SECTION 16050

BASIC MATERIALS AND METHODS

PART 1 - GENERAL

1.1 DESCRIPTION

A. The Drawings are basically diagrammatic, unless detailed dimensioned Drawings are included, and show only approximate locations of equipment, fixtures, panelboards, wiring devices, etc. Exact locations shall be subject to the approval of the Engineer.

B. While the general run of electrical feeders, branch circuits, conduits, etc. is indicated on the Drawings, it is not intended that exact routing be determined therefrom. Circuit designations on Single Line Diagrams, Electrical Schematics, Instrumentation Schematics, Panelboard Schedules and in the form of "Home Runs" on branches indicate the designation of the branch circuit, the size and quantity of branch circuit conductors, the branch circuit overcurrent device rating and the panelboard or interconnection box from which the branch circuit is served. These designations may be modified subject to field conditions and review of the Engineer. The Contractor shall be responsible for reviewing all drawings to determine the wiring and conduit requirements for a fully functioning system.

C. Where the type, size, rating or mounting of equipment, raceways, conductors, wiring devices, etc. indicated in the Contract Documents is not clearly defined, request clarification, in writing, no less than ten (10) days prior to the Bid date. If clarification is not requested within this time frame, provide Electrical work as directed by the Engineer. Electrical Contractor shall verify with the General Contractor and other subcontractors that equipment sizes remain per design prior to submitting bid. Contractor shall verify that all work required for a complete system is included in their bid.

D. Measurements shall be made at the site and in the building during construction and all systems installed as the work progresses in such a manner that the equipment, piping, vents, ducts, conduit, etc., will fit in the space provided, maintain head room and if in unfinished areas, be as neatly installed, as obscure and "out-of-the- way" as physically possible.

E. Prior to submission for review any item of equipment, determine whether or not it will fit in the space provided. Any changes in the size or location of the material or equipment supplied, which may be necessary in order to meet field conditions or in order to avoid conflicts between trades, shall be brought to the immediate attention of the Engineer and no exceptions taken before such alterations are made.

F. All equipment and accessories and its interconnecting piping, ductwork, conduit, etc., shall be installed in such a manner that ample maintenance and passage space and Code-required space/access will be provided.

G. Where more than one trade is involved in an area, space or chase, all shall cooperate and install their own work to utilize the space equally between them in proportion to their individual requirements. In general ductwork shall be given preference (except where grading of piping becomes a problem) followed by piping then electrical wiring. If, after installation of any equipment, piping, ducts, conduit, etc., it is determined that ample maintenance and passage space has not been provided, rearrange work and/or furnish other equipment as required to provide this space. The Contractor shall review drawings for other trades to determine any potential interferences and identify those with other trades.

1.2 QUALITY ASSURANCE

A. In General, the workmanship of the electrical installation shall be as described in the N.E.C.A. Electrical Design Guidelines. All methods of construction, details of workmanship, etc. that are not specifically described therein or indicated in the Contract Documents, shall be subject to the control and approval of the Engineer.
B. Equipment and materials shall be of the quality and manufacture indicated in their respective sections of the Specifications.
C. Work determined by the Engineer to be unsatisfactory according to industry standards shall be redone at the Contractor's expense, with no additional compensation.

1.3 SUBMITTALS TO THE ENGINEER

A. Submit shop drawings for the following equipment, materials, products, etc.:
   1. Conduit, Raceway and Tubing.
   2. Conductors and Cable
   3. Outlet Boxes
   4. Pull and Junction Boxes
   5. Wiring Devices
   6. Motor Starters
   7. Safety Disconnect Switches
   8. Fuses
   9. Metal Framing Channel
B. Submit Shop Drawings per SECTION 16010.
C. Submit test results on all feeder conductors.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Conduit, Raceway and Tubing
   1. Rigid Heavy Wall Steel Conduit (RSC or RGS) shall be constructed of hot dipped galvanized or electro-galvanized steel. Acceptable Manufacturers: Allied, Wheatland, or equivalent.
   2. Intermediate Metal Conduit (IMC) shall be hot-dipped galvanized or electro-galvanized steel. Acceptable Manufacturers: Allied, Wheatland, or equivalent.

