen programmable setpoints shall each have programmable operate and release limits and time delays on operate and release. Relays shall provide selectable pulse mode or tach mode operation.
      ii) Remote control relays operated by commands via the communications port.
      iii) Breaker trip relay (over/under volt, volt unbalance, phase reversal, current unbalance, over/under frequency).
      iv) KWH or VARH pulse output relay.
      v) Alarm relays.

4. Operational Features:
   a. Provide the following operational features:
      i) True RMS measurements.
      ii) Connect directly to PTs and CTs.
      iii) Provision for a fourth current input for measurement of ground or neutral current.

iv) 300 Amperes, one second surge protection on all four current inputs.

v) Three-field, 20 character, high visibility 0.4 inch character height vacuum-fluorescent display with a programmable time out feature.

b. Store in non-volatile memory the following:

i) A time-stamped alarm and event log up to 50 events which records event date, time (to 1 second), event type and value for all over/under limit conditions, all status input activity and all relay operations. Log shall be read via the communications port.

ii) A time-stamped minimum/maximum log, which records the value of any parameter exceeding the previous highest or lowers value recorded. Log shall be read from the front panel display or via communication port.

iii) A time-stamped snapshot (historical) log, with a 100 snapshot capacity and user-definable snapshot interval from 1 second to 400 days which records snapshot values for Average Volts, Average Amps, KW, KVAR, KW Demand, Power Factor, Frequency, KWH, KWH Reverse, KVARH and Auxiliary Volts Input. Log shall be read via the communications port.

iv) All setup data.

5. The device shall be field programmable as follows:
   a. Volts scale, volts mode (wye, delta, single phase), amps scale, baud rate and the relay operation shall be programmable from the front panel.
   b. All parameters above, plus additional alarm/event parameters shall be programmable via the communication port using a portable terminal or a computer.
   c. The programming shall be password protected.
6. Waveform Capture:
   a. Provide waveform capture capability allowing any of the eight voltage and current input channels to be digitally sampled 256 samples/60 Hertz cycle. Waveform capture shall be initiated using commands made via the communications port. Waveform capture data shall be made accessible via the communications port.
7. Data Communication:
   a. Provide a serial communication port which has:
      i) Switchable RS-232C and RS-485 capability.
      ii) Addressable polling of multiple units.
      iii) Packet transmission.
      iv) Selectable transmission at 300 to 19,200 baud.
   b. Provide all communication cables to interconnect monitors with the electrical equipment.

2.04 SURFACE PREPARATION AND SHOP COATINGS

A. All non-current carrying metal parts of the assembly shall be cleaned of all weld spatter and other foreign material and given a heat cured, phosphatized chemical pretreatment to inhibit rust.

B. Indoor equipment shall be finish painted with one coat of Manufacturers standard electrocoated, heat cured enamel. Color shall be ANSI-61 light gray.

2.05 SHOP TESTING

A. Perform Manufacturers standard production testing and inspection in accordance with NEMA and ANSI standards. If requested by the Engineer, the Manufacturer shall submit certified copies of test results.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install the equipment in accordance with the Manufacturers instructions.

B. Touch-up damaged point's finishes.

3.02 FIELD TESTING

A. Make the following minimum tests and checks before the Manufacturers representative is called in for testing and adjustment

1. Remove current transformer shunts after completing secondary circuit.
2. Check polarity and continuity of metering and relaying circuits.

B. In the event of an equipment fault, notify Engineer immediately. After this cause of the fault has been identified and corrected, the Contractor, the Engineer, and the equipment Manufacturers factory service technician shall conduct a joint inspection of the equipment. Repair or replace the equipment as directed by the Engineer prior to placing the equipment back into service.

3.03 ADJUSTMENT

A. The Manufacturer shall provide the services of a factory trained service technician for the time period specified in Section 16010. The first trip shall be coordinated with the equipment start-up. The second trip shall include any necessary follow-up or punch list work, and shall also include instructions to the Owner or to his designated personnel. The Manufacturer's service technician shall demonstrate and test all operation features of the installed equipment to the satisfaction of the Owner. Submit a certified copy of the field inspection to the Engineer. No equipment is to be energized without the approval of the Engineer.

3.04 CLEANING

A. Remove all rubbish and debris from inside and around the enclosure. Remove dirt, or concrete spatter from the interior and exterior of the equipment using brushes, vacuum cleaner, or clean, lint-free rags. Do not use compressed air.

END OF SECTION 16215

SECTION 16264
STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Conditions, Division 1 – General Requirements, and other applicable Specification Sections in the Project Manual apply to the work specified in this Section.

1.02 SUMMARY

A. Scope: Provide design and engineering, labor, material, equipment, related services, and supervision required, including, but not limited to, manufacturing, fabrication, erection, and installation for a static uninterruptible power supply (UPS) as required for the complete performance of the work and as shown on the Drawings and as herein specified.

B. Section Includes: The work specified in this Section includes, but shall not be limited to, a continuous duty, three-phase, solid state, on-line double conversion static UPS.

1. The UPS shall utilize a rack-mounted N+1 redundant, scalable array architecture. The system power train shall be comprised of 10 kVA/10 kW power modules and shall be capable of being configured for N+X redundant operation at the rated system load. In systems operating at a load where the system is N+1 or greater, the UPS shall facilitate the replacement of power modules while the system remains in normal operation, without the requirement to transfer to bypass (trained personnel hot swappable).
2. Each 10 kVA/10 kW power module shall contain a fully rated input rectifier/boost converter hereafter referred to as the input converter, a fully rated output inverter, and battery charging circuit. The system shall also be comprised of a trained personnel hot swappable continuous duty bypass static switch module, trained personnel hot swappable battery modules, redundant control modules, redundant logic power supplies, and LCD interface/display. All of the above system components shall be housed in standard 600 mm wide by 1070 mm deep by 2,000 mm high enclosures.
3. In addition, this Section describes the performance, functionality, and design of the power distribution unit, hereafter referred to as the PDU, and the battery system.
4. The UPS and associated equipment shall operate in conjunction with a primary power supply and an output distribution system to provide quality uninterrupted power for mission critical, electronic equipment load.
5. All programming and miscellaneous components for a fully operational system as described in this Section shall be available as part of the UPS.

1.03 REFERENCES

A. General: The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest date as of the date of the Contract Documents, unless otherwise specified.

B. Institute of Electrical and Electronics Engineers, Inc. (IEEE): ANSI/IEEE 519, "Guide for Harmonic Control and Reactive Compensation of Static Power Converters" (copyrighted by IEEE, ANSI approved).

C. International Organization for Standardization (ISO):

1. ISO 9001, "Quality Management Systems - Requirements."
2. ISO 14001, "Environmental Management Systems - Requirements With Guidance for Use."

D. Underwriters Laboratories, Inc. (UL):

1. UL 1778 second Edition, "Standard for Uninterruptible Power Supply Equipment" (copyrighted by UL, ANSI approved).
2. UL 60950-1, "Standard for Information Technology Equipment."

E. International Electrotechnical Commission (IEC)

1. IEC 61000-4-2, "Electromagnetic Compatibility - Testing and Measurement Techniques; Electrostatic Discharge Immunity Test."
2. IEC 61000-4-3, "Electromagnetic Compatibility - Testing and Measurement Techniques; Radiated, Radio Frequency, Electromagnetic Field Immunity Test."
3. IEC 61000-4-4, "Electromagnetic Compatibility - Testing and Measurement Techniques; Electrical Fast Transient/Burst Immunity Test."
4. IEC 61000-4-5, "Electromagnetic Compatibility - Testing and Measurement Techniques; Surge Immunity Test."
5. IEC 62040-2, "Uninterruptible Power Systems - Electromagnetic Compatibility (EMC) Requirements,"
6. IEC 62040-3, "Uninterruptible Power Systems - Method of Specifying the Performance and Test Requirements."

F. CSA:

1. C22.2 no. 107.1-M95, "General Use Power Supplies."
2. 60950-1, "Information Technology Equipment - Safety - Part 1: General Requirements."

G. EMC:

1. FCC part 15 Class A.

1.04 SYSTEM DESCRIPTION

A. Design Requirements:

1. The UPS shall be sized for 20 kW load.
2. The UPS battery shall be sized for 20 kW at a power factor of 0.8 for 24 hours.

B. System Characteristics:

1. System Capacity: The system shall be rated for full kW output in the following frame sizes:
   a. 100 kVA/kW, can be configured with up to ten, 10 kW power modules for 100 kW or 90 kW N+1.

2. Input: The system input shall be configurable as either single or dual mains derived from a three phase wye source. Standard cable entry shall be through the top. Bottom cable entry shall also be facilitated. Depending on the specific configuration, the use of the optional side car may be required.
   a. AC Input Nominal Voltage: 480 Y/277 V three-phase, 4-wires plus ground, 60 Hz.
   b. AC Input Voltage Window:
   c. ±15 percent for full performance.
      i) Short Circuit Withstand Rating: 30,000 symmetrical amperes.
   d. Maximum Frequency Range: 40 to 70 hertz.
   e. Input Power Factor:
      i) Greater than 0.99 with load at 100 percent.
      ii) Greater than 0.98 with loads above 50 percent.
      iii) Greater than 0.95 with loads above 25 percent.
   f. Input Current Distortion With No Additional Filters: Less than 5 percent at full load.
   g. Soft-Start: Shall be linear from 0 percent to 100 percent input current and shall not exhibit inrush. This shall take place over a selectable 1 second to 60 second time period with a factory default of 10 seconds.

3. UPS Output:
   a. AC Output Nominal Output: 480 Y/277 V, 4-wires plus ground, 60 Hz.
   b. AC Output Voltage Distortion: Less than 2 percent at 100 percent linear load, less than 6.5 percent for non-linear load as defined by IEC/EN 62040-3.
   c. AC Output Voltage Regulation: ±1 percent for 100 percent linear or non-linear load.
   d. Voltage Transient Response: ±5 percent maximum RMS change in a half cycle at load step 0 percent to 100 percent or 100 percent to 0 percent.
   e. Voltage Transient Recovery: Within less than 50 milliseconds.
   f. Output Voltage Harmonic Distortion: Less than 2 percent THD maximum and 1 percent single harmonic for a 100 percent linear load.
   g. Overload Capabilities:
      i) Normal Operation:
         a) 150 percent for 30 seconds before transfer to bypass.
      i) Battery Operation: 150 percent for 30 seconds.
      ii) Bypass Operation:
         a) 125 percent continuous at 208 volts.
         b) 1,000 percent for 100 milliseconds.
   h. System Efficiency:
      i) Normal operation greater than 92.5 percent at 35 percent to 100 percent load.
      ii) Battery operation greater than 92.5 percent at 35 percent to 100 percent load.
   i. Output Power Factor Rating: 0.5 leading to 0.5 lagging without any derating.

1.05 SUBMITTALS

A. General: Submittals shall be made in accordance with the requirements of the General Conditions.

B. Product Data: Submit product data showing material proposed. Submit sufficient information to determine compliance with the Drawings and Specifications. Product data shall include, but shall not be limited to, the following:

1. As bid system bill of materials.
2. Product catalog sheets or equipment brochures.
3. Product guide specifications.

C. Shop Drawings: Submit shop drawings for each product and accessory required. Include information not fully detailed in manufacturer's standard product data, including, but not limited to, the following:

1. Installation information, including, but not limited to, weights and dimensions.
2. Information about terminal locations for power and control connections.
3. Drawings for requested optional accessories.

D. Wiring Diagrams: Submit wiring diagrams detailing power, signal, and control systems, clearly differentiating between manufacturer-installed wiring and field-installed wiring, and between components provided by the manufacturer and those provided by others.

1. Submit system single-line operation diagram.

E. Operation and Maintenance Data: Submit operation and maintenance data to include in operation and maintenance manuals specified in Division 1 – General Requirements, including, but not limited to, safe and correct operation of UPS functions.

1. Submit an installation manual, which shall include, but shall not be limited to, instructions for storage, handling, examination, preparation, installation, and start-up of UPS.
2. Submit an operation and maintenance manual, which shall include, but shall not be limited to, operating instructions.

1.06 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer Qualifications: Manufacturer shall be a firm engaged in the manufacture of solid state UPS of types and sizes required, and whose products have been in satisfactory use in similar service for a minimum of 20 years.
   a. The manufacturer shall be ISO 9001 certified and shall be designed to internationally accepted standards.
2. Installer Qualifications: Installer shall be a firm that shall have a minimum of five years of successful installation experience with projects utilizing solid state UPS similar in type and scope to that required for this Project.

B. Regulatory Requirements: Comply with applicable requirements of the laws, codes, ordinances, and regulations of Federal, State, and local authorities having jurisdiction. Obtain necessary approvals from such authorities.

1. Work shall also be designed in accordance with the following:
   a. UL 1778 second edition
   b. UL 60950-1
2. Where applicable, the UPS shall also be designed in accordance with publications from the following organizations and committees:
   a. National Fire Protection Association (NFPA).
   b. National Electrical Manufacturers Association (NEMA).
   c. Occupational Safety and Health Administration (OSHA).
   d. Institute of Electrical and Electronics Engineers, Inc. (IEEE); ANSI/IEEE 519.
   e. ISO 9001
   f. ISO 14001
   g. FCC

C. Pre-Installation Conference: Conduct pre-installation conference in accordance with Section 01200- Project Meetings. Prior to commencing the installation, meet at the Project site to review the material selections, installation procedures, and coordination with other trades. Pre-installation conference shall include, but shall not be limited to, the Contractor, the Installer, and any trade that requires coordination with the work. Date and time of the pre-installation conference shall be acceptable to the Owner and the Architect/Engineer.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to the Project site in supplier's or manufacturer's original wrappings and containers, labeled with supplier's or manufacturer's name, material or product brand name, and lot number, if any.

B. Store materials in their original, undamaged packages and containers, inside a well-ventilated area protected from weather, moisture, soiling, extreme temperatures, and humidity.

1.08 PROJECT CONDITIONS

A. Environmental Requirements: Do not install the UPS until space is enclosed and weatherproof, wet work in space is completed and nominally dry, work above ceilings is complete, and ambient temperature and humidity conditions are and will be continuously maintained at values near those indicated for final occupancy.

1. Environmental:
   a. Storage Ambient Temperature: 5 °F (-15 °C) to 104 °F (40 °C).
   b. Operating Ambient Temperature: 32 °F (0 °C) to 104 °F (40 °C) (77 °F (25 °C) shall be ideal for most battery types).
   c. Relative Humidity: 0 percent to 95 percent non-condensing.

d. Altitude: Maximum installation with no derating of the UPS output shall be 3280 feet (1,000 m) above sea level. The UPS capacity shall be derated for altitude as follows:
   i) 4,921 feet (1,500 m), 95 percent load.
   ii) 6,562 feet (2,000 m), 91 percent load.
   iii) 8,202 feet (2,500 m), 86 percent load.
   iv) 9,843 feet (3,000 m), 82 percent load.

e. Audible Noise (As Measured 3 Feet From Surface):
   i) 60 dBA at 70 percent load.
   ii) 67 dBA at 100 percent load.

1.09 WARRANTY

A. General: See Section 01700 – Closeout Procedures.

B. Special Warranty: The Contractor shall warrant the work of this Section to be in accordance with the Contract Documents and free from faults and defects in materials and workmanship for period indicated below. This special warranty shall extend the one year period of limitations contained in the General Conditions. The special warranty shall be countersigned by the Installer and the manufacturer.

1. The UPS shall be covered by a full parts and labor warranty from the manufacturer for a period of 12 months from date of installation or acceptance by the Owner or 18 months from date of shipment from the manufacturer, whichever occurs first.

C. Additional Owner Rights: The warranty shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to and run concurrent with other warranties made by the Contractor under requirements of the Contract Documents.

1.10 MAINTENANCE

A. A complete offering of preventative and full service maintenance contracts for the UPS system and the battery system shall be available from the manufacturer. Contract work shall be performed by factory-trained service personnel.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Product specified SG Series as manufactured by GE, Powerware as manufactured by Eaton, or "APC Symmetra PX 100 kW" as manufactured by APC by Schneider Electric. Items specified are to establish a standard of quality for design, function, materials, and appearance. Equivalent products by other manufacturers are acceptable. The Architect/Engineer will be the sole judge of the basis of what is equivalent.

2.02 MODES OF OPERATION

A. Normal: The Input converter and output inverter shall operate in an on-line manner to continuously regulate power to the critical load. The input and output converters shall be capable

of full battery recharge while simultaneously providing regulated power to the load for all line and load conditions within the range of the UPS specifications.

B. Battery: Upon failure of the AC input source, the critical load shall continue being supplied by the output inverter, which shall derive its power from the battery system. There shall be no interruption in power to the critical load during both transfers to battery operation and retransfers from battery to normal operation.

C. Recharge: Upon restoration of utility power to the UPS input, the input converter and output inverter shall simultaneously recharge the battery and provide regulated power to the critical load.

D. Static Bypass: The static bypass shall be used to provide controller transfer of critical load from the inverter output to the bypass source. This transfer, along with its retransfer, shall take place with no power interruption to the critical load. In the event of an emergency, this transfer shall be an automatic function.

E. Maintenance Bypass: The system shall be equipped with an external make-before-break maintenance bypass cabinet (MBC) to electrically isolate the UPS during routine maintenance and service of the UPS. The MBC shall allow for the completely electrical isolation of the UPS.

2.03 INPUT CONVERTER

A. General: The Input converters of the system shall be housed within the removable power modules, and shall constantly control the power imported from the mains input of the system, to provide the necessary UPS power for precise regulation of the DC bus voltage, battery charging, and main inverter regulated output power. These power modules shall be connected in parallel within the UPS frame.

B. Input Current Total Harmonic Distortion: The input current THDI shall be held to less than 5 percent at full system load, while providing conditioned power to the critical load bus, and charging the batteries under steady-state operating conditions. This shall be true while supporting both a linear or non-linear load. This shall be accomplished without the requirement for additional filters, magnetic devices, or other components.

C. Soft-Start Operation: As a standard feature, the UPS shall contain a user-adjustable soft-start, capable of limiting the input current from 0 percent to 100 percent of the nominal input over a default 10 second period, when returning to the AC utility source from battery operation. The change in current over the change in time shall take place in a linear manner throughout the entire operation.

D. Magnetization Inrush Current: The UPS shall exhibit zero inrush current as a standard product. If provided with an optional isolation transformer, inrush should be limited to 11 times the nominal input current of the transformer.

E. Input Current Limit:

1. The Input converter shall control and limit the input current draw from utility to 150 percent of the UPS output. During conditions where input current limit is active, the UPS shall be able to support 100 percent load, charge batteries at 10 percent of the UPS output rating, and provide voltage regulation with mains deviation +15/-5 percent.

2. In cases where the source voltage to the UPS is nominal and the applied UPS load is equal to or less than 100 percent of UPS capacity, input current shall not exceed 125 percent of UPS output current, while providing full battery recharge power and importing necessary power to account for system losses.

F. Redundancy: The UPS shall be capable of being configured with redundant Input converters, each with semiconductor fusing, and logic-controlled contactors to isolate a failed module from the input bus.

G. Back-Feed Protection: The above mentioned logic-controlled contactor shall also provide the back-feed protection required by UL 1778, CSA 22.2, and IEC/EN Standards.

H. Charging:

1. The battery charging shall keep the DC bus float voltage of ±218 volts, ±1 percent.
2. The battery charging circuit shall contain a temperature compensation circuit, which shall regulate the battery charging to optimize battery life.
3. The battery charging circuit shall remain active when in static bypass and in normal operation.
4. Maximum charging power: 10% of output power rating or a maximum charge current of 0.25 CA.

2.04 OUTPUT INVERTER

A. General: The UPS output inverter shall constantly develop the UPS output voltage waveform by converting the DC bus voltage to AC voltage through a set of IGBT driven power converters. In both normal operation and battery operation, the output inverters shall create an output voltage independent of the mains input voltage. Input voltage anomalies such as brown-outs, spikes, surges, sags, and outages shall not affect the amplitude or sinusoidal nature of the output voltage sine wave of the inverters.

B. Overload Capability: Steady-state overload conditions, of up to 150 percent of system capacity shall be sustained by the inverter for 30 seconds in normal and battery operation. Should overloads persist past the outlined time limitation, the critical load shall be switched to the automatic static bypass output of the UPS.

C. Output Contactor: The output inverter shall be provided with an output mechanical contactor to provide physical isolation of the inverter from the critical bus. With this feature a failed inverter shall be isolated from the critical bus.

D. Battery Protection: The inverter shall be provided with monitoring and control circuits to limit the level of discharge on the battery system.

E. Redundancy: The UPS shall be capable of being configured with redundant output inverters, each with semiconductor fusing, and logic-controlled contactors to remove a failed component from the input, DC, and output critical bus.

2.05 STATIC BYPASS

A. General: As part of the UPS, a system static bypass cabinet shall be provided. The system static bypass shall provide no break transfer of the critical load from the inverter output to the static bypass input source during times where maintenance is required, or the inverter cannot support the critical bus. Such times may be due to prolonged or severe overloads, or UPS failure. The UPS and static bypass switch shall constantly monitor the auxiliary contacts of their respective circuit breakers, as well as the bypass source voltage, and inhibit potentially unsuccessful transfers to static bypass from taking place.

B. Design: The design of the static switch power path shall consist of silicon-controlled rectifiers (SCR) with a continuous duty rating of 125 percent of the UPS output rating.

C. Automatic Transfers: An automatic transfer of load to static bypass shall take place whenever the load on the critical bus exceeds the overload rating of the UPS. Automatic transfers of the critical load from static bypass back to normal operation shall take place when the overload condition is removed from the critical output bus of the system. Automatic transfers of load to static bypass shall also take place if for any reason the UPS cannot support the critical bus.

D. Manual Transfers: Manually initiated transfers to and from static bypass shall be initiated through the UPS display interface.

E. Overloads: The static bypass shall be capable of handling overloads equal to or less than 125 percent of the rated system output continuously. For instantaneous overloads caused by inrush current from magnetic devices, or short circuit conditions, the static bypass shall be capable of sustaining overloads of 1,000 percent of system capacity for periods of up to 100 milliseconds.

F. Modular: The static bypass switch shall be of a modular design.

G. System Protection: As a requirement of UL 1778, back-feed protection in the static bypass circuit shall also be incorporated in the system design. To achieve back-feed protection, a mechanical contactor in series with the bypass SCR(s) shall be controlled by the UPS/static switch, to open immediately upon sensing a condition where back-feeding of the static switch by any source connected to the critical output bus of the system is occurring. One such condition could be a result of a shorted SCR.

2.06 DISPLAY AND CONTROLS

A. Control Logic: The UPS shall be controlled by two fully redundant, trained personnel hot-swappable intelligence modules (IM). These modules shall have separate, optically isolated, communication paths to the power and static switch modules. Logic power for the control modules shall be derived from redundant power supplies, each having a separate AC and DC input and output. The communication of the control modules shall be of controller area network (CAN Bus).

