

SECTION 16100 – ELECTRICAL GENERAL PROVISIONS

PART 1 - GENERAL

1.1 GENERAL CONDITIONS

- A. Each Section within Division 16 - Electrical, shall conform to the requirements of the General Conditions of the Contract, including Supplementary General Conditions, Special Conditions, and all requirements of Division 1.
- B. Each Section within Division 16 - Electrical, shall conform to the additional requirements of this Section, Electrical General Provisions.
- C. All materials and labor specified in Division 16 shall be provided by the Electrical Subcontractor, not the General Contractor.

1.2 DEFINITIONS

- A. The term "As indicated" means as shown on drawings by notes, graphics or schedules, or written into other portions of contract documents. Terms such as "shown", "noted", "scheduled" and "specified" have same meaning as "indicated", and are used to assist the reader in locating particular information.
- B. The term "Provide" means furnish and install.
- C. The term "Furnish" means furnish only, for installation by others.
- D. The term "Install" means install whether equipment has been furnished under this Contract, by the Owner, or by others.

1.3 REFERENCE STANDARDS

- A. Material, equipment and installation shall meet requirements of applicable codes and standards listed below. Electrical material and equipment shall bear the UL label except where UL does not label such types of material and equipment.
- B. Reference standards are referred to by abbreviation as follows:
 - 1. American Concrete Institute ACI
 - 2. American National Standards InstituteANSI
 - 3. American Society for Testing and MaterialsASTM
 - 4. Virginia Uniform State Building Code USBC

1.4 LAWS AND REGULATIONS

- A. Comply with applicable laws and regulations in accord with the General Conditions, Supplementary Conditions and General Provisions.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed in each Section form a part of that Section to the extent referenced. The publications are referenced to in the text by the basic designation only.

- B. When a standard is specified by reference, comply with requirements and recommendations stated in that standard, except when requirements are modified by the Contract Documents, or applicable codes establish stricter standards.
- C. When a standard is not specified by reference in a Section, the work of that Section shall comply with applicable codes listed in the General Conditions, and Supplementary General Conditions.
- D. The publication date is the publication in effect as of the bid date, except when a specific publication date is specified.
- E. Obtain copies of referenced standards direct from publication source, when needed for proper performance of work, or when required for submittal by Contract Documents.

1.6 RECORD DRAWINGS

- A. Maintain a dedicated set of drawings on the jobsite and mark all variations taken to the Contract Drawings.

1.7 INTENT OF DRAWINGS AND SPECIFICATIONS

- A. The implied and stated intent of the drawings and specifications is to establish minimum acceptable quality standards for materials, equipment and workmanship, and to provide an operable electrical system complete in every respect.
- B. The drawings are diagrammatic, intending to show general arrangement and location of system components, and are not intended to be rigid in detail.
- C. Due to the small scale of the drawings, and to unforeseen job conditions, all required offsets and fittings may not be shown but shall be provided at no change in Contract price.

1.8 SHOP DRAWINGS

- A. Submit Shop Drawings in accordance with the General Conditions and Supplementary Conditions.
- B. Designate in the construction schedule, or in a separate coordinated schedule, the dates for submission and the dates that reviewed Shop Drawings will be needed.
- C. Shop Drawings shall be presented in a clear and thorough manner.
- D. Submit for approval all drawings prepared by the Contractor, for the Contractor's use.
- E. Prepare product data as follows:
 - 1. Clearly mark each copy to identify pertinent products or models.
 - 2. Show performance characteristics and capacities.
 - 3. Show dimensions and clearances required.
 - 4. Show wiring diagrams and controls.
- F. Manufacturer's standard schematic drawings and diagrams:
 - 1. Modify drawings and diagrams to delete information which is not applicable to the work.
 - 2. Supplement standard information to provide information specifically applicable to the work.

- G. The Contractor shall:
1. Review Shop Drawings prior to submission.
 2. Determine and verify:
 - a. Field measurements.
 - b. Field construction criteria.
 - c. Catalog numbers and similar data.
 - d. Conformance with specifications.
 3. Coordinate each submittal with requirements of the work and of the Contract Documents.
 4. Notify the Engineer in writing, at time of submission, of any deviations in the submittals from requirements of the Contract Documents.
 5. Begin no fabrication or work which requires submittals until return of submittals with Engineer approval.
 6. Make submittals promptly in accordance with approved schedule, and in such sequence as to cause no delay in the work or in the work of any other trade.
- H. Submit Shop Drawings as PDF documents.
- I. Submittals shall contain:
1. The date of submission and the dates of any previous submissions.
 2. The Project title and number.
 3. Contract identification.
 4. The names of:
 - a. Contractor.
 - b. Supplier.
 - c. Manufacturer.
 5. Identification of the product, with the specification section number.
 6. Field dimensions, clearly identified as such.
 7. Relation to adjacent or critical features of the work or materials.
 8. Applicable standards.
 9. Identification of deviations from Contract Documents.
 10. Identification of revisions on resubmittals.

11. Shop Drawing Review Stamp Sheet as found in Part 4 of this Section with Electrical Contractor's section executed certifying to review of submittal, verification of products, field measurements and field construction criteria, and coordination of the information within the submittal with requirements of the work and of Contract Documents.
 13. Each submittal shall be limited to a single specification section. Submittals shall not be grouped with other sections in common binders or under common control sheets. Each submittal shall have a cover/control sheet containing the information listed above (1 thru 11).
 14. Submittals which do not comply with these requirements may be returned with no action taken at the reviewer's discretion.
- L. For resubmission requirements the Contractor shall:
1. Make required corrections and changes in the submittals and resubmit until approved.
 2. Revise initial drawings or data and resubmit as specified for the initial submittal.
 3. Indicate any changes which have been made other than those requested in the previous submittal.
- M. The Contractor shall distribute reproductions of the approved shop drawings and copies of approved product data:
1. Job site file.
 2. Record Documents file.
 3. Other affected contractors.
 4. Subcontractors.
 5. Supplier or fabricator.
- N. The Engineer shall:
1. Review submittals with reasonable promptness and in accordance with schedule.
 2. Affix stamp and initials or signature, and indicate requirements for resubmittal, or approval of submittal.
 3. Return submittals to Contractor for distribution, or for resubmission.
- O. Submit shop drawings for the following identified by section number and product name:
- | | |
|-------|---|
| 16173 | Power System Analysis |
| 16174 | Harmonic Analysis |
| 16180 | Acceptance Testing |
| 16201 | Metallic Raceway |
| 16202 | Nonmetallic Raceway |
| 16219 | Wire, Cable, and Wiring (Single-Conductor) (600 Volt Max) |
| 16220 | Multi-Conductor Cable (600 Volt Max) |
| 16221 | Grounding |
| 16300 | Supporting Devices |
| 16301 | Pull and Junction Boxes |
| 16302 | Wiring Device Boxes |

| | |
|-------|-------------------------------------|
| 16400 | Underground Ducts |
| 16401 | Underground Pull Boxes |
| 16500 | Dry Type Transformers |
| 16501 | Panelboards |
| 16502 | Wiring Devices |
| 16503 | Safety Switches |
| 16504 | Molded Case Circuit Breakers (MCCB) |
| 16505 | Motor Starters |
| 16506 | Surge Protective Devices (SPD's) |
| 16600 | Lighting |

1.9 SUBSTITUTIONS AND PRODUCT OPTIONS

- A. Submit substitutions with the Contractor's bid and include the dollar amount by which the contract will decrease.
- B. When an item of material or equipment which is different to that specified is submitted for approval, it shall be the responsibility of the Contractor to submit data comparing the substitution against the specified item. The data shall indicate that the submitted item is equal in all respects to the specified item.
- C. Where an item of material or equipment is approved as "equal" by the Engineer to the specific or specifics shown or specified in the CONTRACT DOCUMENTS, the work of this DIVISION shall include the cost of an entire responsibility for change in the work as shown or specified, caused by the use of such approved substitutions. In addition, make all such arrangements and assume all costs caused by changes in the work of other trades that may be required in order to install the approved substitution. Such changes shall not be cause of a subsequent Change Order increasing the CONTRACT SUM.
- D. Products List:
1. Within 30 days after Contract Date, submit to Engineer a complete list of major products proposed to be used, with the name of the manufacturer and the installing subcontractor.
- E. Contractor's Options:
1. For Products specified only by reference standard, select any product meeting that standard.
 2. For products specified by naming several products or manufacturers, select any one of the products or manufacturers named, which complies with the specifications.
 3. For products specified by naming one or more products or manufacturers and "or equal", Contractor must submit a request as for substitutions for any product or manufacturer not specifically named.
 4. For products specified by naming only one product and manufacturer, there is no option.
- F. Substitutions:
1. For a period of 30 days after Contract date, Engineer will consider written requests from Contractor for substitution of products.
 2. Submit a separate request for each product, supported with complete data, with drawings and samples as appropriate, including.
 - a. Comparison of the qualities of the proposed substitution with that specified.

