

SECTION 16010 - ELECTRICAL GENERAL PROVISIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general provisions of the contract, including general and special conditions and general requirements, apply to the work specified in DIVISION 16 -ELECTRICAL.

B. Separation of Division 16 into Sections is for convenience only and is not intended to establish limits of work. Sections are as follows:

16010	ELECTRICAL GENERAL PROVISIONS
16100	ELECTRICAL BASIC MATERIALS AND METHODS
16400	ELECTRICAL SERVICE AND DISTRIBUTION SYSTEMS
16500	ELECTRICAL LIGHTING
16600	ELECTRICAL SPECIAL SYSTEMS

1.2 SCOPE

A. The work under this Section includes furnishing and installing wires, conductors, cables, conduit and conduit fittings, underground non-metallic conduit, horizontal directional drillingwiring devices, junction and outlet boxes, 13.8 KV switchgear, circuit breakers, fuses, lighting fixtures, handholes, grounding connections, unit substations, transformers, lightning protection system, and other equipment specified or necessary for a complete installation. The work also includes making building modifications if necessary to get these items to the locations for installation.

B. The work shall include removal of existing electrical equipment not being reused. Lighting fixture and lamp disposal shall meet regulatory agency requirements.

1.3 CUTTING AND PATCHING

A. Contractor shall do his work in such a way to avoid cutting where possible. Holes cut shall be patched in a suitable manner and shall be refinished to match the existing finish. Holes cut in exterior walls shall be patched, flashed, and completely waterproofed. Contractor shall patch and/or repair walls, ceilings, and floors where existing equipment is removed.

B. Cutting and patching for the work of this Division shall be in accordance with the requirements of the General Conditions. Openings around conduit penetrations shall be sealed. At exterior walls, these shall be completely waterproofed.

C. Work of this Division shall include providing information for any required openings to those responsible for concrete slabs and other concrete members.

D. Field cut openings in concrete shall be located to avoid the reinforcing. These areas shall be scanned (x-ray or other suitable method) to obtain locations of reinforcing and other obstructions. Locations shall be subject to approval of the Engineer.

E. No structural members shall be field cut or pierced without the approval of the Engineer.

F. Inserts in slabs and beams for fastening work shall be drilled type

G. For post-tensioned slabs and beams, inserts for fastening work shall be drilled type. Drilling shall not penetrate the post-tensioning tendons. Powder driver fasteners shall not be used.

H. Grouting shall be provided around raceway penetrations through concrete floors equal to the fire rating of the floor using non-shrinking waterproof grout to inhibit water from leaking through the floor.

1.4 DRAWINGS

A. Outlets shown on electrical drawings are located approximately only. Refer to equipment manufacturer's shop drawings and rough-in drawings, and adjust work accordingly to provide a coordinated installation.

1.5 LAWS AND PERMITS

A. The National Electrical Code (2020) and State, Parish, City and local building codes shall be considered a part of these specifications, and pertinent articles will not be repeated herein. These codes shall establish the minimum acceptable criteria where more stringent requirements have not been defined in these specifications and/or drawings.

B. DIVISION 16 - ELECTRICAL shall coordinate with work of all trades to ensure that NFPA 70 (National Electrical Code) working spaces clearances, dedicated equipment spaces, etc. are maintained.

C. The Contractor shall apply for permits and pay inspection fees incidental to electrical work.

D. No work shall be concealed until approved by the local inspector and local regulations shall be adhered to.

E. Upon completion, a certificate of approval from the appropriate regulatory agency shall be furnished to the Engineer.

F. The minimum elevation for the installation of electrical distribution equipment (both inside and outside of building) shall be the greater of either 36" above curb (36" above crown of the highest adjacent roadway in the absence of a curb) or 12" above the FEMA Base Flood Elevation. Contractor shall obtain this flood elevation from a licensed surveyor and pay the cost associated therewith. Contractor shall provide documentation to the Engineer to confirm that this requirement has been met.

1.6 VISITING SITE

The bidder shall visit the site of proposed work so that he may understand the facilities, difficulties, and restrictions attending the execution of the contract. He will be allowed no additional compensation for failure to be so informed.

1.7 INTERRUPTION OF SERVICES

Services in existing building(s) are to be kept in operation at all times, except when specific permission is given to do otherwise. Before any services are interrupted, arrangements shall be made with the occupants to do this work at a time most convenient to them. This procedure may involve working at night, on Saturday or Sunday, or at a special time of the year, with the length of time of the interruption agreed upon in advance. Once any service is interrupted, work to restore the service in the shortest possible time shall be on a continuous basis unless temporary service is provided or approval is obtained from the Owner to do otherwise. Any temporary services required shall be work of this Division. Allowance shall be made in the Contractor's bid for the cost of any overtime work in this connection.

1.8 GUARANTEE

The Contractor shall guarantee materials and workmanship for one year after final acceptance of entire project unless a longer guarantee is indicated hereinafter for specific equipment.

PART 2 - PRODUCTS

2.1 MATERIAL AND WORKMANSHIP

Equipment and materials shall be new and shall be listed by Underwriters Laboratories, Inc. in categories for which standards have been set by that agency. Whenever two or more of the same product are indicated, they shall be of the same manufacturer. In particular, panelboards and switchboards shall be of the same manufacturer. Methods of installation shall be in full accord with the latest and best electrical and mechanical engineering practices.

2.2 SUBSTITUTIONS

A. Names of manufacturers or catalog numbers are mentioned herein in order to establish a standard as to design and quality. Other products similar in design and of equal quality may be used if submitted to the Engineer and found acceptable by him. Refer to General Conditions and other portions of the specifications for additional information.

B. When the Contractor elects to use an acceptable alternate manufacturer's equipment, the Contractor shall be responsible to coordinate the change with the trades affected. The Contractor shall also pay for any additional work required under this Division as well as any other Division if the alternate equipment is used.

C. Lighting fixture substitutions shall also be similar in appearance, construction and photometrics (photometric information shall be based on independent laboratory reports) to specified lighting fixtures.

D. If required by Engineer because of substitutions, the Contractor shall submit for approval 1/4" scale working drawings of equipment areas with both plan and section views, as well as samples.

2.3 SUBMITTALS

A. Within 30 days after award of contract, the Contractor shall submit to the Architect for review one PDF copy of descriptive literature or shop drawings for the following material which he proposes to use. He shall also submit one printed color (hard) copy of this directly to the Electrical Engineer without routing through the Architect:

Wiring devices and
plates.
13.8 kV Switchgear.
Fuses.
Lighting fixtures.
Unit substations.

Transformers.
Horizontal directional drilling.
Lightning protection
system.
Fault current & protective
device coordination study.

B. In addition, the name of the manufacturer of conduit, E.M.T., and conductors to be used shall be submitted for review. Contractor is reminded that 600V conductors shall be rated for wet locations at 90 degrees C.

C. Where applicable, submissions shall include installation drawings and brochures showing locations, methods of anchoring, connections to work of others, wall or ceiling conditions at each particular installation and special floor mounting conditions.

D. Submissions shall be identified with project name, equipment name and number (if assigned a number) same as the name and number indicated on the drawings; shall be properly marked to show model numbers and any accessories being furnished; and shall have the Contractor's stamp showing he has reviewed the submittal and found it to be in accordance with the specifications and drawings. Items of Division 16 to be submitted shall be submitted in one package.

E. Fault current and protective device coordination studies shall be submitted with printed color copies of coordination curves.

F. Submittals which do not comply with the above will be returned without review, for resubmittal.

PART 3 - EXECUTION

3.1 EXCAVATING/BACKFILLING AND HORIZONTAL DIRECTIONAL DRILLING

A. Provide excavating/backfilling and horizontal directional drilling required for the work of this Division. Removal of obstructions, hidden or otherwise, shall be part of this work. Backfill shall be river sand. Backfilling shall be done in two lifts each thoroughly tamped. Surplus earth shall be removed.

B. Before excavating/trenching or horizontal directional drilling, locate and stake out existing underground utilities which may be adversely affected by this work. Work shall be performed in a manner to avoid damage to existing utilities. Repair or replace, at no expense to Owner, any utilities damaged by him. Contractor shall also call 1-800-272-3020 per Louisiana Statutes and coordinate installation prior to beginning work.

3.2 RECORD DRAWINGS

At the completion of the work, unless noted otherwise in the General Conditions, mark-up a set of prints in a neat and understandable manner to show significant changes made during construction. Wiring and raceways installed shall be indicated (routings, wire size and quantity) on the record drawings even if not indicated on the contract drawings. Underground raceways and wiring shall be measured and dimensioned from above-grade structures. Copies of panelboard circuit directories shall be included. These prints shall be scanned and a PDF file (on an external electronic drive), as well as one set of prints made from the PDF, shall be provided. Final payment will be withheld until these drawings are furnished to the Engineer. The Contractor shall pay for the reproduction costs.

3.3 OPERATING INSTRUCTIONS

A. Before final acceptance, prepare and deliver to the Engineer two bound copies of operating instructions, which shall include:

1. Description of major components of power systems and each special system, including the function of major items.

2. Detailed operating instructions and instructions for making routine minor adjustments.

3. Routine maintenance operations.

4. Manufacturer's catalog data and service instructions and parts list for each piece of operating equipment.

5. Final reviewed submittals (including review comments).

B. Instruct Owner in the care and operation of equipment and provide the services of a competent mechanic for this purpose.

C. Literature shall be substantially bound in a suitable number of volumes so as to permit heavy usage and shall include wiring diagrams, fabrication drawings and other information as may be required.

