SECTION 16051

BASIC MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Requirements of the following Division 15 and 16 Sections apply to this Section:

1. Basic Electrical Requirements - Section 16010

C. Requirements of the following Division 7 Section apply to this Section:

1. Firestopping – Section 07840

1.2 SUMMARY

A. This Section includes basic materials and methods for application with electrical installations as follows:

1. Raceways
2. Conductor and Cable
3. Boxes and Fittings
4. Wiring Devices
5. Disconnect Switches and Motor starters
6. Dry Type Transformers

1.3 QUALITY ASSURANCE

A. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."

B. NEMA Compliance: Comply with applicable requirements of NEMA Standards.

C. UL Compliance and Labeling: Comply with applicable requirements of UL standards, Provide products and components listed or labeled UL, ETL, or CSA.

1.4 SEQUENCING AND SCHEDULING

A. Coordinate with other Work, including metal and concrete deck installation, as necessary to interface installation of electrical components with other Work,

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:

1. Conduit Bodies:

a. Adalet-PLM
b. American Electric
c. Appleton Electric Co.
d. Carlon
e. Crouse-Hinds Division, Cooper Industries, Inc,
f. Delta Industrial Products
g. Killark Electric Mfg. Co.
h. Krayloy Products Co.
i. O-Z/Gedney
j. Steel City Electrical Mfg. Co.

2. Wireway:

a. Anchor Electric Co.
b. Hoffman Engineering Co.
c. Robroy Industries, Inc.
d. Square D Co.

3. Surface Metal Raceway:

a. Allied Tube & Conduit
b. American Electric
c. B-Line Systems, Inc.
d. Butler Mfg, Co.
e. Hoffman Engineering Co.
f. Isoduct Energy Systems
g. Isotrol Systems
h. Keystone/Rees, Inc.
i. Square D Co.
j. The Wiremold Co.

4. Surface Nonmetallic Raceway:

a. Anixter Brothers, Inc.
b. Hoffman Engineering Co.
c. Hubbell, Inc.
d. JBC Enterprises, Inc.
e. Panduit Corp.
f. The Wiremold Co.

5. Conductors and Cables:

   a. Carol Cable Co., Inc.
   b. Southwire Co.
   c. Rome Cable Co.
   d. Pirelli Wire and Cable
   e. Canada Wire and Cable
   f. Belden
   g. Alpha

6. Boxes and Fittings:

   a. Adalet-PLM
   b. Appleton Electric
   c. Eagle Electric
   d. OZ/Gedney
   e. Pass and Seymour Mfg., Inc.
   f. RACO
   g. Thomas & Betz Co.

7. Wiring Devices:

   a. Hubbell
   b. Arrow-Hart
   c. Pass and Seymour Mfg., Inc.
   d. Appleton
   e. Leviton

8. Disconnect Switches:

   a. Square D Co.
   b. General Electric
   c. Cutler-Hammer

9. Dry-Type Transformers:

   a. Square D Co.
   b. General Electric
   c. Cutler-Hammer

2.2 MATERIAL

A. Raceways:

1. Rigid Aluminum Conduit: ANSI C80.5.

2. Rigid Steel Conduit: ANSI C80.1.

3. Intermediate Steel Conduit: UL 1242.

4. PVC Externally Coated Rigid Steel Conduit and Fittings: ANSI C80.1 and NEMA RN 1.

5. Electrical Metallic Tubing and Fittings: ANSI C80.3.

6. PVC Externally-Coated Electrical Metallic Tubing and Fittings: ANSI C80.3 and NEMA RN 1.

7. Flexible Metal Conduit: UL 1, zinc-coated steel.

8. Liquid-tight Flexible Metal Conduit and Fittings: UL 360, Fittings shall be specifically approved for use with this raceway.

9. PVC Conduit and Tubing Fittings: NEMA TC 3; match to conduit or conduit/tubing type and material.

10. Underground PVC and ABS Plastic Utilities Duct: NEMA TC 6. Type 1 for encased burial in concrete, Type 2 for direct burial,

11. PVC and ABS Plastic Utilities Duct Fittings: NEMA TC 9; match to duct type and material.

12. Liquid-tight Flexible Nonmetallic Conduit and Fittings: UL 1660, Fittings shall be specifically approved for use with this raceway.

