SECTION 16111

CONDUIT AND WIRE

PART 1 - GENERAL

1.01 SCOPE

A. Work Included: All labor, materials, appliances, tools, equipment, facilities, transportation and services necessary for and incidental to performing all operations in connection with furnishing, delivery and installation of the work of this Section, complete as shown on the drawings and/or specified herein. Work includes, but is not necessarily limited to the following:

1. Examine all other sections for work related to those other sections and required to be included as work under this section.
2. General provisions and requirements for electrical work.

1.02 SUBMITTALS

A. Submit product data sheets for all wire, supports, conduit, fittings and splicing materials.

B. Submit material list for all conduit and conduit fittings.

C. Submit details and structural engineering calculations for conduit support systems.

PART 2 - PRODUCTS

2.01 CONDUIT

A. General

1. The interior surfaces of conduits and fittings shall be continuous and smooth, with a constant interior diameter. Conduits and conduit fittings shall provide conductor raceways of fully enclosed circular cross section. The interior surfaces of conduits and fittings shall be without ridges, burrs irregularities or obstructions. Conduits and fittings of the same type shall be of the same uniform weight and thickness.
2. Type of conduit, type of conduit fittings and conduit supports shall be suitable for the conditions of use and the conditions of location of installation, based on the manufacturer's recommendations and based on applicable codes.
3. All fittings for metal conduit shall be suitable for use as a grounding means, pursuant to the applicable code requirements. All metal conduit and metal conduit fittings shall provide 3 second duration ground fault current carrying ratings, when installed and connected to the respective conduit, as follows:
   a. RMC and EMT conduit fittings.
      1) 0.5 inch through 1.5 inch conduit/fitting size - 10,000 ampere RMS.
      2) 2.0 inch and larger conduit/fitting size - 20,000 ampere RMS.
   b. FMC and LTFMC Conduit Fittings
      1) 0.5 inch through 1.25 inch conduit/fitting size-1,000 ampere RMS (without external bonding jumper).
      2) 1.5 inch through 4.0 inch fitting size-10,000 ampere RMS with bonding jumper.
4. Protective corrosion resistant finish for metal conduit fabricated from steel and metal conduit fittings fabricated from steel, shall be as follows:

a. Clean all metal surfaces (including metal threads) with acid bath "pickle" prior to coating, to remove dirt, oil and prepare surfaces for galvanizing.
b. Hot-dip galvanized zinc coating on all interior and exterior steel surfaces. Minimum finish zinc coating thickness shall not be less than 0.002 inches.
c. Threads shall be hot-dip zinc coated after machine fabrication.
d. Exterior metal surfaces shall be finished with clear organic polymer topcoat layer, after galvanizing.
e. The inner metal surfaces of conduit fittings shall be finished with a lubricating topcoat after galvanizing, to facilitate conductor pulling through the conduit/fitting.

5. Threads for metal conduit and metal conduit fittings shall be taper-pipe-thread, National Pipe Standards(NPS) and shall comply with ANSI-B1.20.1.
6. Metal conduit termination connector fittings shall be provided with a manufacturer installed, insulating throat bushing inside the fitting. The bushing shall protect the wire conductor insulation from cutting, nicks and abrasion during conductor installation and electrical load "cycling" after installation is complete. The bushing shall comply with UL 94V-0 flammability.
7. Provide conduit bonding/grounding jumper from metal enclosures with "concentric ring" knockouts, to positively ground/bond each respective conduit(s) to the metal enclosure.
8. Metal conduit fittings connecting to PVC coated metal conduit shall be PVC coated to match the conduit.
9. The conduit and fittings shall be watertight and airtight without cracks and pinholes.

B. Rigid metal Conduit (RMC)
1. Rigid metal, round tubing, machine threaded at both ends.
   a. The conduit and conduit fittings shall comply with the requirements for a equipment grounding conductor, pursuant to applicable codes.
2. RMC raceway types shall be as follows:
   a. Rigid galvanized steel conduit (RGS), minimum yield strength shall be 35,000 PSI. Shall comply with NEMA standard 5-19 (latest revision); ANSI C80.1 and ANSI-C80.4 (latest revision); U.L. 514-B and UL 6 (latest revisions); National Pipe Standard Specification (latest revision).
   b. Intermediate steel conduit (IMC). Shall comply with NEMA Standard 5-19 (latest revision) ANSI-C80.6 (latest revision); UL 2142 (latest revision).
3. RMC fittings:
   a. Fittings shall be compatible with RGS and IMC.
   b. Fittings shall be rated "liquid tight".
   c. Fittings imbedded in concrete shall be rated "liquid tight" and "concrete tight".
   d. Connectors and couplings for terminating, connecting and coupling to RMC conduit shall be threaded metal.
   e. Fittings shall comply with ANSI C80.4 and ANSI C33-84 (latest revision); NEMA FB1 (latest revision); UL 514 (latest revision).
   f. Conduit seal fittings:
      1) Conduit seals shall prevent the passage of gasses, liquids and vapors past the location of the seal installation in the conduit.
      2) Conduit seals shall be suitable for installation in both vertical and horizontal conduit locations.
      3) Conduit seals shall be visible and accessible for inspection after installation is complete.
      4) Conduit seals shall be rated for the following locations:
         a) Wet locations
         b) Classified hazardous location materials NEC Class 1 Division 1.
         c) Temperature ranges from 0 [minus 20] degrees centigrade through 90 degrees centigrade.
      5) Conduit seals, sealing compound and sealing compound dam shall be the products of the same manufacturer.

4. RMC fittings as manufactured by:
   a. For threaded enclosure, termination connection.
      1) Thomas & Betts - 106 Series bonding locknut, 5302 series sealing ring with stainless steel retainer.
   b. For non-threaded enclosure, termination connector.
      1) Thomas & Betts - 370 Series watertight threaded sealing hub, 106 series threaded bonding lock nut, Sta-Con Series enclosure bonding jumper and 3870 Series threaded ground bushing.
      2) OZ/Gedney-CHMT/CHT watertight threaded hub with bonding locknut and GH50G Series enclosure bonding jumper.
   c. For RMC to RMC conduit-to-conduit coupling
      1) Erickson - 674 (threaded) Series
      2) OZ/Gedney Type 4 (threaded) Series
      3) Threaded RMC conduit couplings, product of the same manufacturer as the RMC conduit.
   d. For RMC Conduit Seals
      1) OZ/Gedney-EYA and EYAM (threaded) Series
      2) Appleton-EYF and EYM (threaded) Series

C. Electrical Metallic Tubing (EMT)
1. Rigid metal round tubing, "thin wall" steel construction, with non-threaded ends.
   a. The conduit and conduit fittings shall comply with the requirements for a equipment grounding conductor pursuant to applicable codes.
   b. The conduit shall be watertight and airtight without cracks and pinholes.
2. EMT shall be allowed for conduit size ranges from 0.5 inch through 4.0 inch.
3. Comply with ANSI C80.3, C80.4, and ANSI C33.98 (latest revisions); UL 594 and UL 797 (latest revisions); CEC Section 12500 (latest revision).
4. EMT fittings:
   a. Connectors and couplings for terminating, connecting and coupling to EMT conduit shall be non-threaded steel fabrication.
   b. EMT termination connector fittings shall be as follows:
      1) Set screw type "concrete tight" when installed in dry interior locations.
      2) Compression types "raintight" and "concrete tight" when installed in wet or damp locations, outdoors and in concrete or masonry construction.
   c. Fittings shall comply with ANSI C33.84 (latest revision); UL 514 (latest revision); NEMA FB-1.
5. EMT fittings as manufactured by:
   a. For threaded and non threaded enclosure, termination connector
      1) Thomas & Betts-TC5031 (set screw type) Series (with locknuts).
      2) OZ/Gedney-4000ST (set screw type) Series.
      3) Thomas & Betts-5123 (compression type) Series (with 2 locknuts).
      4) OZ/Gedney-7000ST (compression type) Series (with locknut).
      5) Thomas & Betts-4240 (compression type) Series (90 degree angle with locknut).
      6) OZ/Gedney-8000WT (compression type) Series (90 degree angle with locknut).
   b. For EMT to EMT conduit-to-conduit coupling:
      1) Thomas & Betts-TK121 (set screw type) Series (with locknut).
      2) OZ/Gedney-5000 (set screw type) Series (with locknut).
      3) Thomas & Betts-5120 (compression type) Series.
      4) OZ/Gedney-6000S (compression type) Series.
   c. For EMT to RMC conduit to conduit combination coupling:
      1) Thomas & Betts-HT221 (set screw type) Series.
      2) OZ/Gedney-ESR (set screw type) Series.
      3) Thomas & Betts-530 (compression type) Series.
      4) OZ/Gedney-ETR (compression type) Series.

D. Flexible Metal Conduit (FMC)

1. Round flexible conduit, fabricated from a single continuous steel strip. The steel shall be factory formed into continuous interlocking convolutions to form a complete lock between steel strips and provide raceway flexibility.
2. Metal to metal grounding contact shall be maintained throughout the length of the FMC conduit.
3. FMC shall be allowed for conduit size ranges from 0.5 inch through 4.0 inch.
4. FMC shall comply with ANSI-C.33.84 and ANSI C33.92; NEMA FB-1; CEC 12-1100.
5. FMC Fittings
   a. FMC fittings shall be malleable iron construction or steel construction.
   b. Fitting shall automatically cause the FMC raceway throat opening to be centered with respect to the fitting throat opening.
   c. Straight and angled connector termination fittings shall be threaded on one end and shall include a threaded locknut, suitable for connection to threaded and unthreaded enclosures.
   d. The attachment of the fittings to FMC shall be angled saddle type, to engage and interlock with the FMC spiral groove, and shall be unaffected by vibration. Direct bearing screw type fittings shall not be used.
   e. Direct FMC conduit-to-FMC conduit coupling of FMC shall not be permitted.
   f. Shall comply with ANSI C33.9, and ANSI C33.92 (latest revision); NEMA FB1 (latest revision); U.L. 514.
6. FMC fittings as manufactured by:
   a. <u>Straight Termination Connectors</u> — <u>45 & 90 Degree Angle Connectors</u>
      1) Thomas & Betts- 3110 Series with locknut) — Thomas & Betts- 3130 Series (with locknut)
   b. FMC to EMT conduit combination coupling:
      1)Thomas & Betts 503TB Series.

E. Liquid Tight Flexible Metal Conduit (LTFMC)

1. The metal conduit core of LTFMC shall comply with the same requirements as FMC conduit, with the addition of a thermoplastic exterior flexible jacket over the metal core.
2. The exterior jacket shall be positively locked to the metal core to prevent jacket "sleeving".
3. The LTFMC shall be rated for installation and operating service temperatures of between 0 [minus 20] degrees centigrade through plus 90 degrees centigrade.
4. The LTFMC jacket shall be suitable for continuous exposure to sunlight, rainwater, water vapor, mineral oils and liquid solvents, without penetrating into the conduit and without deteriorating the jacket.
5. LTFMC sizes from 0.5 inch through 1.25 inches shall include an additional internal ground conductor, fabricated by the manufacturer, as a integral part of the conduit core.
6. Direct LTFMC conduit-to-LTFMC conduit coupling of LTFMC shall not be permitted.
7. LTFMC shall be allowed for conduit size ranges from 0.5 inch through 4.0 inches.
8. In addition to the requirements for FMC conduit, LTFMC shall also comply with ANSI C-33.84 (latest revision); NEMA-FB1 (latest revision); CEC 12-1400 (latest revision).
9. LTFMC fittings
   a. Fittings shall include an external mechanical ground/bond wire connector.
   b. The attachment of the fitting to LTFMC shall be threaded compression type onto the conduit core with locknut and liquid tight jacket compression seal. The fitting shall automatically prevent "sleeving" of the jacket.
   c. Straight and angled termination connector fittings shall be threaded on one end and shall include locknut suitable for connection to threaded and unthreaded enclosures.