3.4 WORK RELATED TO EQUIPMENT NOT FURNISHED AS WORK OF THIS DIVISION

A. Unless specifically indicated otherwise, any required electrical services for and required electrical connections to items shown on the architectural drawings or specified to be furnished in other Divisions of specification or by Owner shall be electrically connected as work of this Division.

3.5 PAINTING

Painting is specified under DIVISION 9 -FINISHES. Damaged surfaces of factory-finished items, however, shall be repaired to the satisfaction of the Engineer as the work of this Division.

3.6 PROTECTION OF WORK

Protect the equipment, fixtures, and work from damage. Damaged work will be rejected and replaced at the expense of the Contractor. Substations, switchgear, lighting fixtures, panels and similar equipment shall likewise be protected from damage and from the weather. Provide adequate and proper storage facilities for such items during the progress of the work.

3.7 BUILDING CODE RESTRICTIONS

Contractor shall assure that he does not install electrical equipment including raceways in or through areas restricted by the building codes. These areas include stairs.

3.8 EXISTING WORK

A. Remove existing lighting fixtures from areas affected by new construction and from areas to be relighted. After completion of work in a given area, the Contractor shall reinstall the existing lighting fixtures or install new lighting fixtures as indicated.

B. Where existing ceilings are being removed, provide new supports for raceways, outlets, junction boxes, and other electrical items which are to remain and which depend upon the existing ceiling suspension system for support. The new supports shall be attached to the structure/slab above.

C. Existing outlets not to be reused shall be removed unless directed otherwise. Where outlets are indicated to remain as junction boxes, wall outlets shall be provided with blank device plates of the type hereinafter specified and ceiling outlets shall be provided with covers to match existing surfaces.

D. Existing exposed conduit and other electrical equipment not to be reused shall be removed. Existing conduit not to be reused and located in accessible attic spaces also shall be removed.

E. Existing conduits in good condition (and of the type and size required) may be reused. Existing conductors, wall switches and receptacles which are required to be removed, unless otherwise individually indicated, shall not be reused.

F. Electrical equipment removed and not to be reused shall be stored in one location on the site; any equipment and material which the Owner does not wish to retain shall become the property of the Contractor and shall be removed from the site by him.

G. Where apparent routings of existing raceways are indicated, it is not possible to guarantee that these routings are correct. The Contractor shall allow for contingencies.

H. Where existing raceways are indicated to be reused, it is not possible to guarantee that the existing raceways are in suitable condition to be reused. Before conductors are installed in existing raceways, the raceways shall be cleaned out and a try-plug $\frac{1}{4}$ " smaller than the inside diameter of the raceway pulled through to assure continuity. Raceways which are found to be broken, blocked, and/or defective in any way shall have the defective sections replaced or entirely new raceway provided with routing subject to approval of the Engineer. The Contractor shall allow for contingencies in connection therewith.

I. Where outlets to remain are fed from outlets in partitions to be removed, or ceilings and walls to which new finishes are to be applied, the Contractor shall provide such new homeruns or other rerouting as may be required by job conditions to insure service to the outlets to remain.

J. Where existing equipment including wiring and raceways is in conflict with work of this project, Contractor shall rework/reroute/relocate this equipment as necessary.

3.9 UTILITY CONNECTIONS

A. Coordinate connection of utilities (raceways, wiring, etc.) which are work of this contract to existing utilities and utilities installed as work of other contracts. Verify connections points prior to commencing any work. No additional compensation will be allow for conflicts that occur due to the lack of coordination.

- END OF SECTION -

SECTION 16100 - ELECTRICAL BASIC MATERIALS AND METHODS

PART 1 - GENERAL

1.1 SCOPE

Work described in this Section includes providing labor, materials and equipment indicated, specified and necessary for a complete and operating electrical system and related systems in accordance with SECTION 16010 - ELECTRICAL GENERAL PROVISIONS.

PART 2 - PRODUCTS

2.1 CONDUIT AND TUBING

A. Rigid steel conduit and electrical metallic tubing shall be manufactured by Allied, Triangle-PWC, Republic, Wheatland, or approved equal. Conduit shall be threaded heavy-wall hot-dipped galvanized (inside and out) steel conduit. Electrical metallic tubing shall have galvanized exterior and galvanized or equivalent plastic coated interior to protect against corrosion.

B. Rigid aluminum conduit shall be manufactured by New Jersey Aluminum, or VAW of America from 6063-T42 extruded Schedule 40 pipe. The interior surface shall be coated with special approved lubricating liner.

C. Rigid nonmetallic conduit shall be polyvinylchloride (PVC) type and manufactured by Allied, Dura-Line, or approved equal. Rigid nonmetallic conduit shall be Schedule 40 or Schedule 80 as required by Code, rated for 90 degrees C, and UL rated. Fittings for rigid nonmetallic conduit shall be manufactured by the same manufacturer as the conduit furnished. Rigid nonmetallic conduit may be used only where indicated in drawings and specifications.

D. High Density Polyethylene (HDPE) conduit shall be manufactured by Allied, Dura-Line, or approved equal. High Density Polyethylene conduit shall be smooth-wall type approved for horizontal directional drilling installation, Schedule 80, rated for 90 degrees C, and UL rated. Color of conduit shall be red where associated with line voltage wiring and orange where associated with communication, alarm, or fiber optic cabling. Fittings for High Density Polyethylene conduit shall be manufactured by the same manufacturer as the conduit furnished. High Density Polyethylene conduit may be used only where indicated in drawings and specifications.

2.2 CONDUCTORS

A. Conductors shall be copper.

B. Branch circuit wiring shall be #12 AWG or larger (as required for the particular equipment to be fed) with flame resistant insulation. Conductors #8 AWG and larger shall be stranded. Insulation on branch circuit conductors shall be type THWN-2 (rated 90 degrees C, dry or wet), unless indicated otherwise or otherwise required by the particular application.

C. Feeds to surface and/or suspended lighting fixtures shall be #12 AWG type THWN-2 or XHHW-2. Wiring through channels of continuous rows shall be #12 AWG and type THWN-2, or XHHW-2. Recessed lighting fixtures shall be fed with #12 AWG type THWN-2 or type XHHW-2 conductors.

D. Lighting standards shall be wired with type THWN-2 from wiring handhole in standard to fixtures unless higher temperature conductors are required for the particular fixtures provided.

E. Feeders shall be of the size as indicated, with type THWN-2 insulation (rated 90 degrees C, dry or wet), unless indicated otherwise.

F. Except as may be otherwise indicated, conductors shall be manufactured by Triangle-PWC, American Insulated Wire, Senator, Royal, Southwire, or approved equal.

2.3 OUTLETS

A. All boxes, fittings and supports (including wireways) shall be galvanized steel.

B. Boxes for concealed wall outlets shall be 4" square by 1½" deep, or larger, with raised device covers. Device covers for 4" square boxes in masonry walls which are not plastered or otherwise finished shall be 1" minimum in depth with straight rectangular openings for dry wall type construction.

C. Outlet boxes for exposed work that is exposed to weather or in damp locations shall be of cast or malleable iron, similar to Crouse-Hinds type FS or FD condulets. Boxes shall have metal covers to accommodate the devices indicated.

D. For conduits 1" and smaller, the following shall be the maximum number of conductors permitted in a box:

<u>Trade Size</u>	<u>Max. No. #12</u>
1-1/2" x 4" octagonal	6
1-1/2" x 4" square	9
1-1/2" x 4-11/16" square	12
2-1/8" x 4-11/16" square	16
2-3/4" x 3" x 2"	6
3-1/2" x 3" x 2"	8

E. Where a fixture stud is installed in box, the number of conductors permitted shall be reduced by one. Where a wiring device is installed in box, the number of conductors permitted shall be reduced by two. A conductor running through the box is counted as one conductor, and each conductor terminating in box is counted as one conductor.

2.4 WIRING DEVICES

A. Wiring devices shall be as manufactured by P&S/Sierra, Hubbell, Leviton, or Eagle. Comparable catalog numbers of devices furnished shall conform with the following, with color as directed by Engineer:

1. Duplex receptacles 20A/2 pole, 3-wire, 125 volt, grounding type,-- Hubbell #HBL5362-I. Face shall be nylon or polycarbonate.

2. GFI duplex receptacles 20A/2 pole, 3-wire, 125 volt, GFI, tamper-resistant, weather-resistant, grounding type, -- Hubbell #GFR5362-ITR. These shall be used for weatherproof applications, and damp locations. Unless noted otherwise, GFI receptacles shall not be used to control downstream receptacles.

3. Wall switches 20A/1 pole -- Hubbell #HBL1221, or equal.

B. All 20A/2 pole, 3-wire receptacles shall be mounted with a "U" shaped grounding connection at the top, except for weatherproof receptacles, and except for locations where existing receptacles are mounted with "U" shaped grounding connection at the bottom.

C. Where receptacles are located in wet or damp locations, they shall be weather-resistant type to meet NEC 406.9.

2.5 DEVICE PLATES

A. Plates shall be of the one-piece type, P&S/Sierra "S-1 N" line or Slater "SSA" line with #302 (non-magnetic) satin stainless steel finish.

B. Where weatherproof switches are indicated, P&S/Sierra type 302 series WP plates shall be used, unless indicated otherwise on drawings.

C. Where weatherproof receptacles are indicated, metal canopy-type weatherproof covers similar to T&B Red Dot Code-Keeper (UL listed for wet locations at all times) shall be used with the weather-resistant receptacles, unless indicated otherwise on drawings.