13. Conduit, Tubing, and Duct Accessories: Types, sizes and materials complying with manufacturer's published product information, Mate and match accessories with raceway.

14. Metallic Conduit and Tubing: Use metallic conduit bodies, Use bodies with threaded hubs for threaded raceways.

15. Conduit Bodies 1 Inch and Smaller: Use bodies with compression-type EMT connectors.

16. Surface Metal Raceway: Construct of galvanized steel with snap-on covers, with 1/8-inch mounting screw knockouts in base approximately 8 inches OIC. Finish with manufacturer's standard prime coating suitable for painting. Provide raceways of types suitable for each application required.

B. Conductors and Cables:

1. General: Provide wire and cable suitable for the temperature, conditions and location where installed. Ampacities shall be based on a 75^{o}C rating, unless equipment and lugs are rated for 90^{o}C use. Provide individual neutral conductors for all circuits. "Shared" or "Common" neutrals shall not be used.

2. Conductors: Provide solid conductors for power and lighting circuits No. 10 AWG and smaller. Provide stranded conductors for sizes No. 8 AWG and larger.

3. Conductor Material: Use the following material for sizes indicated.

   a. No. 6 AWG and Smaller: Copper.
   b. No, 4 AWG and Larger: Copper.

4. Insulation: Provide THHN/THWN insulation for all conductors size 500 KCM and larger, and No. 8 AWG and smaller. For all other sizes provide THW, THHN/THWN or XHHW insulation as appropriate for the locations where installed. Insulation shall be rated 90°C. Provide type XLPE insulation for all variable frequency drive motor leads.

5. Color code secondary service, feeder and branch circuit conductors with factory applied finish as follows:

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

   Where systems of different voltages are combined in the same junction box or enclosure, the neutral for the 480/277 volt system shall be white with a colored stripe (other than green).

6. Jackets: Factory-applied nylon or PVC external jacketed wires and cables for pulls in raceways over 100-feet in length, for pulls in raceways with more than three equivalent 90 deg. bends, for pulls in conduits underground or under slabs on grade, and where indicated.

7. Cables: Provide the following type(s) of cables in NEC approved locations and applications where indicated. Provide cable UL listed for particular application:

   a. Underground Feeder and Branch-Circuit Cable: Type UF
   b. Communication Riser Cable: Type CMR

8. Connectors for Conductors:

   a. Provide UL-listed factory-fabricated, solderless metal connectors of sizes, ampacity ratings, materials, types and classes for applications and for services indicated. Use connectors with temperature ratings equal to or greater than those of the wires upon which used.

C. Boxes and Fittings:

1. Outlet Boxes: Provide galvanized coated flat rolled sheet-steel outlet wiring boxes, of shapes, cubic inch capacities, and sizes, including box depths suitable for installation of respective locations, Construct outlet boxes with mounting holes, and with cable and conduit-size knockout openings in bottom and sides. Provide boxes with threaded screw holes, with corrosion-resistant cover and grounding screws for fastening surface and device type box covers, and for equipment type grounding. Nominal box sizes shall be 4" x 4" and larger as required. All outlet boxes in the boiler room or Chiller Room that are surface mounted shall be cast “FS” type.

2. Outlet Box Accessories: Provide outlet box accessories as required for each installation, including box supports, mounting ears and brackets, wallboard hangers, box extension rings, fixture studs, cable clamps and metal straps for supporting outlet boxes, which are compatible with outlet boxes being used to fulfill installation requirements for individual wiring situations. Choice of accessories is Installer's code-compliance option. All outlet boxes in the boiler room or Chiller Room that are surface mounted shall be cast “FS” type.

3. Device Boxes: Provide galvanized coated flat rolled sheet-steel non-gangable device boxes, of shapes, cubic inch capacities, and sizes, including box depths suitable for installation at respective locations. Construct device boxes for flush mounting with mounting holes, and with cable-size knockout openings in bottom and ends, and with threaded screw holes in end plates for fastening devices. Provide cable clamps and corrosion-resistant screws for fastening cable clamps, and for equipment type grounding. All outlet boxes in the boiler room or Chiller Room that are surface mounted shall be cast “FS” type.