3. Flexible Metal Conduit shall be constructed of one continuous length of U. L. Approved electro-galvanized, spirally wound steel strip with interlocking convolutions and interior surfaces free from burrs and sharp edges. Flexible metal conduit installed in damp and wet locations shall be "liquid-tight" with PVC jacket. Acceptable Manufacturers: Alflex, Electri-Flex, or equivalent.
4. Non-Metallic (P.V.C.) Conduit shall be Schedule 40, heavy wall and U. L. listed for use above ground and direct burial underground. PVC conduit to be direct buried (not encased in concrete) shall be Schedule 80, extra heavy wall and UL Listed for the use intended. Acceptable Manufacturers: Carlon, Rob-Roy, or equivalent.
5. P.V.C. Coated Metallic Conduit.
    a. The galvanized metallic conduit, prior to plastic coating, shall conform to Federal Specifications WW-C-581d, ANSI Standard C80.1, UL Standard #6 and NEMA RN1-1980.
    b. The conduit shall be hot dip galvanized inside and out with galvanized threads.
    c. All conduit, conduit bodies, connectors, support systems and accessories in the corrosive areas, above grade or below grade, shall be coated as specified.
    d. Before coating, the galvanized surface shall be coated with an epoxy-acrylic primer to provide a bond greater than the tensile strength of the coating.
    e. The thickness of the coating is to be a nominal 40 mils except where the configuration or application of the unit dictates otherwise.
    f. The plastic coating shall be factory-applied by the same manufacturer who produces hot dip galvanized conduit. The coated conduit shall conform to NEMA Standard No. RNI-1980 (Type 40).
    g. Every female opening shall have a plastic sleeve extending one pipe diameter or 2", whichever is less, beyond the opening. The inside diameter of the sleeve shall be the same as the outside diameter of the pipe used with it. The wall thickness of the sleeve shall be the same as the plastic coating.
    h. Fittings and Accessories:
        1) All fittings, inside and out and accessories for use with pcv coated conduit shall be coated using the same specifications as that of the conduit.
        2.) Right angle beam clamps and U-bolts will be provided with PVC encapsulated nuts that cover all exposed parts of the threads.
        3) U-bolts will be sized to snugly fit the nominal 40 mil coated conduit.
        4) The screw heads on Form 8 condulets shall be encapsulated with a corrosion-resistant material by the manufacturer. The screw heads (on Form 8 condulets) will be hexagonal with a screwdriver slot.
        5) All PVC coated conduit and fittings shall be installed using tools available from the manufacturer for the use intended.

j. Installation of the system is to be performed in accordance with the manufacturer's instructions.
k. A phenolic coating shall be fusion-bonded to the inside of the conduit, with a thickness of 2 mils minimum..
l. The interior coating shall be applied in such a manner so as to allow field bending without cracking or flaking of the interior coating.
m. Approved material: PLASTI-BOND RED as indicated on the Drawings and as manufactured by ROBROY INDUSTRIES, Verona, Pennsylvania, or approved equal.

6. All fittings shall be of the same material as the respective raceway system.
7. Expansion fittings shall be watertight combination expansion and deflection type designed to compensate for movement in any direction. Fittings shall have flexible copper braid bonding jumpers, neoprene sleeve and stainless steel bands. Acceptable Manufacturer: O.Z./Gedney Type DX or approved equivalent.
8. Conduit wall and floor seals for cored holes and sleeved openings shall be Type CSM series as manufactured by O.Z./Gedney Co., or equivalent.
9. Conduit sealing bushings to seal the ends of conduits entering enclosures from below grade shall be O.Z./Gedney Co. Type CSB series, or equivalent.
10. Provide fittings for freeze expansion as required.