D. Use multi-gang plates where switches, receptacles, and/or other devices are grouped.

E. Plates shall be installed with the four edges in continuous contact with

finished wall surfaces without the use of mats or similar devices. Plaster fillings will not be permitted. Plates shall be installed with an alignment tolerance of 1/16" from the vertical or horizontal.

F. Plates for devices fed with exposed conduit shall be as hereinbefore specified.

2.6 FUSES

Provide one complete set of fuses, together with 33% spares, for each fuseholder. Fuses 600A and below shall be Buss Low-Peak, Littlefuse LL, or Ferraz Shawmut Amptrap 2000, Type RK-1, current limiting and time delay, rejection type, unless noted otherwise. Fuses above 600A shall be Bussman LCL, Littlefuse KLP-C or Shawmut Amptrap, UL listed Class L, current limiting and time delay, with 200,000 amp rms interrupting rating, silver plated contact surfaces. Where fuses are used with magnetic starters, fuses shall be reduced in ampere rating (from the sizes indicated) to the maximum rating allowed for each particular starter, as stated on starter nameplate. All fuses shall be of a single manufacturer.

2.7 WARNING SIGNS

A. Standard industry "DANGER HIGH VOLTAGE" warning signs shall be provided as required by the National Electric Code and as follows:

1. On each door of 13.8 kV switchgear.
2. On each removable panel of transformers.
3. On other equipment (such as time switches, etc.) containing energized components which are exposed when door is opened or access panel is removed.

B. A warning sign shall be provided on switchboards to warn of potential electric arc flash hazards.

PART 3 - EXECUTION

3.1 METHODS OF WIRING

A. Systems shall be 4-wire, 3-phase, 120/208 volts, A.C.; 4-wire, 3-phase, 277/480 volts, A.C.; and 3-wire, 3-phase, 13800 volts, A.C.

B. Provide power wiring as required whether indicated on drawings or not.

C. Where a neutral conductor is required for a branch circuit, it shall be dedicated to that branch circuit and shall not be shared by other branch circuits.

D. Unless otherwise indicated on drawings or specified hereinafter, wiring installed outdoors (not underground or in fill beneath slab and under building) shall be contained in rigid threaded heavy wall galvanized steel conduit (hot dipped, inside and out).

E. Unless otherwise indicated on drawings or specified hereinafter, other wiring shall be contained in electric metallic tubing for sizes 2" and under, and rigid threaded heavy wall galvanized steel conduit (hot dipped, inside and out) for sizes over 2".

F. Unless specifically indicated otherwise on the drawings, aluminum conduit may be used in lieu of steel conduit, provided same does not run underground or in concrete. Where aluminum conduit is used, fittings, outlet boxes, junction boxes, and accessories shall be aluminum.

G. All raceways shall be concealed unless otherwise indicated.

H. Branch circuit raceways feeding outlets in masonry walls shall be concealed in the masonry. Where outlet boxes are indicated in bare masonry walls, the box shall be mounted so that two edges of the box or plaster cover will fall in a mortar joint. Where switch boxes will not accommodate the number of conductors required and 4" square or larger boxes are installed, provide device covers 1" minimum in depth with straight rectangular openings for dry-wall type construction. Where grouting is required to fill up improperly cut openings in the masonry, the work will be rejected. The work of this section shall be coordinated with the masonry work to insure a neat and workmanlike job.

I. Solderless spring type connectors similar to Scotchlok connectors, Ideal colored Wingnuts, or Ideal Crimps with Wrapcaps shall be used for branch circuit wiring and fixture splice connections. Solderless connectors of the split-bolt type shall be used for splices on conductors #8 and larger.

J. Splices in low voltage wiring (50 volts and less) shall be made at terminal blocks furnished with the equipment. At junctions or where other splices are required, these splices shall be soldered or made with approved compression connectors.

K. Termination of branch circuit and feeder conductors shall be made using mechanical or compression lugs, unless noted otherwise. Where lugs are not furnished with equipment (including Owner-furnished equipment), Contractor shall provide lugs, and/or replace lugs with appropriate size, as required for a complete installation. Also, where conductors are to be connected to equipment furnished with lugs not sized for the conductors, Contractor shall change the lugs to the appropriate size.

L. Termination of low voltage wiring (50 volts and less) and control/monitor/instrumentation wiring (120 volts and less) shall be made using compression type (ring or spade) terminals similar to T&B Sta-Kons.

M. Typewritten directory of circuits shall be provided for each panelboard to include spares and spaces. The room numbers and items served shall be indicated for

each circuit. (Circuit numbers indicated on the drawings are shown for the purpose of clarifying the grouping of outlets. The actual number assigned to the circuits in the panelboard shall suit the bussing and branch circuiting to panelboard.) In existing panelboards, the directories shall be corrected as required for changes made to the circuits. Phenolic nameplates (white with black-cut letters) shall be provided in lieu of directories for changes to switchboards, motor control centers, and panelboards without doors.

N. Branch circuit wiring through lighting fixtures shall be in accordance with Articles 410.11, 410.31, 410.32, and 410.33 of the National Electrical Code; however, conductor types shall be as specified hereinbefore.

O. Unless a larger size is indicated or required by code or manufacturer, raceways shall be sized in accordance with Table 1 for the number and conductor size (AWG and MCM) shown or specified. Where combination of secondary (0-600 volt) conductor sizes are indicated, the raceway shall be sized in accordance with Table 2 based on the insulated conductor areas of Table 3, for the project conductor sizes (AWG and MCM) indicated even though the actual diameters and areas of the conductors to be installed may differ from those in Table 3.

Table 1

Maximum Number of Conductors in Trade Sizes of Conduit or Tubing													
	Conduit Trade Size (Inches)												
	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	6
Conductor Size AWG, MCM													
14	3	6	10	18	25	41	58	90	121	155			
12	3	5	9	15	21	35	50	77	103	132			
10	2	4	7	13	18	29	41	64	86	110	138		
8	1	2	4	7	9	16	22	35	47	60	75	94	137
6	1	1	2	5	6	11	15	24	32	41	51	64	93
4	1	1	1	3	5	8	12	18	24	31	39	50	72
3	1	1	1	3	4	7	10	16	22	28	35	44	63
2		1	1	3	4	6	9	14	19	24	31	38	56
1		1	1	1	3	5	7	11	14	18	23	29	42
0		1	1	1	2	4	6	9	12	16	20	25	37
00			1	1	1	3	5	8	11	14	18	22	32
000			1	1	1	3	4	7	9	12	15	19	28
0000			1	1	1	2	4	6	8	10	13	16	24
250				1	1	1	3	5	6	8	11	13	19
300				1	1	1	3	4	5	7	9	11	17
350				1	1	1	2	4	5	6	8	10	15
400				1	1	1	1	3	4	6	7	9	14
500				1	1	1	1	3	4	5	6	8	11
600					1	1	1	2	3	4	5	6	9
700					1	1	1	1	3	3	4	6	8
750						1	1	1	3	3	4	5	8

Table 2

Dimensions and Percent Area of Conduit and of Tubing										
Trade Size	Internal Diameter Inches	Total 100%	Area – Square Inches							
			Not Lead Covered			Lead Covered				
			2 Cond. 31%	Over 2 Cond. 40%	1 Cond. 53%	1 Cond. 55%	2 Cond. 30%	3 Cond. 40%	4 Cond. 38%	Over 4 Cond. 35%
1/2	.622	.30	.09	.12	.16	.17	.09	.12	.11	.11
3/4	.824	.53	.16	.21	.28	.29	.16	.21	.20	.19
1	1.049	.86	.27	.34	.46	.47	.26	.34	.33	.30
1 1/4	1.380	1.50	.47	.60	.80	.83	.45	.60	.57	.53
1 1/2	1.610	2.04	.63	.82	1.08	1.12	.61	.82	.78	.71
2	2.067	3.36	1.04	1.34	1.78	1.85	1.01	1.34	1.28	1.18
2 1/2	2.469	4.79	1.48	1.92	2.54	2.63	1.44	1.92	1.82	1.68
3	3.068	7.38	2.29	2.95	3.91	4.06	2.21	2.95	2.80	2.58
3 1/2	3.548	9.90	3.07	3.96	5.25	5.44	2.97	3.96	3.76	3.47
4	4.026	12.72	3.94	5.09	6.74	7.00	3.82	5.09	4.83	4.45
4 1/2	4.506	15.94	4.94	6.38	8.45	8.77	4.78	6.38	6.06	5.56
5	5.047	20.00	6.20	8.00	10.60	11.00	6.00	8.00	7.60	7.00
6	6.065	28.89	8.96	11.56	15.31	15.89	8.67	11.56	10.98	10.11

Table 3

Dimensions to be Used for Insulated Conductors		
Size AWG MCM	Approx. Diam. Inches	Approx. Area Sq. In.
Col. 1	Col. 2	Col. 3
18	.146	.0167
16	.158	.0196
14	.204	.0327
12	.221	.0384
10	.242	.0460
8	.328	.0854
6	.397	.1238
4	.452	.1605
3	.481	.1817
2	.513	.2067
1	.588	.2715
0	.629	.3107
00	.675	.3578
000	.727	.4151
0000	.785	.4840
250	.868	.5917
300	.933	.6837
350	.985	.7620
400	1.032	.8365
500	1.119	.9834
600	1.233	1.1940
700	1.304	1.3355
750	1.339	1.4082
800	1.372	1.4784
900	1.435	1.6173
1000	1.494	1.7531
1250	1.676	2.2064
1500	1.801	2.5475
1750	1.916	2.8895
2000	2.021	3.2079

P. In 277/480 volt systems, wall switches grouped or ganged in an outlet box shall be so arranged that voltage between adjacent switches does not exceed 300 volts, or the box shall be equipped with permanently installed barriers between adjacent switches. Where wall switches for normal system and emergency system are grouped or ganged in an outlet box, permanently installed barriers shall be provided in the outlet box to separate the normal and emergency systems.

