

MEA No.: 181001

SECTION 16100 – ELECTRICAL - INTERIOR ELECTRICAL WORK

1.1 GENERAL

- A. All applicable requirements of Section 16000 - ELECTRICAL, GENERAL shall apply to this entire section and shall have the same force and effect as if fully included herein.

1.2 SCOPE

- A. This Section of the Specifications covers the furnishing of all labor, materials, equipment and services necessary for and incidental to the installation of all electrical equipment in this building.

1.3 MOUNTING HEIGHTS

- A. Unless otherwise noted, all mounting heights indicated on the Drawings shall be to the centerline of the wall box or device indicated except that devices with operable components including receptacles above and/or below the center line shall be adjusted as necessary so that the most extreme portion of the operable component for all operating positions is below 48 inches and above 15 inches. All device mounting heights shall be ADA compliant for front approach. Devices which protrude more than four-inches from the wall in any part of the means of egress shall be mounted such that the bottom of the device is 80 inches above finished floor.

1.4 LOCATION OF OUTLETS

- A. The Contractor shall verify location of all outlets before roughing in for same. The Owner or the Owner's Representative shall have the right to relocate any outlet on the project ten feet from the location indicated on the plans, prior to roughing in for same.
- B. Maintain a minimum horizontal spacing of 24 inches between all outlets on opposite sides of fire rated walls.
- C. No back-to-back outlets.

1.5 WIRING IN EXISTING BUILDING

- A. The Contractor shall disconnect and remove all existing wiring and electrical equipment in the existing building as indicated on the Drawings.
- B. Where devices and wiring are removed from existing junction boxes, the Contractor shall provide blank cover plates on boxes and knockout snap-in blanks in any open knockout holes.
- C. Where existing flush mounted panelboards are indicated to be removed, they shall have their interiors and covers removed. This Contractor shall provide a new blank cover on the backbox.
- D. It is the intent of this project to provide the Owner with a complete new wiring and conduit system. No existing conduit or wiring shall be retained or re-used unless shown otherwise or approved by the Owner's Representative.

1.6 CONDUIT & RACEWAY

- A. Wherever the terms "conduit" or "raceways" appear, it shall be understood to mean any one, or combination of, the following types:

1. Rigid Galvanized Steel Conduit (RGS)
 2. Intermediate Metal Conduit (IMC)
 3. Rigid Nonmetallic Conduit (PVC)
 4. Electrical Metallic Tubing (EMT)
 5. Flexible Metal Conduit (FMC)
 6. Liquid-Tight Flexible Metal Conduit
 7. Surface Metal Raceway (where specifically called for)
 8. Factory Wiring Assembly Systems (for use in concealed, above slab, areas only)
 9. Other conduits (where specifically called for)
- B. Use of conduit smaller than 3/4 inch trade size is not permitted unless part of a factory wiring assembly system or specifically called for.
- C. RGS, IMC or EMT shall be steel piping, zinc galvanized. It shall be of sufficient weight and toughness to withstand cracking and peeling during bending. RGS, IMC or EMT protected solely by enamel shall not be used.
- D. Only non-flexible types of "conduit" such as RGS, IMC, PVC, or EMT shall be permitted for installations for future wiring or wiring by others.
- E. Each piece of conduit shall be straight, free from blisters and other defects, cut square and taper reamed and shall be furnished in ten foot lengths, threaded at each end. Couplings shall be supplied at one end with a protective sleeve at the other end. All threads shall be cleanly cut. Each length shall bear the Underwriters' label.
- F. All conduit shall be manufactured to UL-6, UL-1242 or UL-797 and ANSI C80.1, ANSI C80.6 or ANSI C80.3 standards.
- 1.7 RIGID GALVANIZED STEEL CONDUIT
- A. The Contractor shall provide RGS conduit for the following applications:
1. In gravel or other sub-base floor fills
 2. Horizontal runs in concrete floor slabs
 3. In masonry walls below grade
 4. Vertical or horizontal runs in poured concrete walls
 5. Areas subject to severe physical damage, such as, but not limited to, mechanical equipment rooms/spaces or corridors with fork truck traffic
 6. Hazardous areas
 7. Areas with corrosive atmosphere

8. For support of fixtures or other equipment
9. On exposed exterior pipe bridges
10. Where RGS is called for on the Drawings
11. Where other types of conduit are not specifically required or permitted in these specifications

B. RGS conduit may be supplied in lieu of IMC, PVC or EMT for all applications.

C. RGS shall not be used:

1. Where other types of conduit are called for on the Drawings
2. For short sections where FMC is required for vibration isolation

1.8 INTERMEDIATE METAL CONDUIT

A. The Contractor may provide IMC in lieu of RGS for the following:

1. Horizontal runs in concrete floor slabs
2. In masonry walls below grade
3. Vertical or horizontal runs in poured concrete walls
4. Hazardous areas
5. Areas with corrosive atmosphere
6. On exposed exterior pipe bridges
7. For support of fixtures or other equipment

1.9 RIGID NONMETALLIC CONDUIT (PVC)

A. PVC conduit shall be provided for direct burial or encasement in concrete duct banks.

B. PVC conduit shall be composed of High Impact PVC, shall conform to industry standards and be UL listed for underground and exposed use.