B. Display unit: A microprocessor-controlled display unit shall be located on a hinged door in front of the system. The display shall consist of an alphanumeric display with backlight, four LEDs for quick status overview, and a keypad consisting of pushbutton switches.

C. Metered Data: The following data shall be available on the alphanumeric display:

1. Year, month, day, hour, minute, second of occurring events.
2. Source input voltage.
3. Output AC voltage.
4. Output AC current.
5. Input frequency.
6. Battery voltage.

D. Event Log: The display unit shall allow trained personnel to display a time and date stamped log.

E. Alarms: The display unit shall allow the Owner to display a log of active alarms. The following minimum set of alarm conditions shall be available:

1. Input frequency outside configured range.
2. AC adequate for UPS but not for bypass.
3. Low/no AC input, startup on battery.
4. Intelligence module inserted.
5. Intelligence module removed.
6. Redundant intelligence module inserted.
7. Redundant intelligence module removed.
8. Number of batteries changed since last on.
9. Number of power modules changed since last on.
10. Number of batteries increased.
11. Number of batteries decreased.
12. Number of power modules increased.
13. Number of power modules decreased.
14. Number of external battery cabinets increased.
15. Number of external battery cabinets decreased.
16. Redundancy restored.
17. Need battery replacement.
18. The redundant intelligence module is in control.
19. UPS fault.
20. On battery.
21. Shutdown or unable to transfer to battery due to overload.
22. Load shutdown from bypass. input frequency, volts outside limits.
23. Fault, internal temperature exceeded system normal limits.
24. Input circuit breaker open.

25. System level fan failed.
26. Bad battery module.
27. Bad power module.
28. Intelligence module installed and failed.
29. Redundant intelligence module installed and failed.
30. Redundancy lost.
31. Redundancy below alarm threshold.
32. Runtime below alarm threshold.
33. Load above alarm threshold.
34. Load no longer above alarm threshold.
35. Minimum runtime restored.
36. Bypass not in range (either frequency or voltage).
37. Back-feed contactor stuck in OFF position.
38. Back-feed contactor stuck in ON position.
39. UPS in bypass due to internal fault.
40. UPS in bypass due to overload.
41. System in forced bypass.
42. Fault, bypass relay malfunction.
43. High DC warning.
44. High DC shutdown.
45. Low battery shutdown.
46. Low battery warning.

F. Controls: The following controls or programming functions shall be accomplished by the use of the display unit. Pushbutton membrane switches shall facilitate these operations:

1. Silence audible alarm.
2. Display or set the date and time.
3. Enable or disable the automatic restart feature.
4. Transfer critical load to and from static bypass.
5. Test battery condition on demand.
6. Set intervals for automatic battery tests.
7. Adjust set points for different alarms.
8. Program the parameters for remote shutdown.

G. Potential Free (Dry) Contacts: The following potential free contacts shall be available on an optional relay interface board:

1. Normal operation.
2. Battery operation.
3. Bypass operation.
4. Common fault.
5. Low battery.
6. UPS off.

H. Communication Interface Board: A communication interface board shall provide the following communication ports which shall be able to be used simultaneously:

1. RS232 serial port #1.

2.07 BATTERY

A. The UPS battery shall be of a modular construction made up of trained personnel hot swappable, fused, battery modules. Each battery module shall be monitored for voltage and temperature for use by the UPS battery diagnostic and temperature compensated charger circuitry.

B. The battery jars housed within each removable battery module shall be of the valve regulated lead acid (VRLA) type.

C. The UPS shall incorporate a battery management system to continuously monitor the health of each removable battery module. This system shall notify the user in the event a failed or weak battery module is found.

2.08 ACCESSORIES

A. Power Distribution Unit: For the purpose of providing power distribution to the protected load, a range of power distribution modules and accessories shall be available.

B. Battery Solutions: For purposes of providing UPS back-up power, battery enclosures shall be available. For ease of maintenance the battery enclosures shall house draw-out battery cartridges. Battery cartridges shall interlock in place within the battery enclosure to ensure proper contact. This will ensure that the customer will not inadvertently withdraw the battery pack in an unsafe manner. The battery solution shall be housed in a standard 24 inch (610 mm) wide, 36 inch (914 mm) deep, 42 U high enclosure. Up to four battery enclosures may be added for increased battery runtime.

C. Software and Connectivity:

1. Network Adaptor: The ethernet web/SNMP adaptor shall allow one or more network management systems (NMS) to monitor and manage the UPS in TCP/IP network environments. The management information base (MIB) shall be provided in DOS and UNIX "tar" formats. The SNMP interface adaptor shall be connected to the UPS via the Network Management Cart Ethernet Port.

2. Unattended Shutdown:
   a. The UPS, in conjunction with a network interface card, shall be capable of gracefully shutting down one or more operating systems.
   b. The UPS shall also be capable of using an RS232 port to communicate by means of serial communication to gracefully shut down one or more operating systems during an on battery situation.

D. Remote Ups Monitoring: The following methods of remote UPS monitoring shall be available:

1. Web Monitoring: Remote monitoring shall be available via a web browser such as Internet Explorer.
2. RS232 Monitoring: Remote UPS monitoring shall be possible via either RS232 or contact closure signals from the UPS.
3. Simple Network Management Protocol (SNMP): Remote UPS monitoring shall be possible through a standard MIB II compliant platform.

E. Software Compatibility: The UPS manufacturer shall have available software to support graceful shutdown for the following systems:

1. Microsoft Windows 95/98/XP.
2. Microsoft Windows NT 4.0 SP6/2000.
3. OS/2.
4. Netware 3.2 – 5.1.
5. MAC OS 9.04, 9.22, 10.
6. Digital Unix/True 64.
7. SGI 6.0-6.5.
8. SCO UNIX.
9. SVR4 2.3, 2.41.
10. SCO Unix Ware 7.0 - 7.11.
11. SUN Solaris 2.6-2.8.
12. SUN OS 4.13, 4.14.
13. IBM AIX 4.3x-4.33g, 5.1.
14. HP-UX 9.x-11.i.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verification of Conditions: Examine areas and conditions under which the work is to be installed, and notify the Contractor in writing, with a copy to the Owner and the Architect/Engineer, of any conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

1. Beginning of the work shall indicate acceptance of the areas and conditions as satisfactory by the Installer.

3.02 INSTALLATION

A. General: Preparation and installation shall be in accordance with reviewed product data, final shop drawings, manufacturer's written recommendations, and as indicated on the Drawings.

B. Factory-Assisted Start-Up: If a factory-assisted UPS start-up is requested, factory-trained service personnel shall perform the following inspections, test procedures, and on-site training:

1. Visual Inspection:
   a. Inspect equipment for signs of damage.
   b. Verify installation per manufacturer's instructions.
   c. Inspect cabinets for foreign objects.
   d. Inspect battery units.
   e. Inspect power modules.
2. Mechanical Inspection:
   a. Check UPS and external maintenance bypass cabinet internal control wiring connections.
   b. Check UPS and external maintenance bypass cabinet internal power wiring connections.
   c. Check UPS and external maintenance bypass cabinet terminal screws, nuts, and/or spade lugs for tightness.
3. Electrical Inspection:
   a. Verify correct input and bypass voltage.
   b. Verify correct phase rotation of mains connections.
   c. Verify correct UPS control wiring and terminations.
   d. Verify voltage of battery modules.
   e. Verify neutral and ground conductors are properly landed.
   f. Inspect external maintenance bypass switch for proper terminations and phasing.
4. Site Testing:
   a. Ensure proper system start-up.
   b. Verify proper firmware control functions.
   c. Verify proper firmware bypass operation.
   d. Verify proper maintenance bypass switch operation.
   e. Verify system set points.
   f. Verify proper inverter operation and regulation circuits.
   g. Simulate utility power failure.
   h. Verify proper charger operation.
   i. Document, sign, and date test results.
5. On-Site Operational Training: During the factory-assisted start-up, operational training for site personnel shall include, but shall not be limited to, key pad operation, LED indicators, start-up and shutdown procedures, maintenance bypass and AC disconnect operation, and alarm information.

3.03 FIELD QUALITY CONTROL

A. General: See Section 01450- Special Inspection and Testing.

B. Manufacturer Field Service:

1. Worldwide Service: The UPS manufacturer shall have a worldwide service organization available, consisting of factory-trained field service personnel to perform start-up, preventative maintenance, and service of the UPS system and power equipment. The service organization shall offer 24 hours a day, 7 days a week, 365 days a year service support.

2. Replacement Parts: Parts shall be available through the worldwide service organization 24 hours a day, 7 days a week, 365 days a year. The worldwide service organization shall be capable of shipping parts within four working hours or on the next available flight, so that the parts may be delivered to the Owner within 24 hours.

3.04 DEMONSTRATION

A. General: Provide the services of a factory-authorized service representative of the manufacturer to provide start-up service and to demonstrate and train the Owner's personnel.

1. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

2. Train the Owner's maintenance personnel on procedures and schedules related to start-up and shutdown, troubleshooting, servicing, and preventive maintenance.

3. Review data in operation and maintenance manuals with the Owner's personnel.

4. Schedule training with the Owner, through the Architect/Engineer, with at least seven day's advanced notice.

B. UPS Training Workshop: A UPS training workshop shall be available from the UPS manufacturer. The training workshop shall include, but shall not be limited to, a combination of lecture and practical instruction with hands-on laboratory sessions. The training workshop shall include, but shall not be limited to, instruction about safety procedures, UPS operational theory, sub-assembly identification and operation, system controls, adjustments, preventative maintenance, and troubleshooting.

3.05 PROTECTION

A. Provide final protection and maintain conditions in a manner acceptable to the Installer, which shall ensure that the solid state UPS shall be without damage at time of Substantial Completion.

END OF SECTION 16264

SECTION 16361
LOW VOLTAGE SWITCHGEAR

PART 1 - GENERAL

1.01 SCOPE

A. Work described in this Section includes furnishing all labor, materials, equipment, tools and incidentals required for a complete and operable installation of metal enclosed low voltage power switchgear, rated 600 volts. All equipment shall be installed, adjusted, tested and placed in operation in accordance with these Specifications, the manufacturer's recommendations and as shown on the Drawings.

B. Contract drawings show only functional features and some of the required external connections. They do not show all components required for a complete installation nor exact dimensions particular to any manufacturer's equipment. Contractor shall supply all parts, devices and equipment necessary to meet the requirements of the Contract Documents and shall make all dimensional adjustments particular to the equipment being furnished. All costs associated with such changes and adjustments shall be considered as being included in the price bid for the work shown and specified.

C. Related Work specified elsewhere:

1. Section 16000 - Electrical Power and Systems.
2. Section 16050 - Basic Electrical Material and Methods.
3. Section 16175 - Instrument Transformers, Meters, Switches and Accessories.
4. Section 16450 - Grounding.

1.02 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions of the Contract Documents. In addition, the following specific information shall be provided:

1. Electrical Elementary Diagrams and Internal Connection Diagrams.
2. Manufacturer's data indicating interrupting, withstand and continuous current ratings of all equipment components.
3. Arrangement and layout drawings of the switchgear enclosures depicting equipment and bus bar arrangement, size and number of busbars per phase, neutral and ground nameplate legends and overall dimension including areas of permissible cable entries. A list of material and components shall accompany the layout drawings.
4. Results of factory tests and field breaker setting tests as specified in paragraph 16361-3.02.
5. Time current curves on 14-inch log-log transparency paper for all protective devices.
6. Mimic bus layout.
7. Catalog data on all electrical devices and components mounted on or within the switches.

1.03 QUALITY ASSURANCE

A. Reference Standards: Comply with all Federal and State laws or ordinances, as well as all applicable codes, standards, regulations and/or regulatory agency requirements including the partial listing below:

1. ANSI, American National Standards Institute.
2. NEMA, National Electrical Manufacturers Association.
3. UL, Underwriters laboratories.

1.04 QUALITY STANDARDS

A. The switchgear covered by these Specifications shall be designed, tested and assembled in accordance with the following standards.

1. ANSI C37.20, Switchgear assemblies including metal enclosed busbars.
2. ANSI C57.13, Requirements for Instrument Transformers.
3. NEMA SG-5, Metal Enclosed Switchgear Assembly.
4. UL 1558, Switchgear Design.

B. Manufacturers offering products that comply with these Specifications include:

1. Square-D Company.
2. General Electric Company
3. Cutler-Hammer Electric Corporation.
4. Or equal.

1.05 WARRANTY

A. Provide a warranty against defective equipment and workmanship in accordance with the requirements of the General Conditions of the Contract Documents.

1.06 DELIVERY, STORAGE AND HANDLING

A. Arrange shipping splits as required for installation. Individually wrap each section and mount on shipping skids.

B. Store in a clean and dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect equipment from dirt, water, construction debris and traffic.

C. Handle in accordance with NEMA PB-2.1 and manufacturer's written instructions. Lift only with lugs provided for the purpose.

PART 2 - PRODUCTS

2.01 GENERAL

A. Furnish switchgear rated 600 volt, 3-phase, 3-wire or 4-wire, 60 Hertz. Brace buses and bus structures for the rms symmetrical amperes, short circuit as indicated on the Drawings.

B. Coordinate all primary parts of the metal enclosed equipment, including circuit breakers, fuses, buses, connections and insulators to withstand mechanical and thermal stresses for use on the proposed system.

C. Furnish steel channel sills with suitable drilled holes for mounting, aligning and bolting switchgear in place. Method of mounting as indicated. Provide size recommended by switchgear manufacturer and acceptable to Engineer. Paint completed sills with two coats of aluminum paint or other acceptable corrosion-resistant finish before setting in place.

D. If switchgear equipment pads are located on concrete floor slabs, furnish painted steel channel mounting sills and anchor bolts, including location instruction for setting in place during construction of the concrete equipment pads.

2.02 ENCLOSURE

A. Switchgear shall be factory assembled and metal enclosed. Each unit shall consist of a stationary structure assembly and one or more air circuit breaker units, disconnecting devices, and other specified equipment. Switchgear shall be suitable for 600V, 3 phase maximum service. Each unit shall be provided with a breaker hoist for removing the breaker for maintenance.

B. Switchgear shall be completely self-supporting structure of required number of vertical sections bolted together to form one metal enclosed switchgear 90 inches (2,300 mm) high. Sides, top and rear covers are code gauge steel, bolted to switchgear structure. Frame structure members die-formed 11 gauge steel bolted together and reinforced at external corners, with rugged gussets internal and external to structure members. Switchgear frame shall be suitable for use as floor sills in indoor installations. Switchgear assemblies shall conform to NEMA Standard SG-5. The switchgear shall be furnished with an indoor NEMA 1 enclosure.

C. Outdoor switchgear shall be fully weatherproof, housed in a factory assembled outdoor enclosure, have lifting plates at the base of the structure, hinged aisle doors with rubber gaskets and pad locking provisions, asphalt base undercoating on the exterior bottom, interior lights, space heater per vertical section, outlets and light switch and space heater switch. Enclosure shall include front aisle space running the full length of the equipment, sloping roof, rear bolted hinged doors, breaker lifting device, wire meshed louvers and rodent guards.

2.03 SWITCHGEAR CONSTRUCTION

A. Provide switchgear with incoming line main devices in individually mounted construction, and feeder devices in group-mounted construction. Incoming line main devices side or rear accessible through bolted-on covers. Group mounted devices, front accessible per NEMA standards, furnished with wiring gutters on front of distribution vertical sections of switchgear. Provide gutters with code gauge steel formed covers bolted to structure frame. Cover unused device space with blank code gauge steel formed covers.

B. Construct metal-enclosed switchgear structure from formed sections of specially smoothed and leveled steel, not less than 11 gage, welded together and reinforced, where necessary, with formed steel members. Resulting structure shall be totally enclosed, self-supporting free-standing.

C. Make provision for conduit and cable entrance from top or bottom as indicated.

D. Enclose bus compartments and the instrument and control power transformer compartments completely with sheet steel and separate from each other by means of tightly fitted steel barriers.

E. Where space is indicated, provide compartment complete with buses, bus supports, insulators, primary and secondary disconnects, rails and other accessories to require only insertion of breaker removable element. Provide insulating barriers in switchgear units to cover all live parts.

F. Each breaker compartment shall be equipped with primary and secondary contacts, rails, and stationary levering mechanism. A rear hinged cover shall be provided for each cable compartment, and a front-hinged door shall be provided for each breaker and metering component.

G. Structures shall be provided with horizontal and vertical barriers to separate different voltage classes, buses and incoming cables.

2.04 BUS BARS

A. Main bus and riser bus shall be tin plated copper supported with high impact, non-tracking insulating material, and braced to withstand mechanical forces exerted during short circuit conditions, to rating of protective devices as indicated.

B. Contact surfaces of main bus joints and all tap connections shall be silver-plated.

C. Current density of bus not to exceed 750 amperes per square inch cross-section. If main circuit protective device is provided, continuous current rating of bus shall be equivalent to frame size rating of that device.

D. Furnish a ground bus and secure to each vertical section structure. Extend ground bus for entire length of switchgear. Ground bus shall have momentary rating equal to highest circuit breaker momentary rating in the assembly and provided with one clamp type terminal at each end for No. 4/0 bare copper ground. Ground bus shall be copper.

E. Furnish a neutral bus for 3- phase, 4-wire system. Neutral bus shall have the same ampacity as the main bus. Neutral bus shall be copper.

2.05 CIRCUIT BREAKERS

A. Breaker element shall consist of a three-pole manually operated electrically and mechanically trip-free power circuit breaker with solid state, overcurrent trip device, arc quenchers, manual stored energy closing mechanism, mechanical pushbutton trip and position indicator. Breaker element shall be suitable for mounting on the drawout mechanism in the circuit breaker compartment. Main and feeder circuit breakers shall have a minimum interrupting current of 100,000 (symmetrical) at 480 volt.

B. Disconnecting devices shall be the self-aligning type with the disconnecting fingers mounted on the breaker. The drawout mechanism shall, rigidly hold the circuit breaker in the fully connected, test, and fully disconnected positions. Interlocks shall be provided to prevent moving the circuit breaker from fully connected, test, or fully disconnected positions unless the breaker is open. Interlocks shall also prevent closing the breaks between any of these, positions.

C. The drawout mechanism shall be designed so that the breaker can be racked to any position without opening the door. A hasp on the breaker escutcheon shall be provided that can receive three padlocks when the breaker is in the open position.

D. Unless otherwise specified, breakers shall be equipped with one normally open and one normal closed auxiliary switch. Switches shall be rated 10 amperes, 120 volts AC wired to terminal blocks.

E. Solid state tripping devices shall consist of current sensor logic assembly, magnetic latch release, and required interconnecting wiring. Tripping devices shall be automatic and self-contained within the breaker frame, and shall not require external relaying or power supplies. Tripping device for feeder breakers shall include current indicating function for each phase, utilizing a digital, LCD display with a clear plastic cover.

F. Tripping device shall be provided with manually resettable fault indicators. As a minimum, fault indicators shall provide indication of tripping caused by overload, short circuit or ground fault.

G. Tripping functions shall be field adjustable and shall provide, as specified, the following tripping characteristics:

1. Overload Tripping:
   a. Adjustable ampere setting.
   b. Adjustable long-time delay.
2. Short Circuit Tripping:
   a. Adjustable short-time pick-up.
   b. Adjustable short-time delay.
   c. Adjustable instantaneous pick-up.
3. Ground Fault Tripping:
   a. Adjustable ground fault pick-up.
   b. Adjustable ground fault delay.
4. Ground fault protection for main circuit breakers shall be accomplished by hard-wired relay 51G, and shall not be included in the solid state tripping device.

H. Ground fault relays for double ended, multiple grounded configurations shall be fully responsive to ground fault currents returning to either source, and shall not respond to line to neutral currents.

I. Provide one 51G ground overcurrent relay for transformer secondary overcurrent protection.

J. Provide 1 current transformers 1,200/5 on the transformer secondary neutral.

2.06 WIRING

A. Switchgear shall be completely wired at factory. All secondary shall be made with standard switchgear wire and cable, single conductor 900 C copper wire UL listed for panel wiring, minimum size No. 14 AWG.

B. Provide acceptable terminal blocks with marking strips for all secondary circuits leaving metal enclosed structure and for interconnecting separate compartments.

C. Enclose all wiring between stationary units in metal raceway or compartments with removable covers.

D. Where wiring connections are made to equipment mounted on hinged doors, provide terminal blocks or wire cleats for all secondary and control circuits leaving metal enclosed structure and for connecting separate compartments. Conductor markers shall be as specified in Section 16120.

2.07 CONTROL POWER TRANSFORMERS

A. Control power transformers shall be rated 480-120 volts, single-phase, 2-wire, 60 Hertz, with kva rating as required by switchgear, but not less than 1.0 kva. Mount current limiting primary fuses for control power transformer on disconnecting or draw out fuse mounts. Provide secondary fuses.

2.08 INSTRUMENTS, RELAYS AND CONTROL EQUIPMENT

A. All instruments and relays shall be provided with semi-flush mounted cases and dust tight. All relays, instruments and meters shall be accurately calibrated for satisfactory operation after installation. Instrument relays shall conform to NEMA Std. 11-2.

B. Protective devices shall be adjusted to the settings specified in Section 16100, prior to energizing switchgear.

C. Fuse blocks and fuses shall be provided as required, for the protection of the instruments.

D. Suitable rated current and potential test blocks shall be furnished with matching plugs, for connecting external instruments installed as indicated. Test blocks shall be 6- or 8-point, suitably marked and connected for inserting both current and potential test leads.

E. Indicating instruments and control switches shall be in accordance with Section 16175, Instrument Transformers, Meters, Switches and Accessories.

2.09 NAMEPLATES

A. Provide nameplates for switchgear main and feeder breakers engraved on laminated plastic with black lettering on white background. Nameplates shall comply with Section 16050-2.11.

2.10 PAINTING

A. All steel surfaces of switchgear assembly shall be chemically cleaned and finished with ANSl No. 61 gray enamel over rust-resistant undercoat.

B. All meters, instruments and relays shall be provided with dull black finish.

2.11 SPARE PARTS

A. Provide spare parts as recommended by manufacturer.

B. Package spare equipment in suitable containers bearing labels clearly indicating contents and in what equipment used.

C. Deliver spare parts at same time as equipment. Properly store and safeguard such spare parts until completion of work, at which time deliver as directed by the Engineer.

2.12 MIMIC BUS

A. Provide a laminated, plastic mimic bus illustrating single line diagram identifying breaker numbers and load supplied by the breaker. Permanently mount the mimic bus with stainless steel screws.

2.13 FACTORY TESTS

A. After assembly, switchgear shall be tested for operation at the specified voltage and current ratings. The main circuits shall be given a dielectric test of 2,200V for 1 minute between the live parts and ground, and between opposite polarities. The wiring and control circuits shall be given a dielectric test of 1500V for 1 minute between the live parts and ground.

