SECTION 16010 - BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.01 SUMMARY
A. This Section includes the following:
   1. Raceways.
   2. Building wire and connectors.
   4. Electrical identification.
   5. Electrical demolition.

1.02 DEFINITIONS
A. EMT: Electrical metallic tubing.
B. FMC: Flexible metal conduit.
C. RMC: Rigid metal conduit.
D. LFMC: Liquidtight flexible metal conduit.
E. RNC: Rigid non-metallic conduit.

1.03 SUBMITTALS
A. Product Data: For each type of product indicated.

1.04 QUALITY ASSURANCE
A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
B. Comply with NFPA 70.

1.05 COORDINATION
A. Coordinate chases, slots, inserts, sleeves, and openings with general construction work and arrange in building structure during progress of construction to facilitate the electrical installations that follow.
   1. Set inserts and sleeves in poured-in-place concrete, masonry work, and other structural components as they are constructed.
B. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work. Coordinate installing large equipment requiring positioning before closing in the building.
C. Coordinate electrical service connections to components furnished by utility companies.
   1. Coordinate installation and connection of exterior underground and overhead utilities and services, including provision for electricity-metering components.
   2. Comply with requirements of authorities having jurisdiction and of utility company providing electrical power and other services.
D. Coordinate location of access panels and doors for electrical items that are concealed by finished surfaces. Access doors and panels are specified in Division 8 Section "Access Doors."
E. Where electrical identification devices are applied to field-finished surfaces, coordinate installation of identification devices with completion of finished surface.

F. Where electrical identification markings and devices will be concealed by acoustical ceilings and similar finishes, coordinate installation of these items before ceiling installation.

PART 2 - PRODUCTS

2.01 RACEWAYS

A. EMT: ANSI C80.3, zinc-coated steel, with compression fittings only (no set screw type).
B. FMC: Zinc-coated steel.
C. RMC: ANSI C80.1.
D. LFMC: Zinc-coated steel with sunlight-resistant and mineral-oil-resistant plastic jacket.
E. RNC: NEMA TC 2, Schedule 40 PVC, with NEMA TC3 fittings.
F. Raceway Fittings: Specifically designed for the raceway type with which used.

2.02 CONDUCTORS

A. Conductors, 6.0mm² and Smaller: Solid copper.
B. Conductors, Larger Than 6.0mm²: Stranded copper.
C. Insulation: Thermoplastic, rated at 75 deg C minimum.
D. Wire Connectors and Splices: Units of size, ampacity rating, material, type, and class suitable for service indicated.

2.03 SUPPORTING DEVICES

A. Material: Cold-formed steel, with corrosion-resistant coating acceptable to authorities having jurisdiction.
B. Metal Items for Use Outdoors or in Damp Locations: Hot-dip galvanized steel.
C. Slotted-Steel Channel Supports: Flange edges turned toward web, and 14-mm-diameter slotted holes at a maximum of 50 mm o.c., in webs.
D. Slotted-Steel Channel Supports:
   1. Coordinate with Drawings.
   2. Channel Thickness: Selected to suit structural loading.
   3. Fittings and Accessories: Products of the same manufacturer as channel supports.
E. Nonmetallic Channel and Angle Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 14-mm-diameter holes at a maximum of 203 mm o.c., in at least one surface.
F. Entire electrical system shall be fully rated.
G. Raceway and Cable Supports: Manufactured clevis hangers, riser clamps, straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring-steel clamps or click-type hangers.
H. Pipe Sleeves: ASTM A 53, Type E, Grade A, Schedule 40, galvanized steel, plain ends.
I. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for nonarmored electrical cables in riser
conduits. Plugs have number and size of conductor gripping holes as required to suit individual risers. Body constructed of malleable-iron casting with hot-dip galvanized finish.

J. Expansion Anchors: Carbon-steel wedge or sleeve type.
K. Toggle Bolts: All-steel springhead type.

2.04 ELECTRICAL IDENTIFICATION
A. Conductor and communication- and control-cable identification materials
B. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 0.08 mm (3 inches) thick by 25 to 50 mm (1 to 2 inches) wide.
C. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
D. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

2.05 EQUIPMENT IDENTIFICATION LABELS
A. Adhesive Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 10 mm (3/8 inch).
B. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 25 mm (1 inch).
C. PANEL DIRECTORIES
D. Printed Circuit Directory in clear plastic case, permanently adhered to the panel cover.
E. Provide new directory, same as schedule on approved drawings, for new panels.
F. For any revision to an existing panels, no matter how minor, provide new directory, printed and mounted as above.

