

DIVISION 26

SECTION 26 00 00

ELECTRICAL

PART 1 - GENERAL

1.00 GENERAL REQUIREMENTS

- A. The GENERAL REQUIREMENTS, DIVISION 01, and PROCUREMENT AND CONTRACTING REQUIREMENTS, DIVISION 00, are hereby made a part of this Specification Section.
- B. Examine all Drawings and all Sections of the Specifications for requirements therein affecting the work and this Section. The exact scope of work of this Sub-bidder cannot be determined without a thorough review of all specification sections and other contract documents.

1.01 SCOPE OF WORK

- A. Conditions of the Contract and Division 01, General Requirements, apply to work of this Section. Where Paragraphs of this Section conflict with similar paragraphs of Division 01, requirements of this Section shall prevail.
- B. Examine Drawings and other Sections of Specifications for requirements that affect work of this Section.
- C. As used in this Section, “provide” means “furnish and install” and “HVAC” means “Heating, Ventilating and Air Conditioning” and “POS” means “Provided Under Other Sections”. “Furnish” means “to purchase and deliver to the project site complete with every necessary appurtenance and support,” and “Install” means “to unload at the delivery point at the site and perform every operation necessary to establish secure mounting and correct operation at the proper location in the project.” “EC” refers to this Electrical Contractor. “GC” refers to General Contractor.
- D. Perform work and provide material and equipment as shown on Drawings and as specified or indicated in this Section of the Specifications. Completely coordinate work of this Section with work of other trades and provide a complete and fully functional installation. Drawings and Specifications form complimentary requirements; provide work specified and not shown, and work shown and not specified as though explicitly required by both. Although work is not specifically shown or specified, provide supplementary or miscellaneous items, appurtenances, devices and materials obviously necessary for a sound, secure and complete installation. Remove all debris caused by contractors’ work.

- E. Drawings are diagrammatic and indicate general arrangement of systems and work included in Contract. It is not intended to specify or to show every offset, fitting or component; however, Contract Documents require components and materials whether or not indicated or specified as necessary to make the installation complete and operational.
- F. Perform work strictly as required by rules, regulations, standards, codes, ordinances, and laws of local, state, and federal government, and other authorities that have lawful jurisdiction.
- G. Give notices, file plans, obtain permits and licenses, pay fees and obtain necessary approvals from authorities that have jurisdiction. All backcharges from the Utility shall be paid for by the Owner.
- H. As work progresses and for duration of Contract, maintain complete and separate set of prints of Contract Drawings at job site at all times. Record work completed and all changes from original Contract Drawings clearly and accurately, including work installed as a modification or addition to the original design.
- I. Work shall include, but shall not be limited to, the following:
 - 1. Motor connections.
 - 2. Transfer switches for Standby and Life Safety Systems.
 - 3. UPS System
 - 4. Panelboards and circuit breakers
 - 5. Safety disconnect switches (fused or unfused).
 - 6. Fuses.
 - 7. Secondary conductors and terminations.
 - 8. Conduit and raceways.
 - 9. Wire and cable.
 - 10. Branch circuit wiring.
 - 11. Surface mounted raceway.
 - 12. Fire seal and fire-proof foam.
 - 13. Sleeving.
 - 14. Pull boxes and cable troughs.
 - 15. Grounding.

16. Commissioning and training.
17. Supervision and approval.
18. Nameplates, labels and tags.
19. Testing.
20. Operating and maintenance instructions and manuals.
21. Coordination drawings and shop drawings.
22. Temporary power and lighting.

1.02 EXAMINATION OF SITE AND DOCUMENTS

- A. Bidders are expected to examine and to be thoroughly familiar with all contract documents and with the conditions under which work will be carried out. The Awarding Authority (Owner) will not be responsible for errors, omissions and/or charges for extra work arising from General Contractor's or Filed Subcontractor's failure to familiarize themselves with the Contract Documents or existing conditions. By submitting a bid, the Bidder agrees and warrants that he has had the opportunity to examine the site and the Contract Documents, that he is familiar with the conditions and requirements of both and where they require, in any part of the work a given result to be produced, that the Contract Documents are adequate and that he will produce the required results.
- B. Pre-Bid Conference: Bidders are strongly encouraged to attend the Pre-Bid conference; refer to ADVERTISEMENT FOR BIDS for time and date.

1.03 CONTRACT DOCUMENTS

- A. Work to be performed under this Section is shown on the Electrical Drawings.
- B. Except where modified by a specific notation to the contrary, it shall be understood that the indication and/or description of any item, in the drawings or specifications or both, carries with it the instruction to furnish and install the item, regardless of whether or not this instruction is explicitly stated as part of the indication or description.
- C. Items referred to in singular number in Contract Documents shall be provided in quantities necessary to complete work.
- D. Drawings are diagrammatic. They are not intended to be absolutely precise; they are not intended to specify or to show every offset, fitting, and component. The purpose of the drawings is to indicate a systems concept, the main components of the systems, and the approximate geometrical relationships. Based on the systems concept, the main components, and the approximate geometrical relationships, the contractor shall provide all other components and materials necessary to make the systems fully complete and operational.

- E. Information and components shown on riser diagrams, but not shown on plans, and vice versa, shall apply or be provided as if expressly required on both.

1.04 DISCREPANCIES IN DOCUMENTS

- A. Address questions regarding drawings to Architect in writing before award of contract; otherwise, Architect's interpretation of meaning and intent of drawings shall be final.

1.05 SITE VISIT

- A. Before submitting bid, visit and carefully examine site to identify existing conditions and difficulties that will affect work of this Section. No extra payment will be allowed for additional work caused by unfamiliarity with site conditions that are visible or readily construed by experienced observer.

1.06 CODES, STANDARDS, AUTHORITIES AND PERMITS

- A. Perform work in strict accordance with the rules, regulations, standards, codes, ordinances, and laws of local, state and federal governments and other authorities having legal jurisdiction over the site.
- B. Underwriters' Laboratories (UL) shall list material and equipment.
- C. Give notices, file plans, obtain permits and licenses, pay fees and back charges, and obtain necessary approvals from authorities that have jurisdiction.

1.07 COORDINATION DRAWINGS

- A. Electrical Coordination Drawings
 - 1. The Electrical Contractor shall prepare Coordination Drawings showing all work to be installed as part of Section 26 00 00. The Coordination Drawings shall be on 4 mil reproducible mylar at not less than ¼ inch for Mechanical and Electrical spaces and at 1/8 inch for all other areas. The Electrical Coordination Drawings shall show all equipment, conduit, transfer switches, panelboards, switchgear, transformers, pull boxes, junction boxes and supports.
 - 2. The Electrical Contractor, after showing all of the Electrical work, shall forward the reproducible coordination drawings to the Contractor.
 - 3. The Electrical Contractor shall attend a series of meetings arranged by the Contractor to resolve any real or apparent interferences or conflicts with the work of the other contractors or with ceiling heights shown on the drawings.
 - 4. The Electrical Contractor shall then make adjustments to his work on the Coordination Drawings to resolve any real or apparent interferences or conflicts and forward to the Contractor.

5. After any real or apparent interferences and conflicts have been incorporated into the Coordination Drawings, the Contractor shall prepare the final Coordination Drawings and submit to the Architect.
6. The Electrical Contractor shall not install any of his work prior to the preparation of the final Coordination Drawings. If Electrical work proceeds prior to the final Coordination Drawings, any change to the Electrical work to correct the interferences and conflicts which result will be made by the Electrical Contractor at no additional cost to the Owner.
7. Coordination Drawings are for the Electrical Contractor's and Owner's use during construction and shall not be construed as replacing any shop, "as-built", or Record Drawings required elsewhere in these Contract Documents.
8. Review of Coordination Drawings shall not relieve the Electrical Contractor from his overall responsibility for coordination of all work performed pursuant to the Contract or from any other requirements of the Contract.