C. Direct buried PVC conduit shall be Schedule 40. Concrete encased PVC conduit used for duct banks may be Schedule EB.

D. PVC conduit shall not be used for interior applications unless called for on the Drawings.

1.10 ELECTRICAL METALLIC TUBING

A. EMT shall be provided for the following applications, except where RGS, IMC, or PVC are required.

1. In masonry walls above grade

2. Concealed locations except in masonry walls below grade and in poured concrete walls and floors.
 3. Exposed interior locations
 4. Exposed exterior locations if RGS or IMC are not required by these specifications
 5. Higher than ten feet in corridors with fork truck traffic
- B. EMT shall not be used for the following applications:
1. Where RGS, IMC or PVC are required
 2. Areas subject to severe physical abuse
 3. Direct burial including burial in cinder fill
 4. Applications subject to galvanic action
- C. RGS or IMC shall be provided for any applications where EMT is prohibited.
- D. EMT applications shall have short lengths of FMC as required for vibration isolation and to allow movement of lighting fixtures.
- E. Concealed conduit shall be EMT except where factory wiring assembly systems are permitted.

1.11 FLEXIBLE METAL CONDUIT

- A. Flexible metallic steel conduit shall be provided for connection to motors, transformers, and other equipment subject to vibration, noise transmission or movement and to recessed lighting fixtures as short whips. This flexible conduit, unless otherwise noted, shall be of the same size as the conduit to which it is connected and shall be bonded. Connection to motors, transformers and other high vibration producing equipment shall not exceed 18 inches in length. Half inch flexible metallic conduit may be used for "fixture whip" final connections to lighting fixtures. Fixture whips shall not exceed 72 inches in length. Where used at wet or damp locations, the flexible conduit shall have an outer, listed liquid-tight, corrosion resistant, plastic coating.
- B. All flexible metallic steel conduits shall be terminated in squeeze type connectors with insulated throats. Connectors shall use two-screw tightening configuration on conduit one inch and above. Where liquid-tight flexible conduit is used, connector shall include screw-in metal ferrules and insulated throats.
- C. Flexible metallic conduit shall not be utilized as part of the "Grounding System." An insulated grounding conductor shall be used at all locations where flexible metallic conduit is installed.

1.12 FACTORY WIRING ASSEMBLY SYSTEMS

- A. Factory wiring assembly systems, such as Type MC cable, are a factory assembly of one or more conductors, each individually insulated and enclosed in a metallic sheath of interlocking tape or smooth or corrugated tube.
- B. The Contractor may provide factory wiring assembly systems for all interior wiring AWG #8 and smaller which is concealed in non-masonry walls above slab and concealed above ceilings,

unless otherwise required to be run in RGS, EMT or other raceway. Type MC AWG #12 shall be the minimum size wiring used.

- C. Factory wiring assembly systems (MC cable) shall not be used for exposed applications.
- D. Where used in health care facilities, MC cable shall have an outer sheath approved for use as a grounding conductor in addition to the separate isolated green grounding conductor.
- E. MC cable shall not be used for any hospital emergency system circuit.
- F. MC cable shall be rated 600V and shall have galvanized steel interlocking armor, copper THHN insulated conductors and a green insulated grounding conductor. MC cable shall be provided with UL listed MC cable fittings and connectors.
- G. Type MC cable shall be supported and secured at intervals not exceeding six feet and shall be secured within 12 inches from every outlet box, junction box, cabinet or fitting. MC cable shall not be supported from the ceiling system or wires nor shall it rest on or drape over the ceiling tiles.
- H. MC cable shall be permitted to be fished into walls and ceilings of existing finished buildings without being supported.

1.13 CONDUIT INSTALLATION - STEEL

- A. The conduit system shall be concealed in the construction except in rooms used exclusively to house mechanical and electrical equipment or in portions of the building where it is impractical. However, at these locations the conduit shall be installed as inconspicuously as possible and in a manner as approved by the Owner's Representative.
- B. Conduits in masonry walls shall be run in core of blocks. The Contractor shall cooperate and coordinate his work with the Masonry Contractor to prevent any cutting or chasing after installation of the masonry walls.
- C. In the existing building, the Contractor shall cut and patch as required to conceal the conduits to new equipment installed.
- D. Conduits shall be installed in such a manner that wires may be removed and replaced at a later date.
- E. All conduits shall be run as straight and direct as possible to hold the number of bends or offsets to a minimum. All conduits shall be installed with runs parallel or perpendicular to walls, ceiling and structural members and with right angle turns utilizing condulets or symmetrical bends.
- F. There shall not be more than the equivalent of four quarter bends (360 degrees total) between pull points, e.g. conduit bodies and boxes.
- G. A separation of six inches shall be maintained between all conduit and hot water lines, steam lines and flues in the building. Where conduits and hot water lines and steam lines are closer than six inches, an approved pipe covering shall be used over the conduit for the length of the run of such exposure.
- H. Running threads shall not be permitted. Approved threaded couplings, such as Erikson or a suitable union shall be used where such construction is required. Support of conduit shall be

spaced not more than ten feet apart and within three feet of outlet boxes, junction boxes or cabinets. Conduit runs shall be supported by approved straps or beam clamps.

