SECTION 16100 – WIRING METHODS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. All of the Contract Documents, as listed on the Table of Contents and including General and Supplementary Conditions and Division 1, General Requirements, shall be included in, and made part of, this Section.

1.2 DESCRIPTION OF WORK

A. The following general systems and equipment shall be provided for the new building, as a minimum, but not necessarily limited to the following:

1. Connections to HVAC, Plumbing, Fire Protection, Automatic Temperature Control, General Contractor and Owner furnished equipment.
2. 120 volt power for remote alarms and connections to oil tank alarms, etc.
3. Hoisting, rigging, setting of all conduit, cable and equipment.
4. Testing, cleaning and adjusting.
5. Alarm panels.
6. Boxes.
7. Cable assemblies (prefabricated).
8. Conductors - 600 volts.
9. Conduit.
10. Elevator related work.
11. Gas alarms, oil tank alarms, wiring and connection.
12. Manholes - precast.
13. Mineral Insulated (MI) metal sheathed cable.
14. Solderless lugs and connectors.
15. Surface mounted raceway system.
16. Underground ductbank system.
17. Wiring devices and device plates.

1.3 RELATED WORK

A. For work to be included as part of this Section, to be furnished and installed by the Electrical Subcontractor, refer to the Related Work section of Specification Section 16010.

B. Carefully examine all of the Contract Documents, criteria sheets and all other Sections of the specifications for requirements which affect work under this Section, whether or not such work is specifically mentioned in this Section.

1.4 WARRANTY

A. Attention is directed to provisions of the General Requirements, Supplementary General Requirements, Section 01784 - Warranties and Section 16010 – Electrical Special Conditions regarding guarantees and warranties for the work under this Contract.

1.5 CONNECTIONS TO ARCHITECTURAL, HVAC, PLUMBING AND OWNER FURNISHED EQUIPMENT

A. The Electrical Subcontractor shall provide all conduit connections to equipment provided under other Sections of the specifications, including final connections to equipment to result in a complete system, fully operational. Coordinate location of all equipment with the General Contractor. Obtain installation diagrams and methods of installation of all equipment, from manufacturers. Follow instructions strictly. If additional information is required, obtain same from Architect.

B. All electrical connections to vibration isolated equipment shall be by flexible conduit of length at least 15 diameters, installed with visible slack, or in a loop configuration, to allow free movement of the equipment and prevent transmission of noise and vibration.

1.6 SUBMITTALS

A. Prepare and submit shop drawings in accordance with the requirements hereinbefore specified, and with the Shop Drawings, Product Data and Samples Section 01330 in the manner described therein, modified as noted hereinafter.

B. All shop drawings shall have clearly marked the appropriate specification number of drawing designation, for identification of the submittal.

C. Disposition of shop drawings shall not relieve the Electrical Subcontractor from the responsibility for deviations from drawing or specifications, unless he has submitted in writing a letter itemizing or calling attention to such deviations at time of submission and secured written approval from the Engineer, nor shall such disposition of shop drawings relieve the Electrical Subcontractor from responsibility for errors in shop drawings or schedules.

D. Shop drawings shall include, but shall not be limited to, the following:

1. Alarm panels.
2. Boxes.
3. Cable assemblies (prefabricated).
4. Conductors - 600 volts.
5. Conduit.
6. Elevator related work.
7. Gas alarms, oil tank alarms, wiring and connection.

8. Manholes - precast.
9. Mineral Insulated (MI) metal sheathed cable.
10. Solderless lugs and connectors.
11. Surface mounted raceway system.
12. Underground ductbank system - routing.
13. Wiring devices and device plates.
14. Routing of all conduits 2½ inches in diameter and larger.

PART 2 - PRODUCTS

2.1 ALARM PANELS AND SYSTEMS FURNISHED BY OTHER TRADES

A. Furnish and install all power wiring connections and conduit (120 volt) as required for alarm panels and metering devices supplied by Plumbing, Fire Protection, HVAC and Automatic Temperature Control Trades. All alarm system panels, components, interface wiring and conduit shall be provided by the respective Trade.

2.2 BOXES

A. Junction Boxes

1. Junction boxes shall be constructed of code gauge galvanized steel and shall be installed at points as required whether indicated on the drawings or not. Minimum dimension shall not be less than NEC requirements.
2. Provide flat plain covers with suitable flat head machine screws or slotted truss head bolts.
3. Boxes exceeding 4'-0" in any direction shall be reinforced with angle iron stiffeners.
4. PVC Schedule 40 junction boxes shall be provided in areas with corrosive atmosphere.
5. Boxes shall be manufactured by one of the following: Lee Products Co., Harry Richmond Co., Commercial Sheet Metal Co., Hoffman, or McKinstry.

B. Outlet Boxes

1. Outlet boxes shall be one-piece galvanized steel construction meeting NEC requirements, of proper size and suitable for location indicated on the drawings.
2. Outlet boxes in wall partitions shall not be installed back-to-back.
3. Boxes for surface mounted devices shall be a finished type (surface box). Boxes shall be stainless steel.
4. Boxes for exterior work shall be FS or FD Series, with cadmium plated covers. Steel boxes will not be permitted.
5. PVC Schedule 40 outlet boxes shall be provided in areas with corrosive atmosphere.
6. Outlet boxes used as junction boxes shall not be less than 4 11/16" square and 2" deep.
7. Outlet boxes shall be manufactured by one of the following: Crouse-Hinds Co., Appleton Electric Co., Steel City Electric Co. or RACO.

C. Pull Boxes

1. Pull boxes shall be constructed of code gauge galvanized steel and shall be installed at points as required whether indicated on the drawings or not. Minimum dimension shall not be less than NEC requirements.
2. Provide flat plain covers with suitable flat head machine screws or slotted truss head bolts.
3. Boxes exceeding 4'-0" in any direction shall be reinforced with angle iron stiffeners and contain two (2) section covers and cable supports.
4. PVC Schedule 40 pull boxes shall be provided in areas with corrosive atmospheres.
5. Pull boxes for medium voltage feeders shall have barriers to separate each medium voltage circuit.
6. Boxes shall be manufactured by one of the following: Lee Products Co., Harry Richmond Co., Commercial Sheet Metal Co., Hoffman, or McKinstry.

2.3 CABLE ASSEMBLIES (PREFABRICATED)

A. General

1. Furnish and install multi-conductor cable assemblies as shown on the drawings and specified herein, including all necessary fittings, hangers, accessories, etc. Multi-conductor cable assemblies shall be prefabricated at the factory and shipped to the site on cable reels.

B. Armored Cable (AC) Hospital Grade

1. Uses Permitted

a. AC cable may be utilized in lieu of conduit and cable in dry, hollow partitions and ceiling cavities for general purpose, 20 ampere, single phase, 120 or 277 volt, normal only branch circuits for receptacles and lighting fixtures only.
b. Branch circuit homeruns to panels shall be run in conduit. AC branch circuit cable shall terminate in a network junction box above the accessible ceiling cavities of room/area served by branch circuits. AC branch circuit cable run in ceiling shall be limited to 25’ when routed from network junction box to wall cavity.
c. Branch circuit cable may be used for fixture whips limited to 6’0”. Branch circuits shall be run with individual neutrals for each circuit’s shared neutrals not allowed.

2. Uses Not Permitted

a. AC cable shall not be utilized in places of assembly.
b. AC cable shall not be allowed in electric rooms or closets.
c. AC cable shall not be used in mechanical or plumbing rooms, closets or shafts, including mechanical penthouse.
d. AC cable shall not be used for emergency circuits or feeders.

3. Reference Standards

a. AC cable shall be in compliance with the latest applicable edition of the following industry standards:

1) National Electrical Code (NEC)

a) NEC 517-13
b) NEC 517-50

2) Federal Specification J-C-30B
3) Underwriters laboratory (UL)
4) UL 4
5) UL 1479

4. Construction

a. Conductors

1) Conductors shall be minimum #12 AWG, soft drawn 98% conductive copper with 90°C, THHN, 600 volt rated insulation. Included with each length of AC cable shall be the required number of phase conductors (maximum 3), one neutral conductor per phase conductor, insulated, full size, grounding conductor and separate uninsulated bonding wire.
2) Where circuits for power and lighting exceed 60'-0" for 120 volt circuits or 120'-0" for 277 volt circuits to the center of the load, #10 AWG wire or larger, as required, shall be used for a maximum 3% voltage drop at full circuit capacity.
3) Each conductor, including ground conductor, shall be wrapped with nylon covering.
4) Color Coding

a) Color coding of conductors shall match the Owners color coding standard. If no standard color coding system exists, use the following:

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

b) Color coding shall be continuous on insulation for all conductors.

c) Electrical Subcontractor shall provide additional identification to identify each neutral conductor with its associated phase conductor.

b. Exterior armor

1) The exterior sheath shall be manufactured of galvanized steel or aluminum armor and shall be wrapped around the conductors at the factory.

5. Manufacturer

a. AC cable shall be as manufactured by AFC Series HFC-90, or equivalent product as manufactured by Allflex or Alliance.