Q. Approved thread lubricant containing powdered zinc or lubricating graphite shall be applied to the male threads only of aluminum conduit to prevent joint seizure.

R. Other routings than those indicated may not be used without the approval of the Engineer, but the Contractor shall make allowance for possible obstruction to routes indicated.

S. Raceways shall be supported in accordance with the National Electrical Code for the particular type of raceway; however, for rigid metal conduit and electrical metallic tubing, the maximum spacing between supports shall not exceed ten feet.

T. Wall switches indicated by doors shall be located on the strike side (lock side), 6" maximum from door frame to the side of the outlet box; however, for double doors switches shall be located where shown, usually clear of the door in the full open position.

U. The Contractor shall install additional boxes or fittings in raceways as required to properly install conductors. The locations of these boxes or fittings shall be subject to the Engineer's approval.

V. Top of wooden poles shall be cut on an angle to allow for drainage of rain water.

W. In multi-section panelboards, circuit breakers, fusible switches, and spaces shall be divided equally between sections (unless indicated otherwise). The circuit arrangement on panelboard schedules is used only to convey circuit assignment, not locations of circuit breakers in panelboard.

X. Where a maximum fuse (or circuit breaker) rating is indicated on the nameplates of the magnetic starters, control panels, contactors, etc. (or equipment containing these components) for the specific mechanical equipment, the Contractor shall reduce ampere rating of fuses (or circuit breaker) to be installed (from the sizes indicated). These ratings shall also be increased as necessary to comply with NEC Paragraph 430.52 (C)(1), Exception 2.

Y. Suitable waterproof cable identification tags shall be installed on each power feeder in each manhole, handhole, and pull (junction) box.

Z. Where conductors without raceway penetrate smoke partitions and/or fire rated partitions and floors, a conduit sleeve shall be installed rigidly in the penetration so that the conductors can pass through it. A UL listed fire-stop putty such as Nelson Flameseal shall be installed around the sleeve and inside the sleeve after the conductors are installed.

AA. Where roof penetrations are required for conduits supplying roof-mounted HVAC equipment, these penetrations shall be of the piping roof curb type per National Roofing Association standards.

BB. Where variable speed drives are used, the disconnect switch at the motor shall have an auxiliary contact wired to the variable speed drive to turn off the drive when the disconnect is opened.

CC. Where electrical work penetrates or is installed in fire and/or smoke partitions, this work shall be installed per UL standards. A U.L. listed fire-stop putty such as Nelson Flameseal shall be installed around raceway penetrations.

3.2 WIRING IN CONDUIT (APPLIES ALSO TO E.M.T.)

A. Where several conduits (concealed and/or exposed) are run parallel to each other, they shall be grouped together on galvanized P-1 000 Unistrut, with suitable clamps, which shall be attached to the wall or hung from the roof or structural ceiling. Where exposed conduit is indicated, the conduit shall be installed parallel with or at right angles to the building walls and/or ceiling (roof) and shall be supported adequately by pipe straps or other approved devices. Where a single conduit is run exposed in a damp and/or wet location, standoff straps of the type which permit a 1/4" air space between the conduit and the wall shall be used. Fastening of conduit shall be as follows: to wood by means of screws; to masonry by means of threaded metal inserts, metal expansion screws, or toggle bolts; and to steel by means of machine straps, bolts, or power actuated fasteners. Raceway fasteners shall be approved for the purpose (tie wire, zip-ties, ty-raps shall not be used).

B. Conduit in concrete slabs shall be located so as not to affect the structural strength of the slabs. Conduit in general shall be located in the center 1/3 thickness of concrete slabs and when installed in slabs poured on grade or fill shall have at least one inch of concrete between conduit and plastic or other waterproof membrane; conduit shall not be installed under the plastic or other waterproof membrane unless it is to be installed "In fill beneath slab" in which case the installation shall meet the requirements indicated heretofore. The maximum size of conduit that may be run in a slab shall be as directed by the Engineer. Conduit larger than 3/4", if permitted in reinforced concrete slabs, shall be parallel with or at right angles to the main reinforcement; when at right angles to the reinforcement, the conduit shall be close to one of the supports of the slab.

C. Underground runs of multiple conduits shall be provided with plastic separators to insure 2" minimum of concrete between adjacent conduits.

D. Unless noted otherwise on drawings, underground runs of conduits shall be installed in concrete envelope of 3" minimum thickness at top, bottom, and sides, so that the top of the concrete envelope shall not be less than 42" below grade for conductors operated over 600V and not less than 24" below grade for 600V or less except that under roads and pavements the minimum for 600V or less shall be 30" below grade. In non-concreted areas, encasement around conduit stub-ups shall extend to a location just above grade, and top shall be sloped to drain.

E. Concrete and reinforcing shall conform to DIVISION 3, CONCRETE. Concrete strength shall be 3000 psi unless noted otherwise on drawings. Concrete shall be colored red for underground conduit applications with an approved admixture.

F. Conduits shall be kept at least 6" from runs of hot water piping, flues, or other hot object.

G. Where conduits rise through a concrete floor, the curved portion shall not be visible above the finished floor. Approved waterproof compound or conduit sealing bushing shall be used where underground conduits enter building, outdoor switchgear pad, outdoor transformer pad, and outdoor substation pad.

H. Where conduit fittings are installed, these shall be Crouse-Hinds or Appleton cast type.

I. Connectors and couplings for electric metallic tubing shall be of the steel compression type. Couplings for rigid heavy wall conduit shall be of the threaded type; two locknuts and one bushing shall be provided where heavy wall conduits enter boxes or equipment. Flexible metal conduit connectors shall be of the squeeze type with screw and locknut. Liquid-tight connectors shall be steel compression type.

J. Insulated bushings shall be provided for conductors #4 and larger.

K. From each flush panelboard and cabinet (including fire alarm control panels, telephone cabinets, etc.), provide three empty ¾" conduits to elbow out 6" into space above ceiling for future use.

L. No wiring shall be installed in raceways until the raceway system is complete. Only approved type pulling lubricant shall be used.

M. During construction, outlet boxes and conduit stub-ups shall be suitably protected against the entrance of foreign materials.

N. Conduit in suspended ceilings shall be located, where practicable, in the space between the ceiling and the concrete slab above. Raceways shall not be installed immediately above accessible acoustical ceiling (restricting tile removal) without written approval of Engineer for the specific location. Raceways shall also not be installed in such a manner to restrict or block access to plenums, equipment, etc.

O. Tie-wires shall not be used for support of raceways. Raceways shall be supported by threaded rods, strut, building structure, etc. that secure the raceways (to prevent both vertical and horizontal movement) in addition to supporting them.

P. Where concrete joist construction is employed, arrange with those responsible for DIVISION 3 - CONCRETE to provide in contact ceilings and in unfinished ceilings such headers as may be required to receive boxes for fixtures.

Q. Where underground raceways stub up on exterior of building, the Contractor shall install two support rods to keep raceways from sinking relative to building. These support rods shall be 3/8" stainless steel, and shall extend concealed through the concrete encasement and tie into the concrete slab of the building.

R. Where flexible metal conduit or liquid-tight flexible metal conduit is installed, it shall be securely fastened within 12" of connection point, and additional supports shall be provided per NEC 348 & 350.

S. Where conduits are installed on roofs, unless indicated otherwise, they shall be installed on supports consisting of rubberized base with galvanized strut (B-Line Dura-Blok series DB or Caddy Pyramid series ST fixed strut supports).

T. Where installed under metal-corrugated sheet roof decking, cables, raceways, and boxes shall be installed and supported so there is no less than 1 1/2" between the lowest surface of roof decking and the top of the cable, raceway, or box.

3.3 UNDERGROUND RIGID NONMETALLIC CONDUITS

A. Rigid nonmetallic conduits shall be used underground only where specifically indicated on the drawings.

B. Underground rigid nonmetallic conduits shall be individual conduits encased in concrete envelope of 3" minimum thickness at the top, bottom and sides, unless otherwise indicated. Conduits shall be 4" size unless otherwise indicated. Conduits shall slope downward toward handholes and away from buildings with a pitch of not less than 3" per 100 feet. Top of concrete envelope shall not be less than 42" below grade for conductors operated over 600V and not less than 24" below grade for 600V or less, except that under roads and pavements the minimum for 600V or less shall be 30" below grade. Separators shall be of plastic and shall maintain a minimum of 2" concrete separation between conduits. The joints of the conduit in banks shall be staggered by rows and layers so as to provide a bank having maximum strength. End bells, flexible couplings, and expansion joints shall be provided as necessary. Exposed vertical runs, including risers up poles and through building slab, and elbows shall be rigid heavy wall threaded galvanized conduit; metallic to nonmetallic conduit adapters shall be provided at a point 10 feet minimum outside perimeter of building slab as required. Steel conduit so installed shall be effectively grounded. Non-metallic conduit shall not be used under buildings.