- I. Where it is necessary to cross expansion joints in the building construction, conduit runs shall be provided with suitable expansion fittings and copper bonding jumpers.
- J. In exterior locations or interior locations subject to extreme temperature fluctuations, long continuous straight runs of conduit shall be provided with suitable expansion fittings and copper bonding jumpers every 200 feet.
- K. All couplings shall be tightened to provide an electrical bond throughout the entire conduit system.
- L. Each end of every conduit run shall terminate with a galvanized locknut and bushing inside and a locknut outside of the terminating box or in an approved hub.
- M. All conduit fittings shall be separate from the conduit and shall be an approved type. Couplings and connections shall be compression type for all EMT and threaded type for IMC or RGS. Indenter type fittings or set screw type conduit fittings are not acceptable.
- N. Do not install crushed or deformed conduits. Prevent plaster, dirt or trash from lodging in conduits. Free clogged conduits of all obstructions.
- O. No horizontal conduit runs shall be made in tile or masonry walls. Conduits shall not be installed in cinder fills unless encased in concrete.
- P. All conduits, which are to remain empty for future introduction of conductors, shall be provided with a 200# test nylon line. Spare conduits shall be tagged at both ends in an approved manner indicating destination and future use.
- Q. All spare or future conduits shall be sealed with metal conduit seals (pennies) and secured in place with a malleable conduit bushing.

1.14 CONDUIT INSTALLATION - PVC

- A. In addition to the applicable portions of "CONDUIT INSTALLATION - STEEL," the following additional requirements apply to the installation of PVC conduit:
 - 1. PVC shall be installed only at locations specifically approved by the Owner's Representative. The Contractor shall obtain said approval for each location where it is desired to install PVC.
 - 2. PVC conduit runs shall transition to the appropriate metal conduit five feet prior to any bend which causes the conduit run to become exposed.
 - 3. PVC shall not be installed where subject to physical damage.
 - 4. PVC shall be cut square and deburred. PVC sections shall be joined using an approved solvent cement applied as recommended by the manufacturer. Each joint shall be completely watertight.
 - 5. All field bends shall be made using an electric hot box bender designed to handle the size of PVC to be bent. The heating, forming and cooling of each bend and the minimum radius of the curve of the inner edge shall be in strict compliance with manufacturer's recommendations and the minimum inner edge bending radius established by the NEC.

6. PVC conduit shall not be used in return air plenum ceiling or fire-rated ceiling assemblies. The Contractor shall review the architectural and mechanical Drawings to determine these locations.

1.15 CONDUCTORS

- A. Unless otherwise directed, all conductors for lighting, power feeders and branch circuit wiring shall be American Wire Gauge, rated 600 volts and 98 percent conductivity copper with THWN-THHN type insulation.
- B. All sizes shown on Drawings, unless noted otherwise, are based on copper. Aluminum conductors shall not be permitted.
- C. Conductor size No. 10 AWG and smaller shall be solid, except that No. 10 AWG or smaller wiring used for motor branch circuit wiring may be stranded. Conductor size No. 8 AWG and larger shall be stranded.
- D. Unless otherwise called for, minimum size conductors for branch circuits shall be No. 12 AWG, except that circuits over 100 feet shall use #10 AWG as the minimum size conductors; for Class 1 power-limited remote-control and signal circuits, No. 14 AWG; and for Class 2 low-energy remote-control and signal circuits, No. 16 AWG.

1.16 WIRING

- A. Great care shall be exercised in pulling wires into conduits so as not to damage insulation. Only approved compounds shall be used to assist in the pulling of wires.
- B. Multiple circuits in common conduit shall have individual neutrals unless otherwise noted. Circuits to modular furniture whips shall have combined neutrals. Any combined neutral circuit (i.e. multi-wire circuit) shall have a circuit breaker which simultaneously disconnects all ungrounded conductors. Multi-wire circuit conductors shall be grouped as required by the code.
- C. The feeder circuits to panelboards with a 200 percent neutral shall have two neutral conductors sized the same as the phase conductors or a single conductor of equivalent ampacity.
- D. Conductors shall be continuous from outlet to outlet and no splice shall be made except within outlet or junction boxes. Where called for, branch circuit wiring may be run as a multi-wire circuit to the extent of three different phases and one neutral per conduit, maximum.
- E. For convenience in maintenance and testing, no painting or taping for identification of cables will be permitted on a permanent basis, except as noted below:
- F. Color coding shall be as follows:
 1. 120 Volt, Two Wire Circuit: Grounded neutral - white; ungrounded leg - black.
 2. 208Y/120 Volt, Three Phase, Four Wire: Grounded neutral - white; one hot leg - black; one hot leg - red; one hot leg - blue.
 3. 240/120 Volt, Single Phase, Three Wire: Grounded neutral - white; one hot leg - black; one hot leg - red.
 4. 480Y/277 Volt, Three Phase, Four Wire: Grounded neutral - gray; one hot leg - brown; one hot leg - orange; one hot leg - yellow.

5. All ground wires shall be green.
- G. Color coding shall be factory applied to the entire length of the conductors by one of the following methods, except as noted and limited below:
 1. Solid color compound.
 2. Solid color coating.
- H. Field applied color coding may be used in lieu of factory coded wire for sizes larger than No. 6 AWG, where allowed by the NEC.
- I. Colored, pressure sensitive plastic or vinyl tape shall be applied in half overlapping turns for a distance of six inches for all terminal points and in all boxes in which conductors are accessible. The last two laps of tape shall be applied with no tension to prevent possible unwinding. Tape shall be 3/4 inch wide, 0.004 inch thick and colors shall be as hereinbefore specified. Tape shall be resistive to acids, alkalines, alcohol, chemicals and weathering. Cable identification markings shall not be obliterated by taping and tape location may be adjusted slightly to prevent obliteration of cable marking.
- J. In every pull or splice box and all other places where wires and cables may not be readily identified by nameplate markings on the equipment to which they connect, each circuit shall be identified with a permanent identification tag securely fastened to the conductors with plastic ties. Identification tags shall have the number of conductors, gauge and circuit identification engraved thereon in 1/4 inch high letters. Tags shall be made on label-maker tape.