6. Fittings

a. Fittings for AC cable shall be suitable for use with the appropriate cable assembly.
b. Fitting shall be as manufactured by Bridgeport, Electroline, OZ Gedney, Thomas and Betts, Neer, ETP or Regal.
c. Include manufacturers literature with shop drawings stating application compatibility with each cable type.

2.4 CONDUCTORS - 600 VOLTS

A. General

1. All feeder, branch circuit, remote control, signal circuit and interlock wiring shall be manufactured of copper, rated at 600 volts, single conductor. Conductors #8 AWG and larger shall be stranded. All wiring #10 AWG and smaller shall be solid.
2. Minimum size wire for branch circuit and power wiring shall be #12 AWG. Remote control signal circuit and interlock wiring may be #14 AWG. Fire alarm wiring shall be per the Fire Alarm System Section of these specifications. When 20 ampere, single pole circuits for power and lighting exceed 60'-0" for 120 volt circuits or 120'-0" for 277 volt circuits to the center of load, #10 AWG wire or larger, as required, shall be used for a maximum 3% voltage drop at full circuit capacity.
3. Wire and cable for lighting, power and control circuits for systems operating between 50 and 600 volts shall be soft drawn, 98% conductive copper with 600 volt rated insulation.
4. All wiring shall be installed in conduit (power, low voltage and control wiring), unless specifically indicated otherwise.
5. Conductors #10 and #12 AWG shall be connected with pre-insulated spring connectors encased in a steel shell and rated at not less than 105°C. A minimum of 3/8" skirt shall cover the bare wires. The connector shall meet with UL approval for fixture and pressure work and shall be "B-Cap" Type B1, B2 and B4 electrical spring connectors as manufactured by the Buchanan Co., or approved equal.
6. All common 20A branch circuits shall be run with a dedicated individual neutral. Share neutrals with other circuits not allowed.

B. References

1. All wiring shall conform to the National Electrical Code for construction and use.
2. Wiring in hot locations and for recessed fixtures shall have heat-resistant insulations recognized by NEC such as RHH, etc.
3. Conductor type THHW shall meet or exceed the following:

    a. ASTM B-3 or B-8
    b. UL
    c. UL listed as type THHW

4. Conductor types THWN shall meet or exceed the following:

    a. ASTM B-3 or B-8
    b. UL Standard 83
    c. UL listed as type THWN

5. Conductor type XHHW shall meet or exceed the following:

    a. ASTM B-3 or B-8
    b. ICEA S-66-524
    c. NEMA WC-7
    d. UL 44
    e. UL listed as type XHHW

6. Conductor type XHHW-2 shall meet or exceed the following:

    a. ASTM B-3 or B-8
    b. ICEA S-66-524
    c. NEMA WC-7
    d. UL 44
    e. UL listed as type XHHW-2

7. Conductor type RHH shall meet or exceed the following:

    a. ASTM B-3 or B-8
    b. ICEA S-66-524
    c. NEMA WC-7
    d. UL Standard 44 and 854
    e. UL listed as type RHH

C. Insulation

1. Insulation types for all conductors shall be as follows:

Description	Location		
	Dry	Damp	Wet
Branch circuits #6 AWG and smaller	THHW	THWN	THWN
Feeder and branch circuits larger than #6 AWG	XHHW	XHHW	XHHW-2
Exterior feeder and branch circuit wiring	XHHW-2	XHHW-2	XHHW-2
Feeders connected to 100% rated circuit breakers	XHHW-2	XHHW-2	XHHW-2

D. Color Coding

1. Color coding of conductors shall match the Owners color coding standard. If no standard color coding system exists, use the following:

208/120 Volts			480/277 Volts		
A Phase	-	Black	A Phase	-	Brown
B Phase	-	Red	B Phase	-	Orange
C Phase	-	Blue	C Phase	-	Yellow
Neutral	-	White	Neutral	-	Grey
Ground	-	Green	Ground	-	Green with Yellow Stripe
Isolated Ground	-	Green with Orange Stripe			

2. Color coding shall be continuous on insulation for all conductors. For conductors larger than #6 where continuous color coding is not available, each conductor shall be marked with color tape at all connections and in all pull, junction and outlet boxes.
3. For 120 volt and 277 volt single phase circuits, Electrical Subcontractor shall provide additional identification to identify each neutral conductor with its associated phase conductor in all pull, junction and outlet boxes.

E. Manufacturers

1. Branch circuit and feeder conductors shall be manufactured by one of the following: Essex (Paranite-Diamond), General Cable, Southwire or Okonite.

2.5 METALLIC CONDUIT

A. General

1. Raceways for feeders and branch circuits shall be metallic, rigid metal conduit, intermediate metal conduit (IMC) or electrical metallic tubing (EMT) subject to the restrictions of the National Electrical Code, minimum of 3/4".

B. Electrical Metallic Tubing (EMT)

1. EMT shall be permitted for both exposed and concealed work.
2. EMT shall not be permitted:

    a. Where subject to physical damage, including mechanical equipment rooms below 10’-0” AFF.
    b. In corrosive areas.
    c. In cinder block construction.
    d. In hazardous (classified) locations.

3. Fittings shall be steel set screw type.

C. Rigid Metal Conduit (RMC)

1. RMC shall be permitted under all conditions subject to the restrictions of the National Electrical Code.
2. All fittings shall be threaded.

D. Flexible liquid-tight metal conduit shall be used only for connection to motors, pumps, air handling units, transformers, modular office furniture, and final connections to all other vibrating equipment and shall be waterproof type, with an interwoven ground conductor. Separate ground conductor shall be installed for all flexible conduit sizes. Flexible conduit may also be used for connecting to lighting fixtures. Maximum length of flexible conduit allowed shall be 5'-0" from the junction box to the fixture. All lighting branch circuit home runs to panelboard shall be in conduit. Flexible liquid-tight metal conduit shall be manufactured by Electri-Flex, AFC, Anamet, or equal.

E. All empty conduit runs shall have nylon pull cords installed. Tie a washer larger than the conduit on each end of nylon pull cord to avoid losing pull cord in conduits.

F. Conduit fittings shall be cast ferrous alloy complete with gaskets and covers where required. Expansion fittings shall be used where conduit passes through building expansion joints, weatherproof telescopic type. The expansion fitting shall permit a minimum movement of 4".

G. Conduit and tubing shall be manufactured by one of the following: Wheatland, Allied Tube & Conduit Co., or LTV.

H. Flexible conduit shall be manufactured by one of the following: Electriflex, AFC or Alflex.

2.6 PLASTIC CONDUIT

A. Direct buried plastic conduit shall be Schedule 40 and concrete encased in duct banks. Conduit shall be composed of PVC, UL listed and shall conform to NEMA Standards.

B. PVC Schedule 40 conduit shall be furnished in corrosive atmosphere areas.

C. All penetrations through floor slabs, foundation walls or manhole walls shall be rigid steel conduits.

D. Plastic conduit and fittings shall be manufactured by one of the following or approved equal: JM, Carlon Products Corp. or Cantex.

2.7 MANHOLES, TELECOMMUNICATIONS AND ELECTRIC

A. Furnish and install, where indicated on the drawings, heavy duty precast reinforced concrete manholes for telecommunications and power.

B. Manholes shall have minimum internal dimensions as indicated on drawings.

C. Concrete Minimum Compressive Strength

1. 5000 psi at 28 days in accordance with ASTM, reinforced in accordance with ASTM specification of H-20 loading.

D. Joints between sections shall have self-aligning V-grooves and asphaltic butyl compound joint sealant.

E. Precast units shall be manufactured by Oldcastle Precast Group, American Precast, or approved equal.

F. Frames and covers shall be cast iron heavy duty type, suitable for H-20 street loading and have machined bearing surfaces. Electric and telecommunications manholes shall have a minimum clear opening of 32" diameter. Refer to details on plans.

G. Manholes shall be provided with the following accessories. All steel components shall be hot dipped galvanized.

1. 7/8" pulling irons.
2. Heavy duty adjustable notched channel cable racks, arms, and free moving porcelain saddle insulators. Provide racks at maximum 3'-0" intervals.

3. Provide a 10'-0" long copper clad steel drive ground rod in each manhole, extended 6" above manhole floor. All exposed non-current carrying metal accessories, and parts in manhole shall be connected to this ground rod via bare #6 AWG copper conductors.

4. Sump pits.

2.8 MINERAL-INSULATED (MI) METAL-SHEATHED CABLE

A. General

1. This section includes type MI mineral-insulated metal-sheathed cable having a seamless copper sheath and cable connectors and connections.

B. References

1. ANSI/NFPA 70 - National Electrical Code
2. UL 2196.

C. Submittals

1. Submittals shall include:

a. Product Data: Provide for each cable assembly type.
b. Manufacturer’s Installation Instructions:

1) Indicate application conditions and limitations of use stipulated by product testing agency specified under Regulatory Requirements.

D. Qualifications

1. Manufacturer shall be a company specializing in manufacturing products specified in this Section with minimum ten years documented experience such as BICC Pyrotenax System 1850, 2 hour fire rated cable.

E. Regulatory Requirements

1. Cable shall conform to requirements of ANSI/NFPA 70.
2. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for purpose specified and shown.