3.4 HORIZONTAL DIRECTIONAL DRILLING (DIRECTIONAL BORING)

A. Where indicated on drawings, horizontal directional drilling shall be provided to create an underground horizontal borehole through which conduit is to be installed. A pilot bore shall be directionally drilled from the entry pit to a pre-determined exit location. The drilling head shall then be replaced with a reamer and the drilling string shall then be pulled back to the entry hole, enlarging the hole while simultaneously pulling the conduit(s) into place. Where parallel conduits are required to be installed, all conduits shall be simultaneously installed so that each conduit is of equal length.

B. The Contractor shall be responsible for the directional drilling method and equipment. The Contractor shall confirm that the drilling rig and mud mixing system have the capacity required to successfully complete the installation knowing the length of the crossing and product type and diameter, and shall consider ground and groundwater conditions that can be reasonably foreseen.

C. Operating range and degree of accuracy of proposed tracking system shall be adequate to meet project conditions. Tracking/steering equipment shall allow for continuous monitoring of the drilling head along the entire proposed alignment. If a poor contact with the transmitter is expected to occur at any section, this shall be communicated to the Engineer prior to commencement of construction.

D. The drilling unit shall be equipped with an electrical strike safety package unless underground electrical utilities are confirmed not in the area. The package shall include warning sound alarm, grounding mats and protective gear.

E. Only trained operators shall be permitted to operate the drilling equipment, and manufacturer's operating instructions and safety practices shall always be followed.

F. The Contractor shall also be responsible for developing and maintaining emergency procedures for inadvertently boring into existing utilities including a live power line, natural gas line, water line, sewer line, or fiber-optic cables.

G. If a drilled hole beneath a man-made surface must be abandoned, the hole shall be filled with grout to prevent future subsidence. The Engineer shall be notified before the borehole is abandoned and the abandoned borehole shall be identified on the as-built plans.

H. Contractor shall prevent drilling fluids from entering the manholes, sanitary and storm sewers, other drainage systems, and any Waters of the United States including creeks and streams.

I. A strict minimum bending radius guideline is imposed so as to avoid an excessively sharp bending radius and consequently, possible damages to the conduit. The entrance angle of the drill string shall be between 8 and 20 degrees to the horizontal, with 12 degrees considered optimal. The exit angle of the drill string shall be within the range of 5 to 10 degrees.

J. Drilling mud shall be used during drilling and back-reaming operations. Drilling mud pressure in the borehole shall not exceed that which can be supported by the overburden to prevent heaving or hydraulic fracturing of the soil.

K. The pilot hole shall be back-reamed to accommodate and permit free sliding of the product inside the borehole. The Contractor shall be responsible for selecting the appropriate reamer size.

L. A sufficient number of pre-reams shall be utilized as to avoid heaving while enlarging the hole to the desired diameter.

M. Pipe rollers, skates or other protective devices shall be used in the installation of conduits (6 in.) in outside diameter or larger.

N. Pipe installation shall be performed in a manner that minimizes the over-stressing and straining of the pipe.

O. During pull-back operations, the conduit shall be sealed with a cap or plug to prevent water, drilling fluids and other foreign materials from entering the pipe as it is being pulled back.

P. Breakaway swivels shall be used with pulling head to limit the amount of force used during pull-back operation.

Q. Sections of High Density Polyethylene (HDPE) conduit shall be assembled and joined on the job site above ground. Joining shall be accomplished by the butt-fusion method in strict conformance with the manufacturer's printed instructions. The butt-fusion method for pipe joining shall be carried out in the field by qualified fusion technicians following the pipe and fitting manufacturer's specifications. The joints shall have a smooth, uniform, double rolled back bead made while supplying the proper melt, pressure and alignment. It shall be the sole responsibility of the Contractor to provide an acceptable butt-fusion joint. The Contractor shall perform a leak test prior to pull back. All joints shall be made available for inspection by the Engineer before insertion.

R. Trenching may be used to join sections at tie-ins of conduits installed by the directional boring method. An additional pipe length, sufficient for joining to the next segment, shall be pulled into the entrance pit. This length of the pipe shall not be damaged or interfere with the subsequent drilling of the next leg. The Contractor shall leave a minimum of 3 feet of conduit above the ground on both sides of the borehole. Polyethylene pipe, tie-ins and connections shall only be made after a suitable time period in order to allow the pipe to recover. Recovery period shall be equal to at least twice the pull-back time.

S. Excess drilling mud slurry shall be contained in a lined pit or containment pound at exit and entry points until recycled or removed from the site. Entrance and exit pits shall be of sufficient size to contain the expected return of drilling mud and spoils.

Precautions shall be taken to keep drilling fluids out of the streets, manholes, sanitary and storm sewers, and other drainage systems including streams and rivers. The Contractor shall make all diligent efforts to minimize the amount of drilling fluids and cuttings spilled during the drilling operation, and shall provide complete clean-up of all drilling mud overflows or spills.

T. All surfaces affected by the work shall be restored to their pre-construction condition. This includes backfilling, replacement of topsoil, seeding and fertilizer.

U. Contractor shall submit a complete methodology specific to each crossing, including equipment specifications and capabilities, size of pilot hole, number and size of pre-reams, use of rollers, baskets and side booms to suspend and direct pipe during pull back, type and capabilities of tracking system, and number of sections in which the conduit is to be installed.

V. Contractor shall submit a shop drawing indicating the proposed drill path including its horizontal and vertical alignments as well as the location of buried utilities and substructures along the path. Contractor shall also submit for approval a drilling fluid management plan detailing proposed methods to control, collect, transport, and dispose of drilling fluids and spoils. Return and spoils are the drilling mud and cuttings collected in the entry and exit pits as well as any fluid, which escapes from the borehole to the surface. The plan shall contain a method of dealing with inadvertent returns or surface seepage of drilling fluids and spoils and a contingency plan in case of spills (i.e., drilling fluids, hydraulic fluids, etc.) including measures to contain and clean the affected area.

3.5 GROUNDING

A. The metallic raceway system and the neutral conductor of the wiring system shall be grounded at the service equipment. The insulated copper service grounding electrode conductor shall be extended with no splices in raceway from the service to within 5 feet of the point of entrance of the metal underground water service pipe that is electrically continuous and is in direct contact with the earth for at least 10 feet per NEC 250.68(C). It shall also be extended without splice to building structure steel frame. Where the raceway routing is via finished areas, it shall be run concealed. Ground connection shall be visible, and connection of raceway and conductor to the water pipe shall be made with an approved ground connector similar to T & B conduit hub and water pipe clamp. Also, see Article 250.50, Grounding Electrode System and Grounding Electrode Conductor of the National Electrical Code for bonding requirements to other items to form the grounding electrode system (this includes bonding to metal frame of building and to a concrete-encased electrode to be located near the service equipment).

B. The above requirements shall be supplemented by grounding to $\frac{3}{4}$ " diameter by 10' long copper clad ground rods, and to an encased electrode (consisting of a 20' minimum length of 4/0 B.C. cast in a grade beam or similar concrete-encased foundation member below the vapor barrier, or in a concrete-encased conduit bank that is in contact with earth.

C. At each point of voltage transformation (including but not limited to transformers and inverters), the secondary neutral conductor and the secondary raceway system shall be grounded with a common insulated ground conductor as described in Article 250.30 of NFPA 70, National Electrical Code. The grounding electrode conductor described therein shall be continuous (no splices) and shall be in a raceway. Where the raceway routing is via finished areas, it shall be run concealed. Ground connection shall be visible. Where water pipe connection is used, connection of raceway and conductor to a water pipe shall be made with an approved ground connector similar to T & B conduit hub and water pipe clamp and the connection shall be within 5 feet of the point of entrance of the metal underground water service pipe that is electrically continuous and is in direct contact with the earth for at least 10 feet per NEC 250.68(C).

D. Where a grounding electrode conductor exits a metal raceway, (conduit or EMT), T&B or equal rigid threaded conduit grounding hub/clamp fitting shall be used.

E. Grounding bushings with bonding jumpers shall be used around concentric or eccentric knockouts on equipment and on raceways stubbed up below open-bottom equipment such as pad-mounted transformers, switchgear, substations, and switchboards.

F. For service equipment, including service-entrance panelboards and switchboards, bonding shall be done per NEC 250.92. As a minimum, ground bushings with bonding jumpers (sized per Table 250.66) or myers hubs shall be used for this.

G. Grounding pole of each polarized receptacle (non-isolated ground type) shall be bonded to its outlet box with conductor sized in accordance with Table 250.122 of the National Electrical Code and a machine or self-tapping screw, unless the receptacle is of the approved self-grounding type. Grounding pole of each isolated ground receptacle shall be connected to an insulated equipment grounding conductor.

H. Grounding conductors used to bond across flexible metal conduits containing transformer secondary conductors shall be sized per NEC Table 250.66 based on size of the secondary conductors.

I. Each branch circuit and feeder shall be provided with a ground conductor installed with the circuit conductors. Each ground conductor shall be a green insulated copper conductor, with minimum size in accordance with Table 250.122 of the National Electrical Code NFPA-70. These grounding conductors are not shown on the drawings.

J. A 3/4" diameter by 10' long copper clad ground rod shall be installed at service pole, and the raceways installed vertically up the service pole shall be bonded thereto with #2 B.C.

K. Where water pipe grounding connection is made underground, a suitable plastic pipe sleeve and flush metal cover shall be installed to provide access to the connection.

L. Where ground connections are made in walls or inaccessible ceilings, access

panels shall be installed. Access panels in walls shall be stainless steel.