1.17 SYSTEM BALANCING

- A. The system of feeder and branch circuits for power and lighting shall be connected to panelboard buses in a manner that loads connected thereto will be balanced on all phases as closely as practicable (within ten percent). Should there be any unfavorable condition of balance on any part of the electrical systems, Electrical Contractor shall make changes to remedy unbalanced condition. Each circuit in a group of circuits having a common neutral wire shall be connected to different phases.

1.18 SPLICES AND TERMINATIONS

- A. Splices and terminations in wires No. 6 AWG and larger shall be made with mechanical splicing or compression type devices and lugs. Mechanical splicing devices and lugs for wires No. 2 AWG and larger shall be of a type in which the contact pressure on the wire is obtained by two or more screws or bolts and so designed that the failure of any one screw bolt or nut will not result in a total loss of contact pressure.
- B. Splices in conductors sizes No. 8 AWG and smaller may be made with pressure connectors consisting of cone shaped coiled springs with insulating covers or, for stranded conductors, with crimped sleeve connectors having insulating covers and installed with proper compression tools.
- C. Splices and terminations in all equipment, material, etc. shall be rated for 75 degree C temperature to allow use of higher rated conductor.
- D. Compression tools shall be ratchet type. Proof of calibration shall be provided upon the Owner's Representative's request.

1.19 FUSES

- A. Provide, for every fuse clip to which a circuit has been connected, a nonrenewable cartridge fuse of the size indicated on the Drawings or as required in accordance with the manufacturer's requirements. All fuses shall be dual element, time delay, unless noted otherwise.
- B. Unless otherwise specified, current limiting fuses shall be Class RK1 dual element or Class L as indicated on the Drawings. Sizes shall be as indicated. All fuse holders for R type fuses shall be provided with rejection clips.
- C. Provide the Owner with three spare fuses for each size and type used on this project.
- D. Fuses shall be manufactured by Buss, Gould, CEFCO or approved equal.

1.20 CAST FITTINGS

- A. All cast fittings shall be provided with heavy threaded hubs to fit the conduit used. Iron cast fittings shall be cast malleable iron thoroughly coated inside and outside after all machined work is completed. Cast fittings shall be used on all conduit runs except at locations where it is impractical. At these locations factory ells can be used. No factory ells shall be used on exterior of building. All conduits on exterior of buildings or locations where they will be subject to moisture shall be weatherproof.

1.21 WIRING TROUGHS

- A. Wiring troughs shall be furnished and installed where indicated on the Drawings or where required by job conditions. Troughs up to six inches square shall be made of 16 gauge sheet steel with larger sizes being made of 14 gauge sheet steel with factory or painted finish; have screwed or hinged cover and insulated cross brackets to support conductors at three foot intervals. Troughs shall be of sufficient size to accommodate feeder conduits and cables and provide ample room for installation and training of conductors.
- B. All troughs shall be supported from the building structure independent of the conduits entering them. Feeders in troughs shall be identified by identification tag as hereinbefore specified.

1.22 OUTLET BOXES

- A. At all locations shown on the Drawings, an outlet box of proper type and size to satisfy the intended requirement shall be provided. Boxes shall be rigidly secured in position, set true and square. Boxes shall be supported independent of conduits entering them.
- B. Outlet boxes shall be sheet steel, zinc coated and be of a class to satisfy the conditions for each outlet.
- C. Concealed outlet boxes shall not be less than four inches square or rectangular and provided with the proper size knockouts for the conduits used. All unused knockouts must remain closed. Boxes in plaster construction shall be provided with approved covers or plaster rings. Where permitted by construction, depth of outlet boxes shall be 2-1/4 inch minimum.
- D. Where voltage between switches exceeds 300 volts, isolating barriers shall be provided between each gang of box. All ganged switches connected to 277 volts shall have isolating barriers.
- E. Where convenience outlets and data/communications outlets are installed in a common box, dividers coated with a foil shield for the isolation of EMI/RFI interference shall be provided between the power and signal sections.

- F. All outlets occurring in other than plaster construction and used for other than lights, shall be provided with flush, rectangular, square cornered boxes made for the purpose. No sectional switch boxes will be permitted and a box shall be installed for each single device. Where devices are ganged, gang-type boxes shall be provided.
- G. Boxes shall be of unit construction and of size required for the number of devices shown. The shape of the box shall be such as to permit surfacing materials to be cut in straight lines and to fit closely around the box. The box shall be so placed that the cover plate will be flush with the finished wall surface.
- H. All boxes for lighting outlets shall be round or octagonal and provided with fixture studs of a size suitable for the weight of the fixture to be supported.
- I. Outlet boxes used for exposed interior conduit runs shall be of cast rust-resisting metal. Gasketed covers shall be provided where the outlet is exposed to weather or moisture, or where indicated on the Drawings. At all locations where boxes are provided for special systems the boxes shall be the type and size recommended by the special system manufacturer.