10. LTFMC fittings as manufactured by:
    a. Termination connector fittings:

Straight	45 and 90 Degree Angle Connectors
1) Thomas & Betts-5331 GR Series.	Thomas & Betts-5341GR and 5351GR Series.
2) Appleton-STB Series; STN-L Series for use with preformed "knockouts".	Appleton-STB-L Series; STN-L Series Series for use with preformed "knockouts".
3)OZ/Gedney-4QLT Series.	OZ/Gedney-4QLT Series

    b. LTFMC to RMC conduit to conduit combination coupling fittings:
        1) Thomas & Betts-5271 GR Series.
        2) OZ/Gedney-4QFML Series

F. Rigid Non Metallic Conduit (RNMC)
    1. General
        a. Conduit and fittings shall be 90 degree centigrade conductor rated. Fabricated from homogeneous material, free from visible crack holes or foreign inclusions, with integral "end-bell". The conduit and conduit fittings shall be watertight and airtight.
        b. Conduit, conduit fittings and conduit fitting assembly "solvent cement" shall all be the product of the same manufacturer. Conduit fittings shall be solvent cement welded watertight.
        c. Conduit and fittings shall be identified with legible markings showing ratings, size and manufacturers name.
        d. RNMC and fitting shall be corrosion resistant, watertight.
        e. Conduit shall be suitable for conductor operating temperatures from minus 20 degrees centigrade to 90 degrees centigrade.
        f. RNMC shall comply with NEMA TC-2 (PVC 40 conduit, latest revision) NEMA TC-6 (EB conduit latest revision) and NEMA TC-3 (fittings, latest revision); UL 514 and UL 651 (latest revision).
    2. Polyvinyl Chloride (PVC)-RNMC
        a. PVC-schedule 40 heavy wall construction.
        b. PVC-schedule 80 extra heavy wall construction.
        c. PVC-type EB.
    3. RNMC fittings connecting to metallic raceways shall be provided with a ground/bond jumper connection.

G. Expansion Joint, Deflection Joint and Seismic Joint Conduit Fittings
    1. Expansion Conduit Fitting - Fitting shall provide for a minimum of two (2) inches straight line movement between two connecting conduits in each direction (total four (4) inches conduit expansion and contraction) parallel to the respective conduit lengths. Fitting shall be watertight.
    2. Deflection Conduit Fitting - Fitting shall provide for a minimum of 30 degrees angular deflection movement ("Shear" deflection) between two connecting conduits, in any direction perpendicular to the length of the respective conduits. Fitting shall be watertight.
    3. Combination Expansion/Deflection Conduit Fitting - Fitting shall provide the combined "expansion" and "deflection" movement capacity between two connecting conduits as described for separate "expansion" and "deflection" conduit fittings. Fitting shall be approved for installation concealed in both masonry/concrete construction and exposed non-masonry/concrete construction. Fitting shall be watertight.
    4. Fittings shall comply with U.L.

5. Fittings as manufactured by:
   a. Conduit expansion fittings exposed or concealed locations as manufactured by:
      1) OZ/Gedney - AX8 Series for RMC conduit.
      2) OZ/Gedney - TX Series for EMT conduit.
      3) Appleton - XJ8 Series for RMC conduit and EMT conduits. Provide RMC to EMT combination conduit coupling fittings for each end of the expansion fitting.
   b. Combination expansion/deflection conduit fittings exposed or concealed conduit locations as manufactured by:
      1) OZ/Gedney - AXDX Series for RMC conduit.
      2) OZ/Gedney - AXDX Series for EMT conduit. Provide RMC to EMT combination conduit coupling fittings for each end of the expansion/deflection fitting.
   c. Conduit expansion/deflection fittings for FMC and LTFMC conduit.
      1) Provide a minimum of 12 inches of "slack" LTFMC in each FMC or LTFMC conduit at building and structure seismic or expansion joint conduit crossings.
      2) Note: Each FMC "slack" expansion/deflection location, shall be considered as not less than a 90 degree conduit bend location, for compliance with the maximum quantity of conduit bends allowed in a raceway.
6. Conduit fitting bonding jumper:
   a. The grounding/bonding path of metal conduit shall be maintained by the fitting.
   b. Provide a bonding jumper at each expansion, deflection and combination expansion deflection conduit fitting.
   c. The jumper shall be a bare flexible copper "braid". The copper braid electrical current carrying capacity shall be equal to the metal conduit.
   d. Provide a factory terminated ground clamp on each end of the braid with adjusting steel conduit grounding clamps and connect to each respective conduit end.
   e. The jumper braid length shall be eight (8) inches longer than the respective conduit fitting.
   f. Bonding jumper for FMC and EMT fittings as manufactured by:
      1) OZ/Gedney - BJ Series
      2) Appleton - XJB Series

I. Conduit Bodies Conduit Fitting
   1. Conduit bodies shall provide conductor access with a removable conduit body cover and wiring area enclosed in metal housing. The conduit body shall facilitate pulling conductors.
   2. In-line form "C" conduit bodies shall be prohibited.
   3. The interior space "length" of 90 degree "elbow" conduit bodies shall not be less than 6 times the diameter size of the largest conduit connecting to the conduit body.
   4. Conduit body covers shall be removable, gasketed; watertight "domed" metal covers with threaded screw attachment to the conduit body.
   5. Lubricated, reusable, wire roller guards inside the conduit body shall protect wire from insulation damage during wire "pulling".
   6. Conduit body fittings shall comply with UL 514.
   7. Conduit bodies as manufactured by:
      a. For RMC Conduit
         OZ/Gedney - LB 6X/Mogul (90 degree elbow) Series - threaded body.
         Appleton - LB/Mogul (90 degree elbow) Series - threaded body.
      b. For EMT Conduit
         1) Same as for RMC conduit. Provide EMT to RMC conduit combination coupling fitting for each outlet body connection.

2.02 CONDUIT SUPPORTS

A. General

1. Conduit Supports, hangers and fasteners for metal conduit shall be steel, hot dip zinc galvanized.
2. Threaded hardware shall be continuous, free running threads.
3. Conduit support systems, including support channels, pipe clamps, braces, anchors, hardware, fasteners, shall be sized to support the full capacity circuit conductors weight, plus the installed conduit weight, plus the conduit fitting weight and support hardware weight, plus a 300 percent additional weight capacity safety factor.
4. Provide lock washer at each "bolted"/threaded connection.
5. Conduit supports, fasteners, channels, braces, hardware, anchors, pipe clamps and hangers as manufactured by Unistrut or Kindorf.
6. Supports shall be free of "BURRS" and sharp edges.
7. Metal supports cut in the field shall be zinc galvanized after cutting to prevent rust.

B. Conduit Hangers

1. Threaded steel hanger rods.
   a. Hanger rods smaller than 0.375 inches in diameter shall not be used for support of individual conduits.
   b. Hanger rods smaller than 0.5 inches in diameter shall not be used for support of multiple conduits.
2. Conduit hanger wires shall be not less than 12 gauge steel.
3. Conduit hangers shall attach to structure fasteners with steel "Clevis" or "Swing" hangers and shall provide a minimum of 45 degrees of angular movement in any direction at the point of the conduit hanger attachment to the structure fasteners.
4. Conduits individually suspended by conduit hangers shall fasten to the respective hangers with "Clevis" type pipe hangers. The pipe hangers shall be steel, adjustable to fit conduit size and shall completely enclose the conduit circumference.

C. Conduit Support Channels

1. "C" channels shall be factory preformed with a minimum 12 gauge thickness metal. The channel shall be factory "punched" with regularly spaced slotted holes for fastener attachments along the length of the channel.
2. The "C" channel shall not deflect more than 0.1 inches between channel supports at maximum installed design load, including required safety factor.
3. Channels shall comply with ANSI-1008 (latest revision) and ASTM-A569 latest revision).
4. Channels shall provide "turned lips" at longitudinal edges to hold (lock-in) fasteners.
5. Conduit support channels suspended from conduit hangers shall attach to conduit hangers with treaded connections. Provide a minimum of two hangers (trapeze style) connected to each channel.
6. Non-suspended conduit support channels shall connect to structure fasteners with threaded connectors.

D. Fasteners

1. Channel fasteners:
   a. Channel fasteners shall "prelocate" and lock into the channel "turned lips" and channel "walls".
   b. A separate metal strap shall "tie" each conduit to each channel with conduit channel fasteners.
2. Structure fasteners:
   a. Structure fasteners for wall and floor mounted conduit attachments shall attach to existing masonry and concrete structures with structure fasteners using drilled, mechanical, expansion shield anchors.

b. Structure fasteners for wall and floor mounted conduit attachments shall attach to new masonry and concrete structures with structure fasteners using steel threaded inserts precast into the structures.

c. Structure fasteners shall attach to steel structural members with "swing-beam clamps", with set-locking screw structure fasteners. Beam clamps shall include integral safety rod, strap or "J"-hook to secure the clamp to the beam flanges on both sides of the beam.

d. Structure fasteners for wall and floor mounted conduit attachments shall attach to wood structural members with flush "through-bolted" wood beam/wood framing stud structure fasteners.

e. Structure fasteners for wall mounted conduit attachments shall attach to steel framing studs and steel structural elements with spot welded steel structure fasteners or drilled and bolted structure fasteners.

E. Brace Connectors

1. Provide lateral brace connectors to resist horizontal, lateral and vertical movement of suspended conduits during seismic earthquakes.
2. The braces shall connect from each conduit support, attach as close to the conduit as possible, and attach to fixed rigid, nonsuspended building "main" structural elements with fixed anchoring.
3. Brace attachment connectors and fasteners shall be rigid preformed steel channels or flexible #10 gauge steel hanger wire.
4. Connect and attach the brace connectors to fixed structural elements in the same manner as conduit support hangers. The connection of braces to structural elements shall be independent of the conduit support hanger structure fasteners.

2.04 WIRE AND CABLE

A. All wire and cable shall be copper, 600 volt, #12 AWG minimum unless specifically noted otherwise on the drawings. Conductors #10 AWG and smaller shall be solid. Conductors #8 AWG and larger shall be stranded. Type of insulation as noted on drawings as follows: Insulation of conductor connected to circuit protection devices required to be "100%" rated, shall be 90 degree rated insulation:

1. Type THHN/THWN insulation used for #4 AWG and smaller.
2. Type THW/XHHW or THHN/THWN insulation used for #2 AWG and larger.
3. Type THWN or XHHW insulation used for all panel feeders' switchboard feeders, motor control center feeders, transformer feeders and service conductors.
4. Type THHN insulation used for circuit conductors installed in fluorescent lighting fixture raceways, for conductors connected to the secondary of fluorescent or mercury vapor fixture ballast or other hot locations.
5. Type XHHW or THWN insulation shall be used where conductors are installed in conduit exposed to the outdoor weather.
6. The following color code for branch circuits:
   Neutral . . . . White (Tape feeder neutrals with white tape near connections)
   a. Normal Power

120/208 Volt	480/277 Volt	
Ground Green	Ground Green	
Phase A Black	Phase A	Brown
Phase B Red	Phase B	Orange
Phase C Blue	Phase C	Yellow

   b. Isolated ground insulation shall be green with a longitudinal yellow stripe.

c. Emergency power same insulation color as normal power except as follows:

120/208 Volt	480/277 Volt
Provide a continuous stripe on each conductor insulation, orange or yellow, except ground	Provide a continuous stripe on each conductor insulation blue or black, except ground

7. When individual neutral conductors are shown for each branch circuit, the color code for the neutral conductors shall be as follows:
   a. 120/208 volt; Phase A - White with Black stripe; Phase B - White with Red stripe; Phase C - White with Blue stripe.
8. Feeders identified as to phase or leg in each panelboard with printed identifying tape.
9. Fire alarm conductors: Use 600-volt, type THHN/THWN conductors and color-coded per equipment manufacturer's recommendations and approved and listed for use on fire alarm systems by the State Fire Marshal.
10. Panel feeders shall be copper only.
11. Color coding for mechanical and plumbing control wiring shall be an agreed upon color code between the Mechanical/Plumbing CONTRACTOR and the Electrical CONTRACTOR, and color code shall be submitted to the OWNER'S REPRESENTATIVE in writing for approval prior to installation.

