DIVISION 26 – ELECTRICAL

260500 – BASIC ELECTRICAL REQUIREMENTS

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 division of the Specifications, Division 26 000, covers the complete interior and exterior electrical systems as indicated on the drawings or as specified herein. Provide all materials, labor, equipment and supervision to install electrical systems.

1.03 QUALITY ASSURANCE

A. All electrical work shall be in accordance with the following codes and agencies:

1. The National Electrical Code (NFPA 70) – 2017 with Georgia Ammendments.
2. The National Electrical Safety Code (ANSI C-2)
3. The Life Safety Code (NFPA 101)
4. The International Building Code
5. Occupation Safety and Health Administration (OSHA)
6. Manufacturer's written requirements.
7. Regulations of the local utility company with respect to metering and service entrance.
8. Municipal and state ordinances governing electrical work.

B. Material Standards: All material shall be new and shall conform to the standards where such have been established for the particular material in question. Publications and Standards of the organization listed below are applicable to materials specified herein.

1. American Society for Testing and Materials (ASTM)
2. Underwriters' Laboratories, Inc. (UL)
3. National Electrical Manufacturer Association (NEMA)
4. Insulated Cable Engineers Association (ICEA)
5. Institute of Electrical and Electronic Engineers (IEEE)
6. National Fire Protection Association (NFPA)
7. American National Standards Institute (ANSI)
8. Manufacturer's Written Requirements

1.04 PERMITS

A. Obtain all permits and inspections for the installation of this work and pay all charges incident thereto. Deliver to the Owner all certificates of said inspection issued by authorities having jurisdiction.

1.05 WARRANTY

A. For warranty of work under Division 16, refer to the GENERAL CONDITIONS.

1.06 DRAWINGS

A. The drawings indicate the arrangements of electrical equipment. Review architectural drawings for door swings, cabinets, counters and built-in equipment; conditions indicated on architectural plans shall govern. Coordinate installation of electrical equipment with structural system and mechanical equipment and access thereto. Coordinate installation of recessed electrical equipment with concealed ductwork and piping, and wall thickness.

B. Do not scale drawings. Obtain dimensions for layout of equipment from Architectural plans unless indicated on Electrical plans.

C. Bring all discrepancies shown on different drawings, between drawings and specifications or between documents and field conditions to the immediate attention of the Engineer.

D. Equipment layout is based on one manufacturer's product. Where equipment selected by the Contractor for use on the job differs from layout, the Contractor shall be responsible for coordinating space requirements and connection arrangements.

1.07 SUBMITTALS:

A. Shop Drawings and Product Data:

1. The Contractor shall submit for review by the Engineer data of materials and equipment to be incorporated in the work. Submittals shall be supported by descriptive material, catalogs, cuts, diagrams, performance curves, and charts published by the manufacturer to show conformance to specification and drawing requirements; model numbers alone will not be acceptable. Provide complete electrical characteristics for all equipment. Submittals for lighting fixtures shall include Photometric data.
2. Refer to the individual sections for identified equipment and materials for which submittals are required.
3. Refer to the SHOP DRAWINGS, PRODUCT DATA AND SAMPLES section for required procedures.

B. Record Documents

1. Refer to Division 1 for record documents and related submittals.

1.08 OPERATION AND MAINTENANCE DATA AND INSTRUCTIONS

A. Refer to Division 1 for detail requirements.

B. Printed Material: Provide required printed material for binding in operation and maintenance manuals.

C. Instructions of Owner Personnel:

1. Before final inspection, as designated by the Engineer provide a competent representative to instruct Owner's designated personnel in systems under this division of the specifications.
2. Use operation and maintenance manuals as basis of instruction. Review contents of manual with personnel in detail to explain all aspects of operation and maintenance.
3. Prepare and insert additional data in Operation and Maintenance Manual when need for such data becomes apparent during instruction.

1.09 EQUIPMENT REQUIRING ELECTRICAL SERVICE

A. Review all specification sections and drawings for equipment requiring electrical service. Provide service to and make connections to all such equipment requiring electrical service. Refer to ELECTRICAL CONNECTIONS FOR EQUIPMENT section for connection requirements.

B. Drawings indicate design loads and voltages and corresponding control equipment, feeders, and overcurrent devices. If equipment actually furnished have loads other than those indicated on the drawings or specified herein, control equipment, feeders, and overcurrent devices shall be adjusted in size accordingly at no additional cost to the Owner. Such adjustment shall be subject to the review of the Engineer.

C. Incidental items not indicated on Drawings or mentioned in Specifications but that can legitimately and reasonably be inferred to belong to the Work or be necessary in good practice to provide a complete system, shall be furnished and installed as though itemized here in detail. This includes connection requirements for air conditioning and refrigeration equipment as outlined by NEC Article 440.

1.10 SCHEDULING OF OUTAGES

A. Electrical work requiring interruption of electrical power which would adversely affect the normal operation of the other portions of the Owner's property, shall be done at time other than normal working hours. Normal working hours shall be considered eight A.M. to five P.M. Monday through Friday.

B. Schedule all work requiring interruption of electrical power two weeks prior to actual shutdown. Submit schedule in writing indicating extent of system to be

de-energized, date and time when power is intended to be interrupted, and date and time power will be restored. Schedule shall be subject to the approval of the Engineer and the Representative of the Owner.

1.11 SITE INVESTIGATION

A. Prior to submitting bids of the project, visit the site of the work to become aware of existing conditions which may affect the cost of the project. Where work under this project requires extension, relocation, reconnections or modifications to existing equipment or systems, the existing equipment or systems, shall be restored to their original condition, with the exception of the work under this contract, before the completion of this project.

PART 2- BASIC MATERIALS

2.01 MATERIALS

A. All materials shall be new.

B. Furnish all materials specified herein or indicated on the drawings.

C. Materials of the same type shall be the product of one manufacturer.

D. All materials shall be UL listed and shall bear UL label. ETL listed material shall bear ETL label. ETL label shall be accepted in lieu of UL when the UL testing standards have been followed.

PART 3 - DISTRIBUTION PRODUCTS

3.01 PRODUCT DELIVERY, STORAGE, HANDLING, AND PROTECTION

A. Inspect materials upon arrival at Project and verify conformance to Contract Documents. Prevent unloading of unsatisfactory material. Handle materials in accordance with manufacturer's applicable standards and suppliers recommendations, and in a manner to prevent damage to materials. Store packaged materials in original undamaged condition with manufacturer's labels and seals intact. Containers which are broken, opened, damaged, or watermarked are unacceptable and shall be removed from the premises.

B. All material, except items specifically designed to be installed outdoors such as pad mounted transformers or stand-by generators, shall be stored in an enclosed, dry building or trailer. Areas for general storage shall be provided by the Contractor. Provide temperature and/or humidity control where applicable. No material for installation, including conductors, shall be stored other than in an enclosed weathertight structure. Equipment stored other than as specified above shall be removed from the premises.

C. Equipment and materials shall not be installed until such time as the environmental conditions of the job site are suitable to protect the equipment or materials. Conditions shall be those for which the equipment or materials are designed to be installed. Equipment and materials shall be protected from water, direct sunlight, cold or heat and high humidity at all times. Equipment or materials damaged or which are subjected to these elements are unacceptable and shall be removed from the premises and replaced.

3.02 CLEANING AND PAINTING

A. Remove oil, dirt, grease and foreign materials from all raceways, fittings, boxes, panelboard trims and cabinets to provide a clean surface for painting. Touchup scratched or marred surfaces of lighting fixtures, panelboard and cabinet trims, motor control center, switchboard or equipment enclosures with paint furnished by the equipment manufacturers specifically for that purpose.

B. Do not paint trim covers for flush mounted panelboards, telephone cabinets, pull boxes, junction boxes and control cabinets unless required by the Engineer, National Electrical Code or other Sections of the specifications. Remove trim covers before painting. Under no conditions shall locks, latches or exposed trim clamps be painted.

C. Unless indicated on the drawings or specified herein to the contrary, all painting shall be done under the PAINTING Section of these Specifications.

D. Where plywood backboards are used to mount equipment provided under Division 26, paint backboards with two coats of light grey semi-gloss paint under Division 26.

3.03 EXCAVATION, TRENCHING AND BACKFILLING

A. Perform all excavation to install conduits, indicated on the drawings or specified herein. During excavation, pile material for backfilling back from the banks of the trench to avoid overloading and to prevent slides and cave-ins. Provide shoring as required by OSHA Standards. Remove and dispose of all excavated materials not to be used for backfill. Grade to prevent surface water from flowing into trenches and excavation. Remove any water accumulating therein by pumping. Do all excavation by open cut. No tunneling shall be done unless indicated on the drawings or unless written permission is received from the engineer.

B. Grade the bottom of trenches to provide uniform bearing and support for conduits on undisturbed soil at every point along its entire length. Tamp overdepths with loose, granular, moist earth. Remove unstable soil that is not capable of supporting equipment or installation and replace with specified material for a minimum of 12" below invert of equipment or installation.

C. Backfill the trenches with excavated materials approved for backfilling, consisting of earth, loam, sandy clay, sand and gravel or soft shale, free from large clods of earth and stones, deposited in 6" layers and rammed until the installation has a cover of not less than the adjacent ground but not greater than 2" above existing ground. Backfilling shall be carried on simultaneously on both sides of the trench so that injurious pressures do not occur. Compaction of the filled trench shall be at least equal to that of the surrounding undisturbed material. Do not settle backfill with water. Reopen any trenches not meeting compaction requirements or where settlement occurs, refill, compact, and restore surface to grade and compaction indicated on the drawings, mounded over and smoothed off.

D. Provide plastic tracable marking tape above all exterior conduits 12" below grade.

3.04 ELECTRICAL SYSTEMS OPERATIONAL TESTS, MANUFACTURERS SYSTEMS CERTIFICATION AND DESIGN AUTHORITY ASSISTANCE.

A. Testing

1. Refer to the individual specification sections and the ELECTRICAL EQUIPMENT ACCEPTANCE TESTING section of the specifications for test requirements.
2. Prior to the final inspection, the systems or equipment shall be tested and reported as therein specified. Five (5) typewritten copies of the tests shall be submitted to the Engineer for approval.
3. All electrical systems shall be tested for compliance with the specifications.

B. Manufacturers Certifications

1. The electrical systems specified herein shall be reviewed for compliance with these specifications, installation in accordance with the manufacturers recommendations and system operation by a representative of the manufacturer. The manufacturer shall submit certification that the system has been reviewed by the manufacturer is installed in accordance with the manufacturer's recommendations and is operating in accordance with the specifications.
2. Provide manufacturers certification for the following systems:
   a. Engine Driven EPSS
   b. Fire Alarm System

C. Design Authority Assistance

1. The Contractor shall provide personnel to assist the Engineer or his representative during all construction review visits. The Contractor shall provide all necessary tools and equipment to demonstrate the system operation and provide access to equipment, including screwdrivers, wrenches, ladders, flashlights, circuit testing devices, meters, keys, radios, etc.
2. Remove equipment covers (i.e. panelboard trims, motor controls, device plates, and junction box covers) as directed for inspection of internal wiring. Accessible ceilings shall be removed as directed for inspection of equipment installed above ceilings.

3. Energize and de-energize circuits and equipment as directed. Demonstrate operation of equipment and systems as directed by the Representative.
4. The Contractor shall provide authorized representatives of the manufacturers to demonstrate to the Engineer compliance with the specifications of their respective system during or prior to the final inspection at a time designated by the Engineer. Refer to the specific specification section for additional testing requirements. Representatives of the following systems are required for demonstrations:
   a. Engine Driven EPSS
   b. Fire Alarm System

END OF SECTION

DIVISION 26 – ELECTRICAL

260519 – WIRES AND CABLES

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. The work required under this section of the specifications consists of furnishing, installation and connections of the building wiring system, 600 volts and below. Exterior branch circuit wiring and feeder conductors extended beyond the building are included. Wiring systems for communication and alarm systems are not included in this section unless specified to be included, by reference, in the respective specification sections for alarm and communication systems.

1.03 QUALITY ASSURANCE

A. Industry Referenced Standards. The following specifications and standards are incorporated into and become a part of this Specification by Reference.

1. Underwriters' Laboratories, Inc. (UL) Publications:
   a. No. 44: Rubber - Insulated Wire and Cables
   b. No. 83: Thermoplastic - Insulated Wires
   c. No. 493: Thermoplastic - Insulated Underground Feeder and Branch Circuit Cables
   d. No. 486: Wire Connectors and Soldering Lugs
2. Insulated Cable Engineers Association Standards (ICEA):
   a. S-61-402: Thermoplastic Insulated Wire and Cable
3. National Electrical Manufacturer's Standards (NEMA):
   a. WC-5: Thermoplastic Insulated Wire and Cable
4. National Fire Protection Association Publication (NFPA):
   a. No. 70: National Electrical Code (NEC)

B. Acceptable Manufacturers. Products produced by the following manufacturers which conform to this specification are acceptable.

1. Hydraulically applied conductor terminations:
   a. Square D
   b. Burndy
   c. Ilsco
   d. Scotch (3M)
   e. Thomas and Betts (T&B)
   f. Anderson

2. Mechanically applied (crimp) conductor terminations:
   a. Scotch (3M)
   b. Ideal
   c. Thomas and Betts (T&B)
   d. Burndy
3. Vinyl electrical insulating tape:
   a. Scotch (3M)
   b. Tomic
   c. Permacel
4. Twist-On Wire Connectors:
   a. Scotch (3M)
   b. Ideal
   c. Buchanan
5. Encapsulated insulating kits:
   a. Scotch (3M)
   b. Raychem
   c. Essex Group, Inc.

C. Performance: Conductors shall be electrically continuous and free from short circuits or grounds. All open, shorted or grounded conductors and any with damaged insulation shall be removed and replaced with new material free from defects.

PART 2- PRODUCTS

2.01 GENERAL MATERIALS REQUIREMENTS

A. Provide all materials under this section of the specifications.

B. All wire and cable shall be UL listed and shall bear a UL label along the conductor length at intervals not exceeding 24 inches.

C. All conductors shall have size, grade of insulation, voltage and manufacturer's name permanently marked on the outer cover at intervals not exceeding 24 inches.

D. Conductor size shall be a minimum of No. 12 AWG. Conductor size shall not be less than indicated on the drawings.

E. Insulation voltage level rating shall be 600 volts.

2.02 PRODUCT/MATERIALS DESCRIPTION

A. Conductors No. 10 AWG and smaller shall be solid copper, 90°C. type THHN, THWN or XHHW unless otherwise indicated on the drawings, required by the National Electrical Code, or specified elsewhere in Division 16. Where fixtures are used as raceway use 90°C type THHN or XHHN conductors.

B. Conductors larger than No. 10 AWG shall be stranded copper, 90°C,, type THHN/THWN, XHHW, unless otherwise indicated on the drawings, required by the National Electrical Code, or specified herein.

C. Fixture wire shall be No. 16 AWG silicone rubber insulated, stranded fixture wire, type SFF-2 (150°C), or No. 16 AWG thermoplastic, nylon jacketed stranded fixture wire, type TFFN (90°C). Color code as specified herein shall not be required for fixture wire; however, neutral conductor shall be identified distinctly from phase conductors.

D. Control conductors for use on 120 volt control wiring systems shall be No. 12 AWG stranded type THHN/THWN, unless indicated otherwise on the drawings.

E. Splices and taps (No. 10 AWG and smaller) - Connectors for solid conductors shall be solderless, screw-on, spring pressure cable type, 600 volt, 105°C. with integral insulation and UL approved for aluminum and copper conductors. Connectors for stranded conductors shall be crimp-on type with integral insulating cover.

F. Splices and taps (No. 8 and larger) - Hydraulically applied crimping sleeve or tap connector sized for the conductors or indent, split-bolt or bolt clamp-type connectors. Insulate the hydraulically applied connector with 90°C., 600 volt insulating cover provided by the connector manufacturer. Insulate the mechanically applied connectors with heat shrink insulator sleeve or plastic electrical insulating type. Insulator materials and installation shall be approved for the specific application, location, voltage and temperature and shall not have an insulation value less than the conductors being joined.

G. Electrical insulating tape shall be 600 volt, flame retardant, cold and weather resistant, minimally .85 mil thick plastic vinyl material; Scotch No. 88, Tomic No. 85, Permacel No. 295.

2.03 VFD CABLE

H. All feeders for motors controlled by variable frequency drives shall be served with cable specifically manufactured to mitigate the EMI and RFI effects on adjacent cables and/or conductors.

I. Acceptable manufacturers: Lapp Group USA, Belden and Alpha Wire.

J. Required characteristics for VFD power cable:

1. Class B stranded copper or tinned copper conductors with XLP/XLPE insulation.
2. Three bare copper ground conductors or integral with the cable.
3. Spiral or helical copper tape for 100% shield.
4. 1000Vminimum rating.
5. 90°C, wet or dry installation, approved for direct burial, TC-ER approved.

6. PVC outer jacket.

PART 3 - EXECUTION

3.01 EXECUTION

A. Install all wiring in raceway system.

B. Connect all conductors. Torque each terminal connection to the manufacturers recommended torque value. A calibrated torqueing tool shall be used to insure proper torque application. Any conductors nicked or ringed while removing insulation shall be replaced.

C. Do not install more conductors in a raceway than indicated on the drawings. A maximum of three branch circuits are to be installed in any one conduit, on 3 phase 4 wire system, unless specifically indicated otherwise on the drawings. A maximum of two branch circuits are to be installed in any one conduit, on 1 phase 3 wire systems, unless specifically indicated otherwise on the drawings. No two branch circuits of the same phase are to be installed in the same conduit, unless specifically indicated on the drawings.

D. Conductors shall be tested to be continuous and free of short circuits and grounds.

E. Identification

1. Conductors within pull boxes shall be grouped and identified with nylon tie straps with circuit identification tag.
2. Identify each control conductor at its terminal points with wrap around tape wire markers. I.D. to indicate terminal block and point designation, or other appropriate identifying indication.
3. Refer to ELECTRICAL IDENTIFICATION section of these specifications for additional identification requirements.

F. Color Code Conductors.

1. Color code all secondary service, feeder and branch circuit conductors. Control and signal system conductors need not be color coded.
2. Coding shall be as follows:
   a. 208Y/120 volt three phase four wire wye system - Phase A: Black, Phase B: Red, Phase C: Blue, Neutral: White
   b. 480Y/277 volt three phase four wire system - Phase A: Brown, Phase B: Orange, Phase C: Yellow, Neutral: Gray
   c. 240/120 volt single phase 3 wire system - Phase A: Black, Phase B: Red, and Neutral: White
3. Grounding conductors shall be green.
4. Conductors No. 6 and smaller shall have solid color compound insulation or continuous color finish. Conductors No. 4 and larger shall have colored phase tape. Colored tape shall be installed on conductors in every box, at each terminal point, cabinet, through manhole or other enclosure.

G. Maintain phase rotation established at service equipment throughout entire project.

H. Group and lace with nylon tie straps all conductors within enclosures, i.e. panels, motor controllers, motor control center, switchboard, switchgear, terminal cabinets and control cabinets.

I. Make splices in conductors only within junction boxes. Do not splice conductors in pull boxes, panelboards, safety switches, switchboard, switchgear, motor control center, wiring troughs or motor control enclosures.

J. Terminate conductors No. 10 AWG and smaller specified in Division 16 to be stranded, with crimp type lug or stud. Direct termination of stranded conductors without crimp terminator to terminal screws, lugs, or other points is not permitted even if terminal is rated for stranded conductors. Crimp terminal shall be the configuration type suitable for terminal point. Crimp lugs shall be applied in strict accordance with the manufacturer's written requirements.

K. Make connections between fixture junction box and fixture with fixture wire.

L. Control, communications or signal conductors shall be installed in separate raceway systems from branch circuit or feeder raceway, unless indicated otherwise on the drawings.

M. Splices in conductors installed below grade are not permitted.

N. VFD cable shall be terminated in accordance with manufacturer's recommendations. For Belden cable refer to Belden Unarmored Variable Frequency Drive (VFD) Cable Termination Guide.

END OF SECTION

DIVISION 26 – ELECTRICAL

260526 – SECONDARY GROUNDING

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. The work required under this section of the specifications consists of furnishing, installation and connections of the building secondary grounding systems. Exterior branch circuit wiring and feeder conductors extended beyond the building are included. The building electrical system shall be a 3 phase, 4 wire grounded wye system supplemented with equipment grounding system. Equipment grounding system shall be established with equipment grounding conductors; the use of metallic raceways for equipment grounding is not acceptable.

1.03 QUALITY ASSURANCE

A. Industry Referenced Standards. The following specifications and standards are incorporated into and become a part of this Specification by Reference.

1. Underwriters' Laboratories, Inc. (UL) Publications:
   a. No. 44: Rubber - Insulated Wire and Cables
   b. No. 83: Thermoplastic - Insulated Wires
   c. No. 467: Electrical Grounding and Bonding Equipment
   d. No. 493: Thermoplastic - Insulated Underground Feeder and Branch Circuit Cables
   e. No. 486: Wire Connectors and Soldering Lugs
2. National Electrical Manufacturer's Standards (NEMA):
   a. WC-5: Thermoplastic Insulated Wire and Cable
   b. WC-7: Cross-Linked-Thermosetting Polyethylene Insulated Wire and Cable
3. National Fire Protection Association Publication (NFPA):
   a. No. 70: National Electrical Code (NEC)

B. Acceptable Manufacturers. Products produced by the following manufacturer which conform to this specification are acceptable.

1. Hydraulically applied conductor terminations:
   a. Square D
   b. Burndy
   c. Ilsco

d. Scotch (3M)
e. Thomas and Betts (T & B)
f. Anderson

2. Mechanically applied (crimp) conductor terminations:
   a. Scotch (3M)
   b. Ideal
   c. Thomas and Betts (T & B)
   d. Burndy
3. Exothermic connections:
   a. Cadweld

PART 2 - PRODUCTS

2.01 GENERAL MATERIALS REQUIREMENTS

A. Provide all materials under this section of the specifications. All materials shall be new.

B. All materials shall be UL listed and bear a UL label.

C. Refer to the specific specification section for the description and requirements of materials mentioned herein for installation.

2.02 GROUNDING CONDUCTORS

A. Grounding electrode conductor shall be bare or green insulated copper conductor sized as indicated on the drawings.

B. Equipment grounding conductors shall be green insulated type THW, THWN, or XHHN conductors sized as indicated on the drawings. Where size is not indicated on the drawings, conductor size shall be determined from the National Electrical Code table on sizes of equipment grounding conductors.

C. Bonding jumpers shall be flexible copper bonding jumpers sized in accordance with the National Electrical Code tables for grounding electrode conductors.

2.03 TRANSFORMERS, MOTOR CONTROLLERS, AND DISCONNECT SWITCHES

A. Provide a conductor termination grounding lug bonded to the enclosure of each equipment item.

2.04 DEVICES

A. Each receptacle and switch device shall be furnished with a grounding screw connected to the metallic device frame.

2.05 GROUND RODS

A. Ground rods shall be 3/4" x 10'-0" copper clad steel.

B. Sectional ground rods shall be hot dip galvanized 5/8" x 10' sections with an internal stainless steel splined coupling pin.

2.06 OTHER MATERIALS

A. Ground bus shall be solid copper, 1/4" thick x 2" x 24", tapped and drilled for conductor termination lug connections.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Ground all non-current carrying parts of the electrical system, i.e., wireways, equipment enclosures and frames, junction and outlet boxes, machine frames and other conductive items in close proximity with electrical circuits, to provide a low impedance path for potential grounded faults.

B. Service entrance and separately derived electrical systems, grounding electrode system.

1. The neutral conductor of the electrical service serving the premises wiring system shall be grounded to the ground bus bar in the service equipment which shall be grounded to the cold water system, the ground rod system, and other grounding electrodes specified herein or indicated on the drawings. Grounding electrode conductors shall be installed in rigid, non-metallic conduit to point of ground connection, unless subject to physical damage in which case they shall be installed in galvanized rigid steel. Where metallic conduit is permitted, bond conduit at both ends to grounding electrode conductor with a UL bonding bushing.
2. Make connection to main water line entering the building. Make connections ahead of any valve or fittings whose removal may interrupt ground continuity. Install a bonding jumper of the same size as the grounding conductor around the water meter.
3. Bond together the following systems to form the grounding electrode system. All system connections shall be made as close as possible to the service entrance equipment and each connected at the service entrance equipment ground bus. Do not connect electrode systems together except at ground bus.
   a. Cold water piping system
   b. Ground rod system
   c. Main rebar in a foundation footing, for a concrete structure
4. Ground the neutral of all dry type transformers to building steel which shall serve as the grounding electrode for the separately derived system. In reinforced

concrete structures building steel shall be considered to be reinforcing steel of vertical columns. Make connection to building steel with an exothermic weld in a location in unfinished space where the connection will not be subject to physical abuse.

5. Ground the neutral and frame of the emergency generator to building steel and the ground rod system, which shall serve as the grounding electrode for the separately derived system. In reinforced concrete structures building steel shall be considered to be reinforcing steel of vertical columns. Make connection to building steel with an exothermic weld in a location in unfinished space where the connection will not be subject to physical abuse.
6. Grounding electrode connections to structural steel, reinforcing bars, ground rods, or where indicated on the drawings shall be with chemical exothermic weld connection devices recommended for the particular connection type. Connections to piping shall be with UL listed mechanical ground clamps.
7. Where more than one service serves a building or interconnected buildings, connect each service equipment ground bus together with a #4/0 copper conductor in PVC conduit.
8. Bonding shall be in accordance with the National Electrical Code.
9. Install ground rods where indicated on the drawings with the top of the ground rods 12" below finished grade.

C. Equipment Grounding Conductor

1. Grounding conductors for branch circuits are not shown on the drawings; however, grounding conductors shall be provided in all branch circuit raceways and cables. Grounding conductors shall be the same AWG size as branch circuit conductors.
2. Grounding conductors for feeders are typically indicated on the drawings and the raceway is sized to accommodate grounding conductor shown. Where grounding conductor size is not indicated on the drawings, conductor shall be in accordance with the equipment grounding conductor table of the National Electrical Code.
3. A grounding conductor shall be installed in all flexible conduit installations. For branch circuits, grounding conductor shall be sized to match branch circuit conductors.
4. A feeder serving several panelboards shall have a continuous grounding conductor which shall be connected to each related cabinet grounding bar.
5. The equipment grounding conductor shall be attached to equipment with bolt or sheet metal screw used for no other purpose. Where grounding conductor is stranded, attachment shall be made with lug attached to grounding conductor with crimping tool.
6. Ground all motors by drilling and tapping the bottom of the motor junction box and attaching the equipment grounding conductor to the box with a round head bolt used for no other purpose. Conductor attachment shall be through the use of a lug attached to conductor with crimping tool.

