SECTION 16050 – BASIC MATERIALS AND 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 and, as a minimum, but not necessarily limited to the following:

1. Grounding.
2. Connections to HVAC, Plumbing, Fire Protection, Automatic Temperature Control, General Contractor and Owner furnished equipment.
3. 120 volt power for remote alarms and connections to oil tank alarms, etc.
4. Testing, cleaning and adjusting.
5. Power company related work and backcharges.
6. Fees, permits, royalties, guarantees.
7. Firestopping, smokeproofing, waterproofing.
8. Shop drawings.
9. Phasing of construction.
10. Access doors.
11. Electrical Identification
12. Hangers and supports.
13. Mechanical suspension channel.
14. Wireways.

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 16010 – Electrical Special Conditions regarding guarantees and warranties for the work under this Contract.

1.5 FIRESTOPPING AND SMOKESTOPPING

A. Where conduits pass through masonry or concrete walls or floors, the Electrical Subcontractor shall provide and set individual sleeves for each conduit and all other work under his charge, as necessary for passage of all raceways. Sleeves shall be of sufficient size to provide 1/2" air space around the conduit passing through the floor or walls. All openings shall be sealed, smokestopped and made tight. The Electrical Subcontractor shall be responsible for the exact location of sleeves provided under this Contract and shall coordinate all requirements for conduit sleeves. Refer to Section 07841 – Through-Penetration Firestop Systems.

B. The Electrical Subcontractor shall review firestop or smokestop systems provided under Section 07842 - Firestopping and coordinate the system installation.

C. Except as otherwise specified, underground piping passing through exterior walls, foundation slabs on grade, or manhole walls, shall have penetration closures of the modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the conduit and wall opening. Links shall be loosely assembled with bolts to form a continuous belt around the conduit and with a pressure plate under each bolt head and nut. After the seal assembly is positioned in the sleeve, tightening of the bolts shall cause the rubber sealing elements to expand and provide an absolutely watertight seal between the conduit and wall, reducing chances of cathodic reaction between these members.

D. The Electrical Subcontractor for work under his charge shall determine the required inside diameter of each individual wall opening or sleeve before ordering, fabrication or installation. The inside diameter of the wall opening shall be sized to fit the conduit and ensure a watertight joint. Where applicable, when installing seals, take into account the conduit O.D. if non-standard due to coating or jacketing.

1.6 WATERPROOFING AND COUNTERFLASHING

A. Electrical Subcontractor shall provide all counterflashing of all conduit and equipment provided by him, which pierce roofs, walls and other weatherbarrier surfaces. Refer to Section 07620.

B. All work shall be performed in a workmanlike manner to assure weatherproof installation. Any leaks developed due to Electrical Subcontractor's work shall be repaired at his expense, to Architect's satisfaction.

C. Conduit passing through slabs shall have the sleeve extended above floors as hereinafter specified to retain any water and the space between the conduit and sleeve caulked with lead wool.

1.7 MISCELLANEOUS IRON AND STEEL

A. Except where specifically indicated for the General Contractor to provide supports, Electrical Subcontractor shall provide all steel supports and hangers required to support all equipment or materials provided under this Contract.

B. All supports shall be cut, assembled, welded and finished by skilled mechanics. Welds shall be ground smooth. Stands, brackets and framework shall be properly sized and strongly constructed.

C. Measurements shall be taken on the job and worked out to suit adjoining and connecting work. All work shall be performed by experienced metal-working mechanics. Members shall be straight and true and accurately fitted.

1.8 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. Access doors.
2. Electrical Identification
3. Hangers and supports.
4. Mechanical suspension channel.
5. Wireways.