4. Device Box Accessories: Provide device box accessories as required for each installation, including mounting brackets, device box extensions, switch box supports, plaster ears, and plaster board expandable grip fasteners, which are compatible with device boxes being utilized to fulfill installation requirements for individual wiring situations. Choice of accessories is Installer's code-compliance option.

5. Rain-tight Outlet Boxes: Provide corrosion-resistant cast-metal rain-tight outlet wiring boxes, of types, shapes and sizes, including depth of boxes, with threaded conduit holes for fastening electrical conduit, cast-metal face plates with spring-hinged watertight caps suitably configure for each application, including face plate gaskets and corrosion-resistant plugs and fasteners. All outlet boxes in the boiler room or Chiller Room that are surface mounted shall be cast “FS” type.

6. Junction and Pull Boxes: Provide galvanized code-gage sheet steel junction and pull boxes, with screw-on covers; of types, shapes and sizes, to suit each respective location and installation; with welded seams and equipped with stainless steel nuts, bolts, screws and washers.

7. Floor Boxes: Provide four compartment, multi-service, cast-iron rain-tight adjustable floor boxes as indicated, with threaded-conduit-entrance ends, and vertical adjusting screws, two receptacle brackets and cable management area. Wiremold Walkerbox # RFB4-SS with RAKMII cover. Install carpet from project in cover to match. Furnish blank plates for communications compartments.

8. Floor Box Accessories: Provide flush type two-pole, three-wire, grounded-pole, 125-volts, 20-amperes, receptacles.

9. Poke-Throughs: Provide factory pre-wired poke-through units, suitable for power and communication work, with UL fire resistance rating of 3-hours. Construct integral fire-stop with cold smoke barrier to prevent passage of smoke where heat is not present. Provide units with separation barrier between power and communication compartments, and with above-floor fittings of contoured die-cast aluminum with satin chrome finish covers. Provide poke-throughs with a single divided through-floor conduit, of proper length for floor thickness indicated, and a 4-11/1611 square x 2-9/16" deep junction box, which is self supporting without attachment of above-floor fitting.

10. Bushings, Knockout Closures and Locknuts: Provide corrosion-resistant box knockout closures, conduit locknuts and malleable iron conduit bushings, offset connectors, of types and sizes, to suit respective installation requirements and applications.

2.3 WIRING DEVICES

A. General: Provide wiring devices, in types, characteristics, grades, colors, and electrical ratings for applications indicated which are UL listed and which comply with NEMA WD 1 and other applicable UL and NEMA standards. Provide gray color devices and stainless steel wall plates except as otherwise indicated.

B. Receptacles: As scheduled on the drawings. Comply with UL 498 and NEMA WD 1.

C. Receptacles, Industrial Heavy Duty: Provide pin and sleeve design receptacles conforming to UL 498.

Comply with UL 1010 where installed in hazardous locations. Provide features indicated.

D. Ground-Fault Interrupter (GFI) Receptacles: As indicated on drawing; provide "feed-thru" type ground-fault circuit interrupter, with integral indicator light and heavy-duty NEMA 5-20R duplex receptacles arranged to protect connected downstream receptacles on same circuit. Provide unit designed for installation in a 2-3/4 inch deep outlet box without adapter, grounding type, Class A, Group 1, per UL Standard 94.3.

E. Surge-Suppressor (TVSS) Receptacles: Provide and install as indicated transient voltage surge suppressor type receptacles, with 3-level MOV protection for phase to phase, phase to ground and phase to neutral. TVSS receptacle shall be 20 amp rated, isolated ground where required and shall include an integral indicator light continuously on when

protection is active and flashes when protection is deactivated. UL listed per Standard 1449, UL suppression rating in accordance with Category B ANSI/IEEE C62.41-1991.

F. Plugs: 15-amperes, 125-volts, 3-wire, grounding, armored cap plugs, parallel blades with cord clamp, and 0.4 inch cord hole; match NEMA configuration with power sources.

G. Plug Connectors: 15-amperes, 125-volts, bakelite-body armored connectors, 3-wire, grounding, parallel blades, double wipe contact, with cord clamp, and 0.4 inch cord hole, match NEMA configuration to mating plugs. Arrange as indicated.