B. Instrument transformers shall have ratio and phase angle tests made in conformance with ANSI C57.13.

C. Three copies of test results shall be submitted to the Engineer.

2.14 NETWORKING

A. Switchgear shall be ModBus compatible. Connect to PLC, pump monitoring panels, and local control panels.

2.15 SURGE PROTECTIVE DEVICE

A. A surge protective device shall be furnished and installed with the switchgear. Refer to SECTION 16445 – SURGE PROTECTIVE DEVICE FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Properly set and level channel sills.

B. Furnish complete, clear; and concise instructions for installation, operation, and maintenance of the equipment

3.02 FIELD TESTS

A. The protective devices shall be adjusted to the settings specified in the coordination study prior to energizing the switchgear.

B. Each switchgear breaker shall be tested in accordance with Section 16999.

END OF SECTION 16361

SECTION 16430
PROTECTIVE RELAYING

PART 1 - GENERAL

1.01 SCOPE

A. Work described in this Section includes furnishing all labor, materials, equipment, tools and incidentals required for a complete and operable installation of all protective relaying. All protective relaying shall be installed, adjusted, tested and placed in operation in accordance with these Specifications, the manufacturer's recommendations and as shown on the Drawings.

B. Contract Drawings show only functional features and some of the required external connections. They do not show all components required for a complete installation nor exact dimensions particular to any manufacturer's equipment. Contractor shall supply all parts, devices and equipment necessary to meet the requirements of the Contract Documents and shall make all dimensional adjustments particular to the equipment being furnished. All costs associated with such changes and adjustments shall be considered as being included in the price bid for the work shown and specified.

1.02 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions of the Contract Documents. In addition, the following specific information shall be provided:

1. Catalog cuts: Full-size time-current curves on vellum similar to the log graph as produced by K&E and instruction manuals shall be submitted to the Engineer for approval within 90 days after receipt of Notice to Proceed.

1.03 QUALITY ASSURANCE

A. Reference Standards: Comply with all Federal and State laws or ordinances, as well as all applicable codes, standards, regulations and/or regulatory agency requirements including the partial listing below:

1. ANSI C37.9, Relays.
2. ANSI C37.91, IEEE Guide for Protective Relay Application to Power Transformers.
3. ANSI C37.92, Guide for Induction Motor Protection.
4. ANSI C37.95, Guide for Protective Relaying of Utility-Consumer Interconnections.

1.04 RELAY SETTINGS

A. The Contractor shall furnish the Engineer with relay settings and exact relay model number not later than 120 days after receipt of the following information from the manufacturers:

1. All motor data sheets for 125 HP and larger.
2. All motor heating curves for motors 125 horsepower and larger.
3. All switchgear and switchboard submittal information.

4. Impedance and ratio submittals on medium and high voltage transformers.
5. Burden, accuracy class and ratio data submittals on all instrument transformers.
6. All protective relay submittal information.

B. The protective relay settings shall be provided to the Engineer not later than 120 days prior to the beginning of compliance testing. Actual time current, time voltage and time frequency configurations shall be determined by the coordination study results. Protective relays required to conform to this study recommendations shall be provided, at no additional cost to the City.

PART 2 - PRODUCTS

2.01 GENERAL

A. Protective relays shall be semi-flush mounting, back connected and have dust-tight cases. Protective relays except timing relays shall have removable chassis construction, which provides for removal of the relay without disconnecting leads or removing the case from the panel. Means shall be provided to automatically short-circuit associated current transformer secondaries when the relay is removed from its case. External circuits which are normally operated open shall remain open during the time the relay is being removed or replaced and while the relay is out of the case, even though the relay contacts may close. Likewise, external circuits, which are normally operated closed shall remain closed. Provisions shall be made to permit inserting test plugs in series with all current transformer secondaries and in parallel with all potential transformer secondaries. Test plugs shall be furnished, each with sufficient points to test all relays. Relay front cover shall be removable from the front without the use of tools. Where available as a standard option, targets and seal-in contacts shall be provided. Targets shall be resettable from the front without removing the cover. The relays, unless specified otherwise, shall be for operation on a 24 volt DC control bus. The relays shall have silver-to-silver non-bouncing contacts rated 30 amperes current closing at 24 volts. The relays Co be provided shall be as specified. All relays shallbe the product of a single manufacturer. Relays are listed in terms of functions and IEEE device number for that function in parentheses.

2.02 OVERCURRENT RELAYS

A. Time Current and Instantaneous Overcurrent Relay (50/51): Used to protect electrical equipment, bus and cables from phase-to-phase and three-phase faults, very inverse time characteristics, 11-12 amperes current range, 60 Hz, with current coil rated 5 amperes continuous, 6-150 amperes instantaneous unit, 0.2/2 ampere seal-in unit with target. Cutler-Hammer Type CO-, General Electric Type IAC, or equal.

B. Time overcurrent (51G): Used to protect generator and transformer from phase-to-ground or phase-to-phase faults, 1.5-6.0 amperes current range, 60 Hz, with current coil rated 5 amperes continuous, 0.2/2 ampere seal-in unit with target. Westinghouse Type CO, General Electric Type IAC, or equal.

C. Time Overcurrent (51N): Used to protect cables from phase-to-ground or phase-to-phase faults, 1.5-6.0 amperes current range, 60 Hz, with current coil rated 5 amperes continuous, 0.2/2 ampere seal-in unit with target. Cutler-Hammer Type CO, or equal.

D. Contractor shall field verify existing relays and match.

2.03 LOCKOUT RELAY (86)

A. Used to lockout or prevent reclosing of circuit breaker when a protective relay senses a fault condition. 125 volts, number of contacts specified, rated 2.0 amperes inductive, hand reset. Westinghouse Type WL, General Electric Type HEA, or equal.

2.04 AUXILIARY RELAYS

A. Auxiliary Relays 24V DC: Number of contacts specified, reversible type contacts, self-reset, flush mounted, Westinghouse Types MG-6 and SG, General Electric Types HFA and HGA, or equal.

B. Auxiliary Relays 120 VAC: Number of contacts specified, reversible type contacts, self-reset, flush mounted, Westinghouse Type MG-6, General Electric Type HFA, or equal.

2.05 NAMEPLATES

A. A lamicoid plastic nameplate, white face, ¾-inch high by 3 inches long shall be provided to identify each protective relay as specified.

2.06 FACTORY TESTING

A. Prior to shipping, all protective relaying circuits shall be completely assembled and tested for proper operation, continuity, and insulation resistance.

PART 3 - EXECUTION

3.01 GENERAL

A. Protective relays shall be installed as specified.

3.02 WIRING

A. All protective relays provided in switchgear shall be completely wired to terminal blocks including spare contacts. Wiring methods shall be as specified in the sections covering the specific switchgears or switchboards.

B. No conductors shall be routed across the rear of a device in a manner, which will cover or obstruct access to lead, terminals or devices.

C. Connection for all external wiring shall be terminated on conveniently located terminal blocks. Terminal block marking strips stamped with the conductor designations as shown on the elementary diagrams shall be provided.

D. Internal wiring shall be so designed so that only one external wire will be attached to each terminal point. Terminations shall be segregated and separated as to low voltage power, low voltage control, metering, and low-level signal circuits.

E. Twenty percent spare terminal points shall be provided.

3.03 GROUNDING

A. All protective relay cases shall be grounded effectively.

3.04 FIELD ACCEPTANCE TESTS

A. Protective relays shall be set as per Engineer's instructions. The Contractor shall, in addition to the tests described in Section 16000, retain the services of a qualified engineering appraisal and testing organization to perform the following tests:

1. Verify all relay settings and calibrations by inserting controlled currents and voltages into the relays.
2. Verify that all instrument transformers are of the correct ratio.

END OF SECTIONS 16430

SECTION 16440
DISCONNECT SWITCHES

PART 1 - GENERAL

1.01 SCOPE

A. Work described in this Section includes furnishing all labor, materials, equipment, tools and incidentals required for a complete and operable installation of disconnect switches, fuses and enclosures. All equipment shall be installed, adjusted, tested and placed in operation in accordance with these Specifications, the manufacturer's recommendations and as shown on the Drawings.

B. Contract drawings show only functional features and some of the required external connections. They do not show all components required for a complete installation nor exact dimensions particular to any manufacturer's equipment. Contractor shall supply all parts, devices and equipment necessary to meet the requirements of the Contract Documents and shall make all dimensional adjustments particular to the equipment being furnished. All costs associated with such changes and adjustments shall be considered as being included in the price bid for the work shown and specified.

1.02 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions of the Contract Documents. In addition the following specific information shall be provided:

1. Product data including outline drawings with dimensions, and equipment ratings for voltage, capacity, horesepower and short circuit.

1.03 QUALITY ASSURANCE

A. Reference Standards. Comply with all Federal and State laws or ordinances, as well as all applicable codes, standards, regulations and/or regulatory agency requirements including the partial listing below:

1. NEC, National Electrical Code.
2. NEMA, National Electrical Manufacturers Association
3. ANSI, American National Standards Institute.

1.04 QUALITY STANDARDS

A. All products covered by these specifications shall be in conformance with the NEMA standards and shall be UL approved.

B. Manufacturers offering products that comply with these Specifications include:

1. Disconnect Switches: General Electric, Siemens, Square D, Cutler-Hammer or equal.
2. Fuses: Bussmann, Gould, Littlefuse or equal.

PART 2 - PRODUCTS

2.01 DISCONNECT SWITCHES

A. Fusible Switch Assemblies: NEMA KS-1; FS W-S-865; quick-make, quick-break, 600 volt heavy duty load interrupter enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position. Handle lockable in OFF position. Fuse Clips: FS W-F-870; designed to accommodate fuses as specified in 16050-2.02.

B. Nonfusible Switch Assemblies: NEMA KS 1; FS W-S-865; quick-make, quick-break, 600 volt heavy duty load interrupter enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position. Handle lockable in OFF position.

C. Enclosures: NEMA KS-1; Type as follows:

1. Indoors: NEMA 12.
2. Outdoors and Corrosive Areas: NEMA 4X nonmetallic.
3. Hazardous Areas: NEMA 7.

2.02 FUSES

A. Fuses 600 Amperes and Less: ANSI 198C, Class as specified in 16050-2.02. Equip with rejection feature where indicated.

B. Interrupting Rating: 200,000 rms amperes.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install disconnect switches where indicated on Drawings.

B. Install fuses in fusible disconnect switches.

END OF SECTION 16440

SECTION 16445
SURGE PROTECTIVE DEVICE FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.01 GENERAL

A. The Surge Protective Device (SPD) covered under this section includes all surge protective devices suitable for use as Type 1 or Type 2 devices per UL1449 3rd Edition, applied to the line or load side of the utility feed inside the facility, at the Service Entrance and Distribution and Branch Panels, Switchgear, Motor Control Centers, and Switchboard assemblies, for low voltage (120-600V) equipment.

B. Contractor shall provide all labor, materials, equipment and incidentals as shown, specified and required to finish and install surge protective devices.

1.02 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating weights, operating characteristics, furnished specialties, and accessories. Package must include shop drawings complete with all technical information, unit dimensions, detailed installation instructions, maintenance manual, recommended replacement parts list and wiring configuration.

B. Field quality control test reports.

C. Operation and Maintenance Data.

D. Warranty Statement.

1.03 QUALITY ASSURANCE

A. Source Limitations: Obtain suppression devices and accessories through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with IEEE C62.41, "IEEE Guide for Surge Voltages in Low Voltage AC Power Circuits," and test devices according to IEEE C62.45, "IEEE Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits."

D. Comply with NEMA LS 1, "Low Voltage Surge Protection Devices."

E. Comply with UL 1283, "Electromagnetic Interference Filters," and UL 1449, 3rd edition 2009 revision.

F. SPD shall be factory tested prior to shipment.

G. Ship the SPD components with the electrical equipment in accordance with the requirements specified in these specifications and protect the equipment from damage, dirt, dust, rain, and other elements.

1.04 PROJECT CONDITIONS

A. Service Conditions: Rate surge protection devices for continuous operation under the following conditions, unless otherwise indicated:

1. Maximum Continuous Operating Voltage: Not less than 115 percent of nominal system operating voltage.
2. Operating Temperature: 0 to 120 deg F.
3. Humidity: 0 to 85 percent, non-condensing.
4. Altitude: Less than 20,000 feet above sea level.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Current Technologies
2. Cutler-Hammer, Inc.; Eaton Corporation.
3. General Electric Company.
4. Siemens Energy & Automation, Inc.
5. Square D; Schneider Electric.

2.02 SWITCHBOARD SUPPRESSORS

A. Electrical Requirement:

1. Refer to Drawing for operating voltage, configuration and surge current capacity per mode for each location.
2. Declared Maximum Continuous Operating Voltage (MCOV) shall be greater than 115 percent of the nominal system operating voltage and in compliance with test and evaluation procedures outlined in the nominal discharge surge current test of UL1449 3rd Edition, section 37.7. MCOV values claimed based on the component's value or on the 30-minute 115% operational voltage test, section 38 in UL1449 will not be accepted.
3. Unit shall have not more than 10% deterioration or degradation of the UL1449 3rd Edition Voltage Protective Rating VPR) due to repeated surges. Unit shall have a monitoring option available to be able to test and determine the percentage of protective available at all times.
4. Each unit shall provide the following features:
   a. Integral disconnect switch.
   b. Field testable while installed.
   c. Phase Indicator lights, Form C dry contacts, surge counter and audible alarm.

d. Measuring capability to indicate the percent protective available in SPD.

e. Surge-event operations counter.

B. Peak Single-Impulse Surge Current Rating: 240 kA per mode or per Drawing, whichever is greater.

C. Connection Means: Permanently wired.

D. Protection modes and UL 1449 suppressed voltage rating for grounded wye circuits with voltages of 480Y/277, 3-phase, 4-wire circuits shall be as follows:

1. Line to Neutral: 800V for 480Y/277.
2. Line to Ground: 800V for 480Y/277.
3. Neutral to Ground: 800V for 480Y/277.

2.03 PANELBOARD SUPPRESSORS (480V)

A. Provide same as for Switchboard above, except:

1. Suitable for 480V, 3 phase, 3 wire or 480V 3 phase, 4 wire as applicable.
2. Surge Current Rating: 160kA per mode or per Drawing, whichever is greater.
3. Integral disconnect switch not required.

2.04 PANELBOARD SUPPRESSORS (208/120V)

A. Provide same as for 480V Panelboard Suppressors above, except:

1. Suitable for 208/120V, 3 phase, 4 wire.
2. Surge Current Rating: 90kA per mode or per Drawing, whichever is greater.
3. Integral disconnect switch not required.

B. Protection modes and UL 1449 suppressed voltage rating for grounded wye circuits with voltages of 208Y/120, 3-phase, 4-wire circuits shall be as follows:

1. Line to Neutral: 400V for 208Y/120.
2. Line to Ground: 400V for 208Y/120.
3. Neutral to Ground: 400V for 208Y/120.

2.05 ENCLOSURES

A. NEMA 250, with type matching the enclosure of panel or device being protected.

PART 3 - EXECUTION

3.01 INSTALLATION OF SURGE PROTECTION DEVICES

A. Each unit shall be installed per Manufacturer's recommended installation and wiring practices, as show on the drawing supplied.

B. Install devices for panelboard 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 bond neutral and ground.

1. Provide multi-pole, 30A, 60A, and 100A circuit breaker as a dedicated disconnect for suppressor, unless otherwise indicated.

3.02 PLACING SYSTEM INTO SERVICE

A. Do not energize or connect service entrance equipment, panelboards, or control terminals to their sources until surge protection devices are installed and connected.

3.03 FIELD QUALITY CONTROL

A. Testing: The SPD manufacturer's technician shall perform a system checkout and start-up in the field to assure proper installation, operation and to initiate the warranty of the system. The technician will be required to do the following:

1. Verify voltage clamping levels using the DTS-2 test equipment.
2. Verify N-G connection when applicable.
3. Record information to product signature card for each product installed

3.04 PRODUCT WARRANTY

A. Warranty on defective material and workmanship for term of 10 years from the date of substantial completion.

B. Copy of Warranty to be sent with submittal.

C. Manufacturer shall warrant all equipment provided under this Section to be free of defects in materials or workmanship for a period of at least one year starting on the date of substantial completion. In general, the substantial completion date will occur prior to commencement of the acceptance tests and 120-day Whole Plant Testing. Warranty periods will not start based on date of delivery of the equipment.

3.05 PROTECTION

A. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and installer, to ensure that coatings, finishes, and cabinets are without damage or deterioration at Substantial Completion.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

2. Repair damage to paint finishes with matching touch-up coating recommended by the manufacturer.

3.06 TRAINING

A. Provide a minimum of 1-hours of training for all similar TVSS systems.

3.07 CLEANING

A. Upon completion of installation of system, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions.

END OF SECTION 16445

SECTION 16450
GROUNDING

PART 1 - GENERAL

1.01 SCOPE

A. Work described in this Section includes furnishing all labor, materials, equipment, tools and incidentals required for a complete installation of grounding system. All work shall be installed, adjusted and tested in accordance with these Specifications, the manufacturer's recommendations and as shown on the Drawings.

B. Contract Drawings show only functional features and some of the required external connections. They do not show all components required for a complete installation nor exact dimensions particular to any manufacturer's equipment. Contractor shall supply all parts, devices and equipment necessary to meet the requirements of the Contract Documents and shall make all dimensional adjustments particular to the equipment being furnished. All costs associated with such changes and adjustments shall be considered as being included in the price bid for the work shown and specified.

1.02 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions of the Contract Documents. In addition, the following specific information shall be provided:

1. Test Reports: Submit directly to the Engineer two copies of the test reports certified by the testing technician.

1.03 QUALITY ASSURANCE

A. Reference Standards: Comply with all Federal and State laws or ordinances, as well as all applicable codes, standards, regulations and/or regulatory agency requirements including the partial listing below:

1. NEC, Article 250.
2. IEEE 81-83.

1.04 DELIVERY, STORAGE AND HANDLING

A. Materials shall be delivered to the site and stored in the area assigned.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Ground rods shall be ¾ inch diameter by 10 feet long, copper-clad steel, Josyln, or equal. Ground rods shall be sectional type with threaded type removable caps and coupler, where lengths greater than 10 feet are required.

B. Conductors shall be stranded copper, except that No. 6 A.W.G., when installed bare, shall be solid. When installed in raceways, conductors shall have specified 600 volt insulation, color coded green.

C. Exposed or accessible connections shall be made with copper or bronze grounding clamps, lugs, through-bolts, or other fittings specifically intended for such use such as grounding bushings, etc. Underground or other inaccessible connections shall be made by the exothermic welding process.

D. Aluminum grounding materials will not be accepted.

PART 3 - EXECUTION

3.01 APPLICATION

A. Items to be grounded shall include, but not necessarily be limited to, the following:

1. Steel building structures and all other above-ground metal structures.
2. Metallic raceways.
3. Electrical equipment enclosures.
4. Electrical system neutrals, only, at the point of supply.
5. Ground buses of switchboards, motor control centers, panelboards, etc.
6. Grounding pole of all receptacles.
7. Lighting fixture housings, outdoor metal light poles, etc.
8. Motors and other electrically operated equipment.
9. Outdoor metal fences.
10. Telephone service equipment (provide grounding leads only).
11. Lightning arresters (where required).
12. Medium and/or high voltage structures, housings, hardware, cable shields, static wires, etc., where applicable, other than items which are Utility Company owned.
13. Transformers.
14. Any equipment likely to become energized due to a malfunction
15. Ground grid systems with ground rod and water pipe connections.

3.02 INSTALLATION

A. The grounding installation shall conform with requirements indicated on the drawings and with the following:

1. Ground rods shall be driven vertically with top of rod 4" below grade, except that, where solid rock is encountered, rods may be tilted or, where necessary, may be placed horizontally.
2. Below grade grounding loops, mats and/or leads shall consist of 4/0 bare stranded copper cable not less than 2'-6" below the finished surface. Where indicated to be outside of building perimeter or other structure lines, foundation pads, etc., conductors shall be located

not less than 3 feet, horizontally, outside of building foundations or from the edge of pads, etc.

3. Grounding risers shall be properly located so as not to comprise an obstruction or hazard to vehicle or pedestrian traffic. Risers for grounding steel columns shall rise within the concrete piers but shall clear column base-plates. Connections to exposed columns shall be "CADWELD" or "THERMO-WELD" type, located approximately 12 inches above the finished surface, and shall be made to the web of H shapes and to the inner surface of channels or angles. Connections to furred or otherwise inaccessible columns shall be made by brazing or welding. Risers to floor mounted equipment, such as switchboard, motor control centers, etc., shall be accessibly located under the equipment and be connected with bolted lugs. At permanent walls risers intended for extension within the building shall rise into an adequately sized junction box, surface or flush mounted to match other wiring within the area, approximately 1 foot above the floor, from which it shall be extended as insulated wire in conduit to the item or items to be grounded. Risers for extension or connection by others shall be left with approximately 4 feet of conductor coiled.

4. Grounding jumpers shall be provided between the building grounding system or the grounded building structure and every incoming metal underground cold water pipe, including all sprinkler risers where such exist.

5. Size of grounding conductors shall not be less than called for on the drawings, and otherwise shall not be less than the following:
   a. 4/0 A.W.G. for all buried or otherwise inaccessible conductors.
   b. For grounding A.C. system neutrals, as required by N.E.C. Table 250-94.
   c. For raceway and equipment grounding, as required by N.E.C. Table 250-95.
   d. No. 2 A.W.G. where installed exposed.
   e. For grounding low voltage ground buses, as required by NEC Table 250-94.

6. Grounding conductors, insulated and color coded green, shall be provided in all low voltage feeder and sub-feeder and branch circuit conduit runs, except low voltage service entrance conduit runs which contain a grounded neutral. These grounding conductors shall be connected to all metallic conduits by means of approved grounding bushings at all conduit terminations at the supply end of such circuits.

7. Outdoor metal fences provided under this Contract shall be bonded in not less than 3 places to an underground 4/0 grounding conductor extending not less than 25 feet on each side of the overhead line with not less than 3 ground rods bonded thereto, one in the center and one at each extremity. Fences around outdoor electrical substations shall be bonded to the substation grounding loop or grid at each corner post, at each gate post, and otherwise at points not greater than 25 feet apart, with flexible bonding jumpers provided for each gate.

8. Install sufficient ground rods in addition to code required grounding so that resistance to ground as tested by standard methods does not exceed 2 ohm unless otherwise accepted. Where more than one rod is required, install rods at least 10 feet apart.

9. Provide a bare conductor through each ductbank, connected to manhole/handhole ground rod. Connect to building ground grid or equipment frame as applicable.

10. Provide a logic ground for main computer and each PLC based local control panel separate from the power system ground. Route a 1/0 insulated copper conductor in a ¾-inch conduit to a ground cluster outside the building.

11. Were the manufacturer of equipment supplied from 120 volt instrument power panels requires an isolated ground, the Contractor shall provide an additional isolated ground

conductor from the equipment through the instrument power panel for connection to a ground cluster outside the building. The isolated ground conductor shall have green insulation with a yellow stripe and shall be run in the same raceway as the power and neutral conductors.