PART 2 - PRODUCTS

2.1 ACCESS DOORS

A. Furnish, for installation by the designated Trade as determined by the General Contractor, all access doors in locations wherever pull or junction boxes, "LB" fittings, equipment, etc., are installed behind gypsum wallboard or masonry walls or ceilings and where such devices would be inaccessible for inspection, maintenance or servicing. Access doors shall be a minimum of 12" by 12" and shall be sized to suit the access requirement to service the equipment and located in a manner approved by the Architect and to meet requirements specified here and elsewhere, for specific applications. Refer to Architectural Section 08305 for additional information.

B. Doors shall be set square and flush in cooperation with the designated Subcontractors performing the work. Particular attention shall be exercised in the selection of doors for masonry walls in order that frame sizes used will match the courses of brick or block. All access panels shall be located in closets, storage rooms and/or other non-public areas where possible, positioned so that the junction can be easily reached and shall be constructed in a workmanlike manner. When access panels are required in corridors, lobbies or other habitable areas, they shall be located as directed by Architect.

C. Access panels shall be flush type with 14 gauge panels and 16 gauge frames, minimum, unless otherwise noted. Each access panel shall be furnished complete with continuous piano hinge and flush screwdriver operated cam latch, with factory applied prime finish. Access panels shall be as manufactured by Inryco/Milcor, Karp Associates Inc., Birmingham Ornamental Iron Co., Miami-Carey, Babcock-Davis or equal approved by the Architect.

D. Access panels shall be installed in gypsum wallboard ceilings only where specifically approved by the Architect. Where possible, all access requirements for raceways and equipment shall be beyond the gypsum wallboard ceilings.

E. Access panels shall be specifically designed for each type of wall, ceiling finish and construction with which they are used, as follows:

1. Suspended latch and gypsum wallboard ceilings: Style K with 16 gauge frame, 14 gauge panel and flush screwdriver operated camlocks.
2. Masonry rated walls: Style M with 16 gauge frame, 14 gauge panel and flush screwdriver operated camlocks.
3. Masonry fire rated walls and at shafts: Fire rated with UL, 1.5-hour "B" rating, 16 gauge frame, 20 gauge sandwich type insulated panel, self-latching lock having interior release mechanism, and flush screwdriver operated camlocks.
4. Where installed at fire rated walls or ceilings, access panels shall be of fire-resistive construction with mineral core panel faced both sides and edges with 20 gauge sheet steel, and shall bear the UL label required to meet the fire rating of the wall.
5. Where installed in surfaces finished with ceramic tile or glazed coatings, access panels shall be of stainless steel with No. 4 finish.

6. Where installed in acoustical ceilings, access panels shall be of type which will accept adhesive mounted acoustical panels flush with surrounding surfaces (acoustical panels to be provided by Acoustical Ceiling Trade).
7. Where installed in gypsum wallboard walls or ceilings, access panels shall be of type with 14 gauge face panels and 16 gauge frames equipped with integral perforated, textured metal casing bead edge which will receive drywall compound for flush finishing. (Compound finishing shall be provided by Gypsum Drywall Trade.)

2.2 ELECTRICAL IDENTIFICATION

A. Nameplates

1. Provide nameplates on switchgear, automatic transfer switches, transformers, remote mounted enclosed circuit breakers, receptacles on emergency (see Wiring Device Section), panelboards and for special purpose motor disconnect switches, remote control stations, starters, etc., or other controls furnished or installed under this section. Nameplates shall designate equipment controller, function, ratings, source of power and voltage.
2. Nameplates shall be laminated, black bakelite with 1/4" high, white recessed letters. Nameplates shall be securely attached to the equipment with galvanized screws. Adhesives or cements shall not be used.
3. Provide a shop drawing of nameplate schedules for approval.
4. Nameplates for devices on emergency power shall be "RED" in color.