7. Equipment grounding conductors shall terminate on panelboard, switchboard, or motor control center grounding bus only. Do not terminate on neutral bus. Provide a single terminals lug for each conductor. Conductor shall terminate in the same section as the phase conductors originate. Do not terminate neutral conductors on the ground bus.

D. Other Grounding Requirements

1. Each telephone backboard shall be provided with a No. 6 grounding conductor. When backboard is located in vicinity of electrical service equipment, the "point of grounding" of this conductor shall be the main cold water service with connections made ahead of any valves or joints. Remote backboards shall use building steel as "point of grounding". Terminate conductor by stapling to backboard.
2. At each building expansion joint flexible copper bonding jumpers shall be attached to building structure by exothermic weld process. Install bonding jumpers in concealed locations that will not subject connections or jumpers to physical abuse. Install 100' on centers across expansion joints.
3. Lighting fixtures shall be grounded with a green insulated ground wire secured to the fixture with a UL listed bond lug, screw, or clip specifically made for such use.

3.02 TESTING

A. Upon completion of the ground rod installation, the Contractor shall test the installation in accordance with the ELECTRICAL EQUIPMENT ACCEPTANCE TESTING section of this specification. Grounding resistance reading shall be taken before connection is made to the building cold water piping system. Ground resistance readings shall not be taken within forty-eight hours of rainfall. Results of ground resistance readings shall be forwarded, in writing, immediately to the Architect.

END OF SECTION

DIVISION 26 – ELECTRICAL

260529 – SUPPORTING DEVICES

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. Extent of supports, anchors, sleeves and seals is indicated by drawings and schedules and/or specified in other Division - 16 sections.

B. Types of supports, anchors, sleeves and seals specified in this section include the following:

1. Clevis hangers.
2. Riser clamps.
3. C-clamps.
4. I-beam clamps.
5. One-hole conduit straps.
6. Two-hole conduit straps.
7. Round steel rods.
8. Expansion anchors.
9. Toggle bolts.
10. Wall and floor seals.

C. Supports, anchors, sleeves and seals furnished as part of factory-fabricated equipment are specified as part of that equipment assembly in other Division - 16 sections.

D. Provide seismic supports for electrical equipment as required by occupancy. Refer to structural and architectural drawings for criteria.

1.03 QUALITY ASSURANCE

A. NEC Compliance: Comply with NEC requirements as applicable to construction and installation of electrical supporting devices.

B. NECA Compliance: Comply with National Electrical Contractors Association's "Standard of Installation" pertaining to anchors, fasteners, hangers, supports, and equipment mounting.

C. UL Compliance: Provide electrical components which are UL-listed and labeled.

PART 2- PRODUCTS

2.01 MANUFACTURED SUPPORTING DEVICES

A. General: Provide supporting devices which comply with manufacturer's standard materials, design and construction in accordance with published product information, and as required for complete installation; and as herein specified. Where more than one type of supporting device meets indicated requirements, selection is Installer's option.

B. Supports: Provide supporting devices of types, sizes and materials indicated; and having the following construction features:

1. Conduit clamps, clevis hangers, round steel rod, conduit clamps, heagon nuts, etc. shall be stainless steel.

C. Anchors: Provide anchors of types, sizes and materials indicated, with the following construction features:

1. Toggle Bolts: Springhead; 3/16" x 4"; approximately 5 lbs. per 100 units.
2. Expansion sleeve anchors by Hilti or Phillips Redhead: 1/2"; approximately 38 lbs. per 100 units.
3. Manufacturers: Subject to compliance with requirements, provide anchors of one of the following:
   a. Ackerman Johnson Fastening Systems Inc.
   b. Hilti
   c. Ideal Industries, Inc.
   d. Joslyn Mfg and Supply Company
   e. McGraw Edison Company
   f. Phillips Redhead
   g. Rawlplug Company Inc.

D. Sleeves and Seals: Provide sleeves and seals, of types, sizes and materials indicated, with the following construction features:

1. Wall and Floor Seals: Provide factory-assembled watertight wall and floor seals, of types and sizes indicated; suitable for sealing around conduit, pipe, or tubing passing through concrete floors and walls. Construct seals with steel sleeves, malleable iron body, neoprene sealing grommets and rings, metal pressure rings, pressure clamps, and cap screws.

E. Conduit Cable Supports: Provide cable supports with insulating wedging plug for non-armored type electrical cables in risers; construct for 2" rigid metal conduit; 3-wires, type wire as indicated; construct body of malleable-iron casting with hot-dip galvanized finish.

F. U-Channel Strut Systems:

1. The approved material for u-channel strut, hardwater and associated items will be either stainless steel or aluminum.
   a. Fixture hangers.
   b. Channel hangers.
   c. End caps.
   d. Beam clamps.
   e. Wiring studs.
   f. Thinwall conduit clamps.
   g. Rigid conduit clamps.
   h. Conduit hangers.
   i. U-bolts.
2. Manufacturers: Subject to compliance with requirements, provide channel systems of one of the following:
   a. Allied Tube and Conduit Corporation.
   b. B-Line Systems, Inc.
   c. Elcen Metal Products Company.
   d. Greenfield Mfg Company, Inc.
   e. Midland-Ross Corporation.
   f. OZ/Gedney Div; General Signal Corporation.
   g. Power-Strut Div; Van Huffel Tube Corporation.
   h. Unistrut Div; GTE Products Corporation.

2.02 FABRICATED SUPPORTING DEVICES

A. Pipe Sleeves: Provide pipe sleeves of one of the following:

1. Sheet Metal: Fabricate from galvanized sheet metal; round tube closed with snaplock joint, welded spiral seams, or welded longitudinal joint. Fabricate sleeves from the following gage metal: 3" and smaller, 20-gage; 4" to 6", 16-gage; over 6", 14" gage.
2. Steel Pipe: Fabricate from Schedule 40 galvanized steel pipe.
3. Iron Pipe: Fabricate from cast-iron or ductile-iron pipe.
4. Plastic Pipe: Fabricate from Schedule 80 PVC plastic pipe.

B. Sleeve Seals: Provide modular mechanical type seals, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with bolts and pressure plates which cause rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation.

PART 3 - EXECUTION

3.01 INSTALLATION OF SUPPORTING DEVICES

A. Install hangers, anchors, sleeves and seals as indicated, in accordance with manufacturer's written instructions and with recognized industry practices to insure

supporting devices comply with requirements. Comply with requirements of NECA and NEC for installation of supporting devices.

B. Coordinate with other electrical work, including raceway and wiring work, as necessary to interface installation of supporting devices with other work.

C. Install hangers, supports, clamps and attachments to support piping properly from building structure. Arrange for grouping of parallel runs of horizontal conduits to be supported together on trapeze type hangers where possible. Install supports in compliance with NEC requirements.

D. Torque sleeve seal nuts, complying with manufacturer's recommended values. Ensure that sealing grommets expand to form watertight seal.

E. Remove burrs from ends of pipe sleeves.

END OF SECTION

DIVISION 26 – ELECTRICAL

260533 – RACEWAYS

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 covers the complete interior and exterior raceway system.

B. Definition: The term conduit, as used in this Specification, shall mean any or all of the raceway types specified.

1.03 QUALITY ASSURANCE

A. Referenced Industry Standard: The following specifications and standards are incorporated into and become a part of this Specification by reference.

1. Underwriters' Laboratories, Inc. (UL) Publications:
   - No. 1 Flexible Metal Electrical Conduit
   - No. 6 Rigid Galvanized Conduit
   - N. 6a Stainless Steel Rigid Conduit
   - No. 467 Electrical Grounding and Bonding
   - No. 651 Rigid Nonmetallic Electrical Conduit
   - No. 797 Electrical Metallic Tubing
   - No. 1242 Intermediate Metal Conduit
2. American National Standards Institute (ANSI):
   - C-80.1 Rigid Galvanized Conduit.
   - C-80.3 Electrical Metallic Tubing.
3. National Fire Protection Association (NFPA):
   - No. 70 National Electrical Code (NEC).

B. Acceptable Manufacturers: Products of the following manufacturers, which comply with these specifications, are acceptable.

1. Metallic Conduit Fittings:
   a. Appleton
   b. Carlon
   c. Crouse Hinds
   d. Killark
   e. O-Z/Gedney

f. RACO
g. Thomas and Betts
h. CalPipe Industries
i. Gibson Stainless

2. Support Channel:
   a. Kindorf
   b. Powers
   c. Unistrut
3. Non-Metallic Conduit and Fittings:
   a. Carlon
   b. Certainteed
   c. Thomas and Betts

C. Coordination

1. Coordinate conduit installation with electrical equipment furnished.
2. Coordinate conduit installation with contract documents and other contractors. Adjust installation to eliminate conflicts. Review all shop drawings submitted under this and other sections to insure coordination with all equipment requiring electrical service and to avoid conflict interferences. Coordinate installation sequence with other contractors to avoid conflicts including equipment access and provide the fastest overall installation schedule.

1.04 STORAGE AND HANDLING

A. Refer to the BASIC ELECTRICAL REQUIREMENTS section of the specifications for storage and handling requirements.

B. Non-metallic conduits stored on site prior to installation shall be stored on a surface off of the ground and shall be protected from the direct rays of the sun and from debris.

C. Damaged, oxidized, warped, improperly stored material or material with excessive amounts of foreign debris will be removed from the project and replaced with new materials.

PART 2- PRODUCTS

2.01 GENERAL MATERIALS REQUIREMENTS

A. Furnish all materials specified herein.

B. All conduit and fittings shall be listed and bear a label by Underwriters' Laboratories (UL) for use as raceway system for electrical conductors.

C. Raceway is required for all wiring, unless specifically indicated or specified otherwise.

D. Size: The minimum size of conduit shall be 3/4". The size of all conduits shall be in accordance with the NEC, but, not less than indicated on the drawings.

2.02 EMT CONDUIT FITTINGS

A. Electrical Metallic Tubing (EMT) couplings and connectors shall be steel "concretetight" type. Malleable iron, die cast or pressure cast fittings are not permitted. Fittings 2.0" and smaller shall be gland and ring compression type. Connectors for conduits 2.5" and larger shall be set screw type with two (2) screws each or compression type. Couplings for conduits 2.5" and larger shall be set screw type with four (4) screws each or compression type. All connectors shall be insulated throat type. All set screw connectors encased in walls or floor shall be taped at all joints.

2.03 STAINLESS STEEL, RIGID AND IMC CONDUIT FITTINGS

A. Fittings for rigid steel and IMC shall be standard threaded couplings, threaded hubs and elbows. All materials shall be steel or malleable iron only. Set screw or non-thread fittings are not permitted. Bushings shall be metallic insulating type consisting of insulating insert molded or locked into the metallic body of the fittings. Erickson-type couplings may be used to complete a conduit run.

2.04 NON-METALLIC CONDUIT AND FITTINGS

A. Non-metallic conduit shall be schedule 80 PVC.

B. Non-metallic conduit fittings shall be of the same material as the conduit furnished and be the product of the same manufacturer.

C. Glue for all non-metallic conduit and fittings shall be provided as required by the manufacturer of the conduit being used.

2.05 CONDUIT SUPPORTS

A. Support channel and rods shall be stainless or aluminum.

B. Conduit straps shall be single hole cast metal type or two hole galvanized metal type.

C. Conduit support channels shall be 1.5" x 1.5" x 14 gauge galvanized (or with equivalent treatment) channel. Channel suspension shall be 3/8" threaded steel rods. Use swivel type connector to attach suspension rods to structure. Spring steel clips are not acceptable. Wire or chain is not acceptable for conduit hangers. Stainless steel channels, fasteners and conduit straps shall be used on all exterior installations.

D. Individual conduit hangers shall be galvanized spring steel specifically designed for the purpose, sized appropriately for the conduit type and diameter, and have pre-assembled closure bolt and nut and provisions for receiving threaded hanger rod. Support with 1/4" threaded steel rod for individual conduits 1.5" and smaller and 3/8" rod for individual conduits 2.0" and larger.

E. Refer to SUPPORTING DEVICES section of these specifications for additional material requirements.

2.06 FLEXIBLE CONDUIT AND FITTINGS

A. Flexible conduit shall be steel metallic type. Where specified herein, indicated on the drawings, or when used in damp or wet locations, as classified by the National Electrical Code, flexible conduit shall be liquid tight.

B. All flexible conduit shall be classified as suitable for system grounding. All flexible (liquid tight) conduits shall be UL listed as sunlight (UV) resistant.

C. Connectors for flexible conduit shall be steel insulated throat type rated as suitable for system ground continuity. Connectors for liquid tight flexible conduit shall be screw-in ground cone type.

D. Flexible conduit shall not be less than 3/4" trade size and in no case shall flexible conduit size be less than permitted by the National Electrical Code for the number and size of conductors to be installed herein.

2.07 MISCELLANEOUS CONDUIT FITTINGS AND ACCESSORIES

A. Vinyl all weather electrical tape for corrosion protection shall be Scotch Temflex

B. Expansion and deflection couplings shall be in accordance with UL 467 and UL 514. They shall accommodate 3/4" deflection, expansion, or contraction in any direction and shall allow 30 degree angular deflections. Couplings shall contain an internal flexible metal braid to maintain raceway system ground continuity.

C. Fire and smoke stop materials shall be rock wool fiber, silicone foam, or silicone sealant, UL rated to maintain the fire floor or fire wall partition rating.

2.08 RIGID ALUMINUM CONDUIT FITTINGS

A. Rigid aluminum conduit fittings shall be standard threaded couplings, locknuts, bushings, and elbows. Material shall be compatible with aluminum conduit of malleable iron, steel or aluminum alloy. Iron or steel fittings shall be zinc or cadmium plated. Aluminum fittings shall not contain more than 0.4 percent copper. Threaded hubs shall be as specified for rigid steel and IMC conduit. Set screw fittings or no-thread fittings are not acceptable.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General

1. Conceal all conduits, except in unfinished spaces such as equipment rooms or where indicated by symbol on the drawings.
2. Leave all empty conduits with a 200 pound test nylon cord pull line.
3. Install as complete raceway runs prior to installation of cables or wires.
4. Flattened, dented, burned, or deformed conduits are not permitted and shall be removed and replaced.
5. Secure rigid conduit i.e., rigid galvanized conduit, rigid aluminum conduit and intermediate metal conduit, to sheet metal enclosures with threaded hubs. Secure EMT to sheet metal enclosures with insulated throat connectors with lock nut.
6. Fasten conduit support device to structure with wood screws on wood, toggle bolts on hollow masonry, anchors as specified on solid masonry or concrete, and machine bolts, clamps, or spring steel clips, on metal studs. Nails are not acceptable.
7. Protect conduits against dirt, plaster, and foreign debris with conduit plugs. Plugs shall remain in place until all masonry is complete. Protect conduit stub-ups during construction from damage; any damaged conduits shall not be used.
8. Seal all conduits originating from outside building from below grade and all conduits entering exterior mounted electrical equipment with insulating electrical putty to prevent entrance of moisture. Spray foam is not acceptable.
9. Install conduit with wiring, including homeruns as indicated on the drawings. Any change resulting in a savings in labor or materials is to be made only in accordance with a contract change. Deviations shall be made only where necessary to avoid interferences and when approved by Engineer by written authorization.
10. Use flexible conduit for connection to vibrating equipment and rotating machinery and for connection from junction box to flush mounted lighting fixtures only.
11. Separate raceway systems are to be installed for power systems and for control, signal and communications systems. Do not install control, signal or communications cables in the same raceways as branch circuit or feeder cables, unless indicated otherwise on the drawings.
12. Provide expansion fitting in all conduits where length of run exceeds 200 feet or where conduits pass building expansion joints.

B. Uses Permitted

1. Conduits installed within concrete floor slabs which are in direct contact with grade or other material shall be galvanized rigid steel (GRS) or intermediate

metal conduit (IMC). Conduits which penetrate the building roof shall be galvanized rigid steel (GRS) or intermediate metal conduit (IMC). Conduits installed within concrete floor slabs which are above grade shall be galvanized rigid steel (GRS), intermediate metal conduit (IMC), or schedule 80 Heavy Wall PVC. Where transition is made from raceway in slab to any type of raceway out of slab, make transition with rigid galvanized elbow. For corrosion protection, where elbow penetrates surface, apply two coats of Scotchrap pipe primer and two overlapping layers of Scotchrap Temflex tape, for 6" above and below concrete surface.

2. Conduits installed in direct contact with earth shall be schedule 80, heavy wall PVC.
3. Service entrance conduits in direct contact with earth shall be PVC. Other conduit in direct contact with earth shall be schedule 80, heavy wall PVC.
4. All other conduit, unless excluded herein, not permitted in accordance with the National Electrical Code, or otherwise indicated on the drawings, shall be electrical metallic tubing (EMT).
5. Conduit types shall not be mixed indiscriminately with other types in the same run, unless specified herein or required by the NEC.
6. Use flexible conduit for connections to motors, dry type transformers and unit heaters.
   a. Flexible conduit used for connection of motors, dry type transformers, electric duct heaters, unit heaters, busway tap devices and voltage regulators shall not exceed 18" in length.
   b. Maintain ground continuity through flexible conduit with green equipment grounding conductor; do not use flexible conduit for ground continuity.
   c. Liquid tight conduit shall be used to connect equipment in mechanical equipment rooms and exterior installations.
7. Feeder conduits installed exposed or concealed in walls or above ceilings shall be galvanized rigid steel (GRS) or intermediate metal conduit (IMC). Service entrance conduits shall be installed "outside" of the building as defined by the NEC. Provide concrete encasement where required.
8. No conduit requiring cutting of cross-webs of concrete masonry units is permitted. Conduit shall be threaded through cells or concrete masonry units lowered around conduit. Neither horizontal joint reinforcement nor bond beam reinforcement shall be cut for conduit installation. Conduits shalal not be run horizontally in walls.
9. Rigid aluminum conduit may be used for all trade sizes 3.0" and larger for conduits not installed in concrete slabs, not installed in direct contact with earth, not installed in hazardous locations as defined by Article 500 of the National Electrical Code and not installed in areas exposed to excessive moisture.
10. All conduits installed exposed from the finished floor to a minimum height of 10 ft. above the floor shall be galvanized rigid steel (GRS).

11. Where hazardous locations, as classified by the National Electrical Code, exist, all conduits and fittings and the installation of these materials shall comply with Article 500 of the National Electrical Code.

C. Below Grade Raceway Installations

1. Direct Burial Conduit
   a. Install top of conduits 24" minimum below finished grade. Maximum depth shall be 36".
   b. Install top of conduits 6" minimum below bottom of building slabs.
   c. Install top of conduits 30" minimum below grade, below roads and any other paved surfaces.
   d. Where transition is made from below grade PVC installation to a metallic conduit system above grade or slab, make transition with rigid galvanized elbow and extend through slab or above grade with galvanized rigid steel conduit. For corrosion protection, where the elbow penetrates surface, apply two coats of Scotchrap pipe primer and two overlapping layers of Scotchrap Temflex tape, for 6" above and below concrete surface.
   e. For excavation and backfilling, refer to earthwork specification section.
   f. Conduit shall be run following the most direct route between points.

D. Raceway Installations Within Concrete

1. Conduit shall be run following the most direct route between points.
2. Conduit shall not be installed in concrete which is less than 3" thick or where the outside diameter is larger than 1/3 of the slab thickness.
3. Conduits installed in concrete slabs shall be buried in the concrete slab. Wire low conduits to upper side of the bottom reinforcing steel, and upper conduits to the lower side of the top reinforcing steel. Separate parallel runs of conduits within slab by at least 1".
4. Conduits shall not be installed within shear walls unless specifically indicated on the drawings. Conduits shall not be run directly below and parallel with load bearing walls
5. Protect each metallic conduit installed in concrete slab or conduits 1.5" and smaller passing through a concrete slab against corrosion where conduit enters and leaves concrete by wrapping conduit with vinyl all-weather electrical tape.
6. The maximum projection of conduit stub-up and bushing above slab shall be 3" in equipment rooms.
7. Protect all conduits entering and leaving concrete floor slabs from physical damage during construction.

E. Concealed (Above Ceilings and in Walls) and Exposed Raceway Installation

1. Conduit shall be run parallel or at right angles to existing walls, ceilings, and structural members.
2. Support branch circuit conduits at intervals not exceeding 10 ft. and within three feet of each outlet, junction box, cabinet or fitting. Attach individual branch circuit conduits to structural steel members with beam conduit clamps and to

non-metallic structural members with one hole conduit straps. For exposed conduits and where conduits must be suspended below structure, single conduit runs shall be supported from structure by hangar rod and conduit clamp assembly. Multiple conduits shall be supported by trapeze type support suspended from structure. Do not attach conduits to ceiling suspension system channels or suspension wires.

3. Attach feeder conduits larger than 1" trade diameter to or from structure on intervals not exceeding 12 ft. with conduit beam clamps, one hole conduit straps or trapeze type support in accordance with support systems described for branch circuit conduits.
4. Where conduits must pass through structural members, obtain approval of Engineer with respect to location and size of hole prior to drilling.
5. Install conduit sleeves in slabs where conduits 2.0" and larger pass through. Sleeves shall extent 1" minimum above finished slab. Seal all spare sleeves and between conduits and sleeves to make watertight.
6. Seal all conduit penetrations, sleeves and conduits penetrating chemical room walls and ceilings to prevent the migration of hazardous gases.
7. Conduits rigidly secured to building construction on opposite sides of a building expansion joint shall be provided with an expansion and deflection coupling. In lieu of an expansion coupling, conduits 2-1/2" and smaller may be provided with junction boxes on both sides of the expansion joint connected by 15" of slack flexible conduit with bonding jumper.

3.02 ADJUSTMENT, CLEANING AND PROTECTION

A. Clean: Upon completion, clean all installed materials of paint, dirt, and construction debris. All conduit systems shall be cleaned of water and debris prior to the installation of any conductors.

END OF SECTION

DIVISION 26 – ELECTRICAL

260533.01 – BOXES

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. The work required under this section of the specifications consists of the installation of outlet boxes, pull boxes, and junction boxes throughout the wiring system including box supports.

B. Definition: Box, as used in this specification, includes all outlet, device, junction, and pull boxes. Feeder shall mean all conductor circuits larger than #8 AWG, including service entrance conductors, and all wiring above 600V.

1.03 QUALITY ASSURANCE

A. Referenced Industry Standards: The following specifications and standards are incorporated into and become a part of this specification by reference.

1. Underwriters' Laboratories, Inc. (UL) Publications:
   a. No. 50: Electrical Cabinets and Boxes
   b. No. 467: Electrical Grounding and Bonding Equipment
   c. No. 514: Electrical Outlet Boxes and Fittings
2. National Fire Protection Association (NFPA):
   a. No. 70: National Electrical Code (NEC)

B. Coordination: Review architectural drawings for areas where outlets occur within specific architectural or structural features and install outlets as shown on architectural drawings; or if not shown, accurately center and align boxes within the architectural features or detail.

C. Acceptable Manufacturers:

1. Exterior junction or pull boxes:
   a. Quaztite: Type PG
   b. Old Castle Synertech
   c. Penecel

PART 2 - PRODUCTS

2.01 GENERAL MATERIALS REQUIREMENTS

A. Furnish all materials specified herein.

B. All boxes shall be UL listed and labeled.

C. Boxes shall be galvanized steel sheet metal, unless rustproof cast metal is specified or required by the NEC, or unless otherwise specified or indicated on the drawings.

2.02 OUTLET AND DEVICE BOXES

A. Outlet boxes for surface mounted and pendant mounted lighting fixtures shall be 4" octagon boxes, 1-1/2" deep.

B. Outlet boxes for flush mounted lighting fixtures shall be 4" square boxes 1-1/2" deep, with blank cover, installed adjacent to fixture. Connection to fixture shall be with flexible conduit and fixture wire.

C. Outlet boxes for switches, receptacles and wall mounted junction boxes shall be 4" square boxes, 1-1/2" deep with square edge tile type cover. Where only one conduit enters box, 3-1/2" deep single gang switch box may be used. Outlet boxes for GFI receptacles shall be 2-3/4" deep.

D. Outlet boxes for switches and receptacles in exposed wiring system shall be cast FS boxes with matching device plate. Device plates for exterior installations shall be spring loaded hinged covers. Use FD box for GFI receptacle.

E. Outlet boxes for individual switches, and receptacles flush mounted in exposed concrete block shall be single gang masonry boxes 3-1/2" deep.

F. Where special purpose device specified requires larger outlet box than specified herein, provide outlet box suitable for specific device. These outlet boxes shall be of the same type as specified herein for the installation required.

G. Outlet boxes installed in poured concrete or cast in place shall be concrete-tight type. The box depth shall allow 2" minimum of concrete cover.

2.03 JUNCTION AND PULL BOXES

A. Dimensions of pull boxes and junction boxes shall not be less than those dimensions required by the National Electrical Code for the number, size and position of conductors entering the box. Extension rings shall not be permitted on a box to increase the volume.

B. Pull boxes installed in finished spaces shall be flush mounted cabinets provided with trim, hinged door and flush latch and lock to match panel trim for flush mounted electrical panelboard.

C. Pull boxes required for horizontal feeders containing more than one feeder shall be provided with reinforced flange and removable 12 gauge 1-1/2" x 1-1/2" galvanized channel for support of conductors. Wood supports within pull boxes are not acceptable.

D. Provide box covers for all junction and pull boxes.

2.04 EXTERIOR JUNCTION OR PULL BOXES, FLUSH WITH GRADE

A. Junction or pull box to be mounted flush with grade shall be as indicated on the drawings. Provide polymer concrete, tier 22 traffic rated sized in accordance with the National Electrical Code minimum requirements. Covers shall be polymer concrete, tier 22 traffic rated with identifying system (i.e. Electrical) in cover secured to box with stainless steel bolts. Conduit entry shall be by field drilled openings.