- b. Changes required in other elements of the work because of the substitution.
 - c. Effect on the construction schedule.
 - d. Cost data comparing the proposed substitution with the product specified.
 - e. Required license fees or royalties.
 - f. Availability of maintenance service, and source of replacement materials.
3. The Engineer shall be the judge of the acceptability of the proposed substitution.
- G. Contractor's Representation:
1. A request for a substitution constitutes a representation that Contractor:
 - a. Has investigated the proposed product and determined that it is equal to or superior in all respects to that specified.
 - b. Will provide the same warranties or bonds for the substitution as for the product specified.
 - c. Will coordinate the installation of an accepted substitution into the work, and make such other changes as may be required to make the work complete in all respects.
 - d. Waives all claims for additional costs, under his responsibility, which may subsequently become apparent.
- H. Engineer will review requests for substitutions with reasonable promptness, and notify Contractor, in writing, of the decision to accept or reject the requested substitution.

1.10 MANUFACTURER'S INSTRUCTIONS

- A. When Contract Documents require that installation of work shall comply with manufacturer's printed instructions, obtain and distribute copies of such instructions to parties involved in the installation, including the Engineer. Maintain one set of complete instructions at the job site during installation and until completion.
- B. Handle, install, connect, clean, condition and adjust products in strict accordance with such instructions and in conformity with specified requirements.
1. Should job conditions or specified requirements conflict with manufacturer's instructions, consult with Engineer for further instructions.
 2. Do not proceed with work without clear instructions.
- C. Perform work in accordance with manufacturer's instructions. Do not omit any preparatory steps or installation procedure unless specifically modified or exempted by Contract Documents.

1.11 TRANSPORTATION AND HANDLING

- A. Arrange deliveries of products in accordance with construction schedules, coordinate to avoid conflict with work and conditions at the site.
1. Deliver products in undamaged condition, in manufacturer's original containers or packaging, with identifying labels intact and legible.

2. Immediately upon delivery, inspect shipments to assure compliance with requirements of Contract Documents and approved submittals, and that products are properly protected and undamaged.
 - B. Provide equipment and personnel to handle products by methods to prevent soiling or damage to products or packaging.
- 1.12 STORAGE AND PROTECTION
- A. Store products in accordance with manufacturer's instructions, with seals and labels intact and legible.
 1. Store products subject to damage by the elements in weathertight enclosures.
 2. Maintain temperature and humidity within the ranges required by manufacturer's instructions.
 - B. Exterior Storage:
 1. Store fabricated products above the ground, on blocking or skids, prevent soiling or staining. Cover products which are subject to deterioration with impervious sheet coverings, provide adequate ventilation to avoid condensation.
 2. Store loose granular materials in a well-drained area on solid surfaces to prevent mixing with foreign matter.
 - C. Arrange storage in a manner to provide easy access for inspection. Make periodic inspections of stored products to assure that products are maintained under specified conditions, and free from damage or deterioration.
 - D. Protection After Installation: Provide substantial coverings as necessary to protect installed products from damage from traffic and subsequent construction operations. Remove when no longer needed.
- 1.13 CUTTING AND PATCHING
- A. Cutting and patching shall be done in a workmanlike manner using tools and materials suitable for the purpose.
- 1.14 CLEANING UP / REMOVAL OF DEBRIS
- A. Clean up all areas affected by this work broom clean. Remove all debris from the jobsite daily
- 1.15 OPERATING AND MAINTENANCE DATA
- A. Compile product data and related information appropriate for Owner's maintenance and operation of products furnished under Contract.
 - B. Instruct Owner's personnel in maintenance of products and in operation of equipment and systems.
 - C. Preparation of data shall be done by personnel:
 1. Trained and experienced in maintenance and operation of described products.
 2. Familiar with requirements of this Section.
 3. Skilled as technical writer to the extent required to communicate essential data.

4. Skilled as draftsman competent to prepare required drawings.
- D. Prepare data in form of an instructional manual for use by Owner's personnel.
- E. Prepare manual as an electronic PDF document
- F. Identify each volume with "OPERATING AND MAINTENANCE INSTRUCTIONS". List:
 - a. Title of Project.
 - b. Identity of general subject matter covered in the manual.
- G. Manual shall contain a table of contents for each volume, arranged in systematic order.
 1. Contractor, name of responsible principal, address and telephone number.
 2. A list of each product required to be included, indexed to content of the volume.
 3. List, with each product, name, address and telephone number of:
 - a. Subcontractor or installer.
 - b. Maintenance contractor, as appropriate.
 - c. Identify area of responsibility of each.
 - d. Local source of supply for parts and replacement.
 4. Identify each product by product name and other identifying symbols as set forth in Contract Documents.
- H. Product Data:
 1. Include only those sheets which are pertinent to the specific product.
 2. Annotate each sheet to:
 - a. Clearly identify specific product or part installed.
 - b. Clearly identify data applicable to installation.
 - c. Delete references to inapplicable information.
- I. Drawings:
 1. Supplement product data with drawings as necessary to clearly illustrate:
 - a. Relations of component parts of equipment and systems.
 - b. Control and flow diagrams.
 2. Coordinate drawings with information in Project Record Documents to assure correct illustration of completed installation.
 3. Do not use Project Record Documents as maintenance drawings.

- J. Written text, as required to supplement product data for the particular installation:
 - 1. Organize in consistent format under separate headings for different procedures.
 - 2. Provide logical sequence of instructions for each procedure.
- K. Copy of each warranty, bond and service contract issued. Provide information sheet for Owner's personnel, stating:
 - 1. Proper procedures in event of failure.
 - 2. Instances which might affect validity of warranties or bonds.
- L. Submittals:
 - 1. For review: Submit one copy as a PDF document.
 - 2. For archives: After the review manual has been approved, submit revised version.
- M. Submit operating and maintenance data on the following:
 - 16173 Power System Analysis
 - 16180 Acceptance Testing
 - 16213 Dry Type Transformers
 - 16416 Panelboards
 - 16816 Molded Case Circuit Breakers (MCCB)
 - 16918 Variable Frequency Drives (VFD's)
 - 16280 Active Harmonic Filters (AHF's)
 - 16313 Surge Protective Devices (SPD's) ???
 - 16410 Lighting
 - 16900 Instrumentation & Controls

1.16 GUARANTEE OF WORK

- A. Where applicable, furnish manufacturer's written warranty for materials and equipment.
- B. Insert warranties in appropriate locations in operating and maintenance manuals.
- C. Materials and equipment, which have seasonal operation limitations, shall be guaranteed for one year from date of seasonally appropriate test, and acceptance in writing by the Owner.

1.17 MATERIALS AND WORKMANSHIP

- A. It is the intent of these specifications to establish quality standards for all material and equipment incorporated in the work of this DIVISION. All materials and equipment installed hereunder shall be new. Exercise proper care in handling all materials and equipment herein specified so as not to injure or mar finished surfaces and to insure that the work is acceptable in every respect upon completion.
- B. Install materials as indicated on the drawings or in accordance with the manufacturer's recommendations as approved by the Engineer. The installation shall be accomplished by workmen skilled in their respective trades.

1.18 PROTECTION OF WORK AND EQUIPMENT

- A. Protect against damage to equipment, apparatus, materials, devices, and accessories during the course of construction, through the use of protective coverings, barriers, railings and similar devices. Utilize protective materials and methods suitable for the application. Correct damage that occurs in the course of the project.

1.19 COORDINATION OF WORK

- A. Coordinate the work of this DIVISION with the work of other DIVISIONS and SECTIONS of these specifications in order to avoid conflicts between the work of the various trades.

1.20 WIRING AND ELEMENTARY DIAGRAMS

- A. Wiring and elementary diagrams for equipment as shown on the drawings are based on the product of the specified equipment manufacturer and are shown for convenience to aid in estimating the extent of the work involved. Wire the equipment actually installed and connect in accordance with the equipment manufacturer's recommendations conforming to details in approved wiring diagrams furnished by the equipment manufacturer. Connect all equipment to operate in a safe, proper and efficient manner. Note that control circuitry is not necessarily shown on the drawings. Install in conduit between the points and devices indicated on the diagrams.

1.21 SETTING OF EQUIPMENT

- A. Coordinate the setting of equipment with the work and requirements of the other trades involved to insure compatibility and to avoid conflicts.
- B. Equipment, base mounted on concrete or masonry slabs, pads and piers, or mounted on stands, gratings, platforms, or other, shall not be set in any manner, except on the finished and permanent support.
- C. Support of equipment on studs or by other means, and the placing or building of the supporting slab, pad, pier, stand, grading, or other, "to the equipment", is prohibited.