2.06 SLEEVES FOR RACEWAYS AND CABLES
A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

2.07 FLOOR, CEILING ROOF and WALL PENETRATIONS
A. For penetrations of any building surface, provide UL listed products intended for the use.
B. Confirm rating of surface, provide materials rated and listed for the location and type of materials. 3M or approved.
C. For Roof penetrations, provide factory system for complete weatherproofing, including curbs, boots and flashing per the manufacturer. Portals Plus or approved.

2.08 CONDUCTORS AND CABLES
A. Refer to Part 3 "Conductor and Insulation Applications" Article for insulation type, cable construction, and ratings.
B. Conductor Material: Copper only complying with NEMA WC 5 or 7; solid conductor for 6.0 mm² and smaller, stranded for 10.0 mm² and larger. Copper shall be 98 percent conductivity and hard drawn.
C. Conductor Insulation Types: Type THHN-THWN, XHHW, or XHHW-2 complying with NEMA WC 5
2.09 CONNECTORS AND SPLICES
   A. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.10 METAL CONDUIT AND TUBING
   A. Rigid Steel Conduit: ANSI C80.1.
   B. Plastic-Coated Steel Conduit and Fittings: NEMA RN 1.
   D. EMT and Fittings: ANSI C80.3.
   E. Fittings: Compression type. Set screw type not permitted.
   F. Connectors: Threaded / locknut type. Snap in type not permitted.
   G. FMC: Zinc-coated steel.
   H. LFMC: Flexible steel conduit with PVC jacket.
   I. Fittings: NEMA FB 1; compatible with conduit and tubing materials.

2.11 NONMETALLIC CONDUIT AND TUBING
   B. RNC: NEMA TC 2, Schedule 40 and Schedule 80 PVC.
   C. ENT and RNC Fittings: NEMA TC 3; match to conduit or tubing type and material.
   D. LFNC: UL 1660.

2.12 BOXES, ENCLOSURES, AND CABINETS
   A. Sheet Metal Outlet and Device Boxes: NEMA OS 1.
   B. Cast-Metal Outlet and Device Boxes: NEMA FB 1, Type FD, with gasketed cover.
   C. Nonmetallic Outlet and Device Boxes: NEMA OS 2.
   D. Floor Boxes: Cast metal, fully adjustable, rectangular.
   E. Floor Boxes: Nonmetallic, nonadjustable, round.
   F. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
   G. Cast-Metal Pull and Junction Boxes: NEMA FB 1, cast aluminum with gasketed cover.
   H. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous hinge cover and flush latch.
   I. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
   K. Cabinets: NEMA 250, Type 1, galvanized steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel. Hinged door in front cover. Key latch as indicated. Include metal barriers to separate wiring of different systems and voltage and include accessory feet where required for freestanding equipment.
2.13 LIGHTING
A. Provide fixtures noted on drawings except as noted below.
B. Fixtures noted on drawings represent the quality, appearance and features intended. Match exactly the lamps, ballasts, finishes, lenses and accessories noted.
C. Substitute fixtures from alternate manufacturers are allowed and encouraged provided they are approved in writing.
D. Bidders are encouraged to submit products for approval prior to bid. Submit product information showing the items noted above, 7 days prior to the bid date. Approvals will be distributed in writing.
E. Alternates may be submitted with the bid, but the bid may be rejected if the fixtures are not acceptable. Provide all pertinent product information.

2.14 FACTORY FINISHES
A. Finish: For raceway, enclosure, or cabinet components, provide manufacturer's standard prime-coat finish ready for field painting.
B. Finish: For raceway, enclosure, or cabinet components, provide manufacturer's standard paint applied to factory-assembled surface raceways, enclosures, and cabinets before shipping.