B. Conductors and Cable

1. All power wiring conductors shall be insulated for 600 volts, unless otherwise noted, and shall be standard AWG and KCMIL sizes. Conductors shall be 98 percent copper, stranded, heat and moisture resistant and cross-linked polyethylene insulated for all sizes No. 12 AWG and larger. Smaller sizes shall not be used except for communications and special systems. For lighting and receptacle circuits, solid wire may be used in lieu of stranded wire, for No. 12 and No. 10 AWG only. Conductors shall be labeled with U.L. approval and be marked with the manufacturer's name, wire size and insulation type. Insulation for all 600 volt conductors shall be Type XHHW. Acceptable Manufacturers: Okonite, Southwire, Pirelli, or equivalent.
2. Variable frequency drive (VFD) motor supply cables shall be provided where indicated on Drawings. VFD cables shall be four (4) conductor tinned stranded copper, with cross-linked polyethylene insulation, overall foil (100% coverage) / tinned copper braid (85% coverage) shields, No. 12 AWG tinned copper drain wire, and outer PVC jacket. Cables shall conform to UL specification for 1000 Volt flexible motor supply cable. Acceptable Manufacturers: Belden, Olflex, or equivalent.
3. All control wiring (120 or 24 volt, AC or DC) conductors shall be insulated for 600 volts, unless otherwise noted, and shall be No. 14 AWG minimum size, or larger if so indicated on the Drawings. Conductors shall be 98 percent copper, stranded, heat and moisture resistant, and thermal plastic insulated, Type THHN/THWN. Acceptable Manufacturers: Okonite, Southwire, Pirelli, or equivalent.

4. All instrumentation control cables (4-20 mA signal) referred to on the Drawings as "twisted shielded pairs", shall be 600V, 80 deg. C, individually shielded twisted pairs, No. 16 AWG, stranded conductors of tinned copper with polyethylene insulation and aluminum-polyester shielding with #18 awg stranded copper drain wire surrounded by a chrome PVC jacket. Control cable shall be rated 600 volt and shall be UL listed with 100% shield coverage. Belden type 8719 or equivalent unless specified otherwise by the instrument manufacturer.
5. Three conductor shielded cable for use with remote potentiometers for varying motor speeds etc. Cable shall be stranded, tinned copper, polyethylene insulated, drain wires with aluminum-polyester shielding with #18 awg stranded copper drain wire surrounded by a chrome PVC jacket. Control cable shall be rated 600 volt and shall be UL listed with 100% shield coverage. Belden type 8618 or equivalent unless specified otherwise by the instrument manufacturer.
6. Data Wiring:
    a. Cables for data wiring shall be Category 5, 4-pair, 24 AWG solid bare copper conductor, unshielded, FEP insulation, plenum rated, Belden Cat. No. 1701A, or equivalent.

C. Outlet Boxes
1. Standard outlet boxes and covers shall be galvanized steel not less than 1-1/2 inches deep, 4 inches square or octagonal, with knockouts. Acceptable Manufacturers: Steel City, Appleton, Raco or equivalent.
2. Outlet boxes exposed to moisture shall be cadmium cast alloy complete with hubs and gasketed screw fastened covers. Acceptable Manufacturers: Steel City, Appleton, Crouse-Hinds, Raco or equivalent.
3. In no case shall boxes be sized smaller than as indicated in Article 370 of the National Electrical Code for the conductor sizes installed.

D. Pull and Junction Boxes
1. Boxes shall be constructed as specified in Section 16160 with trim for flush or surface mounting in accordance with the location to be installed. Provide screw-on type covers. Boxes installed in damp locations shall be of watertight construction with gasketed cover and conduit hubs.
2. In no case shall boxes be sized smaller than as indicated in Article 370 of the National Electrical Code for Conduit and Conductor sizes installed.

E. Wiring Devices
1. Wiring devices shall be specification grade as described herein. Switch handles, receptacles, etc. shall have a brown finish. Provide device cover plates of satin finish stainless steel in finished areas and cadmium finished sheet steel in unfinished areas. Although only one manufacturer has been noted, acceptable manufacturers are: Hubbell, General Electric, Cooper, Pass and Seymour, Bryant, as noted, or approved equal. Provide devices as indicated by Contract Documents.
2. Toggle Switches
    a. 20 Ampere, 1-pole, 277 Volt: Hubbell 1221

b. 20 Ampere, 3-way, 277 Volt: Hubbell 1223
c. Emergency Boiler Shutoff Switch: Hubbell 1221-RDB w/red device plate and engraved lettering reading "Emergency Boiler Shutoff".