PART 3 - EXECUTION

3.01 INSTALLATION

A. All boxes shall be completely accessible and as required by the NEC. Provide access panels in any non-accessible spaces to allow access to boxes installed. Crawling above ceilings to access boxes is not acceptable.

B. Provide an outlet box for each lighting fixture and for each device. Boxes shall not be smaller than indicated in this section of the specifications and shall be larger if required by Article 314 of the National Electrical Code for the number and size of conductors installed. Where lighting fixtures are installed in continuous rows, only one outlet box shall be required.

C. Outlet boxes for flush mounted lighting fixtures shall be accessible. Where fixture installation is in nonaccessible ceiling, outlet box shall be accessible when fixture is removed.

D. Set outlet boxes for flush mounted devices to within 1/8" of finished wall. Spacers or shims between box and device are not acceptable. Modification of boxes or use of extensioin rings to provide for 1/8" of finished wall is not acceptable.

E. Where low voltage device is to be installed in common outlet boxes with line voltage device, provide metal barrier within outlet box to establish two separate compartments.

F. Where drawings indicate ganged installations of switches controlling 277 volt lighting circuits of opposite phase, separate switches with permanently installed nonmetallic barrier. Where space available for horizontal ganged installation is not adequate, install switches vertically to maintain required clearances between energized terminals.

G. Support every box from structure:

1. Secure to wood with wood screws.
2. Secure to hollow masonry with toggle bolts.
3. Secure to metal with sheet metal screws, machine bolts, or clamps.
4. Anchors for solid masonry and concrete shall be self drilling expansion shields, insert expansion shields, or lead shields with machine bolts. Power actuated pin studs may be used in concrete.
5. Secure outlet boxes to metal studs with spring steel clamp which wraps around entire face of stud and digs into both sides of stud. Clamp shall be screwed into stud.
6. Where box is suspended below structure, support from structure with threaded steel rod. Secure rod directly to outlet boxes with double nuts. For pull boxes larger than 18" x 18" x 6", construct 1-1/2" x 1-1/2" x 14 gauge metal channel frame. Connect frame to box by bolting and secure frame to threaded rod at each corner.
7. Hub type cast boxes need not be directly attached to structure if rigid conduit is used and supported in conformance with the NEC.

H. Support outlet boxes for support of surface mounted incandescent lighting fixtures by light weight channel spanning between and attached to main ceiling support member. Attach channel to ceiling support members with galvanized tie wire or nylon tie straps.

I. Do not use outlet boxes for support of lighting fixtures; boxes shall be used only as junction boxes.

J. Remove only knockouts as required and plug all unused openings. Use threaded plugs for cast boxes and snap-in metal plugs for sheet metal boxes.

K. Outlet boxes in the same wall shall not be mounted back-to-back. Offset 6" minimum.

L. Install pull boxes only in unfinished spaces or concealed above ceilings, except when indicated on the drawings or approved by the Engineer.

M. Install pull boxes when any of the following conditions apply:

1. Where indicated on the drawings.
2. Where conduit run exceeds 200 ft. from box to box or box to terminal.
3. Where conduit contains more than 4-90 degree bends or the equivalent offsets.

4. To facilitate conductor installation or to insure that the manufacturer's maximum pulling tension is not exceeded.
5. As described in the RACEWAYS section of the specifications for crossing expansion joints.

N. Do not splice conductors in pull boxes. Splices are not permitted in pull boxes except when approved in writing by the Engineer or where shown on the drawings. Where splices are permitted, make splices with splicing sleeves attached to conductors with hydraulic crimping tool. Split bolt connectors are not acceptable for splices within pull boxes.

O. Where a pull box is required, one shall be installed for each individual branch circuit conduit or each feeder. It shall contain only the feeder conductors or those conductors in the conduit. A combined pull box for multiple branch conduits or feeders is not permitted, unless approved by the Engineer or indicated on the drawings. Where permitted for multiple circuits within pull box:

1. Circuit conductors and feeders shall be individually laced with nylon tie straps of the type with enlarged tab to permit identification of each circuit and feeder within pull box. Identify each with respect to load served.
2. Feeder circuits shall be wrapped, in accordance with manufacturer's recommendations, with arc-proof and fire proof tape.

P. Box covers shall be in place and secured to box.

Q. Identification

1. Refer to ELECTRICAL IDENTIFICATION section of these specifications for additional requirements.

R. Exterior pull or junction boxes

1. Exterior pull or junction boxes shall be mounted flush with the grade, unless specified elsewhere or indicated to be aboveground on the drawings.
2. Flush mounted boxes shall be surrounded on all sides and bottom with 6" minimum of concrete. Top of concrete shall be flush with grade.
3. Seal conduit entries into box with duct seal to prevent entrance of moisture, after conductors are installed.
4. Taps and splices, where permitted by these specifications within exterior junction boxes, shall be performed with an encapsulating watertight splice or tap kit which insulates and moisture seals the connection. Kit shall consist of the appropriate size and type mold, encapsulating resin and end sealing tape.

3.02 CLEANING AND ADJUSTMENT

A. After completion, clean all work of dirt, paint and construction debris.

END OF SECTION

DIVISION 26 – ELECTRICAL

260533.02 – ELECTRICAL CONNECTIONS FOR EQUIPMENT

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. Extent of electrical connections for equipment is indicated by drawings and schedules. Electrical connections are hereby defined to include connections used for providing electrical power to equipment.

B. Applications of electrical power connections specified in this section include the following:

1. To resistive heaters.
2. From electrical source to motor starters.
3. From motor starters to motors.
4. To lighting fixtures.
5. To transformers and similar current current adjustment features of equipment.

C. Electrical connections for equipment, not furnished as integral part of equipment, are specified in Division - 15 and other Division - 16 sections, and are work of this section.

1. Division 1 - GENERAL REQUIREMENTS
2. Division 11 - EQUIPMENT
3. Division 13 - SPECIAL CONSTRUCTION

D. Motor starters and controllers, not furnished as integral part of equipment, are specified in applicable Division - 16 sections, and are work of this section.

E. Junction boxes and disconnect switches required for connecting motors and other electrical units of equipment are specified in applicable Division - 16 sections, and are work of this section.

F. Raceways and wires/cables required for connecting motors and other electrical units of equipment are specified in applicable Division 16 sections, and are work of this section.

G. Electrical identification for wire/cable conductors is specified in Division - 16 section, ELECTRICAL IDENTIFICATION, and is work of this section.

1.03 QUALITY ASSURANCE

A. NEC Compliance: Comply with applicable requirements of NEC as to type products used and installation of electrical power connections (terminals and splices), for junction boxes, motor starters, and disconnect switches. NEC Article 110-14, "ELECTRICAL CONNECTIONS" applies to above.

B. IEEE Compliance: Comply with Std 241, "IEEE Recommended Practice for Electric Power Systems in Commercial Buildings" pertaining to connections and terminations.

C. ANSI/NEMA Compliance: Comply with applicable requirements of ANSI/NEMA and ANSI/EIA standards pertaining to products and installation of electrical connections for equipment.

1. ANSI/NEMA CC3: "Connectors for use between aluminum or aluminum-copper overhead conductors."
2. ANSI/EIA RS-364-21A: "Insulation Resistance Test"
3. STD SG-14: "Unplated split-bolt and Vice-Type Electrical Connectors for Copper Conductors".

D. UL Compliance: Comply with UL Std 486A, "Wire Connectors and Soldering Lugs for Use With Copper Conductors" including, but not limited to, tightening of electrical connectors to torque values indicated. Provide electrical connection products and materials which are UL-listed and labeled.

1. STD. NO. 486A; Wire Connectors and Soldering Lugs for Use with Copper Conductors.
2. STD. No. 486B; Wire Connectors for Use with Aluminum Conductors.
3. STD. NO. 486C; Splicing Wire Connectors.
4. STD. NO. 486D; Insulated Wire Connectors for Use With Underground Conductors.

E. ETL Compliance: Provide electrical connection products and materials which are ETL-listed and labeled.

F. ASTM Compliance: Comply with Standard B539 "Standard Methods for Measuring Contact Resistance of Electrical Connections (Static Contacts)."

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver electrical connection products wrapped in proper factory-fabricated type containers.

B. Store electrical connection products in original cartons and protect from weather, construction traffic and debris.

C. Handle electrical connection products carefully to prevent breakage, denting, and scoring finish.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS:

A. Manufacturers: Subject to compliance with requirements, provide products of one of the following (for each type of product):
1. AMP Incorporated
2. Appleton Electric Company
3. Arrow-Hart Div, Crouse-Hinds Company
4. Bishop Div, General Signal Corporation
5. Burndy Corporation
6. General Electric Company
7. Gould, Inc.
8. Harvey Hubbell Inc.
9. Ideal Industries, Inc.
10. Reliable Electric Company
11. Square D Company
12. Thomas and Betts Corporation

2.02 MATERIALS AND COMPONENTS

A. General: For each electrical connection indicated, provide complete assembly of materials, including but not necessarily limited to, pressure connectors, terminals (lugs), electrical insulating tape, heat-shrinkable insulating tubing, cable ties, solderless wire-nuts, and other items and accessories as needed to complete splices and terminations of types indicated.

B. Metal Conduit, Tubing and Fittings:

1. Provide metal conduit, tubing and fittings of types, grades, sizes and weights (wall thicknesses) indicated for each type service. Where types and grades are not indicated, provide proper selection as determined by Installer to fulfill wiring requirements and comply with NEC requirements for raceways. Provide products complying with Division - 16 BASIC ELECTRICAL MATERIALS and RACEWAYS section, and in accordance with the following listing of metal conduit, tubing and fittings:
   a. Rigid aluminum conduit
   b. Rigid steel conduit
   c. Rigid metal conduit fittings
   d. Electrical metallic tubing
   e. EMT fittings
   f. Flexible metal conduit
   g. Flexible metal conduit fittings

h. Liquid-tight flexible metal conduit
i. Liquid-tight flexible metal conduit fittings
j. Stainless steel conduits and fittings

C. Wires, Cables, and Connectors:

1. Provide wires, cables, and connectors complying with Division - 16 basic electrical materials and methods section "WIRES AND CABLES".
2. Wires/Cables: Unless otherwise indicated, provided wires/cables (conductors) for electrical connections which match, including sizes and ratings, of wires/cables which are supplying electrical power. Provide copper conductors with conductivity of not less than 98% at 20°C (68°F).
3. Connectors and Terminals: Provide electrical connectors and terminals which mate and match, including sizes and ratings, with equipment terminals which are recommended by equipment manufacturer for intended applications.
4. Electrical Connection Accessories: Provide electrical insulating tape, heat-shrinkable insulating tubing and boots, wirenuts and cable ties as recommended for use by accessories manufacturers for type services indicated.

PART 3 - EXECUTION

3.01 INSTALLATION OF ELECTRICAL CONNECTIONS:

A. Install electrical connections as indicated; in accordance with equipment manufacturer's written instructions and with recognized industry practices, and complying with applicable requirements of UL, NEC and NECA's "Standard of Installation" to ensure that products fulfill requirements.

B. Coordinate with other work, including wires/cables, raceway and equipment installation, as necessary to properly interface installation of electrical connections for equipment with other work.

C. Connect electrical power supply conductors to equipment conductors in accordance with equipment manufacturer's written instructions and wiring diagrams. Mate and match conductors of electrical connections for proper interface between electrical power supplies and installed equipment.

D. Cover splices with electrical insulating material equivalent, or of greater insulation resistivity rating, than electrical insulation rating of those conductors being spliced.

E. Prepare cables and wires by cutting and stripping covering armor, jacket, and insulation properly to ensure uniform and neat appearance where cables and wires are terminated. Exercise care to avoid cutting through tapes which will remain on conductors. Also avoid "ringing" copper conductors while skinning wire.

F. Trim cables and wires as short as practicable and arrange routing to facilitate inspection, testing and maintenance.

G. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturers published torque tightening values for equipment connectors. Accomplish tightening by utilizing proper torquing tools, including torque screwdriver, beam-type torque wrench, and ratchet wrench with adjustable torque settings. Where manufacturer's torquing requirements are not available, tighten connectors and terminals to comply with torquing values contained in UL 486A.

H. Provide PVC conduit and fittings as indicated for highly corrosive atmospheres.

I. Provide flexible conduit for motor connections, and other electrical equipment connections, where subject to movement and vibration.

J. Provide liquid-tight flexible conduit for connection of motors and other electrical equipment where subject to movement and vibration, and also where connections are subject to one or more of the following conditions:

1. Exterior location.
2. Moist or humid atmosphere where condensate can be expected to accumulate.
3. Corrosive atmosphere.
4. Water spray.
5. Dripping oil, grease, or water.

K. Fasten identification markers to each electrical power supply wire/cable conductor which indicates their voltage, phase and feeder number in accordance with Division - 16 section ELECTRICAL IDENTIFICATION. Affix markers on each terminal conductor, as close as possible to the point of connection.

3.02 FIELD QUALITY CONTROL

A. Upon completion of installation of electrical connections, and after circuitry has been energized with rated power source, test connections to demonstrate capability and compliance with requirements. Ensure that direction of rotation of each motor fulfills requirement. Correct malfunctioning units at site, then retest to demonstrate compliance.

END OF SECTION

DIVISION 26 – ELECTRICAL

260553 – 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. Extent of electrical identification work is as outlined by this specification.

B. Types of electrical identification work specified in this section include the following:

1. Buried cable warnings.
2. Electrical power, control and communication conductors.
3. Operational instructions and warnings.
4. Danger signs.
5. Equipment/system identification signs.

C. Refer to Division 1 General Requirements section IDENTIFICATION SYSTEMS, for equipment and system nameplates, and performance data; not work of this section.

1.03 QUALITY ASSURANCE

A. NEC Compliance: Comply with NEC as applicable to installation of identifying labels and markers for wiring and equipment.

B. UL Compliance: Comply with applicable requirements of UL Std 969, "Marking and Labeling Systems", pertaining to electrical identification systems.

C. ANSI Compliance: Comply with applicable requirements of ANSI Std A13.1, "Scheme for the Identification of Piping Systems".

D. NEMA Compliance: Comply with applicable requirements of NEMA Std No's WC-1 and WC-2 pertaining to identification of power and control conductors.

PART 2- PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide electrical identification products of one of the following (for each type marker):

1. Almetek
2. Brady, W.H. Company
3. Calpico Inc.
4. Cole-Flex Corporation
5. Direct Safety Company
6. George-Ingraham Corporation
7. Griffolyn Company
8. Ideal Industries, Inc.
9. LEM Products, Inc.
10. Markal Company
11. National Band and Tag Company
12. Panduit Corporation
13. Seton Name Plate Company
14. Tesa Corporation

2.02 ELECTRICAL IDENTIFICATION MATERIALS

A. Except as otherwise indicated, provide manufacturer's standard products of categories and types required for each application. Where more than single type is specified for an application, selection is Installer's option, but provide single selection for each application.

B. Color-Coded Plastic Tape:

1. Provide manufacturer's standard self-adhesive vinyl tape not less than 3 mils thick by 1-1/2" wide.
   a. Colors: Unless otherwise indicated or required by governing regulations, provide orange tape.

C. Underground-Type Plastic Line Marker:

1. Manufacturer's standard permanent, detectable, bright-colored, continuous-printed plastic tape, intended for direct-burial service; not less than 6" wide x 4 mils thick. Provide tape with printing which most accurately indicates type of service of buried cable.

D. Cable/Conductor Identification Bands:

1. Provide manufacturer's standard vinyl-cloth self-adhesive cable/conductor markers of wrap-around type, either pre-numbered plastic coated type, or write-on type with clear plastic self-adhesive cover flap; numbered to show circuit identification.

E. Plasticized Tags:

1. Manufacturer's standard pre-printed or partially pre-printed accident-prevention and operational tags, of plasticized card stock with matt finish suitable for writing, approximately 3-1/4" x 5-5/8", with brass grommets and wire fasteners, and with appropriate pre-printed wording including large-size primary wording, e.g., DANGER, CAUTION, DO NOT OPERATE.

F. Self-Adhesive Plastic Signs:

1. Provide manufacturer's standard, self-adhesive or pressure-sensitive, pre-printed, flexible vinyl signs for operational instructions or warnings; of sizes suitable for application areas and adequate for visibility, with proper wording for each application, e.g., 208V, EXHAUST FAN, RECTIFIER.
2. Colors: Unless otherwise indicated, or required by governing regulations, provide white signs with black lettering.

G. Baked Enamel Danger Signs:

1. General: Provide manufacturer's standard "DANGER" signs of baked enamel finish on 20-gage steel; of standard red, black and white graphics; 14" x 10" size except where 10" x 7" is the largest size which can be applied where needed, and except where larger size is needed for adequate vision; with recognized standard explanation wording, e.g., HIGH VOLTAGE, KEEP AWAY, BURIED CABLE, DO NOT TOUCH SWITCH.

H. Engraved Plastic-Laminate Signs:

1. Provide engraving stock melamine plastic laminate, complying with FS L-P-387, in sizes and thicknesses indicated, engraved with engraver's standard letter style of sizes and wording indicated, black face and white core plies (letter color) except as otherwise indicated, punched for mechanical fastening except where adhesive mounting is necessary because of substrate.
2. Thickness: 1/8", except as otherwise indicated.
3. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate substrate.

2.03 LETTERING AND GRAPHICS

A. General: Coordinate names, abbreviations and other designations used in electrical identification work, with corresponding designations shown, specified or scheduled. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturer or as required for proper identification and operation/maintenance of electrical systems and equipment. Comply with ANSI A13.1 pertaining to minimum sizes for letters and numbers.

PART 3 - EXECUTION

3.01 APPLICATION AND INSTALLATION

A. General Installation Requirements:

1. Install electrical identification products as indicated, in accordance with manufacturer's written instructions, and requirements of NEC and OSHA.
2. Coordination: Where identification is to be applied to surfaces which require finish, install identification after completion of painting.
3. Regulations: Comply with governing regulations and requests of governing authorities for identification of electrical work.

B. Box Identification:

1. After completion, using an indelible wide tip marker, indicate on the cover of each junction and pull box the designation of the circuits contained therein, i.e., A-1, 3, 5. Use a black marker for normal power circuits and a red marker for emergency circuits.

C. Underground Conduit Identification:

1. During back-filling/top-soiling of each exterior underground electrical, signal or communication conduit, install continuous underground-type plastic line marker, located directly over buried line at 6" to 8" below finished grade. Where multiple small lines are buried in a common trench and do not exceed an overall width of 16", install a single line marker.
2. Install line marker for every buried conduit, regardless of whether direct-buried or protected in conduit.

D. Cable/Conductor Identification:

1. Apply cable/conductor identification, including voltage, phase and feeder number, on each cable/conductor in each box/enclosure/cabinet where wires of more than one circuit or communication/signal system are present, except where another form of identification (such as color-coded conductors) is provided. Match identification with marking system used in panelboards, shop drawings, contract documents, and similar previously established identification for project's electrical work. Refer to WIRES AND CABLES section of these specifications for color coding requirements.

E. Operational Identification and Warnings:

1. Wherever required by OSHA or directed by the Owner, to ensure safe and efficient operation and maintenance of electrical systems, and electrically connected mechanical systems and general systems and equipment, including prevention of misuse of electrical facilities equipment by unauthorized personnel, install self-adhesive plastic signs or similar equivalent identification, instruction or warnings on switches, outlets and other controls, devices and covers of electrical enclosures. Where detailed instructions or explanations are

needed, provide plasticized tags with clearly written messages adequate for intended purposes.

F. Danger Signs:

1. In addition to installation of danger signs required by governing regulations and authorities, install appropriate danger signs at locations indicated and at locations subsequently identified by Installer of electrical work or the Owner as constituting similar dangers for persons in or about project.
   a. High Voltage: Install danger signs wherever it is possible, under any circumstances, for persons to come into contact with electrical power of voltages higher than 110-120 volts.
   b. Critical Switches/Controls: Install danger signs on switches and similar controls, regardless of whether concealed or locked up, where untimely or inadvertent operation (by anyone) could result in significant danger to persons, or damage to or loss of property.
2. Provide DANGER signs on covers of all panels, switchboard and motor control centers.

G. Equipment/System Identification:

1. Install engraved plastic-laminate sign on each major unit of electrical equipment in building; including central or master unit of each electrical system including communication/-control/signal systems, unless unit is specified with its own self-explanatory identification or signal system. Except as otherwise indicated provide single line of text, 1/2" high lettering, on 1-1/2" high sign (2" high where 2 lines are required), white lettering in black field. Provide text matching terminology and numbering of the contract documents and shop drawings. Provide signs for each unit of the following categories of electrical work:
   a. Panelboards, electrical cabinets and enclosures.
   b. Access panel/doors to electrical facilities.
   c. Major electrical switchgear.
   d. Motor control centers.
   e. Transformers.
   f. Power generating units.
   g. Automatic transfer switch.
2. Install signs at locations indicated or, where not otherwise indicated, at location for best convenience of viewing without interference with operation and maintenance of equipment. Secure to substrate with fasteners, except use adhesive where fasteners should not or cannot penetrate substrate. Identification of flush mounted cabinets and panelboards shall be on the inside of the device.
3. Panelboards, individually mounted circuit breakers, and each feeder breaker in the distribution panels shall be identified with an engraved plastic laminate sign. Plastic nameplates shall be multicolored laminated plastic with faceplate and core as scheduled. Lettering shall be engraved minimum 1/4" high letters.
   a. 480/277 volt normal power equipment shall be identified with white faceplate with black core.

b. 480/277 volt emergency power equipment shall be identified with white faceplate with red core.
c. 208/120 volt essential power equipment shall be identified with red faceplate with white core.
d. Equipment identification is to indicate the following:
    1) Equipment ID abbreviation.
    2) Voltage, phase, wires and frequency.
    3) Emergency or other system.
    4) Power source origination. Example:
        a) Panel E3HA
        b) 480/277V, 3 phase, 4 wire
        c) Emergency System
        d) Fed by SWBD-7

END OF SECTION

DIVISION 26 – ELECTRICAL

260573 – SHORT-CIRCUIT COORDINATION STUDY/ARC FLASH

PART 1 - GENERAL

1.01 SCOPE

A. The contractor shall furnish short-circuit and protective device coordination studies which shall be prepared by the equipment manufacturer.

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

1.02 RELATED SECTIONS

1.03 REFERENCES

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

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

B. American National Standards Institute (ANSI):

1. ANSI C57.12.00 – Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
2. ANSI C37.13 – Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures
3. ANSI C37.010 – Standard Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
4. ANSI C 37.41 – Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories
5. ANSI C37.5 – Methods for Determining the RMS Value of a Sinusoidal Current Wave and Normal-Frequency Recovery Voltage, and for Simplified Calculation of Fault Currents

C. The National Fire Protection Association (NFPA)

1. NFPA 70 - National Electrical Code, latest edition
2. NFPA 70E – Standard for Electrical Safety in the Workplace
3. submittals for review/approval

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

1.04 SUBMITTALS FOR CONSTRUCTION

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

B. The report shall include the following sections:

1. One-line diagram showing protective device ampere ratings and associated designations, cable size & lengths, transformer kVA & voltage ratings, motor & generator kVA ratings, and switchgear/switchboard/panelboard designations
2. Descriptions, purpose, basis and scope of the study
3. Tabulations of the worst-case calculated short circuit duties as a percentage of the applied device rating (automatic transfer switches, circuit breakers, fuses, etc.); the short circuit duties shall be upward-adjusted for X/R ratios that are above the device design ratings
4. Protective device time versus current coordination curves with associated one line diagram identifying the plotted devices, tabulations of ANSI protective relay functions and adjustable circuit breaker trip unit settings
5. Fault study input data, case descriptions, and current calculations including a definition of terms and guide for interpretation of the computer printout
6. Incident energy and flash protection boundary calculations
7. Comments and recommendations for system improvements, where needed
8. Executive Summary including source of information and assumptions made

1.05 QUALIFICATIONS

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

PART 2 - PRODUCT

2.01 STUDIES

A. Contractor to furnish short-circuit and protective device coordination studies as prepared by equipment manufacturer. By using the equipment manufacturer the study allows coordination of proper breakers, fuses, and current transformers. The coordination study shall begin with the utility company's feeder protective device and include all of the electrical protective devices down to and include the largest feeder circuit breaker and motor starter in the 480 Volt motor control centers and power distribution panelboards. The study shall also include variable frequency drives, harmonic filters, power factor correction equipment, transformers and protective devices associated with variable frequency drives, emergency and standby generators associated paralleling equipment and distribution switchgear.

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

2.02 DATA COLLECTION

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

B. Source combination may include present and future utility supplies, motors, and generators.

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

D. Include fault contribution of existing motors in the study, with motors < 50 hp grouped together. The Contractor shall obtain required existing equipment data, if necessary, to satisfy the study requirements.

2.03 SHORT-CIRCUIT AND PROTECTIVE DEVICE EVALUATION STUDY

A. Use actual conductor impedances if known. If unknown, use typical conductor impedances based on IEEE Standards 141, latest edition.

B. Transformer design impedances and standard X/R ratios shall be used when test values are not available.

C. Provide the following:

1. Calculation methods and assumptions
2. Selected base per unit quantities
3. One-line diagram of the system being evaluated with available fault at each bus, and interrupting rating of devices noted
4. Source impedance data, including electric utility system and motor fault contribution characteristics
5. Typical calculations
6. Tabulations of calculated quantities
7. Results, conclusions, and recommendations

D. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each:

1. Electric utility's supply termination point
2. Incoming switchgear
3. Unit substation primary and secondary terminals
4. Low voltage switchgear
5. Motor control centers
6. Standby generators and automatic transfer switches
7. Branch circuit panelboards
8. Other significant locations throughout the system

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

F. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short circuit ratings
2. Adequacy of switchgear, motor control centers, and panelboard bus bracing to withstand short-circuit stresses
3. Adequacy of transformer windings to withstand short-circuit stresses
4. Cable and busway sizes for ability to withstand short-circuit heating

5. Notify Owner in writing, of existing, circuit protective devices improperly rated for the calculated available fault current

2.04 PROTECTIVE DEVICE COORDINATION STUDY

A. Proposed protective device coordination time-current curves shall be graphically displayed on log-log scale paper.

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

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

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

E. Plot the following characteristics on the curve sheets, where applicable:

1. Electric utility's protective device
2. Medium voltage equipment relays
3. Medium and low voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands
4. Low voltage equipment circuit breaker trip devices, including manufacturer's tolerance bands
5. Transformer full-load current, magnetizing inrush current, and ANSI transformer withstand parameters
6. Conductor damage curves
7. Ground fault protective devices, as applicable
8. Pertinent motor starting characteristics and motor damage points
9. Pertinent generator short-circuit decrement curve and generator damage point
10. Other system load protective devices for the largest branch circuit and the largest feeder circuit breaker in each motor control center

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

2.05 ARC FLASH HAZARD ANALYSIS

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

B. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Alternative methods shall be presented in the proposal.