B. Panel Directories

1. Panelboards shall have typed directories, listing all circuit loads, breaker sizes and phases.

C. Flash Protection Boundaries and Incident Energy Exposures Labeling

1. Provide field labeling of electrical equipment that is likely to require examination, adjustment, servicing or maintenance while energized. Labeling shall be provided in accordance with the following codes and standards:

    a. Massachusetts Electrical Code
    b. National Fire Protection Association

        1) NFPA 70 – National Electrical Code
        2) NFPA 70E - Standard for Electrical Safety Requirements for Employee Workplaces

    c. IEEE Std 1584-2002 & IEEE Std 1584a-2004 - Guide for Performing Arc-Flash Hazard Calculations
    d. Underwriters Laboratories (UL) Factory Mutual (FM)
    e. Occupational Safety and Health Administration (OSHA) – 1910.333
    f. American National Standards Institute (ANSI)

g. American Society of Testing Materials (ASTM)
h. National Electrical Manufacturers Association (NEMA)

2. Flash protection boundaries and incident energy exposures field labeling shall warn persons of potential electric arc flash hazards and include as a minimum, specific to the equipment, the following information:

a. Warning of arc flash hazard
b. Requirement that only qualified personnel access equipment
c. Flash protection boundary limit
d. Incident energy exposure available
e. Date of installation
f. Statement that system changes occurring subsequent to the installation may affect the level of hazard involved and that additional electrical system review may be required to confirm level of hazard has not changed

3. Field labeling shall be applied to all electrical equipment including but not necessarily limited to:

a. Substation and switchboard assemblies
b. Motor control centers
c. Panelboards
d. Disconnect switches
e. Controller equipment such as variable frequency/adjustable speed drives
f. Fuses and circuit breakers
g. Rotating equipment
h. Batteries
i. Generators
j. Automatic transfer switches
k. Premises wiring

4. Field labeling shall be clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment is performed. Field labeling shall conform to the requirements of ANSI Z535.4-1998, *Product Safety Signs and Labels*, provides guidelines for the design of safety signs

D. Wire Markers

1. Markers for wire and cable circuits shall, be as manufactured by, Brady self-laminating vinyl Datab labels.

E. Cable Tags

1. Cable tags shall be brass identification tags with plastic tie wrap.

F. Low Voltage Raceway Identification

1. Provide manufacturer's standard pre-printed, flexible or semi-rigid, permanent, plastic-sheet conduit markers, extending 360° around conduits; designed for attachment to conduit by adhesive, adhesive lap joint of marker, matching adhesive plastic tape at each end of marker, or pretensioned snap-on. Except as otherwise indicated, provide lettering which indicates voltage of conductor(s) in conduit. Provide minimum 8" length for 2" and smaller conduit, 12" length for larger conduit.
2. Color coding for all raceways shall match the Owners color coding. If no color coding exists, paint raceways for emergency systems, fire alarm systems, telecommunication systems and other low voltage systems as indicated below. Spacing of paint markings shall be a maximum of 10'-0″ on centers for entire length of conduit. Painted conduit connectors and junction boxes will be an acceptable means of conduit identification, provided there is a painted connector/box a maximum of 10'-0" on center.

a.	Emergency system – Life Safety	Orange
b.	Critical system	Yellow
c.	Equipment branch	Green
d.	Fire alarm system	Red
e.	Telecommunication System	Blue
f.	Nurse call system	White
g.	Other low voltage systems	Brown

G. Medium Voltage Raceway Identification

1. Where medium voltage raceways run within the interior of the building, including medium voltage raceways that are run in an inaccessible shaft, the raceway shall have "DANGER HIGH VOLTAGE" painted in red paint with 2" tall letters, a maximum of 10'-0" on center

H. Color-Code Tape

1. Colored tape shall be polyvinyl chloride, self-adhesive not less than 3 mils thick and 1 1/2" wide, suitable for use on 90°C conductors, UL listed and shall be furnished in colors as specified herein.

2.3 HANGERS AND SUPPORTS

A. General

1. Hangers, supports, clamps, etc., shall be provided as required for all electrical equipment, including but not limited to, lighting fixtures, junction boxes, pull boxes, conduit, cable tray, busway, trapeze mounted transformers, open plenum type cabling, etc.
2. The Electrical Subcontractor shall provide all labor, materials, equipment and incidentals required for hangers and supports for all electrical equipment including concrete inserts, anchor bolts, metallic hanging and supporting devices, etc. for supporting electrical equipment.