PART 2- PRODUCTS

- 2.1 Not used

PART 3 - EXECUTION

- 3.1 All electrical work shall be performed by or under the direct supervision of a master electrician licensed to work in the project location.
- 3.2 Provide equipment connections complete with motor controls, switches, wiring devices, control devices, protective devices, wiring, and other accessories. All equipment and connections shall be as recommended by the manufacturer or as indicated on drawings or required by specifications.
- 3.3 Equipment connections for equipment furnished by the Owner or under separate contract shall be complete as specified in paragraph above.
- 3.4 Mount on each panelboard, starter, safety switch, remote control pushbutton station, and all similar controls, a nameplate descriptive of the equipment or equipment controlled.

- 3.5 Install on each transformer, switchgear, motor control center, switchboard, safety switch, panelboard, individually enclosed circuit breaker, motor starter, adjustable frequency drive and contactor, a sign stating the category of protective clothing and equipment required for personnel to access the interior of the equipment for the purpose of inspection, adjustment, maintenance and replacement.
- 3.6 Install instrumentation and control wiring for all equipment, mechanical and electrical, in accordance with Division 16 specification sections. Before installing control circuits, ensure that controls and wiring diagrams are in accordance with those furnished with the equipment. Make any changes required due to different equipment, more up-to-date controls or safety devices, so that the equipment operates as required.
- 3.7 INSTRUMENTATION AND CONTROLS
- A. Location of control panels and field-mounted devices specified in Division 17 ?? and detailed on Instrumentation and Controls drawings have been shown on the electrical drawings.
- B. Receive control panels and field-mounted devices from Division 17 ?? Instrumentation and Controls contractor.
- C. Install control panels and field-mounted devices.
- D. Make up conduit to control panels and field-mounted devices. Install wire and cable as indicated on the drawings.
- E. Leave free end of wire and cable coiled in control panels and field-mounted devices for termination by the Division 27 Instrumentation and Controls contractor.
- 3.8 When equipment is supplied with electrical requirements other than those specified or shown on the drawings, associated electrical devices and circuitry of the correct sizes and ratings shall be provided.
- 3.9 TESTING AND PLACING IN SERVICE
- A. Furnish all necessary instruments and equipment and provide testing to confirm proper operation of electrical systems and equipment.
- B. Notify Engineer at least 3 working days in advance of tests.
- C. Submit as a PDF document the test results to the Engineer. Results shall be presented in a complete and legible report.
- D. Material or equipment failing tests shall be repaired or replaced at the Contractor's expense.
- E. Tests shall include the following in addition to test requirements of individual sections of Division 16:
1. Measure the load on each phase of the main service and each phase of every feeder under full load conditions.
 2. Measure the no load and full load voltages (phase to phase and phase to ground for each phase) of each service and each separately derived system.
 3. Measure the ground resistance of the main service grounding electrode and the ground resistance of each separately derived system's grounding electrode.
 4. Using a Bryant 5266PT or equal polarity tester, check polarity of each NEMA 5-15 and 5-20 receptacle.
- 3.10 Instruct Owner personnel in proper operation and maintenance of equipment.

PART 4.0 - SHOP DRAWING REVIEW STAMP SHEET

4.1 See following page.

| | |
|--|--|
| ELECTRICAL CONTRACTOR'S SHOP DRAWING REVIEW | |
| PROJECT NO.: | |
| PROJECT NAME: | |
| SPEC SECTION NO. & NAME | |
| APPROVED <input type="checkbox"/> | APPROVED AS NOTED <input type="checkbox"/> |
| ELECTRICAL CONTRACTOR'S COMPANY NAME: _____ | |
| By: _____ Date: _____ | |

This field above shall be completed before associated shop drawings are submitted.

| | |
|---|--|
| ENGINEER'S SHOP DRAWING REVIEW | |
| PROJECT NO.: | |
| PROJECT NAME: | |
| SPECIFICATION SECTION | |
| APPROVED <input type="checkbox"/> | APPROVED AS NOTED <input type="checkbox"/> |
| NOT APPROVED <input type="checkbox"/> | REVISE & RESUBMIT <input type="checkbox"/> |
| <p>Approval is only for conformance with the design concept of the project and compliance with the information given in the Contract Documents. Contractor is responsible for dimensions to be confirmed and correlated at the job site; for information that pertains solely to the fabrication process or to techniques of construction; and for coordination of the work of all trades.</p> <p>Master Engineers and Designers, Inc.</p> <p>By: _____ Date: _____</p> | |

END OF SECTION 16100

SECTION 16130 - REWORKING EXISTING SYSTEM

PART 1- GENERAL

1.1 ELECTRICAL GENERAL PROVISIONS

- A. Provisions of Section 16100 - Electrical General Provisions shall be made an integral part of this section.

- 1.2 DESCRIPTION: Make indicated changes to existing facilities and equipment. Where indicated changes to nonelectrical facilities require minor associated electrical changes, these changes shall be accomplished even if not specifically indicated.

- 1.3 Provide material and labor necessary for temporary electrical facilities required to maintain facility in full operation for the duration of the project.

PART 2 - PRODUCTS

- 2.1 Products shall be new and as specified in this Division unless reuse of existing facilities is specifically indicated on the drawings.

PART 3 - EXECUTION

3.1 PROTECTION OF EXISTING PREMISES

- A. Protect the existing premises, including the buildings, grounds and appurtenances, from damage which might be done or caused by work performed under this DIVISION. Repair damage so as to restore the damaged areas to their original condition.
- B. Provide protective materials and coverings where necessary, to guard building surfaces and building contents from damage due to the operations of this work.

3.2 MAINTENANCE OF EXISTING PREMISES

- A. During the execution of the work of this DIVISION the Owner will continue to operate the plant and will therefore require continuous operation of all existing facilities. Schedule outages required for construction purposes for the shortest practical periods of time, and then only by pre-arrangement with the Owner for specific, mutually agreeable periods, after each of which the interruption shall cease and service shall be restored.
- B. Perform work under this DIVISION in such a manner as to cause the least amount of interruption of existing services to the occupied spaces.
- C. Outages required to be performed outside of normal working hours in order to meet the project schedule shall be performed without additional cost to the Owner.

3.3 MAINTENANCE OF EXISTING FACILITIES

- A. Perform all work, including any alterations or modifications to the existing system, as may be necessary to provide a complete and usable facility in accordance with the design concept and as shown on the drawings.

- B. Perform alterations to existing electrical work made necessary by the removal or relocation of walls, ceilings, floors or equipment in such a manner as to provide continuous service to those outlets, devices or circuits that are to remain in active use, and to provide for the removal of those to be abandoned. Where making provisions to provide for continuous service, rewire subject equipment and circuits in accordance with good workmanship by rerouting conduits, wiring and relocating devices and equipment to new locations as a part of the work to be performed under this DIVISION. In the removal of equipment or circuits that are not to be retained, remove all portions of such circuits in their entirety where possible. Where they are completely inaccessible, they may be abandoned, provided that equipment has been disconnected and de-energized from all power sources.

3.4 ELECTRICAL DEMOLITION

- A. Disconnect and remove all electrical materials and equipment within the new construction limits not specifically indicated to be reused, to remain, or to be reconnected. This includes, but is not limited to, conduit, conductors, panelboards, lighting fixtures, motor controls, wiring devices, outlet and junction boxes, and auxiliary equipment.
- B. Coordinate all phasing of demolition work with the Owner's representative to minimize interruption of power and the functioning of surrounding spaces.
- C. Where modification of existing circuitry affects the continuity of a circuit supplying areas outside the construction limits, provide materials and labor necessary to maintain circuit integrity.
- D. Disconnect and remove cable and conduit to equipment being removed.
- E. Remove exposed conduit and wiring abandoned prior to this Contract.
- F. Cut back exposed portions of abandoned, concealed conduit to facilitate patching.
- G. See related paragraphs of this SECTION and other DIVISIONS for additional requirements.
- H. Dispose of removed equipment and material.
- I. Update directories of panelboards, switchboards, motor control centers, and the like, from which circuits have been modified or disconnected.
- J. Install blank cover plates on abandoned junction and outlet boxes.