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

D. The Arc-Flash Hazard Analysis shall include all 480V locations and significant locations in 240 volt and 208 volt systems fed from transformers equal to or greater than 125 kVA.

E. Safe working distances shall be specified for calculated fault locations based upon the calculated arc flash boundary considering an incident energy of 1.2 cal/cm2.

F. The Arc Flash Hazard analysis shall include calculations for maximum and minimum contributions of fault current magnitude. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume a minimum motor load. Conversely, the maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.

G. Arc flash computation shall include both line and load side of main breaker calculations, where necessary.

H. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584-2002 section B.1.2.

2.06 REPORT SECTIONS

A. Input Data:

1. Utility three-phase and line-to-ground available contribution with associated X/R ratios
2. Short-circuit reactance of rotating machines with associated X/R ratios
3. Cable type, construction, size, # per phase, length, impedance and conduit type
4. Bus duct type, size, length, and impedance
5. Transformer primary & secondary voltages, winding configurations, kVA rating, impedance, and X/R ratio
6. Reactor inductance and continuous ampere rating
7. Aerial line type, construction, conductor spacing, size, # per phase, and length

B. Short-Circuit Data:

1. Source fault impedance and generator contributions
2. X to R ratios
3. Asymmetry factors
4. Motor contributions
5. Short circuit kVA

6. Symmetrical and asymmetrical fault currents

C. Recommended Protective Device Settings:

1. Phase and Ground Relays:
   a. Current transformer ratio.
   b. Current setting.
   c. Time setting.
   d. Instantaneous setting.
   e. Specialty non-overcurrent device settings.
   f. Recommendations on improved relaying systems, if applicable.
2. Circuit Breakers:
   a. Adjustable pickups and time delays (long time, short time, ground).
   b. Adjustable time-current characteristic.
   c. Adjustable instantaneous pickup.
   d. Recommendations on improved trip systems, if applicable.

D. Incident energy and flash protection boundary calculations.

1. Arcing fault magnitude
2. Device clearing time
3. Duration of arc
4. Arc flash boundary
5. Working distance
6. Incident energy
7. Hazard Risk Category
8. Recommendations for arc flash energy reduction

PART 3 - EXECUTION

3.01 FIELD ADJUSTMENT

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

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

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

D. Following completion of all studies, acceptance testing and startup by the field engineering service division of the equipment manufacturer, a 2-year warranty shall be provided on all components manufactured by the engineering service parent manufacturing company.

E. Provide trip information for distribution equipment to have 'test' switch to allow work on energized equipment.

3.02 ARC FLASH WARNING LABELS

A. The vendor shall provide a 3.5 in. x 5 in. thermal transfer type label of high adhesion polyester for each work location analyzed.

B. The label shall have an orange header with the wording, "WARNING, ARC FLASH HAZARD", and shall include the following information:

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

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

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

1. For each 480 and applicable 208 volt panelboards and disconnects, one arc flash label shall be provided
2. For each motor control center, one arc flash label shall be provided
3. For each low voltage switchboard, one arc flash label shall be provided
4. For each switchgear, one flash label shall be provided

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

3.03 ARC FLASH TRAINING

A. The equipment vendor shall train personnel of the potential arc flash hazards associated with working on energized equipment (minimum of 4 hours). Maintenance procedures in accordance with the requirements of NFPA 70E, Standard for Electrical Safety Requirements for Employee Workplaces, shall be provided in the equipment manuals.

END OF SECTION

DIVISION 26 – ELECTRICAL

262200 – TRANSFORMERS

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. The work required under this section of the specifications consists of the furnishing, connection and installation of dry type transformers.

B. Definition: Dry type transformers, as described herein, applies to those with primary and secondary voltage connections of 600 volts and less. Autotransformers are not acceptable, except where indicated for buck boost or zig-zag connections.

1.03 QUALITY ASSURANCE

A. Referenced Industry Standards: The following specifications and standards are incorporated into and become a part of this specification by reference.

1. Underwriter's Laboratories, Inc. (UL) Publications:
   a. No. 506 Transformers (1000 KVA, 3 phase and below; 167 KVA, 1 phase and below)
2. National Fire Protection Association (NFPA):
   a. No. 70 National Electrical Code (NEC)
3. National Electrical Manufacturers Association (NEMA):
   a. No. ST-20 Dry-type transformers for general applications
4. American National Standards Institute (ANSI):
   a. No. C57.12.80 Terminology for Power and Distribution Transformers
   b. No. C57.12.90 Guide for Short Circuit Testing of Distribution and Power Transformers
   c. No. C57.94 Recommended Practice for Installation, Application, Operation and Maintenance of Dry-Type General Purpose Distribution and Power Transformers

B. Acceptable Manufacturers: Products of the following manufacturers, which comply with these specifications, are acceptable.

1. Eaton
2. Siemens
3. Square D

C. Coordination: Coordinate installation with architectural and structural features, equipment installed under other sections of the specifications and electrical equipment to insure transformer access and clearance minimums are provided, and adequate ventilation is permitted.

1.04 SUBMITTALS

A. Refer to the BASIC ELECTRICAL REQUIREMENTS section for submittal requirements.

B. Manufacturers Product Data:

1. Submit material specifications and installation data for products specified under PART 2 - PRODUCTS. Product data shall indicate sound and temperature rating, overload capacity and efficiency at 25%, 50% and 100% load, available taps, voltage, impedance, nameplate data, wiring diagrams, physical dimensions and net weight. Product data shall also contain certification that transformers are constructed and tested in accordance with standards specified herein.

C. Record Drawings. Include in each set:

1. A complete set of manufacturers product data indicating all post bid revisions and field changes.

PART 2 - PRODUCTS

2.01 GENERAL MATERIALS REQUIREMENTS

A. Furnish all materials specified herein and indicated on the drawings.

B. All transformers shall be UL listed and bear a UL label.

C. Transformers shall be self-cooled, rated for continuous operation at rated KVA, 24 hours per day, 365 days per year with normal life expectancy (IEEE Standard No. 65). KVA ratings shall be as indicated on the drawings.

2.02 GENERAL PURPOSE DRY TYPE TRANSFORMERS

A. Insulation System

1. Single phase 25 - 167 KVA and three phase 30 - 1500 KVA: Transformers shall be rated for average temperature rise by resistance of 150°C. in 40°C. maximum ambient, 30°C average ambient. Transformer insulation system shall be UL rated as 220°C. system.
2. Three phase 3 - 15 KVA: Transformers shall be rated for average temperature rise by resistance of 115°C. Insulation system shall be 180°C.

3. Single phase up through 250 VA: Transformers shall be rated for 55°C. rise by resistance. Insulation system shall be 105°C.
4. Single phase 500 - 3000 VA: Transformers shall be rated for 115°C. temperature rise by resistance. Insulation system shall be 180°C.

B. Sound rating shall not exceed NEMA and ANSI standards for KVA rating. Internal vibration dampening shall be provided as a standard feature of all transformers.

C. Single phase transformers rated up to 15 KVA shall have two, 5 percent full capacity taps below normal rated primary voltage. All other single phase and all three phase transformers shall be provided with six 2-1/2% full capacity taps, two above and four below normal voltage unless only four 2-1/2% taps, two above and two below normal voltage, are standard.

D. Construction and Enclosures

1. Transformers 30 - 1500 KVA: Transformer enclosures shall be open, ventilated, drip-proof with removable front and rear cover panels. Transformers shall be suitable for floor mounting, unless wall mounting is indicated on the drawings.
2. Transformers up through 25 KVA: Transformers shall be totally enclosed, non-ventilated with a resin encapsulated core and coil and drip-proof housing. Removable panel section shall permit access to wiring compartment.

E. Dry type transformers shall provide 3 phase 4 wire 208Y/120 or 1 phase 3 wire 230/115 volt service, as indicated on the drawings, to designated panelboards or other equipment. Primary rating shall be 480 volts.

F. Nominal transformer impedance shall be 4.5 percent minimum, unless otherwise indicated on the drawings.

G. Dry type transformer K-factors shall be as indicated on the drawings and as outlined in ANSI C57.110 "Recommended Practice for Establishing Transformer Capability when Supplying Nonsinusoidal Load Currents."

H. Core assemblies and the center ground connection point of the coil secondaries shall be grounded to their enclosures by adequate, flexible ground straps. Provide grounding lug at the strap to enclosure bonding location for connection of three conductors; the primary and secondary equipment grounding conductors and the grounding electrode conductor.

I. Provide weather shield on transformers indicated on drawings and for all exterior installations.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Dry transformers larger than 15 KVA shall be floor mounted, unless wall or suspension mounting is indicated on the drawings. Transformers 15 KVA and smaller shall be wall mounted. Installation shall provide not less than twelve inch clearance from walls or equipment. Floor mounted transformers shall be mounted on neoprene, waffle type vibration pads 5/8" thick. Where transformers are indicated on the drawings, or specified herein to be mounted on suspended channels of angles or wall mounted, transformers shall be bolted to structure with 5/8" thick vibration pad between transformer base and structural surface. Loosen shipping bolts to free up internal vibration mounts on core and coil assembly.

B. Primary and secondary connections to dry type transformers shall be made with flexible conduit.

C. The secondary windings of each dry type transformer shall be grounded in accordance with the National Electrical Code requirements for separately derived electrical systems. Extend a grounding electrode conductor from the transformer grounding lug to the nearest building structural steel or main column rebar. Connect the primary and secondary feeder equipment grounding conductors to the grounding lug. Refer to the secondary grounding section of these specifications for additional requirements.

D. Install secondary overcurrent protective device within 10 feet of conductor length. Where none is indicated on plans, provide enclosed circuit breaker within 10 feet rated at 125 percent of the transformer full load ampacity but not greater than the secondary conductor ampacity.

E. Do not install equipment over transformer, unless indicated on the drawings.

F. Locate transformers to provide working clearance and full accessibility as required by the National Electrical Code.

3.02 CLEANING AND ADJUSTMENT

A. Prior to final inspection, under maximum available load, measure secondary voltage and adjust tap setting to deliver nominal rated voltage within the percentage limits of one tap setting. Record the voltages of each transformer and submit in accordance with the requirements specified in the basic electrical requirements section.

B. After completion, clean the interior and exterior of dirt, paint and construction debris.

C. Touch up paint all scratched or marred surfaces with factory furnished touch up paint of the same color as the factory applied paint.

3.03 IDENTIFICATION

A. Refer to the ELECTRICAL IDENTIFICATION section of these specifications for identification requirements.

3.04 FIELD QUALITY CONTROL

A. Refer to the ELECTRICAL EQUIPMENT ACCEPTANCE TESTING section of this specification.

END OF SECTION

DIVISION 26 – ELECTRICAL

262413.01 – SWITCHBOARDS – FRONT ACCESSIBLE GROUP MOUNTED FEEDER DEVICES

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. The work required under this section of the Specifications consists of the installation of all switchboards for use on systems 600 volts and below. All materials and devices which are an integral part of the switchboard shall be provided under this section of the specifications.

B. Definition: Switchboards are floor mounted assemblies of one or more enclosed vertical section containing circuit breakers, switches, meters, fuses, and terminals essential to operation of electrical equipment. A dead front switchboard has no exposed live parts on front.

1.03 QUALITY ASSURANCE

A. The following specifications and standards are incorporated into and become a part of this Specification by reference.

1. National Electrical Manufacturers Association (NEMA) Standards:
   a. PB-2: Dead Front Distribution Switchboards
   b. PB-2.1: General Instruction for Proper Handling, Installation, Operation, and Maintenance of Deadfront Distribution Switchboards rated 600 volts or less.
   c. SG-3: Low Voltage Power Circuit Breakers.
2. Underwriters Laboratories, Inc. (UL):
   a. UL-489: Molded Case Circuit Breakers and Circuit Breaker Enclosures
   b. UL-891: Deadfront Electrical Switchboards
   c. UL-977: Fused Power Circuit Devices
3. Institute of Electrical and Electronics Engineers (IEEE):
   a. STD-241: IEEE Recommended Practices for Electric Power Systems in Commercial Buildings
4. National Fire Protection Association (NFPA):
   a. NFPA-70: The National Electrical Code
5. American National Standards Institute (ANSI):

a. C37.13: Low-Voltage AC Power Circuit Breakers used in Enclosures
b. C37.16: Related Requirements and Application Recommendations for Low-Voltage Power Circuit Breakers and AC Power Protectors, Preferred Ratings

B. Equipment Dimensions

1. Dimensions indicated on the drawings are maximum allowable and shall not be exceeded. Where switchboards of acceptable manufacturers listed exceed the maximum dimensions, products of such manufacturers shall not be acceptable.

C. Coordination

1. Review shop drawings submitted under this and other sections, as well as other divisions, to ensure coordination between work required among different trades. Coordinate the installation sequence with other contractors to avoid conflicts and to provide the fastest overall installation schedule. Coordinate installation with engineering and structural features, equipment installed under other sections of the specifications and electrical equipment to insure access and so that clearance minimums are provided.

D. Provide 'test' switches where shown on the drawings to allow work on "energized" equipment within safe limits. Set trip characteristics per Arc-Fault study. When system is in 'test' mode, provide indicator light and label.

1.04 SUBMITTALS

A. Refer to the BASIC ELECTRICAL REQUIREMENTS section for submittal requirements.

B. Product Data: Switchboards including, but not limited to, voltages, number of phases, frequencies, and short-circuit and continuous current ratings. Provide application data for main and branch circuit-breakers, sections, main buses, and basic insulation levels.

C. Shop Drawings: Layout drawings of switchboards showing accurately scaled basic equipment sections including auxiliary compartments, section components, and combination sections.

D. Wiring Diagrams: For switchboards showing connections to electrical power feeders and distribution branches. Differentiate between portions of wiring that are manufacturer-installed and portions that are field-installed.

E. Closeout Submittals: As follows:

1. Record Drawings: Include in each set:
   a. Complete set of switchboard manufacturers' product data and shop drawings indicating all post bid revisions and field changes.

b. Schedule of each overcurrent protection device indicating unit ampere rating and trip rating.
c. Copy of the ground-fault system performance test as required by Article 230-95(c) of the NEC.

1.05 DELIVERY, STORAGE, AND HANDLING:

A. Deliver switchboards and components properly packaged and mounted on pallets, or skids to facilitate handling of heavy items. Utilize factory-fabricated type containers or wrappings for switchboards and components which protect equipment from damage. Install gravity measuring meters in containers which indicate whether container has been bumped or dropped. Return G-meters to manufacturer for re-use upon delivery of switchboards. Inspect equipment to ensure that no damage has occurred during shipment.

B. Store switchboard equipment in original packaging and protect from weather and construction traffic. Wherever possible, store indoors; where necessary to store outdoors, store above grade and enclose with watertight wrapping.

C. Handle switchboard equipment carefully to prevent physical damage to equipment and components. Remove packaging, including the opening of crates and containers, avoiding the use of excessive hammering and jarring which would damage the electrical equipment contained therein. Do not install damaged equipment; remove from site and replace damaged equipment with new.

1.06 SEQUENCING AND SCHEDULING

A. Schedule delivery of switchboard equipment which permits ready building ingress for large equipment components to their designated installation spaces. Coordinate delivery of equipment with the installation of other building components.

B. Coordinate the size and location of concrete equipment pads. Cast anchor bolt inserts into pad. Concrete, reinforcement, and formwork requirements are specified in Division 3.

C. Coordinate with other electrical work including raceways, electrical boxes and fittings, and cabling/wiring work, as necessary to interface installation of switchboards with other work.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton

2. Siemens
3. Square D

2.02 GENERAL

A. AC Dead-Front Distribution Switchboards: Provide factory-assembled, dead-front, metal-enclosed, self-supporting secondary power switchboards, of types, sizes, electrical ratings and characteristics indicated; consisting of vertical panel units, and containing circuit-breakers of quantities, ratings and types indicated. Provide copper main bus and connections to circuit-breaker branches of sufficient capacity to limit rated continuous current operating temperature rise of no greater than 65°C above average ambient temperature of 25°C; with main bus and tap connections silver-surfaced and bolted tightly according to manufacturer's torquing requirements for maximum conductivity. Brace bus for short-circuit stresses up to maximum interrupting capacity. Provide accessibility of line and load terminations from front of switchboard. Equip units with built-in lifting eyes and yokes; and provide vertical individual panel units, suitable for bolting together at project site. Construct switchboard units for the following environment:

1. Installation: Indoors, NEMA Type 1. Provide exterior NEMA 3R where shown.

B. Provide accessory and instrumentation small wiring, necessary fuse blocks and terminal blocks within the switchboard. Control components, such as control transformers, fuse blocks, relays, etc., shall be suitably marked for identification where mounted on the switchboard corresponding to appropriate designations on manufacturer's wiring diagrams. All groups of control wires leaving the switchboard shall be provided with terminal blocks with suitable numbering strips. Provide wire markers at each end of all control wiring.

2.03 BUSSING

A. All bus bars shall be silver-plated copper with bolted connections at joints. The bus bars shall be of sufficient size to limit the temperature rise to 65°C rise based on UL tests, and rated to withstand mechanical forces exerted during short circuit conditions when directly connected to a power source having an available fault current as shown on the drawings. Provide full capacity neutral where a neutral is indicated on the drawings.

B. A ground bus rated a minimum of 25% of main bus ampacity shall be furnished firmly secured to each vertical section structure and shall extend the entire length of the switchboard. An incoming ground lug shall be furnished. Other ground lugs for feeder circuits shall also be supplied as shown in the schedules on the drawings.

C. All hardware used on conductors shall be high-tensile strength and plated. All terminals shall be of the anti-turn solderless type suitable for CU or A1 cable of sizes indicated for 75°C cable.

2.04 CONSTRUCTION

A. Switchboards shown mounted against a wall shall be front accessible. All sections of the switchboard shall be 20" deep except service sections containing large ampacity main disconnects which may be deeper as required. All sections of the switchboard shall align so that the back of the complete structure may be placed flush against a wall i.e. rear aligned only.

B. Construction shall allow maintenance of incoming line terminations, main device connections and all main bus bolted connections to be performed without rear access. The feeder or branch devices shall be removable from the front and shall be panel mounted with the necessary device line and load connections front accessible. Provide lugs on all devices for cable sizes shown on drawings.

2.05 METERING

A. Where indicated on the drawings, provide a separate customer metering compartment with front hinged door and include the following:

1. Current transformers
2. Potential transformers including primary and secondary fuses with disconnecting means for metering as shown on the drawings.
3. Indicating ammeter with ammeter switch indicating voltmeter with voltmeter switch and KWHR demand meter.

2.06 OVERCURRENT DEVICES - GENERAL

A. Main protective devices shall be fixed mounted molded case breaker with interrupting rating, frame and trip ratings as shown on the drawings. Provide drawout breakers where shown.

B. Group mounted feeder protective devices shall be molded case breaker type with frame and trip rating as shown on the drawings and have additional characteristics as specified.

C. Devices shall be manually operated (MO) unless electrically operated (EO) is indicated on the drawings. Provide electrically operated breakers for generators.

2.07 MOLDED CASE BREAKERS

A. Protective devices as shown shall be molded case circuit breakers providing complete circuit overcurrent protection by having inverse time and instantaneous tripping characteristics, and where applicable, be current limiting.

1. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip free. Automatic tripping of the breaker shall be clearly indicated by handle

position. Contacts shall be non-welding silver alloy and arc extinction shall be accomplished by means of arc chutes.

2. Circuit breaker interrupting capacities shall be as indicated on the drawings or as specified hereinafter. Where applicable, circuit breakers shall be listed for series application.

B. Breakers 150 ampere and below shall be thermal-magnetic trip with inverse time current characteristics. Breakers with 250 and 400 ampere frame shall be thermal-magnetic or solid-state trip, as applicable.

C. Breakers with 600 amperes frame and above shall be solid-state trip complete with built-in current transformers, solid-state trip unit and flux transfer shunt trip. Breakers shall have trip rating plugs with ratings as indicated on the drawings. Rating plugs shall be interlocked so they are NOT interchangeable between frames and interlocked such that a breaker cannot be latched with the rating plug removed.

1. Trip units shall have adjustable short time setting with a fixed instantaneous override for circuit protection. Main breakers shall be provided with additional instantaneous and short delay trip time adjustment for increased system coordination.
2. Breakers shall have built-in test points for testing long delay, instantaneous and ground fault functions of the breaker by means of a 120 volt operated test kit. Provide one test kit capable of testing all breakers 600 ampere and above.
3. Where indicated on the drawings, provide built-in ground fault protection with adjustable pick-up rating not exceeding 1200 amperes; ground fault time delay shall be adjustable 0.1 to 0.5 seconds. Provide neutral ground fault current transformer for four wire systems.

D. Where indicated on the drawings, provide zero sequence ground fault protection system with necessary sensor, monitor, test panel, shunt trip and control power source for use with breakers indicated.

2.08 NAMEPLATES

A. Engraved nameplates shall be furnished for all main and feeder circuits including control fuses and also for all indicating lights and instruments. Nameplates shall give item designation and circuit number as well as frame size and appropriate trip rating. Furnish Master nameplate giving switchboard designation, voltage ampere rating, short circuit rating, manufacturer's name, general order number and item number. Refer to ELECTRICAL IDENTIFICATION section of this specification.

2.09 FINISH

A. All exterior and interior steel surfaces of the switchboard shall be properly cleaned and provided with a rust-inhibiting phosphatized coating. Color and finish of the switchboard shall be ANSI 61 and use the manufacturer's standard process.

2.10 CONTROL POWER TRANSFORMERS

A. Control power transformers with primary and secondary protection shall be provided as indicated on the drawings or where required to operate ground fault systems, adequately sized for required burdens.

PART 3 - EXECUTION

3.01 EXAMINATION:

A. Examine areas and conditions under which switchboards and components are to be installed, and notify General Contractor in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to the Installer.

3.02 INSTALLATION OF SWITCHBOARDS:

A. Install switchboards as indicated, in accordance with manufacturer's written instructions, and with recognized industry practices; complying with applicable requirements of NEC, NEMA's Stds Pub/No. PB 2.1, and NECA's "Standard of Installation".

B. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Stds 486 A and B, and the National Electrical Code.

3.03 FIELD QUALITY CONTROL

A. Refer to ELECTRICAL EQUIPMENT ACCEPTANCE TESTING section of this specification.

B. Contractor shall verify in the field that all factory-made connections and terminations are torqued to manufacturer's recommended tolerances.

3.04 ADJUSTING AND CLEANING

A. Adjust operating mechanisms for free mechanical movement.

B. Touch-up scratched or marred surfaces to match original finishes.

3.05 GROUNDING

A. Provide equipment grounding connections for switchboards as indicated. Tighten connections to comply with tightening torques specified in UL Std 486A to assure permanent and effective grounds.

3.06 FIELD QUALITY CONTROL

A. Subsequent to wire and cable hook-ups, energize switchboards and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance.

END OF SECTION

DIVISION 26 – ELECTRICAL

262416 – PANELBOARDS

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. The work required under this section of the specifications consists of the furnishing, installation and connection of lighting and appliance panelboards and distribution type panelboards.

B. Panelboards designated as HDA, HDB, DA, DB, etc., or indicated on the drawings shall be distribution type panelboards. Those designated as HA, HB, A, B, etc., are lighting and appliance type panelboards.

C. Definitions: The term panelboard, as used in this specification or on the drawings, shall mean the complete assembly including the enclosure, bus work, trim hardware and circuit breaker or fused devices. The words panel and panelboard are used synonymously in these contract documents.

1.03 QUALITY ASSURANCE

A. Industry Referenced Standards. The following specifications and standards are incorporated into and become a part of this Specification by Reference.

1. Underwriters' Laboratories, Inc. (UL) Publications:
   a. No. 50: Cabinets and Boxes, Electrical
   b. No. 67: Panelboards
   c. No. 489: Molded Case Circuit Breakers and Circuit Breaker Enclosure
2. National Electrical Manufacturer's Association (NEMA) Publications:
   a. No. PB-1: Panelboards
   b. No. AB-3: Molded Case Circuit Breakers
3. National Fire Protection Association (NFPA):
   a. No. 70: National Electrical Code (NEC)

B. Acceptable Manufacturers: Products of the following manufacturers, which comply with these specifications, are acceptable.

1. Siemens
2. Eaton
3. Square D

C. Coordination: Coordinate installation with architectural and structural features, equipment installed under other sections of the specifications and electrical equipment to insure panel access and insure that clearance minimums are provided.

1.04 SUBMITTALS

A. Refer to BASIC ELECTRICAL REQUIREMENTS for submittal requirements.

B. Manufacturers Product Data:

1. Submit material specifications and installation data for products specified under Part 2 - Products to include:
   a. Circuit breakers
   b. Panelboards

C. Shop Drawings: Submit shop drawings to indicate information not fully described by the product data to indicate compliance with the contract drawings.

1. Include electrical characteristics and ratings for each panelboard with dimensions, mounting, bus material, voltage, ampere rating, mains, poles and wire connection, and any accessories. Indicate method of ground bus attachment to enclosure.
2. Include front elevation bussing diagram indicating each bussing circuit breaker position.
3. Provide a schedule indicating circuit breaker type, trip and size, poles, frame type, and interrupting capacity.

D. Record Drawings. Include in each set:

1. A complete set of panelboard manufacturers product data and shop drawings indicating all post bid revisions and field changes.
2. A copy of each panelboard directory incorporating all post bid revisions and field changes.

PART 2 - PRODUCTS

2.01 GENERAL MATERIALS REQUIREMENTS

A. Furnish all materials specified herein.

B. All panels and circuit breakers shall be UL listed and bear a UL label.

C. Panels shall be of the dead front safety type.

D. Provide panels complete with factory assembled circuit breakers connected to the bus bars in the positions shown on the panel schedules or bus diagrams as indicated on the drawings.