F. Project Conditions

1. Verify that field measurements and conditions are as shown on Drawings.
2. Cable routing shown on Drawings is approximate. Route cable as required to meet project conditions.
3. Where cable routing is not shown, and destination only is indicated, determine exact routing and lengths required.

G. Coordination

1. Coordinate work specified in this section with work provided under other electrical work and the work of other trades.
2. Determine required separation between cable and other work.
3. Determine cable routing to avoid interference with other work.

H. Mineral-Insulated Metal-Sheathed Cable

1. Description: ANSI/NFPA 70, Type MI
2. Conductor: Copper
3. Insulation Voltage Rating: 600 volts.
4. Cable Temperature Rating:

    a. 60 degrees C. for conductors rated 100 amperes and below.
    b. 75 degrees C. for conductors rated 101 amperes and above.

5. Termination Temp. Rating:

    a. 60 degrees C. for conductors rated 100 amperes and below.
    b. 75 degrees C. for conductors rated 101 amperes and above.

6. Insulation Material: Magnesium oxide refractory mineral.
7. Metal-sheath Material: Seamless soft-drawn copper.
8. Fire Rating: Cable assembly, including factory splices and supports shall have a 2 hour fire rating as listed and classified by Underwriters Laboratories, Inc.
9. Overjacket: None required; or PVC if cable is directly buried.
10. Cable sheath shall be marked with conductor size, voltage and UL fire resistant classification number.

I. Wiring Connectors And Terminations

1. Cable Termination:

    a. BICC Pyrotenax Model Pyro-Pak Installation Sheet 545U (for cables with conductors smaller than #8 AWG).
    b. BICC Pyrotenax Model Quick-Term Installation Sheet 599U (for single and multi-conductor cables with conductors #8 AWG and larger).

2. Lug Connection for solid copper conductor:

    a. ILSCO Model Lo-250: #1 AWG through 250 kcMIL
    b. ILSCO Model CRA-300: 350 kcMIL
    c. ILSCO Model CRA-400: 500 kcMIL

3. Cable Splice:

a. All cable spices of MI cable required due to length of conductor shall be factory installed and have 2 hour fire rating equivalent to the conductor itself. Field spices shall not be allowed unless installed within 2 hour fire rated rooms. Field spices within 2 hour fire rated rooms shall be BICC Pyrotenax Model Installation Sheet 550.

J. Examination

1. Verify that cable end factory temporary seals have remained intact, that the insulation has not been exposed to air, and that no moisture has entered cable insulation.
2. Verify that work of other trades likely to damage cable has been completed.

K. Storage

1. Cables shall be shipped from the manufacturer with ends temporarily sealed against moisture ingress.
2. When cables are cut in the field, the end shall be sealed using standard sealing compound and PVC tape.
3. Cable shall be stored in a clean dry location.

L. Handling

1. Cable shall be uncoiled by rolling or rotating supply reel. Do not pull from coil periphery or center.
2. Take precautions necessary to prevent damage to cable from contact with sharp objects, including pulling over foreign material or sheaves.

M. Wiring Methods

1. Fire Rated Locations: Use only fire rated cable.
2. Use wiring methods indicated on Drawings and as specified herein.

2.9 SOLDERLESS LUGS AND CONNECTORS

A. All lugs for 600 volt feeder conductors and connectors for branch circuit joints shall be copper and of the solderless type suitable for copper wire.

B. Lugs and wire connectors shall be one of the following: Ilsco, Anderson, Burndy Corp. or Thomas & Betts Co.

2.10 SURFACE MOUNTED RACEWAY SYSTEM

A. General

1. This specification covers a power wiring system with a factory wired multi-outlet raceway used for branch circuit wiring and/or voice, data, video and other low-voltage wiring. Multiple outlet raceway system shall consist of raceway, appropriate fittings, receptacle harness and receptacle identification to complete the installation as shown on the building plans.
2. The multi-outlet assembly is to be utilized in dry interior locations, and UL Listed as a Multi-outlet Assembly and Surface Metal Raceway as covered in Articles 380 and 386 of the National Electrical Code, as adopted by the National Fire Protection Association and as approved by the American National Standards Institute. The prewired raceway systems shall be listed by Underwriters' Laboratories under File Nos. E68073 Guide PVGT and E77734 Guide RJBT.
3. Submit drawings for approval, show the complete layout of all products that make up the complete system for each floor prior to installation with raceway lengths, device type (power and communications), locations and circuit identification.
4. Three (3) copies of record drawings, showing each raceway section, shall be provided upon delivery of the system.

B. Manufacturer

1. The multi-outlet assembly specified herein shall be the Wiremold Prewired Systems (AL series). Manufacturers requesting consideration as an alternative to the specified prewired systems shall submit documentation establishing their product equality at least 10 days prior to bid date. Request shall include documentation of UL listings as both a Multi-outlet Assembly and a Surface Raceway and include a sample of the prewired components. A list of similar installations in service for two (2) years or longer must be provided. Systems of other manufacturers may be considered equal, if in the opinion, and the written approval of the engineer, they meet all the performance standards specified herein.

C. Raceway

1. Raceway shall have 2 or 3 wiring compartments as indicated on plan with field removable cover(s). Raceway shall have a nominal wall thickness of .060 for Series AL. Multiple compartments and provided with fittings that maintain the separation of compartments. Covers must be removable with a standard straight blade screwdriver without marring. Raceways having two covers must allow each cover to be removed separately without allowing access into the compartment(s) enclosed by the other cover.
2. Raceway shall be manufactured of extruded #6063-T5 aluminum with a heavy etched Architectural Class II clear anodized finish (AA-C22A31) with a minimum thickness of 0.004". Each length of raceway shall be cut to specified job requirements. Field cutting of raceway will not be permitted.

3. Ground continuity shall be maintained throughout the entire raceway length by means of a factory installed grounding conductor. The grounding conductor(s) shall be the same size(s) of the branch circuit(s) serving the raceway.

D. Wiring Devices

1. Wiring devices and other connectors shall be factory installed as indicated on details, electrically wired, and covers labeled with silver, self-adhesive polyester label with black letters as identified in the building plans.
2. Each receptacle shall be identified noting the panel number and circuit number from which it is fed. Receptacles rated higher than a NEMA 50-20R configuration shall also be provided with voltage, phase and amperage identified in the same manner.
3. Receptacles in raceway connected to the optional-standby branch of the emergency power system shall be red.
4. Raceway sections shall be provided with 12" pigtails at feed locations for ease of installation. Grounding shall be maintained by means of factory installed NEC sized grounding conductor(s) and utilize insulation displacement connectors as required.

E. Communication Outlets

1. Raceway covers shall have provision for communications outlets. The raceway must be capable of containing, but not limited to, snap-in modular jacks (3-pair, 4-pair, 4-pair keyed and MMJ) coaxial and F-connectors and communication grommets. Wiring connections of these devices shall be completed at the jobsite by the Owners appointed Contractor.

F. Fittings

1. The multi-outlet system is to consist of factory assembled product with a full complement of fittings including, but not limited to, elbows (90º, internal and external), slide couplings for joining raceway sections, blank and caps for closing open ends of the raceway, and flat tees.

G. Installation

1. Raceway shall be installed with all appropriate fittings in accordance with the manufacturers installation instructions and in compliance with al appropriate codes. Raceway is to be plumb, square, level and in alignment with casework or furniture as required.

2.11 UNDERGROUND DUCT SYSTEM

A. Electrical Subcontractor shall furnish and install raceways and fittings for an underground duct system, as indicated on the drawings and specified herein.

B. Trade size of raceways shall be as per drawings for various systems.

C. Concrete, reinforcing rods, etc., shall be furnished and installed under this Section. The Electrical Subcontractor shall consult a structural engineer for proper placement and quantities of reinforcing rods.

D. Raceways shall transform from PVC to rigid steel conduit within 5'-0" of a manhole. Galvanized steel conduit shall be required within 10'-0" of either side of foundation wall. Electrical Subcontractor shall furnish and install proper coupling(s) to accommodate aforementioned transition.

E. Where offsets are required to clear obstructions and other underground services, a maximum of a 5° angle will be allowed at duct joints with prior approval of the Engineer.

F. Ducts shall be installed so as to drain to manholes.

G. All raceways as previously described shall utilize a mandrel of sufficient size to thoroughly clear raceways of all obstructions prior to installation of any wiring.

H. All concrete construction, excavation and backfill for the underground ductbank system shall be by the General Contractor.

I. Warning tape shall be provided on all duct systems to indicate route during installation.

J. All conduits penetrating into the buildings shall be totally sealed, and waterproofing shall be applied on the conduit from face of the building to 5'-0" beyond in order to prevent any migration of water through the ductbank into the building.

K. Prior to backfilling of underground duct system, the Electrical Subcontractor shall provide a yellow (with black lettering) marking tape, 1'-0" from finished grade, stating, "Caution, Electric Line (Telephone, etc.) Buried Below". Tape shall be manufactured by Panduit or equal.

2.12 WIRING DEVICES

A. Furnish and install wiring devices, Hospital and Specification grade, complete with all accessories as indicated on the drawings and as specified hereunder. All wiring devices shall be the product of a single manufacturer except where specifically stated otherwise.