3.5 GROUNDING

- A. Service entrance:
 - 1. Verify that grounding electrode conductors have been run from the ground bus of the service entrance gear to the following where extant:
 - a. Ground rod
 - b. Building ground counterpoise
 - c. Building cold water service
 - d. Building structure
 - e. Ufer ground
 - f. Other metallic piping systems within the facility

2. Notify the Engineer if conductors to these points do not exist, have been disconnected or are in disrepair.
 3. Verify that the removable link between the neutral and ground bus is in place. Notify the Engineer if the link does not exist, has been disconnected or is in disrepair.
- B. Separately derived systems
1. Verify that a grounding electrode conductor has been run from each separately derived system to at least one of the following:
 - a. Ground rod
 - b. Building ground counterpoise
 - c. Building structure
 - d. Notify the Engineer if conductors to these points do not exist, have been disconnected or are in disrepair.
 2. Verify that the system neutral has been bonded to ground. Notify the Engineer if the bond does not exist, has been disconnected or is in disrepair.
- 3.6 Thoroughly inspect electrical systems in reworked areas and bring to the attention of the Engineer all defective or unserviceable material not scheduled for removal or replacement.

END OF SECTION 16130

SECTION 16173 - POWER SYSTEM ANALYSIS

PART 1 - GENERAL

1.1 ELECTRICAL GENERAL PROVISIONS

- A. Provisions of Section 16100 - Electrical General Provisions shall be made an integral part of this section.

1.2 SUBMITTALS: Submit the power system analysis with the distribution equipment shop drawings.

1.3 SCOPE

- A. Provide a power system analysis consisting of an integrated short circuit study, overcurrent protective device coordination study and an arc flash analysis.
- B. Include all portions of the electrical distribution system from the normal and alternate sources of power. Normal system operating method, alternate operation, and operations which could result in maximum fault and arc flash conditions shall be thoroughly covered in the study.

1.4 QUALITY CONTROL

- A. Coordination study shall be performed by one of the following organizations:

1. ABM Electrical Power Solutions
814 Greenbrier Circle, Suite E
Chesapeake, VA 23320
757 - 819-1246
Tony Baratta
antonio.baratta@abm.com
2. Coordinated Power Engineering
520 McCormick Dr Suite D
Glen Burnie, MD 21061
410-694-9494
Carl E. Rager, PE, President
www.cpeinc.net
3. William R. Jennings, P.E.
2940 Perrowville Road
Forest, VA 24551-2225
434 - 525-7099
bjennings@jenningspe.com

- B. Calculations and studies shall be prepared by a professional engineer licensed in the Commonwealth of Virginia. The engineer shall have at least five years' experience performing this type of study and shall have prepared at least five studies in the past year. The submittal shall be sealed by the professional engineer.
- C. Calculations and printouts shall be made using commercially available power distribution system analysis software.

PART 2 - PRODUCTS

2.1 POWER SYSTEM DATA COLLECTION shall include information regarding:

- A. Power sources (utility, generators) and associated impedances.
- B. Impedance components such as transformers and cable.
- C. Overcurrent protective devices such as fuses, circuit breakers and relays.
- D. Equipment short circuit and withstand ratings.

2.2 SHORT CIRCUIT STUDY

- A. The study shall be prepared in accordance with applicable ANSI and IEEE Standards.
- B. The study input shall include the utility company's short circuit single- and three-phase contribution, with the X / R ratio, the resistance and reactance components of each branch impedance, motor and generator contributions, base quantities selected, and all other applicable circuit parameters.
- C. Study shall be prepared using the per-unit method of calculation, 10 MVA base.
- D, The analysis shall include:
 - 1. Calculation of the maximum root mean square (rms) symmetrical three-phase short circuit current at each significant location in the electrical system.
 - 2. Appropriate motor short circuit contribution at the appropriate locations in the system so that the calculated values represent the highest short circuit current the equipment will be subjected to under fault conditions.
 - 3. A tabular printout which lists the calculated short circuit currents, X/R ratios, equipment short circuit interrupting or withstand current ratings, and notes regarding the adequacy or inadequacy of the equipment.
 - 4. A printout of input circuit data including conductor lengths, number of conductors per phase, conductor impedance values, insulation types, transformer impedances and X/R ratios, motor contributions, and other circuit information as related to the short circuit calculations.
 - 5. A printout identifying the maximum available short circuit current in rms symmetrical amperes and the X/R ratio of the fault current for each bus/branch calculation.
 - 6. A system one-line diagram clearly identifying individual equipment buses, bus numbers used in the short circuit analysis, cable and bus connections between the equipment.
 - 7. A comprehensive discussion section evaluating the adequacy or inadequacy of the equipment including recommendations as appropriate for improvements to the system.
 - 8. Verification that all equipment has an interrupting or withstand rating, as applicable, greater than the available fault current at the point of application.

2.3 PROTECTIVE DEVICE COORDINATION STUDY

- A. A protective device coordination study shall be performed to select power fuse ratings and settings of low-voltage circuit breaker trip characteristics and ratings.

Coordination shall be as selective as possible given the devices specified and scheduled.

- B. The coordination study shall include all voltage classes of equipment from the utility's incoming line protective device down to and including each piece of utilization equipment included in the arc flash analysis. The phase and ground overcurrent protection shall be included, as well as settings for all other adjustable protective devices. It shall also include alternate sources of power such as an emergency generator.
- C. Output from the study shall include:
 - 1. A sufficient number of log-log plots to indicate the degree of system protection and coordination by displaying the time-current characteristics of series connected overcurrent devices and other pertinent system parameters.
 - a. Submitted curves shall be for the actual devices to be installed.
 - b. The plots shall include complete titles, representative one line diagram and legends, associated power company's relays or fuse characteristics, significant motor starting characteristics, complete parameters of transformers, complete operating bands of low-voltage circuit breaker trip curves, and fuse curves.
 - c. The coordination plots shall indicate the types of protective devices selected, transformer magnetizing inrush and withstand curves per ANSI C37.91, cable damage curves, symmetrical and asymmetrical fault currents.
 - d. Maintain reasonable coordination intervals and separation of characteristic curves. Provide coordination plots for phase and ground protective devices on a complete system basis.
 - e. Plots shall be presented in color with each device curve shown in a unique color for clarity.
 - 2. A tabular printout containing descriptions for each of the devices shown, settings of the adjustable devices, the short circuit current availability at the device location when known, and device identification numbers to aid in locating the devices on the log-log plots and the system one-line diagram.
 - 3. A tabular printout containing the selection and settings of the protective devices, listing circuit identification, IEEE device number, manufacturer, type, range of adjustment, and recommended settings. Provide a tabulation of the recommended power fuse selection for all fuses in the system.
 - 4. A system one-line diagram clearly identifying individual equipment buses, bus numbers and device identification numbers.
 - 5. A discussion section which:
 - a. Evaluates the degree of system protection and service continuity with overcurrent devices, along with recommendations as required for addressing system protection or device coordination deficiencies.
 - b. Identifies deficiencies in protection and/or coordination shall be called to the attention of the Engineer and recommendations made for improvements as soon as they are identified.

2.4 ARC FLASH ANALYSIS

- A. Shall conform to NFPA 70E and IEEE Standard 1584-2002, the IEEE Guide for Performing Arc Flash Calculations.
- B. Shall include the following equipment:
 - 1. Safety switches
 - 2. Transformers
 - 3. Panelboards
 - 4. Individually enclosed circuit breakers
 - 5. Individually enclosed motor starters
 - 6. Individually enclosed adjustable frequency drives
 - 7. Generators
 - 8. Transfer switches
 - 9. Process equipment having integral or standalone control panels.

Circuits less than 240 V supplied from transformers less than 125 kva may be omitted from the analysis and will be assumed to have a hazard risk category 0.
- C. Shall calculate arc flash incident energy levels and arc flash protection boundary distances.
- D. Shall be performed in conjunction with the short circuit study and a time-current coordination study.
- E. Shall be performed based upon facility operational conditions, and the final report shall describe, when applicable, how these conditions differ from worst-case bolted fault conditions.
- F. Results shall be submitted in tabular form, and shall include device or bus name, bolted fault and arcing fault current levels, flash protection boundary distances, personal-protective equipment classes and arc flash incident energy levels.
- G. Shall include recommendations for reducing arc flash incident energy levels and enhancing worker safety.
- H. Shall report incident energy values based on the existing incident energy values at all buses within the scope of the study in addition to incident energy values based on the recommended overcurrent device setting changes.
- I. Arc flash labels shall comply with relevant NEC and NFPA standards as well as UL 969.
 - 1. The data fields on the label shall be populated from the results of the arc flash hazard analysis. They shall include the following information:
 - a. Equipment Name
 - b. Arc flash incident energy flash hazard boundary
 - c. Arc flash incident energy value (cal/cm²)

- d. Hazard risk category
 - e. System voltage
 - f. Limited approach boundary
 - g. Restricted approach boundary
 - h. Prohibited approach boundary
2. Where circuits have been omitted from the computer model as permitted by an applicable industry standard a generic label shall be provided.
- C. Shall include a tabulation of the types of signage to be installed on each piece of equipment.