E. Number all panelboard circuits in the following sequence:

1. Circuits No. 1 and 2, Phase A; Circuits No. 3 and 4, Phase B; Circuits No. 5 and 6, Phase C. Connect two pole breakers to phase indicated on the drawings.

2.02 BUSSING AND INTERIORS

A. All bus bars shall be copper. Main lugs and main breakers shall be UL approved for copper or aluminum conductors and shall be of a size range for the conductors indicated on the drawings. Each panel shall contain an equipment grounding bus. Each lighting and appliance panelboard shall contain a full size insulated neutral bus. Where a distribution type panelboard is indicated on the drawings to have a neutral bus, the bus shall be insulated and full size, unless otherwise indicated on the drawings.

B. The neutral and ground busses shall have a sufficient number of lugs to singularly terminate each individual conductor requiring a connection.

C. The ground bus shall be factory brazed, riveted or installed on studs bolted to the panel enclosure or panel frame. The ground bus shall not be attached to the panel interior.

D. Where designated on panel schedule as "space", include all necessary bussing, device support and connections. Provide blank cover for each space.

2.03 ENCLOSURES

A. Panelboard width shall not be less than 20", nor more than 22" unless specific width is indicated on the drawings. Panelboard depth shall not exceed 5-3/4".

B. Distribution panelboard width shall not be less than 31" and the depth shall not exceed 14".

C. Review panelboard schedules and system one line diagram and provide panelboard gutters and bending space at terminals to conform to the National Electrical Code.

D. Provide concealed captive clamping devices, concealed hinges and lock for all flush mounted panels. Key all panels throughout project alike.

E. All surface mounted panels, except exterior rated panels, shall be provided with door-in-door hinged cover trims. Trims shall be secured by piano hinges to enclosure and secured closed by two trim clamps.

F. Provide a directory card, metal holder, and transparent cover permanently mounted on inside of doors.

G. Where indicated on the drawings or required for the environmental conditions, provide a NEMA 4X enclosure.

H. Provide mini-power center panels with integral main breaker, dry type transformer and panel where indicated on the drawings.

2.04 CIRCUIT BREAKERS

A. Interrupting rating of all circuit breakers in panelboards operating on 208Y/120 volt system shall have UL rating of not less than 10,000 RMS symmetrical amps at system voltage. Panelboards for use on 480Y/277 volt system shall contain circuit breakers with UL interrupting rating of not less than 14,000 RMS symmetrical amps at system voltage. Provide circuit breakers with higher interrupting capacity when indicated on the drawings.

B. Circuit breakers shall be provided with trip rating, poles and minimum interrupting rating as indicated on the drawings or specified herein.

C. Multi-pole breakers shall be common trip and common reset; tie handle connection between single pole breakers is not acceptable.

D. Branch circuit breakers in lighting and appliance panels shall be quick-make, quick-break, thermal magnetic type bolted to the bus. Circuit breakers in distribution type panelboards shall be bolted to the bus except, Square D I-line style plug in devices are acceptable.

E. Molded case circuit breakers shall have automatic, trip free, non-adjustable, inverse time, and instantaneous magnetic trips for 100 ampere frame or less. Magnetic trip shall be adjustable for breakers with 600 ampere frames and higher. Factory setting shall be HI, unless otherwise noted.

F. Provide the following special devices and accessories when indicated on the drawings, specified herein, or required by the NEC.

1. Ground fault interrupting circuit breaker (GFI).
2. Provide handle lock-off device to prevent manually turning off device without removal. Install on all circuit breakers indicated on the panel schedule.

2.05 SEPARATELY ENCLOSED MOLDED CASE CIRCUIT BREAKERS

A. Where separately enclosed molded case circuit breakers are shown on the drawings, provide circuit breakers in accordance with the applicable requirements of those specified for panelboards.

PART 3- EXECUTION

3.01 INSTALLATION

A. Mount panelboards with top circuit not more than 6'-6" above finished floor.

B. Lace and group conductors installed in panels with nylon tie straps. Only one conductor shall be installed under terminal of individual circuit breakers. Form and train conductors in panel enclosure neatly parallel and at right angles to sides of box. Uninsulated conductor shall not extend beyond one-eights inch from terminal lug.

C. Do not splice conductors in panels. Where required, install junction box adjacent to panel and splice or tap conductors in box. Refer to number of conductors in a conduit limitation defined in the conductors and cables section of the specifications and do not exceed.

D. Mounting and Support

1. Mounting
   a. Enclosure shall be secured to structure by a minimum of four (4) fastening devices. A 1.5" minimum diameter round washer shall be used between head of screw or bolt and enclosure.
   b. Enclosures shall be mounted where indicated on the drawings or specified herein. Support from the structure with fastening device specified.
   c. Attach enclosure directly to masonry, concrete, or wood surfaces.
   d. Mount enclosure on metal channel (strut), which is connected to structure with fastening device specified, for installations on steel structure or sheet rock walls.

E. Conductors not terminating in panelboard shall not extend through or enter panel enclosure.

F. Maintain conductor phase color code requirement described in the wires and cables section of the specifications.

G. Provide in each panelboard with a typewritten circuit directory mounted under clear plastic in a metal directory frame on interior of panel door. Directory shall reflect any field changes or additions.

H. Install push-in knock-out closure plugs in any unused knock-out openings.

I. Identification

1. Panelboards and individually mounted circuit breakers shall be identified.
2. Refer to the ELECTRICAL IDENTIFICATION section of these specifications for identification requirements.
3. Submit complete schedule with the shop drawings listing all nameplates and information contained thereon.

3.02 CLEANING AND ADJUSTMENT

A. After completion, clean the interior and exterior of dirt, paint and construction debris.

B. Touch up paint all scratched or marred surfaces with factory furnished touch up paint of the same color as the factory applied paint.

C. Adjust and align panelboard interior and trim in accordance with manufacturers recommendations, and to eliminate gaps between the two.

3.03 FIELD QUALITY CONTROL

A. Refer to the ELECTRICAL EQUIPMENT ACCEPTANCE TESTING section of this specification.

B. Contractor shall verify in the field that all factory-made connections and terminations are torqued to manufacturer's recommended tolerances.

END OF SECTION

DIVISION 26 – ELECTRICAL

SECTION 262419 - MOTOR CONTROL CENTERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections apply to this Section.

1.02 SUMMARY

A. The work required under this section of the Specifications consists of the installation of all Motor Control Centers for use on systems 600 volts and below. All materials and devices which are an integral part of the Motor Control Center shall be provided under this section of the specifications.

B. Definition: Motor Control Centers are floor mounted assemblies of one or more enclosed vertical sections having a common horizontal power bus and primarily containing combination Motor Control Units. Units are mounted one above the other in the vertical sections, with power supplied to the individual units by vertical power busses. The words motor control units, starters, and motor controllers are used synonomously in these contract documents.

1.03 QUALITY ASSURANCE

A. The following specifications and standards are incorporated into and become a part of this Specification by reference.
   1. National Electrical Manufacturers Association (NEMA) Standards:
      a. ICS-1: General Standards for Industrial Control and Systems
      b. ICS-2: Industrial Control Devices, Controllers and Assemblies
      c. ICS-3: Industrial Systems
      d. ICS-4: Terminal Blocks for Industrial Control Equipment and Systems
      e. ICS-6: Enclosures for Industrial Controls and Systems
   2. Underwriters Laboratories, Inc. (UL) Publications:
      a. UL 198.4: Class R Fuses
      b. UL 508: Industrial Control Equipment
      c. UL 845: Standard for Motor Control Centers
   3. National Fire Protection Association (NFPA)
      a. NFPA 70: National Electrical Code
   4. American National Standards Institute (ANSI):

a. C97.1: Low Voltage Cartridge Fuses, 600 Volts or Less

B. Acceptable Manufacturers: Products of the following manufacturers, which comply with these specifications, are acceptable.
1. Motor control centers and controllers:
a. Square D
b. Siemens
c. Cuttler Hammer
2. Fuses:
a. Gould-Shawmut
b. Buss
c. Littlefuse

C. Equipment Dimensions
1. Dimensions indicated on the drawings are maximum allowable and shall not be exceeded. Where motor control centers of acceptable manufacturers listed exceed the maximum dimensions, products of such manufacturers shall not be acceptable.

D. Coordination
1. Review shop drawings submitted under this and other sections, as well as other divisions, to ensure coordination between work required among different trades. Coordinate the installation sequence with other contractors to avoid conflicts and to provide the fastest overall installation schedule. Coordinate installation with architectural and structural features, equipment installed under other sections of the specifications and electrical equipment to insure access and so that clearance minimums are provided.

1.04 SUBMITTALS

A. Refer to basic electrical requirements section for submittal requirements.

B. Manufacturer's Product Data:
1. Submit material specifications and installation data for products specified under Part 2 - Products to include:
a. Motor controllers
b. Motor control centers
c. Fuses

C. Shop Drawings: Submit shop drawings to indicate information not fully described by the product data to indicate compliance with the contract drawings.
1. Include electrical characteristics and ratings for each motor control center with dimensions, mounting, bus material, voltage, bracing, ampere rating, mains, poles and wire connection, and any accessories.
2. Include bussing diagram indicating each bussing motor control unit, circuit breaker, or fused switch position.

3. Provide a schedule indicating motor control unit type, or trip and size, poles, frame type, fuse size and type, and interrupting capacity.
4. Identification designation schedule.

D. Record Drawings - Include in each set:
1. A complete set of motor control center manufacturers product data and shop drawings indicating all post bid revisions and field changes.
2. A schedule of each motor's actual full load nameplate rating and NEMA design with the selected overload heater catalog number and current range.

PART 2 - PRODUCTS

2.01 GENERAL

A. Furnish all materials specified herein.

B. Motor control center, motor control units, circuit breakers, and fused devices shall be UL listed and bear the UL label.

C. The type of enclosure shall be in accordance with NEMA standards for Type 1, gasketed construction. All enclosing sheet steel, wireways and unit doors shall be gasketed.

D. The motor control center shall be suitable for operation on a 480 3-phase, 3-wire 60 Hz system.

E. Motor control center wiring shall be NEMA Class I type B.

2.02 STRUCTURE ARRANGEMENT

A. Motor Control Center shall consist of free-standing, standardized vertical sections; each section shall have the following nominal dimensions: 90" H. x 21" W. x 16" D. Maximum overall dimensions, not to be exceeded, shall be as indicated on the drawings.

B. Each section shall contain continuous horizontal and vertical wireways. The horizontal wireway shall be located at the top and bottom of the section. Vertical wireways shall be provided adjacent to each unit. All wireways shall have provisions for cable support, shall be isolated from the bus bars and shall be accessible through hinged doors held closed by captive screws.

C. Adequate space for conduit and conductors entering the top or bottom, in accordance with the National Electrical Code, shall be provided without structural interference. Conductors shall be safely accessible without disrupting service.

D. Individual sections shall be assembled to form a totally enclosed deadfront, front accessible motor control center, as indicated on the drawings.

E. Motor control center design shall permit the future installation of matching vertical sections without the need for transition sections.

2.03 BUS ARRANGEMENT

A. Each vertical section shall contain a continuous three-phase bus, rated as shown on the drawings. Vertical busses shall be connected to the main horizontal bus.

B. A continuous, three-phase, main horizontal bus, rated as shown on the drawings, shall be provided for the distribution of power to the vertical busses. The main bus shall be located in the upper part of the structure.

C. Each vertical section shall contain a neutral bus connected to a main horizontal neutral bus, all rated at 50% of the main bus rating.

D. All non-current-carrying parts of the control center shall be grounded through the use of a continuous horizontal ground bus connected to vertical ground busses in each section. Ground bus rating shall not be less than 25% of main bus rating. Bus design shall include feature that for any plug-on unit the ground bus stab shall make contact with the ground bus before the power bus contact is made.

E. All busses shall be tin-plated copper, rated for a 50 degrees C. temperature rise above a 40 degrees C ambient. The minimum bus bracing, in RMS - symmetrical-amperes, shall be as shown on the drawings. Busbars shall be isolated and insulated with polyester boards front and back.

F. A front accessible main lug compartment shall be provided for incoming line termination. Lugs shall be suitable for terminating the size and quantity of conductors as indicated. The compartment shall be located in the unit space shown on the drawings and shall have a hinged door held closed by captive screws. Door shall have provisions for a padlock.

2.04 UNIT CONSTRUCTION

A. Combination magnetic starters shall be installed in removable units constructed in basic heights of 12" or multiples thereof. Each unit shall be isolated from others on structure. Connection to vertical bus for NEMA size five across the line starters and smaller shall be made with draw out stab type connection. Each plug-in type unit shall have a provision for positive horizontal and vertical alignment. Provisions shall also be included for positive ground connections through plug-in facilities. Each magnetic starter shall contain an overload relay in each phase, three in all. Each unit shall contain

separable control terminal blocks and separable power terminal blocks to permit removal of unit without disturbing control wiring.

B. Magnetic starters shall be the combination type with molded case circuit breakers. UL listed interrupting rating of molded case circuit breaker shall not be less than indicated on the drawings at system voltage.

C. Provide reduced voltage solid state starters where shown. Each starter to have ramp up and ramp down adjustable controls. Coordinate rating of RVSS with motor provided. Provide HOA switch, red 'RUN' pilot lamp, blue 'OVERLOAD' pilot lamp and 2 NO/NC contacts.

D. Where VFD's are shown to be in motor control center, provide as required in section 262923.

E. Individual starter doors and individual overcurrent device doors shall be interlocked to prevent door from being opened until switch is in "OFF" position. However, a "cheater screw" or other inconspicuous means shall be provided to permit access to energized starter, by authorized personnel. An interlock contact shall be provided within the starter to open control circuit to magnetic starter when device handle is in the open position. A door activated interlock switch is not acceptable.

F. Each magnetic starter shall be provided with HOA switch, as indicated on the drawings. Where no device is indicated on the drawings, provide an HOA switch for any motors automatically controlled or an ON-OFF switch for those specified to be manually controlled. Provide each magnetic starter with a "RUN" and an "OVERLOAD" pilot lamp. Control devices shall be of oil tight construction and shall be mounted on a removable panel on the unit door. Identify each control device with a metal tag or plastic laminated label.

G. Overload heaters shall be electronic adjustable type shall be selected in accordance with full load rating of motors actually furnished. Relay switching mechanism shall be single pole, double throw with normally open position connected to operate a door mounted, oil tight blue pilot lamp to indicate starter has tripped on overload.

H. Control voltage for magnetic starters shall be 120 volts obtained from a individual control power transformers in each magnetic starter. Each control power transformer shall be fused.

I. Provide contacts in magnetic starters to provide interlocking control sequence of operation specified under Division 23. Provide two normally open and one normally closed spare auxiliary contacts in each starter.

J. Starter sizes are based on design conditions using horsepower ratings of motors indicated on drawings. If motors actually furnished have horsepower ratings other than

those indicated, motor starters and feeders shall be adjusted in accordance with the rated horsepower at no additional cost to the Owner.

K. Provide, where indicated, molded case circuit breakers for feeder protection. All circuit breakers shall have UL interrupting rating of not less indicated on the drawings, at system voltage. Provide current limiting breakers as required.

2.05 AUXILIARY EQUIPMENT

A. Identification:
   1. The motor control center, each magnetic starter, each feeder protective device, and each auxiliary equipment item shall be provided with an engraved plastic nameplate approximately 1" x 3" permanently attached to the unit exterior door with self-tapping screws. Refer to ELECTRICAL IDENTIFICATION section.
   2. Refer to the basic electrical requirements section of these specifications for nameplate requirements.
   3. Submit complete schedule with the shop drawings listing all nameplates and information thereon.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install motor control center on 4" high concrete pad, the horizontal dimensions of which shall exceed the base dimensions of the motor control center by 3" on all sides.

B. Control and power circuits shall terminate in respective section in which starter is located.

C. Lace and group conductors installed in motor control center with nylon tie straps. Only one conductor shall be installed under each terminal. Form and train conductors in enclosure neatly parallel and at right angles to sides of box. Uninsulated conductor shall not extend beyond one-eighth inch from terminal lug.

D. Do not splice conductors in motor control center. Where required, installed junction box adjacent to enclosure and splice or tap conductors in box. Refer to number of conductors in a conduit limitation defined in the wires and cables section section of the specifications and do not exceed.

E. Conductors not terminating in motor control center section or unit shall not extend through or enter the section or unit.

F. Maintain conductor phase color code requirement described in the wires and cables section of the specifications.

3.02 CLEANING AND ADJUSTMENT

A. After completion, clean the interior and exterior of dirt, paint and construction debris.

B. Touch up paint all scratched or marred surfaces with factory furnished touch up paint of the same color as the factory applied paint.

C. Select and install overload heaters based on the full load current of the motor actually installed. All heaters in a starter shall be of the same size.

3.03 IDENTIFICATION

A. Refer to the ELECTRICAL IDENTIFICATION section of these specifications for identification requirements.

3.04 FIELD QUALITY CONTROL

A. Refer to the ELECTRICAL EQUIPMENT ACCEPTANCE TESTING section of this specification.

B. Contractor shall verify in the field that all factory-made connections and terminations are torqued to manufacturer's recommended tolerances.

END OF SECTION

DIVISION 26 – ELECTRICAL

262726 – WIRING DEVICES

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. The work included under this section of the specifications consists of the installation of wiring devices, i.e. switches and receptacles and device plates. All materials shall be provided under this section of the specifications.

B. Select devices from lists of acceptable devices contained in this section of the specifications.

C. The catalog numbers listed herein for switches and receptacles are for items with brown finish. Notwithstanding catalog numbers, the switches and receptacles provided on this project shall have ivory finish unless otherwise indicated. All special purpose receptacles shall be provided in black finish.

1.03 QUALITY ASSURANCE

A. NEMA WD-1 General Purpose Wiring

B. NEMA WD-5 Specific Purpose Wiring Devices

PART 2 - PRODUCTS

2.01 SWITCHES

A. Select switches from the following:

1. Single pole, 20 amp 277 volt switch: Arrow Hart 1991, Hubbell 1221, Leviton 53521, Pass & Seymour 20AC1.
2. Threeway, 20 amp 277 volt switch: Arrow Hart 1993, Hubbell 1223, Leviton 53523, Pass & Seymour 20AC3.
3. Four way, 20 amp 277 volt switch: Arrow Hart 1994, Hubbell 1224, Leviton 53524, Pass & Seymour 20AC4.
4. Weatherproof, 20 amp 277 volt switch: Arrow Hart 2991-2881G, Hubbell 1281-1750, Pass & Seymour 22515-4515.

2.02 RECEPTACLES

A. Select receptacles from those listed herein. Designation in parenthesis is NEMA configuration required.

1. 15 amp, 125 volt grounded duplex receptacle (5-15R): Arrow Hart 5262, Hubbell 5262, Leviton 5262, Pass & Seymour 5262.
2. 20 amp, 125 volt grounded duplex receptacle (5-20R): Arrow Hart 5739, Hubbell 5362, Leviton 5362.
3. Ground Fault Interrupter (GFI) 15 amp, 125 volt duplex receptacle: Leviton 6194, Arrow Hart 1591, Hubbell GFTWRST82, Pass & Seymour 1591-F.
4. Ground Fault Interrupter (GFI), 15 amp 125 volt duplex receptacle, through feed type: Arrow Hart 1591-F, Leviton 6399, Pass & Seymour 1591-F, Hubbell GFTWRST83.
5. Transient Voltage Surge Suppression (TVSS) receptacles shall comply with ANSI/IEEE C62.41 and LILI449 (July 1987) for categories A and B. Devices shall provide RFI and EMI noise filtration of not less than a 7:1 reduction. Devices shall suppress transients in each of 3 modes: Line-to-neutral, line-to-ground, and neutral-to-ground. Devices shall be provided with an LED for positive indication of failure of protective circuitry or audible alarm. Products complying with this specification manufactured by Arrow Hart, Hubbell, Leviton, or Pass and Seymour are acceptable.

2.03 DEVICE PLATES

A. Device plates shall be one piece single or multi-gang type selected to match the device or combination of devices. Device plates for flush mounted devices shall be type 302 stainless steel unless indicated otherwise.

1. Device plates for use with devices flush mounted in exposed masonry construction shall be jumbo type. Device plates for surface mounted devices shall be for use with the type of outlet box in which the device is mounted. All devices installed in areas exposed to the weather and where indicated on the drawings shall be provided with a weatherproof device plate.
2. Where engraved device plates are indicated on the drawings or specified in Division 16, engraving shall be done by the device plate manufacturer. All lettering shall be 1/8" high and shall be black unless other contrasting color is specified.

PART 3- EXECUTION

3.01 GENERAL INSTALLATION

A. The mounting height of devices are indicated in the legend on the drawings and is intended to mean the bottom of the device above the finished floor unless otherwise indicated on the drawings. Where finished walls are exposed concrete block, brick

or tile, the height shall be adjusted to allow outlet box for device to be mounted at a joint.

B. Review Engineering Drawings for any device requiring specific location. Install receptacles above countertops with major axis horizontal above the backsplash.

C. Mount all devices within outlet boxes to allow device plates to be in contact with wall on all sides. Align devices with major axis of device parallel to adjacent predominate building feature, i.e., doorframes or countertops.

D. Install wall switches on the strike side of doors.

END OF SECTION

DIVISION 26 – ELECTRICAL

262816 – CIRCUIT AND MOTOR DISCONNECTS

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 covers disconnect switches for electrical equipment, 600V and below, and fuses mounted in the disconnect devices.

B. Furnish and install disconnect switches for any of the following conditions:

1. Where indicated on the drawings.
2. For all motors located out-of-sight of its motor controller.
3. For water heaters.
4. For electrical unit heaters.
5. Where required by the National Electrical Code.

1.03 QUALITY ASSURANCE

A. Referenced Industry Standard: The following specifications and standards are incorporated into and become a part of this Specification by reference.

1. Underwriters' Laboratories, Inc. (UL) Publications:
   a. No. 98: Enclosed Switches
   b. No. 198.2: High-Interrupting Capacity Fuses, Current Limiting Type
   c. No. 198.4: Class R fuses
2. National Fire Protection Association (NFPA) Publications:
   a. No. 70: National Electrical Code (NEC)
3. National Electrical Manufacturers Association (NEMA) Publications:
   a. No. KS 1: Enclosed Switches

B. Acceptable Manufacturers: Products of the following manufacturers, which comply with these specifications, are acceptable:

1. Siemens
2. Eaton
3. Square D

C. Coordination: Coordinate installations with architectural and structural features, equipment installed under other sections of the specifications and electrical

equipment to insure disconnect switch access and insure that clearance minimums are provided.

PART 2 - PRODUCTS

2.01 GENERAL MATERIAL REQUIREMENTS

A. Furnish all materials specified herein.

B. All disconnects and fuses shall be UL listed and bear a UL label.

C. Fuses shall be heavy duty, type HD horsepower rated as required for motor load served.

D. Switches shall be 600 volt rated, except for use in system below 240 volt, when they may be 250 volt rated. Switches shall be heavy duty rated. General duty switches are not acceptable.

E. Furnish a solid neutral for each switch being installed in a circuit which includes a neutral conductor.

F. Furnish an equipment grounding conductor lug bonded to the switch enclosure.

G. Disconnect switches shall be non-fusible safety switch, unless fused type is specified or indicated on the drawings, with the number of poles required to disconnect all ungrounded conductors serving equipment.

H. Enclosure shall be NEMA Type One in all interior dry locations and shall be NEMA Type 4X stainless steel in all damp, wet, or exterior locations, unless other type is indicated on the drawings or specified herein.

2.02 PRODUCT/MATERIAL DESCRIPTION

A. Switching mechanism shall be quick-make, quick-break type.

B. Where non-fused disconnect switches are indicated on the drawings or specified for use as disconnects, they shall be the non-fused type.

C. Switches shall have the following features:

1. Provide line terminal shields in all switches.
2. Each switch shall have provisions for padlocking in the "OFF" position.
3. Each switch shall have door interlocks to prevent door from being opened when switch is in closed position. Provide inconspicuous means to defeat interlock mechanism.
4. Provide permanent nameplate indicating switch rating in voltage, amperes and horsepower.

5. Arch chute for each pole.
6. Provide auxillary contacts (break-first/make-last) for VFD driven motors.

D. Disconnect switches for three phase motors rated two horsepower and above shall be three pole nonfusible type rated as indicated on the drawings. Disconnect switches for three phase motors rated below two horsepower shall be three pole manual motor starter switches without overload protection. Disconnect for single phase motors shall be single or two pole horsepower rated switches without overload protection.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Locate disconnect switches to maintain line of sight and to provide working clearance and full accessibility as required by the National Electrical Code.

B. Unless indicated otherwise on the drawings, locate disconnects adjacent to equipment served.

C. Lace and group conductors installed in disconnect with nylon tie straps. Only one conductor shall be installed under terminals. Form and train conductors in enclosure neatly parallel and at right angles to sides of box. Uninsulated conductor shall not extend beyond 1/8" from terminal lug.

D. Mounting and Support

1. Enclosure shall be secured to structure by a minimum of four (4) fastening devices. A 1.5" minimum diameter round washer shall be used between head of screw or bolt and enclosure.
2. Mounting
   a. Enclosures shall be mounted where indicated on the drawings or specified herein. Support from the structure with fastening device specified.
   b. Attach enclosure directly to masonry, concrete, or wood surfaces.
   c. Mount enclosure on metal channel (strut), which is connected to structure with fastening device specified, for installations on steel structure, sheet metal equipment enclosure, or sheet rock walls.
   d. Where enclosure is not indicated on a wall or structure, construct a metal channel (strut) free standing frame secured to floor, pad, or other appropriate building structure. Refer to the detail on the drawing for frame installation and construction information.
   e. Mount switch with handle between 36" and 60" above floor or grade, unless otherwise indicated on the drawings.

E. Do not splice conductors in enclosure. Where required, install junction box or wireway adjacent to disconnect and splice or tap conductors in box. Refer to number of conductors in a conduit limitation defined in the WIRES AND CABLES section of the specifications and do not exceed.

F. Conductors not terminating in disconnect shall not extend through or enter disconnect enclosure.

G. Install push-in knock-out closure plugs in any unused knock-out openings (NEMA1). Provide Hoffman Hole-Seal in NEMA 4X switches.