B. Receptacles

1. Specification grade duplex receptacles shall be U-ground, rated for 125 volts, 20 amperes. Catalog numbers shall be as follows:

a.	Hubbell:	#HBL 5362
b.	Arrow Hart:	#5362
c.	Bryant:	#5362

2. Duplex receptacles with ground fault interrupter characteristics shall be U-ground, rated for 125 volts, 20 amperes, Specification grade, feed-through type. All receptacles in

bathrooms/toilets, within 6'-0" of sink locations (except in laboratories), exterior outlets, utility vault, in wet areas, etc. shall be ground fault type whether indicated on the drawings or not. Provide weatherproof covers for exterior outlets. Catalog numbers shall be as follows:

a.	Hubbell:	#HBL GF5362
b.	Arrow Hart:	#GF5342
c.	Bryant:	#GFR53FT

3. Special purpose receptacles shall be specification grade, back and side wired, U-ground. Catalog numbers shall be as shown on special purpose receptacle schedule on drawings.

C. Hospital Grade Devices

1. Hospital grade receptacles shall be provided in all patient care rooms/areas such as the following, whether or not indicated on the drawings:

a. Patient Bedrooms, Critical, Recovery, etc.
b. Seclusion Rooms
c. Treatment Rooms
d. Examination Rooms
e. Special Procedure Rooms
f. Operating Rooms

2. Tamper resistant receptacles shall be hospital grade and provided in patient care areas of pediatric wards, rooms or areas whether indicated on the drawings or not. Tamper resistant receptacles shall be U-Ground, rated for 125 volts, 20 amperes. Catalog numbers shall be as follows:

a.	Hubbell:	#HBLSG63H
b.	Arrow Hart:	#TR83
c.	Bryant:	#

3. Hospital grade single receptacles shall be U-ground, rated for 125 volts, 20 amperes. Catalog numbers shall be as follows:

a.	Hubbell:	#HBL 8310
b.	Arrow Hart:	#8310
c.	Bryant:	#8310

4. Hospital grade duplex receptacles connected to normal power circuits shall be U-ground, rated for 125 volts, 20 amperes. Catalog numbers shall be as follows:

a.	Hubbell:	#HBL 8300
b.	Arrow Hart:	#8300
c.	Bryant:	#8300

5. All duplex receptacles connected to the life safety, critical or equipment branch of the emergency electrical system shall be Hospital grade, U-ground, rated for 125 volts, 20 amperes with illuminated face. Catalog numbers shall be as follows:

a.	Hubbell:	#HBL 8300-ILR
b.	Arrow Hart:	#5362-HGL
c.	Bryant:	#T83-GL

6. Duplex receptacles with ground fault interrupter characteristics shall be U-ground, rated for 125 volts, 20 amperes, Hospital grade, feed-through type. All receptacles in bathrooms/toilets, within 6'-0" of sink locations, exterior outlets, utility vault, in wet areas, etc. shall be ground fault type whether indicated on the drawings or not. Provide weatherproof covers for exterior outlets. Catalog numbers shall be as follows:

a.	Hubbell:	#HBL GF8300
b.	Arrow Hart:	#GF8300
c.	Bryant:	#GFR83FT
d.	Eagle:	#2091H
e.	Pass & Seymour:	#GF8300

D. Switches

1. Toggle switches shall be full size, heavy duty, AC type, rated for 120/277 volts, 20 amperes. Catalog numbers shall be as follows:

Manufacturer	Single Pole	3-Way	4-Way	Key Switches
Hubbell:	#HBL 1221	#HBL 1223	#HBL 1224	#HBL 1221-L
Arrow Hart:	#1991	#1993	#1994	#1991-L
Bryant:	#4901	#4903	#4904	#4900-L

2. Occupancy sensors

a. Wall mounted occupancy sensors shall be passive infrared rated 1,200 watts at 277 volts or 800 watts at 120 volts and require no minimum load. Sensors shall be compatible with all load types, including electronic and compact fluorescent ballasts. Sensor shall have 180° field of view and shall cover up to 900 sq.ft. Sensor shall have an adjustable time delay from 30 seconds to 30 minutes and a manual "off" override. Catalog numbers shall be as follows:

1)	Unenco:	#IWS-ZP-3P
2)	Hubbell:	#WSS-1200
3)	Watt Stopper:	#WS-120/277

b. Wall sensors for loads in access of 1,200 watts at 277 volts or 800 watts at 120 volts shall utilize relay control of the branch circuit.

c. Ceiling mounted occupancy sensors shall be passive infrared rated 4,800 watts at 277 volts or 2,400 watts at 120 volts and require no minimum load. Sensors shall be compatible with all load types, including electronic and compact fluorescent ballasts. Sensor shall have 360° field of view and shall cover up to 1,000 sq.ft. Sensor shall have an adjustable time delay from 30 seconds to 30 minutes. Catalog numbers shall be as follows:

1)	Unenco:	#PIR-10-P
2)	Hubbell:	#257151SWC/
3)	Watt Stopper:	#CI-200/A120/277E-P

3. Dimmers shall be 120 volt, 1,000 and 2,000 watts with slider control, color selected by Architect, manufactured by Lutron N2000 Series or approved equal. Wattage rating of light fixtures connected to the dimmer shall not exceed 80% of dimmer rating. Provide additional dimmer as required whether shown on drawings or not.

E. Color of all wiring devices shall be per the Architect and conform to the Owners Standards. Receptacles on emergency system shall be red.

F. Device plate shall be as follows:

1. All normal power wiring device plates shall be high impact nylon/thermoplastic:

a.	Hubbell:	#P Series
b.	Arrow Hart:	#P Series
c.	Bryant:	#N Series

2. All emergency power wiring device plates shall be red high impact nylon/thermoplastic with white filled "EMERGENCY" engraved in the plate:

a.	Hubbell:	#PJ*RME Series
b.	Arrow Hart:	#PJ*RME Series
c.	Bryant:	#N MEM Series

2.13 RADIOLOGY SUITES

A. General

1. Work Included

a. The work required on this section is subject to all of the requirements in the General Condition of the specification.
b. The Contractor shall provide all disconnects, panelboards (277/480, 120/208), in-slab wireways, in wall wireways, feeders, branch circuiting, interlock and control wiring, warning lights, door strikes, nurse call devices, etc., as indicated on the final financing system vendor drawings.

2. Description of Work

   a. The extent of the radiology suites system is indicated on the electrical drawings. Final vendor drawing and by the requirements of this section. It is defined to include all electrical systems identified in the final vendor drawings.
   b. The Contractor shall be responsible to provide all electrical systems indicated in the final vendor drawing to allow for a complete and operable radiology suite.
   c. The Contractor shall obtain and use the final vendor drawing for device quantities, types, etc. The location of the radiology suites equipment shall be installed as indicated on the architectural and final vendor drawings. The Contractor shall obtain drawing from Construction Manager.
   d. The Contractor shall provide primed wireway covers in all areas where an architectural finish is to be provided.
   e. The Contractor shall coordinate removable covers and flanges of wireways with architectural wall and floor finishes. Removable covers shall not be hidden.
   f. Requirements are indicated elsewhere in these specifications for work including, but not limited to, raceways, wireways, electrical boxes and listings required for installation of power and control wiring.

3. Quality Assurance

   a. NEC compliance: All components, systems and workmanship shall comply with applicable local and state codes and the National Electrical Codes regarding electric wiring standards.
   b. NEMA compliance: All radiology suites components and installation shall comply with all applicable portions of the NEMA standards regarding the types of electrical enclosures.

4. Submittals

   a. Provide shop drawing with final vendor equipment requirements indicated.

5. Radiology equipment layouts.

PART 3 - EXECUTION

3.1 COOPERATION AND WORK PROGRESS

A. The Electrical work shall be carried on under the usual construction conditions, in conjunction with all other work at the site. The Electrical Subcontractor shall cooperate with the Architect, General Contractor, all other Subcontractors and equipment suppliers working at the site. The Electrical Subcontractor shall coordinate the work and proceed in a manner so as not to delay the progress of the project.

B. The Electrical Subcontractor shall coordinate his work with the progress of the building and other Trades so that he will complete his work as soon as conditions permit and such that

interruptions of the building functions will be at a minimum. Any overtime hours worked or additional costs incurred due to lack of or improper coordination with other Trades or the Owner by the Electrical Subcontractor, shall be assumed by him without any additional cost to the Owner.

C. The Electrical Subcontractor shall furnish information on all equipment that is furnished under this Section but installed under another Section to the installing Subcontractor as specified herein.

D. The Electrical Subcontractor shall provide all materials, equipment and workmanship to provide for adequate protection of all electrical equipment during the course of construction of the project. This shall also include protection from moisture and all foreign matter. The Electrical Subcontractor shall also be responsible for damage which he causes to the work of other Trades, and he shall remedy such injury at his own expense.

E. Waste materials shall be removed promptly from the premises. All material and equipment stored on the premises shall be kept in a neat and orderly fashion. Material or equipment shall not be stored where exposed to the weather. The Electrical Subcontractor shall be responsible for the security, safekeeping and damages, including acts of vandalism, of all material and equipment stored at the job site.