3. Fractional Horsepower Manual Motor Starter with Thermal Overload(s), red running indicating light:
   a. 120 Volt Single-Pole, Surface Mounted: Square-D FG-1P
   b. 120 Volt Single-Pole, Flush Mounted: Square-D FS-1P
4. Receptacles
   a. 20 Ampere, 125 Volt, Single Receptacle: Hubbell 5361
   b. 20 Ampere, 125 Volt, Duplex Receptacle: Hubbell 5362
   c. 20 Ampere, 125 Volt, Duplex G.F.I. Receptacle: Hubbell GF-5362
   d. 20 Ampere, 125 Volt, Duplex, Weatherproof: Crouse Hinds WLGF-FS with GFI receptacle

F. Motor Starters
1. For Single Phase Motors: Shall be fractional horsepower, manual type as indicated in paragraph 2.1 E of this Section.
2. For Three Phase Motors: Shall be combination starter/disconnect type, employing magnetic starter (NEMA Size 1 minimum), rated to match the equipment served, with thermal overload protection for each phase and with an M.C.P. type circuit breaker/disconnect sized per the circuit breaker manufacturer's recommendations for coordination with the thermal overload protection. Combination starters shall be provided with a (480,240 or 208)-120 volt control power transformer with primary and secondary fusing. Provide 2 N.O. and 2 N.C. auxiliary contacts.
3. Acceptable Manufacturers:
   Square-D, Cutler-Hammer, General Electric, Allen-Bradley, Siemens, or approved equal.

G. Safety Switches
1. Furnish and install heavy duty safety switches as indicated on the plans and specifications. All safety switches shall be NEMA Type HD and Underwriters Laboratories listed.
2. All switches shall have switch blades which are fully visible in the "OFF" position when the switch door is open. All current carrying parts shall be plated to resist corrosion and promote cool operation. Switches shall have removable arc suppressers where necessary to permit easy access to line side lugs. Lugs shall be front removable and UL listed for 60°C or 75°C, aluminum or copper wires.
3. Switches shall be quick-make, quick-break such that, during normal operation of the switch, the operation of the contacts shall not be capable of being restrained by the operating handle after the closing or opening action of the contacts has started. The operating handle shall be an integral part of the box, not the cover. Provisions for padlocking the switch in the "OFF" position with at least three locks shall be provided Switches shall have a dual cover interlock to prevent unauthorized opening of the switch door when the handle is in the

"ON" position, and to prevent closing of the switch mechanism with the door open. The handle position shall indicate whether the switch is "ON" or "OFF".

4. Switches shall be horsepower rated for ac and/or dc as indicated by the plans. All fusible switches rated 100 thru 600 amperes at 240 volts and 30 thru 600 amperes at 600 volts shall have a UL approved method of field conversion from standard Class H fuse spacing to Class J fuse spacing. The switch also must accept Class R fuses and have provisions for field installation of a UL listed rejection feature to reject all fuses except Class R. The UL listed short circuit rating of the switches shall be 200,000 rms symmetrical amperes when Class R or Class J fuses are used with the appropriate rejection scheme. The UL listed short circuit rating of the switch, when equipped with Class H fuses, shall be 10,000 rms symmetrical amperes. 800 and 1200 ampere switches shall have provisions for Class L fuses and shall have a UL listed short circuit rating of 200,000 rms symmetrical amperes. The cost of any conversion kit and labor associated with conversion to accommodate the required fuses shall be included in the base bid. In general, U.L. Class H fuses are not to be used. Refer to the paragraph on fuses, this section on further requirements for fuses.
5. Enclosures
   a. Safety switch enclosures for non-hazardous locations shall be as specified in Section 16160. Enclosure NEMA ratings shall be as indicated on the Drawings.
   b. Switches specified as NEMA 7 & 9 shall be furnished in cast aluminum enclosures with conduit provisions as specified. Enclosures shall be provided with a bolted cover and with sealing means for hazardous location protection. "ON" and "OFF" position identification shall be cast into the cover, not painted on or applied with an adhesive.
6. Acceptable Manufacturers:
   Square-D, Cutler-Hammer, General Electric, Siemens, or approved equal.