H. Identification

1. Disconnect switches shall be identified.
2. Refer to the ELECTRICAL IDENTIFICATION section of the specifications for identification requirements.

3.02 CLEANING AND ADJUSTMENT

A. After completion, clean the interior and exterior of dirt, paint and construction debris.

B. Touch up paint all scratched or marred surfaces with factory furnished touch up paint of the same color as the factory applied paint.

END OF SECTION

DIVISION 26 – ELECTRICAL

262913 – MOTOR CONTROLLERS

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. The work required under this section of the specifications consists of the installation of motor controllers for all integral or fractional horsepower motors not controlled by magnetic starters installed in motor control center or by magnetic starters provided as an integral component of a specific piece of equipment. Provide all material under this section of the specifications.

1.03 QUALITY ASSURANCE

A. ANSI/NEMA Standards Publication ICS 1 - General Standards for Industrial Control and Systems.

B. ANSI/NEMA Standards Publication ICS 2 - Standards for Industrial Control Devices, Controllers and Assemblies.

C. UL 508 Standards for Industrial Control Devices, Controllers and Assemblies - Industrial Control Equipment.

1.04 ACCEPTABLE MANUFACTURERS

A. The products of Siemens, Square D, or Eaton conforming to these specifications are acceptable.

PART 2- PRODUCTS

2.01 MAGNETIC STARTERS

A. Magnetic starters shall be across-the-line circuit breaker combination type non-fusible disconnect combination type when remotely located from circuit breaker in panel or switchboard; otherwise magnetic starters shall be non-combination type. Where circuit breaker type are used, UL interrupting rating of circuit breaker shall not be less than the rating of the overcurrent device immediately upstream.

B. Magnetic starters shall be NEMA size one unless other size is shown on the drawings or unless larger size is required by actual motor controlled. Enclosures shall be NEMA one unless otherwise shown on the drawings or specified in this section of the specifications. Starters shall be for operation at the voltage and phase arrangement indicated.

C. Each magnetic starter shall have solid state overload protectin for each phase leg. Control voltage shall be 120 volts provided from a control power transformer built into starter. Provide fuse for control coil. Provide Hand-Off-Automatic switch, in cover of starter unless otherwise indicated on the drawings. Interlocks shall be provided to provide control sequence indicated on the drawings. Interlock contact shall be provided circuit breaker of combination magnetic starters to disconnect control circuit when circuit breaker is in "off" position.

D. Operating handle of disconnect device in combination starters shall be interlocked with door to prevent opening door when starter is energized; however an inconspicuous means shall be provided to defeat this interlock. Operating handle must have provisions for not less than two padlocks.

E. Overload relay shall be solid state type and shall be selected from actual nameplate rating of motor furnished.

2.02 MANUAL MOTOR STARTERS

A. Manual motor starter shall be manually operated, trip free switching device with motor running protection overload elements in each ungrounded conductor of the motor circuit. Overload protection shall be melting alloy or bi-metallic manual reset type.

B. Manual starters installed in finished spaces shall be provided in flush mounted enclosures. Those exposed to the weather shall be provided with NEMA 4X enclosure. All other enclosures shall be NEMA one type.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Secure wall mounted magnetic starters to mounting surface with wood screws on wood, toggle bolts on hollow masonry, and lead shields on solid masonry.

B. Manual motor starters shall be provided for all fractional horsepower, single phase motors rated 1/6 HP or larger.

C. Overload element shall be selected in accordance with full load nameplate rating of motor actually served. A heater schedule shall be provided on inside cover all motor starters.

3.02 IDENTIFICATION

A. Refer to the ELECTRICAL IDENTIFICATION section of these specifications for identification requirements.

3.03 FIELD QUALITY CONTROL

A. Refer to the ELECTRICAL EQUIPMENT ACCEPTANCE TESTING section of this specifiction.

END OF SECTION

DIVISION 26 - ELECTRICAL

SECTION 262923 – VARIABLE FREQUENCY DRIVE UNITS

PART 1 -- GENERAL

1.01 THE SUMMARY

A. General

1. The CONTRACTOR shall provide variable frequency drive (VFD) units, complete and operable, as indicated in accordance with the Contract Documents.
2. It is the intent of this Section to require complete, reliable, and fully tested variable frequency drive systems suitable for attended or unattended operation.
3. This section applies to VFD's in motor control centers and free standing type.

B. The requirements of Section 26 00 00 – ELECTRICAL WORK, GENERAL, apply to the WORK of this Section.

C. Single Manufacturer

1. Like products shall be the end product of one manufacturer in order to standardize appearance, operation, maintenance, spare parts, and manufacturer's services.
2. This requirement, however, does not relieve the contractor of overall responsibility for the work.

D. Coordination

1. Equipment provided under this Section shall operate the electric motor driver and the driven equipment as indicated under other equipment specification Sections.
2. The CONTRACTOR'S attention is specifically directed to the need for proper coordination of the WORK under this Section and the equipment specifications.

1.02 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of shop drawings, product data and samples, except that Shop Drawing information for the drives shall be coordinated with the information for the driven equipment.

B. Shop Drawings: Include the following information:

1. Equipment Information
   a. Name of drive manufacturer
   b. Type and model
   c. Assembly drawing and nomenclature
   d. Maximum heat dissipation capacity in kw
2. Conduit entrance provisions
3. Circuit breaker type, frames, and settings
4. Information related to relays, timers, pilot devices, control transformer va, and fuse sizes, including catalog cuts

5. Ladder Diagram
   a. Submit the system schematic ladder diagram and interconnection diagrams.
   b. The schematic ladder diagram shall include remote devices.
   c. The ladder diagram shall incorporate the control logic on the corresponding elementary schematic as indicated.
   d. Submittals with drawings not meeting this requirement will not be reviewed further and will be returned to the contractor stamped "REJECTED."
6. Factory test data certifying compliance of similar equipment from the same manufacturer with requirements of this Section.
7. Where shown on drawings, provide bypass RVSS starters.

C. The Technical Manual shall include the following documentation:

1. Manufacturer's 2-year warranty
2. Field test report
3. Programming procedure and program settings

D. Spare Parts List

1. Submit information for parts required by this Section plus any other spare parts recommended by the controller manufacturer.

PART 2 -- PRODUCTS

2.01 GENERAL

A. The contractor shall provide variable frequency drives where shown on the drawings. Coordinate rating of VFD with equipment provided.

2.02 EQUIPMENT

A. General

1. The power supply shall be an adjustable frequency inverter designed to convert incoming 3-phase, 480-volt, 60-Hertz power to a DC voltage and then to adjustable frequency AC by use of a 3-phase inverter.
2. Current-source inverters will not be accepted.
3. Inverters shall be sized to match the KVA and inrush characteristics of the motors actually provided.
4. The contractor shall be responsible for matching the controller to the load (variable torque or constant torque) as well as the speed and current of the actual motor being controlled.
5. The contractor shall provide "clean power" 18-pulse VFD's or 6 pulse VFD's integrated with AP Broadband Filters for VFDs that are operating motors greater than or equal to 50 HP. Alternatively, Active Front End VFD designs with 3-level type active rectification will be acceptable, given the harmonic THDi contributed at the drive input terminals is no more than 5%.

B. Inverter

1. The inverter shall be of a voltage-source design, producing a pulse-width-modulated type output.
2. All VFDs shall be 18 pulse drive to conform to IEEE 519.
3. Motor Coordination
   a. Inverters shall be capable of operating with 460-volt, 3-phase, 60-Hertz, squirrel-cage, high-efficiency, inverter duty, induction motors.
   b. Inverters shall be capable of operating motors over the range of 50-100 percent of base speed without derating or requiring any motor modifications.
   c. Provide proper size VFD's for high torque applications.
4. Inverters shall be capable of delivering the nameplate horsepower exclusive of service factor without the need for mandatory thermostats or feedback tachometers.
5. The VFD shall vary both the AC voltage and frequency simultaneously in order to operate the motor at required speeds.

C. The minimum VFD inverter efficiency shall be 95 percent at 100 percent speed and load, and 85 percent efficiency at 50 percent speed and load.

D. Power Outage

1. The VFD shall shut down in an orderly manner when a power outage occurs on one or more phases.
2. Upon restoration of power and a START signal, the motor shall restart and run at the speed corresponding to the current process input signal.

E. The VFD shall be provided with the following features:

1. Inrush current adjustment between 50 and 110 percent of motor full load current (factory set at 100 percent)
2. Overload capability at 110 percent for 60 seconds for variable torque loads and 150 percent for constant torque loads.
3. Adjustable acceleration and deceleration
4. Input signal of 4 - 20 ma from process
5. Output speed signal of 4 - 20 ma; signals other than 4 - 20 mA will not be accepted.
6. Upon loss of input signal, the VFD shall operate at a preset speed.
7. A minimum of 2 selectable frequency jump points in order to avoid critical resonance frequency of the driven system.
8. Additional devices and functions as indicated
9. Ethernet communications to transmit VFD data to/from a plant PLC-based control system.
10. For VFD's serving submersible motors, provide leak and high temp interface devices. Where motors are provided with internal temp monitoring, provide thermal modules as required.

F. The VFD shall be provided with, as a minimum, the following protection features:

1. Input line protection with metal oxide varistor (MOV) and RC network
2. Protection against single phasing
3. Instantaneous overcurrent protection
4. Electronic overcurrent protection

5. Ground fault protection
6. Overtemperature protection for electronics
7. Protection against internal faults
8. Ability to start into rotating motor (forward or reverse rotation)
9. Additional protection and control as indicated and as required by the motor and driven equipment

G. The VFD shall be designed and constructed to satisfactorily operate within the following service conditions.

1. Elevation
   a. Elevation to 3300 feet
   b. For elevation greater than 3300 feet, the VFD shall be derated in accordance with the manufacturer's recommendation
2. Ambient Temperature: 0 to 40 degrees C
3. Humidity: 0 to 95 percent, non-condensing
4. AC Line-Voltage Variation: plus 10 percent to minus 10 percent
5. AC Line-Frequency Variation: plus and minus 2 Hertz

H. Electrical equipment provided in addition to the adjustable frequency inverter for each drive shall include:

1. 2-1/2-percent (minimum) line reactors integral to the drive enclosure.
2. Provide a dV/dT filter device at the motor or VFD output per the manufacturer's recommendation for all motors over 100ft from VFD and as shown on the drawings. Submit documentation demonstrating where such devices are required, along with mounting and cabling requirements.
3. Fused 480-to-120-volt control transformer to provide system control power for the logic and pilot lamps.
4. Provide an input circuit breaker.

I. Inverter Signal Circuits

1. The inverter signal circuits shall be isolated from the power circuits and shall be designed to accept an isolated 4-20 mA signal in the automatic mode of operation.
2. The inverter shall follow the setting of a remote or local potentiometer control while in the manual mode.
3. Refer to the Elementary Schematic indicated on the Drawings for speed control and START/STOP methods.
4. Access to set-up and protective adjustments shall be protected by key-lockout.
5. The following operator monitoring and control devices for the inverter shall be provided on the face of the VFD enclosure, either as discrete devices or as part of a multi-function microprocessor-based keypad access device:
   a. AUTO/HAND selection from a remote logic relay or switch
   b. While in AUTO, the inverter shall operate from the remote 4-20 mA input, where applicable, and while in HAND control shall operate from a local or remote manually operated speed potentiometer; speed pot ratings shall be coordinated with the supplier of the Local Control Station.
   c. Speed indicator calibrated in percent speed

d. Inverter fault trip pilot light and output alarm contacts
e. Trip reset pushbutton
f. RUN and OFF indicating lights
g. Provide amber pilot lights for internal safeties with manual reset pushbuttons.
h. Provide other controls and readouts normally furnished as standard equipment, or as otherwise indicated on the Elementary Schematics indicated on the Drawings.

J. Properly identified screw type terminal boards shall be provided for interconnection to remote controls and instrumentation

K. Pilot devices, control relays, time delay relays, elapsed time meters, and indicators provided as a part of the VFD equipment package. For each VFD, provide HOA switch with additional contacts. Provide all auxiliary contacts required per plant controls requirements.

L. All VFDs shall be provided with a Modbus TCP/IP ethernet connection for interface to Emerson SCADA. Connection shall be natively without a getaway.

2.03 SPARE PARTS

A. The CONTRACTOR shall furnish the spare parts listed below, suitably packaged and labeled with the corresponding equipment number.

B. Modified Parts

1. At any time prior to Substantial Completion, the CONTRACTOR shall notify the ENGINEER in writing about any manufacturer's modification of spare part numbers, interchangeabilities, or model changes.
2. If the ENGINEER determines that the modified parts no longer apply to the equipment provided, the CONTRACTOR shall furnish other applicable parts as part of the WORK.

C. The following spare parts shall be furnished:

1. Provide one set of spare power fuses of each form, voltage, and current rating.
2. Provide 10 spare control and power fuses of each type and rating.
3. Provide 10 panel lamps of each type (form, voltage, and current rating).
4. Provide one set of any special tools required for maintenance of the VFD units

2.04 MANUFACTURERS

A. Schneider Electric/Square D

B. Eaton

C. ABB

D. For other manufacturers to be considered, provide verification that VFD can interface with Emerson SCADA system per paragraph 2.02.L.

PART 3 -- EXECUTION

3.01 MANUFACTURER'S SERVICES

A. General

1. An authorized service representative of the manufacturer shall be present at the Site to furnish the services listed below.

B. The authorized service representative shall supervise the following and shall certify that the equipment and controls have been properly installed, aligned, and readied for operation:

1. Installation of the equipment
2. Inspection, checking, and adjusting the equipment
3. Startup and field testing for proper operation
4. Performing field adjustments such that the equipment installation and operation comply with requirements
5. Document all settings of VFD's and RVSS in record drawings

C. Instruction of OWNER's Personnel

1. The authorized representative shall instruct the OWNER's personnel in the operation and maintenance of the equipment, including step-by-step troubleshooting with test equipment.
2. The instruction shall be specific to the VFD models provided.
3. Training shall be scheduled a minimum of 3 weeks in advance of the first session.
4. Training shall include individual sessions for 4 shifts of plant personnel.
5. Proposed training materials shall be submitted for review, and comments shall be incorporated.
6. Training materials shall remain with the trainees.
7. The OWNER may videotape the training for later use with the OWNER's personnel.

3.02 INSTALLATION

A. Conduit stub-ups for interconnected cables and remote cables shall be located and terminated in accordance with the drive manufacturer's recommendations.

B. Programming

1. The CONTRACTOR shall perform programming of drive parameters required for proper operation of the VFDs included in this project.
2. Submit records of programming data in the equipment Technical Manual, including setup and protective settings.

3.03 FIELD TESTING

A. Testing, checkout, and startup of the VFD equipment in the field shall be performed under the technical direction of the manufacturer's service engineer.

B. Under no circumstances shall any portion of the drive system be energized without authorization from the manufacturer's representative.

C. Verify proper operation of control logic in every mode of control.

D. Document all settings of all values in record documents.

END OF SECTION

DIVISION 26 – ELECTRICAL

263213 – ENGINE DRIVEN EMERGENCY POWER SUPPLY SYSTEM

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. The work required under this section of the specifications consists of the installation of the complete Engine Driven Emergency Power Supply System. All materials and devices which are an integral part of this system shall be provided under this section of the specifications.

B. Definition: The Emergency Power Supply System (EPSS) shall consist of one or more engine driven generator sets, each of which contains an engine directly coupled to an electric generator, together with the necessary switchgear, controls, accessories, transfer devices, and fuel supply to provide electric power for the duration of any failure of the normal power supply.

1. Automatic Transfer Switch (ATS): An automatic transfer switch is self-acting equipment for transferring one or more load conductor connections from one power source to another.

C. For this project the contractor shall provide two 2000kW/2500kVA diesel engine-generator sets with permanent magnet excitation using simple paralleling, a Level 2 sound-attenuated 150mph wind rated aluminum housing, 8,000 gallon capacity double wall sub-base tank for each generator, a 4000A 4-pole closed transition isolation/bypass automatic transfer switch.

Each generator shall extend power to free-standing outdoor switchgear. This switchgear to be provided by the generator manufacturer.

Each generator to include provisions to allow communications with the plant Emerson SCADA system using an ethernet connection. Communications between emergency power system and SCADA system shall use modbus TCP/IP ethernet protocol natively without gateway. Coordinate with Emerson system and provide interface as required.

D. The existing Cummins 500 KW diesel generator located at the influent pump station shall be modified to add a new Gateway to provide a Modbus connection to the plant SCADA system. Use Alan Bradley Compac Logic.

1.03 QUALITY ASSURANCE

A. The following specifications and standards are incorporated into and become a part of this specification by reference.

1. National Fire Protection Association (NFPA):
   a. NFPA-37 Combustion Engines
   b. NFPA-70 National Electrical Code
   c. NFPA-110 Emergency and Stand-By Power Systems
2. Diesel Engine Manufacturers Association (DEMA) Standard: Standard Practices for low and medium speed stationary diesel and gas engines.
3. Electrical Generating Systems Association (EGSA) Standards:
   a. EGSA CEP2 Codes for Emergency Power by States and Major Cities
   b. EGSA GTD3 Glossary of Standard Industry Terminology and Definitions
   c. EGSA ECB1 Performance Standard for Engine Cranking Batteries
   d. EGSA TSS1 Performance Standard for Transfer Switches for use with Engine Generator Sets
   e. EGSA BCES1 Performance Standard for Battery Chargers
   f. EGSA ICAE1 Performance Standard for Electric Generator Set Instrument Control and Auxiliary Equipment
4. Institute of Electrical and Electronics Engineers (IEEE) Standards:
   a. IEEE 446 IEEE Recommended Practices for Emergency and Standby Power Systems
   b. IEEE 472 Voltage Surge Withstand Capabilities
5. National Electric Manufacturers Association (NEMA) Standards:
   a. MG-1 Motors and Generators
   b. ICS1-109 Test and Test Procedures for Automatic Transfer Switches
   c. ICS2-447 A.C. Automatic Transfer Switch
6. Underwriters Laboratories Inc. (UL) Publications:
   a. UL 1008 Automatic and Non-Automatic Transfer Switches
7. American National Standards Institute (ANSI):
   a. C37.90a Voltage Surge Withstand Capability

B. Acceptable Manufacturers: Products of the following manufacturers, which comply with these specifications, are acceptable:

1. Engine Driven Generator Sets:
   a. Cummins – No substitutions. Contact John Carper, Cummins South, (912) 210-3383 for information. See paragraph 1.02C for communications requirements with SCADA.
2. Transfer Switches and Generator Switchgear:
   a. Cummins – No Substitutions.
3. Sub-Base Fuel Tanks:
   a. Pryco
   b. Simplex

C. Equipment Dimensions:

1. Dimensions indicated on the drawings are maximum allowable and shall not be exceeded. Where equipment of acceptable manufacturers listed exceeds the maximum dimensions, products of such manufacturers shall not be acceptable.

D. Coordination:

1. Review shop drawings submitted under this and other sections, as well as other divisions, to insure coordination between work required among different trades. Coordinate the installation sequence with other contractors to avoid conflicts and to provide the fastest overall installation schedule. Coordinate installation with architectural and structural features, equipment installed under other sections of the specifications, and electrical equipment to insure access and to insure clearance minimums are provided.

1.04 SUBMITTALS

A. Refer to the SHOP DRAWINGS, PRODUCT DATA AND SAMPLES Section for required procedures.

B. Manufacturer's Product Data:

1. Submit material specifications and installations data for products specified under Part 2 - Products to include:
   a. Engine driven generator sets
   b. Transfer switches
   c. Sub-base fuel tanks
   d. Swtichgear
   e. Gateways

C. Shop Drawings: Submit shop drawings to indicate information not fully described by the product data to indicate compliance with the contract drawings. Submittals containing less than the information listed below will be rejected.

1. Shop drawings for the engine driven generator sets shall contain not less than the information listed as follows:
   a. Certification that the engine driven generator set(s) furnished will serve electrical loads indicated including motor starting loads with type(s) of starting indicated. Submit generator loading program with actual load information with shop drawings.
   b. Continuous and stand-by rating of engine driven generator set(s) including voltage and phase.
   c. Frequency and voltage regulation with maximum instantaneous voltage dip and time of recovery to stable operation.
   d. Output voltage adjustment range in percentage of rated plant voltage.
   e. Alternator type and method of connection to prime mover.
   f. Components contained in alternator instrument panel.
   g. Rating of engine at operating speed, engine cycle and number of cylinders.
   h. Type of engine lubrication system and verification of components specified.

i. Type of engine governor.
j. Components contained in engine instrument panel.
k. Fuel consumption at rated load.
l. Starting batteries including ampere hour rating.
m. Verification that all accessories specified are to be provided. This includes tank with capacity indicated, cold weather starting aid with rating and voltage indicated, exhaust system with muffler type indicated, and outdoor housing with verification of space available within housing for batteries.
n. Line and machinery constants of the generator furnished.

2. Shop drawings for the transfer switch shall contain not less than the information listed as follows:
   a. List of accessories contained in the control panel.
   b. Withstand rating in RMS symmetrical amperes.

D. Quality and Service:

1. All materials and parts of the EPSS shall be new and unused. Each component shall be of current manufacture from a firm regularly engaged in the production of such equipment. Units and components offered under these specifications shall be covered by the manufacturer's parts and labor warranty for a minimum of five years from date of Owner acceptance of the project on a new machine, a copy of which shall be included in the shop drawings submittal.
2. Submittals will be accepted only on engine driven generator sets and transfer switches which can be properly maintained and serviced without requiring the Owner to stock spare parts or wait longer than twenty-four hours for service. Submittals shall include the nearest location of permanent parts outlet from which parts may be obtained and written assurance that trained service personnel will be available on twenty-four hour's notice. Units with service centers more than 50 miles from project site will not be accepted.

E. Record Drawings

1. Include in each set three sets of operating, maintenance, and parts manuals covering all components for the EPSS. Each supplier shall provide instructions to the Owner in operation and maintenance of his equipment, both in written form and with on-site personnel for a minimum of eight hours.

PART 2 - PRODUCTS

2.01 ENGINE DRIVEN EMERGENCY POWER SUPPLY (EPS)

A. Engine

1. The engine driven emergency power supply (EPS) shall be two internal combustion diesel driven prime movers using simple parallelling. The generator sets shall have the following characteristics:
   a. 2-2000 KW Capacity
   b. 2-2500 KVA Capacity

c. 480Y/277V
d. 60Hz
e. 0.8 Power Factor
f. 3 Phase
g. 4-Wire

2. Refer to drawings for loads which are to be powered from the emergency power system. One generator shall be sized to starter and run all loads listed under Phase I. The emergency power system shall be sized to start and run all loads in Phase 2 if the generators are connected in parallel.

   Coordinate with SCADA and Kubota to provide load starting to match steps shown.

3. The rated net horsepower of the engine at the generator synchronous speed, with all accessories, shall not be less than that required to product the KW specified in paragraph 1 above. The horsepower rating shall take into account generator efficiency and all accessory losses such as fans, battery charger, etc. The generator set shall be capable of producing the specified KW (without overload) for the duration of the power outage, under the following ambient conditions:
   a. Altitude: 50 feet above mean sea level.
   b. Air temperature at engine intake: 104 degrees F.
   c. Humidity Range: 5 - 95%.
4. Included with the shop drawing submittal shall be the manufacturer's estimate of supply fuel and oil consumption for the engine. The engine shall have an oil filter with replaceable elements, and a lube oil cooler.
5. The engine shall be equipped with a suitable governor (engine speed control) to maintain frequency within limit specified below by controlling engine and generator speed. Provide controls to allow generator speed to be adjusted for forced closed transition operation.
   a. Type: Isochronos
   b. Stability: 1/2% maximum steady state frequency variation at any constant load from no load to full load.
   c. Regulation: 5% maximum frequency deviation between no-load steady state and full load steady state.
   d. Transient: 2 seconds maximum recovery time for maximum motor start.
6. The engine shall be electric start, provided with a solenoid energized motor with either positive engagement or clutch drive to the engine.
7. The engine starting batteries shall be sealed lead-acid recombination type. Batteries shall be rack mounted inside the weatherproof plant housing to minimize the distance from the batteries to the starter. Provide battery straps and battery heaters.
8. A float type battery charger, compatible with the batteries selected, shall be furnished at the engine which shall maintain the starting batteries at full charge. The charging system shall permit charging from either the normal or the

emergency power source. Provide battery straps and battery heater per NFPA110.

9. It shall have an equalize rate and a float rate charging system. An ammeter and voltmeter shall indicate the charge rate and the circuit shall be protected by either fuses or circuit breakers. The charger or charging circuit shall be so designed that it will not be damaged during the engine cranking cycle, for example, by a current limiting charger or a crank disconnect relay. It shall also be capable of recharging a discharged battery in 12 hours while carrying normal loads. The charger shall be equipped with alarm relays as required for remote annunciation equipment.
10. The engine shall be liquid cooled. The type of liquid cooling system shall be unit mounted radiator - consideration shall be given for air temperature rise across the engine in addition to ambient. Minimum capacity shall be rated for 104°F. minimum engine ambient temperature plus air temperature rise across the engine.
    a. Provide an electric heater, thermostatically controlled, in the engine coolant system as a cold weather starting aid. Heater shall be for operation on 120 or 240 volt single phase A.C. and shall be permanently connected to a circuit from the generator panel. Heater shall maintain 70°F. to 90°F.
    b. Provide isolation valves or quick connect couplings for jacket water heater.
11. Air Supply/Exhaust System
    a. Cleaner: An air cleaner and silencer shall be furnished, located and mounted as recommended by the engine manufacturer.
    b. Exhaust: An exhaust system of suitable size, configuration, and material in accordance with engine manufacturer's recommendations shall connect the exhaust outlet of the engine to a silencer. The type of silencer shall meet the requirements of engine manufacturers and shall be critical. The silencer shall be located inside of the outdoor enclosure.
    c. The exhaust system including silencer shall be of such size that back pressure on the system will not exceed the back pressure permitted by the engine manufacturer's recommendation. A flexible connection shall be mounted at the engine exhaust outlet and the discharge end shall be protected against entry of precipitation. Provide vertical discharge with rain cap. Piping and silencer within reach of personnel or with 8'-0" of finished floor or grade shall be protected by screening and shall be insulated with two inches of calcium silicate insulation with aluminum jacket. All exhaust piping shall be gas tight.
12. The engine instrument panel shall be mounted at the engine and shall contain the following:
    a. Oil pressure gauge to indicate lubricating oil pressure.
    b. Temperature gauge to indicate cooling medium temperature.
    c. Hour meter to indicate total actual running time.
    d. Battery charging meter to indicate satisfactory performance of battery charging means.

e. Other instruments as recommended by the manufacturer for proper maintenance.
f. Manual stop/start controls: All instruments, controls, and indicating lights shall be properly identified. All wires shall be individually identified and must agree with the wiring diagram provided. All wiring shall be harnessed or flexibly enclosed. Terminals on all terminal blocks shall be individually identified.