H. Snap Switches: Quiet type AC switches as indicated on the drawings. Comply with UL 20 and NEMA WD1. Switches shall be gray in color.

I. Combination Switch and Receptacle: General duty 3-way quiet switch, 20-amperes, 120-277 volts AC, with toggle switch handle, and 3-wire grounding receptacle, 15-amperes, 120-volts, equip with plaster ears, and with break-off tab feature which allows wiring with separate or common feed, with NEMA configuration 5-15R.

J. Dimmer Switches: Solid state dimmer switches conforming to NEMA WD 1, mounted in outlet boxes as indicated and in accordance with the following:

1. Incandescent Lamp Dimmers: Modular dimmer switches for incandescent fixtures; switch poles and wattage as indicated, 120-volts, 60-Hz, with continuously adjustable rotary knob or toggle, anodized aluminum face, single-pole, with soft-tap or other quiet on-off switch. Equip with electromagnetic filter to eliminate noise, RF and TV interference, and 5 inch wire connecting leads. Lightolier neptune slide No. MP1000-1 or equal.

2. Fluorescent Lamp Dimmers: Full-wave modular type AC dimmer switches, for fluorescent fixtures; wattage and voltage ratings as indicated, and electromagnetic filters to minimize noise, and RF and TV interference. Construct with continuously adjustable trim potentiometer for adjustment of low end dimming, anodized heat sinks, 5 inch wire connecting leads and quiet on-off switch.

2.4 WIRING DEVICE ACCESSORIES

A. Wall plates: Single and combination, of types, sizes, and with ganging and cutouts as indicated. Provide plates which mate and match with wiring devices to which attached. Provide metal screws for securing plates to devices with screw heads colored to match finish of plates. Provide wall plate color to match wiring devices except as otherwise indicated. Provide wall plates with engraved legend where indicated. Conform to requirements of Section "Electrical Identification." Provide plates possessing the following additional construction features:

1. Material and Finish: Steel plate, galvanized in unfinished areas.
2. Material and Finish: Brushed stainless steel in all finished areas.

B. Floor Service Outlets: Modular, above-floor service outlets and fittings of types and ratings indicated, Construct of die cast aluminum, satin finish. Use design compatible

with floor outlet wiring methods indicated. Provide 20-amperes, 125-volts, gray duplex receptacles, NEMA configuration 5-20R where indicated. Provide with 3/4 inch or 1 inch NPT, 1 inch long, locking nipple for installation where compatible with wiring method.

C. Poke-Through Assembly Devices: Factory-fabricated poke-through assembly devices with modular, above-floor service outlets, multi-channeled thru-floor raceway/fire stop assembly and below-floor junction box assembly. Construct above floor service fitting of die cast, satin finished aluminum with 20-ampere, 125-volts, gray duplex NEMA 5-20R receptacle and modular communication/data service outlet with separation barrier between power and low-tension section. Provide integral assembly UL listed as a total unit, with fire rating consistent with that of floor penetrated.

D. Telephone/Power Service Poles: Factory-assembled combination telephone/power poles of types, sizes and ratings indicated; for use with telephone and power systems installed above suspended ceilings. Construct with provisions for two 4-pair telephone cable, and (2), 20-amperes, 125-volts, 3-wire receptacles. Isolate power section from telephone compartment with separating metal barrier. Extend wiring from receptacles to junction box at top of pole where connections are made above suspended ceiling. Provide ceiling trim plate and pole foot with carpet pad. Where poles are located in accessible ceiling areas, provide bracing arranged for positive connection to ceiling supports. Provide finish treatment and color as selected by the Architect. Wiremold # 25DTP-412 or equal. Power poles shall not be used without the approval of the Architect.

2.5 CIRCUIT AND MOTOR DISCONNECT SWITCHES AND STARTERS

A. General: Provide circuit and motor disconnect switches in types, sizes, duties, features, ratings, and enclosures as indicated. Provide NEMA 1 enclosure for general use except for outdoor switches, provide NEMA 3R enclosures with rain-tight hubs, for all others provide whatever NEMA rating is required for the intended use of the room. For motor and motor starter disconnects, provide units with horsepower ratings suitable to the loads, combination type in single enclosure with H-0-A selector switch, green run light and Square D, MPS 8430 phase failure relay connected to control circuitry.