1.23 JUNCTION BOXES, PULL BOXES AND TERMINAL BOXES

- A. Junction boxes of ample size shall be provided as required by the construction. Boxes shall be constructed of cast rust-resisting metal or of 14 gauge galvanized steel with riveted or welded joints and provided with covers of the same material which shall be screwed or hinged to the box. Boxes shall be flanged and tapped to receive machine screws. Holes in covers shall be in alignment with tapped holes in box. Where no sizes are given on the Drawings, boxes shall be no smaller than the minimum size allowed by NEC. Where feeders of different systems or voltages pass through the same box, barriers shall be provided for proper separation.
- B. Flush mounted boxes shall be fitted with a cover, which overlaps the box one inch all around. Boxes shall be installed every 100 feet in all major feeders.
- C. Boxes shall not be placed in locations made inaccessible by piping, ducts, conduits, or other equipment. Attached to all junction and pull boxes shall be the manufacturer's label, Underwriter's label, and an indication of the metal gauge. Each junction box and pull box shall contain an identification plate on the cover indicating the characteristics of the service therein. Boxes shall be rigidly secured to building construction in position, set true and square. Boxes shall be supported independent of conduits entering them.
- D. Terminal boxes shall be used in all cases where splices are required in cables or conductors for control wiring or for the telephone and communications systems. All terminal boxes shall include an interior mounting panel and have a hinged cover. For communication system, use terminal block type as recommended by equipment manufacturer.

1.24 CONVENIENCE RECEPTACLES

- A. Convenience receptacles, either duplex or simplex, shall be Specification grade 20 amp, two pole, three wire, 125 volts, NEMA 5-20R, shall be listed under FED SPEC WC-596, UL 498 and NEMA WD6 and shall be constructed of heavy duty high impact nylon with brass triple wipe contacts, side wired and designed to accommodate up to and including #10 solid or stranded copper wire. Mounting bracket and screws shall be steel zinc plated. Spring clip type ("Push In") termination is not allowed.
- B. All receptacles shall have green grounding screws. Receptacle and cover plate color shall be as directed by the Owner's Representative except that receptacles powered from the emergency generator shall have a red face unless otherwise directed by the Owner.

- C. Unless otherwise shown, mount wall receptacles 18 inches above finished floor.
- D. Convenience receptacles shall be manufactured by Hubbell, Leviton, Bryant or approved equal.

1.25 GFCI RECEPTACLES

- A. Ground Fault Circuit Interrupter Receptacles (GFCI) shall be provided at the locations shown on the Drawings and at all other locations where required by the NEC. This shall include but is not limited to outlets for drinking fountains and/or electric water cooler (EWC) receptacles. Where shown, they shall be wired in a "non-feed-through" manner. These devices shall be the same grade as the Convenience Receptacles specified above and be listed under FED SPEC WC-596, UL 498, NEMA WD 6 and UL Standard 943, Class A, Group 1, rated 20 amp, 125 volts, 60 Hz and provided with a 20 amp NEMA 5-20R rectangular duplex receptacle face. Receptacle face and cover plate color shall be as directed by the Owner's Representative.
- B. GFCI receptacles shall be manufactured by Hubbell, Leviton, Bryant or approved equal.

1.26 WEATHERPROOF RECEPTACLES

- A. Outdoor receptacles shall be listed as weather resistant, be protected by a GFCI, and have weatherproof covers, which retain their rating while in use. Weatherproof receptacles shall meet all the same specifications as GFCI Receptacles in addition to these specifications.
- B. Weatherproof covers shall be manufactured by Bell, Mulberry, Leviton or approved equal.

1.27 WALL PLATES

- A. All local control switches, telephone outlets, receptacles, blank outlets and similar devices shall be provided with a specification grade, UL listed, smooth, thermoplastic wall plate with beveled edges. Where more than one switch or device is installed in an outlet box, gang plates shall be used. Wall plate color shall be as directed by the Owner's Representative. Screws shall match color of plates.
- B. Finished wall plates shall be manufactured by Hubbell, Leviton, Bryant or approved equal.
- C. At locations where FS and FD device boxes are used for switches and receptacle outlets, a stainless steel plate shall be used. Plate shall fit flush with all sides of the box.
- D. Stainless steel plates shall be manufactured by Hubbell, Leviton, Bryant or approved equal.

1.28 DISCONNECT SWITCHES

- A. Disconnect switches shall be of the rating indicated on Drawings. Disconnect switches shall be heavy-duty type, fused or non-fused, as indicated, with positive quick-make and quick-break operating mechanism with external operating handle. Switches for indoor use shall be contained within a general purpose, NEMA Type 1 enclosure and for outdoor use, in a NEMA 3R enclosure, unless otherwise indicated. Switch shall be painted gray inside and outside. Each switch shall be equipped to accommodate size wire indicated on the Drawings. Where used as service entrance equipment, disconnect switches shall be provided with service entrance labels.
- B. Unless otherwise called for, the switches shall disconnect each phase and shall contain a solid neutral bar where a neutral is indicated, and a ground bar. The enclosure shall be provided with openings in the proper location to permit installation of the conduit and wiring system indicated on the Drawings. Disconnect switches provided with "R" type fuses shall have rejection clips.