2.05 MC CABLE

A. General
   1. Metal clad electrical cable type "MC", UL listed and labeled; low smoke per IEEE-FT4 1212 procedure and UL-1685 and 1569. Fire stop penetration rated. Rated for installation in environmental air plenums.
   2. The cable assembly shall be rated for continuous full load operation in ambient temperatures as follows:
      a. Dry locations 90 degrees centigrade.
      b. Wet locations 75 degrees centigrade.
   3. The type of MC cable, MC fittings and supports shall be suitable for the conditions of use and the conditions of location of installation, based on the manufacturer's recommendations and based on applicable codes.

B. Conductors
   1. Wire conductors shall be 600 volt 60HZ AC thermoplastic insulated, copper wire conductor.
      a. Wire sizes smaller than #8 AWG shall be solid conductors. Wire sizes #8 AWG and larger shall be stranded conductors.
      b. Copper conductor - soft annealed copper, ASTM-B3 or B8. Minimum wire conductor size shall not be less than #12 AWG.
      c. Aluminum conductors are not allowed.
   2. 600 volt color-coded insulation phase wire conductors.
   3. 600 volt white insulation neutral wire conductor.
   4. 600 volt green insulation ground wire conductor. A second redundant, independent ground conductor shall be provided inside the MC cable. The ground conductors shall be bare or insulated conductor wire, type and size to match the main ground conductor.
   5. A 100 percent coverage internal jacket binder tape shall enclose all conductors, located directly under the jacket armor. The binder tape shall provide isolation of "movement" (reduce friction contact) between the conductors and the metal jacket.
   6. The insulation of each wire conductor shall be individually 100 percent enclosed in a continuous tape. The tape shall provide isolation of "movement" (reduce friction contact) between individual conductors insulation and between conductor insulation and the internal jacket tape.

C. Jacket

1. Interlocking flexible metal armor shall be galvanized steel armor jacket. The armor jacket shall 100 percent enclose the insulated wire conductors inside the armor jacket. Aluminum jacket is not allowed.
2. PVC overall cable jacket:
   a. A continuous polyvinyl chloride (PVC) flexible jacket shall be applied over the armor jacket 100 percent enclosing coverage.
   b. The PVC jacket hall be impervious to water infiltration, free of cracks and "pin-holes".
   c. The PVC jacket shall be provided on MC locations as described in the Contract Documents.
3. The interior surfaces of fittings shall be continuous and smooth, with a constant interior diameter. Fittings shall provide fully enclosed circular cross section. The interior surfaces of fittings shall be without ridges, burrs irregularities or obstructions. Fittings of the same type shall be of the same uniform weight and thickness.
4. Protective corrosion resistant finish for MC fittings fabricated from steel, shall be as follows:
   a. clean all metal surfaces (including metal threads) with acid bath "pickle" prior to coating, to remove dirt, oil and prepare surfaces for galvanizing.
   b. Hot-dip galvanized zinc coating on all interior and exterior steel surfaces. Minimum finish zinc coating thickness shall not be less than 0.002 inches.
   c. Threads shall be hot-dip zinc coated after machine fabrication.
   d. Exterior metal surfaces shall be finished with clear organic polymer topcoat layer, after galvanizing.
   e. The inner metal surfaces shall be finished with a lubricating topcoat after galvanizing, to facilitate conductor pulling through the fitting.
5. Threads for MC cable fittings shall be taper-pipe-thread, National Pipe Standards (NPS) and shall comply with ANSI-B1.20.1.
6. Terminal connector fittings shall be provided with a manufacturer installed, insulating throat bushing inside the fitting. The bushing shall protect the wire conductor insulation from cutting, nicks, and abrasion during conductor installation and electrical load "cycling" after installation is complete. The bushing shall comply with UL 94V-0 flammability. The bushing shall be visible and provide physical isolation between the jacket metal armor and the internal conductor insulation.
7. Fittings connecting to MC cable with PVC jacket coating, shall be PVC coating to match the cable.

2.06 CHEMICAL GROUND ROD

A. General

1. Self contained ground rod(s) using chemically enhanced grounding shall be provided where specifically indicated on the drawings. As manufactured by Lyncole XIT Grounding Systems, 22412 South Normandie Avenue, Torrance, CA. TEL # (800) 962-2610; Superior Grounding Systems, Irwindale, CA. Telephone # (800)747-7925; ERICO.
2. The ground rod shall operate from changes in atmospheric pressure pumping air through the ground rod, hygroscopically extracting moisture from the air to activate the ground electrolytic chemicals and improve the ground rod performance.
3. Ground rod system shall be U.L. listed.
4. Ground rod system shall be 100% self-activating, sealed and maintenance free. The addition of chemical or water solutions shall not be required.

B. Ground Rod

1. Ground rod shall consist of a 2 inch nominal diameter hollow, copper tube. The tube shall be permanently capped on the top and bottom, air breather holes shall be provided in the top of tube. Drainage holes shall be provide in the bottom and sides of the tube for electrolyte drainage into the surrounding soil.

2. The ground rod shall be chemically filled at the factory with environmentally non-hazardous water-soluble metallic salts to enhance electrical grounding performance.
3. Ground rod shall be a minimum of ten feet long for straight (vertical) installation; or "L" shape minimum twenty feet long for horizontal installation.
4. Ground wire clamping "U-Bolt" with pressure plate on the top end of the tube sized for 1#2 thru 500 MCM AWG ground electrode conductor connection, and stranded 4/0 AWG copper pigtail exothermically welded to the side of rod for ground electrode conductor connection.

C. Ground Box
1. Precast concrete box with slots for conduit entrances. Approximately ten-inch diameter by twelve inches high. Cast iron grate flush cover with "Breather" slots XIT Box #XB-12.

D. Backfill Material
1. Natural volcanic, non-corrosive Bentonite Clay backfill material.
2. Shall absorb water at a minimum of thirteen times its dry volume or approximately 14 gallons for 50 pounds of clay.
3. PH value 8-10 with maximum resistivity of 2.5 OHMS-M at 300% moisture content by weight.

2.07 FLEXIBLE CORDS AND PORTABLE CABLES

A. General
1. Multi-conductor insulated flexible cable with jacket rated extra heavy duty, extra hard-use and high abuse duty; ozone, sunlight, grease, oil resistant-UL 83 and water resistant; rated for indoor/outdoor use.
2. Quantity of conductors and conductor sizes as indicated on the drawings but in no case less than five 16 AWG.
3. Characteristics:
   a. Conductors - stranded copper, soft annealed conforming to ASTM-B-174 and ASTM-B-172. 600 volt individually insulated and color-coded. Separate green insulated ground conductor.
   b. Insulation - rubber conforming to UL 62; temperature range plus 105° Centigrade to minus 50° Centigrade.
   c. Flame resistance shall conform with MSHA-P123-103.
   d. Jacket - black for equipment connections and yellow for outlet connections. Rated for temperature range plus 105° Centigrade to minus 50° Centigrade, water, sunlight and ozone resistant. Permanently mark jacket a minimum of 40 inches on center with rated voltage, manufacturer's name, wire/insulation type, AWG conductor size and quantity (minimum 24 inches on center).

2.08 CABLE RACKS

A. Cable racks, installed on the vertical walls of the structure, including hooks and porcelain insulator cable cradles, shall be sufficient to accommodate the cables and splices.

B. Vertical racks shall be installed on all walls of the structure a minimum of 24-inches on center within 6-inches of floor and top of wall. A rack shall be installed within 18-inches of each corner of each wall. Additional racks spaced equally on each wall shall be installed, spacing between vertical wall racks shall not exceed 24-inches.
1. Wall racks shall be slotted to accept removable hooks and lock hooks into place.
2. Non-metallic, 50 percent (minimum) glass reinforced nylon or non-metallic material of the same characteristics.

3. The installed cable racks, cable support hooks with arms and wall anchor bolts shall support the following minimum loads for each hook/arm, with a 200 percent minimum safety factor. Based on multiple hook/arms located not less than 9-inches on center along the entire vertical length of the support rack:

Hook/Arm Length	Minimum Weight Each Hook/Arm Supported	Maximum Allowable Hook/ Arm Deflection
a. 8-inch	450 pounds	0.25-inch
b. 14-inch	350 pounds	0.37-inch
c. 20-inch	250 pounds	0.37-inch

(Based on load, concentrated 1-inch from the end of each hook/arm.)

4. Racks shall be bolted to the precast and cast-in place structure walls, within 3-inches of each rack end and not less than 9-inches on center. Provide cast-in place or after set drilled expansion concrete anchors.

PART 3 - EXECUTION

3.01 TRENCHING, FOOTINGS, SLEEVES

A. Provide trenching, concrete encasement of conduits, backfilling, and compaction for the underground electrical work, in accordance with applicable sections of this specification.

B. Provide footings for all post and/or pole-mounted lighting fixtures: concrete shall conform to the applicable sections of this specification.

C. Sleeves
1. Provide sleeves for raceways and conduit passing through the following construction elements:
   a. Concrete and masonry foundations, floors, walls and slabs.
   b. Lath and plaster walls and ceilings.
   c. Building structures (i.e., foundations, walls, floors, ceilings, and roofs) with a fire rating exceeding 20 minutes.
2. Sleeves shall extend 1.5 inches above floors, except under floor standing electrical equipment. Sleeves shall be flush with wall ceiling foundations and partitions exposed to public view and extend approximately 0.5 inch past penetration in fire rated construction. Sleeves shall be installed at exact penetration locations and angles to accommodate raceway and conduit routings.
3. Joists, girders, beams, columns or reinforcing steel shall not be cut or weakened. Where construction necessitates the routing of conduit or raceways through structural members, framing or footings, written permission to make such installation shall first be obtained from the OWNER'S REPRESENTATIVE. Such permission will not be granted, however, if any other method of installation is possible.
4. The layout and design of raceways and conduits located in or routed through masonry or reinforced beams or the OWNER'S REPRESENTATIVE shall review walls before any work is performed. All sleeving shall be accomplished according to the instructions of the OWNER'S REPRESENTATIVE and shall be accepted before any concrete is poured.
5. Sleeves, raceways and conduit shall be located to clear steel reinforcing bars in beams. Reinforcing bars in walls shall be offset to clear piping and sleeves.
6. Provide a continuous clearance between the inside of a sleeve and exterior of conduits and raceways passing through the sleeve not less than the following:
   a. 0.5 inch clearance except as required otherwise.
   b. 1.0 inch clearance through outside walls below grade.
   c. 3.0 inch clearance through seismic joints.

7. Sleeves set in fire rated construction shall be caulked between sleeve and building structure, additionally sleeves shall be caulked between the sleeve and the conduits/raceways passing through the sleeve. The caulking shall be a fireproof sealant, equal to the fire rating being penetrated. Clearance between conduits inside of sleeve and exterior of conduit(s) passing through sleeve and between conduits inside the sleeve shall comply with fireproof sealant manufacturer's recommendations.
8. Sleeve material:
   a. In floor construction: Schedule 40 black steel pipe, with upper surface to be sealed watertight.
   b. In concrete or masonry walls roofs or ceilings: Schedule 40 black steel pipe. When installed in roofs or outside walls, seal outer surface watertight.
   c. In fire rated construction; lath and plaster construction: 24 gauge galvanized iron or steel.
   d. Sleeves through waterproof membranes: Cast iron or Schedule 40 steel with flashing clamp device and corrosion resistant clamping bolts. Caulk space between pipe and sleeve and surfaces between sleeve and conduits sealed watertight.

3.02 GROUNDING

A. Grounding shall be executed in accordance with all applicable codes and regulations, both of the State and local authorities having jurisdiction.

B. Where nonmetallic conduit is used in the distribution system, the CONTRACTOR shall install the proper sized copper ground wire in the conduit with the feeder for use as an equipment ground. The electrical metallic raceway system shall be grounded to this ground wire.