3.03 GROUNDING CONNECTIONS

A. Unless shown otherwise, make connections of grounding conductors to ground rods at the upper end of the rod with the end of the rod and the connection point below finished grade. Provide ground well, as shown on the Drawings to allow for inspection.

B. Make connections of sections of outdoor ground mats (counterpoise) for substations or other equipment underground. Make connections of other grounding conductors generally accessible.

C. In handholes and manholes, install ground rods with ends 4 to 6 inches above the floor with connections of duct bank grounding conductors fully visible and accessible.

D. When making thermo welds, wire brush or file the point of contact to a bare metal surface. Use thermo welding cartridges and molds in accordance with the manufacturer's recommendations. After welds have been made and cooled, brush slag from the weld area and thoroughly clean the joint. For compression connectors, use homogeneous copper, anticorrosion, surface treatment compound at connectors in accordance with connector manufacturer's recommendations. Use connectors of proper size for conductors and ground rods specified. Use connector manufacturer's compression tool. Notify Engineer prior to backfilling any ground connections.

E. Compression connectors shall be cast copper as manufactured by Thomas and Betts or equal.

3.04 EQUIPMENT GROUNDING

A. Ground each piece of electrical equipment by means of a grounding conductor installed in raceway feeding that piece of equipment with copper wire sized in accordance with NEC. Grounding conductors installed in conduit furnished with green, 600-volt insulation.

B. Connect transformer cases and neutrals to grounding system. Connect neutral ground connection at transformer terminal. Provide two separate, independent, diagonally opposite, connections for power transformers so removal of one connection will not impair continuity of other.

C. Connect two separate ground connections from ground grid to ground bus of switchgear assemblies, motor control centers and all outdoor substation equipment. Ensure that each connection for item of equipment is from different section of ground grid.

D. Install a separate grounding conductor from ground system to motors of 480 volts and higher, in addition to raceway system. Ground motor ground connection to motor frame, independent of mounting bolts or sliding base. Ground motor to nearest point on grounding system, unless otherwise indicated.

E. Connect lightning arrestors to ground system by suitable conductors.

F. Ground each street lighting standard by ground rod driven near base of standard, in accordance with requirements of NEC. Connect ground rods to grounding connector brought with street lighting feeder cable.

G. Where lightning arrestors are furnished with electrical equipment and grounding connections are not inherently provided, ensure that suitable separate grounding conductor connects lightning arrestors with system ground.

H. Bond service entrance equipment ground bus in each building to the ground grid with a #4/0 bare copper conductor.

3.05 FIELD TESTS

A. Test in the Engineer's presence the ground resistance of the grounding system.

B. The Contractor shall test the resistance of the grounding electrode system by the fall-of-potential method. The Contractor shall supply a Biddle No. 6322 Earth Tester, or equal, and make the test in the presence of the Engineer with grounding conductors disconnected. If the grounding electrode test resistance exceeds 1 ohm, the Contractor shall add ground rods or other grounding electrodes to the grounding electrode system until the grounding electrode test resistance is 3 ohms or less. Methods which change soil resistivity are not acceptable as means of lowering the grounding electrode test resistance. This test shall not be made within 24 hours after rainfall.

C. Test all ground fault circuit interrupter (GFCI) receptacles and circuit breakers for proper connection and operation with methods and instruments prescribed by the manufacturer.

D. Provide copies of reports of all grounding system tests for inclusion in Operation and Maintenance Manuals and for review by the Engineer.

END OF SECTION 16450

SECTION 16461
DRY TYPE TRANSFORMERS

PART 1 - GENERAL

1.01 SCOPE

A. Work described in this Section includes furnishing all labor, materials, equipment, tools and incidentals required for a complete and operable installation of dry type two winding transformers. All dry type transformers shall be installed, adjusted, tested and placed in operation in accordance with these Specifications, the manufacturer's recommendations and as shown on the Drawings.

1.02 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions of the Contract Documents. the following specific information shall be provided:

B. Product data. Include outline and support point dimensions of enclosures and accessories, unit weight, voltage, kVA, and impedance ratings and characteristics, loss data, efficiency at 25, 50, 75 and 100 percent rated load, sound level, tap configurations, insulation system type, and rated temperature rise.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Store in a warm, dry location with uniform temperature. Cover ventilating openings to keep out dust.

B. Handle transformers using only lifting eyes and brackets provided for that purpose. Protect units against entrance of rain, sleet, or snow if handled in inclement weather.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Equal to:

1. Cutler-Hammer.
2. Schneider Electric.
3. Siemens.
4. General Electric.

2.02 DRY TYPE TRANSFORMERS

A. Dry Type Transformers: NEMA ST-20; factory-assembled, air-cooled dry type transformers; ratings as indicated. Transformers shall be two winding power type. Three phase units shall be connected delta primary and wye secondary. Scott or Tee connections and autotransformers are not acceptable.

B. Insulation: 220 degrees C, 115 degree C rise for ratings 30 kVA and larger; 185 degrees C, 80 degree C rise for ratings below 30 kVA.

C. Taps: Two, 5% below rated primary for ratings smaller than 15 kVA; six, 2-1/2% two above and four below rated primary for ratings 15 kVA and larger.

D. Ground core and coil assembly to enclosure by means of a visible flexible copper grounding strap.

E. Mounting: Transformers 75 kVA and less shall be suitable for wall, floor, or trapeze mounting; transformers larger than 75 kVA shall be suitable for floor or trapeze mounting.

F. Isolate core and coil from enclosure using vibration-absorbing mounts.

G. Specialty transformers shall be provided as indicated on the Contract Drawings.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Set transformer plumb and level. Clear walls and ceilings by at least 6 inches to allow for air circulation.

B. Use flexible conduit, 2 ft minimum length, for connections to transformer case. Make conduit connections to side panel of enclosure.

3.02 FIELD QUALITY CONTROL

A. Check for damage and tight connections prior to energizing transformer.

B. Measure secondary voltage under normal load conditions and make appropriate tap adjustments.

END OF SECTION 16461

SECTION 16470
PANELBOARDS

PART 1 - GENERAL

1.01 SCOPE

A. Work described in this Section includes furnishing all labor, materials, equipment, tools and incidentals required for a complete and operable installation of panelboards. All panelboards shall be installed, adjusted, tested and placed in operation in accordance with these Specifications, the manufacturer's recommendations and as shown on the Drawings.

B. Contract drawings show only functional features and some of the required external connections. They do not show all components required for a complete installation nor exact dimensions particular to any manufacturer's equipment. Contractor shall supply all parts, devices and equipment necessary to meet the requirements of the Contract Documents and shall make all dimensional adjustments particular to the equipment being furnished. All costs associated with such changes and adjustments shall be considered as being included in the price bid for the work shown and specified.

1.02 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions of the Contract Documents. In addition, the following specific information shall be provided:

1. Quality and rating of circuit breakers provided with each panelboard.

1.03 QUALITY ASSURANCE

A. Reference Standards. Comply with all Federal and State laws or ordinances, as well as all applicable codes, standards, regulations and/or regulatory agency requirements including the partial listing below:

1. NEC, National Electrical Code.
2. Ul, Underwriters Laboratories.
3. NEMA, National Electrical Manufacturers Association.

1.04 QUALITY STANDARDS

A. The panelboards covered by these specifications shall be designed, tested and assembled in accordance with the following standards:

1. NFPA 70, National Electric Code (NEC).
2. UL67, Underwriters Laboratories, Electrical Panelboards.
3. UL489, Modeled Case Circuit Breakers and Circuit Beaker Enclosures.
4. UL50, Cabinet and Boxes.
5. NEMA PB-1, Panelboards.

B. Manufacturers offering products that comply with these Specifications include:

1. General Electric.
2. Siemens.
3. Square D.
4. Cutler-Hammer.
5. Or equal.

1.05 WARRANTY

A. Provide a warranty against defective equipment and workmanship in accordance with the requirements of the General Conditions of the Contract Documents.

PART 2 - PRODUCTS

2.01 GENERAL

A. Panelboard schedule is shown on the drawing.

2.02 PANELBOARDS

A. Panelboards: NEMA PB-1; UL 67.

B. Rating: Voltage and ampere ratings are shown on the Drawings. Unless otherwise indicated interrupting ratings (RMS symmetrical) are 65,000 amps for 480 volt panelboards and 65,000 amps for 240 and 208 volt panelboards.

C. Boxes: Code gage galvanized steel; sized to accommodate devices indicated and afford wire bending space in accordance with NEC requirements.

D. Fronts: Surface or flush as indicated, dead front construction, finished in light grey enamel over a rust inhibitor. Furnish flush lock for fronts less than 48 inches high and vault type handle with three point catch for fronts 48 inches and higher. Key all locks alike.

E. Provide copper busbars full sized throughout their length. Make complete provisions for mounting future circuit breakers throughout the full length of the bus provided regardless of the number of units and spaces called for. Provide all machining, drilling, or tapping required to add or change circuit breakers in the future. Bolt together and rigidly support bus bars and connection straps on molded insulators.

F. Furnish an insulated neutral bus bar rated the same as the phase bus bars and having at least one terminal screw for each branch circuit. Furnish a copper ground bus bar installed on the panelboard frame, bonded to the box, and containing at least one terminal screw for each circuit.

G. Circuit Breakers: NEMA AB-1; molded case type, thermal-magnetic trip with internal common trip on multipole breakers. Provide breaker fully rated for interrupting ratings noted; series ratings are not acceptable. Furnish circuit breakers in locations where diagram or schedule indicates spare. Furnish only complete provisions for future circuit breakers where indicated space. Breakers shall be bolt-on type, listed in accordance with UL489 for the service specified, and rated for 500 C environment.

H. Provide engraved nameplates giving the voltage rating and panel designation as indicated. Provide a UL service entrance label for panelboards used as service entrance equipment.

I. Two section panels: Box and front same height each section.

J. Furnish ground fault interrupted circuit breakers for certain circuits as indicated on the Drawings.

K. Furnish single pole breakers with full module size. Do not install two pole breakers in a single module.

2.03 SURGE PROTECTIVE DEVICE

A. A surge protective device shall be furnished and installed with the panelboards. Refer to SECTION 16445 – SURGE PROTECTIVE DEVICE FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install boxes so they are rigidly supported and correctly aligned. Select mounting height so that operating handles are not higher than 6 feet 6 inches or lower than 24 inches above the floor.

B. Prior to energizing panelboards clean out construction dirt and debris. Paint any scratches on the trims or dead front barriers. Meggar each phase to phase and to ground to insure that no short circuits exist.

C. Adjust panel barriers so that no openings occur between them and the panel front. Provide filler plates and plugs as necessary to maintain dead front integrity.

D. Type directory cards with circuit loads and/or area served. Note spare circuits in pencil. Provide a directory holder with clear plastic plate and metal frame on the inside of the door.

3.02 FIELD QUALITY CONTROL

A. Measure steady state load currents at each panelboard feeder. Should the difference at any panelboard between phases exceed 20 percent, rearrange circuits in the panelboard to balance the phase loads within 20 percent. Take care to maintain proper phasing for multi-wire branch circuits.

3.03 TESTING

A. Panelboards shall be tested for proper operation and function per Section 16999.

END OF SECTION 16470

SECTION 16475
FUSES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes the following: Fuses.

1.03 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product Data for each fuse type specified.

C. Product Data for each fuse type specified. Include the following:

1. Descriptive data and time-current curves.
2. Let-through current curves for fuses with current-limiting characteristics.
3. Fuse size for elevator feeder and disconnect applications.

D. Field test reports indicating and interpreting test results.

E. Maintenance data for indicating and interpreting test results.

1.04 QUALITY ASSURANCE

A. Source Limitations: Obtain fuses from one source and by a single manufacturer.

B. Comply with NFPA 70 for components and installation.

C. Listing and Labeling: Provide fuses specified in this Section that are listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.
2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

D. See also Spec 16010 Part 1 for listing of applicable reference standards.

1.05 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.

1. Spare Fuses: Furnish Quantity equal to 20 percent of each fuse type and size installed, but not less than one (1) set of three (3) of each type and size.
2. Fuse Holder: Furnish one fuse holder for all projects that require more than 100 fuses.
3. Fuse Puller: Provide one fuse puller for each of the fuse sizes as necessary and recommended by the manufacturer.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering fuses that may be incorporated into the Work include, but are not limited to, the following:

1. Cooper Industries, Inc.; Bussman Div.
2. General Electric Co.; Wiring Devices Div.
3. Gould Shawmut.
4. Tracor, Inc.; Littelfuse, Inc. Subsidiary.

2.02 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuse; class as specified or indicated; current rating as indicated; voltage rating consistent with circuit voltage.

2.03 SPARE FUSE CABINET

A. Cabinet: Wall-mounted, 0.05-inch (1.27 mm) thick steel unit with full-length, recessed piano-hinged door with key-coded cam lock and pull. Mount cabinet in main electrical or mechanical room.

1. Size: Adequate for orderly storage of spare fuses specified with 15 percent spare capacity minimum.
2. Finish: Gray, baked enamel.
3. Identifications: Stencil legend "SPARE FUSES" in 1-1/2-inch (40 mm) letters on door.
4. Fuse Pullers: For each size fuse.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine utilization equipment nameplates and installation instructions to verify proper fuse locations, sizes, and characteristics.

B. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.02 FUSE APPLICATIONS

A. Main Service: Class RK1, time delay.

B. Main Feeders: Class RK1, time delay.

C. Motor Branch Circuits: Class RK1, time delay.

D. Other Branch Circuits: Class RK5, non-time delay.

3.03 INSTALLATION

A. Install fuses in fusible devices as indicated. Arrange fuses so fuse ratings are readable without removing fuse.

3.04 IDENTIFICATION

A. Install typewritten labels on inside door of each fused switch to indicate fuse replacement information.

END OF SECTION 16475

SECTION 16481
LOW VOLTAGE MOTOR CONTROL CENTERS

PART 1 - GENERAL

1.01 SCOPE

A. Work described in this Section includes furnishing all labor, materials, equipment, tools and incidentals required for a complete and operable installation of low voltage motor control centers. All equipment shall be installed, adjusted, tested and placed in operation in accordance with these Specifications, the manufacturer's recommendations and as shown on the Drawings.

B. Contract drawings show only functional features and some of the required external connections. They do not show all components required for a complete installation nor exact dimensions particular to any manufacturer's equipment. Contractor shall supply all parts, devices and equipment necessary to meet the requirements of the Contract Documents and shall make all dimensional adjustments particular to the equipment being furnished. All costs associated with such changes and adjustments shall be considered as being included in the price bid for the work shown and specified.

C. Motor horsepower ratings and enclosures shown are what is expected. This information is for guidance only and does not limit the equipment size. When motors furnished differ from the expected ratings indicated, obtain the Engineer's review before proceeding.

D. Related Work specified elsewhere:

1. Section 16000 - Electrical Power and Systems.
2. Section 16050 - Basic Electrical Materials and Methods.
3. Section 16120 – Wire and Cable.
4. Section 16450 - Grounding.

1.02 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions of the Contract Documents. In addition, the following specific information shall be provided:

1. Elementary diagrams. Provide a separate elementary diagram for each starter unit following the format shown on the Contract Drawings and showing numbered terminal points and interconnections of remote devices.
2. Reference Data. Submit one set of full size (11" x 14") time current curves on log-log transparency paper for all overcurrent protective devices. Exception: A tabulation of heater sizes or elements versus motor current rating may be submitted in lieu of time current curves for overload relays.
3. Operation and maintenance data including recommended maintenance procedures and intervals, spare parts listing, and instruction books for the equipment and components.
4. List of starters and feeder compartments indicating the size and type of current protection.

1.03 QUALITY ASSURANCE

A. Reference Standards. Comply with all Federal and State laws or ordinances, as well as all applicable codes, standards, regulations and/or regulatory agency requirements including the partial listing below:

1. NEMA, National Electrical Manufacturers Association.
2. UL, Underwriters laboratories.

B. Provide a UL label where applicable, on each unit and each vertical section. If a unit or section cannot be UL labeled so note on submittals along with reasons for same.

1.04 QUALITY STANDARDS

A. Provide motor control centers manufactured and tested in accordance with NEMA ICS-2 and UL 845.

B. Manufacturers offering products that comply with these specifications include:

1. General Electric 8000 Line.
2. Cutler-Hammer 2100 Series Freedom & Advantage.
3. Allen Bradley Centerline.
4. Square D Model 4.
5. Or equal and newer models.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Arrange shipping splits as required for installation. Individually wrap each section and mount on shipping skids.

B. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

C. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to motor control center components, enclosure, and finish.

PART 2 - PRODUCTS

2.01 RATINGS

A. Service: 480 Volt, 3 Phase, 60 Hz.

B. Short Circuit: Unless otherwise indicated device interrupting rating and bus bracing is 100,000 amperes rms symmetrical. Provide fully rated devices; series ratings are not acceptable.

C. Ampacity: See Contract Drawings Rating to be in accordance with UL standards for temperature rise and a half size neutral bus where specified.

2.02 CONSTRUCTION

A. Equipment consists of the required number of vertical sections to accommodate all devices indicated and specified herein, each nominally 90 inches high and 20 inches deep. Sections are bolted together to form a rigid free standing, front accessible, dead front assembly. Only 72 inches must be used for mounting starters and breakers.

B. Provide each section with isolated horizontal wireways at the top and bottom and isolated vertical wireways with hinged door and cable tie supports. Unused spaces are to have bussing for future units and blank door covers.

C. Indoor enclosures shall be NEMA 1A gasketed painted in the manufacturer's standard grey over a rust inhibitor treatment. Outdoor enclosures shall be NEMA 3R, non-walkin.

2.03 INCOMING MAINS

A. Provide incoming main circuit breaker if shown on the drawing. Main breaker shall be molded case type with thermal magnetic trips meeting UL 489 and NEMA AB-1.

B. Arrange main breaker for cable entry without requiring 90 degree bends in the incoming conductors.

C. Where motor control centers serve as service entrance equipment, provide a UL service entrance label on the incoming section.

2.04 STARTER UNITS

A. Starters: Motor circuit protector combination type with contactor rated in accordance with NEMA size designations. Fractional sizes and ratings per IEC recommendations are not acceptable. Minimum size shall be 1.

B. Breakers: Adjustable magnetic trip only equipped with current limiters as required for the interrupting rating noted.

C. Contactors: NEMA 165-2; NEMA Size 1 minimum; magnetically held; field replaceable coil and contacts; auxiliary contacts field installable and removable. Terminal temperature rise is not to exceed 500 C per NEMA standards. Provide two normally open and two normally closed auxiliary contacts, rated 10 amperes at 120 volts AC, wired out to terminal blocks, unless otherwise shown on the Drawings.

D. Overload Relays: Overload relay shall be provided with three heater elements; ambient compensated; adjustment from 90 to 110 percent of normal heater ratings; solid state overload relays; normally closed, isolated auxiliary contact; manually reset by means of an external reset button; and capable of handling the horsepower range of the starter by changing the thermal elements only. Provide one (1) three phase sets of N.O. or N.C. contact of the overload as shown on the drawings for each starter.

E. Units: Constructed to fully compartmentalize the starter and arranged to permit access to starter, control power transformer, fuses, and other components without requiring disassembly. NEMA size 1 thru 4 are plug in, size 5 and larger are bolt on. Equip unit door with a defeatable interlock

to prevent opening unless the disconnect is open. Equip disconnect operator to accommodate three padlocks in the "OPEN" position.

F. Terminal Blocks: Pull apart type for power and control to allow unit withdrawal without disconnecting wiring. Use screw type terminals suitable for ring and tongue lugs for control wiring and box lug type for power wiring.

G. Provide an encapsulated surge suppressor for each starter unit, for direct mounting to the starter coil. Suppressor shall be rated 120VAC, with no additional panel space required.

H. Motor control centers shall be provided with NEMA Class I, Type "B" wiring. Provide terminal blocks for control wiring as shown on the Drawings. Terminal blocks shall be provided for power wiring for starter size 2 and smaller. Control wiring shall be lugged with ring-tongue or locking spade crimp type terminals made from electrolytic copper, tin-plated.

2.05 FEEDER UNITS

A. Breakers: Molded case type, thermal-magnetic trips meeting UL 489 and NEMA AB-1. Ampere rating and interrupting ratings as noted.

B. Units: Individually compartmentalized with not more than one breaker per unit unless otherwise indicated. Use red color to indicate on position as described above for starter units.

C. Breaker shall be equipped with toggle type handle, quick-make, quick-break mechanism, ON-OFF position clearly indicated. Minimum short circuit capacity 100,000 amps.

2.06 BUS

A. Material: Copper, tin plated at all joints.

B. Isolation: Locate main bus at the top or center, completely compartmentalized with sliding or removable barriers for access to joints. Provide phase isolation for vertical bus by polyester barriers enclosing each phase bar or providing adequate creepage to restrict fault propagation. Plug all holes not used to stab in units.

C. Provide ground bus rated 300 amps minimum extending the full length of the lineup. Where three phase, four wire control centers are indicated provide full length neutral bus rated a minimum of 50 percent of the main bus. Where three phase three wire control centers are used as service entrance equipment provide neutral bus in the incoming main section only.

2.07 METERING RELAYING AND CONTROL DEVICES

A. Instrument transformers and metering devices shall meet the requirements of Section 16175.

B. Elapsed time indicator: Six digit, non reset, 3-½-inch square case; equal to GE type 236.

C. Indicating lights, pushbuttons and selectors: Heavy duty, oiltight, industrial grade with octagonal ring. Pilot lights are transformer type. Equal to Allen Bradley Bulletin 800T.

D. Control Relays: Heavy duty, 600 volt, industrial grade, 10 amp contact rating. Equal to Allen Bradley bulletin 700 type P.

E. Supply individual control power transformers where indicated. The transformers shall have sufficient capacity to serve the connected load plus 100 VA and limit voltage regulation to 15 percent during contactor pickup. Fuse one side of the secondary winding and ground the other side. Provide two primary, current limiting fuses. Provide each starter unit with blown fuse indicators.

F. Each starter unit shall be provided with a motor control circuit disconnecting device that meets the requirements of NEC 430-74(a).

2.08 SPARE PARTS

A. Starter Contacts: One (1) set for each NEMA size furnished.

B. Starter Coils: One (1) for each NEMA size furnished.

C. Control Circuit Fuses: Three (3) for each rating furnished. Provide one (1) fuse puller.

D. Pilot Light Lamps: Standard lot cartons equal to ten (10) percent of the number of lights furnished, one carton minimum.

E. Touch-Up Paint: One (1) can.

2.09 NETWORKING

A. MCC shall be ModBus compatible. Connect to PLC, pump monitoring panels, and local control panels.

2.10 SURGE PROTECTIVE DEVICE

A. A surge protective device shall be furnished and installed with the MCC. Refer to SECTION 16445 – SURGE PROTECTIVE DEVICE FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS.