M. See drawings for additional grounding requirements.

3.6 MOUNTING HEIGHTS

A. If not otherwise indicated, mounting heights to centerline of outlets shall be as follows:

1. Receptacles -- 18" above floor.
2. Switches -- 48" above floor.
3. Wall-mounted lighting fixtures -- 7'0" above floor or, where mounted above exterior door, mirror or medicine cabinet, at a height just sufficient to clear the swing of the door or medicine cabinet.

B. The above mounting heights may be adjusted as required to permit bottom or top of plate to align with mortar joints in unfinished masonry walls, provided joints are not raked. Where joints are raked, adjust height as required to insure that center of outlet box will be in the center of masonry unit. Where outlets at different levels are shown adjacent, they shall, where possible, be installed on a common vertical centerline. Where these adjustments are made, 18" shall be the minimum mounting height for receptacles, telephone outlets, and computer outlets, and 48" shall be the maximum mounting height for switches.

3.7 MARKING OF STARTERS, SAFETY SWITCHES, AND PANELBOARDS

A. Each surface manual starting switch out of sight of the motor which it controls, and each panelboard, switchboard, transformer, enclosed circuit breaker, automatic transfer switch, contactor, magnetic starter, safety switch, and toggle switch used as an in-sight disconnect for any equipment regardless of location, shall be suitably identified by means of 1/4" high letters cut in white laminated phenolic strips to show black letters. Strips shall be attached to cover by means of two screws. Device plate for each flush manual starting switch and wall switch used as starting switch or safety switch shall be suitably engraved to identify the equipment controlled.

B. A permanent plaque/directory (white laminated phenolic to show black letters) shall be provided at each service disconnect location new and existing denoting all other services, feeders, and branch circuits supplying the building.

C. A sign shall be provided at service disconnect location indicating type and location of on-site power sources.

D. A phenolic nameplate shall be provided on switchboards to indicate the upstream device (panelboard, switchboard, etc.) where the power originates (e.g. "Panel ____ (fed from Panel ____)", etc.).

E. Where an in-line electrical meter is installed on the load side of a disconnect switch, a phenolic nameplate shall be provided on the disconnect switch to read "Meter Disconnect - Not Service Equipment".

- END OF SECTION -

SECTION 16400 - ELECTRICAL SERVICE AND DISTRIBUTION SYSTEM

PART 1 - GENERAL

1.1 SCOPE

Work described in this Section includes providing labor, materials, and equipment indicated, specified, and necessary for a complete and operating distribution system and related systems, in accordance with SECTION 16010 - ELECTRICAL GENERAL PROVISIONS.

1.2 APPLICABLE PARAGRAPHS

Applicable paragraphs of SECTION 16100, ELECTRICAL BASIC MATERIALS AND METHODS, shall apply to this Section as though repeated herein.

1.3 EQUIPMENT LOCKS

Panelboards, cabinets, and other electrical equipment having doors with locks, shall be keyed alike. Keys (one set for each electrical equipment item containing locks) shall be provided to the Owner.

1.4 SERVICE EQUIPMENT

Safety switches, panelboards, and switchboards used as service equipment shall be Underwriters Laboratories listed and labeled for the application. Barrier shall be included in these switchboards and panelboards per NEC 408.3(A)(2). A phenolic nameplate (white with black-cut letters) shall be provided on service equipment to indicate "available fault current is ____KA" and date that "calculation was made on ____".

1.5 JOB NAMEPLATE

An 8" x 5" white micarta job nameplate with black-cut letters (minimum 3/16" high) as directed shall be provided on the main switchgear SWGR A; it shall include name of Architects, name of Engineers, name of Contractor, and year. Submittal shall include a full-size representation of this for review.

1.6 PANELBOARD CONFIGURATION

Panelboard configurations shall be altered (bus ratings, heights, etc.) as necessary to suit specified panelboard options (feed through lugs, surge protection devices, etc.).

PART 2 - PRODUCTS

2.1 PRIMARY SWITCHGEAR

See drawings.

2.2 UNIT SUBSTATIONS

See drawings.

2.3 CIRCUIT BREAKERS

A. Each circuit breaker shall have continuous current rating visible without removing an enclosure cover, and the rating shall be engraved. This may be accomplished by installation of a phenolic label (white with black cut letters) adjacent to the circuit breaker. Circuit breakers shall be suitable for use with 75 degree C conductors. Where circuit breakers are used to supply HVAC equipment having motor group combinations, type HACR circuit breakers shall be used.

B. Unless indicated otherwise, circuit breaker spaces and spare circuit breakers shall be divided equally between sections of multi-section panelboards.

C. Where ground-fault protection is provided for 3-pole circuit breakers (or fusible switches), performance testing of the ground fault protection system shall be provided after installation. Written documentation for this test shall be provided to the Engineer.

D. Where a circuit breaker with adjustable long time trip (where cover over adjustment is not lockable per NEC 240.6 (C)) is used, conductor size for the protected feeder shall be increased by the Contractor to match maximum long time setting of the circuit breaker.

E. Circuit breakers in panelboards shall be fully rated for AIC; that is, series ratings are not acceptable.

F. Circuit breakers used to supply power to transformers shall have pad-lock "off" feature, unless the circuit breaker is within sight of the transformer.

G. Where the highest continuous current trip setting of a circuit breaker is rated or can be adjusted to 1200A or higher, the circuit breaker shall have solid state trip unit with clearing time reduction feature per NEC 240.87.

H. Circuit breakers for circuits feeding appliances that are hard-wire connected and do not have integral disconnects or sight disconnects shall be provided with permanently-attached handle padlockable lock-off to meet the requirements of NEC 422.31(B) & (C). Examples of this would be hand dryers, fire alarm panels, hardwired electric water coolers, engine generator water jacket heaters, and battery chargers.

2.4 DRY TYPE TRANSFORMERS

A. Transformers shall have copper windings, 220 degree insulation, and maximum 115 degree C rise. Transformers shall be 480 volt single phase to 120/240 volt with 2 - 5% FCBN taps, and 480 volt 3-phase delta to 120/208 volt, 4-wire, 3-phase, wye, with 4 - 2½% FCBN and 2 - 2½% FCAN taps. Transformers shall have built-in vibration dampening system, and sound level shall not exceed NEMA ST-20 standards. Transformer shall have DOE 10 CFR Part 431 (2016) efficiency.

B. Unless noted otherwise on drawings, transformers 30 KVA and below shall be wall mounted, and transformers above 30 KVA shall be floor mounted on 3" high concrete base reinforced with 6 x 6 - 6/6wvf. Where walls cannot properly support transformer, galvanized strut frames supported to floor and ceiling structure shall be provided to support transformers.

C. Unless noted otherwise on drawings, transformers installed indoors shall have ventilated enclosures; transformers installed outdoors shall have totally enclosed enclosures approved for outdoor applications or shielded, ventilated enclosures approved for outdoor applications.

D. Transformer submittal shall include inrush current data plotted on primary overcurrent device curves.

E. Equipment shall be manufactured by GE, Cutler Hammer, Square D, or Siemens.

F. Contractor shall set the transformer taps to the optimum setting after loads are applied.

2.5 PRIMARY CABLES (15 KV)

A. Primary cables shall be single-conductor, ethylene-propylene base compound insulated, shielded, polyvinyl chloride compound sheathed cable for use in conduit, underground duct and cable tray; 15 KV ungrounded Okonite type Okaguard-Okoseal or equal. See drawings for conductor size. Equal conductors as manufactured and tested by Anaconda, Pirelli, or Phelps Dodge will be acceptable, if all features are equal to the Okaguard - Okoseal.

B. Conductor shall be copper with Class "B" stranding. The conductor shall have an extruded EP semi-conducting strand screen over which shall be applied a 220 mil wall of ethylene-propylene base compound insulation (105 degrees C continuous operating temperature and 140 degrees emergency overload rating). Over the insulation shall be an extruded 40 mil EP semi-conducting insulation screen and a 5 mil bare copper shielding tape (minimum 12.5% overlap). Overall shall be polyvinyl chloride jacket of .080" thickness.

C. After being submerged in water for at least six hours, the cable shall be tested at 33 KV AC for 5 minutes.

D. The 15 KV power cables shall be given DC high potential tests of 65 KV for ten minutes. These tests shall be made after installation and after potheads or other terminations have been made, but before connections have been made to busses or apparatus. A DC milliammeter in series with the ground connection of the high voltage transformer shall be used to read the leakage current in the cable at one minute intervals during the test. A variable ratio voltage regulator of adequate rating shall be used to permit the raising of test voltage at a slow, but uniform rate from zero to test value. Testing time shall be started when the voltage on the cable has attained test value. If a cable fails, the fault shall be located and all cables in that conduit between the nearest termination or splice on each side of the failure shall be withdrawn. If, in the opinion of the Engineer, the other cables in the same conduit have not been damaged, they may be re-installed, but the cable which failed shall be replaced by new cable. After the replacement of the faulty cable, and any other damaged cables, all cables of the circuit in that conduit shall be re-tested.

E. An insulated ground conductor with 600 volt polyvinyl chloride insulation to be compatible with jacket of 15 KV conductors shall be provided with each primary feeder conduit.

F. Each set of feeder cables shall be grouped/binded with its ground conductor inside equipment, manholes, etc.

2.6 TERMINATIONS FOR PRIMARY CABLES, INSULATED 15 KV

A. Each termination in the 15 KV metal enclosed switchgear and 15 KV substations shall be made in porcelain potheads or preformed stress control terminals with skirted insulator, bracket, lug, and required accessories. Each shall be as required to suit that particular equipment.

B. Terminations shall be as manufactured by Blackburn, Burndy, Elastomold, General Electric, 3M company, G & W, or Joslyn.