F. The Electrical Subcontractor shall be responsible for unloading all electrical equipment and materials delivered to the site. This shall also include all large and heavy items or equipment which require hoisting. Consult with the General Contractor for hoisting/crane requirements. During construction of the building, the Electrical Subcontractor shall provide additional protection against moisture, dust accumulation and physical damage of the main service and distribution equipment. This shall include furnishing and installing temporary heaters within these units, as approved, to evaporate excessive moisture and ventilate it from the room, as may be required.

G. It shall be the responsibility of the Electrical Subcontractor to coordinate the delivery of the electrical equipment to the project prior to the time installation of equipment will be required; but he shall also make sure such equipment is not delivered too far in advance of such required installation, to ensure that possible damage and deterioration of such equipment will not occur. Such equipment stored for an excessively long period of time (as determined in the opinion of the Architect) on the project site prior to installation may be subject to rejection by the Architect.

H. Prior to installation, the Electrical Subcontractor has the responsibility to coordinate the exact mounting arrangement and location of electrical equipment to allow proper space requirements as indicated in the NEC. Particular attention shall be given in the field to group installations. If it is questionable that sufficient space, conflict with the work of other Subcontractors, architectural or structural obstructions will result in an arrangement which will prevent proper access, operation or maintenance of the indicated equipment, the Electrical Subcontractor shall immediately notify the Contractor and not proceed with this part of the Contract work until definite instructions have been given to him by the Architect.

I. The Electrical Subcontractor shall obtain from the Plumbing and HVAC Subcontractors copies of all shop drawing prints showing the ductwork and piping installation as they will be put in place on the project. These drawings shall be thoroughly checked by the Electrical Subcontractor and the routing of all conduits and installation of all outlets and electrical equipment shall be coordinated with the ductwork and piping so as to prevent any installation conflict. Such coordination shall be done prior to roughing in conduits, outlets and electrical equipment.

J. Location of all wall outlets shall be verified with the Architect prior to roughing in conduits. Refer to details and wall elevations on the Architectural drawings. Mounting heights indicated on these drawings and/or specific dimensional information given to the Electrical Subcontractor by the Architect shall take precedence over such information indicated on the Electrical drawings.

K. Refer to all other drawings associated with this project. Any and all equipment which require an electrical supply circuit, switch, controls or connections, whether indicated on the Electrical drawings or not, shall be furnished and installed as directed by the Architect.

L. Refer to the Architectural drawings for areas in which the concrete slab is poured on grade. In these areas a waterproofing membrane will be installed on the grade fill or earth prior to pouring of slab. Electrical conduits shall be installed to avoid the necessity of penetrating this waterproofing membrane. Penetration of the membrane, if required, shall only be made when specifically allowed by the Architect, and shall be made only at locations directed by the Architect.

3.2 INSTALLATION

A. General

1. Unless specifically noted or indicated otherwise, all equipment and material specified in Part 2 of this specification or indicated on the drawings shall be installed under this Contract whether or not specifically itemized herein. This Section covers particular installation methods and requirements peculiar to certain items and classes or material and equipment.
2. The Electrical Subcontractor shall obtain detailed information from manufacturers of equipment provided under Part 2 of this specification as to proper methods of installation.
3. The Electrical Subcontractor shall obtain final roughing dimensions and other information as needed for complete installation of items furnished under other Sections or furnished by the Owner.
4. The Electrical Subcontractor shall keep fully informed of size, shape and position of openings required for material and equipment provided under this and other Sections. Ensure that openings required for work of this Section are coordinated with work of other Sections. Provide cutting and patching as necessary.
5. All miscellaneous hardware and support accessories, including support rods, nuts, bolts, screws and other such items, shall be of a galvanized or cadmium plated finish or of another approved rust-inhibiting coating.

6. Throughout this Section where reference is made to steel channel supports, it shall be understood to mean that the minimum size shall be 1 5/8" mild strip steel with minimum wall thickness of 0.105", similar to Unistrut P1000 or equal products manufactured by Kindorf or Husky Products Co. Where reference to channel supports is made under "Lighting Fixtures" paragraph of this Section, the maximum length of span shall be 10'-0". If longer spans are required, the size and wall thickness of the steel channel support shall be as specifically approved by the Engineer.

B. Cable Assemblies - Prefabricated

1. Multiconductor cable assemblies shall be installed concealed only in areas as permitted in these specifications.
2. Multiconductor cable assemblies shall be run through openings in metal studs. The cable assembly shall be attached with approved clips to metal studs as follows:

   a. 4'-0" on center for vertical runs
   b. Within 12" of each outlet box
   c. 6'-0" on center for horizontal runs

3. Where multiple runs of multiconductor cable assemblies are run together, all cables shall be bundled and secured together in a neat and workmanlike manner utilizing tie wraps, etc.

C. Conduits

1. Conduit shall be run concealed in finished areas above suspended ceilings, in wall spaces, etc. Exposed conduit runs in finished areas require Architect's approval. All conduit runs shall be properly grouped and installed parallel to walls, ceilings, etc., and supported with proper hangers, clamps, etc. Door swings shall be checked before installing back boxes for switches and receptacles.
2. Conduit bends shall be made with conduit bending machines or by an approved hickey. Lock nuts and insulated throat bushings of the compatible material shall be used to fasten conduit to outlet boxes, cabinets, etc.
3. Feeder and branch circuit conduit runs are not allowed in any floor slabs. Feeder and branch circuit conduit may run below the basement floor slab provided it is supported from the basement floor slab 5'-0" on center.
4. No plastic conduit runs are allowed in any floor slabs. PVC Schedule 40 may be run below the lowest floor slab, provided it is encased in concrete and is supported from the lowest floor slab 5'-0" on center.
5. Conduit ends shall be cut square, threaded and reamed to remove burrs and sharp edges. Field threads shall be of the same type and have the same effective length as factory cut threads. Excessive exposed threads will not be allowed. Turns, wherever required in exposed conduit runs, shall be made by the use of factory-made bends, or field-made bends as approved. In condulets, or in the event of a multiplicity of conduits making the same turn, a steel junction box with a removable steel cover may be used. Offsets and bends for changes in elevation of exposed conduit runs shall be made at walls or beams and not in open spaces between walls or beams. Conduits shall be routed so as not to interfere with the operation or maintenance of any equipment. The entire job shall be

done in a neat and workmanlike manner, as approved by the Architect. Steel supports or racks shall be galvanized steel channel and fittings.

6. All conduit work shall be carefully cleaned and dried inside before the installation of conductors. Wire shall not be pulled into conduit system until building roof and walls are weathertight and all rough spackling is completed. Plug conduit ends to exclude dust, moisture, plaster or mortar while building is under construction. No lubricants or cleaning agents which might have a deleterious effect on conductor coverings shall be used for drawing conductors into raceways.
7. Drawings, in relation to routing of conduits, are diagrammatic. Except where additional conduits may be required to avoid derating of branch circuits, as required elsewhere within this Section, the number and size of conduits and wire shall be furnished and installed as indicated by the drawings. Conduits shall be routed in the field so as to be coordinated with the building structure. Permanently concealed conduit shall be as short and direct as possible. Exposed conduit and conduit concealed by removable finishes such as accessible ceiling tile shall be run in straight lines parallel and perpendicular to walls, beams and columns and with right angle bends.
8. Conduits passing through floors, walls and beams shall be of such size, number and in such locations so as not to impair the strength of the construction.
9. Raceways in ceiling spaces shall be routed in such an approved manner as to eliminate or minimize the number of junction boxes required, but also shall be routed in an orderly and organized manner. Support rods and clamps shall be furnished and installed as directed by the Architect. Support of conduits by use of wire is strictly prohibited. Conduits shall be supported and secured by conduit support devices as approved by the Architect.
10. Emergency electrical raceways that are part of the emergency distribution system shall be located in spaces fully protected by an approved automatic fire suppression system or in spaces with a one (1) hour fire resistance rating.
11. Where rigid metal conduit is threaded in the field, a standard conduit cutting die providing 3/4" taper per foot shall be employed. Threadless coupling shall not be used on rigid metal conduit except where specifically allowed by the Architect. Running threads shall not be used on rigid metal conduit. Compression fittings shall not be used with rigid steel, intermediate metallic or aluminum conduit.
12. Conduit work shall be installed in such a manner to keep exposed threads to an absolute minimum, and in no case shall more than (3) threads be left exposed after the conduit work is made up tight.
13. Provide flexible conduits for connections to equipment furnished under HVAC, Plumbing Sections and other equipment as specified under Part 2 of this specification and where available space dictates; and where noise transmission must be eliminated or reduced. Flexible conduit shall be liquid-tight except for connections to recessed lighting fixtures.
14. Conduit and EMT runs shall be mechanically and electrically continuous from service entrance equipment to distributing equipment. Conduit shall enter and be secured to cabinet, junction box, pull box or outlet box with locknut outside and bushing inside, or with liquid-tight, threaded, self-locking, cold-weld wedge adapter. Locknuts and bushings or self-locking adapters will not be required where conduits are screwed into tapped connections. Vertical conduit runs that terminate in bottoms of wall boxes or cabinets shall be protected from entrance of foreign material before installation of conductors.