H. Power Distribution Fuses
1. All fuses rated 600 volts and below shall be rejection type dual-element, time-delay type. Acceptable Manufacturers are Bussman, Littlefuse and Shawmut.
2. Fuses shall be U.L. Class and rating as shown on the drawings or as required by the manufacturer of the equipment they are protecting. In general, shall be:
   a. U.L. Class RK1 for service entrances and feeders supplying combination motor loads.
   b. U.L. Class RK5 for motor branch circuits.
3. Provide two (2) complete sets of fuses for all fusible disconnect switches.

I. Metal Framing Channel
1. Channel for dry locations shall be roll formed from 12 gauge steel standard ASTM A570, Grade 33.
2. Channel for wet or exterior locations shall be roll formed from 12 gauge steel and shall be hot-dip galvanized after fabrication, material standard ASTM A570, Grade 33, and finish standard ASTM A123.
3. Channel for corrosive locations shall be roll formed from stainless steel AISI Type 316.

4. Use fittings of same material as channel. Fittings shall be by same manufacturer.
5. Metal framing shall be B-Line Systems, Inc. of Highland, Illinois or equivalent.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Unless otherwise noted, wiring for all systems indicated in the Contract Documents shall consist of insulated conductors installed in raceways. Raceways shall be continuous from outlet box to outlet box and from outlet box to cabinet, junction or pull box. Secure and bond raceways to all boxes and cabinets such that each system of raceways will be electrically continuous throughout.

B. Unless otherwise indicated on the Drawings, install all wiring in the following applicable raceway system:

1. Wiring 600 volts or less in dry exposed indoor locations (NEMA 1 or 12): Galvanized intermediate metal conduit, galvanized rigid heavy wall steel conduit.
2. Wiring 600 volts or less in outdoor, above grade locations (NEMA 3R): Galvanized rigid heavy wall steel conduit or intermediate metal conduit.
3. Wiring 600 volts or less in indoor wet locations (NEMA 4): Galvanized rigid heavy wall steel conduit.
4. Wiring 600 volts or less in indoor or outdoor corrosive locations (NEMA 4X): PVC-coated rigid steel conduit, or PVC Schedule 40 or 80 conduit where not subject to physical damage (8 feet or more above finished floor).
5. Underground Raceways:
   a. Underground raceways shall be galvanized rigid heavy wall steel conduit or Schedule 80 extra heavy wall PVC conduit installed as directed below.
   b. Encase all underground raceways described hereafter in concrete envelope:
      1) Raceways beneath areas of vehicular traffic. Encasement shall be to 10'-0" from edge of traffic.
   c. All other underground raceways (branch circuits, instrumentation, control, etc.) shall be bedded in compacted sand except when in the same trench as those raceways required to be encased in concrete or as noted on the Drawings. Sand shall be 6-inch minimum thickness at top, bottom and sides of raceways, 7½ inch minimum center-to-center spacing between raceways. Top raceway shall be not less than 30 inches below finished grade.
   d. For all underground raceways, bottom of trench shall be solid undisturbed earth. Earth showing extensive signs of peat, cinders, rubble or any conditions not suitable for a stable foundation should be reported to the Engineer for recommendation. Small packets (up to 1 cu. yd.) of unsuitable soil shall be excavated and replaced with compacted gravel borrow maximum rock size 2 inches. In areas which have had fill work completed

during the progress of work under this contract, verify that the bottom of trench is 95 percent compaction minimum. If compaction is less than 95 percent provide additional compaction in bottom of trench.

e. Provide underground electrical marking tape for the full length of all trenches for underground raceways. Marking tape shall be SETON #210 Electrical or equivalent.