3. Hangers and supports shall be approved standard design and shall be adequate to maintain the supported load in proper position and alignment under all operating conditions. All supports shall be designed to adequately secure the equipment against excessive dislocation due to thermal expansion and contraction and all probable external forces such as equipment, conduit and personnel contact.
4. All electrical equipment shall be supported in such a manner as to prevent any strain being imposed on the equipment supported.
5. All material used in manufacturing hangers and supports shall be capable of meeting the respective ASTM Standard Specifications with regards to tests and physical and chemical properties, and be in accordance with MSS SP-58.
6. Hangers and supports shall be spaced in accordance with MSS SP-69 Table 3.
7. Hangers and supports shall be as manufactured the following manufactures. Product numbers used herein are based on B-Line Systems , Inc.

    a. B-Line Systems, Inc.
    b. Caddy/Eristrut
    c. Unistrut
    d. Kindorf
    e. Superstrut

B. Hangers

1. All hangers and supports shall have some form of adjustment available after installation. Hanger material shall be compatible with the conduit material.
2. Hangers for conduit 2” and smaller shall be B-Line series B3170NF, B3174 or B3198. Hangers for conduit 2 1/2” and larger shall be B-Line series B3100, B3102 or B3170.

C. Hanger Rods

1. Hanger rods shall be B-Line series ATR (All Threaded Rod) or series B3205 with threaded at ends with allowance for adjustments. Wire and strap hangers will not be permitted. All electrical equipment shall be supported by rods, hangers, etc., using bolts.
2. Hanger rods shall be subjected to tension only. Lateral and axial movements shall be accommodated by proper linkage in the rod assembly.
3. Hanger rod diameters shall be based on MSS SP-69 Table 4.

D. Beam Clamps

1. All beam clamps shall be concentric loaded type clamps which engage both edges of the beam flange. The hanger shall be located directly below the web of the beam. Consult with Structural Engineer to ascertain maximum loading on hanger in each area.
2. Beam clamps shall be B-Line series B3054, B3055 or B3291 through B3297.

E. Concrete Inserts

1. Concrete inserts for hangers shall be continuous metal or spot inserts designed to be used in ceilings, walls or floors and shall be as follows:

   a. Continuous concrete inserts shall be used where applicable for hanger rod sizes up to 3/4" diameter. Inserts may be used where supports are parallel to the main slab reinforcement and shall be B-Line series B22I, B32I or B52I.
   b. Spot concrete inserts shall be used where applicable for hanger rod sizes up to and including 7/8" diameter. Inserts shall be B-Line series B2505 through B2508, B2500, B2501 or B3014.

F. Welded Steel Brackets

1. Wall or column supported conduits shall be supported by welded steel brackets B-Line series B3064 or B3066.

G. Stanchions

1. For floor supported equipment, such as safety switches in mechanical areas, provide either cast-in-place concrete supports or field installed supports. Each support shall be screwed or welded to the corresponding size base stand. Supporting pipe shall be of schedule 40 steel pipe construction. Each base stand shall be secured to the concrete floor by expansion bolts. Base stands shall be B-Line series B3088 or B3088T.

H. Riser Conduits

1. Riser conduits shall be supported independently from of any horizontal conduits.
2. Support all vertical runs of conduits at each floor with B-Line series B3373 or B3373CT as required.

I. Strut Channel

1. Strut channel trapeze hangers shall be used to support parallel conduit runs. Conduit racks or stanchions fabricated with strut channel shall be used in areas with multiple conduit runs. Strut clamps and straps shall be used to maintain proper alignment. Strut shall be a minimum of 1 5/8" wide, B-Line series B22 or heavier as required. Clamps and straps shall be B-Line series B2000 suitable for the conduit material (EMT, IMC or RGS).
2. Provide strut channel above ceilings for support of electrical equipment such as lighting fixtures where mechanical equipment and ductwork interfere with direct mounting methods. Strut shall be used to span the width of the interference and supported by rods on each end.
3. Provide all required appurtenances required to properly hang and assemble strut supports.