PART 3 - EXECUTION

- 3.1 Collect data listed in the paragraph entitled Power System Data Collection. This will require an on-site inventory.
- 3.2 Prepare the power system analysis as specified above.
- 3.2 Install arc flash incident energy labels on all equipment, new and existing, involved in the project in accordance with NFPA 70E.

END OF SECTION 16173

SECTION 16200 - ELECTRIC SERVICE

PART 1 - GENERAL

1.1 ELECTRICAL GENERAL PROVISIONS

- A. Provisions of Section 16100 - Electrical General Provisions shall be made an integral part of this section.

1.2 REFERENCES

- A. National Electrical Manufacturers Association (NEMA) Standards Publications
 - 1. ICS 6 Enclosures for Industrial Control and Systems

1.3 Electric service voltage and configuration shall be as shown on the drawings.

1.4 SUBMITTALS:

- A. Notify the Power Company of proposed work affecting electrical service requirements prior to beginning construction. Provide copies of drawings and specifications as requested.
- B. Assist Owner with preparation of Power Company service application.

1.6 PROJECT CONDITIONS

- A. Charges by the Power Company for aid-to-construction costs for permanent electrical service will be paid by the Owner.
- B. Charges for temporary electrical service required during construction shall be paid by Contractor.

PART 2 - PRODUCTS

2.1 Metering cabinet shall have the following features:

- A. General: Cabinet construction shall meet the requirements for NEMA 1 enclosures prior to installation of any equipment or machining of opening for raceway.
- B. General: Cabinet construction shall meet the requirements for NEMA 3R enclosures prior to installation of any equipment or machining of opening for raceway.
- C. Exterior Sheet Metal
 - 1. 12-gage steel braced and supported to form a rigid structure suitable to support equipment to be mounted therein
 - 2. No holes or knockouts prior to machining of openings
 - 3. Door[s]
 - 4. Three-point latching mechanism
 - 5. Pad-lockable handle

- 6. Removable center post (two door enclosures only)
- D. Interior Subpanel: Steel or plywood per Power Company
- E. Finishes
 - 1. One coat primer, two coats finish enamel
 - 2. Interior color: Grey
 - 3. Exterior color: Grey
- F. Dimensions: As required by Power Company.

PART 3 - EXECUTION

- 3.1 Coordinate electric service with the Power Company.
- 3.2 Assist Owner in making application for service.
- 3.3 Metering provisions shall meet requirements of Power Company.
 - A. Install meter base furnished by the Power Company.
 - B. Install metering cabinet.
 - C. Install conduit between the metering cabinet and the meter base as required by Power Company.
 - D. Mount Power Company metering transformers supplied by the Power Company.

END OF SECTION 16201

SECTION 16201 - METALLIC RACEWAYS**PART 1 - GENERAL****1.1 ELECTRICAL GENERAL PROVISIONS**

- A. Provisions of Section 16100 - Electrical General Provisions shall be made an integral part of this section.

1.2 REFERENCES: ANSI PUBLICATIONS

- A. C80.1 Rigid Steel Conduit, Zinc Coated
- B. C80.3 Electrical Metallic Tubing, Zinc Coated
- C. C80.5 Rigid Aluminum Conduit

- 1.3 SCOPE OF CONDUIT WORK: Provide and install conduit necessary to enclose all wiring.

PART 2 - PRODUCTS

- 2.1 RIGID STEEL CONDUIT (RSC): Low carbon, hot-dipped galvanized inside and outside, with threaded ends, minimum size 3/4 inch. Threaded fittings - cast iron or alloy steel, galvanized.

- 2.3 RIGID ALUMINUM CONDUIT (RAC): 3/4 inch minimum size with threaded ends. Fittings: Standard threaded aluminum.

2.4 ELECTRICAL METALLIC TUBING (EMT)

- A. High strength galvanized, 3/4 inch minimum size, 4 inch maximum size.
- B. Fittings of same finish and material as tubing. Use compression type fittings only.

- 2.5 LIQUID TIGHT FLEXIBLE METAL CONDUIT: Sealtite Type U.A. by Anaconda, Liqueflex Type LA by Electric-Flex Company, Type GU by International Metal Hose Company, or Sealflex-U by Universal Metal Hose Company. Fittings shall be Thomas & Betts Series 6000.

- 2.6 PLASTIC JACKETED RIGID STEEL CONDUIT (PJRSC): Polyvinyl chloride jacket (0.035 Inch minimum thickness) bonded to rigid steel conduit. Connectors shall be plastic jacketed. Jacket shall extend beyond connector body so that when joints are made up, jacketing is continuous.

- 2.7 THRUWALL SEALING FITTINGS: Type CSMI by O-Z / Gedney Electrical Manufacturing Company.

2.8 CONDUIT BUSHINGS

- A. Insulated
 - 1. Type B or SBT as applicable, by O-Z / Gedney
 - 2. Series 1100 or series 2800, as applicable by Raco
 - 3. Series BU500 or series TC700, as applicable by Steel City.

- B. Grounding:
 - 1. O-Z / Gedney Type BLG
 - 2. Raco series 1222 thru 1236
 - 3. Steel City Type BG.
 - C. Sealing for conduits entering enclosure: O-Z / Gedney Type GRK or Type CSB.
- 2.9 SEALANT FOR CONDUITS ENTERING BUILDING: Polywater FST foam duct sealant.
- 2.10 PULL ROPE: 5/32 inch polyethylene rope.
- 2.11 THREAD LUBRICANT / SEALANT: Crouse-Hinds Type STL or equal by Ideal or O-Z / Gedney.
- 2.12 CONDUIT STANDOFF HARDWARE SHALL BE ONE OF THE FOLLOWING:
- A. O-Z / Gedney Company clamp back and nest back spacers Type G and NG, respectively.
 - B. Carlon "Snap Strap" Series E978 non-metallic conduit support straps.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Install rigid steel conduit, plastic-jacketed rigid steel conduit, rigid aluminum conduit and electrical metallic tubing as indicated on the drawings.
- B. Flexible metal conduit
 - 1. Install flexible metal conduit for connections to motors and other equipment subject to vibration, and for connections to recessed or semi-recessed lighting fixtures in dry areas.
 - 2. Install liquid tight flexible metal conduit for all other connections to equipment subject to
- C. Install thruwall sealing fittings as indicated on the drawings.

3.2 CONDUIT INSTALLATION:

- A. Cut all conduit with hacksaw or approved cutting machine and ream after threading to remove all burrs.
- B. Arrangement
 - 1. Space groups of conduits uniformly. For bends and offsets, use an approved hickey or bending machine.
 - 2. Install runs of conduit parallel or perpendicular to walls, structural members, or intersections of vertical planes and ceilings.
 - 3. Provide right angle turns consisting of fittings or symmetrical bends.
 - 4. Avoid condensation pockets in installations.

- C. Conduits less than 1 inch may be installed in concrete but shall not cross each other. Installation of larger conduits in concrete must be approved by Engineer.
- D. Join conduit with approved couplings. No running threads will be allowed.
- E. Keep conduit, fittings, and boxes free from foreign matter, before, during, and after installation.
- F. Conduit shall not penetrate concrete bases designed for vibration isolation.
- G. Install foam duct sealant in all conduits entering building.
- H. Conduits buried in earth outside buildings shall have 30 inch cover.

3.3 CONNECTION OF CONDUIT TO SHEET METAL BOXES AND ENCLOSURES:

- A. Fasten conduit securely to outlets, junctions, and pull boxes to ensure electrical continuity of the raceway system.
- B. Connection to NEMA 1 type boxes and enclosures;
 - 1. Rigid conduit: Install insulated bushings and double locknuts.
 - 2. EMT: Install compression type box connectors with insulated throats.
 - 3. Flexible conduit: Insulating bushings and double locknuts.
- C. Connection to NEMA 3R, 4, 4X, and 12 type boxes: Install insulated bushings and sealing locknuts or hubs for both rigid conduit and liquidtight flexible conduit.
- D. Install conduit bushings on all threaded connections (rigid and flexible conduit) to enclosures.
- E. When conduits enter floor mounted enclosures from below, where there is not sheet metal to which to attach; install grounding bushing on the conduit. Bond bushings to ground bus using a conductor the same size as required for an equipment grounding conductor sized for the given circuit.

3.4 CORROSION PROTECTION:

- A. Apply thread lubricant / sealant to joints of all conduit buried in earth, encased in concrete, or installed outdoors.
- B. Where breaks or nicks occur in the jacket of plastic jacketed conduit, nipples, or fittings, repair same with a material of the same composition as the jacket.
- D. Rigid aluminum conduit (RAC)
 - 1. Do not install RAC close against masonry.
 - 2. For single runs of RAC conduit, use conduit standoff hardware.
 - 3. For parallel runs of RAC conduit, use factory fabricated channels.