6. Concrete Encasement of Raceways:
   a. Form concrete envelope around raceways, 3 inch minimum thickness concrete at top, bottom and sides of duct bank 7-l/2 inch minimum center-to-center spacing between raceways. Concrete shall be full width of trench. Top raceway shall be not less than 30 inches below finished grade, except where under building slabs. Open trench for its complete length before concrete is poured; if any obstructions are encountered, make provisions to avoid them. Support raceways minimum 3 inches above bottom of trench before pouring concrete.
   b. Furnish and install precast concrete, plastic or fiber spacers in order to achieve consistent spacing between raceways. Stagger couplings. Securely tie raceways in place to prevent floating. Pour concrete as soon as possible after placing and securing of raceways.
   c. Pull iron-shod mandrel, not more than l/4 inch smaller than bore of raceway, through each raceway to remove concrete and other obstructions. Clean raceway by drawing through properly sized cylindrical brushes as many times as necessary to remove dirt.
   d. Whenever non-metallic raceways are used, concrete envelope shall be 6 inch minimum thickness concrete at top, bottom, and sides, of duct bank and shall contain reinforcing rods. Reinforcing shall be continuous runs of No. 4 deformed rods located in all four corners as well as top and bottom of envelope between each raceway.
   e. In locations where non-metallic raceways are used, change to heavy wall metallic conduit of same internal diameter before rising out of ground; furnish and install metallic conduit elbows. Carry concrete envelope to a point l2 inches minimum above grade or floor slab at rise point. Slope top of concrete away from raceway, chamfer edges.
   f. Where raceways rise above grade and terminate in building, provide conduit sealing bushing on each raceway as specified in Paragraph 2.1.A.
7. Flexible metal conduit shall be used for final connection to all motors, final connection to rotating or vibrating equipment, and final connections to dry type transformers. Liquid-tight flexible conduit shall be used in all wet or damp locations. Maximum length of flexible conduit shall be 36 inches.
8. Instrumentation cables (analog 4-20 mA DC) shall be installed in steel conduit, either rigid galvanized steel conduit, IMC, or PVC-coated rigid steel conduit, in accordance with the NEMA rating of the area of installation.

C. Raceways Shall Be:
1. Sized as indicated on the Drawings. Where sizes are not indicated, raceways shall be sized per the National Electrical Code in accordance with the quantity,

size, type and insulation of conductors to be installed; however, raceways shall be minimum one-half inch (1/2") trade size for branch circuit wiring and minimum three-quarter (3/4") trade size for all instrumentation systems and for all branch circuit "Home Runs" to panelboards.

2. Installed to provide adequate grounding between all outlets and the established electrical system ground. Bond conduit systems per NEC.
3. Cut square, free of burrs due to field cutting or manufacture, and bushed where necessary.
4. Installed with exterior surfaces not less than six inches (6") from any surface with a temperature of 200 degrees F or higher.
5. Plugged at the ends of each roughed-in raceway with an approved cap or disc to prevent the entrance of foreign materials during construction.
6. Installed parallel or perpendicular to floors, walls and ceilings.
7. Installed with a minimum of bends and offsets. All bends shall be made without kinking or destroying the cross section contour of the raceway. Factory made bends shall be used for raceways one-inch (1") trade size and larger.
8. Installed with U. L. approved raintight and concrete-tight couplings and connectors.
9. Firmly fastened within three feet of each outlet box, junction box, cabinet or fitting. Raceways shall not be attached to or supported by wooden plug anchors or supported from Mechanical Work such as ductwork, piping, etc.
10. Installed with a #14 AWG fish wire in all "Spare" or "Empty" conduit runs to facilitate future installation of conductors.
11. Installed with expansion fittings at all building expansion joints such that no undue stress is placed on any electrical raceway due to the proper functioning of expansion joints.
12. Arranged in a neat manner for access and allow for access to work installed by other trades.
13. If it is necessary to burn holes through webs of beams or girders, call such points to the attention of the Engineer and receive written approval both as to location and size of hole before proceeding with work. All holes shall be burned no larger than absolutely necessary.
14. Wherever a cluster of four or more raceways rise out of floor exposed, provide neatly formed 6" high concrete envelope with chamfered edges around raceways.
15. Support adequately by malleable iron pipe clamps or other approved methods. In exterior or wet locations supports shall allow not less than 1/4 inch air space between raceway and wall. Firmly fasten raceway within 3 feet of each outlet box, junction box, cabinet or fitting. The following table lists maximum spacing between supports. Additional supports may be required due to field conditions, strength of supporting members, etc. Furnish and install such supports at no additional cost to Owner.