1.08 GUARANTEE AND 24 HOUR SERVICE

- A. Guarantee work in writing for one year from date of final acceptance. Repair or replace defective materials or installation at no cost to Owner. Correct damage caused in making necessary repairs and replacements under guarantee at no cost to Owner.
- B. Submit guarantee to Architect before final payment.
- C. Statement of guarantee requirements shall not be interpreted to limit Owner's rights under law and this contract.

1.09 RECORD DRAWINGS

- A. Maintain record drawings on site. Record set must be complete and current and available for inspection when requisitions for payment are submitted.

1.10 SUBMITTALS

- A. Refer to Section 01 33 00 of submittal procedures.
- B. Material and equipment requiring Shop Drawing and Product Data submittal shall include but shall not be limited to:
 1. Automatic Transfer Switch.
 2. Panelboards, circuit breakers.
 3. Dry type transformers.
 4. UPS System
 5. Safety disconnect switches (fused or unfused).

6. Fuses.
7. Conduit and raceways.
8. Wire and cable.
9. Branch circuit wiring.
10. Telephone conduit and outlet system.
11. Surface mounted raceway.
12. Wiring devices and plates.
13. Fire seal and fire-proof foam.
14. Sleeving.
15. Pull boxes and cable troughs.

C. Electrical Subcontractor shall provide a complete set of approved submittals to the owners.

1.11 OPERATING AND MAINTENANCE INSTRUCTIONS

A. Submit operation and maintenance data complete with at least the following:

1. Table of Contents
2. Introduction:
 - a. Explanation of manual and its use
 - b. Description of all systems
3. Plant Operation
 - a. Operating instructions for all Electrical apparatus, as listed below.
4. Maintenance
 - a. Maintenance and lubricating chart for generator: Furnish three sets of charts indicating equipment tag number, location of equipment, equipment service, greasing and lubricating requirements, lubricants and intervals of lubrication.
 - b. Recommended list of spare parts: Furnish two typed sets of instructions for ordering spare parts with sectional views of the equipment showing parts numbered or labeled to facilitate ordering replacements, including a list with itemized prices of those parts recommended to be kept on

hand as spares, as well as the name and address of where they may be obtained.

5. Manufacturer's Literature
 - a. Switchboard
 - b. Automatic Transfer Switches
 - c. Panelboards
 - d. Dry-type Transformers
 - e. UPS System

1.12 SEQUENCING

- A. Coordinate work of this Filed Subcontract with that of other trades, affecting or affected by this work, and cooperate with the other trades as is necessary to assure the steady progress of work.
- B. Do not order or deliver any materials until all submittals, required in the listed Specification Sections included as part of this Filed Subcontract, have been received and approved by the Architect.
- C. Before proceeding with installation work, inspect all project conditions and all work of other trades to assure that all such conditions and work are suitable to satisfactorily receive the work of this Section and notify the Architect in writing of any which are not. Do not proceed further until corrective work has been completed or waived.

1.13 CUTTING AND PATCHING

- A. All cutting and patching one (1) square foot and less in area, or the circular equivalent, necessary for the proper installation of work to be performed under this Section and subsections shall be performed by the Electrical Sub-Contractor. All cutting and patching greater than one (1) square foot in area, or the circular equivalent, necessary for the proper installation of work performed under this Section and subsections shall be performed by the General Contractor.

PART 2 - PRODUCTS

2.00 RACEWAYS

- A. Rigid metallic conduit shall be zinc-coated steel that conforms to industry standards, by Allied Tube and Conduit, Republic Steel, Wheatland Tube or approved equal.
- B. Intermediate metal conduit (IMC) shall be zinc-coated steel that conforms to industry standards, by Allied tube and Conduit, Triangle/PWC or approved equal.

- C. Electrical metallic tubing (EMT) shall be zinc-coated steel that conforms to industry standards, by Republic Steel, Allied Tube and Conduit, Triangle/PWC or approved equal.
- D. Wireways shall be sheet steel with hinged spring-latched covers, galvanized or painted to protect against corrosion. Provide necessary bends, couplings, connectors and other appurtenances. Interior parts shall be smooth and free of sharp edges and burrs. Wireways shall be by Square D or approved equal.
- E. Non-metallic conduit shall be Schedule 40 100% virgin polyvinyl chloride (PVC), 90 degrees C UL-rated, by Carlon or approved equal. Utility conduits shall be concrete encased and shall meet all requirements of NSTAR.
 - 1. Conduit shall meet NEMA requirements and shall be UL-listed as required by Article 347 of NEC.
 - 2. Conduit, fittings and solvent cement shall be by single approved manufacturer.
 - 3. Material shall have minimum tensile strength of 7,000 psi at 73.4 °F, minimum flexural strength of 11,000 psi, and minimum compressive strength of 8,600 psi.
- F. Flexible metallic conduit shall be galvanized, spiral wrapped metallic conduit (Greenfield) or liquid-tight flexible metallic conduit as specified for specific equipment.
- G. Conduit expansion fittings shall be threaded hot-dipped galvanized malleable iron with internal bonding assembly by O.Z./Gedney or approved equal.
- H. Conduit fire seat fittings shall have heat-activated intumescent material for fire rating equal to or higher than that of floor or wall by O.Z./Gedney or approved equal.
- I. Provide water-tight gland sealing assemblies with pressure bushings as required for penetrations.
- J. Provide threaded malleable iron or steel connectors and couplings with insulated throats; manufactured elbows; locknuts; and plastic or bakelite bushings at terminations, as necessary. Couplings and connectors shall be gland and ring compression or stainless steel multiple point locking or steel concrete-tight set screw. Compression couplings and connectors shall form positive ground. Set-screw connectors and couplings shall have wall thickness equal to conduit, case-hardened, hex-head screws and separate ground wire. Bushings for rigid steel conduit and connectors for EMT shall have insulating inserts that meet requirements of UL 514 flame test.

2.01 OUTLET BOXES

- A. Outlet boxes on concealed work shall be at least 4 inches square or octagonal, galvanized pressed steel with plaster rings as required. Outlet boxes for exposed conduit work shall be cast aluminum alloy with cast aluminum alloy covers.
- B. Where installed in plaster, boxes shall be fitted with galvanized steel plaster covers of required depth to finish flush with finished wall or ceiling.

- C. Switch boxes, receptacle boxes and other outlet boxes shall be standard 4 inches square with plaster rings or gang covers as required.
- D. Outlet boxes shall be by Steel City Electric Company, Appleton Electric Company, National Electric Products Company or approved equal.
- E. Outlet boxes for various systems and components shall be as required by manufacturer.
- F. Waterproof boxes shall be Condulet Cast Boxes with water-proof devices and covers. Provide hot-dipped galvanized corrosion-resistant epoxy enamel finish or PVC-coated products, where noted on Drawings.
- G. Provide screw-joint outlet boxes, with gasketed weatherproof covers in exterior locations, where exposed to moisture, at kitchen and cafeteria equipment with or next to water or steam connections, and where indicated as weatherproof on Drawings.
- H. Provide only enough conduit openings to accommodate conduits at individual location. Each box shall be large enough to accommodate number and sizes of conduits, wires and splices to meet NEC requirements, but shall be at least size shown or specified. Necessary volume shall be obtained by using boxes of proper dimensions. Box depths greater than 2-1/8 inches shall not be used to obtain necessary volume, but may be used with Architect's approval to facilitate installation. Standard concrete boxes may be 6 inches deep where necessary to permit entrance of conduits into sides of boxes without interference with reinforcing bars. Octagonal hung ceiling boxes with suspension bars may be 3-1/2 inches deep. Rectangular boxes for inter-connection of branch circuit conduits may be 2-1/2 inches deep.