3.5 ROOF PENETRATIONS:

- A. Provide pitch pocket where conduit penetrates roof.

- B. If conduit(s) penetrate roof, coordinate penetrations with roofing contractor so that appropriate sleeve and flashing is installed.
- 3.6 EMPTY CONDUIT: Install empty conduit for future use as indicated on the drawings. Conduit shall be complete with pull wire or rope, junction and outlet boxes.

END OF SECTION 260300

SECTION 16202 - NONMETALLIC RACEWAY

PART 1 - GENERAL

1.1 ELECTRICAL GENERAL PROVISIONS

- A. Provisions of Section 16100 - Electrical General Provisions shall be made an integral part of this section.

1.2 REFERENCES

- A. NEMA TC-2 Electrical Plastic Tubing and Conduit.
- B. NEMA TC-3 PVC Fittings for use with Rigid PVC Conduit and Tubing.
- C. NEC Article 347 - Rigid Nonmetallic Conduit.
- D. UL 651 Rigid Nonmetallic Electrical Conduit.
- E. UL 514 Electrical Outlet Boxes and Fittings.
- F. ASTM D 2564 Solvent Cements for PVC Plastic Pipe and Fittings.

- 1.3 SCOPE: This section applies to nonmetallic raceway installed exposed or concealed indoors or above grade outdoors.

PART 2 - PRODUCTS

- 2.1 ELECTRICAL PLASTIC TUBING: Designed for encasement in concrete and made of polyvinyl chloride (EPT-PVC for Type I application). Minimum size shall be 3/4".

- 2.2 SCHEDULE 40 ELECTRICAL PLASTIC CONDUIT: Designed for underground installation without concrete encasement and normal duty application above ground and made of polyvinyl chloride (EPC-40-PVC for Type II and III applications). Minimum size shall be 3/4".

- 2.3 PVC PLASTIC FITTINGS: Designed to be joined in the field by means of a solvent cement system.

- 2.4 SOLVENT CEMENT: ASTM D 2564 or in accordance with raceway manufacturer's printed recommendations.

- 2.5 DUCT SEALANT: Polywater FST foam duct sealant.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Install EPC-40-PVC for above or below ground without concrete encasement applications when PVC conduit is indicated on the drawings without further definition.
- B. Install EPT-PVC where PVC raceway for concrete encasement is indicated on the drawings. Under concrete slab is not considered to be encased.
- C. Install EPC-40-PVC to enclose grounding electrode conductors full length both within the building and above or below ground outside.

- D. Install foam duct sealant within ducts entering manholes or buildings.

3.2 CONDUIT CONNECTION

- A. Join raceway by means of solvent cement in accordance with the suggested methods indicated in the appendix of NEMA TC-2 for "severe" service conditions.
- B. Install socket type couplings for joining raceway.
- C. Install female adapters with female threads on one end and socket end on the other for adapting nonmetallic raceway to threaded metallic raceway.
- D. Install terminal adapters for adapting nonmetallic raceway to boxes, threaded fitting, and metallic systems. Male threads on one end, socket end on the other.
 - 1. Connection to NEMA 1 type, metallic boxes: Secure with locknut.
 - 2. Connection to NEMA 3R, 4, 4X, and 12 type, metallic boxes: Install O-ring seal on exterior and sealing locknut on interior.

3.3 BENDS

- A. Bends shall be made with factory elbows or with electric heaters designed specifically for the purpose. The use of torches or other flame-type devices will not be permitted. Sections of raceway showing evidence of scorching (brownish color) will be disapproved.
- B. Field bends for 2-inch diameter and larger raceway shall be made using internal support to prevent crimping or deforming during the bending process.

- 3.4 SUPPORT: Support raceways based on the temperatures at the application, but in no case shall the distance between supports be less than the requirements of NEC. Install raceway at least 6 inches away from steam lines and other heat sources.

END OF SECTION 16400

SECTION 16219 - WIRE, CABLE, AND WIRING

PART 1 - GENERAL

1.1 ELECTRICAL GENERAL PROVISIONS

- A. Provisions of Section 16100 - Electrical General Provisions shall be made an integral part of this section.

1.2 This section specifies single-conductor wire, cable and wiring for power, lighting and control systems, generally 24 through 600 volts ac.

1.3 REFERENCES: NEMA PUBLICATIONS

- A. WC 5 Thermoplastic-insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
- B. WC 7 Cross-linked-thermosetting-polyethylene-insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

1.4 CONDUCTOR SIZES: Conductor sizes are based on copper unless otherwise indicated on drawings.

1.5 SCOPE OF WIRING WORK:

PART 2 - PRODUCTS

2.1 CONDUCTOR CODING

- A. Color code insulated grounding conductors in accordance with NEC.
- B. Color code current carrying conductors (except control and instrumentation conductors) as follows:
- 1.

| | 208Y/120 Volt System | 480Y/277 Volt System |
|---------|----------------------|-------------------------|
| Phase A | Black | Brown |
| Phase B | Red | Orange |
| Phase C | Blue | Yellow |
| Neutral | White | Grey |
| Ground | Green | Green w / yellow stripe |

2. No. 12 thru No. 6 conductors shall have continuous insulation color.
 3. Color code conductors larger than No. 6 which do not have continuous insulation color by application of at least two laps of colored tape on each conductor at all points of access including junction boxes.
- C. Each coil of wire shall be delivered to the job in its original package bearing the UL label. Wire shall be marked with size and type every two feet. The neutral and each phase wire shall be furnished with different color insulation in sizes up to and including No. 6 AWG. Sizes No. 4 and larger may be provided in black, if identified by a series of two or more, colored bands completely encircling the conductor, located at or near each terminal point, in all junction boxes and at all other points so

designated by the inspecting authority. Colored bands shall not be less than 3 inch nor less than two conductor diameters in width, whichever is greater. The same color shall be used for each phase wire throughout the system for all three phase and feeder circuits as applicable for each voltage category, i.e., 120/208 volts, 277/480 volts.

2.2 CONDUCTOR REQUIREMENTS: All conductors shall be copper.

2.3 POWER AND CONTROL CONDUCTORS

- A. Conductors shall be soft annealed copper except as specified below.
- B. Conductors shall be stranded.
- E. Insulation
 - 1. Shall be type THW, THWN, XHHW.
 - 2. Shall be rated for 600 volts, 75 deg C unless otherwise indicated.
- I. Wiring in hot locations and for recessed fixtures shall have heat-resistant insulations applicable for the purpose.

2.4 VARIABLE FREQUENCY DRIVE CABLES (VFDC) shall have the following features:

- A. Listed uses: Indoors and outdoors, cable trays, raceway, wet locations
- B. Type: Shielded, flexible motor cable
- C. Material: Copper, stranded, tinned
- D. Insulation:
 - 1. Chemically cross-linked polyethylene
 - 2. Temperature: 90 degC
 - 3. Voltage: 1000 volts
- E. Shielding: 100% aluminum foil polyester tape covered with 85% tinned copper braid and drain wire
- F. Outer jacket: Polyvinyl chloride, sunlight resistant

2.5 MOTOR CONNECTIONS

- A. Connection lugs shall be one or two-hole, compression type, Thomas and Betts Catalog Number Series 53000 and 54000.
- B. Insulation shall be one of the following:
 - 1. Motor stub splice insulators, Thomas and Betts Catalog Numbers MSC8, 2, 20, 250, 500 as applicable.
 - 2. 3M Electrical Products Division, unshielded cable motor lead connection, Series 5300 thru 5314.
 - 3. Raychem stub connection insulation kit, Series RVC-1V thru RVC-4V.

2.6 SPLICES

- A. Splices for conductors No. 10 and 12 AWG shall have the following features:
1. Pre-insulated spring connector encased in a steel shell and rated at not less than 105 degrees C.
 2. Insulated vinyl cap with a minimum 3/8 inch skirt to cover the bare wires.
 3. UL approved for use in enclosures, junction boxes and fixtures.
 4. Manufacturer and type:
 - a. 3M Company, "Scotch Lok" Type Y, R and B
 - b. Ideal Industries, Wire Nut
 - c. Approved equal.
- B. Splices for No. 8 and larger conductors shall be:
1. ClearTap Insulated Multi-Tap Connectors by IIsco.
 2. Insulated Connector Blocks: Series IT, ISR, IPL, IPLD, IPLDH or IPLM by NSI Industries, Inc.
 3. AMT Series by Thomas & Betts, Blackburn

2.7 TERMINATIONS: All cable terminations shall be the compression barrel type with spades or studs for final connection to the equipment terminals.