2.4 MECHANICAL SUSPENSION CHANNEL

A. Mechanical suspension channel shall be furnished and installed to support electrical equipment, (panelboards, disconnect switches, starters, transfer switches, transformers, etc.) independent of walls. Where walls back up to occupied spaces, the suspension channels shall be at least 1/2" clear of the wall and shall not be connected or braced to the wall.

B. Channel shall be Unistrut, Type P3000 or approved equal. All fasteners and fittings shall be supplied to provide a complete installation as required. Channel shall be sized and mounted to allow for future conduits.

C. All channel and fittings shall be furnished with the manufacturer's standard rustproofed finish.

D. Channel shall be manufactured by one of the following: Unistrut Products Co., Kindorf, or B-Line.

2.5 WIREWAYS

A. Furnish and install wireways as required and/or as indicated on the drawings. Wireways in electric rooms shall be minimum 6” x 6”, mounted a minimum of 6’-6” above finished floor. Wireway covers shall be completely removable.

B. Wireways shall be as manufactured by Cutler Hammer, General Electric Square D or Siemens.

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

C. 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.

D. 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.

E. 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.

F. 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.

G. 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.

H. 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. Access Panels

1. Access panels shall be furnished to the General Contractor for installation by his designated Contractor.

C. Hangers and Supports

1. All horizontal runs of conduits shall be properly grouped, aligned, using substantial hangers, straps, etc. Hangers and supports shall be installed at intervals not exceeding NEC requirements.
2. Structural Support Interface

    a. All conduit, raceways, electrical equipment and other similar system components which are supported by roof or floor joists shall be hung from the top chord or bottom chord panel point or a panel point shall be provided by applying a vertical web member. The maximum load shall not exceed 250 pounds.
    b. All conduit, raceways, electrical equipment, etc., which are supported by roof/floor beams shall be hung from the beams with clamp attachments which engage both edges of the beam flange. The hanger shall be located directly below the web of the beam and the hanger load shall be limited to 1000 pounds in area above mechanical room and 250 pounds in remaining areas, unless otherwise approved by the Architect.
    c. All additional supports, clamps, web members, etc., required to comply with the above requirements shall be provided by the Electrical Subcontractor, as applicable, for the work furnished and installed under this Contract.

3.3 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.

3.4 GROUNDING

A. Install a complete equipment grounding system. Equipment grounding system shall be designed so metallic structures, enclosures, raceways, junction boxes, outlet boxes, cabinets, machine frames, metal fences, portable equipment and other conductive items in proximity to electrical circuits operate continuously at ground potential and provide low impedance path for possible ground fault currents.

B. System shall meet NEC requirements, and as shown on the drawings and as specified. Bonding jumpers shall be installed at all locations required by NEC.

C. A main electrical service copper ground bus shall be installed surrounding the electric room. The bus shall be 3" by 1/4" in cross-section and supported off the walls with 3/4" spacers on 2'-0" centers. All electrical equipment in the electric room shall be properly bonded to the ground bus with an adequately sized copper conductor as well as the driven ground rod system external to the building.

D. Provide a complete grounding network, per NEC requirements, for main service equipment, consisting of, but not limited to, the following:

1. Ground loop buried around the building, 500 kcMIL copper, bare with down conductors from main electrical service ground bus in the main electric room. Down conductors shall be 500 kcMIL copper conductors in conduit to the ground loop.
2. Appropriate number of 3/4" diameter, 10'-0" long copper-clad steel ground rod clusters and copper ground wire connections from grounding loop.
3. Connections from ground loop to the building structural steel. Where the steel structure is discontinuous, each section of structure shall be connected to the grounding network. Connections to building steel shall be 500 kcMIL copper conductors to the ground loop.
4. Metallic piping systems, including water piping, gas piping, etc. shall be bonded to the main service ground bus. Ground conductors to metallic piping shall be 500 kcMIL copper conductors in conduit
5. Ground points shall be driven to achieve 5 ohms maximum resistance to ground. Provide additional rods as required to achieve 5 ohms overall. Where geological conditions dictate, ground wire mesh may be provided or additional rods shall be driven in compacted earth areas as required to meet 5 ohm resistance requirement. Plate electrodes may be used where ground rods cannot be driven to achieve grounding requirements.
6. All grounding connections, including to ground loop system, building steel, etc shall be made with Cadweld process. Ground connections to metallic piping shall be with approved grounding clamp.

E. Provide separate green insulated equipment grounding conductor for each single- or 3-phase feeder and each branch circuit. Install grounding conductor in common conduit with related phase and neutral conductors. Parallel feeders installed in more than (1) raceway shall have individual full size green insulated equipment ground conductors in each.

F. Determine numbers and sizes of screw terminals for equipment grounding bars in panelboards and other electrical equipment. Provide screw terminals for active circuits, spares and spaces.

G. Provide green, insulated equipment ground conductor in same raceway with associated phase conductors, as follows:

1. From main service ground to ground bus in service entrance equipment to ground bus in all distribution panels, remote panels, motor control centers, etc., size as shown on the drawings.
2. From green ground terminals of receptacles to green 10-32 washer-in-head outlet box machine screw and to panelboard grounding bus. (Receptacles with special cast boxes and factory designed and approved ground path do not require separate ground jumper.)
3. From panelboard ground bus to green 10-32 washer-in-head machine screw in ceiling outlet box or junction box, through flexible metallic conduit to ground terminal on lighting fixture and from green 10-32 washer-in-head machine screw in ceiling outlet box or junction box through flexible metallic conduit to green 10-32 washer-in-head machine screw in switch outlet box.
4. From panelboard ground bus to green 10-32 washer-in-head machine screw in junction box or disconnect switch through flexible metallic conduit to ground terminal in connection box mounted on single-phase fractional horsepower motor.

5. From equipment ground bus in motor control center through conduit and flexible metallic conduit to ground terminal in connection box mounted on 3-phase motors. Ground conductors for motors with separate starters and disconnect devices shall originate at ground bar in panelboard and shall be bonded to each starter and disconnect device enclosure.
6. From dry type transformer neutrals to the building steel (or the ground grid system) by means of copper wire, as scheduled on the drawings.

H. Provide green insulated grounding conductor in all non-metallic conduits.

I. The building grounding grid system shall be as follows:

1. 3/4" by 10'-0" driven ground rods shall be copper weld type. Connections to buried ground rods shall be Cadweld. Tops of all buried ground rods shall be a minimum of 6" below grade. Where rock is encountered, grounding plates may be used in lieu of grounding rods. Grounding plates shall be copper. Sizes of plates shall be as required.
2. All exposed connections shall be made by means of approved grounding clamps. Exposed connections between different metals shall be sealed with no-oxide paint Grade A. All buried connections shall be made by the Cadweld process.
3. Dry season resistance of the grounding system shall not exceed 5 ohms. If such resistance cannot be obtained with the grounding system indicated on the drawings, the Electrical Subcontractor shall provide additional grounding as required and as directed by the Architect, to provide the 5 ohms resistance value.
4. A test shall be conducted at the completion of the grounding system installation in the presence of the Architect or his designated representative. The Electrical Subcontractor shall pay for all materials and workmanship. Defects appearing under the tests shall be corrected by the Electrical Subcontractor.
5. An interior and exterior buried grounding grid system shall connect the building steel and lightning protection system to driven ground rods.

J. All empty conduit runs shall be provided with insulated and grounding bushing and grounded by a #12 AWG green ground conductor to the nearest panel ground bus.

END OF SECTION