2.02 JUNCTION BOXES, PULL BOXES AND CABLE TROUGHS

- A. Provide code gauge galvanized steel junction and pull boxes for conduit 1-1/4 inches trade size and larger, where indicated and as necessary to facilitate installation, of required dimensions, with accessible, removable screw-on covers. Provide junction and pull boxes in special sizes and shapes determined in field where necessary.
- B. Junction box covers shall be accessible. Do not install junction boxes above suspended ceilings except where ceiling is removable or where access panel is provided.
- C. Sheet metal pull boxes shall be supported adequately to maintain shape. Larger boxes shall have structural steel bracing welded into rigid assembly formed adequately to maintain alignment in shipment and installation. Secure covers with corrosion-resistant screws or bolts.
 - 1. Pull boxes exposed to rain or in wet locations shall be weatherproof.
 - 2. Pull boxes used with aluminum conduit shall be metal compatible with aluminum.
 - 3. Provide clamps, grids and other appurtenances to secure cables. No cable shall be unsupported for more than 30 inches.

4. No pull box shall be within 2 feet of another.
 5. Provided sealed, cast-alloy, hazardous-location boxes with sealing fittings in garages and other areas in which flammable gases or vapors may be present to prevent transmission of gases or vapors through conduits.
 6. Pull boxes connected to concealed conduits shall be mounted with covers flush with finished wall or ceiling. No aluminum pull box shall be embedded in concrete.
- D. Provide cable troughs of special shapes, design and construction required to install, support and enclose feeder cable throughout indicated routing. Troughs shall be as specified above for junction and pull boxes, with reinforcing, insulating supports and clamping for cable installation. Cables shall be continuous throughout troughs, and shall be racked in distributed phase groupings arranged with phase cables surrounding neutral conductors.

2.03 WIRE AND CABLE (600 V INSULATION)

- A. Provide single-conductor, annealed copper wire and cable with insulation rated 600 V, of sizes specified and scheduled on Drawings, by General Electric, Rome, Okonite or approved equal, for secondary service, feeders, branch and system wiring. Wire insulated for 300 V may be used where voltage is less than 100 V, if isolated from higher voltages. Wire sizes shown and specified are American Wire Gauge for copper.
- B. Armored cable shall be Type MC 600 V copper with full-sized insulated ground conductor, in accordance with NEC Article 330. Minimum size shall be #12 AWG unless specified otherwise.
- C. Wire #8 and larger shall be stranded; #10 and smaller shall be solid. Wire and cable shall have THWN-THHN or XHHW insulation.
- D. Motor control circuits and signal wiring may be #14 if NEC requirements are met. Branch circuits longer than 75' feet for 120 V and 175 feet for 277 V shall be at least #10 from panel to last outlet.
- E. Wiring within light fixtures and other high-temperature equipment shall have 150 °C insulation as required by NEC.
- F. Splices and Terminations:
 1. Make splices in branch circuit wiring with UL-listed, solderless connectors rated 600 V, of sizes and types required by manufacturer's recommendations with temperature ratings equal to those of wires. Splice connectors shall be screw-on. Insulate splices with integral covers or with plastic or rubber friction tape to preserve characteristics of wire and cable insulation.
 2. Provide standard bolt-on lugs with hex screws to attach copper wire and cable to panelboards, switchboards, disconnect switches and electrical equipment.

3. Make terminations and splices for conductors #6 and larger with corrosion-resistant, high-conductivity pressure indent, hex screw or bolt-clamp connectors, with or without tongues, designed specifically for intended service. Connectors for cables 250 MCM and larger shall have two clamping elements or compression indents. Terminals for bus connections shall have two bolt holes.
4. Ampacity of splices and connectors shall be equal to those of associated wires and cables.

G. Arc-proofing:

1. Provide flexible, flame-retardant, organic-composition-coated elastomer arc-proofing tape on power cable in manholes and handholes, suitable to withstand 200 A arc for 30 seconds. Tape shall be self-extinguishing and shall not support combustion.
2. Apply tape in single, half-lapped layer as required by manufacturer's recommendations. Secure with strips of red plastic film tape on 208Y/120V conductors and yellow plastic film tape on 408Y/277V conductors.

H. Provide three-ply marlin twine lacing or self-extinguishing nylon straps with -65 to 350 ° F range for bundling conductors.

2.04 FEEDER IDENTIFICATION

- A. Provide nonferrous identifying tags or pressure-sensitive labels for cables, feeders, and power circuits in pull boxes, manholes and switchboard rooms, at cable termination and in other locations.
- B. Tags or labels shall be stamped or printed to correspond with markings on Drawings or marked so that feeder or cable may be identified readily. If suspended tags are provided, attach with 1/32 inch diameter nylon 55-pound test monofilament line or slip-free plastic cable lacing unit.

2.05 COLOR CODING

A. Color code secondary service, feeders and branch circuit conductors as follows:

<u>208/120 Volts</u>	<u>Phase</u>	<u>480/277 Volts</u>
Black	A	Brown
Red	B	Orange
Blue	C	Yellow
White	Neutral	Gray
Green	Ground	Green

B. Colors shall be factory-applied entire length of conductors by one of the following methods except as noted and limited below:

1. solid color compound,
 2. solid color coating,
 3. colored stripping (2 stripes 180 degrees apart),
 4. colored bands or hash marks with maximum spacing of 18 inches,
 5. colored fibrous covering, or
 6. surface printing every 12 inches, maximum spacing of 18 inches.
- C. Branch circuit conductors #12 and #10 shall have solid color compound, solid color coating. Neutrals and equipment grounds shall have solid compound or solid color coating (white, gray and green), except that neutrals with colored stripe shall be used where required by NEC. Conductors #8 and larger with stripes, bands or hash marks shall have background color other than white, green and gray.
- D. Solid color coating, stripes, bands or hash marks shall be strongly adherent paint or dye, sufficiently wide and clear to be readily distinguishable after installation.
- E. Alternative field-applied color coding methods may be used for wire #10 or larger, with color code specified in Subparagraph A:
1. Apply $\frac{3}{4}$ inches colored pressure-sensitive plastic tape in half overlapping turns for 6 inches from all terminal points and in boxes in which splices or taps are made. Apply last two laps of tape with no tension. Do not cover cable identification markings.
 2. Identify with nylon, self-extinguishing, self-locking colored cable ties. Ties shall accommodate wire sizes $\frac{1}{16}$ inches through $1\frac{3}{4}$ inches in diameter and shall not be less than 0.18 inches wide. Minimum tensile strength shall be at least 50 lbs. Temperature range shall be -65 degrees F to +350 degrees F. Provide three ties to each wire at each terminal point starting 3 inches from terminal and spaced 3 inches apart and three ties to each wire in boxes where splices or taps are made with special tool or pliers, and cut off excess.

2.06 WIRE PULLING EQUIPMENT

- A. Provide polyethylene ropes for pulling wire.
- B. Provide fish wires in telephone conduits and other empty conduit systems required, without splices and with ample exposed lengths at each end.
- C. Provide wire pulling lubricants that meet applicable UL requirements as necessary.

2.07 CABLE SUPPORTS AND BOXES

- A. Provide cable supports and boxes for vertical feeders as required by NEC. Boxes shall be 10 gauge steel plates fastened to angle iron frame with removable covers secured with brass machine screws.
- B. Provide split wedge cable supports with clamps for cable without metallic sheath. Provide basket weave or approved equal cable supports approved by cable manufacturer for cable with metallic sheath. Supports shall be by O.Z./Gedney or approved equal.

2.08 SAFETY DISCONNECT SWITCHES

- A. Provide quick-make/quick-break safety switches: Type HD, heavy duty, Class 3, Design 3, unless specified otherwise. Provide NEMA 1 or NEMA 12 enclosure for dry applications and NEMA 3R for wet. Switches shall be rated 240 or 600 V minimum as required for voltage of associated circuit and shall be rated in horsepower. Fuses shall interrupt locked rotor current of associated motor or ten times full rates load current, whichever is greater.
- B. Mount switch parts on insulating bases to facilitate replacement from front of switch. Current-carrying parts shall be high-conductivity copper. Contacts shall be silver-tungsten or plated. Provide positive pressure fuse clips and switch operating mechanism suitable for continuous use at rated capacity without auxiliary springs in current path.
- C. Switches shall withstand available fault current or let-through current before operating, without damage or rating change.