Conduit Trade	Type of	Horizontal Spacing in	Vertical Spacing in

Size	Run	Feet	Feet
1/2", 3/4"	Concealed	7	10
1", 1-1/4"	Concealed	8	10
1-1/2" & lgr.	Concealed	10	10
1/2", 3/4"	Exposed	5	7
1", 1-1/4"	Exposed	7	8
1-1/2" & lgr.	Exposed	10	10

16. Where raceways puncture roof, install pitch pockets as required in order that the roof warranty is maintained.
17. Where raceways penetrate fire-rated walls, floors, or ceilings, install firestops equal to the rating of the wall, floor, or ceiling, per specification section 07270, "Firestopping".
18. Provide a bushing at each conduit termination unless fitting at box where conduit terminates has hubs designed in such a manner to afford equivalent protection to conductors. Provide grounding type insulated bushings on all conduit sizes one and one-quarter inch (l-l/4") trade size and larger, and on all feeder raceways regardless of size. Provide standard bushings for conduits one inch (l") and smaller unless otherwise stated. Provide sealing bushings for all conduits entering from below grade.

D. Become familiar with the general construction of the building and place sleeves, inserts, etc., as required. All penetrations through existing concrete floors and walls shall be core drilled and sleeved. In areas where dampness or gases are present, seal around conduits using fittings as specified in Paragraph 2.1.A.

E. Wiring Methods
1. Do not pull conductors into raceways until raceway system, including all outlets, cabinets, bushings and fittings, is completed. Verify that all work of other trades which may cause conductor damage is completed. Use only U.L. approved cable lubricants when necessary. Do not use mechanical means to pull conductors No. 8 or smaller.
2. In general, conductors shall be the same size from the last protective device to the load.
3. All wiring systems shall be properly grounded and continuously polarized throughout, following the color coding specified. Connect branch circuit wiring at panelboards, as required, in order to provide a "balanced" three-phase load on feeders.
4. All feeder connections shall be made to bus and other equipment using solderless, pressure type terminal lugs, as manufactured by Burndy, National, O.Z., T. & B., or equivalent.
5. For splices and taps, No. l0 AWG and smaller, use solderless "Thread-On" connectors having spiral steel spring and insulated with a vinyl cap and skirt, as manufactured by 3M Co. (pre- insulated "Scotch-Lock"), Ideal ("Wing-Nuts"), or approved equal.

6. For splices and taps, No. 8 and larger, use solderless "Split Bolt" type connector as manufactured by Anderson, Burndy, Kearney, Thomas & Betts, or equivalent.
7. Make all splices and connections in accessible boxes and cabinets only.
8. Cover uninsulated splices, joints and free ends of conductor with rubber and friction tape or PVC electrical tape. Plastic insulating caps may serve as insulation.
9. On termination at branch circuit outlets, leave a minimum of eight inches (8") free conductor for installation of devices and fixtures.
10. Feeder conductors shall be continuous from point of origin to load termination without splice. If this is not practical, contact the Engineer and receive written approval for splicing prior to installation of feeder(s). Where feeder conductors pass through junction and pull boxes, bind and lace conductors of each feeder together. For parallel sets of conductors, match lengths of conductors as near equal as possible.
11. Branch circuit conductors installed in panelboards, and control conductors installed in control cabinets and panels shall be neatly bound together using "Ty-Raps" or equivalent.
12. Lighting fixtures, etc. shall be installed with exposed conduit after equipment, ductwork, piping, etc., are in place. In general, lighting shall be as located on the Drawings, however, where conflicts exist, locate lights for best distribution.
13. Contractor may group certain wiring with the approval of the Engineer, as follows. Power 120V may be grouped with power 120V. Control 120V may be grouped with control 120V. Instrumentation may be grouped with instrumentation. Specialty wiring may be grouped with like systems. Power wiring at 480V shall not be grouped, except in cable trays. The installation shall be installed in accordance with all requirements of the NEC (including wire ampacity derating factors), manufacturer's requirements, and the Engineer. Excessive grouping which interferes with functionality and reliability will not be allowed. The wiring configuration as shown on the drawings is the baseline requirement for the work.