2.15 WIRING DEVICES, GENERAL
A. Wiring Devices: Provide U.S. NEMA type wiring devices and associated devices, boxes, and covers in the CAA. Outside the CAA all wiring devices shall be the U.S. NEMA type, however with the written approval of DE/EEB, exceptions may be made to use local devices. Receptacles other than 120-volt or 220-volt general-purpose convenience outlets shall be marked on the cover plates with voltage, amperage, phase, and frequency. Matching plugs shall be provided.
B. Wire and Cable: Select types of insulation according to the application. See the NEC for insulation types, operating temperatures, ambient temperature, and voltage classes. Cable and wire sizes, types, and insulation shall be properly specified by the A/E using U.S. standards in order to obtain the highest quality transmission for security, data, and other signal cables. Provide solid conductors for conductors sized 6.0 mm² and smaller. Provide stranded conductors for conductors sized 10 mm² and larger. Provide copper branch circuits and feeder conductors sized at 125 percent of full load capacity. Use full-sized neutral conductor and a separate ground conductor for each circuit. Circuits and feeders that supply power for electronic equipment may require an oversized neutral to compensate for high harmonic neutral currents. Such feeders must be identified in the design and the neutral increased to a minimum of two times full rated size. Non-metallic sheathed cable (“Romex”) is prohibited, and armored or metal clad cable, Types AC or MC is prohibited except as permitted in limited applications by DE/EEB.
C. Overload Protection: Copper conductors shall be provided overload protection in accordance with NEC Table 310-6. Overload protection shall not exceed 15A for 2.5 mm² conductors, 20A for 4.0 mm² conductors or 30A for 6.0 mm² conductors.

2.16 RECEPTACLES
A. Receptacles, General: General-purpose receptacles shall be installed on 15 and 20-amp branch circuits, and shall be of the grounding type with effective grounding contacts. NEMA type receptacles shall be used in all spaces. A mix of NEMA type
receptacles and local standard receptacles may be used in non-CAA spaces with the approval of DE/EEB. Local standard receptacles may be rated 220V, 13A or 16A. Flexible arrangements, such as for floor outlets or cable trays in office areas shall be provided to allow for partition rearrangement. An underfloor duct system shall not be used except where specifically requested by OBO. G.F.C.I. protection shall be provided for receptacles in bathrooms, kitchen, other wet areas and outdoors per NEC requirements. Where 220V circuits are used, G.F.C.I. circuit breakers may be required in lieu of protection at the receptacle.  

B. Straight-Blade and Twist Locking Receptacles: Heavy-Duty grade. NEMA 6-20R for 220 or 240V applications.  
C. GFCI Receptacles Shall not be used. Outlets designated for GFCI protection shall be fed from a GFCI circuit breaker. One GFCI breaker, rated for 10mA ground fault trip, 50Hz, 240V (line to ground) shall be installed in an enclosure adjacent to the first receptacle in the branch circuit. This breaker will provide ground fault protection for all receptacles in the circuit.  
E. Snap Switches: Heavy-Duty grade, quiet type.  
F. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on/off switches and audible frequency and EMI/RFI filters.  
   1. Control: Continuously adjustable slider; with single-pole or three-way switching to suit connections.  
   2. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.  
G. Provide one 20 A and one 15 A cord plug cap for each duplex receptacle, Hubbell HBL5466C or equal, and two of each for each quadraplex receptacle. Plug caps shall be of the grounding type, utilizing only screw terminals for terminating conductors.  

2.17 WALL PLATES  
A. Single and combination types to match corresponding wiring devices.  
   1. Plate-Securing Screws: Metal with head color to match plate finish.  
   3. Material for Unfinished Spaces: Galvanized steel  

2.18 FINISHES  
A. Color:  
   1. All device faceplate shall have brushed stainless steel finish.  

PART 3 - EXECUTION  

3.01 ELECTRICAL INSTALLATION  
B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements. Minimum 2 meters high by 1 meter wide for access paths, unless approved in writing.
D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
E. Right of Way: Give to raceways and piping systems installed at a required slope.
F. Electrical equipment shall be designed and rated to operate in unusual environmental conditions such as wind-blown sand, salt atmosphere, flooding, ultraviolet rays due to altitude, high winds such as hurricanes and tornadoes, etc. Where standard ratings are not available to match environmental conditions, equipment shall be derated as required to compensate for factors such as high altitude and ambient temperature. Equipment installed in conditioned spaces shall be designed and rated for the conditioned ambient.