- C. All switches shall be of proper horsepower rating as applicable and have dual cover interlocks designed to prevent opening of the switch door when the handle is in the "ON" position and to prevent closing of the switch mechanism with the door open. The handle position shall indicate whether the switch is "ON" or "OFF." Unit cover shall be provided with a suitable means of interlock release. Provisions shall be made for locking the operating handle in the "OFF" position.
- D. Approved type NEMA enclosures shall be supplied for switches exposed to weather. At locations where special enclosures are provided, conduit sealing fittings shall be installed for conduit entering the enclosure.
- E. Disconnect switches shall be manufactured by Square D, Siemens, General Electric or approved equal.

1.29 ENCLOSED CIRCUIT BREAKERS

- A. Enclosed circuit breakers shall be of the rating indicated on Drawings. Enclosed circuit breakers for indoor use shall be contained within a general purpose, NEMA Type 1 enclosure and for outdoor use, in a NEMA 3R enclosure, unless otherwise indicated. At locations where special enclosures are provided, conduit sealing fittings shall be installed for conduit entering the enclosure. Enclosed circuit breakers shall be painted gray inside and outside. Each enclosed circuit breaker shall be equipped to accommodate size wire indicated on the Drawings. Where used as service entrance equipment, enclosed circuit breakers shall be provided with service entrance labels. Provide warning labels on the front of enclosures warning of potential electric arc flash hazard in accordance with the National Electric Code.
- B. Unless otherwise called for, the enclosed circuit breakers shall contain a solid neutral bar where a neutral is indicated, and a ground bar. Lugs shall be rated to allow use of 75 degree C rated conductors. The enclosure shall be provided with openings in the proper location to permit installation of the conduit and wiring system indicated on the Drawings.
- C. Circuit breakers shall have a short circuit rating equal to the short circuit rating of the next upstream protective device unless otherwise noted. The handle position shall indicate whether the breaker is "ON" or "OFF." Provisions shall be made for locking the operating handle in the "OFF" position.
- D. Provide 120 VAC shunt tripping device where indicated on the Drawings.
- E. Circuit breakers shall be manufactured by Square D, Siemens, General Electric or approved equal.

1.30 PANELBOARDS - CIRCUIT BREAKER TYPE

- A. All panelboards shall be of the dead front type, shall be manufactured in accordance with UL 67 and shall have branch circuit protectors in the quantity and of ratings indicated on the Drawings. Panelboards shall be provided with a neutral bar insulated from the cabinet and a ground bar bonded to the steel cabinet. Isolated ground panelboards shall have a second ground bar isolated from the cabinet and the normal ground bar. Panelboards shall be sequence phased.
- B. Bus bars and all current carrying parts of panelboards, exclusive of circuit breakers, shall be tin or silver plated copper, sized in accordance with the requirements of the Underwriter's Laboratories, Inc.
- C. Branch circuit protectors of each panelboard shall be interchangeable, bolt-on (except that Square D I-Line breakers are acceptable), thermal magnetic type; single or multiple pole with a

voltage rating as indicated on the Drawings. All circuit breakers within each panelboard (unless approved otherwise by the Owner's Representative) shall be by the same manufacturer as that of the panelboard.

- D. Branch circuit breakers shall have short circuit interrupting capacities as indicated, not less than 10,000 amperes symmetrical for 208/120 volt system and 14,000 amperes symmetrical minimum for 480/277 volt system. Service and feeder circuit breakers and breakers in main panels shall have short circuit interrupting capacities as indicated or not less than 35,000 amperes symmetrical unless the short circuit available current provided by the local utility is less. In this case the short circuit rating may be reduced to the next standard size which is at least 2,000A greater than the value provided by the utility. Series rating of circuit breakers to achieve the required short circuit interrupting ratings is not allowed. (Electrical Contractor shall be responsible for coordinating the main distribution panelboard equipment AIC rating with available short circuit value as provided by the utility.) Contractor shall obtain system short circuit currents from the power company and shall include this information in his shop drawing submittal to the owner's representative.
- E. Circuit breakers shall be readily removable from front of panelboard without disturbing adjacent units. Circuit breakers shall have their ampere rating engraved on the breaker handle. They shall have quick-make and quick-break toggle mechanisms, non-fusible contacts, with inverse time-current characteristics. Breakers shall trip free on overload and shall indicate clearly whether they are in open, tripped or closed position. Multiple pole units shall have a thermal element in each pole and a single handle. Closely grouped circuit breakers and thermal tripping devices mounted in a common cabinet shall be derated when necessary in accordance with NEMA standard recommended practices for high ambient temperatures. All circuit breakers for lighting circuits shall be "SWD" rated or "HID" rated for HID lighting fixtures, "HM" rated for lighting fixture circuits with inherent high inrush current or individual dimmer applications and "HACR" rated for heating, air conditioning and refrigeration. Provide arc-fault circuit interrupter (AFCI) circuit breakers for all single-phase circuits to dwelling unit bedrooms.
- F. Circuit breakers shown on the Drawings to be installed in existing panelboards shall be of the same manufacturer, type and configuration as the existing panel circuit breaker.
- G. All lugs installed in panelboards shall be copper or high percentage copper alloy rated for use with 75 degree C wiring. Any lug with screws or bolts, which, after installation, operates at a higher temperature than the cable it connects, shall be replaced by the Contractor at no additional cost to the Owner.
- H. All bus contact surfaces shall be plated. The bus bars shall be hard drawn tin or silver plated copper of at least 98 percent conductivity, in continuous lengths and of such size and current density so that when carrying the full rated capacity they shall not have a temperature rise of more than 30 degrees C above that of the surrounding atmosphere. Each panel shall have a neutral bus unless otherwise noted. Provide a neutral bus with 200 percent current capacity where indicated. Provisions for future breakers shall include all bus and hardware for the future breakers.
- I. Where integral surge protection is indicated, panelboards shall include factory installed integrated transient voltage surge suppression (TVSS) which conforms to NEMA LS1, UL 67, 1449 and 1283 and is suitable for ANSI/IEEE C62.4 category C1 environments. The minimum total surge current shall be 120 KA per phase and 60 KA permode for 9000 C3 waves at 10 KA. The TVSS shall be immediately installed on the load side of the main breaker or main lugs via a direct bus bar connection (cable connection is not acceptable). The TVSS shall not limit the use of feedthrough lugs. The panelboard shall be capable of being energized upon removal of the TVSS. Monitoring diagnostics features shall be visible from the front of the equipment.