2.09 FUSES

- A. Provide current-limiting, high-interrupting-capacity fuses for equipment provided under this and other Sections. Except as specified otherwise, provide 10% spares at least three of each size, in cabinet in main electric room. Cabinet trim shall match that of panelboard trim. Coordinate with equipment manufacturers and with work of other Sections.
- B. Fuses larger than 600 A shall be Class L time delay Bussman KRP-C or approved equal. Fuses 600 A and smaller that serve motors, fusible circuit breaker panelboards and transformers shall be dual-element current limiting Class RKI or approved equal.
- C. Submit specific fuse locations, types, manufacturers and ratings. Test data will be waived if fuses are products of single manufacturer and selectivity is substantiated by published catalog data. Provide data for short circuit and protection coordination study as directed.
- D. Switch sizes and fuse ratings shown on Drawings and specified represent general approximate values for each motor hp delineated. Coordinate fuse values with motor switch sizes. Obtain recommended fuse rating data from fuse manufacturer. In case of discrepancy between Contract Documents and manufacturer's recommendations, manufacturer's recommendations shall govern work. Revise switch sizes to accommodate recommended fuse values and revise assembled equipment as necessary. Furnish necessary change information to equipment manufacturers. Submit changes in switch sizes to Architect for approval. Certify that motor circuits have adequate short circuit protection with fuses provided.

2.10 PANELBOARDS

- A. Provide UL-listed safety dead-front lighting and power panelboards where shown on Drawings and as scheduled. Panelboards shall meet or exceed requirements of NEMA Standard Publication PB-1, and UL-50 and 67. Provide cabinets with flush hinges and combination catch and lock. Provide wiring gutters to accommodate large multiple feeder cables and lugs. Except as shown otherwise on Drawings, wiring gutters shall be at least 4 inch for lighting and 208 V panels and 6 inch for 480 V panels.
- B. Where two section panels are required, bolt boxes together to form one unit. Trim shall be two-piece construction with doors of equal size over each section.
- C. Provide molded case, bolt-on, thermal-magnetic trip, single, two or three pole branch circuit breakers as shown on Drawings. Multiple pole breakers shall be single handle, common-trip. All circuit breakers shall be rated for switching purposes.
- D. Main bus work of panels shall carry at least full rating of feeder overcurrent device that supplies panel.
- E. Panel separate equipment ground bus for each panelboard. Ground bus shall be insulated from panel enclosure where isolated ground bus is indicated on the drawings.
- F. Power and lighting panels shall have heavy-duty, continuous, section vertical-hinged to box section for access to wiring gutters in addition to trim door.
- G. Panelboards shall have integrated short circuit current rating equal to or greater than circuit breaker AIC ratings schedule on Drawings.
- H. Panels shall be by Square D, Type NQOB for 225 A and below, and I-line distribution for 400 A and above, or equal by Siemens, Cutler Hammer, or General Electric.
- I. Provide surface metal tubs ready for painting.
- J. Provide bus connections for future overcurrent device with suitable insulation and bracing to maintain proper short circuit rating and voltage clearances, where required on Drawings. Provide for ready insertion of future breaker.
- K. Main bus bars shall be copper, sized as required by UL standards to limit temperature rise on current-carrying parts to 50 degrees C above ambient 40 degrees C maximum.
- L. Provide ½ inch spacers for panelboards mounted at exterior walls below grade to establish ½ inch air space behind panel.
- M. Provide typed panel directories that show use of each circuit and electrical characteristics of panelboard. Directory shall be mounted inside of each panelboard within clear plastic cover.

2.11 AUTOMATIC TRANSFER SWITCHES

- A. Automatic transfer switches shall be 4-pole and consist of power transfer module and control module, interconnected to provide complete automatic operation. Automatic transfer switches shall be mechanically held and electrically operated by single-solenoid mechanism energized from source to which load is to be transferred. Switches shall be rated for continuous duty and shall be inherently double throw. Switches shall be mechanically interlocked to ensure only one of two possible positions: normal or emergency. Automatic transfer switches shall be suitable for use with engine- or turbine-driven emergency generator or other utility source.
- B. Main contacts shall be silver protected by arcing contacts 400 A and over. Contacts shall be blow-on configuration and segmented or brush construction in ratings 600 A and over. Operating transfer time in either direction shall not exceed one-sixth of one second.
- C. Contacts, coils, springs and control elements shall be removable from front of transfer switch without major disassembly or disconnection of power conductors.
- D. Control module shall have protective cover and shall be mounted separately from transfer switch. Sensing and control logic shall be solid-mounted on plug-in printed circuit boards. Printed circuit boards shall be keyed to prevent incorrect installation. Provide industrial control grade plug-in interfacing relays with dust covers.
- E. Automatic transfer switches with components of molded-case circuit breakers, contactors or components not designed for continuous duty or repetitive load transfer switching will not be accepted. Circuit breaker switches will not be accepted.
- F. Automatic transfer switches shall meet NEMA ICS 2-447 and UL-1008 standards and shall be UL-listed for use in emergency systems in accordance with NEC Articles 517 and 700, and rated in amperes for total system transfer including control of motors, electric-discharge lamps, electric-heating and tungsten-filament lamp loads as specified in Paragraph 30.9 of UL-1008.
- G. Transfer switches rated 400 A and less shall be suitable for 100% tungsten-filament lamp load. Switches rated above 400 A shall be suitable for 30% or 400 A tungsten-filament lamp load, whichever is higher.
- H. Automatic transfer switches shall be rated to withstand rms symmetrical short circuit current available at automatic transfer switch terminals.
- I. Operation: Automatic transfer switch control panel shall use solid-state sensing on normal and emergency for automatic positive operation.
 - 1. Phases of normal shall be monitored line-to-line. Provide close differential voltage sensing. Pickup voltage shall be adjustable from 85% to 100% of nominal; dropout voltage shall be adjustable from 75% to 98% of pickup value. Transfer to emergency shall be initiated upon reduction of normal source to 85% of nominal voltage and retransfer to normal shall occur when normal source reaches 95% of nominal.

2. Time delay to override momentary normal source outages shall delay transfer switch signals and engine starting signals. Time delay shall be field-adjustable from 0.5 to 6 seconds and factory set at 1 second.
 3. Time delay on retransfer to normal source shall be bypassed automatically if emergency source fails and normal source is available. Time delay shall be field-adjustable from 0 to 30 minutes.
 4. Unloaded running time delay for emergency generator cool-down shall be field-adjustable from 0 to 5 minutes.
 5. Time delay on transfer to emergency shall be field-adjustable from 0 to 5 minutes for controlled timing of load transfer to emergency, where indicated.
 6. Independent single phase voltage and frequency sensing of emergency source: 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 shall occur upon normal source failure when emergency source voltage is 90% or more of nominal and frequency is 95% or more of nominal.
 7. Provide gold-plated contact that opens when normal source fails for initiating engine starting, rated 10 A, 32 V DC.
 8. Provide white signal light to indicate when automatic transfer switch is connected to normal source, and yellow signal light to indicate when automatic transfer switch is connected to emergency source.
 9. Provide three auxiliary contacts that are closed when automatic transfer switch is connected to normal and two auxiliary contacts that are closed when automatic transfer switch is connected to emergency. Contacts shall be rated 10 A, 480 V AC, 60 Hz.
- J. Provide engine generator exercising timer adjustable in 15-minute increments.
- K. Provide switches in NEMA 1 locking cabinet.
- L. Transfer switches shall be by generator manufacturer or approved equal.
- M. Program Transition Motor Transfer:
1. Transfer switch shall be double-throw activated by electrical operators energized momentarily and connected to transfer mechanism with over-center linkage. Minimum transfer time shall be 400 milliseconds.
 2. Provide for time delay between opening closed contacts and closing open contacts sufficient to demagnetize loads.
 3. Motor and transformer loads shall be re-energized with normal in-rush current after transfer.