3.02 RACEWAY APPLICATION
A. Use the following raceways for outdoor installations:
   1. Exposed: EMT, compression fittings
   2. Concealed: EMT, compression fittings
   3. Underground, Single Run: RNC.
   4. Underground, Grouped: RNC.
   5. Connection to Vibrating Equipment: LFMC.
   6. Boxes and Enclosures: NEMA 250, Type 3R or Type 4.
B. Use the following raceways for indoor installations:
   1. Exposed: EMT.
   2. Concealed: EMT.
   3. Connection to Vibrating Equipment: FMC; except in wet or damp locations, use LFMC.
   4. Damp or Wet Locations: IMC.
   5. Boxes and Enclosures: NEMA 250, Type 1, unless otherwise indicated.

3.03 RACEWAY AND CABLE INSTALLATION
A. Conceal raceways and cables, unless otherwise indicated, within finished walls, ceilings, and floors.
B. Install raceways and cables at least 150 mm away from parallel runs of flues and steam or hot-water pipes. Locate horizontal raceway runs above water and steam piping.
C. Use temporary raceway caps to prevent foreign matter from entering.
D. Make conduit bends and offsets so ID is not reduced. Keep legs of bends in the same plane and straight legs of offsets parallel, unless otherwise indicated.
E. Use raceway and cable fittings compatible with raceways and cables and suitable for use and location.
F. Install raceways embedded in slabs in middle third of slab thickness where practical, and leave at least 25-mm-concrete cover.
1. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement.
2. Space raceways laterally to prevent voids in concrete.
3. Install conduit larger than 25 mm parallel to or at right angles to main reinforcement. Where conduit is at right angles to reinforcement, place conduit close to slab support.
4. Transition from nonmetallic tubing to Schedule 80 nonmetallic conduit, rigid steel conduit, or IMC before rising above floor.
5. Make bends in exposed parallel or banked runs from same centerline to make bends parallel. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for exposed parallel raceways.

G. Install pull wires in empty raceways. Use No. 2.5 mm² zinc-coated steel or monofilament plastic line with not less than (90-kg) tensile strength. Leave at least (300 mm) of slack at each end of the pull wire.

H. Install telecommunications and signal system raceways, 50 mm and smaller, in maximum lengths of 45 m and with a maximum of two 90-degree bends or equivalent. Separate lengths with pull or junction boxes where necessary to comply with these requirements, in addition to requirements above.

I. Connect motors and equipment subject to vibration, noise transmission, or movement with a maximum of 1830-mm flexible conduit. Install LFMC in wet or damp locations. Install separate ground conductor across flexible connections.

J. Set floor boxes level and trim after installation to fit flush to finished floor surface.

3.04 RACEWAY APPLICATION

A. Indoors:
   1. Exposed: EMT Conduits may be exposed in utility spaces such as electrical and mechanical rooms.
   2. Concealed: EMT.
   3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC; except use LFMC in damp or wet locations.
   4. Damp or Wet Locations: RNC.
   5. Boxes and Enclosures: NEMA 250, Type 1, except as follows:
      a. Damp or Wet Locations: NEMA 250, Type 4, stainless steel.

B. Minimum Raceway Size: 16mm DN 16. Exception: 12mm as noted.

C. Raceway Fittings: Compatible with raceways and suitable for use and location.
   1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
   2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings approved for use with that material. Patch all nicks and scrapes in PVC coating after installing conduits.
   3. Use only compression type fittings on EMT; use of set screw fittings on EMT is not permitted.
   4. Provide factory spacers for underground utility runs. Carlon or approved.