- J. Panelboards shall be manufactured by Square D, Siemens, General Electric, or approved equal.

1.31 PANELBOARD CABINETS

- A. All panelboards shall be mounted in a sheet steel enclosing cabinet designed for surface or flush mounting as indicated on the Drawings. Cabinets shall be fabricated of code-gauge, galvanized sheet steel and, unless otherwise specified, shall be furnished with manufacturer's standard gray finish. Provide warning labels on the front of enclosures warning of potential electric arc flash hazard in accordance with the National Electric Code. The rear of the cabinets shall be provided with a suitable means of supporting the panelboard in such a manner that adjustments may be made in all directions.
- B. Cabinets shall have suitable lugs for mounting and be provided with steel trims and doors. Doors shall be hung on trim with heavy flush butt hinges. Doors and trims shall be of integral single-door construction and so designed that doors will close without a rabbet. Doors 48 inches high or less shall be equipped with spring locks and catches. Doors larger than 48 inches in height shall be provided with a vault type handle.
- C. Panelboards located indoors shall be rated NEMA 1 unless otherwise noted. Panelboards located outdoors shall be rated NEMA 3R unless otherwise noted.
- D. Unless otherwise shown, panelboards shall be installed so that the operating handle of the top branch circuit protector does not exceed 72 inches above finished floor and the bottom of the cabinet is not less than 18 inches above finished floor.
- E. All cabinets shall have wiring gutters at top, bottom and sides of sufficient size to adequately accommodate the conduits, wires and cables entering and leaving same and having minimum depth of 5-3/4 inches and a minimum width of 20 inches. Cabinets shall be manufactured in accordance with Underwriter's Laboratories, Inc. standard for Cabinets and Boxes (UL 50). Unless otherwise called for, no splicing of wires shall be allowed in panelboard backboxes.
- F. Fronts of all cabinets shall have adjustable indicating type clamps and angle iron rest near the bottom to aid in installation and removal. All two-section panelboards shall have split covers.
- G. All cabinets shall be provided with the proper number and size openings for conduits installed. No openings will be permitted which are not to be utilized.
- H. Circuit directory holders shall be metal frames welded to inside of each cabinet and have transparent cover under which shall be placed neatly typewritten schedules identifying circuit control.
- I. All panelboards in areas exposed to other than authorized personnel shall be provided with lockable covers with all locks keyed alike.
- J. The Contractor shall provide the Owner with two keys for each panelboard.

1.32 CIRCUIT BREAKER "LOCK-ON" DEVICES

- A. Provide, install and connect handle "Lock-On" devices on the circuit breakers indicated on the schedules. "Lock-On" devices shall prevent accidental turning "off" of critical circuits. These devices shall be "trip-free" and permit the circuit breaker to trip automatically on overload. Lock-on devices shall be of the type recommended by the panelboard and circuit breaker manufacturer.

1.33 MANUAL MOTOR STARTERS

- A. Full voltage manual starters for single phase, single speed, non-reversing motors up to one horsepower shall be horsepower rated and operated by means of an OFF/ON toggle mechanism. The toggle mechanism shall be positive acting quick-make and break, toggle action with double-break silver alloy contacts.
- B. A "trip-free" current sensing overload mechanism with inverse time limit features shall be an integral part of the starter and it shall be so designed as to open the contacts if the motor is overloaded. Provide overload heater of the proper size based on the horsepower, voltage and RPM of the motor, or on motor full load current.
- C. Manual motor starters shall be manufactured by Square D, Siemens, General Electric or approved equal.

1.34 MOTOR STARTER RELAYS

- A. Motor starter relays for single phase, single speed, non-reversing motors up to one horsepower shall be horsepower rated with one 30A N.O. contact for 120V motors and two 30A N.O. contacts for 208V or 240V motors.
- B. Motor starter relays shall be controlled by a continuous rated coil of AC or DC voltage as required by the ATC Contractor. Coordinate requirements with the ATC Contractor prior to purchase. For installation not controlled by the ATC system, provide 120 VAC coils.
- C. Indoor installations shall be provided in the available NEMA 1 enclosure. Outdoor installations shall be an open relay mounted in a separate NEMA 3R or 4 box.
- D. Motor starter relays shall be Class 8501 Type C manufactured by Square D or approved equal.