PART 3 - EXECUTION

3.01 INSTALLATION

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

B. Settings: Install the adjustment stop pin on magnetic only breakers so that the adjustment cannot exceed 13 times the full load amps. When the line voltage is at or above its normal value, adjust each magnetic only breaker to the lowest value that will allow reliable starting. Install the correct thermal overload relay element in each motor starter. The sizing of the overload element shall be based on motor nameplate amps, motor service factor, expected difference between motor and starter ambient temperature, any other factors the starter manufacturer requires. Prepare a table of motor name, motor horsepower, nameplate full load current, heater catalog number, heater current range, protective device trip setting, and include a copy in the Operations and Maintenance Manual.

C. Install control centers on 4-inch concrete pads and secure to sills imbedded in the concrete with ½-inch threaded bolts and nuts.

D. Touch up paint scratches and vacuum to remove construction debris and dirt. Install all doors, wireway covers etc., and plug any unused device holes.

3.02 TESTS

A. Install overload relay thermal elements based on motor nameplate rating. If capacitors are installed between the relay and motor, select thermal elements based on the measured motor current. Adjust other overcurrent protective devices to settings per the coordination study.

B. Megger each bus, phase-to-phase and phase-to-ground.

C. Motor control centers shall be tested in accordance with Section 16999, Acceptance Testing and Calibration

END OF SECTION 16481

SECTION 16485
CONTACTORS

PART 1 - GENERAL

1.01 SCOPE

A. Lighting contactors.

B. Enclosures.

1.02 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions of the Contract Documents. In addition, the following specific information shall be provided:

B. Product data: Include outline drawings with dimensions, and equipment ratings for voltage, capacity, and poles.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. General Electric.

B. Square D.

C. Cutler-Hammer.

D. Or equal.

2.02 LIGHTING CONTACTORS

A. Contactors: NEMA ICS-2; electrically held, 2 wire control.

B. Coil Operating Voltage: 120 volts, 60 Hertz.

C. Contacts as indicated.

D. Enclosure: NEMA ICS-6; Type 1.

E. Provide solderless pressure wire terminals.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

END OF SECTION 16485

SECTION 16486
REDUCED VOLTAGE SOFT STARTERS

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Provide all labor, materials, equipment and incidentals required, and install, place in operation and field test solid-state starter (s).

B. The solid-state starter(s) shall be microprocessor controlled, suitable for use with three phase induction motors rated 600 VAC or less. The starter(s) shall provide a closed loop current ramp for smooth and stepless motor acceleration and deceleration.

C. The solid-state starter(s) must fit in the space indicated on the drawings.

1.02 QUALITY ASSURANCE

A. The solid-state starters shall be the product of a manufacturer who has produced solid-state starters of the same type and size for a minimum of 10 years consecutive.

B. Codes: Provide equipment in full accordance with the latest applicable rules, regulations, and standards of:

1. Local Laws and Ordinances
2. State and Federal Laws.
3. National Electric Code (NEC)
4. Underwriters Laboratories (UL)
5. American National Standards Institute (ANSI)
6. National Electrical Manufacturers Association
7. Institute of Electrical and Electronics Engineers (IEEE).

C. The solid-state starter(s) shall be UL listed.

D. Acceptable Manufacturers:

1. Benshaw.
2. Eaton, Cutler Hammer.
3. Square D.
4. Allen-Bradley.
5. General Electric Company.

E. Environmental Requirements:

1. Temperature: 0 degrees C to + 50 degrees C (32 degrees F to 122 degrees F)
2. Storage Temperature -20 degrees C to + 70 degrees C (-4 degrees F to 155 degrees F)

3. Relative Humidity: up to 95%, non-condensing
4. Suitable for use in H2S concentrations per OSHA regulations for continuous worker exposure.
5. Input Power: 200-600V AC, 3 Phase, +/- 10% 50-60 Hz, +/- 3 Hz.
6. Meet Uniform Building Code on non-building structures for zone requirements.

1.03 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions.

B. Provide the following:

1. Elementary wiring and interconnection diagrams in accordance with NEMA ICS standards.
2. Size, type, and rating of all system components
3. Enclosure frontal elevation and dimension drawings.
4. Internal component layout diagrams.
5. Available conduit entry and exit locations.
6. Manufacturer's product data sheets.

1.04 WARRANTY

A. Equipment furnished herein shall include a minimum of one year manufacturer's warranty from date put in service.

1.05 DELIVERY, STORAGE AND HANDLING

A. Handling and shipment of the equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.

B. Equipment shall be stored indoors in a clean, dry environment. Energize space heaters if furnished.

PART 2 - PRODUCTS

2.01 EQUIPMENT DESIGN CRITERIA

A. At a minimum, the Starter(s) shall conform to the following:

1.	Size:	As shown on Contract Drawings (or smaller)
2.	Minimum Overload Rating:	500% of Starter FLA for 30 sec., 125% cont.
3.	PIV Ratings:	1,800V Minimum
4.	Rated Short Circuit Amps:	65KAIC Minimum
5.	Insulation Test:	2,500VAC Minimum
6.	Overall Efficiency w/o Bypass:	Average 99.7%
7.	Overall Efficiency w/Bypass:	99.94%

8.	SCR Firing Technique:	Hard Drive with "picket fence"
9.	Transient Voltage Protection:	dV/dT circuits or SIOV/ phase
10.	Under voltage Protection:	80% Pickup; 60% Dropout
11.	Control Input:	120 VAC or dry contact, 2/3 wire.
12.	Max Time Between Restarts:	Not more than 2 minutes
13.	Audible Noise:	Not to exceed 60dbA @ 1 meter at any time
14.	Network:	ModBus compatible. Connect to PLC, pump monitoring panels, and local control panels.

2.02 ENCLOSURE CONSTRUCTION

A. NEMA 1, Construct to comply with NEMA Part ICS 2.

B. Provide incoming fused disconnect switch suitable for padlocking and external operation. Furnish complete with current limiting fuses.

C. Basic structure shall be welded type construction utilizing minimum 14 GA sheet metal.

1. Doors shall be minimum 14 GA sheet metal, pan type with flanges formed to provide sturdy, rigid structure.
2. Door latches and hinges capable of holding door closed during maximum fault condition.
3. Provide door interlocks to prevent doors from being opened with power applied
4. Provide removable lifting provisions on floor mount enclosures.

D. Finish:

1. Metal parts to be given thorough rust resistant treatment.
2. Primer shall be Manufacturer's standard.
3. Finish shall be Manufacturer's standard.
4. Color shall be Manufacturer's standard.

E. Complete with internal power and control wires including terminations for external connections. Phase sequencing shall have proper identification and control wires shall have suitable markings at terminations.

2.03 MAIN AND BYPASS CONTACTORS

A. Inline (main) contactor and a bypass contactor shall be provided.

1. Full rated (IEC rated contactors are not acceptable)
2. Current rating: Manufacturer standard for horsepower rating.
3. Voltage rating: Up to 600 VAC.
4. The main and/or bypass contactor shall be sequenced by the Starter manufacturer for proper operation of the solid-state starter.

5. The bypass contactor shall bypass the SCRs after starting and while the starter is in the run (full voltage) mode.

2.04 CONTROL DEVICES

A. Control Power Transformer

1. Provide an appropriately rated (but not less than 1 kVA) internal 480V-120VAC step-down transformer.
2. Supply two fuses on primary and one fuse on secondary side with one leg grounded.

B. Control Wiring: minimum 16 GA stranded, rated for 600V.

C. Terminal Strips: Rated for 600V, suitable for contractor termination of up to 10 GA wire.

D. Hand-Off-Auto selector switch, push buttons, pilot lights, and control relays, heavy duty, rated to 600V. Include at a minimum control devices as shown on the Project Contract Electrical and P&ID Drawings.

2.05 SOLID STATE STARTER LOGIC CONTROL

A. Provide a door mounted Display & User Interface Module with the following functions

1. Backlit LCD- 2 Lines, 16 Characters
2. Tactile Feedback Buttons
3. Pass Code Protection
4. Built in Start/Stop Pushbuttons
5. Status Indication via LCD Display and LED's
6. Scrolling Menu/Parameters
7. Discrete Enter Command Button
8. Meter Mode Display
9. Selectable Meter Mode Scroll Rate

B. Programmable Motor Control Functions

1. Motor Starting/Running
   a. Programmable Current Ramp
   b. Ramp to Limit
   c. Full Voltage Start
   d. Initial Current Limit (50-600%)
   e. Start Ramp Time (0-300 Sec.)
   f. Maximum Current (100-800%)
   g. Dual Kick Start (0.1-10 Seconds)
   h. Dual Ramps
   i. Programmable 1-6,400 Amps
   j. Motor Service Factor (1.0 – 1.99)

k. Torque Ramp
l. Power Ramp
m. Voltage Ramp

2. Motor Stopping
   a. Fully Programmable "S" Curve Pump Decel
   b. Soft Stop
   c. Auxiliary Motor Feeder Control

3. Interlocking/Logic
   a. Overload Lockout
   b. Assignable Digital Relay Outputs (3)
   c. Frequency Tracking
   d. Up to Speed Indication/Contact
   e. Preassigned Digital Inputs (4)
   f. Analog Input
   g. 4-20mA analog output

4. Maintenance
   a. Emergency Restart After Fault Lockout
   b. Selectable CT Ratios
   c. Current Limited Jog
   d. Factory Control Mode for Supervisory Control (Optional)
   e. Real Text Event Recorder

C. Programmable Motor Protection Functions

1. Motor/Machine Faults
   a. Electronic Overload
   b. Selectable Overload Curves, Class 1-40
   c. Overload Reset
   d. Overload Warning
   e. Acceleration Time
   f. Instantaneous Overcurrent
   g. Motor Thermal Capacity Protection
   h. Undercurrent Alarm (Selectable Trip or Warning)
   i. Time Between Restarts
   j. Machine Ground Fault Protection

2. Electrical System Faults
   a. Undercurrent Protection
   b. Current Unbalance (10-40%)
   c. Undervolt Protection (10-30%)
   d. Protection (10-30%)
   e. Phase Reversal Protection
   f. Underfrequency Protection

g. Overfrequency Protection
h. Overload Alarm
i. Ground Overcurrent Protection

D. Diagnostics Functions

1. Alpha/Numeric Fault Display
2. Motor Thermal % Capacity Display
3. Closed Loop Motor Stall Detection
4. Open Loop Motor Stall Detection
5. Starter Status Indication
6. Pre-Start: Pending Fault Indication
7. Pre-Start: Phase Rotation Indication
8. LED Indication SCR Status
9. Full Screen Meter Mode

E. Metering Functions

1. Standard Meter Displays:
   a. Average Current
   b. Current, L1
   c. Current, L2
   d. Current, L3
   e. Percent Current Imbalance
   f. Ground Fault Current
   g. Average Voltage
   h. Voltage, L1- L2
   i. Voltage, L2 - L3
   j. Voltage, L3 -L1
   k. Line Frequency (50-60Hz)
   l. % Overload
   m. Run Time - Day
   n. Run Time - Hour
   o. Watts
   p. Kilowatt Hours
   q. Megawatt Hours
   r. Phase Order
   s. # Of Starts
   t. Tru Torque %
   u. Power %
   v. Power Factor

F. Programmable Relay Outputs

1. Standard Programmable Relay Outputs
   a. Overload
   b. Overload Lock
   c. Overload Warn
   d. Running
   e. Up To Speed
   f. Shunt Trip NFS
   g. Shunt Trip FS
   h. Ground Fault
   i. Over Current Trip
   j. Under Current Trip
   k. Energy Saver
   l. Starter Ready
   m. Heating
2. Output relay contacts shall be rated 5 Amps inductive and 16 Amps resistive.

G. Programmable Analog Outputs

1. Provides minimum four (4) programmable analog outputs.

2.06 LABELING

A. Each control panel or cabinet shall be provided with exterior nameplate that identifies the panel in accordance with the panel name and description as shown on the Contract Drawings. Nameplates shall be at least 1-inch high x 3-inch wide constructed of plastic laminate that is at least 1/16 inch (1.6 mm) thickness for nameplates up to 20 square inch (129 square cm) or at least 1/8 inch thick (3.2 mm) for larger sizes. Nameplate shall be engraved using a "sans serif" type font like Arial or Helvetica typefaces. Lettering shall be approximately ¼" in height, consisting of White Lettering on a Black background. Nameplates shall be beveled and attached to panels by self-tapping stainless-steel screws or No. 10/32 stainless-steel machine screws with nuts and flat and lock washers. Nameplates that are only adhesive bonded or glued to the panel or cabinet shall not be accepted.

B. Additionally each control panel or cabinet shall be provided with nameplates identifying each component, selector switches, pilot lights, and all internal components and etc. Nameplates shall be laminated plastic, engraved white letters with a black background. Nameplates shall be mounted adjacent to but not on each component. Nameplates shall be permanently affixed with stainless steel self-tapping screws.

C. Where applicable, also provide a nameplate, which reads as follows "CAUTION - THIS PANEL CONTAINS A VOLTAGE FROM AN EXTERNAL SOURCE." Engraving shall be approximately 3/16" in height, consisting of black lettering on a high visibility yellow background. Nameplates shall be beveled and attached to panels by self-tapping stainless-steel screws or No. 10/32 stainless-steel machine screws with nuts and flat and lock washers. Adhesive bonded or glued on nameplates shall not be accepted.

PART 3 - EXECUTION

3.01 TESTING

A. All incoming material shall be inspected and/or tested for conformance to quality assurance specifications.

B. Power semiconductors shall be fully tested for proper electrical characteristics, including dv/dt and di/dt.

C. All subassemblies shall be inspected and/or tested for conformance to quality assurance specifications.

D. Each completed unit shall be functionally tested prior to shipment to assure conformance to the Specifications.

3.02 STARTUP AND TRAINING

A. Contractor shall include two visits, consisting of two consecutive days each, for startup and training. Services shall include startup of equipment and field/classroom training for Owner's personnel. Factory direct personnel shall provide startup and training only. The use of agents, manufacturer's representatives, associated integrators or manufacturer's distributors for startup and training shall not be permitted.

3.03 SPARE PARTS

A. A complete set of Spare Parts shall be included. Spare parts shall include, but not be limited to:

1. One each of each type of Printed Circuit Board.
2. One of each type and size of control fuse.
3. Three of each type and size of power fuse.
4. One complete spare Power Cell of each type and size used.

END OF SECTION 16486

SECTION 16489
LARGE VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.01 SCOPE

A. Description: This Section specifies 480 volt, 3-phase, low voltage variable frequency drive (VFD) systems, to operate in conjunction with submersible type centrifugal pump induction motors. Each VFD system shall use pulse width modulated (PWM) technology. The VFD system shall include phase-shift isolation transformers, harmonic filters, input converter unit, output inverter unit, output filter unit, control circuitry, protective equipment, interconnecting cabling and other accessories required to provide the specified functions. The VFD assembly shall be suitable for front access and top and bottom conduit entry.

B. The variable frequency drives specified in this section shall be furnished by the manufacturer of the submersible pumps specified in Section 11199.

C. Type: The PWM variable frequency drive shall be 480 volt, 3-phase. The drive shall be a minimum 18-pulse design.

D. VFD Schedule: See the Contract Drawings for equipment quantities and numbers.

E. Design Requirements: The drive shall meet the following requirements:

1. Minimum VFD efficiency shall be 97 percent at 100 percent speed and 100 percent torque.
2. The VFD shall operate within the specified limits with input voltage 480 volt plus 10 percent to minus 10 percent; frequency 57 to 63 Hertz.
3. Service factor of 1.15 based upon the nominal rating of the drive.
4. The VFD shall satisfactorily operate at an ambient temperature rating from 0 to 40 degrees C, and at maximum humidity of 95 percent.
5. The unit shall operate without overload over the full operating range specified.
6. Based on the available fault current on the input side, the VFD supplier shall verify the VFD can withstand the corresponding fault current and ground fault on the output side.
7. The VFD shall be capable of operating a motor load with a minimum speed range of 30 to 66 Hz.
8. The VFD shall be capable of providing breakaway torque for the load.
9. The VFD shall be capable of operation up to a maximum of 66 Hz.
10. The elevation shall be about 827 feet above MSL.
11. The power unit ranging basis shall be 100 percent rated current continuous.
12. Displacement power factor shall be 95 percent or higher throughout the entire operating speed range, measured at drive terminals.
13. Copper bus shall be braced for 85,000 amperes minimum.

14. Each VFD shall have molded case, circuit breaker type main power disconnect switch with an external operating handle. The circuit breaker shall have minimum short circuit rating of 85,000 amperes RMS symmetrical interrupting capacity and meet UL 489 requirements.

15. All drives shall be furnished by the same manufacturer.

16. The VFD shall comply with the latest applicable standards of American National Standard Institute (ANSI), National Electrical Manufacturers Association (NEMA), Institute of Electrical and Electronics Engineers (IEEE), and the latest edition of the National Electrical Code (NEC).

17. The supplier of the VFD shall coordinate with the mechanical equipment supplier for any technical data or information necessary to design the VFD for its appropriate function. To meet the specification requirements, coordinate with the Engineer.

1.02 SUBMITTALS

A. The following information shall be provided in accordance with the General Conditions and the requirements of Division 1:

1. Certificate of Unit Responsibility attesting that the supplier has assigned unit responsibility in accordance with the requirements of this Section. No other submittal material will be reviewed until the certificate has been received and found to be in conformance with these requirements.

2. A copy of this Specification Section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate Specification compliance or marked to indicate requested deviations from specification requirements. Check marks (√) shall denote full compliance with a paragraph as a whole. If deviations from the Specifications are indicated and, therefore requested by the supplier, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the supplier with the Specifications. The submittal shall be accompanied by detailed, written justification for each deviation. Failure to include a copy of the marked up Specification Sections, along with justification(s) for any requested deviations to the Specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

3. Suppliers product literature, technical data, and instructions and start-up manuals.

4. Test setup and testing procedure as specified in paragraph 1.03 B.

5. Shop drawings shall include front panel layout and dimensions of the equipment, recommended equipment foundation, anchorage and support, shipping section dimensions, weight, and conduit entrances.

6. Control schematic showing internal wiring connection diagrams, external interconnection wiring drawings showing the function, and identification of all terminals requiring field connections.

7. Continuous and fault ratings of drive and disconnecting means.

8. Calculation of VFD efficiencies at 50, 75, and 100 percent speed.

9. Suppliers certification acknowledging that the supplier will submit detailed schematics, parts list, and diagnostic information for their equipment, as required per Section 01730.

10. Harmonic analysis and the harmonic distortion calculations, per paragraph 1.03 B. The analysis shall be accompanied with a report summarizing the harmonic calculation program used, a tabulation of the data used in the study, a list of assumptions with valid justifications for the assumptions, and a statement of the results that the filter designed shall meet the specified system requirement. The report shall be signed and sealed by a Registered Professional Electrical Engineer.

11. Component fabrication drawings consisting of layouts for all electrical and electronic components. In addition, these will include the technical data, suppliers name and catalog sheets for all prefabricated cables, raceways, etc., that need to be assembled at site.

12. Proprietary factory test setup and testing procedure shall be presented verbally to confirm compliance with paragraph 1.03 B.

13. Each page of the individual submittal shall be identified with the item/equipment number provided in paragraph 1.01 E.

1.03 QUALITY ASSURANCE

A. References: This section contains references to the following documents. They are a part of this section as specified and modified. The latest edition of the referenced documents, at the time of bidding, shall be applicable. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

1. ANSI/IEEE 519-92, Guide for Harmonic Control and Reactive Compensation of Static Power Converters.

2. NEMA ICS 6-88, Enclosures for Industrial Control and Systems.

3. NFPA 70-, Current Editions of the National Electrical Code (NEC) as adopted by the City of Atlanta.

B. Factory Tests: The factory tests for all components shall be conducted in accordance with the requirements of the Testing Section and also as specified in this section.

1. All components shall be 100 percent tested. All components including printed circuit boards shall be burned-in continuously for 96 hours at 60 degrees C. The printed circuit boards shall be tested throughout the burn-in to ensure they are functioning within specification. Every thyristor shall have the following critical parameters tested at rated current: gating, turn-on, turn-off, high temperature, forward blocking, reverse blocking and waveform characteristics. All assembled phase cells shall be tested for cell balance at rated voltage, maximum current, maximum dV/dT and maximum dI/dT.

2. Control power shall be applied to microprocessors, printed circuit boards, diagnostic boards and similar devices including software to test for proper operation, sequencing, logic and diagnostics.

3. All wiring shall be checked for continuity and for compliance with the wiring diagrams.

4. The VFD supplier shall provide certification that these factory tests have been completed.

5. Harmonic analysis shall be performed for the drive at unit full load using a harmonic analyzer by Hewlett Packard, or equal. Results shall be corrected for a source impedance (available from the Engineer) delineated in terms of noncontributing short circuit amps listed below and shall be listed in a report. Tests shall prove that sufficient filtering has been

provided to limit the total harmonic distortion to a magnitude of 3 percent of the fundamental. The report shall include the following:

a. Expected harmonic components through the 99th harmonic, calculated with and without harmonic filtering.

b. RMS value of total harmonic distortion (THD) expected.

c. The total harmonic distortion for voltage and current, at the point of common coupling (PCC) shall meet the requirements of the latest edition of IEEE 519, and the requirements of this Specification.

d. The PCC shall be defined as the low voltage bus feeding the drive motors and other loads. This point shall be used for all harmonic analysis calculations and field measurements for both voltage and current harmonic distortions. For the location of PCC, see the applicable low voltage switchgear one-line diagram.

e. The results of the harmonic analysis calculation shall be submitted per paragraph 1.02.

C. Unit Responsibility: The supplier shall have the unit responsibility for the proper functioning of the VFD in conjunction with the pump motor.

1.04 SHIPMENT HANDLING AND STORAGE

A. General: Equipment, products and, materials shall be shipped, handled, stored, and installed in ways which will prevent damage to the items. Damaged items will not be permitted as part of the work except in cases of minor damage that have been satisfactorily repaired and are acceptable to the Engineer.

B. Package and Marking: All equipment shall be protected against damage from moisture, handling, or other cause during transport from suppliers premises to site. Each item or package shall be marked with the number unique to the specification reference covering the item.

C. Stiffeners shall be used where necessary to maintain shapes and to give rigidity. Parts of equipment shall be delivered in assembled or sub-assembled units where possible.

D. Identification: Each item of equipment shall have permanently affixed to it a label or tag with its equipment number designated in this contract. Marker shall be of stainless steel. Location of label shall be easily visible.

E. Shipping: Vents and other types of openings shall be wrapped or otherwise sealed to prevent contamination by grit and dirt. Damage shall be corrected to conform to the requirements of the contract before the assembly is incorporated into the work. The supplier shall bear the costs arising out of dismantling, inspecting, repair and reassembly.

F. Storage: During the interval between the delivery of equipment to the site and installation, all equipment, unless otherwise specified, shall be stored by the Contractor in an enclosed space affording protection from weather, dust and mechanical damage and providing favorable temperature, humidity and ventilation conditions to ensure against equipment deterioration. Suppliers' recommendations shall be adhered to in addition to these requirements.