15. Size of rigid steel conduit, intermediate metal conduit, electrical metallic tubing and flexible metallic conduit shall be as shown on the drawings.
16. For recessed mounted panels furnish and install three (3) 1” EMT conduits from each recessed panel and stub out 6” above nearest accessible ceiling.
17. Check raceway sizes to determine that green equipment ground conductor fits in same raceway with phase and neutral conductors to meet NEC percentage of fill requirements. Increase duct, conduit, tubing and raceway sizes shown or specified as required to accommodate conductors.
18. Conduit secured rigidly on opposite sides of building expansion joints and long runs of exposed conduit subject to stress shall have expansion fittings. Fittings shall safely deflect and expand to twice distance of structural movement. Provide separate external copper bonding jumper secured with grounding straps on each end of fitting.
19. Threaded sealing fittings for rigid steel conduits shall be zinc or cadmium-coated, cast or malleable iron. Sealing fittings for aluminum conduit shall be threaded cast aluminum. Fittings that prevent passage of water vapor shall be continuous drain. Install and seal fittings as required by manufacturer's recommendations. In concealed work, install fittings in flush steel box with blank cover plate.

    a. Install sealing fittings at following points, and elsewhere as shown:

        1) Where conduits enter or leave hazardous areas equipped with explosionproof lighting fixtures, switches, receptacles and other electrical devices.
        2) Where conduits pass from warm to cold locations.
        3) Where required by NEC.

    b. Secure conduit system as required by NEC.

20. A minimum 3/16" diameter, twisted nylon plastic type fish cord shall be furnished and installed in all empty raceways. Provide a tag and washer sized larger than the conduit on each end of fish cord indicating the location of the other end.
21. All medium voltage raceways that are run exposed shall be painted red and shall have permanent white label on 5'-0" centers, indicating "DANGER - HIGH VOLTAGE - KEEP OUT".

D. Underground Conduits

1. Steel conduits in ground or on vapor barriers shall be field coated with asphaltum or shall have additional outside factory coating of polyvinyl chloride or phenolic-resin-epoxy material or other equally flexible and chemical resistant material. Couplings and damaged areas of coated conduits shall be field-coated with same compound as conduits. Joints shall be threaded.
2. Joints in conduits and fittings shall be watertight and shall meet the requirements of manufacturer's installation recommendations. Threaded portions of steel conduits not encased in concrete, and adjoining ends of conduits, couplings and fittings shall be coated with asphaltum after installation. Connections between conduits of different types shall be made in an approved manner, using adapters and other materials and methods recommended by conduit manufacturers.

3. Where nonmetallic underground conduit enters the building and continues inside to the main electric service, pull box, cabinet or other electrical apparatus, the portion of the conduit that passes through the floor or wall and the remainder of the raceway inside the building shall be steel. Provide an adapter outside the building (5'-0" beyond building wall minimum) wall to connect plastic and metal conduit.
4. All metal conduit buried in the earth or fill shall be coated with (2) coats of heavy asphalt paint or PVC coated over its entire length, including couplings.
5. Where underground conduit enters the building through membrane-waterproofed wall or floor, provide a malleable iron seal with gland assembly and adjustable pressure bushings secured to masonry construction with (1) or more integral flanges. Membrane waterproofing shall be secured to device in a watertight manner.
6. Where underground conduit, without concrete envelope, enters the building through non-waterproofed wall or floor, provide Schedule 40 galvanized pipe sleeve. Fill space between conduit and sleeve with suitable plastic expandable compound or oakum and lead joint on each side of wall or floor.
7. Excavation, shoring, bracing, backfilling and grading will be provided by the General Contractor. Trenches shall be evenly graded so that conduits slope uniformly a minimum 3" per 100'-0", without horizontal or vertical waves. Unless specified otherwise, conduit shall slope uniformly from (1) manhole to the next or from a high point between manholes to prevent pooling of water. Conduits run from building to manhole shall slope toward manhole to avoid water draining into the building. Avoid low points between manholes or upturned elbows.
8. Run conduits straight between manholes and upturned elbows. Unavoidable bends in nonmetallic conduits shall be made by assembling couplings at a slight angle if resulting radius is at least 100'-0". For radii less than 100'-0", use 5° angle couplings or 5° factory-made bend sections. Conduit shall terminate in end bells where raceway enters manholes. All conduit bends for telecommunication ductbanks shall be 12'-6" radius sweeps. Conduit bends for power cable conduits shall be minimum 36" radius.
9. Support multiple conduit runs and banks on preformed nonmetallic spacing block separators on 4'-0" centers. Separator containing metal shall have metal non-continuous and shall not form a magnetic loop. Unless otherwise shown on the drawings, spacing between exterior surfaces of conduits shall be as follows:

    a. 2" between telephone conduits
    b. 2" between conduits containing cables operating at 600 volts or less
    c. 12" between telephone conduit and power conduit in the same concrete envelope
    d. 2 1/2" between conduits containing cables operating at more than 600 volts
    e. Space conduit separators to prevent sagging of raceway and breaking of couplings and watertight seals, to maintain deformation of conduit at separators to 0.10" or less. Secure with cords where necessary. Do not use tie wires, reinforcing rods or other metallic materials.

10. Stagger conduit couplings so that couplings on adjacent conduits do not lie on the same transverse plane. Space end bells 9" center-to-center at manhole wall face for 4" conduits and space proportionately for other sizes. Transition to end bell spacing shall start 10'-0" from face of manhole wall. Conduit slope shall equal that of main bank. Make new conduit entrances into manholes and building walls consistent with grading requirements

and entrances. Waterproof all conduit entrances into manholes and buildings as required by the Architect.

11. Where underground metallic conduits pass below the grade level floor, they shall be supported every 5'-0" from the concrete floor. Plastic conduits run below the grade level floor shall be encased in concrete and shall be supported every 5’-0” form the concrete floor.
12. Concrete for conduit envelopes shall be as required or as specified under Division 3. Concrete shall extend a minimum 3" beyond exterior surface of each conduit in bank. Coordinate work of this Section with that of Division 3.
13. Concrete envelopes between manholes, or between manhole and building, shall be poured in a single operation. Where more than (1) pour is necessary, provide 3/4" reinforcing rod dowels extending 18" into concrete on each side of joint. Dowels shall be coated with bonded adhesive prior to the second pour. Concrete envelopes installed over extensive area of disturbed earth shall have a separate concrete base.
14. Concrete envelopes that cross other conduits or pipelines or are run under roads and driveways shall be reinforced. Provide reinforcement where envelopes connect to manhole and building walls. Concrete envelopes that terminate for future extension shall have dowels as specified for joints between pours. Reinforcement shall be as required; consult with Structural Engineer.
15. Trenches shall not be backfilled until concrete envelopes have had sufficient time to set. After concrete envelopes have set, nonmetallic conduits shall be cleared with mandrel of the same size as the conduit.
16. Where conduits cross under existing roadways, walks or other paved areas, steel conduits may be driven instead of conduits in trenches. After installation, paved grass areas and other areas disturbed shall be restored to original condition.
17. Cap ends of spare conduits 5'-0" beyond pavement and protect them from mechanical damage. Mark the location of conduit ends with concrete monuments, 6" in diameter by 18" long, set flush in the ground with "S/C" indented in the top.
18. Arrange multiple conduits as shown on the drawings. Make minor changes in location, or cross-sectional arrangement as necessary. Where conduit runs cannot be installed as shown because of conditions not discoverable prior to digging of trenches, request the Architect's instructions before further work is done. Coordinate this work with other outside service work.
19. Seal active and spare conduits that enter the building with oakum or other plastic expandable compound until conductors are ready for installation.

E. Pull, Junction and Outlet Boxes

1. The Electrical Subcontractor shall furnish and install pull boxes for all feeders as required by NEC. Pull boxes shall be code gauge steel plates fastened to angle iron frames with removable covers. Covers shall be secured with brass machine screws.
2. The Electrical Subcontractor shall furnish and install junction boxes for feeders and branch circuits as required. Boxes shall be sized in accordance with NEC. Junction boxes shall be code gauge steel with removable covers. Covers shall be secured with brass machine screws.
3. The Electrical Subcontractor shall furnish and install outlet boxes for all wiring devices. Bar hanger type outlet boxes shall be used in hollow frame partitions, other than masonry

or construction block partitions. For metal stud partitions, bar hanger shall be secured with self-threading metal screws or drill through hangers with caddy clips.

4. Through-the-wall outlet boxes shall not be permitted. Outlet boxes shall not be installed back-to-back but shall be staggered on opposite sides of partitions a minimum of 12" on center.
5. If any discrepancies regarding the locations of outlet boxes are found to exist between the Electrical drawings and any other drawings associated with the project, notify the Architect at once and have location verified before outlets are installed. Any reasonable change in location of outlets prior to roughing shall not involve additional expense to the Owner. The term "reasonable" shall be interpreted as moving outlet locations a maximum of 10'-0" in any direction from the location indicated on the drawings.
6. Whenever outlet boxes of any system are installed in brick, masonry or concrete construction, furnish and install the necessary boxes and conduit in connection therewith so that the Contractor may build them in as the work progresses. Box offsets shall be made at all outlets to provide for proper adjustment to finished surfaces.
7. The Electrical Subcontractor is responsible for cutting openings in brick, tile and all types of construction blocks at outlets. Exposed mortar shall not be permitted around device plates.
8. All boxes shall be rigidly mounted to construction and shall be equipped with suitable screw fastened covers. Unused open knockouts in all boxes shall be plugged with suitable blanking devices. All boxes installed that do not have equipment mounted on them shall be provided with blank covers.