D. Do not use aluminum conduit.
3.05 INSTALLATION
A. Keep raceways at least 150 mm away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
B. Support raceways as specified in Division 16 Section "Basic Electrical Materials and Methods."
C. Install temporary closures to prevent foreign matter from entering raceways.
D. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portions of bends are not visible above the finished slab.
E. Make bends and offsets so ID is not reduced. Keep legs of bends in the same plane and keep straight legs of offsets parallel, unless otherwise indicated.
F. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.
   1. Install concealed raceways with a minimum of bends in the shortest practical distance, considering type of building construction and obstructions, unless otherwise indicated.
G. Raceways Embedded in Slabs: Install in middle 1/3 of slab thickness where practical and leave at least 50 mm of concrete cover.
   1. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement.
   2. Space raceways laterally to prevent voids in concrete.
   3. Run conduit larger than 25 mm parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
   4. Change from nonmetallic tubing to Schedule 80 nonmetallic conduit, or rigid steel conduit, before rising above the floor.
H. Install exposed raceways parallel or at right angles to nearby surfaces or structural members and follow surface contours as much as possible.
   1. Run parallel or banked raceways together on common supports.
   2. Make parallel bends in parallel or banked runs. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for parallel raceways.
I. Join raceways with fittings designed and approved for that purpose and make joints tight.
   1. Use insulating bushings to protect conductors.
J. Terminations:
   1. Where raceways are terminated with locknuts and bushings, align raceways to enter squarely and install locknuts with dished part against box. Use two locknuts, one inside and one outside box.
   2. Where raceways are terminated with threaded hubs, screw raceways or fittings tightly into hub so end bears against wire protection shoulder. Where chase nipples are used, align raceways so coupling is square to box; tighten chase nipple so no threads are exposed.
K. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 90-kg tensile strength. Leave at least 300 mm of slack at each end of pull wire tied off with 25mm locknut.
L. Telephone and Signal System Raceways, 53 and Smaller: In addition to above requirements, install raceways in maximum lengths of 30 m and with a maximum of two 90-degree bends or equivalent. Separate lengths with pull or junction boxes.
where necessary to comply with these requirements. Pull or junction boxes shall not be used as a bend.

M. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with UL-listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces and from conditioned to non-conditioned spaces.
2. Where otherwise required by NFPA 70.

N. Stub-up Connections: Extend conduits through concrete floor for connection to freestanding equipment. Install with an adjustable top or coupling threaded inside for plugs set flush with finished floor. Extend conductors to equipment with rigid steel conduit; FMC or LFMC may be used 150 mm above the floor. Install screwdriver-operated, threaded plugs flush with floor for future equipment connections.

O. Flexible Connections: Use maximum of 1830 mm of flexible conduit for recessed and semirecessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for all motors. Use LFMC in damp or wet locations. Install separate ground conductor across flexible connections.

P. Surface Raceways: Install a separate, green, ground conductor in raceways from junction box supplying raceways to receptacle or fixture ground terminals.

Q. Set floor boxes level and flush with finished floor surface.
R. Set floor boxes level. Trim after installation to fit flush with finished floor surface.
S. Install hinged-cover enclosures and cabinets plumb. Support at each corner.

3.06 DEVICE INSTALLATION
A. Install devices and assemblies level, plumb, and square with building lines.
B. Install wall dimmers to achieve indicated rating after derating for ganging according to manufacturer's written instructions.
C. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' written instructions.
D. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical, and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates where possible.
E. Remove wall plates and protect devices and assemblies during painting.
F. Adjust locations of floor service outlets to suit arrangement of partitions and furnishings.

3.07 DEVICE IDENTIFICATION
A. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.
B. Switches: Where three or more switches are ganged, and elsewhere as indicated, identify each switch with approved legend engraved on wall plate.

3.08 CONNECTIONS
A. Ground equipment per NEC.
B. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A.
C. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
   1. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.
D. Wiring at Outlets and Switches: Install conductor at each outlet, with at least 300 mm of slack.

3.09 PROTECTION
A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
   1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
   2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.10 CLEANING
A. After completing installation of exposed, factory-finished raceways and boxes, inspect exposed finishes and repair damaged finishes.

3.11 WIRING METHODS FOR POWER, LIGHTING, AND CONTROL CIRCUITS
A. Feeders: Type THHN/THWN insulated conductors in raceway.
B. Underground Feeders and Branch Circuits: Type THWN or XHHW insulated conductors in raceway.
C. Branch Circuits: Type THHN/THWN insulated conductors in raceway.
D. Remote-Control Signaling and Power-Limited Circuits: Type THHN/THWN insulated conductors in raceway for Classes 1, 2, and 3, unless otherwise indicated.