4. Switch shall transfer in either direction with 70% rated voltage applied to terminals.

2.12 UPS SYSTEM CHARACTERISTICS

A. System Capacity: The system shall be rated in the following sizes:

1. 20kVA /16kW

B. Input:

1. AC Input Nominal Voltage: 208V, 3 Phase, 4 wire plus ground, 60 Hz.
2. AC Input Voltage Window: +/-15% of nominal (while providing nominal charging to the battery system).
3. Short Circuit Withstand Rating: 30,000 Symmetrical Amperes
4. Maximum Frequency Range: 40-70Hz
5. Input Power Factor:
 - a. .98 for loads greater than 50%
6. Input Current Distortion with no additional filters:
 - a. < 5% at 100% load
7. Soft-Start: Shall be linear from 0-100% input current and shall not exhibit inrush. This shall take place over a 15 second time period when transferring from battery operation to mains operation

C. UPS Output:

1. AC Output Nominal Output: 208V, 3 Phase, 4 wire plus ground, 60 Hz.
2. AC Output Voltage Regulation: +/- 1% For 100 % Linear or Nonlinear Load, +/- 5% maximum for 100% linear load step
3. Voltage Transient Recovery within <50 milliseconds
4. Output Voltage Harmonic Distortion:
 - a. <2% THD maximum for a 100% linear load
 - b. <5% THD maximum for a 100% non-linear load
5. Phase Angle Displacement:
 - a. 120 degrees +/- 1 degree for balanced load

- b. 120 degrees +/- 1 degrees for 50% imbalanced load
- c. 120 degrees +/- 3 degrees for 100% imbalanced load

6. Overload Rating:

- a. Normal Operation:
 - 1) 150% for 30 seconds
 - 2) 100% continuous
- b. Bypass Operation:
 - 1) 110% continuous

- 7. System AC-AC Efficiency: >98% for loads higher than 50% of rated system capacity
- 8. Output Power Factor Rating: .5 leading to .5 lagging.

D. UPS Modes of Operation

- 1. Normal: The input converter and output inverter shall operate in an on-line manner to continuously regulate power to the critical load. The input and output converters shall be capable of full battery recharge while simultaneously providing regulated power to the load for all line and load conditions within the range of the UPS specifications.
- 2. Battery: Upon failure of the AC input source, the critical load shall continue being supplied by the output inverter, which shall derive its power from the battery system. There shall be no interruption in power to the critical load during both transfers to battery operation and retransfers from battery to normal operation.
- 3. Static Bypass: The static bypass shall be used to provide transfer of critical load from the Inverter output to the bypass source. This transfer, along with its retransfer, shall take place with no power interruption to the critical load. In the event of an emergency, this transfer shall be an automatic function. The UPS will be capable of charging the batteries while in static bypass.
- 4. Internal Mechanical Bypass: As a standard feature, the UPS shall be equipped with an internal, make before break, bypass switch. This switch shall mechanically bypass the UPS for times where maintenance is required.

E. Environmental

- 1. Storage Ambient Temperature: -58°F to 122°F (-50°C to 50°C).

2. Operating Ambient Temperature: +32°F to 104°F (0°C to 40°C). (77°F is ideal for most battery types).
 3. Relative Humidity: 0 to 95% Non-condensing
 4. Altitude: Maximum installation with no derating of the UPS output shall be 3280 feet (1000m) above sea level. At higher altitudes the following derating shall apply:
 - a. 1500 m derating factor of .95
 - b. 2000 m derating factor of .91
 - c. 2500 m derating factor of .86
- F. Audible Noise: The UPS shall not produce audible noise at a distance of 1m (39”) in excess of the following:
1. 20-30kVA 67dBA
- G. Input Power Converter
1. The input power converters of the system shall constantly control the power imported from the mains input of the system, to provide the necessary UPS power for precise regulation of the DC bus voltage, battery charging, and Main Inverter regulated output power..
 2. Input Current Total Harmonic Distortion: The input current THDI shall be held to 5% or less at full system, while providing conditioned power to the critical load bus, and charging the batteries under steady-state operating conditions. This shall be true while supporting loads of both a linear or non-linear type. This shall be accomplished with no additional filters, magnetic devices, or other components.
 3. Soft-Start Operation: As a standard feature, the UPS shall contain soft-start functionality, capable of limiting the input current from 0-100% of the nominal input over a default 15 second period, when returning to the AC utility source from battery operation. The change in current over the change in time shall take place in a linear manner throughout the entire operation. (di/dt= constant)
 4. Magnetization Inrush Current: The UPS shall exhibit 0 inrush current as a standard product. If provided with an optional isolation transformer, inrush shall be limited to 6 times the nominal input current of the transformer.
 5. Input Current Limit:
 6. The system input current limit, shall be designed to provide 100% load will fully charging the batteries at 10% of the system rating. The system shall be capable of this with up to a +/-15% variation of the nominal input voltage.

H. Charging:

1. The battery charging shall keep the DC bus float voltage of +/- 220v, +/-1%
2. The battery charging circuit shall contain a temperature compensation circuit, which will regulate the battery charging to optimize battery life.
3. The battery charging circuit shall remain active when in Static Bypass and in Normal Operation.
4. Battery Charge Current Limit: The UPS shall be capable of limiting the energy sourced from the mains for purposes of battery charging. As a default setting, the battery charge energy will be set to 100% of its nominal value. When signaled by a dry contact, (such as from an emergency generator) the UPS shall be capable of limiting the battery charge energy taken from the mains. This shall take place in user selectable increments of 75%, 50%, 25%, 10% and 0% of the nominal charge power. The selection shall be made from the UPS front panel display/control unit.
5. Back-feed Protection: The logic controlled input contactor shall provide the back-feed protection required by UL1778.

I. Output Inverter

1. The UPS output inverter shall constantly recreate the UPS output voltage waveform by converting the DC bus voltage to AC voltage through a set of IGBT driven power converters. In both normal operation and battery operation, the output inverters shall create an output voltage independent of the mains input voltage. Input voltage anomalies such as brown-outs, spikes, surges, sags, and outages shall not affect the amplitude or sinusoidal nature of the recreated output voltage sine wave of the output inverters.
2. Overload Capability: Steady-state overload conditions of up to 150% of system capacity shall be sustained by the inverter for 30 seconds in normal and battery operation. Overloads of 125% shall be sustainable by the inverter for up to 60 seconds. Should overloads persist past the time limitation, the critical load will be switched to the automatic static bypass output of the UPS.
3. Output Contactor: The output inverter shall be provided with an output mechanical contactor to provide physical isolation of the inverter from the critical bus. With this feature a failed inverter shall be removed from the critical bus.
4. Battery Protection: The inverter shall be provided with monitoring and control circuits to limit the level of discharge on the battery system.