B. Generator

1. The generator shall be an engine-driven single or two bearings type, synchronous, brushless, conforming to applicable standards. It shall be connected to the engine flywheel by means of a flexible type coupling for single bearing generators and elastic coupling for two bearing generators.
2. The generator shall be rated for 40°C. ambient. Class of insulation shall be NEMA Class F. The voltage regulation shall be plus or minus 2% from no load to full load with plus or minus 5% speed change and a 15°C. rise in ambient. The generator voltage dip from no load to full load shall not exceed 16%.
3. The generator shall be capable of sustaining at least 250% of rated current for at least ten (10) seconds under a three phase symmetrical short by inherent design or by the addition of an optional current boost system. A line sensing protection system shall be furnished which protects the generator from damage due to its own high current capability. This shall not trip within the ten seconds specified above to allow selective tripping of downstream fuses or circuit breakers under a fault condition.
4. Provide 120 volt condensation heater in generator windings.
5. The generator shall be the Permanent Magnet type generator.

C. Voltage Regulation

1. The generator shall be equipped with a volts-per-hertz type voltage regulator to maintain voltage within limits specified below:
   a. Stability: 2% maximum voltage variation at any constant load from no load to full load.
   b. Regulation: 4% maximum voltage deviation between no load steady state and full load steady state.
   c. Transient: 20% voltage dip or overshoot on one-step application or removal of 0.8 power factor full load.

D. Start and Stop Controls

1. Automatic starting and stopping controls shall be furnished to start the engine automatically when the normal electrical power fails or falls below specific limits and to stop the engine automatically after the normal power supply resumes. The signal for starting or stopping the engine shall be sensed through an auxiliary contact in the automatic transfer switch. The controls shall be capable of operating at 50% of normal DC system supplied voltage.

2. The cranking cycle shall be initiated by manual start, loss of normal power at any transfer switch, clock exerciser, or the manually operated test switch at each ATS.
3. Crank control and the time delay relays shall provide a minimum of 4 crank attempts of at least 7 seconds each, separated by appropriate rest periods. A sensing device shall automatically disconnect the starting circuit when the engine has started. If the engine has not started at the completion of the starting program, the overcrank signal shall indicate. The engine starting controls shall be locked out and no further starting attempts shall take place until the overcranking device has been manually reset.
4. A selector switch shall be incorporated in the automatic engine start and stop controls. It shall include an "off" position that prevents manual or automatic starting of the engine; a "manual" position that permits the engine to be started manually by the pushbutton on the control cabinet and run unloaded; an "automatic" position that readies the system for automatic start or stop on demand or the automatic load transfer switches or of the programmed exerciser.
5. A remote weatherproof manual stop station for each generator similar to a break-glass station shall be provided on switchgear enclosure exterior and shall be tied into the engine controls to stop the engine when activated. Provide laminated plastic label with 1/4" minimum engraved letters to read "EMERGENCY GENERATOR SHUTDOWN". Background to be red and core to be white.

E. Instrumentation

1. Local and remote engine control and safety panel shall be provided for each generator, containing the following:
   a. Automatic remote start capability.
   b. "Manual-Off-Auto" switch.
   c. Controls to shut down and lock out the prime mover under the following conditions: failure to start after specified cranking time, overspeed, low lubricating oil pressure, high engine temperature, or operation of remote manual stop station.
   d. Battery powered individual alarm indication to annunciate visually at the control and safety panel the occurrence of any condition itemized below; contacts or circuits for a common audible alarm signaling locally the occurrence of any itemized conditions listed below. Test switch shall be provided to test the operation of all lamps.
      1) Indicator Function, Level 1 (At Battery Voltage):

		Local and Remote Control Panels Mounted Visual Indication	Shutdown of EPS	Audible
a)	Overcrank	X	X	X
b)	Low Water Temp. < 70°F (21°C)	X		X
c)	High Engine Temp. Pre-alarm	X		X
d)	High Engine Temp.	X	X	X
e)	Low Lube Oil Pressure Pre-alarm	X		X
f)	Low Lube Oil Pressure	X	X	X
g)	Overspeed	X	X	X
h)	Low Fuel Main Tank	X		X
i)	EPS Supplying Load	X		
j)	Control Switch Not In Auto Pos.	X		X
k)	Battery Charger Malfunctioning	X		X
l)	Low Voltage in Battery	X		X
m)	Lamp Test	X		X
n)	Contacts for Local & Remote			
o)	Common Alarm	X		X
p)	Audible Alarm Silencing Switch			
q)	Fuel in Containment Basin	X		X
r)	Remote Emergency Stop	X	X	X

2) Controls to shutdown the prime mover upon removal of initiating signal or manual emergency shutdown.
3) A.C. voltmeter with selector switch off position and positions for phase to phase and phase to neutral.
4) A.C. ammeter with selector switch with positions for each phase.
5) Frequency meter -- digital electronic type.
6) Voltage adjusting rheostat to allow plus or minus 5% voltage adjustment.

7) Manual reset circuit breaker.
8) Water temperature gauge.
9) Manual stop/start control.
10) Elapsed time meter.
11) Panel lights.
12) Indicator lights for signals from engine instrument panel.
13) Light to indicate switch has been left in the "off" position.

2. All instruments, controls, and indicating lights shall be properly identified. All wires shall be individually identified and must agree with the wiring diagram provided. All wiring shall be harnessed or flexibly enclosed. Terminals on all terminal blocks shall be individually identified. All instrumentation must be isolated from engine generator set vibration.
3. Provide gateway as specified for each generator to communicate with SCADA system. Coordinate all parameters required by owner.

F. Enclosures and Connections:

1. All electrical enclosures, i.e, terminal cabinets, wireways, circuit breaker enclosures, etc., shall be of adequate size to provide minimum bending radius as required by the NEC for the size conductor actually terminated within or passing through the enclosure.
2. All factory provided enclosures shall have gasketing and finish appropriate for the environment in which the unit is to be mounted. All wiring, wiring harness, etc., shall be protected from the elements, such as direct sunlight, moisture, etc. or shall be UL listed for direct exposure to the applicable elements. Include written documentation of the above with the shop drawing submittal.

G. Provide flexible fuel connections at supply at return piping. Flexible hoses shall be steel reinforced type. Provide solenoid valve in series with gate valve in supply line. Solenoid valve shall be powered from generator batteries and shall be open only when generator is running.

H. Provide service lights, switch and receptacle within the generator enclosure. Connect to generator panel. Provide battery pack with two heads inside each enclosure.

I. For each generator, provide a mini-power panel consisting of a pre-assembled 60A/2P main breaker, single phase, 480 volts, 15 kVA single phase 480-230/115V dry type transformer with secondary panel consisting of an 80A/2P main breaker and at least 12-20A/1P breakers and 2 pole breakers as required.

2.02 GENERATOR SWITCHGEAR

A. Switchgear Ratings:

1. The paralleling/distribution power switchgear shall be configured as shown on the contract drawings and rated for operation at voltage and current levels as

shown on the contract drawings. It shall contain devices and equipment as shown on the drawings, in addition to meeting the requirements of this section.

2. The generator switchgear shall allow the emergency power system for operate in parallel using "single paralleling" controls. Loads shall be evenly distributed when both generators are on line provide interface controls to SCADA system as shown on the drawings.

B. Construction:

1. Each section of the paralleling system shall be listed and labeled under the requirements of UL 891, including all covers, barriers, and supports. Breakers shall be isolated from individual control sections by metal or insulating barriers.
2. The system bus shall be silver plated copper with bolted joints for all three phases, with a full neutral, and a 1/4 x 2-inch ground bus extending through all sections. Bus shall be rated as required for proper operation with source and load currents, shall be braced for peak symmetrical amperage available from all generator sets plus motor contributions and shall be rated at 100,000 amps RMS, minimum.
3. The framework and all other sheet metal components of the system shall be primed with a rust-inhibiting primer and finished with two coats of satin finish ANSI 61 gray enamel. Switchgear shall be for exterior locations.
4. The switchgear shall be UL891 listed and labeled.
5. Switchgear wiring shall be composed of UL listed, 105-degree centigrade rated material, with all wiring labeled at each end.
6. Paralleling circuit breakers shall be rated for operation at the system voltage, with continuous current rating of as shown on the drawings. Breakers shall be electrically operated for both opening and closing and shall close within 5 electrical cycles from command by the paralleling controls.
7. Current transformers as required for proper system operation and metering as described herein shall be provided. Current ratios and relay and metering accuracy as required for function of the system. Transformers provided shall have a mechanical rating equal to the momentary rating of the circuit breakers, and insulated for the full voltage rating
8. Note space available and access requirements for the paralleling equipment and provide equipment that will fit into the space allowed. Note that switchgear equipment is front access only.
9. All door mounted control components shall be industrial type oil-tight devices with contact ratings a minimum of twice the maximum circuit ampacity they are controlling. Toggle switches and other light duty control devices are not acceptable. Indicator lamps shall be high intensity LED type devices. Indicator lamp condition (on or off) shall be easily visible in bright room lighting conditions.
10. AC control circuits in the switchboard shall be protected with properly sized fuses in safety fuse blocks, with visible fuse blown indication for each fuse. Potential transformers shall be protected on line and load side.
11. All CT installations shall include shorting type terminal blocks.

C. Distribution Equipment:

1. Provide feeder distribution breakers of the number and size as shown on the project drawings.
2. The breakers shall be manually operated, and of the same manufacturer as the paralleling breakers.
3. Generator breakers to be electrically operated.
4. For each main breaker provide test switch with indicator light to set tripping characteristics to lower arc fault rating to a safe level.

D. Control Equipment Construction

1. Note space available and access requirements for the paralleling equipment and provide equipment that will fit into the space allowed.
2. Each section of the paralleling control system shall be listed and labeled under the requirements of UL 891, including all covers, barriers, and supports. Individual control sections shall be isolated from each other by metal or insulating barriers.
3. All wiring shall be UL listed 105-degree C, 600 volt rated, and sized as required. Each wire, device or function shall be suitably identified by silk-screen or similar permanent identification.
4. The framework and all other sheet metal components of the system shall be primed with a rust-inhibiting primer and finished with two coats of satin finish ANSI 61 gray enamel.
5. All door mounted control components shall be industrial type oil-tight devices with contact ratings a minimum of twice the maximum circuit ampacity they are controlling. Toggle switches and other light duty control devices are not acceptable. Indicator lamps shall be high intensity LED type devices. Indicator lamp condition (on or off) shall be easily visible in bright room lighting conditions.
6. AC control circuits in the switchboard shall be protected with properly sized fuses in safety fuse blocks, with visible fuse blown indication for each fuse. Potential transformers shall be protected on line and load side.
7. All CT installations shall include shorting type terminal blocks.
8. All field control interconnecting wiring shall be sized as specified by system manufacturer (wiring not designated by the system manufacturer shall be minimum 14 AWG copper). All control interconnect wiring shall be stranded.

E. System Control Power

1. Control power for the paralleling system shall be derived from the generator set 24VDC starting batteries. A solid state, no break "best battery" selector system shall be provided so that control voltage is available as long as any battery bank in the system is available, and that all battery banks are isolated to prevent the failure of one battery from disabling the entire system. Generator set governing, voltage regulation, load sharing, synchronizing, protection, and control

equipment shall be capable of proper operation with battery voltage levels down to 8VDC.

2. Paralleling breaker control power shall be derived from the generator set for charging, opening, and closing the breakers. Breaker open circuit shall be provided from a DC source on each generator set.

F. Outdoor Enclosures:

1. The paralleling/distribution switchgear and controls shall be provided in a UL-listed non-walk-in style NEMA 3R outdoor enclosure.

G. Paralleling Controls. Provide a paralleling control panel for each generator set in the emergency/standby power system. The paralleling control functions may be integrated with the generator set control functions (with duplicate functions eliminated) and mounted on the generator set. Each paralleling control panel shall contain the components and devices as described in this section.

1. Operator Panel. Each paralleling control panel shall be provided with a panel to allow the operator to view the status and control operation of the specific generator set being paralleled. The operator panel shall be provided with the following features and capabilities.
   a. 1% accuracy generator set AC output instruments; Ammeter, Voltmeter, Frequency Meter, Wattmeter, KW-hour meter, Power Factor Meter. Selector switches to allow viewing of voltage and current for each phase shall be provided. For 3-phase/4-wire systems the voltmeter shall indicate line to line and line to neutral conditions. Voltmeter, ammeter, frequency meter, kW meter and power factor meter shall have both analog and digital displays. Switches and/or other provisions shall be included to allow reading of bus voltage and frequency from this metering set.
   b. Synchroscope and "generator set synchronized" indication. Indication may be synchronizing lamps, LED indication, or other provisions, but must be located on the paralleling control panel, adjacent to the paralleling breaker control switches.
   c. Running Time Meter, Start Counter. These devices shall display total running time and number of generator set starts, as well as the same functions since last reset.
   d. Generator Set Mode Selector Switch: Switch shall provide run (manual operation), off, and automatic functions for control of the generator set. Run/manual mode causes the generator set to immediately start and accelerate to rated speed and voltage, but paralleling breaker doe not automatically close. Off mode prevents generator set from starting, or immediately shuts down the generator set if it is running. Auto mode allows genset starting from a remote-control system.
   e. Breaker open/close switch with breaker status indicating lamps. The switch shall be interlocked with the control system such that breaker closure is not possible unless the mode select switch is in the run position and the generator set is synchronized with the system bus.

f. Control Reset push-button switch with indicating lamp. Lamp shall flash to indicate that generator set is locked out due to a fault condition.
g. Lamp test push-button switch. Operation of this switch shall cause all lamps on the panel to be simultaneously tested.
h. The control panel shall be provided with a set of DC-powered lamps with a switch to allow viewing of all functions on the front panel when other lighting systems are not available.
i. Emergency Stop switch. The emergency stop switch shall be a red, mushroom head switch which maintains its position until manually reset. The switch shall be provided with a lock-out/tag-out provision.
j. Precision voltage and frequency adjust raise/lower switches. Switches shall allow the generator set frequency and voltage to be adjusted plus or minus 5% when the generator set is operating independently of the system bus. Voltage and frequency adjustment switches shall be located adjacent to the generator set and bus metering, breaker control switches, synchroscope and manual paralleling panel, for ease of use by the operator. Voltage and frequency adjustments through these switches shall not impact on the load sharing control system.
k. Alarm and status indicating panel to indicate the following conditions, along with all engine alarm functions from the engine ECM:

Function	Lamp Color	Shutdown Unit
Low DC Voltage	Amber	
High DC Voltage	Amber	
Weak Battery	Amber	
Fail to Sync	Amber	
Low Oil Pressure Alarm	Amber	
Low Fuel - daytank	Amber	
High Engine Temp Alarm	Amber	
Overcurrent Alarm	Amber	
Breaker Failure	Red	*
Breaker Tripped	Red	*
Not in Auto	Red	*
High Engine Temp	Red	*
Low Oil Pressure	Red	*
Overcurrent	Red	*
Short Circuit	Red	*
Loss of Excitation	Red	*

Reverse Power	Red	*
Overcrank	Red	*
Overspeed	Red	*
Under Frequency	Red	
Under Voltage	Red	*
Over Voltage	Red	*
Phase Rotation	Red	*
Low Coolant Level	Red	*
Automatic	Green	
Generator Running	Green	
Breaker Open	Green	
Breaker Closed	Red	
Demand Mode Standby	Green	
Timing for Start	Green	
Timing for Shutdown	Green	

2. Provide auxiliary contacts as shown on the drawings for input to SCADA.
3. Internal Controls. The following internal control components or functions shall be provided for each generator set in the system.
   a. Generator set start contacts rated 10 amps at 32 VDC. A redundant network-based starting system shall also be provided.
   b. Equipment shall be provided to monitor the generator set as it is starting and verify that it has reached at least 90% of nominal voltage and frequency before closing to the bus. The equipment provided shall positively prevent out-of-phase paralleling if two or more engine-generator sets reach operating conditions simultaneously by providing a lockout signal to disable breaker closure for generator set(s) in the system which have not been selected to be the first units to close to the bus. Controls to recognize the failure of the first breaker signaled to close and allow system operation to proceed in spite of this failure shall also be provided (breaker failure alarm). Systems using dead bus relay schemes without a disable signal to positively prevent out-of-phase paralleling shall not be acceptable under this specification. System shall include an independent backup to automatically operate in the event that the primary system fails.
   c. Controls shall be provided to verify generator set and bus phase rotation match prior to closing the paralleling breaker.
   d. Provide a first start sensing system to prevent simultaneous closure of two generator sets to the system bus on a black start condition.

e. Synchronizer to electronically adjust the engine fuel rate and alternator excitation to match the voltage, frequency and phase angle of the bus. Synchronizer shall maintain the engine-generator voltage within 1% of bus voltage and phase angle within 20 electrical degrees of the bus for 0.5 seconds before circuit breaker closing. The synchronizer shall be operational in a range of -40% to plus 10% of nominal frequency and voltage. Each generator set shall have its own synchronizer; systems using a switching scheme to utilize a single system synchronizer will not be approved. Synchronizers and systems which utilize a motor driven pot for control of AC voltage during the synchronizing process will not be accepted. The system shall be provided with a fail to synchronize time delay that is adjustable from 10-120 seconds. Control logic for fail to synchronize function shall allow field configuration of function for either alarm or shutdown of the generator set on failure condition.

f. Controls shall include a permissive (sync check) function, to be used with "generator synchronized" indicator during manual paralleling, to prevent accidental closure of the breaker with the generator set out of phase with the bus. Provisions to allow manual closure of the first generator set to a de-energized bus shall be included.

g. Electronic isochronous kW load sharing control to control the engine fuel rate to provide isochronous load sharing when the generator set is paralleled. The control system shall allow sharing of real kW load between all generator sets in the system to within 1% of equal levels, without introduction of frequency droop into the system. The isochronous load sharing system and engine governor shall be a coordinated system of a single manufacturer.

h. Electronic kVAR load sharing control to operate the alternator excitation system while the generator set is paralleled. The control system shall allow sharing of reactive load between all generator sets in the system to within 1% of equal levels, without introduction of voltage droop into the system. The control system shall include all equipment required for VAR load sharing with an infinite bus in either a constant VAR or constant power factor mode for future application flexibility. (Mode and adjustments selectable by the operator)

i. Controls shall include three phase sensing reverse power equipment, to prevent sustained reverse power flow into the generator set. When the reverse power condition exceeds 5% of the generator set kW for more than 3 seconds, the paralleling circuit breaker shall be tripped open and the generator shut down.

j. Electronic alternator overcurrent alarm and shutdown protection. This protection is required in addition to the overcurrent trip on the paralleling breaker and shall sense current flow at the generator set output terminals. The overcurrent alarm shall be indicated when the load current on the generator set is more than 110% of rated current for more than 60 seconds.

The overcurrent shutdown shall be matched to the thermal damage curve of the generator set and shall not have an instantaneous function.

k. Electronic alternator short circuit protection. This protection is in addition to the overcurrent trip on the paralleling breaker. The short circuit shall occur when the load current on the generator set is more than 175% of rated current and an aggregate time/current calculation indicates that the system is approaching the thermal damage point of the alternator. The equipment used shall not have an instantaneous function.

l. Provide overcurrent and short circuit protection for the feeder connecting the generator set to the paralleling switchgear. This protection may be integrated with alternator protection but must be positively coordinated to prevent tripping of the paralleling breaker prior to the operation of the alternator protective equipment.

m. Controls shall be provided to sense a reverse kVAR condition to the alternator while paralleled to the system bus. The protection shall be adjusted to operate at a value that is 10% below the maximum reverse kVAR that can be supported by the alternator provided. A reactive capability curve shall be submitted to verify the setting that is required.

n. Controls shall be provided to shut down generator set and initiate alarm when the generator set is at less than 85% of nominal voltage for more than 15 seconds, more than 110% of nominal voltage for more than 10 seconds, or more than 130% of nominal.

o. Cooldown time delay, adjustable: 0-600 seconds. The control panel shall indicate the time remaining before shutdown.

p. Provide all other components required, such as properly sized current transformers, transducers, terminal blocks, etc., for reliable system operation, as described herein under "SYSTEM OPERATION".

H. System Control. Provide system controls to manage the operation of the system to prevent overloading of the system bus on a black start condition or due to overload of the bus or shutdown of a generator set. The control system shall contain the components and functions described in this section.

1. Internal Control Components. The following internal controls shall be provided for system operation:

a. Load pick-up output contacts, rated 10 A at 600 VAC (3 contacts per level). The load pickup contacts shall operate based on the number of generator sets available and connected to the bus.

b. The load pickup contacts shall be interconnected with designated transfer switches to prevent connection of the designated transfer switches to the generator bus until sufficient capacity is available to serve the load.

c. Load shed output contacts, rated 10 A at 600 VAC.

d. The load shed contacts shall be operated based on system overload or bus under frequency. On indication of system overload or under frequency, designated transfer switches shall switch to a neutral position. The switches shall automatically reconnect to the generator bus if the under-frequency

condition is cleared, and to the utility source if it recovers before the under-frequency condition is cleared.

2. Provide all other components required, such as properly sized current transformers, transducers, terminal blocks, etc., for reliable system operation.

I. Loss Of Normal Power:

1. System is given signal to start by receipt of start signal from automatic transfer switches or other remote device. On receipt of this signal, all generator sets automatically and independently start, accelerate to rated frequency and build up to rated voltage. The first start system monitors this process, and on finding a generator set at 90% of rated voltage and frequency, automatically disables all other units from closing to the bus, and closes the ready unit to the bus. At this time the first priority loads close to the bus.
2. The priority (load add) controls prevent overloading of the system bus by providing control signals to delay operation of designated system loads until sufficient generating capacity is available on the bus.
3. After the first unit is closed to the bus, the control of the remaining units is switched to the synchronizer in each generator paralleling control, which causes the generator set to synchronize with the system bus, and then close to it at the proper time.
4. As each unit closes to the bus, the unit assumes it's proportional share of the total load on the bus, and the control system will automatically add loads to the generator bus by operating specified priority control devices.

J. Failure Of A Unit To Start Or Synchronize:

1. If a unit fails to start, after the fail to start time delay (in the generator set control) has expired, the unit will be shut down, and an alarm will sound. The priority control will prevent the lowest priority loads from being added to the system without manual intervention.
2. If a unit fails to synchronize, after a preset time delay, an alarm will sound, but the unit will continue to attempt to synchronize until signaled to stop by manual operation of the control switches on the generator set.

K. Bus Overload:

1. If a bus overload occurs for any reason, a load shed signal will be generated to initiate load shedding in the system.
2. Loads that are shed due to overload shall require manual reset via the operator interface panel.

L. Return of Normal Power

1. When all of the system start signals are removed from the generator sets, the system will begin a retransfer process.
2. The system shall sequentially transfer back to the utility by operating each transfer device sequentially.

3. When all loads have been transferred back to the utility, the generator set paralleling breakers shall all open, and the generator sets shall operate at no load for a cooldown period. When the cooldown period has been completed, the generator sets shall shut down.
4. If a system start signal is received during the cooldown period, one generator set shall immediately close to the system bus and all other units shall synchronize to it, as described in "Loss of Normal Power" above.

M. System Testing

1. Test with Load Mode:
   a. The system shall allow the generator sets to be tested by transfer of the system loads to the generator sets.
   b. Sequence of operation in this mode shall be similar to that described for a power failure condition.
2. Generator Set Exercise (Test) Without Load Mode
   a. The system shall allow testing of the generator sets at no load. In this operation mode the generator sets will start, build up to rated speed and voltage, synchronize and close to the generator bus, but system loads shall not automatically transfer to the generator system. If a power failure occurs during a test period, loads shall immediately close into the system on a priority basis.

N. Factory Testing. The system manufacturer shall perform an operational test on each major component of the paralleling system (including generator sets, paralleling controls, and power switchgear) prior to shipping from the factory. A certified test report shall be provided, included in the operator's manuals, and permanently retained by the system manufacturer.

2.03 TRANSFER SWITCH(ES)

A. Transfer switch(es) shall be rated at not less than as indicated on the drawings at rated voltage. Transfer switch(es) shall be rated and marked for total system load.

B. Transfer switch(es) serving three phase four wire loads shall be four pole. Provide closed transition, bypass isolation type. Provide timed intermediate position type if closed transition is not active.

C. Transfer switch(es) shall be the automatic type with power contact assemblies. Transfer switches shall be U.L. listed and labeled 1008.

D. Transfer switch(es) shall be floor mounted in a NEMA 1 painted steel enclosure. Enclosure shall have hinged door with three point latching and provisions for pad locking.

E. Operation shall be inherently double-throw whereby all contacts move simultaneously. Electrical spacing shall be equal to or exceed those listed in Table

15.1 of UL-1008. Only those main contact structures specifically designed for transfer switch service shall be acceptable. An overload or short circuit shall not cause the switch to go to a neutral position. A manual operating handle shall be provided. All main contacts shall be silver alloy type protected by arc quenchers and, for switches rated 600 amps and larger, by arching contacts. Operating transfer time shall be 1/15 second or less on switches rated below 600 amps. The transfer sequence shall be "Closed Transition". Provide controls to adjust the generator's frequency to force parallel to utility on transfer.

F. All switch and contacts, coils, springs and control elements shall be removable from the front of the transfer switch without removal of the switch panel from the enclosure and without disconnecting power conductors or drive linkages. Control and sensing relays shall be continuous duty industrial type with minimum contact rating of ten amps.

G. Transfer switch shall be rated to withstand in RMS symmetrical amperes not less than the available symmetrical RMS amperes when protected by the circuit protective device on the line side of the transfer switch. Withstand rating of switch shall be based on switch contacts not welding under fault conditions.