F. Cutting, Patching and Conduit Sleeves

1. The Electrical Subcontractor shall be responsible for all core drilling required for his work, but in no case shall he cut into any structural elements without the written approval of the Architect.
2. All cutting, rough patching and finish patching required for electrical work shall be provided by the Electrical Subcontractor.
3. All concrete and masonry equipment bases and pads, concrete duct banks, curbs, chases, pockets and openings required for the proper installation of the work under this Contract will be provided by the General Contractor, using dimensions, templates, bolts, anchors, as required by the manufacturer's installation details of the various equipment.
4. Where conduits pass through masonry or concrete walls, foundations or floors, the Electrical Subcontractor shall set such sleeves as are necessary for passage of the conduits. Sleeves shall be of sufficient size to provide air space around the conduit passing through for fireproofing. The Electrical Subcontractor shall be responsible for the exact location of sleeves provided under his Contract.
5. Conduit passing through exterior walls and floors below grade shall be made watertight with caulking compound and pipe sleeves with wall collar located at the center of the wall extending 8" all around the conduit. Collar shall be 1/8" thick steel welded to sleeve. Coordinate material requirements with the Contractor.
6. Sleeves and inserts shall not be used in any portions of the building where their use would impair strength or construction features of the building. Elimination of sleeves must be approved by Architect.

7. Pipe sleeves shall be Schedule 40 galvanized steel and shall be set, as follows:

    a. Set sleeves 6" above finish floor and flush on each side of walls.
    b. Set sleeves 6" above finished floor and flush on each side of walls and electric room floors.
    c. Sleeves in walls and partitions shall terminate flush with finished floor.
    d. Sleeves shall be set securely in place before concrete is poured.
    e. Sleeves shall be minimum 2" larger in diameter than the pipe passing through it.

8. Conduits passing through fire partitions shall be provided with 10 gauge steel pipe sleeves and firestopped.
9. All cutting and patching required by the Electrical Subcontractor in finished areas which require access shall have access panels as specified elsewhere in this specification.
10. Fill for floor penetrations shall be fire-resistant, compatible with floor material and finished to prevent passage of water, smoke and fumes. Fill in walls shall be similar to wall material, shall be fire-resistant in fire walls, and shall prevent passage of air, smoke and fumes. Fill spaces in openings after installation of conduit or cable. All fireproofing inside sleeves shall be by the Electrical Subcontractor. Fireproofing required outside of sleeves shall be by the General Contractor.
11. Where conduits passing through openings are exposed in finished rooms, finishes of filling materials shall match and be flush with adjoining floor, ceiling and wall finishes.
12. Fill slots, sleeves and other openings in floors and walls if opening is not used. Identify unused sleeves and slots for future installation.
13. Lay out conduit and openings in advance, to permit provision in work. Set sleeves and conduit in forms before concrete is poured. Provide remedial work where sleeves and conduits are omitted or improperly placed.
14. Bus duct penetrations through floors shall have concrete curbs built around the floor openings, 3" minimum height.

G. Feeder and Branch Circuit Conductors (600 Volts)

1. Install wire and cable in approved raceways as specified and as approved by Authorities that have jurisdiction. Surface metal raceways shall not be used unless explicitly specified and shown on the drawings. Do not use surface raceways on floor.
2. Wire from point of service connection to receptacles, lighting fixtures, devices, equipment, outlets for future extension, and other electrical apparatus as shown on the drawings. Provide slack wire for connections where required. Tape ends of wires and provide blank covers for outlet boxes designed for future use.
3. Conductors #10 and smaller in branch circuit panelboards, signal cabinets, signal control boards in switchboards and motor control centers shall be bundled.
4. The branch circuit wiring shall include a separate neutral conductor for each 120 volt and 277 volt circuit. Shared neutrals not allowed. Home runs may be combined in a common raceway provided that no more than three phase conductors (each of a different phase leg), three neutral conductors and one ground conductor are installed in the same conduit.
5. Follow homerun circuit numbers shown on the drawings to connect circuits to panelboards. Where homerun circuit numbers are not shown on the drawings, divide similar types of connected loads among phase busses so that currents in each phase are within 10% of each other during normal usage.

6. All feeder, branch circuit or auxiliary system wiring passing through pull boxes and/or being made up in panelboards shall be properly grouped, bound and tied together in a neat and orderly manner in keeping with the highest standards of the Trade, with plastic cable ties. Loose ends of the cable ties shall be properly trimmed after making up same. Cable ties shall be Ty-Raps, as manufactured by Thomas & Betts, Holub Industries, Inc., Quick-Wrap, Burndy Unirap or equal.
7. Branch circuits and auxiliary system wiring shall be peeled out of the wiring gutters at the terminal cabinet and panels at 90° to circuit breakers and terminal lugs for connecting to same.
8. For large size conductors available only in black, use colored plastic tape at all ends, where connections and splices are made and in all pull boxes for the specified color code identification. Tape shall be wrapped around the conductor (3) complete turns.
9. Joints and splices shall be made in an approved manner and shall be equivalent, electrically and mechanically, to the conductor insulation. All conductors shall be connected by use of solderless crimp (compression) type connectors; these joints and splices shall be taped with (1) wrap of varnish cambric tape and then a minimum of (3) wraps of No. 88 Scotchbrand (3M Company) all-weather vinyl plastic electrical tape, or equal Permacel or Plymouth Co. Each wrap of tape shall be half-lapped. Conductors of size #4 AWG or larger shall have (2) coats of insulating varnish applied over the tape for joints in manholes, handholes or exposed-to-weather conditions.
10. Provide nonferrous identifying tags or pressure-sensitive labels for cables, feeders, and power circuits in pull boxes, manholes and switchboard rooms, at cable termination and in other locations.
11. Tags or labels shall be stamped or printed to correspond with markings on the drawings or marked so that feeder or cable may be identified readily. If suspended tags are provided, attach with 1/32" diameter, nylon, 55 pound test monofilament line or slip-free plastic cable lacing unit.
12. The number and size of conductors in each run of conduit is indicated on the drawings. Where there is a conflict between the number of wires indicated and the actual number required, the actual number and size shall be installed.
13. All branch circuits shall be connected to breakers at Electrical Subcontractor's discretion. The balancing of all loads between phases shall be the Electrical Subcontractor's responsibility.
14. Splices, taps and lugs shall be electrically and mechanically secure and solderless lugs, and crimp connectors shall be used. Lugs shall be used for conductor sizes #8 AWG and larger. All lugs shall be of the proper size, and in no case shall strands be cut from a conductor in order to fit the conductor into a lug. Provide lug/cable adapters for breakers where oversized cables are indicated. All lug connections to buses in switchboards, unit substations, motor control centers, etc., shall be 2-bolt/nut connections.
15. Provide 1/4" polyethylene ropes for pulling wire. Provide wire pulling lubricants that meet applicable UL requirements as necessary.
16. Provide cable supports for vertical feeders as required by NEC. Vertical feeders shall be supported at every other floor level.
17. Provide split wedge cable supports with clamps for cable without metallic sheath in pull boxes. Supports shall be as manufactured by O.Z./Gedney or approved equal.
18. All wiring shall be installed and supported in accordance with the requirements of the NEC.

H. Mineral Insulated (MI) Metal-Sheathed Cable

1. Install products in accordance with manufacturer's instructions.
2. Bending:

    a. Not less than five (5) times the cable diameter for cable not more than ¾ inch (250 kcMIL).
    b. Not less than ten (10) times the cable diameter for cable more than ¾ inch (350 and 500 kcMIL).

3. Pulling:

    a. For all cables up to and including #1 AWG use ten inch (250mm) or larger sheaves.
    b. For #1/0 through 250 kcMIL inclusive, use 18 inch (460mm) or larger sheaves.
    c. For 350 kcMIL and larger cables, use 24 inch (590mm) or larger sheaves.
    d. On pulls of over 360 degrees, contact manufacturer for assistance.
    e. 350 and 500 kcMIL cables shall not be pulled more than 360 degrees in total.

4. Splicing:

    a. All fire rated splices shall be made in the factory.
    b. In the event a field splice is necessary, it must be made within a 2 hour fire rated room, approved by the engineer and:

        1) Made in the field by manufacturer's field technician, or
        2) Made in the field by personnel trained by the cable manufacturer using manufacturer's components.

5. Terminations:

    a. Field made terminations shall be made with cable manufacturer's termination kits only. Stripping tools, crimping and compression tools available from the manufacturer shall be used for proper cable termination.
    b. Terminations must be completed immediately once started to avoid moisture ingress from surrounding air. Prior to completing each termination, test insulation resistance and follow manufacturer's drying procedures until insulation resistance reaches an acceptable level.
    c. Connections to ferrous cabinets for single conductor cables shall incorporate brass plates 1/4 inch (6mm) thick by 4 inch (100mm) wide by length as required with 1/2 inch (12mm), 3/4 inch (19mm), 1 inch (25mm) or 1 1/4 inch (32mm) drilled and tapped holes. Install per manufacturers' drawing .