J. Static Bypass

1. As part of the UPS, a system static bypass switch shall be provided. The system static bypass shall provide no break transfer of the critical load from the Inverter output to the static bypass input source during times where maintenance is required or the inverter can not support the critical bus. Such times may be due to prolonged or severe overloads or UPS failure.
 2. The design of the static switch power path shall consist of Silicon Controlled Rectifiers (SCR) with a continuous duty rating of 110% of the UPS output rating.
 3. Automatic Transfers: An automatic transfer of load to static bypass shall take place whenever the load on the critical bus exceeds the overload rating of the UPS. Automatic transfers of the critical load from static bypass back to normal operation shall take place when the overload condition is removed from the critical bus output of the system. Automatic transfers of load to static bypass shall also take place if for any reason the UPS cannot support the critical bus.
 4. Manual Transfers: Manually initiated transfers to and from static bypass shall be initiated through the UPS display interface.
 5. Overloads: The static bypass shall be rated and capable of handling overloads equal to or less than 110% of the rated system output continuously. For instantaneous overloads caused by inrush current from magnetic devices or short circuit conditions, the static bypass shall be capable of sustaining overloads of 800% of system capacity for periods of up to 500 milliseconds.
 6. System Protection:
 - a. As a requirement of UL1778, back-feed protection in the static bypass circuit shall also be incorporated in the system design. To achieve back-feed protection, a mechanical contactor in series with the bypass SCR(s) shall be controlled by the UPS/static switch, to open immediately upon sensing a condition where back-feeding of the static switch by any source connected to the critical output bus of the system is occurring. One such condition could be a result of a shorted SCR.
 7. Dual Feed
 - a. For purposes of increased reliability, the static bypass shall be capable of being fed from a separate feed from the input power converter.
- K. Display and Controls
1. Display Unit: A microprocessor controlled display unit shall be located on the front of the system. The display shall consist of an alphanumeric display with backlight, an alarm LED, and a keypad consisting of pushbutton switches.
 2. Metered Data: The following metered data, shall be available on the alphanumeric display:

- a. Year, Month, Day, Hour, Minute, Second of occurring events
 - b. Source Input Voltage
 - c. Output AC voltage
 - d. Output AC current
 - e. Input Frequency
 - f. Battery voltage
 - g. Highest Internal Battery temperature
3. Event log: The display unit shall allow the user to display a time and date stamped log of the 64 most recent status and alarm events.
4. Alarms: The display unit shall allow the user to display a log of all active alarms. The following minimum set of alarm conditions shall be available:
- a. Static bypass switch on
 - b. EPO Active
 - c. Mechanical bypass activated
 - d. External bypass switch (Q3) activated
 - e. Battery discharged
 - f. Return from low battery
 - g. Low battery
 - h. Load not powered from UPS
 - i. UPS in bypass
 - j. Runtime calibration aborted
 - k. Runtime calibration started
 - l. Runtime calibration complete
 - m. Battery self test aborted
 - n. Battery self test started
 - o. Battery self test completed

- p. Number of battery modules decreased
 - q. Number of battery modules increased
 - r. Fan fault
 - s. SBS fault
 - t. System not in sync.
 - u. Bypass not available, frequency/voltage out of range
 - v. Mains voltage/frequency out of range
 - w. Site wiring fault
 - x. Low battery voltage shut down
 - y. XR battery breaker or fuse open
 - z. Defective battery detected
 - aa. Runtime is below alarm threshold
 - bb. Load is above alarm threshold
 - cc. Battery over-voltage warning
 - dd. Battery over-temperature warning
 - ee. Emergency power supply fault
 - ff. Output overloaded
5. Controls: The following controls or programming functions shall be accomplished by use of the display unit. Pushbutton membrane switches shall facilitate these operations.
- a. Silence audible Alarm
 - b. Set the alphanumeric display language
 - c. Display or set the date and time
 - d. Enable or disable the automatic restart feature
 - e. Transfer critical load to and from static bypass
 - f. Test battery condition on demand

- g. Set intervals for automatic battery tests
 - h. Adjust set points for different alarms
 - i. Program the parameters for remote shutdown.
6. Front Panel Interface: The following shall make up the UPS front panel user interface.
- a. Indicating LED's
 - 1) Load On When Green, this LED indicates the load is being supported by the UPS output
 - 2) On Battery When Yellow, this LED indicates the UPS is running from Battery power
 - 3) Bypass When Yellow, this LED indicates the load is being supported by static bypass/mechanical bypass
 - 4) Fault When Red, this LED indicates there is a fault condition present in the UPS.
 - b. Push Button User Controls
 - 1) Up Arrow
 - 2) Down Arrow
 - 3) Help Key
 - 4) Escape Key
 - 5) Enter Key
7. Potential Free (Dry) Contacts
- a. The following potential free contacts shall be available on an optional relay interface board (AP9610 or equivalent). (Note: This may require the use of an external chassis if used in conjunction with web based management or other “smart slot” type devices):
 - 1) Normal Operation
 - 2) Battery Operation
 - 3) Bypass Operation
 - 4) Common Fault

- 5) Low Battery
 - 6) UPS Off
8. Communication Interface: For purposes of remote communications with the UPS the following shall be available and contained within the UPS on a removable, “hot swappable” “smart slot” interface card:
- a. RJ-45 Interface port for remote communications with a network via web browser or SNMP, or APC InfraStruXure Manager.
 - b. Environmental monitoring feature, capable of locally monitoring temperature and humidity as well as one additional generic set of user determined dry contacts capable of taking an input signal from any APC or third party on/off signal, such as water detection, smoke detection, motion, or fire detection.

L. Battery

1. The UPS battery shall be of modular construction made up of user replaceable, hot swappable, fused, battery modules. Each battery module shall be monitored for voltage and temperature for use by the UPS battery diagnostic, and temperature compensated charger circuitry.
2. The battery jars housed within each removable battery module shall be of the Valve Regulated Lead Acid (VRLA) type.

2.13 SCAFFOLDS AND STAGING

- A. General: Filed Subcontractors shall obtain required permits for, and provide scaffolds, staging, and other similar raised platforms, required to access their Work as specified in Section 01 50 00 - TEMPORARY FACILITIES AND CONTROLS and herein.
1. Scaffolding and staging required for use by this Filed Subcontractor pursuant to requirements of Section 01 50 00 - TEMPORARY FACILITIES AND CONTROLS shall be furnished, erected, maintained in a safe condition, and dismantled when no longer required, by this Filed Sub-Trade requiring such scaffolding.
 2. Each Filed Subcontractor is responsible to provide, maintain and remove at dismantling, all tarpaulins and similar protective measures necessary to cover scaffolding for inclement weather conditions other than those required to be provided, maintained and removed by the General Contractor pursuant to MGL (Refer to Section 01 50 00 - TEMPORARY FACILITIES AND CONTROLS and as additionally required for dust control).
 3. Furnishing portable ladders and mobile platforms of all required heights, which may be necessary to perform the work of this trade, are the responsibility this Filed Subcontractor.

2.14 HOISTING MACHINERY AND EQUIPMENT

- A. All hoisting equipment, rigging equipment, crane services and lift machinery required for the work by this Filed Subcontractor shall be furnished, installed, operated and maintained in safe conditions by this Filed Subcontractor, as referenced under Section 01 50 00 - TEMPORARY FACILITIES AND CONTROLS.

2.15 SOFTWARE AND CONNECTIVITY

- A. Network Adaptor: The Ethernet Web/SNMP Adaptor shall allow one or more network management systems (NMS) to monitor and manage the UPS in TCP/IP network environments. The management information base (MIB) shall be provided in DOS and UNIX "tar" formats. The SNMP interface adaptor shall be connected to the UPS via the RS232 serial port on the standard communication interface board.
- B. Unattended Shutdown
 - 1. The System, in conjunction with a network interface card, shall be capable of gracefully shutting down one or more operating systems during when the UPS is on reserve mode.
 - 2. The System shall also be capable of using an RS232 port to communicate by means of serial communications to gracefully shut down one or more operating systems during an on battery situation.

2.16 REMOTE SYSTEM MONITORING

- A. The following three methods of remote UPS monitoring shall be available:
 - 1. Web Monitoring: Remote monitoring shall be available via a web browser such as Internet Explorer.
 - 2. RS232 Monitoring: Remote UPS monitoring shall be possible via either RS232 or contact closure signals from the UPS.
 - 3. Simple Network Management Protocol (SNMP): Remote UPS Monitoring shall be possible through a standard MIB II compliant platform.

PART 3 - EXECUTION

3.00 MATERIALS AND WORKMANSHIP

- A. Work shall be executed in workmanlike manner and shall present neat, rectilinear and mechanical appearance when completed. Maintain maximum headroom at all times. Do not run pipes and ducts exposed unless shown exposed on drawings. Material and equipment shall be new and installed according to manufacturer's recommended best practice so that completed installation shall operate safely and efficiently.