B. Fusible Switches: Heavy duty switches, with fuses of classes and current ratings indicated. Where current limiting fuses are indicated, provide switches with non-interchangeable feature suitable only for current limiting type fuses. If fuse type is not indicated provide type RK5 with time delay option.

C. Non-fusible Disconnects: Heavy duty switches of classes and current ratings as indicated, with NEMA rating suitable for the location considering use of space.

2.6 DRY TYPE TRANSFORMERS

A. Furnish dry-type transformers in quantities and sizes shown on the drawings. All transformers over 112.5 KVA in size shall be CLASS 155 as defined by the NEC and rated with an 80 degree temperature rise. Transformers shall UL listed, with copper windings, full capacity taps, and ventilated steel enclosures. Bond all transformer secondary neutral connections to building steel.

PART 3 - EXECUTION

3.1 WIRING METHOD

A. Outdoors: Use the following wiring methods:

1. Exposed: Rigid Galvanized Steel.
2. Concealed: Intermediate Metal Conduit.
3. Underground, Concrete Encased: Rigid Galvanized Steel or Schedule 40 PVC Conduit.
4. Underground, Direct Buried: Rigid Galvanized Steel or Schedule 40 PVC Conduit as indicated on the drawings.
5. Connection to Vibrating Equipment: Including transformers and hydraulic, pneumatic, or electric solenoid or motor-drive equipment in moist or humid location or corrosive atmosphere, or where subject to water spray or dripping oil, grease, or water: liquid-tight flexible metal conduit in lengths not exceeding three (3') feet.

B. Indoors: Use the following wiring methods:

1. Connection to Vibrating Equipment: Including transformers and hydraulic, pneumatic or electric solenoid or motor-operated equipment: flexible metal conduit in lengths not exceeding three (3') feet.
2. Exposed: Electrical metallic tubing or rigid aluminum conduit.
3. Concealed: Electrical metallic tubing, rigid galvanized steel or type MC cable.
4. Environmental Air Spaces: EMT, rigid galvanized steel, or cable assemblies approved for use in environmental air spaces.

3.2 INSTALLATION OF RACEWAYS

A. General: Install electrical raceways in accordance with manufacturer's written installation instructions, applicable requirements of NEC, and as follows:

1. Conceal Conduit and EMT, unless indicated otherwise, within finished walls, ceilings, and floors. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot water pipes, Install raceways level and square and at proper elevations.

2. Elevation of Raceway: Where possible, install horizontal raceway runs above water and steam piping.

3. Complete installation of electrical raceways before starting installation of conductors within raceways.

4. Provide supports for raceways as specified elsewhere in Division 16.

5. Prevent foreign matter from entering raceways by using temporary closure protection.

6. Protect stub-ups by using temporary closure protection.

7. Make bends and offsets so the inside diameter is not effectively reduced. Unless otherwise indicated, keep the legs of a bend in the same plane and the straight legs of offsets parallel.

8. Use raceways fittings that are of types compatible with the associated raceway and suitable for the use and location. For intermediate steel conduit, use threaded rigid steel conduit fittings except as otherwise indicated.

9. Run concealed raceways with a minimum of bends in the shortest practical distance considering the type of building construction and obstructions except as otherwise indicated. This does not apply to conduits in crawl spaces.

10. Raceways embedded in slabs: Install in middle third of the slab thickness where practical and leave at least 1-inch concrete cover.
Tie raceways to reinforcing rods or otherwise secure them to prevent sagging or shifting during concrete placement. Space raceways laterally to prevent voids in the concrete. Run conduit larger than 1-inch trade size, parallel with or at right angles to the main reinforcement, the conduit shall be close to one of the supports of the slab.

11. Install exposed raceways parallel or perpendicular to nearby surfaces or structural members and follow the surface contours as much as practical.

12. Run exposed, parallel, or banked raceways together. Make bends in parallel or banked runs from the same center line so that the bends are parallel. Factory elbows may be used in banked runs only where they can be installed parallel. This requires that there be a change in the plane of the run such as from wall to ceiling and that the raceways be of the same size. In other cases provide field bends for parallel raceways.