PART 2 - PRODUCTS

2.01 ACCEPTABLE PRODUCTS

A. Drive shall be Allen Bradley, Cutler-Hammer, Square D, or equal, to provide the specified features and to meet the specified design requirements.

2.02 ENCLOSURE

A. The enclosure shall be a dead-front, freestanding assembly. Working height shall be not greater than 90 inches. Doors shall be 12 gauge sheet steel with pin type hinges. The doors shall be no wider than 44 inches and shall be key lockable. A continuous bare copper ground bus (1/4 inch by 1 inch) shall be provided along the entire length of the enclosure. Removable lifting angles shall be provided.

B. All sections involving operator control switches, handles, disconnects, or monitoring instruments, and indicators shall be front panel mounted.

C. Unless otherwise specified, the enclosure shall be NEMA 1. Enclosure shall be suitable for either top or bottom cable entry and front access only.

D. Enclosure shall be treated with zinc phosphate, bonderized or otherwise given a rust-preventive treatment. Equipment shall be printed, painted with enamel, and baked. Minimum dry film thickness shall be 3 mils. The exterior color of the enclosure shall be ANSI 49 gray.

E. Nameplates shall be provided on each item of equipment and shall contain the specified equipment name or abbreviation an equipment number. Equipment nameplates shall be engraved or stamped stainless steel and fastened to the equipment in an accessible location with stainless screws or drive pins.

2.03 VFD SYSTEM COMPONENTS

A. Design Feature: The VFD shall include converter, indicator, inverter, DC link, and low voltage sections. These sections shall be grouped into separate sections with each section modularized for ease of troubleshooting. All Silicon Control Rectifiers (SCRs) used in the converter and inverter sections shall be standard rectifier grade devices containing the SCR suppliers standard catalog numbers such that they can be readily cross-referenced and interchanged with other SCR suppliers devices. SCR catalog numbers must be submitted as part of the submittal package. No fast switching SCRs will be allowed. The highlights of the VFD design features are addressed below:

1. The converter section shall be a full wave, phase controlled, three-phase converter to change input AC power to DC power.
2. The output of the converter shall feed an inductor and the converter/inductor combination shall form a current source whose output is regulated and limited. The current limit feature of the converter shall be sufficiently fast and effective so as to protect against a sudden and/or random application of a short circuit to the output terminals of the current source.
3. The inverter section shall convert the DC power of the current source to adjustable frequency power to the motor. The VFD shall not induce excessive power losses in the motor. The worst case Root-Mean-Square (RMS) motor line current measured at rated

speed, torque, and voltage shall not exceed the rated RMS motor current for pure sine wave operation.

4. The VFD supplier shall provide the necessary design and filtering required to meet the harmonic requirements of latest edition of IEEE 519, and as specified. A preliminary harmonic analysis shall be provided prior to design. Total harmonic distortion reflected back into the system shall be limited to 3 percent.

B. Accessories: The AC power units shall be enclosed in a sheet metal housing of NEMA1 construction requiring front access only. VFDs requiring rear access for any maintenance are not acceptable. VFD shall be constructed with air-cooled SCR assemblies and inductors for a minimum amount of complexity and highest reliability. VFDs using liquid-cooled assemblies in conjunction with associated pumps, piping, and separate remote mounted heat exchangers are not acceptable. The following accessories shall be provided:

1. Input disconnect switch handle interlocked with power unit door.
2. One three-position mode selector switch marked "HAND-OFF-AUTOMATIC."
3. One "Power On" light.
4. One VFD emergency stop reset pushbutton for remote reset.
5. Input MOV surge arrestors for surge protection.
6. The drive shall include 100 percent capacity cooling fans.
7. One two-position selector switch marked "LOCAL-REMOTE".
8. One "Run" light.
9. One "Off" light.
10. One "Fail" light.
11. All pilot lights shall be push-to-test.

C. Output Contractor: Furnish and install an output contractor.

2.04 CONTROL, MONITORING, ANNUNCIATION AND PROTECTIVE FEATURES

A. The VFDs shall include the following except where specified alternative controls are indicated on the Project Piping & Instrument Diagrams and/or pump control descriptions.

1. With the "HAND-OFF-AUTOMATIC" switch in the "HAND" position, the drive shall operate at a predefined speed.
2. With the "HAND-OFF-AUTOMATIC" switch in the "AUTOMATIC" position, the drive shall operate when directed by a remote signal.
3. With the "LOCAL-REMOTE" switch in the "LOCAL" position, the output speed shall be controlled by the VFD furnished panel.
4. With the "LOCAL-REMOTE" switch in the "REMOTE" position, the output speed shall be controlled by a 4-20 mA demand signal from remote.
5. The VFD shall shut down on high motor winding temperature, high motor bearing temperature where applicable.

6. VFD run status, failure status, and speed shall be provided for remote indication.
7. Optical isolation shall be provided to accept the grounded or ungrounded 4-20 mA input demand signal.
8. Manual remote or local restart after drive trip or utility failure, upon remote or local reset.
9. Speed profile: Individual adjustable settings for start, stop, acceleration and deceleration rates, and minimum and maximum speed points.
10. Process signal inverter: Software selectable to allow speed of drive to vary inversely with input signal.
11. A door-mounted digital keypad/display unit shall be provided and capable of controlling the VFD and setting drive parameters.
12. The digital display shall normally display:
    a. Speed demand in percent
    b. Output current in amperes
    c. Frequency in hertz
    d. Control Mode: local/remote
    e. Total three-phase kW
13. The keypad will display diagnostic messages and parameter values when accessed.
14. The digital keypad/terminal shall allow operations to enter exact numerical settings in English engineering units. A user menu is to be provided as a guide to parameter setting. Coded messages on the keypad will not be acceptable. Drive parameters are to be factory set in EEPROM and resettable in the field through the keypad. One level of password security shall be available to protect drive parameters from unauthorized personnel. The EEPROM stored drive variables must be able to be transferred to new boards to reprogram spare boards.
15. The keypad/display shall have a key switch to control operation of the keypad. Key to be removable in either "ENABLED" or "DISABLED" positions. Keypad module shall contain a "self-test" software program that can be activated to verify proper keypad operations.
16. The controller shall have the following adjustments available, accessible through a keypad display unit or serial communication links:
    a. Speed: Frequency-Max., Frequency-Min.
    b. Independent acceleration/deceleration rates: 4 to 300 seconds.
    c. Voltage Parameters: V-min., V-max. Current Limit: 5 to 110 percent of drive rating.
    d. Inverse time overload, limit, time.
    e. Current Boost.
    f. Speed shedding current limit.
    g. Speed Profile: Entry, Exit, Min. Speed, Max. Speed.
    h. Inverse Profile
    i. Selectable follower/set point control.
17. All drive setting adjustments and operation parameters shall be stored in a parameter log which lists allowable maximum and minimum points as well as the current set values. This parameter log shall be accessible via an RS232 serial port as well as on the keypad display.
18. The converter shall be protected against internal faults.

19. The power circuit design shall be such that the following fault conditions can occur without damage to the power circuit components:
    a. Single phase fault or three-phase short circuit on VFD output terminals.
    b. Failure to commutate inverter SCR due to severe overload or other conditions.
    c. Loss of input power due to opening of VFD input or utility power failure during VFD operation.
    d. Loss of one (1) phase of input power.
    e. VFD shall be protected against open circuit conditions on output of VFD. If an open circuit occurs, VFD shall automatically shut down in an orderly fashion without component failures.
20. To ensure safety and reliability of the equipment, the VFD shall include these features:
    a. Static instantaneous overcurrent and overvoltage trip, with adjustable voltage, current, and time.
    b. Static overspeed (overfrequency) protection.
    c. Phase sequence detector, line fuse loss, and undervoltage protection, with adjustable voltage and time.
    d. Motor inverse time overload protection; device separate from electronic protective function.
    e. Printed circuit boards shall include a solder mask and a clear varnish coating for corrosion protection.
    f. All bus shall be tin plated copper or all conductors shall be copper.
21. Control power transformer with 120VAC secondary, two primary and one secondary fuse and 200 VA additional capacity for external devices.
22. Provide start inhibit timer. Agastat or equal, 1-10 minute adjustable time.
23. Provide jam protection consisting of CT with ground fault relay or equal.

2.05 VFD FAULT INITIATION, TEST FEATURES, AND MONITORS

A. Fault Initiation: The following fault conditions shall cause an orderly drive shutdown:

1. Loss of input power.
2. Undervoltage.
3. Sustained gradual overload.
4. Instantaneous severe overload.
5. SCR overtemperature.
6. Overvoltage.
7. Blown fuse.
8. Logic power supply failure.
9. Restart shall be manually initiated (either local or remote) upon local or remote reset. Two unsuccessful restart attempts shall result in permanent shutdown and alarm.

B. Test Features: The VFD shall have the following test feature:

1. Lights on each converter and inverter SCR and inverter diodes to indicate an SCR or diode failure.
2. SCR gate pulse lights to provide diagnostic checks as follows:
   a. Lights to indicate the presence of gate pulses on each converter SCR.
   b. Lights to indicate the presence of gate pulses on each inverter IGBT.
3. Test meter or display/terminal with switch to test for the following control signals:
   a. Frequency command.
   b. Voltage command.
   c. Motor voltage feedback.
   d. Inverter bus voltage.
   e. Current command.
   f. Current feedback.
   g. Converter command.
   h. Filtered inverter bus voltage.
4. Test modes as follows:
   a. The gating test mode shall ensure that proper gating is taking place.
   b. Open Circuit Test – with VFD in this position, VFD shall be capable of operation with no motor load connected. This is to verify correct VFD operation.

C. Monitors: The following monitoring features shall be provided:

1. The VFD shall include a comprehensive microprocessor-based digital diagnostic system which monitors its own control functions and displays faults and operating conditions.

2.06 VFD AND MOTOR PROTECTION INTERFACE

A. VFD shall interface with pump monitor supplied by the pump manufacturer. This monitor shall provide pump protection for moisture and temperature. Also, where indicated on the Piping & Instrument Diagrams, provide interface relay, control etc., as required for pump vibration.

2.07 SPARE PARTS

A. Spare parts shall be stored in accordance with the provisions of this paragraph. Spare parts shall be tagged by project equipment number and identified as to part number, equipment manufacturer, and subassembly component (if appropriate). Spare parts subject to deterioration such as ferrous metal items and electrical components shall be properly protected by lubricants or desiccants and encapsulated in hermetically sealed plastic wrapping. Spare parts with individual weights less than 50 pounds and dimensions less than 2 feet wide, or 18 inches high or 3 feet in length shall be stored in a wooden box with a hinged wooden cover and locking hasp. Hinges shall be strap type. The box shall be painted and identified with stenciled lettering stating the name of the equipment, equipment numbers, and the words "spare parts". A neatly typed inventory of spare parts shall be taped to the underside of the cover. The following spare parts shall be provided for the sizes and types furnished in the equipment:

2 – each printed circuit board type of each type furnished in the equipment, and, 1 card extender of each type

2 – each relay type

1 – inverter IGBT assembly (+bus)

1 – inverter IGBT assembly (-bus)

1 – converter assembly

2 – sets of each size and type of power and control fuses

3 – spare light bulbs of each type and size provided in the equipment

1 – set of all special tools required for normal operation and maintenance

2.08 PRODUCT DATA

A. The following information shall be provided in accordance with Division 1:

1. Applicable operation and maintenance information as specified. Operation and maintenance (O&M) instructions. Provide each paragraph check-marked to show compliance. O&M instructions shall be submitted after all submittals have been approved. The O&M instructions shall reflect the approved materials and equipment.
2. Certification of completion of load, heat, harmonic tests, and harmonic analysis calculations, as specified in paragraph 1.02.
3. Suppliers product literature.
4. Suppliers certification that drive can withstand fault conditions specified in paragraph 16489-1.01 E.
5. Installation certification as specified in paragraph 3.02.
6. Testing procedures and forms as specified in 3.03.
7. Training certification form as specified in paragraph 3.04.
8. Factory testing results, specified in paragraph 3.01 B.

2.09 LABELING

A. Each control panel or cabinet shall be provided with exterior nameplate that identifies the panel in accordance with the panel name and description as shown on the Contract Drawings. Nameplates shall be at least 1-inch high x 3-inch wide constructed of plastic laminate that is at least 1/16 inch (1.6 mm) thickness for nameplates up to 20 square inch (129 square cm) or at least 1/8 inch thick (3.2 mm) for larger sizes. Nameplate shall be engraved using a "sans serif" type font like Arial or Helvetica typefaces. Lettering shall be approximately ¼" in height, consisting of White Lettering on a Black background. Nameplates shall be beveled and attached to panels by self-tapping stainless-steel screws or No. 10/32 stainless-steel machine screws with nuts and flat and lock washers. Nameplates that are only adhesive bonded or glued to the panel or cabinet shall not be accepted.

B. Additionally each control panel or cabinet shall be provided with nameplates identifying each component, selector switches, pilot lights, and all internal components and etc. Nameplates shall be laminated plastic, engraved white letters with a black background. Nameplates shall be mounted adjacent to but not on each component. Nameplates shall be permanently affixed with stainless steel self-tapping screws.

C. Where applicable, also provide a nameplate, which reads as follows "CAUTION - THIS PANEL CONTAINS A VOLTAGE FROM AN EXTERNAL SOURCE." Engraving shall be approximately 3/16" in height, consisting of black lettering on a high visibility yellow background. Nameplates shall be beveled and attached to panels by self-tapping stainless-steel screws or No. 10/32 stainless-steel machine screws with nuts and flat and lock washers. Adhesive bonded or glued on nameplates shall not be accepted.

2.10 NETWORKING

A. VFD shall be ModBus compatible. Connect to PLC, pump monitoring panels, and local control panels.

PART 3 - EXECUTION

3.01 FACTORY TESTING

A. The supplier shall perform the factory testing for all equipment, including the items specified in paragraph 16489-1.03 B., in accordance with Section 01660. All tests shall comply with the latest versions of IEEE, UL, NEMA, and other applicable standards. The test results shall be submitted per paragraph 16489-2.08.

3.02 INSTALLATION

A. The equipment shall be installed and tested under the direction of factory-trained personnel. The installation shall meet all the requirements of the latest edition of the National Electrical Code (NFPA 70). The installation shall be certified.

B. Furnish and install a 4" high concrete housekeeping pad beneath each drive.

3.03 FIELD TESTING

A. General: The field testing certificate shall be submitted by the supplier. The testing procedure and forms shall be provided.

B. Field tests of the drive shall be made by the drive supplier who will furnish all equipment and record all data. The Contractor shall be present during testing. Field tests are the basis of demonstrating equipment proficiency and correct operation.

C. If the drive performance does not meet the specifications, corrective measures shall be taken to satisfy the conditions specified. A seven (7) day (actual operation) operating period of the drive will be required before acceptance. If a drive fails to perform and must be replaced, the rejected drive shall not be removed until the replacement drive has been delivered to the site. The Owner shall be allowed to use any drive supplied immediately following installation and testing whether or not the pump meets the conditions specified.

D. The drive supplier shall test the drive controller similar to the existing motor load prior to shipment.

3.04 TRAINING

A. On-Site Training: On-site training shall be scheduled through the Contractor with the Owner. A minimum of 16 hours of training shall be provided for on-site training. A maintenance training class shall be presented at two different times. All training shall be certified. All travel cost for the training shall be furnished by the Contractor.

B. Training will not be permitted until all equipment is fully operational. In the event that the equipment becomes inoperable under warranty provisions, additional on-site training will be provided at no additional cost to the Owner as follows:

Inoperable Period	Additional Training
0 – 2 weeks	None
2 – 6 weeks	8 hours
More than 6 weeks	16 hours

END OF SECTION 16489

SECTION 16510
LIGHTING FIXTURES

PART 1 - GENERAL

1.01 SCOPE

A. Work described in this Section includes furnishing all labor, materials, equipment, tools and incidentals required for a complete and operable installation of lighting fixtures, including luminaries and accessories, lamps and ballasts. All fixtures shall be installed, adjusted, tested and placed in operation in accordance with these Specifications, the manufacturer's recommendations and as shown on the Drawings.

B. Contract drawings show only functional features and some of the required external connections. They do not show all components required for a complete installation nor exact dimensions particular to any manufacturer's equipment. Contractor shall supply all parts, devices and equipment necessary to meet the requirements of the Contract Documents and shall make all dimensional adjustments particular to the equipment being furnished. All costs associated with such changes and adjustments shall be considered as being included in the price bid for the work shown and specified.

1.02 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions of the Contract Documents. In addition, the following specific information shall be provided:

1. Product data including dimensions, accessories, installation and construction details and photometric data.
2. Complete data, including computer printouts showing maintained luminance values using a 0.81 M.F.

1.03 QUALITY ASSURANCE

A. Reference Standards: Comply with all Federal and State laws or ordinances, as well as all applicable codes, standards, regulations and/or regulatory agency requirements including the partial listing below:

1. NEC, National Electrical Code.

1.04 QUALITY STANDARDS

A. The products covered by these Specifications shall be in conformance with the latest edition of the NFPA to (NEC).

B. Manufacturers offering products that comply with these specifications include:

1. Fixtures: As specified on the lighting fixture specification sheet.
2. Lamps: General Electric, Sylvania, Phillips Lighting, or equal.
3. Ballasts: General Electric, Advance, Universal, Holophane or equal.

1.05 WARRANTY

A. Provide a warranty against defective equipment and workmanship in accordance with the requirements of the General Conditions of the Contract Documents.

PART 2 - PRODUCTS

2.01 LUMINAIRES AND ACCESSORIES

A. Provide fixtures as specified on the Lighting Fixture Specification sheets. Lighting Fixture Specification sheets are attached to the end of this Section of the Specifications.

B. Where flat acrylic lenses are specified in fluorescent fixtures, use 100% virgin acrylic, pattern 12 0.125-inch thickness.

C. Provide fixture housings and frames to match the ceilings called for on the architectural drawings.

D. Provide a conduit backpan for surface mounted fixtures, wall or ceiling, where surface mounted conduit is used.

E. HID Luminaries: Pre-wired, with integral ballast.

2.02 LAMPS

A. General Use Incandescent Lamps: Inside frosted type, rated 130 volts.

B. Incandescent Reflector Lamps: Shape as scheduled, rated 130 volts.

C. Fluorescent Lamps: Cool white, all by same manufacturer.

D. High Pressure Sodium Lamps: Clear, suitable for all burning positions.

2.03 FLUORESCENT BALLASTS

A. Provide high power factor type ballasts (unless otherwise indicated) conforming to UL 935, ANSI C82.1 standards; labeled by certified ballast manufacturers (CBM); certified by Electrical Testing Laboratories (ETL).

B. Provide Class P ballast with sound rating "A" (unless otherwise noted).

C. Furnish 0 degrees F ballast for exterior luminaries.

D. Coordinate ballast-operating voltage with supply voltage as shown on drawings.

2.04 HID BALLASTS

A. Provide single-lamp, high power factor type, constant wattage autotransformer (CWA) or regulator ballast (unless otherwise indicated) conforming to UL 1029 and ANSI C82.4 standards.

B. Temperature: reliable starting to minus 20 degrees C, designed for normal operation in ambient 40 degrees C.

C. Use ballasts constructed so that open circuit operation will not reduce the average life.

D. Provide High Pressure Sodium (HPS) ballasts with a solid-state igniter/starter with an average life in the pulsing mode of 10,000 hours at an igniter/starter case temperature of 90 degrees C.

2.05 LIGHTING CONTROL

A. Provide electrically held contactors with 120 VAC operating coils, and 20 amp contacts. Provide controller and contactor in common NEMA 1 enclosure. Number of contacts as required.

B. Acceptable Manufacturers

1. Contactor-Equal to ASCO, Square D, or General Electric

2.06 SITE JUNCTION BOXES

A. Junction boxes for the distribution of outdoor lighting circuits shall be precast concrete, set flush with the ground. Size shall be approximately 10.5" x 17.25" x 12" inches deep. Lid shall be cast iron with cast inscription: STREET LIGHTING". Boxes shall be Brooks Products, Christy Concrete Products, Forni Corporation, Utility Vault Company, or equal.

2.07 PHOTOELECTRIC CELL UNITS

A. Photoelectric cell units shall consist of a cadmium sulfide cell housed in a plug receptacle assembly. The plug receptacle assembly shall be three-prong polarized locking type. Assembly shall be suitable for outdoor mounting and shall be rated for 1800 VA at 120V maximum capacity.

2.08 POLES

A. Light poles shall be as specified in the electrical standard detail and light fixture schedule,E0-601.

2.09 LED LOW BAY LUMINAIRES

A. The LED Low Bay Luminaire shall be MADE IN AMERICA.

B. Physical and Mechanical Requirements

1. Physical Dimensions
   a. Nominal Fixture size as installed: 19.7" X 16" X 5.5"
2. Mechanical
   a. Mounting Method to allow for direct mount to a standard 4" ceiling electrical box, a hanging ¾" pendent or via six knock out holes for surface mounting.
   b. Mounting bracket to be an integral part of the Luminaire fixture and fully removable from the main lighting housing to allow for easy mounting of bracket assembly and electrical connections prior to main lighting housing attachment.
   c. Mounting bracket to have inverted "T' slots to allow the main lighting housing to hang freely during electrical installation and hook up.

d. The fixture shall utilize modular components that fully field replaceable without the need of special tools. The LED module shall be a self-contained unit and have a M12 screw in electrical connection to allow easy disconnect.

3. Materials
   a. All metal housing/bracket materials used shall be weather resistant either Aluminum or Stainless Steel.
   b. Metal coating shall be a high quality thermal baked dry spray powder material.
   c. All hardware to be stainless steel.
   d. Materials used for the module lens and LED module construction shall conform to ASTM specifications where applicable.
   e. Lens shall use UV stabilized material.
   f. Enclosures containing the power supply and electronic components of the LED module shall be made of UL94VO flame retardant material.
   g. All electrical wires and connectors to meet UL standards.
   h. Installation requirements: Installation of an LED fixture into existing pole/mast arm shall only require the removal of the existing light fixture and shall connect directly to existing electrical wiring. Installation shall not require special tools.
   i. The module shall provide Type 2 or Type 3 radiation pattern as required and must meet minimum roadway surface candela requirements as per IES national roadway standard.

C. Environmental Requirements

1. The LED fixture shall be rated for use in the ambient operating temperature range of -30°C to 70°C.
2. The LED fixture shall be protected against dust and moisture intrusion as per NEMA standard 250-1991 type 4 meeting an IP67 classification.
3. The fixture shall be certified as a wet location fixture.
4. Nominal temperature for all specification compliance measurements is 22°C +/- 3°C.
5. The lens surface shall be generally smooth on the outside to reduce dust and dirt collection. There shall be no diffused, Fresnel or rough surfaces.