3.01 CONTINUITY OF SERVICES

- A. Do not interrupt existing services to existing building without Owner's and Architect's approvals.

3.02 SPECIAL RESPONSIBILITIES

- A. Coordinate work of this Section with work of other Sections.
 - 1. Provide information about items furnished under this Section to be installed under other Sections, as necessary.
 - 2. Obtain detailed information from manufacturers of equipment provided under this Section as to proper methods of installation.
 - 3. Obtain final roughing dimensions and other information as needed for complete installation of items furnished under other Sections or by Owner.
 - 4. Keep fully informed of shape, size and position of openings required for material and equipment provided under this and other Sections. Ensure that openings required for work of this Section are coordinated with work of other Sections. Provide cutting and patching as necessary.

3.03 TESTING, INSPECTION AND CLEANING

- A. Test and inspect work provided under this Section as required by Contract Documents, codes, standards and authorities that have jurisdiction, to satisfaction of Architect. Notify Architect and authorities at least 48 hours before testing or inspection. Do not cover work before testing or inspection.
- B. Furnish Architect with certificates of testing and inspection for electrical systems, indicating approval of authorities that have jurisdiction and conformance with requirements of Contract Documents.
- C. Test wiring and connections for continuity and grounds before fixtures are connected; demonstrate insulation resistance by megger test as required. Insulation resistance between conductors and grounds for secondary distributions systems shall meet NEC requirements.
- D. Verify and correct as necessary: voltages, tap settings, trip settings and phasing on equipment from secondary distribution system to points of use. Test secondary voltages at bus in main switchboard, at panelboards, and at other locations on distribution systems as necessary. Test secondary voltages under no-load and full-load conditions.
- E. Test lighting fixtures with specified lamps in place for 10 hours; check fixtures in sections. Do not operate lamps other than for testing before final inspection by Architect. Replace lamps that fail within 90 days after acceptance by Architect within Contract Price.
- F. Provide necessary testing equipment and testing.

- G. Failure or defects in workmanship or materials revealed by tests or inspection shall be corrected promptly and retested. Replace defective material.
- H. Perform high potential DC test on 15 kV equipment and cable as specified and as required by local electric company. Provide services of approved independent testing company, in presence of Architect, Owner and local electric company.
- I. Clean switchboard, panels, generator and other equipment. Panelboard interiors shall be cleaned and vacuumed. Equipment with damage to painted finish shall be repaired to Architect's satisfaction.
- J. After completion of project, clean the exterior surface of equipment included in this section, including concrete residue.

3.04 NAMEPLATES

- A. Provide nameplates in or on panelboards, junction boxes and cabinets, and for special purpose switches, motor disconnect switches, remote control stations, starters or other controls furnished or installed under this Section. Nameplates shall designate equipment controlled and function.
- B. Nameplates shall be laminated black bakelite with ¼ inch high white recessed letters. Nameplates shall be securely attached to the equipment with galvanized screws. Adhesives or cements shall not be used.

3.05 WIRING METHODS

- A. Install wire and cable in approved raceways as specified and as approved by authorities that have jurisdiction. Surface metal raceways shall not be used unless explicitly specified and shown on Drawings. Do not use surface raceways on floor. Do not use armored cable except as approved by local code for lighting and receptacle circuits in suspended ceilings and stud-wall partitions. Homeruns for lighting circuits shall be 3-phase, 4-wire run in conduit.
- B. Wire from point of service connection to receptacles, lighting fixtures, devices, equipment, outlets for future extension, and other electrical apparatus as shown on Drawings. Provide slack wire for connections. Tape ends of wires and provide blank covers for outlet boxes designated for future use.
- C. Conductors #10 and smaller in branch circuit panelboards, signal cabinets, signal control boards, switchboards and motor control centers shall be bundled. Conductors larger than #10 in switchboards, motor control centers and pull boxes shall be cabled in individual circuits.
- D. Two or more conduits installed instead of single conduit shall contain duplicate conductors, including neutrals and ground conductors where required; total capacity of duplicate conductors shall be at least equal to capacity of conductors replaced.

- E. Follow homerun circuit numbers shown on Drawings to connect circuits to panelboards. Where homerun circuit numbers are not shown on Drawings, divide similar types of connected loads among phase buses so that currents are approximately equal in normal usage. Connect each branch circuit homerun with two or more circuits and common neutral to circuit breaker or switch in three-wire or four-wire branch circuit panelboard so that no two circuits are fed from same bus. Where panelboard cabinets are recessed, provide conduits with sufficient capacity for future conductors for spare branch circuit protective devices and spaces in panelboard; stub up concealed to junction box. Provide extensions above ceiling.
- F. Electrical metallic tubing may be used generally, if approved by local codes, for lighting fixture and receptacle circuits, telephone, inter-communications, signal and instrumentation circuits, and for control circuits. EMT may be used generally, if approved by authorities, in masonry walls, above hung ceilings, in equipment rooms, in mechanical and electrical chases and closets, in exposed locations along ceilings or walls above normal traffic level and where not subject to accidental damage or abuse. Do not run EMT exposed below 8 feet above finished floor. Conduit below 8 feet – 0 inches AFF exposed shall be rigid steel.
- G. Install connectors and couplings as recommended by manufacturers. Compression fittings shall not be used with rigid steel, intermediate metallic or aluminum conduit. Set screw fittings shall not be used with rigid aluminum conduit and shall not be used for other applications, unless specified and approved by Architect. If set-screw connectors are used, tighten to imbed screws in conduit.
- H. Conduit in concrete shall be rigid steel. EMT shall not be installed underground, in slabs on grade, in wet locations, in hazardous areas, or for circuits operating at more than 600 V. Buried metallic conduit shall be rigid steel. Run conduit in slabs above bottom steel reinforcing, below top reinforcing and inside beam stirrup, wall reinforcements and column ties.
- I. Rigid non-metallic conduit as specified in Part 2 of this Section may be used, if approved by local authorities, for installation in concrete slabs when installed as required by NEC and manufacturer's requirements. Penetrations from concrete slabs shall be made with rigid steel conduit and rigid steel conduit fittings only.
- J. Maximum outside diameters of raceways in conduit shall be 1/3 slab thickness. No more than two ¾ inches raceways shall cross in floor slab at a single point. Submit raceway crossing locations for approval before pouring slabs and relocate at no expense to Owner as directed by Architect. Lateral spacing of parallel raceways shall be at least 6 inches on centers. Do not run conduit in slab less than 3 inches thick without express approval and direction of Architect.
- K. Raceways with outside diameters larger than 1/3 slab thickness shall be run concealed in hung ceilings in finished areas, exposed in unfinished Mechanical/Electrical and storage areas, below slabs on grade.

- L. Penetrate waterproof walls of structural slabs and foundation walls only where approved by Architect. Submit proposed penetration points, size openings and penetration methods to Architect for approval.
- M. Provide flexible conduits for connections to electrical equipment and to equipment furnished under other Divisions that are subject to movement, vibration or misalignment; where available space dictates; and where noise transmission must be eliminated or reduced. Flexible conduit shall be liquid-tight under following conditions:
 - 1. Exterior locations
 - 2. Moisture or humidity-laden atmospheres
 - 3. Corrosive atmospheres
 - 4. Where wash-down operations are possible
 - 5. Where seepage or dripping of oil, grease or water is possible
- N. Run concealed conduit and EMT in as direct lines as possible with minimum number of bends of longest possible radius. Run exposed conduit and EMT parallel to or at right angles to building lines. Ends shall be free from dents or flattening.
- O. Conduit and EMT runs shall be mechanically and electrically continuous from service entrance to outlets. Conduit shall enter and be secured to cabinet, junction box, pull box or outlet box with locknut outside and bushing inside, or with liquid-tight, threaded, self-locking, cold-weld wedge adapter. Provide additional locknut for rigid conduit and wrench-tighten locknut for EMT or flexible conduit where circuit voltage exceeds 250 V. Locknuts and bushings or self-locking adapters will not be required where conduits are screwed into tapped connections. Vertical conduit runs that terminate in bottoms of wall boxes or cabinets shall be protected from entrance of foreign material before installation of conductors.
- P. Size rigid steel conduit, EMT and flexible metallic conduit as required by NEC except as specified or shown on Drawings otherwise. Unless shown otherwise on Drawings, telephone conduits shall be at least 1 inch.
- Q. Check raceway sizes to determine that green equipment ground conductor fits in same raceway with phase and neutral conductors to meet NEC percentage of fill requirements. Increase duct, conduit, tubing and raceway sizes shown or specified as required to accommodate conductors.
- R. Unless specified or shown on Drawings otherwise, install conduit and EMT concealed. Unless specified or shown otherwise, conduit and EMT may be run exposed on unfinished walls and unfurred basement ceilings and in unfinished penthouses, attics and roof spaces. Provide stand-off clips for conduits on exterior masonry walls.
- S. Install conduit systems complete before drawing in conductors. Blow through and swab after plaster is finished and dry, and before conductors are installed.