13. Join raceways with fittings designed and approved for the purpose and make joints tight. Where joints cannot be made tight, use bonding jumpers to provide electrical continuity of the raceway system. Make raceway terminations tight. Where terminations are subject to vibration, use bonding bushings or wedges to assure electrical continuity. Where subject to vibration or dampness, use insulating bushings to protect conductors.

14. Tighten set screws of threadless fittings with suitable tool.

15. Terminations: Where raceways are terminated with locknuts and bushings, align the raceway to enter squarely and install the locknuts with dished part against the box. Where terminations cannot be made secure with one locknut, use two locknuts, one inside and one outside the box.

16. Where terminating in threaded hubs, screw the raceways or fitting tight into the hub so the end bears against the wire protection shoulder. Where chase nipples

are used, align the raceways so the coupling is square to the box, and tighten the chase nipple so no threads are exposed.

17. Install pull wires in empty raceways. Use No. 14 AWG zinc-coated steel or monofilament plastic line having not less than 200-lb tensile strength. Leave not less than 12 inches of slack at each end of the pull wire.

18. Telephone, Signal and Control System Raceways 2-Inch Trade Size and Smaller: In addition to the above requirements, install raceways 2-inch and smaller trade size in maximum lengths of 150 feet and with a maximum of two, 90-deg bonds or equivalent. Install pull or junction boxes where necessary to comply with these requirements.

19. Install raceway sealing fittings in accordance with manufacturer's written instructions. Locate fittings at suitable, approved, 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 and elsewhere as indicated:

    a. Where conduits enter or leave hazardous locations.
    b. Where conduits pass from warm locations to cold locations, such as the boundaries of refrigerated spaces and air-conditioned spaces.
    c. Where required by the NEC.
    d. Where conduits enter or leave moist or damp spaces, such as crawl spaces or cellars.

20. Stub-up Connections: Extend conduits through concrete floor for connection to free standing equipment with an adjustable top or coupling threaded inside for plugs and set flush with the finished floor. Extend conductors to equipment with rigid steel conduit; flexible metal conduit may be used 6 inches above the floor. Where equipment connections are not made under this contract, install screwdriver-operated threaded flush plugs flush with floor.

21. Flexible Connections: Use short length (maximum of 6 ft.) of flexible conduit for recessed and semi-recessed lighting fixtures, for equipment subject to vibration, noise transmission, or movement; and for all motors. Use liquid-tight flexible conduit in wet locations. Install separate ground conductor across flexible connections.

22. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and they pass through concrete, install in a nonmetallic sleeve.

23. Do not install aluminum conduit embedded in or in contact with concrete.

24. PVC externally coated rigid steel conduit: Use only fittings approved for use with that material. Patch all nicks and scrapes in PVC coating after installing conduit.

25. Surface Metal Raceway: Install a separate green ground conductor in raceway from the junction box supplying the raceway to receptacle or fixture ground terminals.

26. Select each surface metal raceway outlet box to which a lighting fixture is attached to be of sufficient diameter to provide a set for the fixture canopy.

27. Where a surface metal raceway is used to supply a fluorescent lighting fixture having central stem suspension with a backplate and a canopy, with or without extension ring, the backplate and canopy will serve as the outlet box and no separate outlet box need be provided.

28. Provide surface metal raceway outlet box, in addition to the backplate and canopy, at the feed-in location of each fluorescent lighting fixture having end stem suspension.

29. Where a surface metal raceway extension is made from an existing outlet box on which a lighting fixture is installed, provide a backplate slightly smaller than the fixture canopy, and no additional surface mounted outlet box need be installed.

3.3 INSTALLATION OF WIRES AND CABLES

A. General: Install electrical cables, wires, and connectors in compliance with NEC.

B. Coordinate cable installation with other Work.

C. Pull conductors simultaneously where more than one is being installed in same raceway. Use UL listed pulling compound or lubricant, where necessary.

D. Use pulling means including, fish tape, cable, rope, and basket weave wire/cable grips which will not damage cables or raceways. Do not use rope hitches for pulling attachment to wire or cable.