C. The maximum ground/bond resistance to the grounding electrode shall not exceed 1 ohms from any location in the electrical system. The maximum ground resistance of the grounding electrode to earth shall not exceed 5 ohms.

D. Ground/Bond Conductors
   1. Provide an additional, dedicated, green insulation equipment ground/bond wire inside each conduit type as follows. The metal conduit shall not be permitted to serve (function) as the only (exclusive) electrical ground return path:
      a. All types of nonmetallic conduit raceways including but not limited to: RNMC - Rigid Nonmetallic Conduit.
      b. FMC - Flexible Metal Conduit.
      c. LTFMC - Liquid Tight Flexible Metal Conduit.
      d. RMC - Rigid Metal Conduit.
      e. EMT - Electrical Metal Tubing.
   2. The equipment ground/bond wire shall be continuous from the electrical circuit source point of origin to the electrical circuit end termination utilization point as follows:
      a. Every conduit path containing any length of the above identified conduits.
      b. Every conduit path connected to any length of the above-identified conduits.
   3. The equipment ground/bond wire shall be sized as follows, but in no case smaller than indicated on the drawings. Install equipment ground/bond wire in each conduit/raceway, with the respective phase conductors:
      a.

Feeder, Subfeeders & Branch Circuit Protection	Minimum Equipment Ground Wire Size
15 Amp	#12
20 Amp	#12
30 to 60 Amp	#10

70 to 100 Amp	#8
101 to 200 Amp	#6
201 to 400 Amp	#2
401 to 600 Amp	#1
801 to 1000 Amp	2/0
1001 to 1200 Amp	3/0
1201 to 1600 Amp	4/0
1601 to 2000 Amp	250 MCM
2001 to 2500 Amp	350 MCM
2501 to 4000 Amp	500 MCM

4. Isolated grounds - Raceways containing branch circuit or feeder phase conductors connected to panelboards equipment, or receptacles with isolated grounds or isolated ground bus shall contain a dedicated insulated ground conductor connected to the isolated ground system only. The isolated ground conductor shall be continuous the length of the raceways and connected only to the isolated ground terminals in addition to and independent of the equipment bonding/ ground conductor. The isolated ground conductor shall be sized as indicated above, for equipment ground/bond wire.
5. Splices in ground/bond wires shall be permitted only at the following locations:
   a. Ground buses with listed and approved ground lugs.
   b. Where exothermic welded ground/bond wire splices are provided.
6. Provide ground/bond wire jumpers for conduit fittings with ground lugs, expansion and deflection conduit fittings at conduit fittings connecting between metallic and non-metallic raceways and to bond metal enclosures to conduit fittings with ground lugs.

E. Where conductors are run in parallel in multiple raceways, the grounding conductor shall be run in parallel. Each parallel equipment-grounding conductor shall be sized on the basis of the ampere rating of the overcurrent device protecting the circuit conductors in the raceway. When conductors are adjusted in size to compensate for voltage drop, grounding conductors, where required, shall be adjusted proportionately in size.

F. Ground conductors for branch circuit wiring shall be attached at each outlet to the back of the box using drilled and tapped holes and washer head screws, 6-32 or larger.

G. Each panelboard, switchboard, pull box or any other enclosure in which several ground wires are terminated shall be equipped with a ground bus secured to the interior of the enclosure. The bus shall have a separate lug for each ground conductor. No more than one conductor shall be installed per lug.

H. UFER Ground
   1. In addition to all cold water and structural steel grounds provided to meet this specification, there shall be a main ground system of the UFER ground style.
   2. The UFER ground electrodes shall be a minimum of two 20 ft. lengths of #4/0 AWG bare stranded copper cable embedded horizontally in the cast in place concrete footing, extending in opposite directions in the footings. All portions of the ground electrodes shall be placed inside the concrete, between 2 inches and 4 inches from the earth surrounding the concrete.
   3. The lengths of cable shall extend in opposite directions in the footings, with the center end of each cable terminated onto the main electrical service ground bus for the main electrical service equipment.
   4. All wire cable connection terminations onto the ground bus shall be exothermic weld type.

5. The "UFER" grounding electrode, embedded in concrete, shall be exothermically welded to each steel reinforcing bar (rebar) and each steel anchor bolt located within 18 inches of the grounding electrode inside the concrete. Note: Reinforcing steel (rebar), in concrete foundations, attached with metal "tie-wraps" and in direct physical contact to other adjacent rebar that is in turn exothermic welded to the UFER grounding electrode, may be classified as attached to the UFER grounding electrode, and does not require additional exothermic weld connections to the UFER grounding electrode.

I. Provide a separate ground/bond insulated grounding electrode conductor, copper wire from the main electrical service ground bus to each of the following locations. The ground/bond conductor shall be sized to comply with applicable codes and as indicated on the drawings, but in no case smaller than the following:
   1. Main service entrance equipment ground bus:
      a. Services smaller than 1200 ampere 1.5 inch conduit with 1#4/0.
      b. Services 1200 ampere and larger 2.5 inch conduit with 1#500MCM.
      c. Where a separate ground bus is not required, connect ground to electrical equipment metal housing
   2. Each telephone backboard and signal system backboard location, 1.0 inch conduit with 1#1.
   3. Metal cold water pipe located inside the building, 1.5 inch conduit with 1#4/0.
   4. Outdoor underground metal cold water pipe, make connection five feet from the building, 1.5 inch conduit with 1#4/0.
   5. Each transformer (size as indicated and to comply with applicable codes).
   6. Each service entrance ground bus and each separately derived ground rod system:
      a. Services smaller than 1200 ampere 1.5 inch conduit with 1#4/0.
      b. Services 1200 ampere and larger 2.5 inch conduit with 1#500MCM.
   7. Separate
      1.25 inch conduit with 1#2 (AWG) bonding conductor to each interior metal pipe system located in the same building, including but not limited to, the following:
      a. Fire sprinkler system each stand pipe location (water based and non-waterbased).
      b. HVAC chilled water supply and return, at each pump location.
      c. Roof drains.
      d. Waste liquid disposal systems.
      e. Metal gas pipe service entrance and service meters.
      f. Hydraulic elevator hydraulic pipes.

3.03 CONDUIT

A. General
   1. The sizes of the conduits for the various circuits shall be as indicated on the drawings, but not less than the conduit size required by code for the size and quantity of conductors to be installed in the conduit.
   2. Conduits shall be installed concealed from view. Install conduits concealed in walls, concealed in/below floors and concealed above ceilings, except as specifically noted otherwise.
   3. The following systems shall be considered as circuits 100 volts and less, all other circuits shall be considered to be over 100 volts (power circuits) unless specifically noted otherwise: Fire alarm, energy management control, telephone, public address, data, computer, television, intercom, intrusion alarm and nurse call.
   4. Conduits shall be provided complete with conduit bends, conduit fittings, outlet boxes, pullboxes, junction boxes, conduit anchors/supports, grounding/bonding for a complete and operating conductor/wire raceway system.

5. Metal and nonmetal conduits shall be provided mechanically continuous between termination connection points. Metal conduit shall be provided electrically continuous between termination connection points.
6. Individual conduit paths and home runs shown on the drawings shall be maintained as separate individual conduits for each homerun and path.
7. Conduits, conduit fittings and installation work occurring in classified hazardous materials locations shall comply with applicable code Class 1 Division 1 requirements, unless specifically noted otherwise.
8. Transitions between conduits constructed of different materials and occurring in above grade locations shall be allowed only at outlet boxes, junction boxes, pull boxes and equipment enclosures unless specifically indicated otherwise. Provide outlet boxes and junction boxes.
9. Metal conduit terminating to nonmetal enclosures; terminating into metal enclosures with "concentric.ring" knockouts; terminating into metal enclosures with knockout reducing washers, including but not limited to equipment housings, outlet boxes, junction boxes, pull boxes, cable trenches, manholes, shall be provided with a ground/bonding lug integrated with the conduit termination conductor fitting construction, by the fitting manufacturer. The lug shall provide for connection of a grounding/bonding conductor (insulated or uninsulated). The grounding lug shall be located on the fitting, inside the termination enclosure.
10. The type of conduit, type of conduit fittings, and type of conduit supports and method of conduit installation shall be suitable for the conditions of use and conditions of location of installation based on the manufacturer's recommendations; based on the applicable codes and based on the requirements of the contract documents.

B. RMC Installation Locations

RGS, IMC conduits and RGS, IMC fittings shall be installed in the following locations:
1. Embedded in floors, walls, ceilings, roofs, foundations, and footings constructed with concrete.
2. Embedded in walls and foundations constructed with brick and masonry.
3. Interior of buildings, within nine feet of finish floor lines for exposed conduit locations.
4. Exterior of building for exposed conduit locations.
5. Damp or wet locations, exposed or concealed locations.
6. Exposed on roofs.
7. In hazardous materials areas and locations; below hazardous materials areas and locations; above hazardous materials areas and locations.
8. Exposed on utility service poles, for pole risers less than 9 feet above finish grade.
9. RMC conduit and RMC fittings may be installed in any location where EMT and FMC conduit is permitted to be installed.

C. PVC Coated RMC Installation Locations

PVC coated RMC conduit and PVC coated RMC fittings shall be installed in the following locations:
1. Underground conduit locations for elbows and bends with a radius of less than 36 times the conduit diameter.
2. Underground vertical risers extending above grade.
3. Entire length of underground conduits for the following circuits:
   a. Audio microphones
   b. Lighting dimming controls
4. Installed in contact with earth or corrosive materials.
5. Exposed in "cold" rooms and "refrigerated" rooms, rooms with a maintained temperature below 65 degrees Fahrenheit.

D. EMT Installation Locations

EMT conduit and EMT fittings may be installed in the following locations, for circuit conductors operating below 600 volts to ground; locations containing only "non-hazardous materials"; only dry locations:

1. Concealed in hollow non masonry, metal stud frame and wood stud frame walls.
2. Concealed above ceilings.
3. Exposed inside interior enclosed crawl spaces.
4. Exposed interior locations placed 9 ft. or higher above finished floors.
5. Exposed in the following dedicated function areas, interior enclosed room locations:
   a. Indoor enclosed electrical equipment rooms and closets.
   b. Indoor enclosed data and telecommunication terminal rooms and closets.
   c. Indoor enclosed HVAC equipment rooms and closets.
6. Any location where FMC is described to be installed, except as the final connection to rotating or vibrating equipment.

E. FMC Installation Locations

FMC conduit and FMC fittings may be installed in the following locations for circuit conductors operating below 600 volts to ground; locations containing only "non-hazardous materials"; only dry, interior locations:

1. Concealed in hollow non-masonry metal stud frame and wood stud frame fully enclosed walls.
2. Concealed above fully enclosed ceiling spaces.
3. FMC conduit shall be installed in continuous lengths between termination points. FMC shall not be "spliced" or coupled directly to FMC or any other conduit type under any circumstance.
4. The maximum continuous length of FMC that shall be installed between termination end points is 6 feet. Circuits requiring continuous conduit lengths exceeding 6 feet between termination end points shall be installed using either RMC or EMT conduits. FMC lengths shorter than 16 inches are prohibited.
5. The minimum size FMC conduit shall be as shown on the drawings but not be less than the following:
   a. FMC lengths of six feet or less, minimum FMC conduit size shall be 0.50 inches.
   b. FMC lengths exceeding six feet, minimum FMC conduit size shall be 1.0 inches.

F. LTFMC Installation Locations

LTFMC conduit and LTFMC fittings shall be installed in the following locations for circuit conductors operating below 600 volts to ground; locations containing only "non-hazardous materials":

1. Final electrical connection to vibrating or rotating equipment; control and monitoring devices mounted on vibrating and rotating equipment including the following. Minimum conduit length shall not be less than 24 inches:
   a. Motor, engines, boilers, solenoids, and valves.
   b. Fixed mounted "shop" (manufacturing) production equipment.
   c. Fixed mounted food preparation equipment and "kitchen" equipment.
2. All locations where exposed flexible conduit connections are required, both indoor and outdoor.
3. Final connection to indoors electrical transformers. Minimum conduit length shall not be less than 24 inches, maximum conduit length shall not exceed 72 inches.
4. Do not install LTFMC located in environmental air plenums.