1.35 MOTOR STARTERS AND CONTACTORS

- A. Unless otherwise specified, motor starters shall be of the magnetic type, NEMA class, size and type as indicated on the Drawings with red indicating light, HAND-OFF-AUTOMATIC selector switch, four auxiliary contacts (two N.O. and two N.C.) and fused control power transformer to provide 120 volts AC control voltage. Surge protection shall be provided for the motor starting coil.
- B. Connections to selector switch shall be such that only normal automatic regulatory control devices will be bypassed when the switch is in the "hand" position. All safety control devices, such as low and high pressure cutouts, high temperature cutouts and motor overload protective devices shall be connected in the motor control circuit in both the "hand" and the "automatic" positions. Overload protective devices shall give adequate protection to the motor windings, be of the solid state type which also provide phase loss protection and include a manual-reset type pushbutton on the outside of the case.
- C. Motor starters and contactors shall be manufactured by Square D, Siemens, General Electric or approved equal.

1.36 COMBINATION MOTOR STARTERS

- A. Unless otherwise specified, combination motor starters shall be of the fused disconnect switch type complete with dual element, current limiting fuses. Unit shall be of the NEMA Class and size as noted on the Drawings, with overload protection in each pole. Overload elements shall be of the proper size to protect the motor. Unless otherwise noted, units shall be equipped with

red indicating light, HAND-OFF-AUTOMATIC selector switch, four auxiliary contacts (two N.O. and two N.C.) and fused control power transformer to provide 120 volts A.C. control voltage. Surge protection shall be provided for the motor starting coil.

- B. Connections to the selector switch shall be such that only the normal automatic regulatory control devices will be bypassed when the switch is in the "hand" position. All safety control devices, such as low and high pressure cutouts, high temperature cutouts and motor overload protective devices shall be connected in the motor control circuit in both the "hand" and the "automatic" positions. Overload protective devices shall give adequate protection to the motor windings, be of the solid state type which also provide phase loss protection and include a manual-reset type pushbutton on the outside of the case.
- C. Disconnect operating handle shall be interlocked with the door so that the door cannot be opened with the switch in the "ON" position, except through an interlock release mechanism known only to authorized personnel. The operating handle shall be arranged for padlocking in the "OFF" position with up to three padlocks.
- D. Combination motor starters shall be manufactured by Square D, Siemens, General Electric or approved equal.

1.37 GROUNDING

- A. All electrical systems shall be suitably grounded, including all non-current carrying components of all equipment and metallic conduits. Grounding shall be accomplished by means of the following grounding systems and shall be in complete accordance with the latest issue of the National Electrical Code.
- B. The grounding electrode conductor system shall comprise a common ground conductor interconnected to an acceptable coldwater service pipe. Grounded conductor shall be continuous throughout its length without any splices. The water pipe connection shall be made with a mechanical clamp type ground fitting that bonds both conduit and cable to the water pipe ahead of meter. Provide jumper around water meter and hot water heaters. Unless otherwise specified, conductor shall be installed in exposed conduit with conductor securely bonded to the conduit where it enters and leaves the raceway.
- C. Contractor shall install a water stop for each grounding conductor, which passes through a foundation wall.
- D. Unless otherwise specified, the grounding system shall be augmented by the following:
 - 1. Extend grounding electrode conductor to steel frame of building and to 20 feet of #4 AWG copper conductor located in the concrete footing near the building perimeter with a minimum of 2 inches of cover. Where steel building frame or grounded water pipe does not exist, install grounding counterpoise.
 - 2. Grounding counterpoise shall consist of three 3/4 inch x 10 foot copper clad steel ground rods spaced 10 feet zero inches (minimum) on center. Rods shall be installed with top of rod 12 inches below finished grade. Rods shall be interconnected by means of a #2 (minimum) copper ground wire. Ground conductor shall be bonded to ground rods with exothermic bond type ground connectors.
- E. Connect grounding electrode conductor to neutral of separately derived systems (transformers) and to structural steel of building. Unless otherwise indicated, size per NEC.

- F. A code size ground conductor shall be extended in each conduit. Where parallel conduits are indicated a full code size ground conductor shall be extended in each parallel conduit.
- G. All connections to equipment and conduits shall be made with an approved type solderless connector. Connectors shall be securely bolted or clamped to the equipment. All contact surfaces shall be thoroughly cleaned and bright before connections are made in order to insure a good metal-to-metal contact.
- H. All connections to ground conductors shall be made accessible for visual inspection. The resistance between the grounding system and absolute earth shall not exceed 10 ohms and shall be measured by the Electrical Contractor in the presence of the Owner or the Owner's Representative prior to placing equipment in operation.
- I. All grounding conductors shall be identified by green color insulation unless indicated to be bare.
- J. Access flooring system grounding conductor shall match or exceed size of largest power source feeder grounding conductor provided for any of the electrical equipment installed in or on the access flooring system. Selection of power source grounding conductors shall conform to the NEC.

1.38 CONTROL RELAYS

- A. Control relays shall be industrial electro-mechanical type, UL listed with standard cartridge-type contact assemblies to allow individual removal of cartridge without disturbing adjacent cartridges. Relay shall be provided with two normally open contacts and two normally closed contacts and a control coil rated for operation at 120 volts A.C. Control relay shall be mounted in a NEMA 1 enclosure and shall be manufactured in accordance with NEMA standard ICS2.
- B. Control relays shall be manufactured by Square D, Siemens, General Electric or approved equal.

END OF SECTION 16100