2.8 PULLING COMPOUND: Pulling compound shall be Ideal Industries Yellow 77, Polywater Lubricant J or WJ, or approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Furnish and install all wire and cable of AWG sizes indicated on the drawings and as specified hereinafter or required for the complete installation.
- B. Install wiring in conduit unless otherwise shown.
1. Complete and clean out conduit system before pulling wire.
 2. Use compound as required to facilitate pulling.
 3. Pull conductors using recognized methods and equipment leaving ample lengths of wire at junctions for connections.
- C. Form and tie all wiring in panelboards, switchboards, switchgear, motor control centers, control panels and the like.
1. Bundle wiring and tie at 6 inch intervals.
 2. Bundles shall contain conductors leaving panelboard in a given conduit or cable.

3. Train bundles parallel to adjacent enclosure surfaces and in such a manner as to prevent abrasion due to rubbing or contact with bus work or other non-associated wiring.
- D. Identify all wiring at all points of access including junction and pull boxes.
1. Identify lighting and receptacle branch circuits by name of panelboard from which they originate and circuit number.
 2. Identify motor branch circuits by name of equipment from which they originate, circuit number, and phase.
 3. Identify feeders by name of equipment from which they originate, circuit number, and phase.
 4. Identify control wiring using a contractor selected numbering system allowing a unique number for each wire.

3.2 SPLICING

- A. Install conductors continuous from outlet to outlet with splices made only in junction and outlet boxes, and in pull boxes only as required to meet certain conditions.
- B. Install splice-free conductors within ducts and conduits. Wiring installed in underground conduits or ductbanks shall not be spliced underground. They shall be installed in continuous runs from the device served back to their source in a building or in an aboveground junction box or other enclosure.
- C. Instrumentation conductors shall be splice free from transmitter to receiver.

3.3 MOTOR CONNECTIONS

- A. Make motor connections using connection lugs with motor stub splice insulators.
- B. Install cable connectors on all flexible cables entering enclosures.

END OF SECTION 260519

SECTION 16220 - MULTI-CONDUCTOR CABLE

PART 1 - GENERAL

1.1 ELECTRICAL GENERAL PROVISIONS

- A. Provisions of Section 16100 - Electrical General Provisions shall be made an integral part of this section.

1.2 REFERENCES: NEMA PUBLICATIONS

- A. WC 5 Thermoplastic-insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
- B. WC 7 Cross-linked-thermosetting-polyethylene-insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

PART 2 - PRODUCTS

2.1 MULTI-CONDUCTOR POWER CABLES shall have the following features:

- A. Listed uses: Indoors and outdoors, cable trays, raceway, direct burial in the ground.
- B. Current-carrying conductors:
 - 1. Material: Copper, Class B stranded
 - 2. Insulation:
 - a. Chemically cross-linked polyethylene or ethylene propylene rubber
 - b. Temperature: 90 degC
 - c. Voltage: 600 volts
 - d. Phase identification: Insulated phase conductors printed with the numbers A1", A2" and A3" on the surface of the insulation.
- C. Ground conductor(s) material: Copper, un-insulated, Class B stranded
- D. Assembly: Twisted, length of lay not to exceed 35 times the phase conductor diameter
- E. Fillers: Non-hygroscopic
- F. Binder tape
- G. Outer jacket: Polyvinyl chloride, sunlight resistant

2.2 MULTI-CONDUCTOR CONTROL CABLES shall have the following features:

- A. Listed uses: Indoors and outdoors, cable trays, raceway, direct burial in the ground.
- B. Current-carrying conductors:
 - 1. Material: Copper, Class B stranded, tinned

2. Insulation:
 - a. Chemically cross-linked polyethylene
 - b. Temperature: 90 degC
 - c. Voltage: 600 volts
 - d. Conductor identification: ICEA Method 1 for National Electrical Code applications
 - e. Ground conductor(s) material: Copper, un-insulated, Class B stranded, tinned
 - C. Assembly: Cabled together with fillers to make a round cross-section
 - D. Fillers: Non-hygroscopic
 - E. Binder tape
 - F. Outer jacket: Polyvinyl chloride, sunlight resistant
- 2.3 VARIABLE FREQUENCY DRIVE CABLES shall have the following features:
- A. Listed uses: Indoors and outdoors, cable trays, raceway, wet locations
 - B. Type: Shielded, flexible motor cable
 - C. Current-carrying conductors (quantity, 3) & equipment grounding conductor (quantity, 1 minimum, 3 preferred)
 1. Material: Copper, stranded, tinned
 2. Insulation:
 - a. Chemically cross-linked polyethylene (XPLE)
 - b. Temperature: 90 degC
 - c. Voltage: 1000 volts
 - D. Shielding: 100% aluminum foil polyester tape covered with 85% tinned copper braid and drain wire
 - E. Assembly: Cabled together with fillers to make a round cross-section
 - F. Outer jacket: Polyvinyl chloride, sunlight resistant
- 2.4 LOW SIGNAL LEVEL INSTRUMENTATION CABLES shall have the following features unless specified by manufacturer's catalog number:
- A. Conductor
 1. Gage: #16AWG
 2. Type: Stranded, copper

- B. Insulation
 - 1. Type: Chemically cross-linked polyethylene or flame retardant ethylene propylene, 90n degrees C, 600 volts.
 - 2. Bonding: The insulation for the conductors in each pair shall be continuously bonded to prevent separation and misalignment of the pair's conductors during pulling.
 - C. Arrangement: Twisted pair, 1-1/2 inch minimum lay.
 - D. Shield: Overall aluminum polyester with stranded, tinned, copper drain wire
 - E. Outer jacket: Polyvinyl chloride, sunlight resistant
- 2.5 WIRE MARKERS shall be wrap-around tags, shrinkable PVC sleeving with hot-stamped blocks or slip-on beads.
- 2.6 MOTOR CONNECTIONS
- A. Connection lugs shall be one or two hole, compression type, Thomas and Betts Catalog Number Series 53000 and 54000.
 - B. Insulation shall be one of the following:
 - 1. Motor stub splice insulators, Thomas and Betts Catalog Numbers MSC8, 2, 20, 250, 500 as applicable.
 - 2. 3M Electrical Products Division, unshielded cable motor lead connection, Series 5300 thru 5314.
 - 3. Raychem stub connection insulation kit, Series RVC-1V thru RVC-4V.
- 2.14 PULLING COMPOUND: Pulling compound shall be Ideal Industries Yellow 77, Polywater Lubricant J or WJ, or approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install cable in conduit.
- B. Complete and clean out conduit system before pulling wire.
- C. Use compound as required to facilitate pulling.

Pull conductors using recognized methods and equipment leaving ample lengths of wire at junctions for connections.

3.2 TERMINATION:

- A. Terminate cables using connectors approved for the purpose and atmosphere.
- B. Terminate cables only at equipment enclosures and junction boxes.

- 3.3 FORM AND TIE wiring in enclosures.
- A. Bundle wiring and tie at 6 inch intervals.
 - B. Train bundles parallel to adjacent enclosure surfaces and in such a manner as to prevent abrasion due to rubbing or contact with bus work or other non-associated wiring.
- 3.5 IDENTIFY each wire using wire markers at all points of access.
- A. Identify power wiring by panelboard name and circuit number.
 - B. Identify feeders by name of equipment from which they originate, circuit number, and phase.
 - D. Identify control wiring by its function.

END OF SECTION 16220

SECTION 16221 - GROUNDING

PART 1 - GENERAL

1.1 ELECTRICAL GENERAL PROVISIONS

- A. Provisions of Section 16100 - Electrical General Provisions shall be made an integral part of this section.

1.2 SCOPE

- A. Grounding shall be in accordance with NEC as a minimum. Additional grounding requirements shall be as specified or indicated on drawings.

1.3 QUALITY CONTROL

- A. All system connectors shall be listed by Underwriters Laboratories for direct burial in earth or embedment in concrete per ANSI/UL467 Standard for Grounding and Bonding Equipment.
- B. All ground connectors shall meet the requirements of IEEE Std 837 Standard for Qualifying Permanent Connections Used in Substation Grounding.

PART 2 - PRODUCTS

2.1 GROUND RODS: Ground rods shall be copper clad steel, 10 feet in length and 3/4 inch in diameter.

2.2 CONDUCTORS

- A. Grounding electrode conductors shall be bare copper.
- B. Equipment grounding conductors in raceways shall be insulated copper.

2.4 CONNECTORS

A. GENERAL

- 1. All ground connectors shall be designed for fault-duty loading and shall have the fault capacity of the maximum sized conductor for which it is designed.
 - 2. Pad terminals and in-line splices shall accommodate only one conductor size. All other ground connectors may be range taking.
 - 3. Structural steel and bus bar ground connectors shall accommodate only one rigid member conductor.
 - 4. All mechanical bonding connectors shall be designed to withstand 150% of the recommended installation torque.
- B. Exothermic type connectors shall be Cadweld, Thermoweld, or approved equal.
 - C. Compression connectors shall have the following features:
 - 1. Manufactured from pure, wrought copper in compliance with ASTM B30.
 - 2. Shall be provided with a corrosion-inhibiting compound pre-applied to the contact surfaces. The compound shall be compatible with the conductors accommodated by the contractor.