2.7 FAULT CURRENT AND PROTECTIVE DEVICE COORDINATION STUDY

A. A fault current and protective device coordination study shall be prepared by the Contractor within 30 calendar days following final review of circuit protective devices, including circuit breakers, fuses, overloads, and protective relays. The study shall include calculations and composite time-current characteristic coordination curves (in color) to demonstrate optimum coordination of protective devices to be installed and to protect equipment and conductors against fault currents and sustained overload conditions for conductors and equipment to be installed. The study shall include the proper ratings of fuses and proper settings of adjustable circuit breakers associated with the protection of equipment and conductors and optimum selective coordination. If necessary, the study shall also make recommendations for changes to new protective devices, and these changes shall be made by the Contractor at no additional cost to the Owner; for this reason, the study shall be finalized prior to Contractor releasing equipment for production.

Also for this reason, the Contractor should consider using the panelboard manufacturer to make this study. Contractor shall test and calibrate protective devices in accordance with the manufacturers' specification after making the proper device settings and before the initial energization of the conductors and equipment. Contractor shall obtain required data from the utility company for coordination with the utility company's facilities. The Study shall be submitted as printed copies using color copies for the coordination curves. The Study shall be prepared by a registered professional Engineer and shall contain his signed and dated seal on the first page.

B. The scope of this study shall not only be limited to the equipment indicated on the Schematic Feeder Diagram; rather, the study shall also address safety switches, motor starters, branch circuits (including those rated 20A and less), etc. This will require a complete understanding of the entire set of construction documents by the preparer of the study.

C. Unless otherwise noted, selective coordination shall consist of localization of an overcurrent condition to restrict outages to the circuit or equipment affected, accomplished by the selection and installation of overcurrent protective devices and their ratings or settings for the full range of available overcurrents, from overload to the maximum available fault current, and for the full range of overcurrent protective device opening times associated with those overcurrents.

D. Partial or limited coordination, such as coordination for operating times of only 0.1 seconds or longer, will not be considered acceptable. Selective coordination shall be documented in the study for all times, including those (below 0.01 seconds) that may not be able to be represented using time-current curves. This documentation may further require manufacturer-specific testing results, ampacity ratio tables for specific fuses, coordination testing results for circuit breaker frame sizes at specific fault current levels, etc.

E. The study shall be prepared by a licensed professional engineer engaged primarily in the design, installation, or maintenance of electrical systems. Furthermore, the study shall contain the engineer's seal and date indicating responsibility for the correctness of the study. The selection shall be documented and made available to those authorized to design, install, inspect, maintain, and operate the system.

F. A phenolic nameplate (white with black-cut letters) shall be provided on each item of switchboards, switchgear, and panelboards to indicate "available fault current is ____ KA" and date that "calculation was performed on ____".

2.8 ARC FLASH HAZARD STUDY

A. An ARC flash hazard study in accordance with NFPA 70E guidelines shall be prepared by the Contractor, to provide a summary table to include energy levels/faults, equipment characteristics, working boundaries, and hazard/risk categories for all new substations, medium-voltage transformers, circuit breakers, safety switches, etc. The study shall include complete descriptive narratives of methods used and effect of the results. The Contractor shall also install the specific NFPA 70E arc flash labels on the exterior surfaces of each of these equipment items. In order to accomplish this, it will be necessary for the Contractor to prepare an abbreviated fault current study to obtain the fault levels necessary. Contractor's work shall include obtaining information on the upstream distribution system. Contractor shall also obtain required data from the utility company as power source (and shall consider engine generators as the power source as necessary). This study shall be prepared, and a report booklet shall be submitted to include a copy of each specific NFPA 70E arc flash label along with the name of the equipment on which it will be installed. The Contractor shall also install the specific NFPA 70E arc flash labels on the exterior surfaces of each equipment item; except for panelboards in dwelling units.

PART 3 - EXECUTION

3.1 UNDERGROUND MAIN SERVICE

A. Arrange with local power company to provide 4-wire, 3-phase, 13800 volt main service to the point indicated.

B. Main underground service feeders shall be furnished and installed from the building service equipment to the connection to the power company service as work of this Section.

C. Provide primary raceways from transformer to power company pole with nylon pull rope in active raceway.

D. Provide concrete pad and ground grid for pad-mounted transformer.

E. Primary cable and transformer will be provided by the power company.

F. Metering equipment, including current transformers and enclosure, meter, conduit and wiring, shall be in accordance with the power company's regulations.

G. Work of this Section shall begin at the point where the power company terminates its work.

H. Fees and charges in connection with the above shall be paid as work of this Section and shall be included in the bidder's price.

3.2 INSTALLATION OF PRIMARY CABLES, INSULATED, 15 KV

A. Unless otherwise indicated, terminations shall be made with porcelain potheads or with preformed stress control cable terminations, 15 kv, single conductor type. Terminations and splices shall be made in accordance with the manufacturer's recommendation for the 15 KV cable installed. No splices in the cable will be permitted unless specifically noted on drawings. Terminations shall be made by experienced high-tension cable splicer mechanic. Contractor shall submit for approval a description of the past experience of each proposed man and such submission shall include types of cable splices, approximate number and types of splices, cable voltages, name and location of projects and of employers.

B. Primary conductors shall be installed in accordance with the manufacturer's recommendations, good engineering and installation practices and in such a manner that the conductors will not be damaged or the maximum permitted pulling tension exceeded. Where installed in conduits, conductors shall be installed using pulling eyes attached to the copper conductors.

3.3 RACEWAY STUB-UPS

A. Where raceways were stubbed up under substations and switchgear, grounding bushings shall be installed on the raceways.

1. Bonding jumpers shall be installed between bushings and ground bus (sized per NEC Table 250.66 or Table 250.122 as applicable).

3.4 PANELBOARD SIZING AND LOCATIONS

A. Panelboards shall be sized so that they are located above the Base Flood Elevation and that all circuit breakers and fusible switches meet the requirements of NEC 404.8 to be used as switches.

3.5 ELECTRICAL EQUIPMENT AREAS

A. Contractor shall review the physical sizes of the substations, panelboards, transformers, etc. (based on shop drawings) and assure that they will fit in the electrical equipment areas with proper code clearances. The locations may require adjustment. Contractor shall provide a 1/4" scale drawing of each area containing electrical equipment to demonstrate that the equipment fits properly.

3.6 POWER COMPANY SERVICE

A. The location of power company facilities (power poles, manholes, pads, etc.) are shown where designated by power company during the design phase. Contractor shall coordinate the exact locations of these with power company and plan for contingencies.

- END OF SECTION -

SECTION 16500 - ELECTRICAL LIGHTING

PART 1 - GENERAL

1.1 SCOPE

Work described in this Section includes labor, materials, and equipment indicated, specified, and necessary for a complete and operating lighting system and related systems in accordance with SECTION 16010 - ELECTRICAL GENERAL PROVISIONS.

1.2 APPLICABLE PARAGRAPHS

Applicable paragraphs of SECTION 16100 - ELECTRICAL BASIC MATERIALS AND METHODS, shall apply to this Section as though repeated herein.

PART 2 - PRODUCTS

2.1 LIGHTING FIXTURE GENERAL REQUIREMENTS

A. Fixtures shall be as specified in schedule on drawings. However, each lighting fixture shall be fully compatible with the ceiling type in the area in which it is to be installed. During the preparation of submittal, Contractor shall coordinate the mounting type required for each lighting fixture with the type of ceiling system in the area in which the fixture is to be installed. Contractor shall coordinate with architectural ceiling plans and other details and adjust the mounting type of each lighting fixture proposed to be installed to suit the associated ceiling system regardless of the specified lighting fixture mounting details specified. Submittal shall also include recommended installation details for each lighting fixture to suit the type of associated ceiling system.

B. Fixtures to be installed in damp or wet locations shall be labeled by Underwriters' Laboratory for that purpose.

C. Fixtures shall be finished (painted or other finish as specified) after fabrication.

2.2 LED (LIGHT EMITTING DIODE) LIGHTING FIXTURES

A. Provide LED fixtures complete with LED module, aluminum heat sink, drivers, and other accessories as shown on drawings.

B. Fixtures shall be completely designed based on LEDs and not designed around an LED-based lamp meant to install into an existing fixture. Retrofit LED lamp/module into an existing fixture shall not be allowed.

C. Aluminum Heat Sinks: All LED luminaires shall have an aluminum heat sink integral to fixture housing and designed for proper electrical bonding of LED module to allow maximum heat dissipation and to provide thermal management within the allowable operating range of the LED as specified by the LED manufacturer. The junction temperature (Tj) of each LED shall not exceed the maximum junction temperature specified in the manufacturer's product data sheet.

D. Unless noted otherwise on the drawings, LEDs installed in each fixture shall be of the type specifically recommended by the manufacturer of the fixture for use in the fixture.

2.3 LAMPS

A. Where existing fixtures are to be relocated or removed and reinstalled, each shall be completely relamped using the existing (properly operating) lamps and supplemented by new lamps.

2.4 LED (LIGHT EMITTING DIODE) DRIVERS

A. Provide LED system drivers, of ratings, types and makes as recommended by LED manufacturer. Driver for LED systems shall be electronic, 1 phase, 60 hertz, high power factor, constant current without elevated inrush current, electronic, low noise level, a minus 40 deg C temperature rating, and shall be furnished by the manufacturer of each type or particular lighting fixture specified.