G. RNMC Installation Locations

RNMC conduit and RNMC fittings shall be installed in the following locations containing only "non-hazardous material":

1. Underground, concealed below earth grade, unless specifically noted or specified otherwise.
2. Exposed on utility service poles, for pole risers at 9 feet or higher above finish grade, schedule 80 PVC only.
3. RNMC type "EB" conduit(s) shall be concrete encased along the entire length of the conduits for all installation locations.

H. Conduit Installation

1. Conduit Supports
   a. Securely and rigidly support all raceways/conduits from the building structure. Raceways/Conduits shall be supported independent of all piping, air ducts, equipment ceiling hanger wires, and suspended ceiling grid systems. Secure conduit to structural element by means of U.L. listed and approved hangers, fasteners, "C" channels and pipe clamps.
   b. Provide conduit supports spaced along the length of the conduit as follows:
      1) RMC and EMT conduit, maximum not to exceed 96 inches on center; within 24 inches of each conduit bend and conduit termination location.
      2) FMC and LTFMC conduit, maximum not to exceed 24 inches on center; within 6 inches of each conduit bend and conduit termination location.
   c. Suspended conduit methods:
      1) Individual, suspended raceways/conduits separated by more than 12 inches from any other conduit and suspended from ceilings and roofs shall be supported as follows:
         a) Conduits smaller than 1.5 inches by means of hanger rods or hanger wires.
         b) Conduits 1.5 inches and larger by means of hanger rods.
         c) The conduit shall attach to the hangers with pipe clamps.
      2) Suspended raceways/conduits positioned within 24 inches of any other conduit shall be grouped and supported by hanger rods using trapeze type conduit support channels ("C" channels). Conduits shall individually attach to common channels side-by-side, with pipe clamps.
   d. Non-suspended conduit methods:
      1) Individual raceway/conduits placed against wall/ceiling/floors, placed inside hollow wall/ceiling construction or structure framing (i.e., "dry- wall" or plaster hollow wall construction), shall be secured by means of individual pipe clamps and fasteners attached to the framing studs or other structural members and the conduit/raceway.
      2) Provide common "C" channel supports for all multiple raceway/conduits placed against vertical or horizontal surfaces and positioned within 24 inches of other raceways/conduits. Attach channels to the framing studs or other structural members. Attach the conduits/raceway individually to common channels, side-by-side, with pipe clamps.
      3) The use of toggle bolts is prohibited.
   e. Conduit rising from floor for motor connection shall be independently supported if extending over 18" above floor. Support shall not be to a motor or ductwork, which may transmit vibrations.

f. Provide conduit anchoring, conduit support and conduit bracing systems conforming to Earthquake Seismic Zone 4 requirements. The conduit support/anchoring system capacity shall include the weight of the conduits, conduit fittings, conduit supports and conductors/wires/cables installed in the conduits plus a 300 percent safety factor. Submit shop-drawing details showing each typical conduit anchor, conduit support and conduit brace location. Submit structural calculations performed by and signed by a Professional Structural Engineer (P.E.) with a P.E. license, registered in the state of California, U.S.A.

2. Conduit separation:
   a. Conduit installed underground or below building slab without full concrete encasement: Shall be separated from adjacent conduits of identical systems (i.e. signal to signal, data to data, power to power, control to control etc.) by a minimum of 3 inches. Conduits of non-identical systems (i.e. signal to power; data to power; power to control; signal to control, etc.) shall be separated by a minimum of 12 inches.
   b. Conduit installed underground with full concrete encasement; shall be separated from adjacent conduits of similar systems (100 volt and less) by a minimum of 2 inches; conduits for non power systems (100 volts and less to ground) shall be separated by a minimum of 6 inches from power circuits (over 100 volts to ground); conduits for power circuits shall be separated from adjacent conduits of similar power systems (over 100 volts to ground) by a minimum of 3 inches.
   c. Separation of conduits entering termination points or crossing other conduits may be reduced as required within 60 inches of the termination or crossing points.
   d. Conduits containing Utility Company service circuits (i.e. electrical power, telephone, or cable television) shall be separated a minimum of 12 inches from all other utilities and conduits, with or without concrete encasement; metallic or non-metallic conduit, above grade or underground conduit locations.
   e. Conduits shall be separated from hot water piping, exhaust flues/chimneys, steam piping, boilers, furnaces, ovens by a minimum of 12 inches.
3. Conduit stubs:
   a. Branch circuit and telephone conduits turned up from floor at the following locations shall terminate each conduit in a flush conduit coupling at the floor and then extend into partition or to equipment. Refer to OWNER'S REPRESENTATIVE'S drawings for location of walls and partitions.
      1) Interior demountable partitions.
      2) Below, into or adjacent to equipment not installed directly adjoining to a wall.
      3) Up from below the floor into hollow stud frame walls.
   b. From each panel, and signal cabinet which is wall mounted, stub up from top of the panel/cabinet a minimum of (3) three 1 inch conduits to the nearest accessible ceiling spaces or other accessible location. Where the floor below the panel is accessible or is a ceiling space, stub an additional (3) three 1 inch conduits from the bottom of the panel into the accessible space below the panel. Cap conduits for future use.
   c. Conduits stubbed underground outside of building line for future use shall be terminated a minimum of five feet clear (whichever distance is greater) of building or adjacent concrete walks and A.C. paving. The stubout conduit shall be capped. Provide concrete monuments , 6" x 6" x 15" deep, buried flush with grade over the capped ends. The face of monument shall be furnished with 3" square brass plates securely mounted and engraved with the number and size of conduits and type of service (i.e., "POWER", "TEL.", etc.).

d. Conduits stubbed into ceiling or floor spaces from outlets for telephone, video, computer/data or television shall be provided with an insulated throat bushing, on the end of each conduit stubout.

e. Conduit stubouts from outlet boxes and equipment located in hollow stud walls, into ceiling and floor spaces, shall be EMT or RMC conduit. The stubouts shall terminate into the ceiling and floor spaces with a conduit termination connector fitting.

f. Empty conduit stubs into building spaces and equipment shall be individually identified with a "ID-tag" located at each end of the conduit. The ID-tag shall state the origination point and termination point of the respective conduit (i.e., "from PNL-A/to Room #121"; "from outlet #24/to outlet #17 in Room #120"; etc.).

g. Provide a conduit termination fitting with insulated throat bushing and mechanical ground lugs at each conduit "stub-up" location.

4. Conduit concrete encasement:

a. Conduits which are run underground exterior to building slab shall be continuously concrete encased except, 15 and 20 ampere power branch circuit conduits underground do not require concrete encasement.

b. PVC rigid-non-metallic-type EB conduit, of any size and any location shall be continuously concrete encased the full length of the conduit installation, including under building slab.

c. Concrete for encasement of underground conduits shall be 2500 PSI 28 days cure strength with a maximum of 3/4" gravel. Concrete encasement of conduits shall be continuous without voids. The encasement shall extend 3-inches past the edges of all conduits on all sides of the circuit. Provide ten pounds of red oxide cement coloring uniformly mixed with each cubic yard of concrete for conduit encasement.

d. Conduits located below or adjacent to structural foundations shall be separated from the foundation by a minimum of 12 inches. Conduits located below structural foundations shall be fully and continuously concrete backfilled and encased between the bottom of the foundation to the bottom of the conduits. The concrete shall be 4000 PSI 28 day cure strength instead of 2500-PSI concrete.

e. Conduits of any size and type (including 15 ampere and 20 ampere power branch circuits) located under roads, paved areas and "transit-system" right of way shall be concrete encased.

5. Underground conduits:

a. Three or more underground conduits larger than 1" in size and occupying the same trench shall be separated and supported on factory fabricated, non-metallic, duct/conduit support spacers. The spacers shall be modular, keyed interlocking type, "built-up" to accommodate quantity, size orientation and spacing of installed conduits.

The spacers shall maintain a constant distance between adjacent conduit supports and hold conduits in place during trench backfill operations. Minimum support spacer installation interval along with length of the conduits shall be as follows:

1) Concrete encased conduits, not less than 8 ft. on center.

2) Non-concrete encased conduits, not less than 5 ft. on center.

b. Provide trenching, excavation, shoring and Backfilling required for the proper installation of underground conduits. Tops of backfill shall match finish grade.

c. Bottoms of trenches shall be cut parallel to "finish grade" elevation. Make trenches 12 inches wider than the greatest diameter of the conduit.

d. Backfilling Trenches for Conduits without Concrete Encasement Requirements
   1) Conduits which are not required by the Contract Documents to be concrete encased and are located exterior to building slab, shall be set on a 3 inch bed of damp clean sand. Conduit trenches shall be backfilled to within 12 inches of finished grade with damp sand after installation of conduit is completed. Remainder of backfill shall be native soil.
   2) Conduits located under a building which are not required by the Contract Documents to be concrete encased, shall be completely backfilled and compacted with clean damp sand to the same level as the building foundation pad.
   3) Provide a continuous yellow 12 inch wide flat plastic tracer tape, located 12 inches above the conduits in the trench. The tracer tape shall be imprinted with "Warning-Electric Circuits" a minimum of 24 inches on center.

e. Backfilling trenches for conduits under paved areas:
   1) In addition to the requirements of conduit concrete encasement, conduits under walkways, roads, parking lots, driveways, and buildings shall be cast in place concrete "slurry mix" backfill. The slurry mix shall cover each side and top of conduits and conduit concrete encasement. The slurry mix shall be continuous to the underside of the finish subgrade surface.

f. Backfilling trenches for conduits with concrete encasement requirements by the contract documents:
   1) Trenches with all conduits concrete encased, shall be backfilled with clean damp sand when located under building pads.
   2) Trenches with all conduits concrete encased and not located under a building pad and not located under paved areas, shall be backfilled with clean damp sand or native soil.

g. Backfill material:
   1) Sand and native soil backfill of trenches shall be machine vibrated in 6-inch lifts to provide not less than 90 percent compaction of backfill.
   2) Concrete and slurry mix shall be machine vibrated during installation to remove "air-voids".
   3) Soil shall have no stones, organic matter of aggregate greater than 3 inches.
   4) The slurry mix shall consist of concrete, clean sand and clean water mixture. Maximum shrinking of slurry mix shall not exceed 5 percent wet to dry.

h. Do not backfill until OWNER'S Representative has approved installation and as-built drawings are up to date. Promptly install conduits after excavation has been done, so as to keep the excavations open as short a time as possible. Excess soil from trenching shall be removed from the site.

i. Install underground conduit, except under buildings, not less than 24" [18"] below finished grade in non-traffic areas and 30" [24"] below finished grade in traffic areas, including roads and parking areas. Not less than 48" below finished grade under public/private transit system right of way and railroad right of way. Dimensions shall be measured to the top of the conduit.

j. Conduit crossing existing underground utilities shall cross below the bottom depth of the existing utilities. If the top portion of the existing utility depth below finish grade exceeds 72 inches and the specified separation and depths are maintained when crossing over the top of the existing underground utility, the conduit may cross above the existing underground utility.

k. Provide long radius horizontal bends (minimum radius of 36 times the conduit diameter) in underground conduits where the conduit is in excess of 100 feet long.

l. Conduits installed below grade and on grade below buildings, shall not be smaller than 0.75 inches. Conduits for circuits exceeding 600 volts shall not be smaller than 5.0 inches.

m. Underground conduits entering a building shall be sloped. The conduit direction of slope shall be away from the building, and shall prevent water in the conduit from "gravity draining" towards the building. The conduit slope "high point" shall originate from the building, out to the first exterior pullbox, manhole etc. exterior conduit termination "low point". The minimum slope angle shall be a constant 8 inches (or greater) of fall for each 100 feet of conduit length.

n. Dewatering:

1) Provide pumping to remove, maintain and dispose of all water entering the excavation during the time the excavation is being prepared, for the conduit laying, during the laying of the conduit, and until the backfill at the conduit zone has been completed. These provisions shall apply on a continuous basis.