3.12 WIRING INSTALLATION
A. Install splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
B. Install wiring at outlets with at least 300 mm of slack conductor at each outlet. Pigtailing conductors is not permitted.
C. Connect outlet and component connections to wiring systems and to ground. Tighten electrical connectors and terminals, according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A.

3.13 ELECTRICAL SUPPORTING DEVICES
A. Damp Locations and Outdoors: Hot-dip galvanized materials or nonmetallic, U-channel system components.
B. Dry Locations: PVC coated Steel materials.
C. Support Clamps for PVC Raceways: Click-type clamp system.
D. Selection of Supports: Comply with manufacturer's written instructions.
3.14 SUPPORT INSTALLATION

A. Install support devices to securely and permanently fasten and support electrical components.

B. Install individual and multiple raceway hangers and riser clamps to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assemblies and for securing hanger rods and conduits.

C. Support parallel runs of horizontal raceways together on trapeze- or bracket-type hangers.

D. Size supports for multiple raceway installations so capacity can be increased by a 25 percent minimum in the future.

E. Support individual horizontal raceways with separate, malleable-iron pipe hangers or clamps.

F. Install 6-mm diameter or larger threaded steel hanger rods, unless otherwise indicated.

G. Spring-steel fasteners specifically designed for supporting single conduits or tubing may be used instead of malleable-iron hangers for 38-mm and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings and for fastening raceways to slotted channel and angle supports.

H. Arrange supports in vertical runs so the weight of raceways and enclosed conductors is carried entirely by raceway supports, with no weight load on raceway terminals.

I. Simultaneously install vertical conductor supports with conductors.

J. Separately support cast boxes that are threaded to raceways and used for fixture support. Support sheet-metal boxes directly from the building structure or by bar hangers. If bar hangers are used, attach bar to raceways on opposite sides of the box and support the raceway with an approved fastener not more than 610 mm from the box.

K. Install metal channel racks for mounting cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices unless components are mounted directly to structural elements of adequate strength.

L. Install sleeves for cable and raceway penetrations of concrete slabs and walls unless core-drilled holes are used. Install sleeves for cable and raceway penetrations of masonry and fire-rated gypsum walls and of all other fire-rated floor and wall assemblies. Install sleeves during erection of concrete and masonry walls.

M. Securely fasten electrical items and their supports to the building structure, unless otherwise indicated. Perform fastening according to the following unless other fastening methods are indicated:

   1. Wood: Fasten with wood screws or screw-type nails.

   2. Masonry: Toggle bolts on hollow masonry units and expansion bolts on solid masonry units.

   3. New Concrete: Concrete inserts with machine screws and bolts.

   4. Existing Concrete: Expansion bolts.

N. Powder-actuated devices with written approval only.

   1. Instead of expansion bolts, threaded studs driven by a powder charge and provided with lock washers may be used in existing concrete.

   2. Steel: Welded threaded studs or spring-tension clamps on steel.

      a. Field Welding: Comply with AWS D1.1.
3. Welding to steel structure may be used only for threaded studs, not for conduits, pipe straps, or other items.
4. Light Steel: Sheet-metal screws.
5. Fasteners: Select so the load applied to each fastener does not exceed 25 percent of its proof-test load.

3.15 IDENTIFICATION MATERIALS AND DEVICES
A. Install at locations for most convenient viewing without interference with operation and maintenance of equipment.
B. Coordinate names, abbreviations, colors, and other designations used for electrical identification with corresponding designations indicated in the Contract Documents or required by codes and standards. Use consistent designations throughout Project.
C. Self-Adhesive Identification Products: Clean surfaces before applying.
D. Identify raceways and cables with color banding as follows:
E. Bands: Pretensioned, snap-around, colored plastic sleeves or colored adhesive marking tape. Make each color band 50 mm wide, completely encircling conduit, and place adjacent bands of two-color markings in contact, side by side.
F. Band Locations: At changes in direction, at penetrations of walls and floors, at 15-m maximum intervals in straight runs, and at 8-m maximum intervals in congested areas.
   1. Colors: As follows:
      c. Telecommunication System: Green and yellow.
G. Tag and label circuits designated to be extended in the future. Identify source and circuit numbers in each cabinet, pull and junction box, and outlet box. Color-coding may be used for voltage and phase identification.
H. Install continuous underground plastic markers during trench backfilling, for exterior underground power, control, signal, and communication lines located directly above power and communication lines. Locate 150 to 200 mm below finished grade. If width of multiple lines installed in a common trench or concrete envelope does not exceed 400 mm, overall, use a single line marker.
I. Color-code 380/220-V system secondary service, feeder, and branch-circuit conductors throughout the secondary electrical system as follows:
   1. Phase A: Brown.
   2. Phase B: Orange.
   3. Phase C: Yellow.
J. Install warning, caution, and instruction signs where required to comply with 29 CFR, Chapter XVII, Part 1910.145, and where needed to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.
K. Install engraved-laminated emergency-operating signs with white letters on red background with minimum 9-mm-high lettering for emergency instructions on power transfer, load shedding, and other emergency operations.