E. Conceal all cable in finished spaces.

F. Install exposed cable parallel and perpendicular to surfaces or exposed structural members, and follow surface contours, where possible.

G. Keep conductor splices to minimum.

H. Install splice and tap connectors which possess equivalent or better mechanical strength and insulation rating than conductors being spliced.

I. Use splice and tap connectors which are compatible with conductor material.

J. Provide adequate length of conductors within electrical enclosures and trim the conductors to terminal points with no excess. Bundle multiple conductors. Make terminations so there is no bare conductor at the terminal.

K. Tighten electrical connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A and UL 486B.

L. Control (HVAC and boiler) system wiring shall be installed in EMT were exposed and shall be otherwise be installed in accordance with this specification.

M. Cables shall not be bundled with more than 14 cables per bundle. Separate bundles by at least 8". Cables shall be supported with devices designed for the purpose such as a "Caddy" type clips or “J” hooks. Contractor shall not use excess conductors or wiring as supports.

N. Motor lead conductors for motors operating from a variable frequency drive shall be installed in individual conduits in unbroken runs. Conduits shall not be shared between motors. Conductors shall not be installed in wireways.

3.4 INSTALLATION OF ELECTRICAL BOXES AND FITTINGS

A. General: Install electrical boxes and fittings as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC and NECA's "Standard of Installation", and in accordance with recognized industry practices to fulfill project requirements.

B. Coordinate installation of electrical boxes and fittings with wire/cable, wiring devices, and raceway installation work.

C. Provide weather-tight outlets for interior and exterior locations exposed to weather or moisture.

D. Provide knockout closures to cap unused knockout holes where blanks have been removed.

E. Install electrical boxes in those locations which ensure ready accessibility to enclosed electrical wiring.

F. Do not install boxes back-to-back in walls. Provide not less than 6" (150 mm) separation.

G. Do not install aluminum products in concrete. Wall boxes installed in concrete or block shall be made of steel as per this specification.

H. Position recessed outlet boxes accurately to allow for surface finish thickness.

I. Set floor boxes level and flush with finish flooring material.

J. Do not use round boxes where conduit must enter box through side of box, which would result in difficult and insecure connections when fastened with locknut or bushing on rounded surfaces.

K. Fasten electrical boxes firmly and rigidly to substrates, or structural surfaces to which attached, or solidly embed electrical boxes in concrete or masonry,

L. Provide electrical connections for installed boxes.

M. Subsequent to installation of boxes, protect boxes from construction debris and damage.

N. Install backboxes for all wall mounted Class 2 wiring devices and HVAC wall mounted control devices such as thermostats.

3.5 INSTALLATION OF WIRING DEVICES AND ACCESSORIES

A. Install wiring devices and accessories as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC and in accordance with recognized industry practices to fulfill project requirements.

B. Coordinate with other Work, including painting, electrical boxes and wiring installations, as necessary to interface installation of wiring devices with other Work.

C. Install wiring devices only in electrical boxes which are clean; free from building materials, dirt, and debris.

D. Install galvanized steel wall plates in unfinished spaces.

E. Install wiring devices after wiring work is completed.

F. Install wall plates after painting work is completed.

G. Install telephone/power service poles in accordance with final furnishings arrangement plan, plumb, true, and secure.

H. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for wiring devices. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standard 486A, Use properly scaled torque indicating hand tool.

3.6 GROUNDING

A. Upon completion of installation work, properly ground electrical boxes and demonstrate compliance with requirements.

3.7 PROTECTION

A. Protect installed components from damage. Replace damaged items prior to final acceptance.

3.8 ADJUSTING AND CLEANING

A. Upon completion of installation of raceways, inspect interiors of raceways; clear all blockages and remove burrs, dirt, and construction debris.

3.9 FIELD QUALITY CONTROL

A. Testing: Prior to energizing circuits, test wiring for electrical continuity, and for short-circuits. Ensure proper polarity of connections is maintained. Subsequent to energizing, test wiring devices and demonstrate compliance with requirements, operating each operable device at least six times.

B. Test ground fault interrupter operation with both local and remote fault simulations in accordance with manufacturer recommendations.

END OF SECTION