H. Transfer switches shall be U.L. listed and labeled for service entrance. Transfer switches shall be furnished with an insulated neutral, bonding jumper and a ground bar bolted to the transfer switch enclosure.

I. The control panel for each automatic transfer switch shall contain the following accessories and Features.

1. ATS Control Panel
   a. The automatic transfer switch(es) shall provide a control panel mounted into the front of the switch. This control panel shall display source condition information including:
   b. AC voltage for each phase of normal and emergency source. All three phases shall be displayed on a single screen for viewing of voltage balance and on 4-wire systems, line to neutral voltage shall be displayed for each phase.
   c. Frequency of each source.
   d. Display source status including indication whether source is/is not connected.
2. The ATS control panel shall allow the operator to make adjustments to and/or set nominal voltage and frequency of the ATS, frequency sensor operation set points, time clock functions, and load sequence functions. The operator may also enable/disable ATS functions, set up exercise and load test operation conditions, normal system time delays for transfer, time delay to start, stop, transfer and retransfer. These parameters may only be accessed following password input from the authorized operator.

3. The display shall include real time clock data, including date, time (HH:MM:SS) and log total operating hours for the control system.
4. The display shall include a service history for the ATS and a fault history on the ATS.
5. Adjustable 0.5 to 6 second time delay on starting of EPS to override momentary power dips and interruptions of the normal services. Time delay shall be factory set at 1 second.
6. Time delay on transfer to emergency adjustable from 0 to 60 seconds, factory set at 0 seconds.
7. Test switch on enclosure door to simulate failure of the normal power source. ATS shall transfer load to the EPS.
8. Push button to bypass time delay on re-transfer to normal.
9. Close differential voltage sensing shall be provided on all phases of the normal power supply. The pickup voltage shall be adjustable from 85% to 100% of nominal and the dropout voltage shall be adjustable from 75% to 98% of the pickup value. The transfer to emergency will be initiated upon reduction of normal source to 85% of nominal voltage and re-transfer to normal shall occur when normal source restores to 95% of nominals.
10. Independent single phase voltage and frequency sensing of the emergency source. The pickup voltage shall be adjustable from 85% to 100% of nominal. Pickup frequency shall be adjustable from 90% to 100% of nominal. Transfer to emergency upon normal source failure when emergency source voltage is 90% or more of nominal and frequency is 95% or more of nominal.
11. A time delay on re-transfer to normal source. The time delay shall be automatically bypassed if the emergency source fails and normal source is available. The time delay shall be field adjustable from 0 to 25 minutes and factory set at 15 minutes.
12. An unloaded running time delay for emergency generator cool-down, factory set at 5 minutes.
13. Provide adjustable timed intermediate position in both directions when not in closed transition mode.
14. Pilot light for indicating switch in normal position (include fuses and auxiliary contact).
15. Pilot light for indicating switch in emergency position (include fuses and auxiliary contact).
16. An exerciser for exercising standby power plant on a weekly basis shall be provided in the transfer switch. Exerciser shall be set to exercise standby plant for one half hour per week under load. Time of plant exercise shall be set in field. Exerciser timer shall have reserve power back-up, either by battery or spring-wound clock, to ride through power outages to the switch.
17. Auxiliary contact (gold plated) which closes when normal source fails. (Closed after override delay of 0.5 to 6 seconds).
18. Auxiliary contact (gold plated) which opens when normal source fails. (Opens after override delay of 0.5 to 6 seconds).

19. Auxiliary contacts on same shaft as main contacts (closed on normal.)
20. Auxiliary contacts on same shaft as main contacts (closed on emergency).
21. Provide 'ready to transfer' signal in both directions.

J. Bypass Isolation Switch

1. The bypass isolation switch(es) shall have the same specification requirements as the automatic transfer switch portion of this specification except as described below:
   a. The automatic transfer and bypass-isolation switch shall be provided to manually permit convenient electrical bypass and isolation of the automatic transfer switch. Bypass of the load to either the normal or emergency power source with complete isolation of the ATS shall be possible regardless of the status of the ATS. The bypass-isolation switch shall permit proper operation by one person through the movement of a maximum of two handles at a common dead front panel. The entire system shall consist of two elements: The automatic transfer switch and the bypass-isolation switch furnished completely factory interconnected and tested.
   b. The operating speed of the bypass switch contacts shall be the same as the automatic transfer switch and independent of the speed of operation of the bypass handle.
   c. The automatic transfer and bypass-isolation switch shall be the product of one manufacturer and be completely factory interconnected and tested so that only the service and load connections to the bypass-isolation switch are required for field installation. All interconnections between the transfer switch, bypass switch and isolation switch shall be by silver-plated copper bus bar. A visual position indicator shall be provided to indicate bypass-isolation switch positions, and availability of normal and emergency sources. A prominent and detailed instruction plate shall be furnished for convenient operation.
   d. The automatic transfer and bypass-isolation switch shall provide manual bypass of the load and isolation of all service and load terminals of the automatic transfer switch to permit periodic testing, maintenance, and service of the automatic transfer switch.
   e. The bypass-isolation switch shall be capable of bypassing the load to either source. Provisions shall be made to assure continuity of auxiliary circuits necessary for the proper operation of the system.
   f. The isolation handle shall provide for automatic operation, testing, or removal of the automatic transfer switch. The Test position shall permit electrical testing of the automatic transfer switch without disturbing the load. The open position shall completely isolate the transfer switch from both lines and load without actual removal of the line or load conductors, and allow its removal for inspection, adjustment and maintenance. The transfer switch shall be arranged for drawout operation to facilitate its removal. Also, while in the Test or Open positions, the bypass switch shall function as a manual transfer switch to allow load transfer to either source

of power regardless of the position or condition of the transfer switch, including the condition when the automatic transfer switch is removed, and without reconnecting the load terminals of the automatic transfer switch.

2.04 FUEL SUPPLY

A. A double wall 8000 gallon fuel storage tank for each generator shall be located in the skids below the generator set, and shall be complete with all piping and fittings connected. No galvanized material shall be used in the tank or fueling system. The tanks shall be vented to atmosphere. A fuel level gauge shall be located as indicated on the drawings. The system shall be supplied to deliver an adequate amount of fuel to the engine from the storage tank. Pipe sizes shall be no smaller than the minimum recommended by the engine manufacturer to avoid fuel flow restriction. The engine supply and return line shall be equipped with a length of flexible fuel lines, unions, and gate valves. No copper lines are acceptable. Provide lockable fill, and all venting as required. The tank shall fit within space provided.

B. Provide a work platform around the sides and controls end of the generator, extending a minimum of three (3) feet from the generator, but in no case shall the platform be narrower than the length of the service doors so that the generator remains fully accessible for servicing. The platform shall be provided with a handrail, four feet high. The platform deck shall be equal in elevation to the top of the fuel tank and shall be supported by the concrete pad of the generator. The platform shall be fabricated from welded aluminum tubing, the deck shall be heavy duty aluminum grating, the platform shall be provided with aluminum steps as required to access the working deck elevation. All bolts to be aluminum. All anchor bolts to be stainless steel.

C. Provide a set of normally open contacts in fuel level indicating system of fuel tank. Interconnect with remote low fuel alarm specified earlier in this section.

D. Provide 'Fuel in Containment' contact in basin and Leak Detection System.

E. Provide fuel sensing system for each tank so that if fuel level is over 90% an audible and visual alarm shall alarm. Provide engraved sign reading "DISCONTINUE FILLING IF ALARM SOUNDS."

F. Provide 4000 gallons of fuel for each tank at start of load bank testing.

PART 3- EXECUTION

3.01 EPS INSTALLATION

A. The plant shall be anchored to a concrete base. See structural for slab details. Refer to the detail on the plans

B. Provide a laminated sign at the service entrance equipment indicating type and location of on-site emergency power sources.

C. For exterior installations, the EPS shall be provided in outdoor, weatherproof housing with removable panels for access to equipment. The starting batteries shall be rack mounted within the housing.

D. The enclosure shall be constructed of pre-painted aluminum, panels and posts shall be 0.125" thick (ASTM B209, 5052 H32). The housing shall be wind rated to 150 mph per ASCE 7-98 exposure D, category 1 importance factor. The enclosure shall be required to provide sound attenuation, level 2.

E. Provide LED service lights and weather proof switch within the housing. Connect the light to the battery charger 120 volt circuit. Provide receptacle and battery powered emergency light.

F. Extend 120 and/or 230 volt emergency power circuits for chargers and cold weather starting aids from the control panel wiring system.

3.02 TRANSFER SWITCH INSTALLATION

A. Locate transfer switch(es) to provide working clearance and full accessibility as required by the National Electrical Code.

B. Lace and group conductors installed in transfer switch with nylon tie straps. Only one conductor shall be installed under terminals. Form and train conductors in enclosure neatly parallel and at right angles to sides of box. Uninsulated conductor shall not extend beyond one-eights inch from terminal lug. Conductors shall be installed such that no stresses are transferred to terminal lugs.

C. Mounting and Support

1. Mounting
   a. Enclosure shall be secured to structure by a minimum of four (4) fastening devices to floor.
   b. Do not splice conductors in enclosure. Where required, install junction box or wireway adjacent to transfer switch and splice or tap conductors in box.
   c. Conductors not terminating in transfer switch shall not extend through or enter transfer switch enclosure.
   d. Install push-in knock-out closure plugs in any unused knock-out openings.
   e. Free standing transfer switch(es) shall be installed on a four inch high concrete pad, with horizontal base dimension exceeding base dimension of switch by three inches.
   f. Cleaning and Adjustment
      1) After completion, clean the interior and exterior of dirt, paint and construction debris.

2) Touch up paint all scratched or marred surfaces with factory furnished touch up paint of the same color as the factory applied paint.

3.03 TESTING

A. Submit verification letter to Engineer indicating successful completion of sequence of operations testing and certification that all functions are operational. Letter to request load testing approval and schedule of proposed test. Prior to load test, written approval must be provided by Engineer. Representatives of the generator and transfer switch shall be present. The local authority having jurisdiction shall be given advance notification of the time of the final test in order that he may witness the tests.

B. A failure of any test or any component during a test will require a complete retest program at no additional cost to the Owner.

C. Provide all fuel, lubricants, and other consumables for testing.

D. An on-site acceptance test shall be conducted as a final approval test for all Emergency Power Supply Systems.

1. The test shall be conducted after completion of the installation with all EPSS accessory and support equipment in place and operating.
2. Test Results. The EPSS shall perform within the limits specified in the standard NFPA-110, Level 1.

3.04 O&M MANUALS

A. At least three sets of an instruction manual(s) for all major components of the EPS shall be supplied by the Manufacturer(s) of the EPS and shall contain:

1. A detailed explanation of the operation of the system.
2. Instruction for routine maintenance.
3. Detailed instructions for repair of the EPS and other major components of the EPS.
4. Pictorial parts list and part numbers.
5. Pictorial and schematic electrical drawings of wiring systems, including operation and safety devices, control panels, instrumentation and annunciators.

3.05 GA POWER DOCUMENTATION AND ACCESSORIES

A. Contractor shall contact GA Power and provide all necessary information as required for new generator with closed-transition transfer switch, ready for owner's signatures.

B. Provide and install a 86 Rolloff N.O. Reset switch for main breaker and all signage as required by Georgia Power.

END OF SECTION

DIVISION 26 – ELECTRICAL

266500 – ELECTRICAL EQUIPMENT ACCEPTANCE TESTING

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. The work required under this section of the specifications consist of the start-up testing and inspection of the electrical equipment designated within. All labor and testing equipment which is required shall be provided under this section of the specifications.

1.03 GENERAL

A. The Contractor shall perform the tests as outlined below to insure system acceptance.

B. When the tests and inspections have been completed, a label shall be attached to all devices tested. The label shall provide the name of the testing company, the date the tests were completed, and the initials of the licensed electrical contractor who performed the tests.

C. The tests shall insure that the equipment is operational and functioning within industry standards and manufacturer's tolerances. Forward all test reports to the Engineer at least two weeks prior to the project final inspection for review. Reports shall be bound as required by Division 1 of this specification.

1.04 QUALITY ASSURANCE

A. The testing and inspection shall comply with all applicable sections of the following codes and standards:

1. American National Standards Institute - ANSI
2. American Society for Testing and Materials - ASTM
3. Association of Edison Illuminating Companies - AEIC
4. Institute of Electrical and Electronics Engineers - IEEE
5. Insulated Power Cable Engineers Association - IPCEA
6. International Electrical Testing Association - NETA Acceptance Testing Specifications
7. National Electrical Code - NEC

8. National Electrical Manufacturers Association - NEMA
9. National Fire Protection Association - NFPA
10. State and Local Codes and Ordinances

B. The inspection and testing shall comply with the project plans and specifications as well as with the manufacturer's drawings, instruction manuals, and other applicable data for the apparatus tested.

1.05 DIVISION OF RESPONSIBILITY

A. The contractor shall perform all tests.

B. The contractor shall supply a suitable and stable source of electrical power to each test site. The testing firm shall specify the specific power requirements.

C. The contractor shall notify the testing firm when equipment becomes available for acceptance tests. Work shall be coordinated to expedite project scheduling.

D. The contractor is responsible for obtaining and approving a short-circuit analysis and coordination study prepared by the switchgear manufacturer.

E. The testing firm shall notify the Engineer prior to commencement of any testing.

F. Any system, material or workmanship which is found defective on the basis of acceptance tests shall be reported to the Engineer.

G. The electrical contractor shall maintain a written record of all tests and, upon completion of project, shall assemble and certify a final test report.

1.06 SAFETY AND PRECAUTIONS

A. Safety practices shall comply with applicable state and local safety orders as well as with the Occupational Safety and Health Act of 1970 (OSHA). Compliance with the National Fire Protection Association standard NFPA 70E and the Accident Prevention Manual for Industrial Operations of the National Safety Council shall be observed.

B. Tests shall only be performed on apparatus which is de-energized. The testing company's lead test engineer for the project shall be a designated safety representative and shall supervise testing observations and safety requirements. Work shall not proceed until he has determined that it is safe to do so.

C. Power circuits shall have conductors shorted to ground by a hotline grounded device approved for the purpose. Warning signs and protective barriers shall be provided as necessary to conduct the tests safely.

1.07 REPORTS

A. The test report shall include the following sections:

1. Scope of testing
2. Equipment tested
3. Description of test
4. Test results
5. Conclusions and recommendations
6. Appendix, including test forms

B. Each piece of equipment shall be recorded on a data sheet listing the condition of the equipment as found and as left. Included shall be recommendations for any necessary repair and/or replacement parts. The data sheets shall indicate the name of the engineer who tested the equipment and the date of the test completion.

C. Record copies of the completed test report shall be submitted no more than 30 days after completion of the testing and inspection.

1.08 TEST EQUIPMENT

A. All test equipment shall be in good mechanical and electrical condition. All field instruments shall have been calibrated within six months of the testing date, and dated calibration labels shall be visible on the testing equipment. Submit calibration certification in the final report.

PART 2 – PRODUCTS

2.01 MATERIALS

A. All materials are specified under other sections of this specification. All testing equipment required shall be provided under this section of the specifications.

PART 3 - EXECUTION

3.01 EQUIPMENT TO BE TESTED

A. The following equipment shall be tested in accordance with the scopes of work which follow. The party responsible is identified in accordance with the following key: C = Contractor; M = Manufacturer.

1. Dry Type Transformers - C
2. Low Voltage Switchboards - C
3. Molded Case Circuit Breakers - C
4. Motor Controllers – C
5. Automatic Transfer Switches - M
6. Emergency Power Supply-Engine Driven - M

7. Grounding System - C
8. Cables, Low Voltage, 600 Volts Maximum - C
9. Ground Fault Systems - C

3.02 DRY TYPE TRANSFORMERS

A. Visual and Mechanical Inspection

1. With case covers removed, inspect transformer core and coil assembly and enclosure interior. Cloth wipe and/or brush major insulating surfaces.
2. Check primary, secondary, and ground connections.
3. Check tap connections and tap changer.
4. Inspect all bolted connections. The electrical contractor shall torque wrench tighten or remake any questionable connections.
5. Inspect insulators, spacers, and windings.
6. Inspect for adequate electrical clearance.
7. Check base or support insulators, including vibration isolation supports.
8. Check accessory devices for condition and proper operation.
9. Verify that the transformers have been provided with adequate spacing for ventilation.

B. Electrical Tests

1. Insulation Resistance Test: Megger transformer windings high to low and ground, low to high and ground, and high and low to ground.
2. Include measured secondary voltage (line-to-line and line-to-ground) for each transformer in the test report. Secondary voltage readings, at each transformer, phase to phase neutral, and phase load readings shall be recorded and tap positions of transformer taps noted. This test shall be conducted with a calibrated voltmeter.
3. Each ground rod installation shall be tested after all connections to ground rods are made before grounding conductor connection is made to the transformer. Ground rod installations shall be tested by "fall of potential" measuring method using ground resistance test meter and two auxiliary electrodes driven into the earth, interconnected through the meter with the ground rod installation being tested.
4. Placement of auxiliary electrodes shall be in accordance with operating instructions of test meter, but in no case shall auxiliary current electrodes be placed within 70' of the grounding system being tested. Test data shall indicate placement of auxiliary electrodes with respect to systems being tested, date readings were taken and lowest resistance recorded.

3.03 LOW VOLTAGE SWITCHBOARDS

A. Visual and Mechanical Inspection

1. Verify that the contractor has cleaned enclosure interiors of accumulated dust, dirt, oil films, and other foreign materials.

2. Inspect all electrical and mechanical components for condition and any evidence of defects or failure.
3. Check for proper travel and alignment of any drawout or plug-in circuit breakers.
4. Check breaker connections to bus.
5. Inspect bolted connections. The electrical contractor shall torque wrench tighten or remake any questionable connections.
6. Inspect for missing or loose hardware or accessories.
7. Inspect ground bus connections.
8. Operate key and door interlock devices to assure proper operation.
9. Test 'arc limiting' switches.

B. Electrical Tests

1. Insulation Resistance Test: Megger main secondary bus and feeder circuits phase-to-phase and phase-to-ground.
2. Energize any space heater circuits to insure proper operations.

C. Check phase rotation with a Biddle phase rotation meter.

D. Instruments and Meter Tests

1. Inspect panel mounted instruments and meters.

3.04 MOLDED CASE CIRCUIT BREAKERS

A. Visual and Mechanical Inspection

1. Inspect cover and case, and check for broken or loose terminals.
2. Operate breaker to check operation.

B. Electrical Tests (400 ampere frame and larger)

1. Insulation Resistance Test: Megger main poles of breaker pole-to-pole, from each pole to ground, and across the open contacts of each pole.
2. Contact Resistance Test: Ductor across main pole contacts with breaker closed and latched to check for good, low resistance contact.
3. Test overcurrent trip device and calibrate. Where primary injection testing is specified, test each pole of the breaker individually. Data shall be compared with manufacturer's published data.
   a. All trip units shall be tested by primary injection.
   b. Static overcurrent trip devices shall be tested per manufacturer's instructions.
   c. Test for minimum pick-up current.
   d. Apply 300% of pick-up current and measure time necessary to trip breaker (long time delay).
   e. Where short time delay characteristics are provided, test short time pick-up and delay.
   f. Test instantaneous trip by passing current sufficiently high to trip breaker instantaneously.

g. Where ground fault protection is provided, test ground fault pick-up and delay.
h. Check reset characteristics of trip unit.

4. Electrically test any auxiliary devices such as shunt trips, undervoltage trips, alarm switches, and auxiliary switches.

3.05 MOTOR CONTROLLERS

A. Visual and Mechanical Inspection

1. Verify that the contractor has cleaned structure interiors and starter cells of accumulated dust, dirt, oil films, and other foreign material.
2. Inspect bolted connections. The electrical contractor shall torque wrench tighten or remake any questionable connections.
3. Check mechanical operation of starters for freedom from binding.
4. Check motor circuit protector setting and overload relay size against contractor furnished list of motor nameplate full load current values.

B. Electrical Tests

1. Verify operation of each starter.
2. Contact Resistance Test. Ductor across main pole contacts of each breaker or switch with device closed and latched to check for good, low resistance contact.

3.06 AUTOMATIC TRANSFER SWITCHES

A. Visual and Mechanical Inspection

1. Verify that contractor has cleaned enclosure interiors and all components of accumulated of dust, dirt, oil films, and other foreign material.
2. Inspect all electrical and mechanical components for condition and any evidence of defect or failure.
3. Perform inspection checks on individual components as recommended by the manufacturer.
4. Inspect connections for looseness. The electrical contractor shall torque wrench tighten or remake any questionable connections.
5. Inspect for missing or loose hardware or accessories.
6. Check for proper mechanical operation and lubricate, as necessary.
7. Check transfer mechanism for alignment and friction-free operation. Lubricate, as necessary.
8. Check all connecting wiring for condition.

B. Electrical Tests

1. Use test switch, when available, to check the electrical operation of the transfer switch.
2. When a test switch is not available, a failure of the normal source power will be simulated by disconnecting a voltage sensing lead.

3. Test and adjust all sensing relays, and other devices specifically associated with the transfer switch.
4. Contact Resistance Test: Ductor across main pole contacts of power switching circuit breakers, switches or contactor contacts with device closed and latched to check for good, low resistance contact.
5. Demonstrate bypass operation.

3.07 EMERGENCY POWER SUPPLY-ENGINE DRIVEN

A. Visual and Mechanical Inspection

1. Verify that contractor has cleaned enclosure interiors of accumulated dust, dirt, oil films, and other foreign material.
2. Inspect all electrical and mechanical components for condition and any evidence of defects or failure.
3. Check output circuit breaker(s) bus connection.
4. Inspect bolted connections. The electrical contractor shall torque wrench tighten or remake any questionable connections.
5. Inspect for missing or loose hardware or accessories.
6. Inspect grounding system connections.
7. Operate key and door interlock devices to assure proper operation.
8. Inspect all associated systems and circuits for proper operation, including but not limited to the fuel supply system, jacket heater, battery charger, engine mounted control panel, remote monitoring and control panel, emergency cut-off, battery lighting system, exhaust system, radiator system, and ventilator system.
9. Inspect anchoring and vibration isolation systems.

B. Electrical Tests.

1. Insulation resistance test: Megger main poles of output circuit breaker(s) pole-to-pole, from each pole to ground, and across the open contacts of each pole.
2. Contact Resistance Test: Ductor across main pole contacts of output circuit breaker(s) with breaker closed and latched to check for good, low resistance contact.
3. Follow completely the load testing procedures of the latest issue of NFPA-110 for EPS systems, including prior notification of the local inspection authority having jurisdiction. Include all measured data and conditions in the final report. All non-compliance items shall be corrected by the contractor and retested until full compliance with NFPA-110 is achieved.

3.08 GROUNDING SYSTEM

A. Visual and Mechanical Inspection

1. Inspect wiring system outlet and junction boxes for proper grounding. Green grounding conductor shall be connected to outlet and junction boxes.

2. Verify connections of grounds for the secondary of separately derived grounding systems, i.e. at dry type transformers. Note type of connection, i.e. mechanical or exothermic.
3. Verify proper connection to all components of building service entrance grounding system. Note all system components which are interconnected and type of connection either mechanical or exothermic. Note depth of driven ground rods.

B. Electrical Tests (Small Systems)

1. Perform ground-impedance measurements utilizing the fall-of-potential method per ANSI/IEEE Standard 81 "IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System". Instrumentation utilized shall be specifically designed for ground impedance testing. Provide sufficient spacing so that plotted curves flatten in the 62% area of the distance between the item under test and the current electrode.

C. Equipment Grounds

1. Utilize two-point method of IEEE Std. 81. Measure between equipment ground being tested and known low-impedance grounding electrode or system.

D. Test Values

1. The main ground electrode system impedance-to-ground should be no greater than 25 ohms for commercial or industrial systems. Equipment grounds, depending on size and length of grounding conductor, should be only fractionally higher than system ground.

3.09 CABLES - LOW-VOLTAGE - 600V MAXIMUM

A. Visual and Mechanical Inspection

1. Inspect cables for physical damage and proper connection in accordance with single-line diagram.
2. Test cable mechanical connections to manufacturer's recommended values using a calibrated torque wrench.
3. Check cable color coding with applicable engineer's specifications and National Electrical Code standards.

B. Electrical Tests

1. Perform insulation-resistance test on each feeder on the riser diagram with respect to ground and adjacent conductors. Applied potential shall be 1000 volts dc for 1 minute.
2. Perform continuity test to insure proper cable connection.

C. Test Values

1. Evaluate results by comparison with cables of same length and type. Investigate any values less than 50 megohms.

3.10 GROUND-FAULT SYSTEMS (NEC 230-95)

A. Visual and Mechanical Inspection

1. Inspect for physical damage and compliance with drawings and specifications.
2. Inspect neutral main bonding connection to assure:
   a. Zero-sequence sensing system is grounded.
   b. Ground-strap sensing systems are grounded through sensing device.
   c. Ground connection is made ahead of neutral disconnect link on zero-sequence sensing systems.
   d. Grounded conductor (neutral) is solidly grounded.
3. Inspect control power transformer to ensure adequate capacity for system.
4. Manually operate monitor panels (if present) for:
   a. Trip test
   b. No trip test
   c. Nonautomatic reset
5. Record proper operation and test sequence.
6. Set pickup and time-delay settings in accordance with the settings provided by the coordination study.

B. Electrical Tests

1. Measure system neutral insulation to ensure no shunt ground paths exist. Remove neutral-ground disconnect link. Measure neutral insulation resistance and replace link.
2. Determine the relay pickup current by current injection at the sensor and operate the circuit interrupting device.
3. Test the relay timing by injecting three hundred percent (300%) of pickup current, or as specified by manufacturer.
4. Test the system operation at fifty-seven percent (57%) rated control voltage, if applicable.
5. Test zone interlock systems by simultaneous sensor current injection and monitoring zone blocking function.
6. On multiple source, tie breaker, etc., systems, devise a simulation scheme that fully proves correct operation.

C. Test Parameters

1. System neutral insulation shall be a minimum of one hundred (100) ohms, preferably one (1) megohm or greater.
2. Relay timing shall be in accordance with manufacturer's published time-current characteristic curves but in no case longer than one (1) second for fault currents equal to or greater than 3,000 amperes.
3. Relay pickup value shall be within +/- 10% of setting and in no case greater than 1200A.

END OF SECTION