3.16 FIRESTOPPING
A. Apply firestopping to cable and raceway penetrations of fire-rated floor and wall assemblies to achieve fire-resistance rating of the assembly.
B. UL or CE listed materials only
C. 3M, Dow Corning or approved.

3.17 CONDUCTOR AND INSULATION APPLICATIONS
A. Service Entrance: Type XHHW or XHHW-2 single conductors in raceway.
B. Exposed Feeders: Type THHN-THWN, single conductors in raceway.
C. Feeders Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.
D. Feeders Concealed in Concrete, below Slabs-on-Grade, and in Crawlspace: Type THHN-THWN, single conductors in raceway.
E. Exposed Branch Circuits, including in Crawlspace: Type THHN-THWN, single conductors in raceway.
F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.
G. Branch Circuits Concealed in Concrete and below Slabs-on-Grade: Type THHN-THWN, single conductors in raceway.
H. Underground Feeders and Branch Circuits:. Type THHN-THWN, single conductors in raceway.
I. Cord Drops and Portable Appliance Connections: Type SO, hard service cord.
J. Fire Alarm Circuits: Type THHN-THWN, in raceway.
K. Class 1 Control Circuits: Type THHN-THWN, in raceway.
L. Class 2 Control Circuits: Type THHN-THWN, in raceway.
M. Neutral Conductor: Where a secondary distribution system requires a neutral conductor, a full-sized neutral conductor shall be used throughout the system, such that that neutral conductor is not shared with any other branch circuit or feeder. If the secondary distribution system supports computers or other equipment that generates harmonics, double size neutrals shall be run from the subpanel boards feeding this equipment back to the MDP or service entrance. Neutral buses shall be sized to accommodate these conductors. Insulated equipment grounding conductors run with branch circuits shall be installed such that that conductor is not shared with any other branch circuit.

3.18 CABLE and WIRE INSTALLATION
A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.
B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
E. Support cables according to Division 16 Section "Basic Electrical Materials and Methods."
F. Seal around cables penetrating fire-rated elements according to Division 7 Section "Through-Penetration Firestop Systems."
G. Identify and color-code conductors and cables according to Division 16 Section “Electrical Identification.”
H. Install outdoor underground feeders in concrete encased ductbank.
I. Each electronic equipment rack shall be fed by an individual circuit breaker protected branch circuit.

3.19 FIELD QUALITY CONTROL
A. Testing: Perform the following field quality-control testing:
   1. After installing conductors and cables and before electrical circuitry has been energized, test for compliance with requirements.
   2. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.3.1. Certify compliance with test parameters.
B. Test Reports: Prepare a written report to record the following:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
C. Inspect installed components for damage and faulty work, including the following:
   1. Raceways.
   2. Building wire and connectors.
   4. Electrical identification.
   5. Electricity-metering components.
   6. Concrete bases.
   7. Electrical demolition.
   8. Cutting and patching for electrical construction.

3.20 REFINISHING AND TOUCHUP PAINTING
A. Refinish and touch up paint. Paint materials and application requirements are specified in Division 9 Section "Painting."
   1. Clean damaged and disturbed areas and apply primer, intermediate, and finish coats to suit the degree of damage at each location.
   2. Follow paint manufacturer’s written instructions for surface preparation and for timing and application of successive coats.
   3. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
   4. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 16010