Water shall be disposed of in a manner to prevent damage to adjacent property. Trench water shall not be drained through the construction. Groundwater shall not be allowed to rise around the pipe until joining compound has firmly set.

2) The OWNER'S Representative shall be notified 48 hours prior to commencement of dewatering.

6. Raceway/Conduits, which are installed at this time and left empty for future use, shall have 0.25 inch diameter polyvinyl rope left in place for future use. The pull rope shall be 500-pound minimum tensile strength. Provide a minimum of 5 feet of slack at each end of pull ropes.

7. Unless otherwise restricted by structural drawings and specifications, the maximum size conduit permitted in slabs, wall ceilings and roofs constructed of masonry or concrete shall not be greater than 25 percent of the concrete/masonry thickness. Conduits installed in these locations shall not cross.

8. Provide openings in building structures for conduit penetrations:

a. New construction shall be provided with conduit sleeves, to provide conduit penetrations.

b. Existing construction shall be drilled (core drill masonry and concrete) and provide conduit sleeves installed after drilling, to provide conduit penetrations.

c. Where the structure penetrations for underground conduits penetrating through foundations will not comply with the (restriction/penetration) shown in the Contract Documents, install the conduits below and clear of the foundation lowest point.

9. Conduit bends risers and offsets:

a. The minimum bend radius of "factory or field" fabricated conduit bends shall not be less than the following. The bend radius shall be measured at the surface, inside radius of the conduit wall:

1) FMC and LTFMC conduit - conduit minimum bend radius 12 times the conduit diameter.

2) RMC and EMT conduit minimum bend radius - conduit for power circuits over 100 volts and less than 600 volts, 8 times conduit diameter. Conduit for power circuits over 600 volt, 12 times conduit diameter. Conduit for signal and fiber optic circuits, 10 times conduit diameter.

3) RNMC conduit - conduit minimum bend radius 36 times the conduit diameter. Under building reduce minimum bend radius to 10 times the conduit diameter. Conduit bends and offsets in RNMC with less than 36 times conduit diameter bend/offset radius, shall be RNMC PVC schedule 80 or PVC coated RGS.

4) Conduits for utility company conductors. Conduit minimum bend radius shall comply with the respective utility company requirements.

b. Bends and offsets in conduits shall be kept to an absolute minimum. The total summation of all bends and offsets permitted in a conduit segment, occurring between two conduit termination/connection end points, shall not exceed the following, including conduit fittings:
   1) RMC and EMT conduit - 360 angular degrees
   2) FMC and LTFMC conduit - 180 angular degrees
   3) RNMC conduit - 270 angular degrees

c. Each field fabricated conduit offset, bend and elbow which are not the standard product of the raceway/conduit manufacturer shall be mandrel tested. The test shall be conducted after the conduit installation is complete and prior to pulling-in any wire, in the same manner as for underground conduits.

d. Factory manufactured angle connector conduit fittings shall be installed in exposed conduit locations only. Installation in locations normally concealed from view shall not be permitted. Not more than one (1) factory manufactured angle connector shall be permitted in any length of conduit between conduit termination end points.

e. RNMC conduit risers from below grade shall be PVC coated RGS. Conduit risers, bends or offsets entering into a building shall be PVC coated RGS.

f. If (3) three or more conduit-bends of the same conduit size and same conduit material type, installed, as part of the contract work, fail to comply with the required minimum conduit bend radius or conduit angular degree limits. The following corrective actions shall occur:
   1) The CONTRACTOR shall remove all the non-complying conduit bends and the respective wire in the conduit from the project site. Provide new conduit and wire, complying with the contract documents.
   2) Where the conduit bends similar to the non-complying conduit bends are installed concealed in walls, floors, above ceilings or below grade, the Contractor shall expose the conduit bends to allow visual observation.
   3) The CONTRACTOR shall remove the non-complying conduit bends and dispose off the project site. The CONTRACTOR shall provide new conduit bends and conductors complying with the contract documents.
   4) All the costs to correct the deficient material and work along with costs to repair the direct, indirect, incidental damages and contract delays shall be the sole responsibility of the CONTRACTOR and shall be included in the bid price.

10. Expansion joint, deflection joint and seismic joint fittings.

a. Provide a conduit expansion fitting for each conduit length and conduit type as follows(Note - The installation of specified combination expansion/deflection fittings at seismic joints shall satisfy this spacing requirement also):

Conduit Type		Conduit	Fitting Length Spacing
1)	RMC and EMT	Exposed exterior locations	200 ft
2)	RMC and EMT	Interior weather protected locations	400 ft

b. Provide a conduit combination expansion/deflection fitting for each conduit, crossing the following elements:
   1) At each building or non-building structure seismic joint.
   2) At each building on non-building structure expansion joint.
   3) At each conduit penetration of a "sound-rated" wall, floor or ceiling.

11. Provide two locknuts and an insulated throat bushing at each metal conduit terminating at enclosures, including but not limited to outlet boxes, junction boxes, terminal cabinets, switchgear, transformers, switchboards, distribution panels and panelboards.
12. Provide metallic or plastic closure caps on all conduit ends during construction, until installation of conductors in the respective conduit.
13. Conduit run exposed, shall be run at right angles or parallel to the walls or structures. All changes in directions, either horizontally or vertically, shall be made with conduit outlet bodies as manufactured by Crouse Hinds, OZ or equal. Conduits run on exposed beams or trelliswork shall be painted to match surrounding surfaces.
14. Conduit exposed on roof:
    a. Conduits installed exposed on roofs shall be installed on conduit sleepers. Place the conduit sleepers a maximum 5-foot on center along the entire length of the conduit; under conduit expansion/deflection fittings; under each junction box and within 24 inches of each conduit bend.
    b. Provide a conduit support "C" channel continuous along the top length of the sleeper and rigidly bolted to the sleeper. Conduits shall be loosely fastened to each sleeper "C" channel with pipe clamps to allow for relative movement between the sleeper and conduit.
    c. Conduits shall not block or interfere with roof hatches, doors, ventilation openings, dampers, equipment access panels/doors, roof water drainage.
    e. Conduit sleepers shall be fabricated from "clear" solid redwood 4 inch x 4 inch (nominal) size. Sleeper length shall extend a minimum of 9 inches past the conduits attached to the sleeper, but in no case shall the length of the sleeper be less than 24 inches.
    f. Provide a pad under each sleeper, sleepers shall not be installed in direct contact with the roofing. Sleeper pads shall extend a minimum of 6 inches past each side of the sleeper. The sleeper pad shall be semi-rigid mineral surfaced composition board, not less than 0.375 inch thickness, bituminous impregnated, manufactured for application on the specific roofing material. Remove roofing "ballast" (gravel) under pad, prior to installation of sleeper pad. Do not puncture roof membrane.
    g. Position the "length" of the conduit sleepers' perpendicular to the roof slope, to prevent obstruction of roof drainage water flow. Where the conduit routing prevents placing the conduit sleeper parallel to the roof slope, provide two separate sleeper pads for the conduit sleeper, with a continuous 3 inch wide water drainage gap between the sleepers. Align the water drainage gap to allow unimpeded water travel along the roof slope drainage flow line between the pads.
    h. Sleepers and sleeper pads shall be set in nonhardening mastic, a minimum of 0.25 inch thickness. Mastic shall be inorganic, nonhardening, and complying with ASTM-D1227. Mastic shall be applied with continuous uniform coverage, minimum 0.25 inch thickness, on all the surfaces of each conduit sleeper and on the sleeper pad contact surface with the roof.
15. Rigid steel conduit or electrical metallic tubing shall not be strapped or fastened to equipment subject to vibration or mounted on shock absorbing bases.
16. RMC conduit threads:
    a. Machine cut threads on RMC conduit required for field fabrication shall comply with NPS and ANSI-B1.20.1.
    b. The length of bare metal exposed during thread fabrication shall be completely covered by conduit couplings and fittings. Additionally, the thread length shall insure that conduit joints will reach "torque" tightness and become secure before conduit ends "butt" together and before conduit ends "butt" into the "shoulders" of other conduit fittings.
    c. Running threads or right/left handed threads shall not be used to connect RMC.

17. RNMC conduit:
    a. Joints and fittings shall be solvent welded to RNMC conduit. Joints and fittings shall be watertight and airtight after fabrication.
18. Tighten each conduit fittings and fitting appurtenance, to the "torque" (allowable tolerance ±5 percent)value recommended by the fitting manufacturer and applicable code. If three (3) or more conduit fittings are found to not be in compliance with the manufacturer's "torque" (tightness) recommendations, the following corrective actions shall occur:
    a. The CONTRACTOR shall tighten "re-torque" the defective fittings and all similar conduit fittings installed as part of the contract documents in the presence of the OWNER's REPRESENTATIVE.
    b. If the respective conduit fittings similar to the deficient "torque tightness" fittings are installed concealed in walls, floors, above ceilings or below grade, the CONTRACTOR shall expose the fitting, to allow retightening each similar conduit fitting to the manufacturers recommended "torque" values.
    c. All the cost to repair the direct, indirect, incidental damages and contract delays resulting from complying with these requirements shall be the sole responsibility of the CONTRACTOR and shall be included in the bid price.

I Conduit Seals
1. Provide conduit seal fittings at each location where a conduit transitions or passes through the following areas and where indicated on the drawings:
    a. Refrigerated areas.
    b. Temperature control rooms including warming rooms, steam rooms, saunas etc.
    c. Classified hazardous material areas.
    d. Water intrusion areas.
2. Provide conduit seals on each conduit entering a building from a below grade area located outside the building (i.e., basement, vault etc.) and connecting to the following types of equipment .
    a. Transformers
    b. Panelboards
    c. Motor control centers
    d. Switchboards
    e. Switchgear
    f. Motors
    g. Terminal cabinets
    h. Terminal backboards
    i. Cable trenches
3. Conduit seals shall be installed in locations where the fitting is visible and accessible.

J. Nailing Shields
1. The nail shields shall be flat nominal 1.5 inch x 3 inch, 14-gauge steel, and hot dip zinc galvanized with "nailing spurs".
2. Provide nailing shields on the front face and rear face of each FMC penetration. The shield shall be centered on each penetration through the respective framing, stud framing blocking, and stud framing plates.

K. Conduit Bodies
1. Conduit bodies shall be installed in exposed conduit locations only or above accessible ceilings.
2. Conduit bodies shall be accessible for removing body cover and pulling wire through the conduit body.
3. Conduit bodies shall not be installed inside enclosed walls.

L. Preparation of Reuse of Existing Conduits

1. Prepare existing conduits shown to be reused as part of contract work as follows: Complete the required work prior to installing any conductors or cables in respective existing conduits.
   a. "Rod" out existing raceways to be used under this contact, with approved test and flexible mandrels to remove all obstructions to clear debris from inside conduits.
   b. Use test mandrels at least 12-inch long, 0.25-inch inch less than diameter of duct at center, tapering to 0.5-inch less than duct size at ends.
2. If test mandrels cannot be pulled through raceways, CONTRACTOR shall perform the following to clear the existing raceways:
   a. Force rigid or semi-rigid rods through the raceways to clear the obstructions from one to both ends of the raceway.
   b. Force a power driven rotating router device through the conduit from one or both ends of raceways. Device shall incorporate small diameter cutting blades. Repeat the "router" process in incremental stages to a cutting blade diameter approximately 1/8" smaller than the raceway inside diameter.
3. After clearing the raceway of obstructions, pull a test mandrel or brush through the raceway to clear the remaining debris from the raceway.

3.04 WIRE AND CABLE

A. Branch circuit and fixture joints for #10 AWG and smaller wire shall be made with UL-approved connectors listed for 600 volts, approved for use with copper and/or aluminum wire. Connector to consist of a cone-shaped, expandable coil spring insert, insulated with a nylon shell and 2 wings placed opposite each other to serve as a built-in wrench or shall be molded one-piece as manufactured by 3M-"Scotchlok".