B. Driver shall have a Class A sound rating.

C. Driver shall have a guaranteed minimum power factor of 0.90. (PF = Watts/Volt-Amps).

D. Driver shall be installed inside an electrical enclosure. Wiring inside electrical enclosure shall comply with 600V/105degC rating or higher.

E. Driver shall be available in a plastic/metal can or all metal can construction to meet all plenum requirements.

F. Driver shall be provided with poke-in wire trap connectors or integral leads color coded per ANSI C82.11.

G. Driver shall comply with UL standard UL1012

H. Driver shall have a rated lifetime of 50,000 hours

I. Driver shall operate from 60 Hz input source of 120 to 277V with sustained variations of +/- 10% (voltage and frequency) with no damage to the driver.

J. Driver output shall be regulated to +/- 5% across published load range.

K. Driver input current shall have Total Harmonic Distortion (THD) of less than 20%

L. Driver shall reduce output power to LEDs if its case temperature exceeds 85C - thermal protection.

M. Driver shall tolerate sustained open circuit and short circuit output conditions without damage and without need for external fuses or trip devices

N. Driver shall be IP64 rated except as indicated.

O. Driver shall not contain PCBs.

P. Driver shall comply with ANSI C62.41 Category A for Transient protection.

Q. Driver shall comply with the requirements of the Federal Communications Commission (FCC) rules and regulations, Title 47 CFR part 15, Non-Consumer (Class A) for EMI/RFI (conducted and radiated).

R. Driver shall be manufactured in a factory certified to ISO 9002 Quality System Standards.

S. Driver shall carry a five-year manufacturer's warranty from date of manufacture against defects in material or workmanship, including replacement, for operation at a maximum case temperature of 90C.

T. Driver manufacturer shall have a fifteen year history of producing electronic drivers for the North American market.

U. Battery backup shall be manufactured to provide a minimum of 1400 lumens per fixture for 1½ hours operation during the emergency mode. Fixture shall contain an integral manual test button for testing purposes to provide a visual and audible alarm. A test button remotely installed from the fixture is not acceptable.

2.5 LED (LIGHT EMITTING DIODE) MODULES

A. LED Modules shall be of the type, color, and optical distribution indicated, as shown, and scheduled

B. LEDs shall be handled and soldered to printed circuit boards (PCBs) according to the manufacturer's specifications.

C. LEDs shall produce a white light of the color temperature shown on the Fixture Schedule located on the drawings and not less than 75CRI value on the color rendering index.

- D. LEDs shall be high brightness and high output.
- E. LED performance and lumen maintenance testing shall be performed in accordance with IES LM-79-08 and LM-80-08.
- F. LEDs shall provide approximately 50,000 hours of lighting at a level not less than 70% of initial lumen output. LEDs shall operate from 60 Hz input source of constant 350mA with sustained variations of +/- 10% (current and frequency) with no damage to the LEDs.
- G. LED lumen output shall be regulated to meet or exceed the published standard minimum Luminous flux.
- H. Unless stated otherwise, LEDs shall be 3500K in color and shall be within +/- 200K of specified color temperature and shall be from the same bin.
- I. LED manufacturer shall utilize strict binning and labeling techniques to ensure consistent brightness within +6 lm of published standard luminous flux and consistent chromaticity within +/-200K of specified color temperature per bin. Each bin shall be labeled with appropriate bin code relative to luminous flux and chromaticity.
- J. LEDs shall have a minimum operating temperature of -40C.
- K. LEDs shall be environmentally friendly, contain no mercury, lead or other heavy metals, and manufactured in compliance with RoHS and REACH.
- L. LEDs and associated components of the LED Modules shall be manufactured in a factory certified to ISO 9002 Quality System Standards.
- M. LEDs and associated components of the LED Modules shall carry a five-year manufacturer's warranty from date of manufacture against defects in material or workmanship, including replacement, for operation within specified system design parameters.
- N. LED manufacturer shall have a fifteen year history of producing LEDs for the North American market.

PART 3 - EXECUTION

3.1 LOCATION OF FIXTURES

- A. The locations of fixtures in Electrical Enclosures are approximate. The Contractor shall determine exact locations based on exact locations of equipment.

3.2 INSTALLATION AFTER PAINTING

Fixtures to be installed in or on painted ceilings and/or walls shall not be installed until painting is completed. Fixtures installed with paint applied over factory finishes will be rejected.

3.3 PROCEDURE

The Contractor shall demonstrate to the Owner at his convenience the proper procedure for relamping each type of fixture.

3.4 FIXTURE COORDINATION

Lighting fixture submittal shall include data on each type of ceiling suspension system and associated acoustical tile. Information on the ceiling suspension systems shall include types of recessed fixture suitable for use with each type as well as recommended installation details.

- END OF SECTION -

SECTION 16600 - ELECTRICAL SPECIAL SYSTEMS

PART 1 - GENERAL

1.1 SCOPE

Work described in this Section includes providing all labor, materials, and equipment indicated, specified, and necessary for complete and operating systems in accordance with SECTION 16010 - ELECTRICAL GENERAL PROVISIONS.

1.2 APPLICABLE PARAGRAPHS

Applicable paragraphs of SECTION 16100 - ELECTRICAL BASIC MATERIALS AND METHODS, shall apply to this Section as though repeated herein.

1.3 SYSTEMS INVOLVED

A. Systems involved include the following:

1. Lightning Protection System

PART 2 - PRODUCTS

2.1 LIGHTNING PROTECTION SYSTEM

A. Lightning protection system equipment shall be installed on the building/structure and shall be copper and shall be as manufactured by Advanced Lightning Technology or East Coast Lightning Equipment. Aluminum material may be used only where a material compatibility issue occurs (roofs that utilize aluminum, galvalume, or galvanized metal parapets); for this, the down leads and grounding shall utilize copper with bimetal transition occurring at the thru-roof assemblies. Installed system shall comply in all respects with the requirements of Underwriters' Laboratories, Inc. for Master Label Certificate of Inspection, which necessitates that the installation be made by an accredited installer and that the appropriate UL listed surge protection devices (per UL1449, latest edition) are installed on the exterior of the service equipment (to be visible to the inspector). The installer shall be LPI certified (submit copy of LPI certificate with submittals). Before acceptance of project, an LPI Master Certificate of Inspection shall be provided to the Owner.

B. Prior to the commencement of any work, the Contractor shall submit for approval complete installation drawings, including roof plan, manufacturer's catalog data, and field installation details including references to UL and LPI.

C. Air terminals shall extend above the roof or parapet not less than 10" nor more than 36". Air terminals exceeding 24" in height shall be supported with suitable brace located at a point not less than one-half of the air terminal. Air terminals shall be of the blunt-end type. Air terminals shall be flexible spring type to avoid breakage by vandals.

D. Conductors shall be copper and not less than 204 lbs per thousand feet for buildings up to 75 ft. high.

E. Downleads of lightning protection system shall penetrate roof similar to N.R.C.A., details M-2 and U, 1989, using stainless steel threaded rod thru-roof assembly in 2" schedule 40 PVC capped conduit and as necessary to meet the Engineer's approval. Pitch pockets will not be allowed. Submittal shall include proposed detail.

F. The lightning protection Contractor shall submit specific details of the proposed system to both the roofing Contractor and roofing material manufacturer, and secure their written approval of the system including a statement that nothing in the lightning protection system will compromise the warranty/bond required to be furnished for the roofing system.

PART 3 - EXECUTION

3.1 LIGHTNING PROTECTION SYSTEM INSTALLATION

A. Conductors shall be concealed wherever possible. Conductors may be installed exposed on parapet walls and on membrane roofs. Downleads (and associated conduit that may be required) shall be concealed; however, structural steel may be used in lieu of downleads, if adequate. The Contractor shall cooperate with the roofing and sheet metal Contractor to insure adequate flashing where conductors pierce the roofing material. Where necessary to run conductors in conduit, the conductor shall be bonded to the top and bottom of the conduit.

B. No bend of a conductor shall form an angle of less than 90 degrees nor have a radius of bend of less than 8". Fasteners shall be spaced not more than 3 feet apart on all conductors and shall be of the same material as the conductor. Nails, screws, or bolts employed to secure the fasteners shall be of the same material as the fasteners or shall be of a material that is as resistant to corrosion as that of the fasteners. Galvanized or plated steel nails, screws, or bolts are not acceptable. Fasteners in masonry shall have anchors employing machine screws having a thread diameter of not less than 1/4" and shall be set with care. Holes made to receive the shank of the fastener or fitting shall be of the correct size, made with the proper tools, preferably made in the brick or stone rather than in the mortar joints. When set, the fit shall be tight against the moisture and the effect of frost and shall be capable of withstanding a test pull of 100 pounds. Acceptable connector fittings shall be used on all lightning conductors at end-to-end, tee or wye splices, they shall be attached so as to withstand a test pull of 200 pounds.

C. Connections of down conductors to ground electrodes shall be made at a point not less than 1 foot below grade level and 2 feet away from foundation wall. The lightning conductor, or acceptable electrodes, shall extend vertically not less than 10 feet into the earth; the earth shall be thoroughly tamped and made tight against the conductor or electrodes the full distance to which they are sunk. Clamps used to connect the down conductors to driven ground rods shall make contact with the ground rod for a distance of 1½", measured parallel to the axis of the ground rod. Electric and telephone service water pipe grounds shall be bonded to the lightning protection system ground.

D. Housing of roof exhaust fans shall be connected to the lightning conductor system, using bolt tension fittings of an acceptable type. Soil vent pipes within 6 feet of a main conductor shall be connected thereto. Antenna masts shall also be bonded to the main conductor.

-END OF SECTION -