D. Module Identification

1. Each LED light fixture shall be identified with the manufacturer's name and serial number clearly showing date of manufacture.
2. The following operating characteristics shall be identified: nominal operating voltage, power consumption and Volt-Ampere.
3. The LED fixture shall clearly show a safety compliance listing mark.
4. The LED module shall clearly show a UL listing mark.
5. The Power supply shall clearly show a UL listing mark.
6. The fixture shall clearly show marking indicating MADE IN AMERICA.

E. Photometric Requirements

1. Photometric measurement shall be documented by an independent test lab report according to IESNA specification.
2. All certified independent test lab reports shall include IES format file for use with lighting software.
3. The standard chromaticity color for the LED light fixture shall be cool white.
4. The color temperature shall be typical 6200°K +/- 500°K.
5. The Color Rendering Index (CRI) shall be 75 +/- 3.
6. The fixture shall have a minimum lumen efficiency of 70lm/W.
7. Each individual LED module shall have a minimum output of 2000 lumens.
8. The LED fixture as properly installed in intended application shall meet the minimum lighting levels as indicated in the IESNA publication RP-20-98, "Lighting for Parking Facilities".

F. Electrical

1. The fixture shall be certified to meet standards UL 1598, UL 8750, CSA 22.2 #250.0.08 standards. Certification to be via a qualified 3rd party testing laboratory, Intertek, UL or other.
2. LED light fixture shall operate from a 50-60 Hertz AC line power over a voltage range from 90 VAC RMS to 277 VAC RMS.
3. Nominal operating voltage for all specification compliance measurements shall be 120+/- 3 VAC RMS.
4. Fluctuation in the line over the voltage range shall not affect luminous intensity by more than +/- 10%.
5. Fixture power supply shall be UL approved with a class 2 rating.
6. Transient Voltage Protection: The LED fixture and the on-board circuitry shall include voltage surge protection to withstand high-repetition noise transients and low-repetition, high-energy transients as stated in section 2.1.6, NEMA Standard TS-2, 1992.
7. EMC Noise
   a. The LED fixture and the on-board circuitry must meet Federal Communications Commission (FCC) Title 47, subpart B, section 15 regulations concerning the emission of electronic noise.
8. Power Factor (PF) and AC Harmonics
   a. LED light fixture shall provide a power factor of .9 or greater.
   b. Total Harmonic distortion shall be less than 20%.

9. Power Consumption
   a. Typical power consumption for each fixture shall be as follows;

1 LED Module	28 watts
2 LED Module	56 watts
3 LED Module	84 watts

2.10 LED WALL PACK LUMINAIRE

A. The LED Wall Pack Luminaire shall be MADE IN AMERICA.

B. Physical and Mechanical Requirements

1. Physical Dimensions
   a. Nominal Fixture size as installed: 9" X 13" X 7.75"
2. Mechanical
   a. Mounting method shall provide the option for direct mount to an industry standard 4" electrical box or via knock out holes for surface mounting.
   b. The fixture shall utilize modular components that are fully field replaceable without the need of special tools. The LED module shall be a self-contained unit and have a M12 screw-in electrical connection to allow easy disconnect.
   c. Modular components at a minimum shall be; LED modules, Power Supply, Interconnecting cable assemblies, power cord.
3. Materials
   a. All metal housing/bracket materials used shall be weather resistant either Aluminum or Stainless Steel.
   b. Metal coating shall be a high quality thermal baked dry spray powder material.
   c. All hardware to be stainless steel.
   d. Materials used for the module lens and LED module construction shall conform to ASTM specifications where applicable.
   e. Lens shall use UV stabilized material.
   f. Enclosures containing the power supply and electronic components of the LED module shall be made of UL94VO flame retardant material.
   g. All electrical wires and connectors to meet UL standards.

C. Environmental Requirements

1. The LED fixture shall be rated for use in the ambient operating temperature range of -30°C to 70°C.
2. The LED fixture and contained modular components shall be protected against dust and moisture intrusion as per NEMA standard 250-1991 type 4 meeting a wet listing classification.
3. The luminaire fixture shall be certified as a wet location fixture.
4. Nominal temperature for all specification compliance measurements is 22°C +/- 3°C.

5. The lens surface shall be generally smooth on the outside to reduce dust and dirt collection. There shall be no diffused, Fresnel or rough surfaces.

D. Module Identification

1. Each LED light fixture shall be identified with the manufacturer's name, model number, serial number and clearly showing date of manufacture.
2. The following operating characteristics shall be identified: nominal operating voltage, power consumption and Volt-Ampere.
3. The LED fixture shall clearly show a safety compliance listing mark with regulatory file number.
4. The LED module shall clearly show a UL listing mark.
5. The Power supply shall clearly show a UL listing mark.
6. The fixture shall clearly show marking indicating MADE IN AMERICA.
7. The fixture shall clearly show "SUITABLE FOR WET LOCATION".

E. Photometric Requirements

1. Photometric measurement shall be documented by an independent test lab report according to IESNA specification.
2. All certified independent test lab reports shall include IES format file for use with lighting software.
3. The standard chromaticity color for the LED light fixture shall be cool white.
4. LEDs shall be either Cree®, Lumiled® or Nichia® industry standard product.
5. IES L70 lumen depreciation level to be a minimum of 120,000 hrs at 55°C.
6. The color temperature shall be typical 6200°K +/- 500°K.
7. The Color Rendering Index (CRI) shall be 75 +/- 3.
8. The fixture shall have a minimum lumen efficiency of 74lm/W.
9. Each individual LED module shall have a minimum output of 2000 lumens, total fixture lumen shall equate to the number of modules times the minimum lumen per each module.

F. Electrical

1. The LED luminaire fixture shall be certified to meet standards UL 1598, UL 8750, CSA 22.2 #250.0.08 standards. Certification to be via a qualified 3rd party testing laboratory, I.e., Intertek, UL or other. Fixture shall be clearly marked with listing file number.
2. The individual LED Lighting Module Brick shall have a UL listing to UL 1598, UL 8750 and shall be clearly mark with UL listing file number.
3. LED light fixture shall operate from a 50-60 Hertz AC line power over a voltage range from 90 VAC RMS to 277 VAC RMS.
4. Nominal operating voltage for all specification compliance measurements shall be 120+/- 3 VAC RMS.

5. Fluctuation in the line over the voltage range shall not affect luminous intensity by more than +/- 10%.

6. Fixture power supply shall be UL approved with a class 2 rating.

7. Transient Voltage Protection: The LED fixture and the on-board circuitry shall include voltage surge protection to withstand high-repetition noise transients and low-repetition, high-energy transients as stated in section 2.1.6, NEMA Standard TS-2, 1992.

8. EMC Noise: The LED fixture and the on-board circuitry must meet Federal Communications Commission (FCC) Title 47, subpart B, section 15 regulations concerning the emission of electronic noise.

9. Power Factor (PF) and AC Harmonics
   a. LED light fixture shall have a power factor of 0.9 or greater.
   b. Total Harmonic distortion shall be less than 20%.

10. Power Consumption
    a. Typical power consumption for each fixture shall be as follows;

1 LED Module	28 watts
2 LED Module	56 watts

2.11 LIGHTING CONTROL CENTER

A. Provide a 365-day digital microprocessor based on solid-state time control center suitable for use with electrically held contactor. Controller shall switch lights "ON" at sunset and "OFF" at sunrise. Units shall automatically adjust for length of daylight hours.

B. Control shall provide an additional "ON" and "OFF" event as well as selectable daylight savings time adjustment and automatic leap year correction. Control shall have a Skip-A-Day, Offset to Sunrise and/or sunset and Manual Override. Control shall have adjustable latitude from 10 degrees to 70 degrees northern or southern hemisphere and selectable 12 or 24-hour clock format. Control shall have 275 hours of carry-over with a lithium battery.

C. The control shall switch 15 amps at 120VAC, resistive or inductive, on each pole of the DPDT outlets.

D. Provide electrically held or electronically held contactor as indicated with 120VAC operating coils, 4 poles, and 20 amp contacts. Provide controller and contactor in common NEMA 1 enclosure. See drawing E0-601

E. Acceptable Manufacturers

1. Time Controller - Paragon, Tork or equal.
2. Contactor - ASCO, Square D, General Electric or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install lamps in luminaries and lamp holders.

B. Install fixtures to center or replace acoustical tile sections. Support fixtures from the building structure through the use of the ceiling support system, where the ceiling support system is designed for the lighting fixture's weight. Fluorescent lighting fixtures installed in exposed ceiling grid ceilings: provide two (2) "safety clips" or "safety hooks" for securing fixture to ceiling grid, and located at opposite corners of fixture.

C. Where fluorescent fixtures are installed in exposed grid ceilings provide #14 gauge galvanized safety hanger wires which attach the fixture to the building structural system to prevent the fixture from falling due to movements in ceiling suspension channels. Attach the safety wire to fixture at a point other than where safety clips are attached.

D. Provide suspended fixtures with swivel hangers and threaded rod. For single-unit suspended fluorescent fixtures, provide twin suspension hangers.

E. Support surface lighting fixtures of more than ten pounds in weight with threaded rods from the building structure.

F. HID Luminaries: Use power hook hangers rated 500 pounds minimum or provide safety chain between ballast and structure. Provide safety chain between reflector and ballast.

G. Lighting plans show location, type and circuit number of lighting fixtures and receptacles only. Conduit and conductor shall be provided from the lighting fixtures, light switches and receptacles to the lighting panel in accordance with the NEC. Conduit and conductor shall be provided in accordance with Section 16111 and 16120.

H. Photoelectric cells shall be oriented toward the north.

3.02 RELAMPING

A. Relamp all burned out lamps upon completion of work.

3.03 ADJUSTING AND CLEANING

A. Clean lenses and diffusers at completion of Work. Clean paint splatters, dirt, and debris from installed luminaries.

B. Touch up luminaries at completion of work.

C. Mount continuous rows of luminaries in straight line. Utilize alignment clips between reflectors, where applicable.

3.04 LIGHTING FIXTURE SPECIFICATION SHEETS

A. Notes:

1. Lighting fixtures, including their related accessories, options, and hardware are specified on individual lighting specification sheets located at the end of this section.
2. The manufacturer's catalog numbers listed are examples of the basic model, or series, and the overall quality required. While the referenced catalog numbers attempt to be as definitive available literature permits, such items as voltage, mounting style, modifications,

and other special features may not be included. The Contractor, supplier, and manufacturer shall verify and provide all of the specified requirements.

3. Each lighting fixture specification sheet and lighting fixture type shown on the Drawings is identified with a unique acronym of two digits as follows:
   a. Lamp Sources: The first digit of the fixture type indicates the basic or predominant lamp source from which the light is produced, as follows:

      F=Fluorescent

      I=Incandescent

      M=Metal halide

   b. Family groups: The second digit of the fixture type indicates a family of fixtures, which share physical characteristics, such as appearance, construction or function. The family general requirements apply to all members of the family. All family members shall be produced by the same manufacturer and have matching characteristics. Family groups are as follows:

      C= Corrosion-resistant

      D= Downlight

      E= Emergency

      F= Floodlight

      I= Industrial

      V= Vaportight

      X= Exit sign

   c. Lighting fixtures specified in the lighting fixture specification sheet are alphabetically arranged by lamp source and function.

LIGHTING FIXTURE SPECIFICATION SHEET NO. 1

Family group	IB - Incandescent, Wall bracket
Group description	Surface, white opal glass.
Family members	IB1: Two 100-watt lamps. Six (6) inches high by 17 inches wide. Example: Prescolite No. WB-19
Construction	Finish: White, baked enamel base.
Lighting	Distribution: General, diffuse. Shieldinq: Formed white satin opal glass.
Lamps	Standard
Electrical	Input voltage: 120
Mounting	Surface on wall
Acceptable products	Halo, Lightolier, Marco, Prescolite, or equal.

LIGHTING FIXTURE SPECIFICATION SHEET NO. 2

Family group	IE - Incandescent, Emergency
Group description	Battery-powered emergency lighting unit. Corrosion resistant. 90-minute minimum light from integral batteries.
Family members	IE1: Power unit with batteries, power supply and charger and two lighting heads mounted on top. Example: Dual-Lite, No. 4 x 7-12V-TDR.
Lighting	Distribution: Adjustable light heads.
Lamps	25 watt, 12-volt sealed-beam incandescent, one per head.
Electrical	Input voltage: 120. Integral 12-volt transformer and battery charger.
Mounting	Power unit wall mounted in custom angle iron bracket assembly with bottom at +7-½ feet. See detail on Drawing.
Acceptable products	Chloride, Dual-Lite, Dyna-Ray, Exide, Holophane, Lithonia, Sure-Lites, or equal.

LIGHTING FIXTURE SPECIFICATION SHEET NO. 3

Family group	IX - Incandescent, Exit sign
Group description	IX1: Exit signs with 6 inch green letters. Directional arrows as shown. Oil, dust and corrosion resistant. Example: Dual-Lite N4X-ER-1-EP Dimensions: Approximately 9-½-inches high, 12-½-inches wide, universal snap on arrows.
Construction	Housing: Lightweight, unbreakable, injection molded, polycarbonate material. Finish: Poolycoated, aluminum backed stencil in white finish.
Lighting	Distribution: Light through red letters plus maximum down light.
Lamps	Two 15T6 ac lamps and two double contact bayonet base sockets with 3.6 watt.
Electrical	Input voltage: 120.
Mounting	Surface ceiling or wall mounting. See symbols on Drawing.
Acceptable products	Dual-Lite, Daybrite, McPhilben, Moldcaste or equal. Example: Dual-Lite No. N4X-ER-1-EP

LIGHTING FIXTURE SPECIFICATION SHEET NO. 5

Family group	FI - Fluorescent, Industrial
Group description	Bare lamp industrial with downlight reflector. Indoor use, nominally 1 foot wide by 4 feet long. Surface and pendent mounted.
Family members	FI1: Two lamps wide, 4 foot length.
Construction	Housing: Die-formed code gage steel housing. Finish: White, dry polyester powder finish over phosphate pretreatment.
Lighting	Distribution: General downlight. Reflector: Apertured, with 10 percent uplight. Shieldina: None.
Lamps	Standard grade: 32 watt
Electrical	Input voltage: 120. Ballasts: Ultrapremium grade, magnetic.
Mounting	Surface or pendent: ½-inch RSC threaded stems. Outlet boxes: Cast metal with threaded conduit entries. Ball aligners. See detail on Drawings.
Acceptable products	Day-Brite "CFI-10" series, or equal.

LIGHTING FIXTURE SPECIFICATION SHEET NO. 6

Family group	FC - Flourescent, Corrosion-resistant
Group description	Industrial indoor, enclosed surface and pendent, waterproof and chemical-resistant. Nominal 1 foot wide by 4 feet long.
Family members	FC1: Two 34-watt energy-saving T-12 lamps. FC3: same as FC1, plus integral emergency power supply.
Construction	Housing: Nonmetallic housing, injection molded, high-impact thermoplastic. Finish: Any interior metallic parts shall be stainless steel or zinc-phosphated steel painted with powder-coat white epoxy finish.
Lighting	Distribution: General downward. Shielding: Impact-resistant patterned acrylic diffuser.
Electrical	Input voltage: 120. Ballasts: Ultrapremium grade, magnetic.
Mounting	Surface or pendent stems.
Special	UL Damp Location label
Acceptable products	Day-Brite Vaporlume, Lithonia DL, Metalux VT, or equal.

END OF SECTION 16510

SECTION 16601
LIGHTNING PROTECTION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes a complete UL Master Labeled Lightning Protection System for buildings and associated structures and requirements for lightning protection system components. Unless indicated otherwise, the extent of the lightning protection system designed, furnished, installed, Master Labeled and documented under this Section shall include all site buildings, structures and appurtenant installations, both new and existing, as required to provide "total" site lightning protection.

B. Product Data for each component specified.

C. Shop Drawings detailing lightning protection system. Include air terminal locations, conductor routing and connections, and bonding and grounding provision. Include indications for use of raceway and data on how concealment requirements will be met.

D. Qualification data for firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience.

E. Certification, signed by Contractor, that roof adhesive for air terminals is approved by manufacturers of both the terminal assembly and the roofing material.

F. Field inspection reports indicating compliance with specified requirements.

1.03 QUALITY ASSURANCE

A. Materials and installation to conform to NFPA 70, National Electrical Code and to NFPA 780, Lightning Protection Systems.

B. Installer Qualifications: Engage and experienced installer who is NRTL listed or who is certified by the Lightning Protection Institute as a Master Installer/Designer.

C. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.
2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

D. Provide UL Master Label.

E. See also Spec 16010 Part 1 for listing of applicable reference standards.

1.04 SEQUENCING AND SCHEDULING

A. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.

1.05 CONTRACT DRAWINGS

A. Contract Drawings for lightning protection systems furnished by Owner / Architect / Engineer to Contractor are diagrammatic in nature, and are intended only to provide general indication of the overall extent and intent of the lightning protection system scope. Materials and methods, where indicated, are generic and diagrammatic and are provided for illustrative purposes only. Quantities and details of materials and installation methods shall be developed by Contractor. Contractor shall submit his own catalog cuts of proposed materials and detailed design drawings for approval, as indicated.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work, include, but are not limited to, the following:

1. A-C Lightning Security, Inc.
2. Approved Lightning Protection Co., Inc.
3. Heary Bros. Lightning Protection Co.
4. Thompson Lightning Protection Co.

2.02 LIGHTNING PROTECTION SYSTEM COMPONENTS

A. Comply with UL 96.

B. Comply with NFPA 780, Class I or Class II as specified and / or required.

C. Hardware for Lightning Protection System: UL type and of the same material as the air terminal, or of brass or bronze, as approved for the application.

2.03 GROUND RODS

A. Copper-clad steel with a minimum of 27 percent of rod weight in copper cladding.

B. Diameter: 3/4 inch (19 mm).

C. Length: 10 feet (3 meter)

2.04 AIR TERMINALS

A. UL approved, solid copper or nickel, with a diameter not less than as required per NFPA 780, having the tip as specified or indicated.

2.05 ROOF/DOWN CONDUCTORS FOR LIGHTNING PROTECTION SYSTEM

A. Copper cable meeting UL 96, with minimum size per NFPA 780, or larger as indicated.

2.06 LIGHTNING PROTECTION SYSTEM

A. Consists of cables, air terminals, mounting bases, fittings, couplings, connectors, fasteners, and other devices for a complete, coordinated system including interconnections to ground rods and ground grid.

B. Materials, except bolts, screws, and related type hardware: Copper or high-copper content bronze or nickel, or brass, and the standard product of a manufacturer regularly engaged in production of lightning protection systems. Materials shall comply in weight, size, and composition for a Class I or Class II structure to be protected in accordance with NFPA 780. Bolt, screws, and related type hardware shall be stainless steel.

C. Fittings, except cable holders: Heavy-duty type bronze casting; stamped, pressed, and crimped type pressure devices are not permitted.

D. Methods of fastening air terminals to roof: Compatible with roof composition. Do not attach copper materials to aluminum; adhesives for attaching materials to roofing shall be approved for use by the specific roofing manufacturer.

2.07 BOND AND WELD SEALANT

A. Vinyl-backed compound

2.08 TRANSIENT VOLTAGE SURGE SUPPRESSORS

A. Furnish and install appropriate transient voltage surge suppressors or similar devices on all electrical, telephone, signaling, communication, television and similar service entrances at the protected building / structure.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine surfaces, areas, and conditions, with Installer present, for compliance with installation tolerances and other conditions affecting performance of lightning protection. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install lightning protection as indicated, according to manufacturers written instructions.

B. Comply with UL 96A, LPI-175, and NFPA 780.

C. Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends and narrow loops. Where indicated, run conductors in nonmetallic raceway, Schedule 40, minimum.

D. Conceal down conductors.

E. Conceal interior conductors.

F. Provide notification at least 48 hours before concealing lightning protection components.

G. Cable Connections: Use approved exothermic-welded connections for all conductor splices and connections between conductors and other components, except those above single-ply membrane roofing.

H. Bond extremities of vertical metal bodies exceeding 60 feet (18 m) in length to lightning protection components.

I. Bond ground terminals to counterpoise conductor.

J. Bond grounded metal bodies on building within 12 feet (4 meter) of ground to counterpoise conductor.

K. Bond grounded metal bodies on building within 12 feet (4 meter) of roof to counterpoise conductor.

L. Bond lightning protection components to grounded metal bodies on building at every 60 feet (18 meter).

M. Bond all underground metal piping entering / exiting the structure to the ground loop or closest ground rod.

3.03 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture, unless moisture is permanently excluded from the junction of such materials.

B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

3.04 FIELD QUALITY CONTROL

A. UL Inspection: Apply for inspection by UL as required for UL Master Labeling of system. Submit evidence of master labeling for record.

END OF SECTION 16601

SECTION 16721
FIRE ALARM SYSTEM

PART 1 - GENERAL

1.01 DESCRIPTION

A. Work described in this Section includes furnishing all labor, materials, equipment, tools and incidentals required for a complete and operable addressable fire alarm system. All components shall be installed, adjusted, tested and placed in operation in accordance with these Specifications, the manufacturer's recommendations and as shown on the Drawings.

B. Contract drawings show only functional features and some of the required external connections. They do not show all components required for a complete installation nor exact dimensions particular to any manufacturer's equipment. Contractor shall supply all parts, devices and equipment necessary to meet the requirements of the Contract Documents and shall make all dimensional adjustments particular to the equipment being furnished. All costs associated with such changes and adjustments shall be considered as being included in the price bid for the work shown and specified.

C. Refer to Sections 16000 (Electrical Power and Systems) for additional scope requirements.

1.02 RELATED WORK

A. Division 16 – Electrical

1.03 REFERENCES

A. Reference Standards: Comply with all Federal and State laws or ordinances, as well as all applicable codes, standards, regulations and/or regulatory agency requirements including the partial listing below:

1. NFPA 70.
2. NFPA 72.
3. NFPA 101.
4. NEC Article 760.
5. Standard Building Code as amended and adopted by the City of Atlanta.
6. State of Georgia Rules of Safety Fire Commissioner.
7. ADA requirements.

B. All equipment comprising the system shall be listed and labeled by Underwriter's Laboratories, Inc.

1.04 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions of the Contract Documents. In addition, the following specific information shall be provided:

1. Relevant experience references.
2. Manufacturer's certifications.
3. Manufacturer's equipment data sheets.
4. Connection and wiring diagrams.
5. Operation and Maintenance Manuals.
6. Voltage drop calculations.
7. Standby battery calculations.
8. All complete "As built" system wiring drawings including field wiring to and from Fire Control panels shall be provided to the Engineer for review before work is accepted by the **City.**

B. Refer to Section 01350, Paragraph 1.03 for additional requirements.

1.05 QUALITY ASSURANCE

A. The Contractor shall comply with all requirements for permits and tests shall provide all certificates and shall pay all costs for same.

B. The fire alarm system shall be furnished by a single manufacturer who shall assume full responsibility for providing a complete, operating system designed for long life with a minimum of required maintenance meeting the requirements specified herein and as shown on the drawings.