6. Sheath induction reduction:

    a. When multi-phase circuits have paralleled single conductors, cables shall be run in groups having one of each phase in each group.

b. Each set of paralleled conductors shall be separated by at least two single cable diameters.
c. On balanced three-phase wye circuits neutral conductors may be located within the two cable diameter space between groups of phase conductors.
d. Each group of cables shall be fastened tightly together, at least once between each cable support on horizontal runs and twice on vertical runs, using ½ inch (13mm) wide by 0.030 inch (0.75mm) thick stainless steel straps.

7. Exposed or Surface installations:

a. Cable may be secured directly to fire rated building structure using an approved method such as one, or any combination, of the following:

1) Straps: ½ inch (13mm) wide x 3 1/2 inch (38mm) long by 0.030 (0.75mm) thick stainless steel or copper straps. Each strap shall contain two ¼ inch (6mm) holes for securing with 3/16 inch (5mm) by minimum 1 3/4 inch (44mm) long steel anchors.
2) Steel struts and cable tray: Use only the steel strut framing system and support recommended by Pyrotenax. Aluminum or other materials are not acceptable.

b. Supports shall not exceed three (3) feet on center horizontally, or six (6) feet vertically.
c. Cables shall be installed parallel to building lines.

8. Embedded Installations:

a. Cables will be run in the same trifoil configuration as exposed installations.
b. Protect against damage during pulling, and during concrete pouring or backfill and tamping.
c. Where cables emerge from grade, provide PVC conduit, metal plate or angle iron. This protection shall minimally extend from 18 inches (460mm) below grade to 8 ft. (2.5m) above grade.

9. Wall or floor penetrations:

a. Provide sleeve to protect cable and penetration opening during pulling.
b. Provide approved fire stopping of all penetrations.

10. Neatly train and lace cable inside boxes, equipment, and panelboards.
11. Field Quality Control

a. Inspect cable for physical damage and proper connection.
b. Measure tightness of bolted connections and compare torque measurements with manufacturer's recommended values.
c. Verify continuity of each conductor.
d. Prior to energizing cables, measure insulation resistance of each cable. Tabulate and submit for approval.

e. Provide certification from cable manufacturer that installation is in accordance with their requirements.

I. Wiring Devices

1. All wiring devices shall be installed in appropriately sized outlet boxes. Where more than (1) switch or a double duplex receptacle is indicated on the drawings multiple gang outlet boxes shall be provided to accept all devices in the area. Separate boxes are required for wiring devices on emergency circuit, ganging of boxes, using barriers, are not acceptable.
2. All duplex receptacles shall be mounted vertically with the grounding post on the bottom side of the outlet as viewed from the front.
3. Each and every receptacle either wall or raceway mounted, shall have panel and circuit identification engraved on their faceplates.
4. All toggle switches, single pole, 3-way and 4-way, shall be so installed such that, when lights are off, all switch posts shall be in the down position.
5. All device plate screws shall be colored alike to the device plates. All screws shall be installed "finger-tight" to avoid damage to device plate.

3.3 ELEVATOR AND RELATED WORK

A. Furnish and install all power wiring as required by the elevator manufacturer. Consult elevator manufacturer and obtain final accepted elevator shop drawings prior to installing feeders, disconnect switches, elevator pit light/receptacles, telephone empty conduits, 120 volt control power circuits for the machine room and control wiring for selective operation of elevators when the building power system is derived from the generators.

B. The elevator machine safety switch shall contain a normally closed, dry auxiliary contact that opens when the safety switch opens. The Electrical Subcontractor shall run a pair of wires between the auxiliary contact in the safety switch to the respective elevator controller to avoid activation of elevator recall function when the safety switch is in the open position

C. The circuit breaker for the elevator machine shall include a shunt-trip mechanism with a normally closed, dry auxiliary contact. The auxiliary contact shall open when the circuit breaker is shunt-tripped or open manually. The contact shall remain closed when the circuit breaker is tripped on overload or short circuit. Provide control wiring, in conduit, from the shunt trip mechanism and from the auxiliary contact on each elevator machine circuit breaker to the elevator controller in the machine room for use by the elevator manufacturer. Consult elevator manufacturer for size and amount of control wiring.

D. The Electrical Subcontractor shall also provide the necessary wiring and devices for security, firefighters telephone, evacuation speaker and elevator recall. The Electrical Subcontractor shall turn over to the elevator manufacturer for installation in the elevator cab.

E. Provide control wiring from each elevator dispatcher (one per elevator bank) to the automatic transfer switch serving the elevators for selective operation of elevators when on emergency power. Provide control wiring from each elevator dispatcher (one per elevator bank) to the

automatic transfer switch serving the elevators to send a signal to the elevators prior to transferring in either direction, when both sources are energized.

3.4 GAS ALARMS, OIL TANK ALARMS, WIRING AND CONNECTION

A. The Electrical Subcontractor shall furnish and install conduit and power wiring, etc. indicated on the drawings and as required by the Plumbing and HVAC Trades, connections to alarm panels, remote alarms, etc. Also, refer to HVAC and Plumbing drawings for location and numbers of panels/alarms to be connected. All wiring shall be per the manufacturer's recommendations.

3.5 MATERIALS AND WORKMANSHIP

A. All materials and equipment shall be new and unused and shall meet requirements of the latest Standards of NEMA, UL, IPCEA, ANSI and IEEE. Equipment shall have components required or recommended by OSHA, applicable NFPA documents and shall be UL listed and labeled.

B. Despite references in the specifications or on the drawings to materials or pieces of equipment by name, make or catalog number, such references shall be interpreted as establishing standards of quality for materials and performance.

C. Finish of materials, components and equipment shall not be less than Industry good practice. When material or equipment is visible or subject to corrosive or atmospheric conditions, the finish shall be as approved by the Architect.

D. Provide proper access to material or equipment that requires inspection, replacement, repair or service. If proper access cannot be provided, confer with the Architect as to the best method of approach to minimize effects of reduced access.

E. All work shall be installed in a neat and workmanlike manner and shall be done in accordance with all Local and State Codes.

F. The Owner will not be responsible for material, equipment or the installation of same before testing and acceptance.

3.6 EQUIPMENT CONNECTIONS

A. Motors furnished under Heating, Ventilating and Air Conditioning Section and the Plumbing Section shall be 460 volts, 3 phase, 60 Hz for motors 1/2 HP and above, except as indicated otherwise on the drawings.

B. Kitchen equipment motors, heating elements, shop equipment and miscellaneous items will be of a voltage and phase as indicated on the drawings.

C. Make all final connections to equipment. Special plugs for receptacles indicated on the special purpose receptacle schedule shall be connected to the cord of the equipment, where this equipment is available to the Electrical Subcontractor prior to the completion of the work; otherwise the plug shall be delivered to the Owner.

D. Equipment grounding integrity of all equipment and non-current-carrying metal parts must be ensured.

E. All equipment requiring electrical connections which is furnished under other Sections and by others shall be connected under this Section.

F. Before connecting any piece of equipment, check the nameplate rating against the information shown on the drawings and call to the attention of the Architect any discrepancies.

G. The Electrical Subcontractor shall carefully study all equipment manufacturer's wiring diagrams and make corrections accordingly.

H. The Electrical Subcontractor shall be held responsible for any damage done to motors or equipment driven by motors, due to incorrect direction of rotation, caused by faulty electrical connections, and incorrectly sized motor circuit protection, furnished under this Contract.

I. Drawings and specifications of other Subcontractors and equipment suppliers furnishing motors shall be consulted for verification of size, speed and operation.

J. Motor and equipment disconnect switches indicated on the drawings are attached to the motor symbol and are indicated this way for drafting convenience only. All such switches shall not be attached to the motor itself, but shall be mounted adjacent to the motor and supported independent of the motor.

K. Motor starters furnished by other Subcontractors shall be furnished complete with individual running overcurrent protection in each phase and shall be installed and wired by the Electrical Subcontractor. Sizing of motor running overcurrent protection for starters furnished by others shall be the responsibility of the Subcontractor who furnishes the motor starter. Motor starters for motor control centers shall be furnished complete under this Section. Refer to schedules on the drawings.

L. Furnish, install, wire and connect all motor disconnect switches, motor starters and remote control stations, except as otherwise indicated on the drawings. All automatic temperature control wiring for equipment furnished by the HVAC Subcontractor will be furnished and installed under Heating, Ventilating and Air Conditioning Section, except as otherwise indicated on the Electrical drawings.

M. Motor starters, where grouped, shall be mounted on 3/4" thick, exterior grade plywood mounting board painted with fire-resistant paint of a color to match starter enclosures. Coordinate backboards with Section 01605, Miscellaneous Carpentry.

N. On multi-speed motors, the isolating switches at the motor location shall be so interlocked or shall be of such a type that operation of (1) switch shall simultaneously open all conductors to the motor.

O. All electrical connections to vibration isolated equipment shall be by flexible conduit of length at least 15 diameters, installed with visible slack, or in a loop configuration, to allow free movement of the equipment and prevent transmission of noise and vibration.

END OF SECTION