B. Branch circuit joints of #8 AWG and larger shall be made with screw pressure connectors made of high strength structural aluminum alloy and UL-approved for use with both copper and/or aluminum wire as manufactured by Thomas & Betts. Joints shall be insulated with plastic splicing tape, tapered half-lapped and at least the thickness equivalent to 1.5 times the conductor insulation. Tapes shall be fresh and of quality equal to Scotch.

C. Use U.L. listed pulling compound for installation of conductors in conduits.

D. Correspond each circuit to the branch number indicated on the panel schedule shown on the drawings except where departures are approved by the OWNER'S REPRESENTATIVE or the OWNER'S Representative.

E. All wiring, including low voltage, shall be installed in conduit.

F. Control wiring to conform to the wiring diagrams shown on the mechanical drawings and the manufacturer's wiring diagrams.

G. All splices in exterior pull boxes and light poles shall be cast resins encapsulated.
   1. Power conductor splices - 3M Scotchcast Series 82/85/90; Plymouth or equal.
   2. Control and signal circuits 3M Scotchcast series 8981 thru 8986, Plymouth or equal.

H. Neatly group and lace all wiring in panelboards, motor control centers and terminal cabinets with plastic ties at 3" on centers. Tag all spare conductors.

3.05 MC CABLE INSTALLATION

A. General

1. MC cable shall not be "spliced" or coupled directly to any other conduit type under any circumstance.
2. MC cable shall not be installed exposed. Where exposed installation occurs, provide a conduit to completely enclose and protect the MC Cable. The inside diameter of the conduit shall be sized 1.6 times the outside diameter of the MC cable. The conduit type and installation methods shall comply with the Contractor Documents.
3. MC cable shall be continuous length between end point terminations, without intermediate splices or junctions.
4. MC cable shall be supported and attached. MC cable supports and attachments shall be the same as contract document requirements for conduit, with the following exceptions:
   a. Support at not more than 3ft. intervals along the entire length of the MC cable.
   b. Support within 12 inches of each bend or change of direction.
   c. Support within 12 inches of each termination entrance.
5. The minimum installed bending radius shall not be less than 8 times the outside diameter of cable assembly, as measured at the inside radius cable jacket surface.
6. Cable lengths of less than 6ft. shall not be permitted.
7. MC cable shall be installed and terminated to comply with Manufacturer's recommendations.

B. Permitted Applications

1. MC cable may be provided only for electric power circuits and where complying with all of the following conditions:
   a. Circuits operating on line to ground 60HZ-AC circuit voltages, exceeding 100 volts and less than 500 volts.
   b. The full load ampere rating and circuit conductor quantities of the proposed MC cable shall be equal to or greater than the full load ampere rating for the conduit and wire conductors shown on the contract drawings.
   c. The electrical circuit voltage drop of the proposed MC cable shall be equal to or less than for the conduit and wire conductor sizes shown on the contract drawings.
   d. The conductor sizes in MC cable shall not be smaller than the conductor sizes described for conduit and wire installations.
   e. MC cable shall <u>not</u> be permitted on circuits with more than one (1) phase conductor per phase.
   f. MC cable circuits or portions of MC cable circuits shall not be connected to wiring devices, lighting equipment or motors. MC cable shall not be permitted for circuit wire sizes #4AWG or smaller.
2. MC type cable may only be installed in the following locations in areas that do not contain classified hazardous materials (MC cables without PVC jacket):
   a. Concealed in hollow non-masonry metal stud frame and wood stud frame fully enclosed walls.
   b. Concealed above fully enclosed ceiling spaces.
3. MC Cables with PVC jacket may only be installed in the following locations:
   a. Underground installation locations.
   b. MC cable installed below grade shall be not less than #4 AWG conductor size.
   c. The underground installation requirements for MC cable shall be the same as for conduit and wire systems including but not limited to trenching, burial depth, circuit separation, supports, concrete encasement, etc.
   d. MC cables shall not be installed below areas with classified hazardous materials.

3.06 CHEMICAL GROUND ROD

A. General
   1. Install ground rod system in compliance with manufacturer's instructions.
   2. Install rods vertically. Where subterranean hard rock conditions prevent vertical installation horizontal "L" shape ground rod shall be installed.
   3. Where ground rod is installed in an indoors dry location set ground box flush with finish floor. Where ground rod is installed outdoors set the top of the ground box four inches above finish grade.
   4. Do not remove sealing tape from ground rod holes until time of installation in ground.
   5. Separate ground rods from all other grounding electrodes and from each other by not less than 12ft. horizontal distance.

B. Excavation
   1. Vertical installation bore a 12 inch diameter vertical hole in the ground six inches deeper than ground rod length.
   2. Horizontal installations excavate a twelve-inch wide trench, slope rod and trench to insure end cap of rod is 2 inches lower than the elbow.

C. Backfill
   1. Surround the entire rod with a minimum of 10 inches of bentonite clay mixed with water at six times volume to form a paste. Approximately 14 gallons for each 50 pounds of clay. Remove any excavation liners from the rod excavation area.
   2. Install ground box and complete backfill.

D. Connect grounding electrode conductor(s) to ground rod.

3.07 CABLE RACKS

A. General
   1. Provide cable racks in precast and cast-in place concrete pullboxes, manholes and cable trenches.

3.08 TESTING

A. Testing Conduit and Conduit Bends

The CONTRACTOR shall demonstrate the usability of all underground raceways, and field fabricated conduit bends installed as part of this contract.

1. A round tapered segmented semi-rigid mandrel with a diameter approximately 1/4 inch smaller than the diameter of the raceway, shall be pulled through each new raceway.
2. The mandrel shall be pulled through after the raceway installation is completed. Conduits which stubout only, may have the mandrel pulled after the concrete encasement is completed, but prior to completing the backfill.
3. OWNER'S REPRESENTATIVE shall witness the raceway testing for usability. A representative of the Respective Utility Company shall witness the raceway testing where applicable.
4. CONTRACTOR shall repair/replace any conduit and conduit bend provided under this contract which will not readily pass the mandrel during this test.

END OF SECTION

SECTION 16115

PULLBOXES

PART 1 - GENERAL

1.01 SCOPE

A. Work Included: All labor, materials, appliances, tools, equipment, facilities, transportation and services necessary for and incidental to performing all operations in connection with furnishing, delivery and installation of the work of this Section, complete as shown on the drawings and/or specified herein. Work includes, but is not necessarily limited to the following:

1. Examine all other sections for work related to those other sections and required to be included as work under this section.
2. General provisions and requirements for electrical work.

1.02 SUBMITTALS

A. Submit product data sheets for all racks, hooks, supports, ladders, covers, grounding, manholes, vaults, pullboxes, joint sealing compound etc.

B. Submit detailed shop drawings including dimensioned plans, elevations, details, structural calculations signed by a California State registered Structural ENGINEER and descriptive literature for all component parts.

PART 2 - PRODUCTS

2.01 GENERAL

A. Each concrete precast section shall be identified by having the manufacturer's name and address, along with respective section weight cast into an interior face or permanently attached thereto. Associated Concrete Products, Jensen Precast Products, Brooks Products or equal.

B. Structure Construction

1. The precast steel reinforced concrete structure walls, floor and roof shall safely sustain the loads and pressure resulting from vertical and lateral earth loading and vehicular loading. Based on the following criteria:
   a. Minimum earth density shall be 120 lbs./cu.ft.
   b. Minimum equivalent fluid pressure for lateral pressure due to earth shall be 85 lbs./sq.ft. undrained earth conditions, minimum safety factor for buoyancy shall be 1.25.
   c. Vehicular load rating shall be H-20 in compliance with latest AASHO specifications.
   d. Design shall be based on maximum depth of fill over the structure as indicated on the drawings, but not less than 36 inches.
   e. Design and details shall comply with minimum ACI 318-63 code requirement. Minimum concrete 28 day cure strength shall be 3000 psi.
2. Precast structure shall be designed to withstand forces due to additional inward load of 4,000 pounds (working load) with safety factor of two (2), acting perpendicular to the surface at any pulling iron.

3. Structures shall be single piece or horizontal multi-section construction as required for field installation conditions. Multi-sections shall interlock with "Tongue and groove" joint mating surfaces to insure a rigid assembly.
4. All structure precast joints shall be sealed with preformed cold field applied plastic joint sealing compound. Joint sealing compound shall not leak, sag or flow at the joints with 10 psi water pressure applied for 24 hours. Chemically resistant to acid, alkali's and saturated hydrogensulfide.
5. Each precast structure section shall have suitable knockouts or openings in the vertical walls for the duct banks and conduits entering the structure. Provide a 1 inch diameter knockout in each corner of the floor slab, 6 inch from adjacent walls, for installation of ground rods.

C. Intercept Pullbox Structures
1. Intercept type pullbox structures shall comply with the requirements of non-intercept pullboxes, respectively. Plus the additional requirements listed below.
2. Pullboxes shown to be installed at the same location as replacement for existing pullbox shall be custom fabricated "intercept" multi-section type.
3. The structure shall be provided with multiple, vertical and horizontal custom fabricated sections for fitting around existing conduits/duct banks/conductors entrances into the structure during pullbox installation without disturbing existing pullboxes. The structures shall allow placement of the structures without disconnecting or disrupting existing circuits during the installation. The structure walls shall be slotted to fit around existing concrete encased conduit entrances.
4. Provide cast-in-place concrete steel reinforced foundation/footings and floor for the intercept structure. The foundation shall be installed prior to removal of existing pullbox. The floor shall be installed after removal of the existing pullbox structure. The foundation/footing and floor shall be designed, and engineered as part of precast structure.
5. The structure foundation/footings shall be "keyed" to match keying of pullbox precast wall sections.

2.02 PULLBOXES

A. Pullboxes shall have deep recess conduit knockout concrete extensions at two opposite end walls. Additional shallow recess knockouts shall be provided on the other two walls for conduit entrances.

B. Pullboxes shall be provided with a minimum of one precast concrete 6 inch extension grade ring "tongue and groove" matting surfaces to insure rigid assembly.

C. Pullbox sizes shall be as indicated on drawings but in no case less than required by applicable codes. Minimum depth of the pullbox shall not be less than 42 inch.

D. The pullbox floor sump shall extend through the concrete floor into the gravel bedding, below the pullbox.

2.03 COVERS AND FRAME ASSEMBLIES

A. Traffic Rated per AASHO for H20 Loading
1. Covers shall comply with Federal ADA, UL, State, and Local AHJ for slip resistance.

B. Pullboxes
1. Hot dip galvanized steel single piece flush fitting with threaded flush hold down, slotted head, stainless steel studs.

2. Topping frame shall be hot dip galvanized steel angle frame where the pullbox is installed in paving or concrete work.
3. Top ring frame shall be armor band type where the pull box is installed in exposed earth or landscaping.
4. Cover openings larger then eight (8) square feet of surface area, shall be provided with "split" two-piece cover type. Each "split" cover shall be hinged open-close with Torsion-Spring type cover, to assist in the ease of opening and closing the cover.
5. Cover openings eight (8) square feet or smaller surface area shall be single piece covers.

C. Covers shall be permanently marked in the cover metal as follows:
1. "E" or "Electric" for covers on structures containing power circuits under 600 volts and "HV" or "High voltage" for covers on structures containing power circuits over 600 volts.
2. "Signal" for covers containing signal circuits.

PART 3 - EXECUTION

3.01 EXCAVATION

A. Excavate for installation of precast structures removes excess excavated material from the site. Saw cut existing paving and concrete as required for excavation.

B. Provide a minimum of 6 inch deep bedding base of crushed rock 3/8 inch - 1/2 inch size in the bottom of the excavation. Bedding shall be level and well compacted by a minimum of four passes with a plate type mechanical vibrator.

C. Back fills and compact earth around precast structure after installation of the structure to 90% minimum compaction in 12 inch lifts. Replace paving concrete, landscaping above structure to match existing.