C. Manufacturers shall provide written calculations and other data demonstrating that the equipment provided under this Specification has been amply designed and is a suitable application for these service conditions. A certificate of unit responsibility shall be provided. Nothing in this provision, however, shall be construed as relieving the Contractor of his overall responsibility for this portion of the work.

D. Unit responsibility certificates provided by suppliers, vendors, or other second party representatives of the pump manufacturer shall not be accepted.

E. Manufacturers offering equipment that complies with these specifications include:

1. Simplex Grinnell, 4100 System.
2. Firelite Alarms, Inc.
3. Gamewell.
4. Or equal.

1.06 DELIVERY, STORAGE AND HANDLING

A. Provide factory-wrapped waterproof flexible barrier material for covering materials, where applicable, to protect against physical damage in transit.

B. Handle materials carefully to avoid damage, breaking, denting and scoring. Damaged equipment or materials shall not be installed.

C. Refer to Section 16000 for additional requirements.

1.07 SPECIAL REQUIREMENTS

A. Provide a warranty against defective equipment and workmanship in accordance with the requirements of the General Conditions of the Contract Documents.

PART 2 - PRODUCTS

2.01 GENERAL

A. The fire alarm system shall consist of local fire alarm control panels and addressable detection devices.

B. The fire alarm system shall have the capability for transmitting alarms and status of each alarm initiating and addressable detection device via fiber optic communication link to the central fire alarm control and monitoring system.

C. All devices shall be housed in enclosures suitable for the environmental and/or hazardous area classifications and conditions.

2.02 SYSTEM OVERVIEW

A. Two (2) fire alarm panels shall be provided and shall be located in the Diversion Facility Pump Station and the Jet Mixing Pump Station. The panels furnished under this section shall be capable of "Stand alone" operation. In addition, the new panels shall interface with the existing main fire alarm panel located an the R.M. Clayton Water Reclamation Center.

B. All panels shall be interconnected by fiber optic cable. All required hardware and software additions or modifications to the existing panel shall be furnished and installed under this Section and is included in this Contract.

2.03 PERFORMANCE REQUIREMENTS

A. The system shall include the following features as a minimum:

1. During an alarm condition, the associated alarm LED shall flash until acknowledged and this shall allow determination of where the last alarm has taken place.
2. Ground fault detection in wiring on either plus or minus side.
3. Separate alarm and trouble LED for each zone or addressable point.

4. "Dead" Front design control panel with all LED alarm trouble and power on indicators and all switches located behind a locked tempered glass door.

5. Resound features.

6. Solid state construction.

7. All alarm initiating circuit wiring, alarm signaling wiring and annunciator wiring shall be supervised.

8. Automatic transfer to standby batteries upon power failure.

9. Functional System Test capability which when in the test mode, activated initiating devices will report their individual addresses at the control panel and audibly via a code pattern and voice which automatically resets within four seconds. Integrity of the installation conductors and indicating appliance circuit can be verified by momentarily opening any circuit. The indicating appliance will operate for four seconds and automatically reset.

10. Smoke detector alarm verification operating whereby the system shall reset the alarmed detector and wait for a second alarm. If, after reset, a second alarm is reported from the same or any other smoke detector within one minute, then the system shall process the alarm per the operation listed above. If no second alarm occurs within one minute, then the system shall resume normal operations. This alarm verification operation shall be only for smoke detector alarms. All other sources of alarm shall be processed immediately.

2.04 LOCAL CONTROL PANEL

A. Provide surface mounted Fire Alarm Control Panels with a key lock.

B. Panels shall have a minimum of two SPDT alarm relays and one SPDT trouble relay. All relays shall have contacts rated at 3 amps 120/vac/24 vdc.

C. Panels shall have offsite monitoring output capability with converter for fiber optic connections to transmit alarm and trouble information to a central location.

D. Panels shall have 60 hours of battery reserve and shall be capable of sounding all alarm devices for at least ten minutes after the 60 hours.

E. Power supply unit shall be supervised for A.C. power interruption, blown fuses, battery charge, and loose, disconnected or reversed battery.

2.05 DETECTION DEVICES AND ALARMS

A. Manual Stations:

1. Furnish Wall Mounted Manual Alarm Stations as shown on the plans. The station body shall be so constructed that chips and scratches will not expose metal. All stations shall be master keyed with the control equipment. When actuated, the "pull lever" shall remain at a right angle to the station body until reset. Stations, which utilize screwdrivers, allen wrenches, or other commonly available tools shall not be accepted.

B. Photoelectric Smoke Detectors:

1. Provide Photoelectric Smoke Detector as shown on the plans. Detectors shall be of the solid-state photoelectric type utilizing a stable LED light source and a silicone photo diode as the receiving element to form a highly accurate means of smoke detection. Internal detector circuits shall be shielded against electrical interference and resistant to transients, "noise and RF interference".

2. Nominal detector sensitivity shall be 1.4% per foot obscuration with a range of 1% to 1.84%. Regardless of sensitivity settings, the detector's stability shall be unaffected by high air velocity. No radioactive materials shall be used.

3. Each detector shall have a dual purpose red LED. This LED shall blink continually to show that the device is powered. When the detector goes into alarm, this LED shall stop blinking and shall come on steady. In addition, every detector base must be capable of operating an auxiliary relay. This relay is to be used to release magnetically held doors, interface with the elevator controller, interface with the HVAC or pressurization system, or any other use deemed necessary now or in the future.

C. Alarm Signals:

1. Provide audio-visual unit with horn, and flashing light when activated. Provide trims for audiovisual units to match wall finish.

D. Duct Mounted Photoelectric Smoke Detectors:

1. Provide Photoelectric Duct Mounted Smoke Detectors with sampling tubes as shown on the plans. Duct mount smoke detectors shall be coordinated with the contractor and connected to the Fire Alarm System by the electrical contractor. Each detector to have its own SPDT 2 amp rated relay and be capable of operating a remote LED to indicate its alarm condition.

2. Each duct detector must be capable of either two or four wire operation.

E. Shutdown Relays:

1. Provide relays operated by the fire alarm system to shutdown associated motors vial electrically isolated relays/contacts.

2. Ratings shall be suitable for the load.

3. Wiring between the relays and the controlled devices is part of this Section.

F. Ionic Smoke Detector

1. Provide ionic smoke detectors as shown on the Drawings. Ionic smoke detectors shall be coordinated with the Contractor and connected to the Fire Alarm System by the Electrical Contractor.

2. The detector shall have a visible LED which will blink in standby and catch on in alarm. The detector shall have a sensitivity of 1.9±0.6%/ft., as measured in UL smoke box. Wiring connectors shall be made by means of SEMS screws.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Provide all equipment, wiring, conduit and outlet boxes required for the installation of a complete and operating system in accordance with applicable local, state and national codes, the manufacturer's recommendations, these plans and specifications. Color code shall be used throughout.

B. All local fire alarm control stations shall be connected to the fire alarm control panel over a fiber optic data highway. Provision shall be made for remote monitoring and control of each detection device.

C. Interconnection of fire alarm system devices shall be via approved wiring in conduit of the type suitable for the environmental and/or hazardous area classifications and conditions.

D. All conduit in corrosive areas shall be PVC coated rigid steel.

3.02 FIELD TESTS

A. The manufacturer's authorized representative shall provide supervision of final system panel connections, perform a complete functional test of the system and submit a written report to the contractor attesting to the proper operation of the system.

3.03 MANUFACTURER'S SERVICES

A. Warranty service for the equipment shall be provided by the manufacturer's factory trained representative during normal working hours, Monday through Friday excluding holidays.

B. All complete "As built" system wiring drawings including field wiring to and from Fire Control panels shall be provided to Engineer for review before work is accepted by the City.

C. Upon completion of the installation, the electrical contractor shall provide to the Engineer, a signed written statement from the manufacturer's representative attesting that all system equipment was installed in accordance with these Specifications and in accordance with wiring diagrams, instructions and directions provided to the contractor by the manufacturer.

D. After the equipment has been placed in satisfactory operating condition, the Contractor shall provide a minimum of one (1) working day of training of the City's personnel on the operation and maintenance of the system.

END OF SECTION 16721

SECTION 16742
TELEPHONE/DATA SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provision of the Contract, including General and Supplementary Conditions and Division 1 Specifications Sections apply to this Section.

1.02 SUMMARY

A. Telephone/Data Raceway Systems:

1. Drawings and General Provisions of the contract include General and Supplementary Conditions and Division 1 Specification sections apply to this section.
2. Miscellaneous Electrical Materials and Methods sections apply to work specified in this section.
3. The Contractor shall furnish and install a complete telephone/data raceway system including connection from utility pole to the telephone backboard.

B. Telephone/Data Systems:

1. Route all telephone circuits to the telephone backboard.
2. Route all data circuits to the data backboard.
3. Emergency phone.
4. Provide conduit sleeves (two (2) 4 inch conduit unless noted otherwise) between the point of telephone company incoming service and the telephone closet.

1.03 REFERENCED DOCUMENTS

A. Industry Standards:

1. American National Standards Institute (ANSI):
   a. C2 National Electrical Safety Code
2. National Electrical Manufacturers Association (NEMA):
   a. ICS 6 Enclosures for Industrial Controls and Systems

1.04 SUBMITTALS

A. General: Submit the telephone equipment according to the Conditions of the Contract and Division 1 Specifications Sections.

B. Submit operation instructions, detailed parts list, recommended spare parts list, cable wire lists, circuit diagrams, maintenance procedures, and troubleshooting procedures.

1.05 QUALITY ASSURANCE

A. Comply with NFPA 70, for components and installation.

B. Testing of installed products, specified in this Section, shall be performed by persons having not less than five (5) years of telephone cable and equipment testing experience.

PART 2 - PRODUCTS

2.01 PRODUCTS

A. Wall boxes shall be 4-11/16" X 4-11/16" square with stainless steel cover and 4-1/2" x 4-1/2" square and minimum 2-1/2" deep.

B. Conduit and fittings shall be as specified.

C. Jacks: Each jack shall be clearly labeled with a jack location number corresponding to a label on the station block for that particular termination.

1. Telephone: RJ-11.
2. Data: RJ-45.

D. Cable: Category five (4 pair) cable from each jack location to the backboard.

1. Telephone Cables shall be terminated on an AT&T S110 modular terminal blocks. Each termination on the terminal block shall be labeled with a corresponding jack location number.
2. Data Cables shall terminate with a RJ-45 male connector. Each cable shall be labeled with a corresponding jack location. Provide 6 feet of slack cable.
3. Plenum rated cable.

E. Plywood backboards shall be exterior grade, 4'-0" X 8'-0" X 3/4" thick, located as shown on the Drawings. Backboards shall be treated with fire retardant, gray primer and painted with two coats of flat gray paint.

F. Wire Manager – The Contractor shall furnish and install wire managers.

PART 3 - EXECUTION

3.01 EXECUTION

A. The Contractor shall contact and verify with local telephone company serving the existing area, regarding disconnection and reconnection of temporary services (where required) and equipment supplier prior to installation of any electrical work.

B. The Contractor shall furnish and install a complete system of cabinets, outlet boxes, conduit and miscellaneous fittings and materials to provide a complete system.

C. The Contractor shall verify the type and arrangement of the equipment with telephone and data equipment supplier prior to the installation of any electrical work. Any work installed, which

must later be relocated as a result of the Contractor negligence in coordinating with the equipment supplier shall be done as directed by the Owner's Representative at no additional cost.

D. Desk telephone shall have wall boxes mounted 12 inches above finished floor unless otherwise note. The boxes shall be double gauged stainless steel with cover plate, modular outlet and jack.

E. Wall telephone shall be furnished with a box similar to the one specified for the desk telephones and mounted 48 inches above finished floor. The outlet shall be equipped with necessary cover plate for wall telephone installation.

F. Stub 3/4 inch conduit from outlet boxes to above accessible ceiling. Route cables to backboard. Tie wrap cables together and to structure for support. Do not route cables on top of lay-in ceiling grid or panels.

G. A nylon fish wire shall be installed and left in place in all empty conduit runs.

H. Use 1-1/2 inch sleeve or conduit for penetrations in walls, extending a minimum of 6 inch on both sides of the wall. Provide appropriate sealants and stopping for fire rated walls.

3.02 SYSTEM TESTS

A. Cables: Test shields and conductors for open and shorts. Measure loop resistance of each pair. Measure insulation resistance.

END OF SECTION 16742

SECTION 16960
CONTROL CIRCUITS AND PILOT DEVICES

PART 1 - GENERAL

1.01 SCOPE

A. This Section includes furnishing, unless otherwise indicated, and installing all materials and providing all labor and supervision pertaining to control circuits and pilot devices.

B. Unless otherwise indicated, all pilot devices, such as pushbutton stations, selector switches, thermostats, firestats, smoke switches, pressure switches, limit switches, float switches, flow switches, pneumatic-electric switches, recorder controllers, and the like, shall be furnished by the supplier of each item or group of items of driven equipment specified in other Divisions of these specifications. The Contractor shall refer to the appropriate Divisions under which driven equipment, or control system applicable thereto, is to be furnished for all specific requirements which may have a bearing on work under this Section, and shall provide the proper services and other electrical work required to make the equipment operable.

C. In general, all "line" voltage (120 volts and higher) control wiring shall be provided under this Section and lower voltage wiring, such as for low voltage temperature control systems and the like, shall be furnished under the requirements of other Sections.

1.02 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of the General Conditions of the Contract Documents. In addition, the following specific information shall be provided:

1. Catalog cuts, electrical ratings, adjustment ranges, enclosure types and dimensions, necessary internal and interconnection diagrams, etc.

1.03 QUALITY CRITERIA

A. Control devices shall comply with U.L., NEMA, and N.E.C. requirements.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Pilot devices shall generally be heavy-duty industrial type with adequately rated precious metal contacts and with enclosures suitable for the type and class of area and for the environment in which they are to be installed.

B. Specific requirements for pilot devices to be provided under this Division shall be as indicated on the drawings or as called for under other Sections of this Division.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Pilot devices and wiring thereto shall be properly supported.

B. Control circuits shall be provided and connected in accordance with diagrams indicated on the drawings and/or in accordance with diagrams to be furnished by the supplier of the driven equipment or by the supplier of the control system involved therewith.

C. All required device adjustments and settings and all required re-connections shall be provided to make all systems and equipment operate in a satisfactory manner.

END OF SECTION 16960

SECTION 16999
ACCEPTANCE TESTING AND CALIBRATION

PART 1 - GENERAL

1.01 SCOPE

A. This Section includes the field testing, inspection and adjusting of all material and equipment installed. Other Electrical Sections covering individual types of equipment may have additional testing requirements.

1.02 QUALITY ASSURANCE

A. Reference Standards: Comply with all Federal and State laws or ordinances, as well as all applicable codes, standards, regulations and/or regulatory agency requirements including the partial listing below:

1. NEC, National Electrical Code.
2. NEMA, National Electrical Manufacturers Association.
3. ASTM, American Society for Testing Materials.
4. IEEE, Institute of Electrical and Electronics Engineers.
5. NETA, National Electrical Testing Association.
6. ANSI, American National Standards Institute.
7. IPCEA, Insulated Power Cable Engineers Association.
8. OSHA, Occupational Safety and Health Act.

B. Items not passing test will be rejected and shall be repaired or replaced with acceptable new items. The repaired and replacement items shall be tested.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.01 GENERAL

A. Inspect, test and calibrate in accord with manufacturer's instructions supplemented by this Specification.

B. Institute and maintain rigorous precautions for all test procedures. Maintain telephone or voice radio contact between the potential source location and energized remote locations during any potential testing operations.

C. Contractor shall utilize the services of a testing firm, approved by the Engineer, which is regularly engaged in the testing of electrical equipment, devices, installations and systems to conduct all of the testing specified in this Section. The testing firm shall meet the qualification criteria set forth in NETA acceptance testing specification.

3.02 POWER CIRCUIT BREAKERS

A. Preparatory Work: Prior to testing, remove each breaker from its compartment. Clean, lubricate, inspect and adjust each breaker in accord with manufacturer's published maintenance instructions. Inspect contacts, arc quenchers, primary and secondary disconnects, current sensors, small wiring and trip devices. Examine contacts for condition, clearance, pressure and wipe.

B. Tests and Data: Determine and record the following data:

1. Breaker identification, including City's designation, manufacturer's ratings, serial number, trip device type, ranges and time bands.

2. Test each breaker electrically for proper tripping characteristics by passing 60 Hz. sinusoidal low voltage current through each pole, one at a time, with test current injection at the primary disconnects. Adjust trip devices for required pickup characteristics. Perform tests at operating trip device settings as specified. Include this information in the report plus the record of the settings "as left" after calibration.

3. Apply sufficient current to actuate each mode of trip device, i.e., long time pickup, long time delay band, short time pickup, short time delay band, instantaneous pickup, ground pickup and ground delay band as applicable. Test current and elapsed time at tripping. For each pole, state whether or not breaker tripping is within the manufacturer's tolerances.

4. Perform insulation resistance test on each breaker. With contacts closed, apply 1,000 volts DC for each 600 V and under and 250 V DC up to 5 KV and make readings after one minute energization between each pair of poles and from each pole to the breaker frame.

C. Molded Case Circuit Breakers and Motor Circuit Protectors. Test automatic molded case circuit breakers for acceptance. Quantity to be tested is indicated below.

1. Thermomagnetic Trips. (Breakers Only). Test breakers having thermomagnetic trips in a temperature controlled environment maintained at 400 C plus or minus 30 C. A temperature stabilization period of 15 minutes is required prior to testing the inverse-time automatic tripping characteristics. Test each pole of each breaker at 90% and 200% of its continuous current rating. Replace any breaker or trip device which trips within 10 minutes at 90%, or which fails to trip at 200% within the time indicated in the following table:

Rated Continuous Current, Amperes	Max. Tripping Time, Minutes	Breakers tested per Panel or Switchboard
15 - 40	2	10% (not less than 2)
50	4	20% (not less than 1)
60 - 100	6	50% (not less than 1)
125 - 225	8	100%
250 - 400	10	100%
500 - 600	12	100%
700 - 800	14	100%
1,000	16	100%
1,200	18	100%

2. Instantaneous Trips. Test each pole of each breaker and motor circuit protector for automatic instantaneous tripping with slowly rising current. Replace any breaker or trip device which fails to operate within the following values:

3. Non Adjustable Trips - plus or minus 20% of fixed setting. Adjustable Trips - plus or minus 10% of the high setting of the rms values of the instantaneous tripping current.

4. Motor Circuit Protectors after testing shall be placed in service at the minimum position which permits motor starting based on motor nameplate data following MCP manufacturer's instructions.

3.03 MOTORS AND MOTOR CONTROLS

A. Inspect and test motors and motor wiring, power and control for proper connection, circuit continuity, wire identification, insulation resistance and proper functioning or operation. Test insulation resistance from line to line and from each line to ground with a test instrument. Make tests prior to energizing circuits. Test motors for correct rotation. Test proper operation of starters and control devices. Record the nameplate data of motors for the selection of the proper overload relay heater size.

B. Test and inspect power distribution equipment for damage, defects and for proper functioning of all electrical and mechanical components. Test line and load bus, connections and conductors and test circuit breakers for proper electrical and mechanical operation.

C. Place motor circuit protectors in service at the minimum position which permits motor starting, based on motor nameplate data and following MCP manufacturer's instructions.

3.04 LIQUID FILLED TRANSFORMERS

A. Inspect for physical damage, cracked insulators, leaks and tightness of connections. Verify proper auxiliary device operation. Verify proper liquid level in all tanks and bushings. Perform specific inspections and mechanical tests as recommended by manufacturer. Verify proper equipment grounding.

B. Perform insulation-resistance tests, winding-to-winding, and windings-to-ground. Perform a turns-ratio test between windings at all tap positions. Sample insulating liquid in accordance with ASTM D-923. Sample shall be laboratory tested for, acid neutralization number, specific gravity, interfacial tension and color.

C. Perform all other tests not specified here, but required to conform to the requirements of NETA.

3.05 SPECIAL SYSTEMS

A. Exercise care in the testing of electrical systems so as not to damage special, electronic or instrumented circuits. Do not undertake to check or test special electronic or instrumented circuits beyond the manufacturer's instructions included with the equipment and performed for

B. equipment installation. Test the continuity only for alarm, instrumentation, or similar special wiring systems prior to the final equipment connections.

C. Medium Voltage switchgear 15kV shall have hi-pot testing.

3.06 INSULATION TESTS

A. Furnish the necessary test equipment and labor to test the insulation of electrical equipment and circuits before they are energized. Use a 1,000 volt "Megger" or other approved instrument, to test the insulation resistance of circuits insulated for 600 volts, associated motors and transformers, low-voltage motor control centers and low voltage switchboard.

B. Insulation Tests: Include, but are not limited to, the following:

1. Transformers: Test primary to ground, secondary to ground and primary to secondary.
2. Services: Test phase to phase and each phase to ground.
3. Cables: Test phase to phase and each phase to ground.
4. Perform continuity test to ensure proper cable connection.
5. Motors: Test winding to ground.
6. Load Side of 600 Volt Circuits: Test each phase to ground and phase to phase.
7. Minimum Acceptable Megger Readings (Megohms at 20 C) for 600 volt class equipment:

Transformers	Megohms
Primary to ground	20
Primary to Secondary	20
Secondary to Ground	5
Services - Motor Starters and Buses	20
Motors	2
Load side of 600 volt circuits less motor	20

C. Control power transformers, potential transformers and other devices connected phase to phase or phase to ground and any devices not designed to withstand the test voltages must be disconnected when testing insulation resistance in switchboard, motor control centers and other apparatus.

D. Keep written record of tests performed on forms approved for the purpose and turned over to Engineer upon request, or at the termination of the Work. Identify each circuit or piece of apparatus tested, the date of the test, the temperature at the time of testing, the instrument used, the test voltage applied, the resistance values found and the name of the person in charge of and witnessing the test.

3.07 FINAL INSPECTION AND TEST

A. Upon completion of the various phases of the project, or at convenient times during progress of the Work, check and/or test as herein specified all equipment and wire installed.

B. Upon receipt of written notice that the work has been completed, including tests herein specified, Engineer's representative will give the entire work a thorough inspection. Any defects or omissions noted shall be corrected before acceptance of the work.

C. The inspections and tests to be made by the Contractor shall include, but are not limited to, the following:

1. Visually inspect wires and cable connections including internal wiring of switchgear, transformers and other equipment.
2. Verify continuity of power and control conductors.
3. Make insulation tests as herein specified.
4. Check control circuits for short circuits and extraneous grounds.
5. Check equipment for proper mechanical adjustment and freedom of operation and removal of shipping blocks and/or stops.
6. Check closing, tripping, supervision and alarm functions of the controlled equipment.
7. Operate motor controllers, contactors, etc., from their control devices.
8. Check operation of alarm circuits.
9. Check motors for proper rotation and motor currents measured under load conditions. Any motor found to be operating incorrectly shall be inspected to determine the cause and the condition shall be corrected to the satisfaction of Engineer. Furnish a record of these tests to Engineer.

END OF SECTION 16999