- T. Expansion/Deflection Fittings: Conduit buried or secured rigidly on opposite sides of building expansion joints and long runs of exposed conduit subject to stress shall have expansion fittings. Fittings shall safely deflect and expand to twice distance of structural movement.
1. Provide separate external copper bonding jumper secured with grounding straps on each end of fitting.
 2. Conduits buried in concrete shall cross building expansion joints at right angles; provide expansion fittings as required by manufacturer's instructions. Provide insulated bushings at ends of conduits.
- U. Sealing Fittings: Threaded sealing fittings for rigid steel conduits shall be zinc- or cadmium-coated, cast or malleable iron; sealing fittings for aluminum conduit shall be threaded cast aluminum. Fittings that prevent passage of water vapor shall be continuous drain.
1. Install and seal fittings as required by manufacturer's recommendations. In concealed work, install fittings in flush steel box with blank cover plate.
 2. Install sealing fittings at following points, and elsewhere as shown:
 - a. Where conduits enter or leave hazardous areas equipped with explosion-proof lighting fixtures, switches, receptacles and other electrical devices.
 - b. Where conduits pass from warm to cold locations.
 - c. Where required by NEC.
 3. Secure conduit system as required by NEC.
- V. Attach pull ropes to conductors with basket-weave grips on pulling eyes. Pull cables that share conduit at same time.
- W. Provide inserts, hangers, anchors and steel supports as necessary.

3.06 GROUNDING

- A. Provide equipment grounding system as shown on Drawings. Equipment grounding system shall be designed so metallic structures, enclosures, raceways, junction boxes, outlet boxes, cabinets, machine frames, portable equipment and other conductive items in close proximity with electrical circuits operate continuously at ground potential and provide low impedance path for possible ground fault currents.
- B. System shall meet NEC requirements, modified as shown on Drawings and as specified.
- C. Provide separate green insulated equipment grounding conductor for each single or three-phase feeder and each branch circuit. Install grounding conductor in common conduit with

related phase or neutral conductors, or both. Parallel feeders installed in more than one raceway shall have individual full size green insulated equipment ground conductors.

- D. Determine numbers and sizes of screw terminals for equipment grounding bars in panelboards and other electrical equipment. Provide screw terminals for active circuits, spares and spaces.
- E. Provide green insulated grounding conductor in same raceway with associated phase conductors, as follows:
 - 1. From green ground terminals of receptacles to green 10-32 washer-in-head outlet box machine screw. (Receptacles with special cast boxes and factory-designed and approved ground path do not require separate ground jumper.)
 - 2. From green 10-32 washer-in-head machine screw in ceiling outlet box or junction box through flexible metallic conduit to ground terminal in fixture.
 - 3. From green 10-32 washer-in-head machine screw in ceiling outlet box or junction box through flexible metallic conduit to green 10-32 washer-in-head machine screw in switch outlet box in movable partitions.
 - 4. From green 10-32 washer-in-head machine screw in junction box or disconnect switch through flexible metallic conduit to ground terminal in connection box mounted on single phase fractional horsepower motor.
 - 5. From equipment ground bus in motor control center through conduit and flexible metallic conduit to ground terminal in connection box mounted on three-phase motor. Ground conductor motors with separate starters and disconnect devices shall originate at ground bar in panelboard and shall be bonded to each starter and disconnect device enclosure.
 - 6. From switchgear equipment ground bus to panelboard equipment ground bus.
 - 7. From switchgear equipment ground bar to equipment grounding bar on busway.
 - 8. From computer area power panel ground bar for branch circuits as required by NEC. No ground conductor circuit shall exceed 3 ohms resistance to building ground system.
- F. Provide green insulated grounding conductor in nonmetallic conduits or ducts unless specified otherwise.

3.07 COMMISSIONING:

- A. Electrical Sub-Contractor and all other Sub-Contractors required for the work of this Section shall provide all labor, materials and equipment required to assist with the building commissioning of this project in accordance with the requirements outlined in Division 01.

3.08 UPS SYSTEM

A. FACTORY ASSISTED START-UP

1. If a factory assisted UPS start-up is requested, factory trained service personnel shall perform the following inspections, test procedures, and on-site training:
 - a. Visual Inspection:
 - b. Inspect equipment for signs of damage.
 - c. Verify installation per manufacturer s instructions.
 - d. Inspect cabinets for foreign objects.
 - e. Inspect Battery Units.
 - f. Inspect Power Modules.
2. Mechanical Inspection:
 - a. Check all UPS and external maintenance bypass cabinet internal control wiring connections.
 - b. Check all UPS and external maintenance bypass cabinet internal power wiring connections.
 - c. Check all UPS and external maintenance bypass cabinet terminal screws, nuts, and/or spade lugs for tightness.
3. Electrical Inspection:
 - a. Verify correct input and bypass voltage.
 - b. Verify correct phase rotation of all mains connections.
 - c. Verify correct UPS control wiring and terminations.
 - d. Verify voltage of all battery modules.
 - e. Verify neutral and ground conductors are properly landed.
 - f. Inspect external maintenance bypass switch for proper terminations and phasing.
4. Site Testing:
 - a. Ensure proper system start-up.
 - b. Verify proper firmware control functions.
 - c. Verify proper firmware bypass operation.

- d. Verify proper maintenance bypass switch operation.
 - e. Verify system set points.
 - f. Verify proper inverter operation and regulation circuits.
 - g. Simulate utility power failure.
 - h. Verify proper charger operation.
 - i. Document, sign, and date all test results.
5. On-Site Operational Training: During the factory assisted start-up, operational training for site personnel shall include key pad operation, LED indicators, start-up and shutdown procedures, maintenance bypass and AC disconnect operation, and alarm information.

B. MANUFACTURER FIELD SERVICE

1. Worldwide service: The UPS manufacturer shall have a worldwide service organization available, consisting of factory trained field service personnel to perform start-up, preventative maintenance, and service of the UPS system and power equipment. The service organization shall offer 24 hours a day, 7 days a week, 365 days a year service support.
2. Replacement parts: Parts shall be available through the worldwide service organization 24 hours a day, 7 days a week, and 365 days a year. The worldwide service organization shall be capable of shipping parts within 4 working hours or on the next available flight, so that the parts may be delivered to the customer site within 24 hours.

C. MAINTENANCE CONTRACTS

1. A complete offering of preventative and full service maintenance contracts for the UPS system and the battery system shall be available. All contract work shall be performed by APC factory trained service personnel.

D. TRAINING

1. UPS service training workshop: A UPS service training workshop shall be available from the UPS manufacturer. The service training workshop shall include a combination of lecture and practical instruction with hands-on laboratory sessions. The service training workshop shall include instruction about safety procedures, UPS operational theory, sub-assembly identification and operation, system controls and adjustment, preventative maintenance, and troubleshooting.

END OF SECTION