F. Outlet Boxes
1. Consider location of outlets shown on Drawings as approximate only. Study Architectural, Mechanical, Plumbing, Process, and Structural Drawings and note surrounding areas in which each outlet is to be located. Locate outlet so that when fixtures, motors, cabinets, equipment, etc., are placed in position, outlet will serve its desired purpose. Where conflicts are noted between Drawings, contact Engineer for decision prior to installation. Comply with Article 370 of National Electrical Code relative to position of outlet boxes in finished ceilings and walls.
2. Prior to installation, relocate any outlet location a distance of five feet in any direction from location indicated on Drawings if so directed by the Engineer. Prior to completion of wall construction, adjust vertical height of any outlet

from height indicated if so directed by Engineer. The above modifications shall be made at no additional cost to the Owner.

3. Where outlets at different mounting heights are indicated on Drawings adjacent to each other (due to lack of physical space to show symbol on Drawings), install outlets on a common vertical line.
4. Where switch outlets are shown adjacent to strike side of door, locate edge of outlet box approximately 3 inches from door frame.
5. Outlet boxes in separate rooms shall not be installed "back-to- back" without the approval of the Engineer.
6. Outlet boxes shall be sized to accommodate the wiring device(s) to be installed.
7. Outlet boxes installed in tile, brick or concrete block walls shall be installed with extra-deep type raised tile covers or shall be 3-l/2 inches deep boxes with square corners and dimensions to accommodate conductors installed.
8. Surface ceiling mounted outlet boxes shall be minimum 4 inches square, l-l/2 inches deep, galvanized sheet metal.
9. Surface wall mounted outlet boxes shall be cast type boxes having threaded or compression type threadless hubs. Exterior boxes shall be cast type with threaded hubs and gasketed cover plates secured by non-ferrous screws.
10. Install a device cover plate over each and every outlet indicated on Drawings. Do not install plates until painting, cleaning and finishing of surfaces surrounding the outlet are complete. Install single one-piece multi-gang covers over multi-gang devices.

G. Junction and Pull Boxes

1. Install junction and pull boxes in readily accessible locations. Access to boxes shall not be blocked by equipment, piping, ducts and the like. Provide all necessary junction or pull boxes required due to field conditions and as required by the National Electrical Code.

H. Equipment Mounting Heights

1. Unless otherwise noted, mount devices and equipment at heights measured from finished floor to device/equipment base as follows: (Device base to be set at CMU joint unless otherwise noted.)

a.	Toggle switches (up position "on")	48"
b.	Receptacle outlets (long dimension vertical, ground pole nearest floor)	l6"
c.	Receptacle outlets, weatherproof, above grade	24" min.
d.	Branch circuit panelboards, to top of backbox	72"
e.	Distribution panelboards, to top of backbox	72"
f.	Terminal cabinets, control cabinets, control panels, to top of backbox	72"
g.	Disconnect switches, motor starters, enclosed circuit breakers, to top of box	60"

2. Where structural or other interferences prevent compliance with mounting heights listed above, consult Engineer for review to change location before installation.

I. Hangers and Supports
   1. Provide steel angles, channels and other materials necessary for the proper support and erection of motor starters, distribution panelboards, large disconnect switches, pendant-mounted lighting fixtures, etc.
   2. Panelboards, cabinets, large pull boxes, cable support boxes and starters shall be secured to ceiling and floor slab and not supported from conduits. Small panelboards, etc., as approved by Engineer, may be supported on walls. Racks for support of conduit and heavy electrical equipment shall be secured to building construction by substantial structural supports.

3.2 TESTS

A. Branch circuits shall be tested during installation for continuity and identification and shall pass operational tests to determine that all circuits perform the function for which they are designed.

B. For all feeder wiring rated 600 volts or less, provide 1,000 volt "Megger" insulation test prior to energizing feeders. Use a motor driven megger for all tests. Test voltage shall be applied until readings reach a constant value, and until three (3) equal readings, each one (1) minute apart, are obtained. Minimum megger reading shall be 45 megohms for feeder conductors. Document test results and submit for approval prior to energizing conductors.

END OF SECTION