3.02 INSTALLATION

A. Install precast structures per manufacturer recommendations to provide a dry watertight installation. Set cover flush with existing grade or finish surface. Where precast structure is installed in pedestrian walkway or vehicular traffic way with a sloping finish grade. Slope cover to match existing finish surface slope.

B. Install structures to avoid surface water drainage flow lines, and existing utilities.

C. Exterior concrete walls tops and bases of precast structure shall be damp-proofed with two coats of a bituminous damp-proofing material, minimum finish thickness 4-mil.

D. Connections to Precast Structure
1. Lines connecting to precast structures shall be constructed to have a cast in place concrete tapered section adjacent to the structure and extending a minimum of 48 inch out from the structure to provide shear strength.
2. Precast structure shall be constructed to provide for keying the concrete envelope of the conduit/duct line into the wall of the structure. Mechanical vibrators shall be used when this portion of the envelope is poured to assure a seal between the envelope and the wall of the precast structure.

E. Entrances of conduits/ducts shall terminate with endbells inside the precast structure. Slope conduit entrances into manhole to insure top of conduit entrances into manhole are a minimum of 6 inches below manhole ceiling. Maximum conduit slope shall not exceed 1 inch per "running" foot of conduit.

F. Manholes and pullboxes shown to intercept existing conduit, remove portion of existing conduit approximately 4 ft. back from manhole wall, regrade and excavate conduit entrance and extend existing conduit into manhole or pullbox to match existing conduit quantity and size. Provide "horizontal, split" conduit and split conduit coupling to extend existing conduit into manholes and pullboxes.

3.03 GROUNDING

A. Provide 10 ft. long x 0.75 inch diameter copper clad, steel, driven ground rods through the floor of the precast structure. Provide one ground rod in pullboxes. Ground rod shall extend 6 inch above the floor line. Where rock bottom is encountered, bury ground rod in horizontal trench with projection into precast structure. Seal off openings around ground rods.

B. Ground permanently and effectively together all metal equipment cases, metallic, cable racks, ladders, etc., with #4 bare copper bonding conductor. Provide U.L. compression bonding fittings at each ground connection.

END OF SECTION

SECTION 16116

SURFACE MULTIOUTLET RACEWAY/WIREWAY

PART 1 - GENERAL

1.01 SCOPE

A. Work Included: All labor, materials, appliances, tools, equipment, facilities, transportation and services necessary for and incidental to performing all operations in connection with furnishing, delivery and installation of the work of this Section, complete as shown on the drawings and/or specified herein. Work includes, but is not necessarily limited to the following:
   1. Examine all other sections for work related to those other sections and required to be included as work under this section.
   2. General provisions and requirements for electrical work.

1.02 SUBMITTALS

A. Submit product data sheets for all wire, conduit, fittings, raceways, covers and splicing materials.

B. Submit material list for all raceway fittings, devices and outlet boxes.

PART 2 - PRODUCTS

2.01 GENERAL

A. Multioutlet raceways shall consist of a base, removable cover, wireclips, fittings, transitions, elbows, couplings, connectors, tees, blank end fittings, dividers, outlets, outlet boxes, mounting hardware, conductors and wiring devices, complete per manufacturer's recommendations.

B. Raceway system shall comply with U.L.-5 and National Electrical Code.

C. As manufactured by Wiremold-Plugmold Series, or Walker-Walkermold series.

D. Raceway system shall be standard 5 ft. or 10-ft. lengths, custom length field cut and installation locations as shown on the drawings. The raceway system and covers shall be fabricated as follows:
   1. Steel housing raceway, rust inhibitors primed, and finish painted, nominal 0.04 inch Stainless steel housing raceway, brushed, stainless steel, nominal 0.04 inch thickness, type 304.

2.02 RACEWAYS

A. General
   1. Unless noted otherwise on the drawings, raceways shall be surface mounted.
   2. Raceways shall be suitable for installation of power and/or signal conductors, mechanically and electrically continuous the entire length of the installed raceway. (Note: Non-metallic raceway shall contain continuous internal ground/bonding conductor).
   3. Snap on raceway cover, self-grounding, the entire length of the raceway, with cutouts for outlets and devices shown on the drawings.

4. Provide device bracket support frames and sub-coverplates for each outlet shown in the drawings. Coverplates for signal/telephone outlets shall be sized for "RJ" style outlet jacks unless noted otherwise. Finish outlet coverplates shall be stainless steel unless indicated otherwise.

B. Internal Dividers
1. Provide internal continuous divider barrier(s) the length of the raceway, grounded to the raceway to create multiple continuous internal isolated raceways under the following conditions:
   a. Power and signal/control circuits in the same raceway.
   b. Emergency and normal power circuits in the same raceway.
   c. Where indicated on the drawings.

C. Raceway Size
1. Minimum raceway internal sizes shall be as indicated below but in no case less than shown on the drawings. (Cross section area does not include wiring devices).
   a. "2100" size raceway; minimum cross section area - 0.81 square inches, nominal 0.875 inch deep x 1.25 inch wide.
   b. "3000" size raceway; minimum cross section area - 3.51 square inches, nominal 1.53 inch deep x 2.75 inch wide.
   c. "4000" size raceway; minimum cross section area - 7.5 square inches, nominal 1.75 inch deep x 4.75 inch wide [with horizontal internal divider for two segregated internal raceways].
   d. "6000" size raceway; minimum cross section area - 15.82 square inches, nominal 3.56 inch deep x 4.75 inch wide. [With horizontal internal divider for two segregated internal raceways]
   e. "Triple size" raceway; Two internal dividers to form three equally sized isolated raceways under a common cover. Minimum 2.8 square inches nominal cross section area for each divided raceway. Nominals 1.625 inch deep x 6.375 inch wide.
2. Provide cutouts in the back of the raceway base, sized to match the outlet box behind the raceway. Where a raceway divider is installed, cutout shall not extend past divider. Provide continuous grommet shields around perimeter edges of the cutout. Provide a stainless steel coverplate over the outlet box where the outlet box opening extends beyond the edge of the raceway.

2.03 OUTLET BOXES (ADDITIONAL REQUIREMENTS)

A. Provide a minimum of one (1) outlet box flush in the wall centered behind the multioutlet raceway where the homerun is shown on the drawings; additionally, provide a minimum of one (1) outlet box spaced 30 feet on center along the length of each raceway segment or any portion thereof.

B. Outlet box sizes shall be as indicated on the drawings but in no case less than the following. Provide conduit knockouts in outlet boxes to accommodate conduits shown on the drawings and specified herein:
1. "2100" size raceway, 4.68 inch x 4.68 inch x 2.125 inch deep outlet box with single gang extension/plaster ring coverplate.
2. "3000" size raceway and "triple size" raceway, 4.68 inch-H x 8.625W inch x 2.5 inch deep outlet box with 3-gang extension/plaster ring coverplate.
3. "4000" size raceway, 4.68 inch H x 10.43 inch W x 2.5 inch deep outlet box with 4-gang extension/plaster ring coverplate.
4. "6000" size raceway, 4.68 inch H x 14.125 inch W x 2.5 inch deep outlet box with 6-gang extension/plaster ring coverplate.

5. "Triple-Size" raceway - 4.69 inch x 14.125 inch x 2.5 inch deep outlet box with 6-gang ring extension/plaster.

C. Provide conduit knockouts in outlet boxes to accommodate conduits shown on the drawings and specified herein.

D. Provide dividers in outlet boxes for each raceway with internal dividers. The outlet box divider quantity shall match the quantity of dividers in the corresponding raceway, to maintain separation of circuits in outlet boxes and raceways.

2.04 CONDUCTORS (ADDITIONAL REQUIREMENTS)

A. The minimum electrical power conductor size installed in the multioutlet raceway from the respective outlet box shall be #10 AWG (THHN/THWN insulation).

B. The drawings do not indicate the size or quantity of the electrical power branch circuit conductors inside the multioutlet raceways. Provide the quantity and size of conductors required for the outlets and branch circuits shown on the drawings.

C. Provide a separate dedicated neutral conductor for each individual branch circuit in the multioutlet raceway. Do not use a common neutral conductor for multi-conductor electrical power branch circuits in the raceway.

D. Provide internal conductor retention clips 36" on center, within 6" of each side of wiring devices in the raceway and at each change of direction in the raceway routing.

2.05 LINE VOLTAGE RECEPTACLE OUTLETS

A. Outlet Configuration
1. Electrical Power Receptacle Outlets for "2100" Raceway, factory prewired.
2. Electrical Power Receptacle outlets for "3000", "4000", "6000", "triple size" and "5500" raceways, shall be 120 volt 60HZ AC duplex convenience receptacles or other receptacles as indicated on the drawings, factory prewired or wired in the field.

B. Outlet Types and Spacing
1. Individual "plug" receptacles rated 20 amps, 125 volts, 3-wire grounding, 60 Hz A.C. NEMA 5-20R, semi-flush mounted in raceway, color as selected by Architect for non isolated ground/non-emergency, orange color for isolated ground type. Main body of receptacle nominal size 0.688 inch deep x 2.969 inch long.
2. Receptacles shall be spaced 18" [24", 30", 36", 48"] on center along the length of the raceway; and at specific locations shown on the drawing.
3. A maximum of two [three, four, five, six] receptacles shall be connected on each 20-ampere branch circuit.
4. Receptacles shall be alternately connected (i.e. Phase A, B, C; Phase A, B, C etc., unless indicated otherwise on the drawings.

PART 3- EXECUTION

3.01 INSTALLATION

A. Multioutlet raceways shall be installed parallel and perpendicular to adjacent building surfaces. Unless noted otherwise on the drawings, the mounting height of the raceway shall be as follows:
1. 18 inch above finish floors to the bottom of the raceway where fixed counter tops do not occur.
2. +6 inch above the splash of fixed counter tops to the bottom of the raceway.

B. Attach and anchor multioutlet raceway base to building structure not less than 16 inches on center. Raceway attachment anchor shall be made directly to building wall stud, stud backing, masonry surface, or structural member. Do not anchor raceways to drywall, plaster or tile surfaces as the only support for the raceway.

C. Provide wiring outlet devices in multi-outlet raceway as shown on the drawing. The raceway outlet locations shown are approximate. Verify exact installation locations with the OWNER's representative prior to installation. Outlet wiring devices shall be installed flush in the raceway unless specifically noted otherwise.

D. Where multioutlet raceways extend through building partitions, the raceway cover shall be removable to within 3 inches of the partition.

3.02 GROUNDING (ADDITIONAL REQUIREMENTS)

A. Provide a #10 AWG (minimum) ground/bond conductor in all raceways (one in each divided raceway, where a raceway divider is installed). Connect the ground conductor to each section of the raceway base. Connect the ground conductor to the metal feeder raceways(s) supplying the multi-outlet raceway and to the ground/bond conductor in the feeder raceways(s).

B. Provide a #12 AWG minimum ground jumper from the wiring device grounding connection to the raceway base. Provide a ground lug connection at the raceway base for each device.

C. Isolated ground wiring devices provide a dedicated, individual, insulated ground conductor from the wiring device to the branch circuit source isolated ground bus. Wiring device ground shall be isolated from the multi-outlet raceway ground.

3.03 IDENTIFICATION (ADDITIONAL REQUIREMENTS)

A. The face of the wiring device coverplate shall be engraved with the circuit number and supply source name, (i.e., P-1,3 or MSB-5; "TV"; "data/computer", "telephone"; etc.).

3.04 MULTIOUTLET RACEWAY FEEDER SUPPLY RACEWAYS (ADDITIONAL REQUIREMENTS)

A. In addition to the feeder raceways shown on the drawings, provide spare empty conduit only stubouts from each multioutlet raceway outlet box from each divided section of each outlet box as follows:
   1. (3)-0.75 inch C.O. into accessible ceiling space.
   2. (3)-0.75 inch C.O. into accessible ceiling space of the floor below (omit for slab/floor on grade).

B. Supply feed homeruns for multioutlet raceways shall terminate in the outlet box located behind the respective raceway, containing the wiring device(s) connecting to the supply feed.

END OF SECTION