3. Shall be provided with tin plating where required by the application.
 4. Shall be clearly and permanently marked with the following information:
 - a. Manufacturer's inspection symbol
 - b. Catalog number
 - c. Conductor accommodation(s)
 - d. Installation die index or die catalog number (compression)
 - e. Underwriter's Laboratories Listing Mark
 - f. The words "Suitable for Direct Burial", or "Direct Burial", or "Burial" as specified per ANSI/UL467
 5. Shall be Burndy HYGROUND or equal.
 6. Compression dies shall provide embossment of the connector upon successful installation. The embossed index shall match the marking on the installed connector.
 7. Connector marking information shall be legible after installation for inspector cross-reference.
 8. Closed barrel connectors shall have inspection holes at the appropriate location to verify proper cable insertion.
- D. Cable-to-pipe (water) connectors shall be as follows.
1. General: Bolts ("u" and straight), nuts, and lock washers shall be stainless steel.
 2. For connections to 2 to 1-1/2 inch (IPS) pipe: O-Z / Gedney Company Type ABG, Burndy Type GAR series, Thomas & Betts Cat No 2-TB or 3-TB, or approved equal.
 3. For connections to 2 to 8 inch (IPS) pipe: O-Z / Gedney Company Type CB, Burndy Type GAR series, Thomas & Betts Cat No 3900 series, or approved equal.

PART 3 - EXECUTION

3.1 Grounding electrode conductors and ground counterpoise

- A. Use bare copper for connecting ground rods.
- B. Connect grounding electrode conductors to pipes using cable-to-pipe connectors. Remove all finishes and oxidation from pipe sufficiently to allow 100 percent contact of connector with pipe.
- C. If earth resistance of the service grounding electrode is more than 25 ohms, notify Engineer.
- E. If earth resistance of the service grounding electrode is more than 25 ohms, install one additional ground rod a minimum of 16 feet from other electrode.

3.2 Equipment grounding

- A. Install equipment grounding conductors in all raceways containing conductors having 100 volts or more to ground.
- B. Ground all enclosures.
- C. Make certain that the metallic raceway system is electrically continuous.

3.3 CONNECTORS:

- A. Use compression or exothermic connectors for all connections that will be direct buried or inaccessible for inspection after construction is complete.
- B. Compression Connectors: Install compression connectors in accordance with the manufacturer's recommendations for conductor preparation (cleaning, pre-crimp), installation tool and die selection, and application of the proper number of crimps.

END OF SECTION 260526

SECTION 16300 - SUPPORTING DEVICES

PART 1 - GENERAL

1.1 ELECTRICAL GENERAL PROVISIONS

- A. Provisions of Section 16100 - Electrical General Provisions shall be made an integral part of this section.
- B. Supporting material shall be complete with hangers, connectors, bolts, clamps, and necessary accessories to make a complete installation.

1.2 LOADING

- A. Spans up to 5 Feet: Deflection shall not exceed 1 / 240 of span.
- B. Spans 5 Feet and Greater: Deflection shall not exceed 1 / 360 of span.
- C. Compressive loading shall not exceed 33 percent of manufacturer's published ratings.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Supporting material shall be complete with hangers, connectors, bolts, clamps, and necessary accessories to make a complete installation.
- B. Indoors in dry areas: Materials shall be galvanized or cadmium plated steel.
- C. Indoors in wet, damp, or corrosive areas: Threaded materials shall be stainless steel. All other materials shall be aluminum or stainless steel.
- D. Outdoors: All materials shall be stainless steel.
- E. Support systems shall be composed of standard structural shapes or factory fabricated. Acceptable manufacturers of factory fabricated support systems are:
 - 1. B-Line Systems, Inc.
 - 2. Midland-Ross Corporation, Electrical Products Division (Kindorf)
 - 3. Unistrut

2.2 CONDUIT STANDOFF HARDWARE SHALL BE ONE OF THE FOLLOWING:

- A. O-Z / Gedney Company clamp back and nest back spacers Type G and NG, respectively.
- B. Carlon "Snap Strap" Series E978 non-metallic conduit support straps.

PART 3 - EXECUTION

3.1 LAYOUT

- A. Install supports suspended from above to maintain minimum 7'-6" clear headroom.

- B. Install supports from walls to meet ADA requirements.

3.2 SUPPORT

- A. General: Support all equipment which is not inherently self-supporting in such a manner as to effect a rigid and permanent installation.
 - 1. Use factory-fabricated channel, support systems, and as appropriate, other structural shapes such as angles, "C" channels, pipe, and the like.
 - 2. Do not support equipment from metal roof deck.
- B. Conduit support
 - 1. Runs along walls:
 - a. Single runs: Use standoff hardware.
 - c. Multiple runs: Channel support with conduit fittings, 25 percent spare capacity.
 - 2. Suspended runs: Trapeze rack with 25 percent spare capacity.
 - 3. Vertical runs: Single runs: Use standoff hardware.
 - c. Parallel runs: Channel support with conduit fittings, 25 percent spare capacity.
 - 4. Rigid aluminum conduit (RAC)
 - a. Do not install RAC close against masonry.
 - b. For single runs of RAC, use conduit standoff hardware.
 - c. For parallel runs of RAC, use factory fabricated channels.

3.3 ANCHOR METHODS

- A. Hollow masonry: Toggle bolts or spider type expansion anchors.
- B. Solid masonry: Lead expansion anchors or preset inserts.
- C. Metal surfaces: Machine screws, bolts, or welded studs.
- D. Concrete surfaces: Self-drilling anchors or powder- driven studs.

END OF SECTION 16527

SECTION 16301 - PULL AND JUNCTION BOXES

PART 1 - GENERAL

1.1 ELECTRICAL GENERAL PROVISIONS

- A. Provisions of Section 260100 - Electrical General Provisions shall be made an integral part of this section.

1.2 DESCRIPTION

- A. This section specifies boxes installed within buildings and outside above grade.

PART 2 - PRODUCTS

2.1 SHEET METAL BOXES

- A. NEMA 1 BOXES SHALL HAVE THE FOLLOWING FEATURES:

1. Constructed of code gage, hot-rolled sheet steel.
2. Removable covers suitable for surface or flush mounting as applicable.
3. Finish:
 - a. Hot-dipped galvanized finish for boxes 4 x 4 inches and smaller.
 - b. Paint for boxes larger than 4 x 4 inches.
4. Cadmium plated hardware.
5. Manufacturer and type
 - a. Boxes 4 by 4 inches and smaller: Steel City 52141, 52151, and 52171 series, with 52-C series covers.
 - b. Boxes larger than 4 by 4 inches: Hoffman Bulletin A-90.
 - c. Specialty boxes:
 - (1) J. M. Gillin
924 W. Saratoga Street
Baltimore, MD 21223
(410) 728-9700
 - (2) TruCut Fabricators
135 Vista Centre Drive
Forest, Virginia 24551
434-316-5310

B. NEMA 4 SERIES BOXES SHALL HAVE THE FOLLOWING FEATURES:

1. Acceptable Materials
 - a. NEMA 4 boxes: Type 5052 aluminum, minimum 0.080 inch thick.
 - b. NEMA 4X boxes: Type 304 stainless steel, minimum 14 gage.
2. Continuously welded seams.
3. No knockouts.
4. Rolled lip around door.
5. Neoprene gasketed covers.
6. Stainless steel hardware.
7. Manufacturer and Type:
 - a. Hoffman Bulletin A-4 or A-51.
 - b. J. M. Gillin
924 W. Saratoga Street
Baltimore, MD 21223
(410) 728-9700
 - c. TruCut Fabricators
135 Vista Centre Drive
Forest, Virginia 24551
434-316-5310

2.2 CAST METAL BOXES SHALL HAVE THE FOLLOWING FEATURES:

- A. Copper-free aluminum construction.
- B. Finish: Gray epoxy powder
- C. Hardware: Stainless steel, brass, or bronze.
- D. Manufacturer: Appleton, Crouse-Hinds, Killark or Red Dot.

2.3 CONDUIT BODIES

- A. Where of sufficient size, conduit bodies may be used in lieu of pull and junction boxes provided they meet the requirements of the NEMA standards referenced above.
- B. Material: Cast copper-free aluminum.
- C. Finish: Gray epoxy powder
- E. Hardware: Stainless steel.
- F. Manufacturer: Appleton, Crouse-Hinds, or Killark.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Install NEMA 1 boxes in dry, non-corrosive areas indoors.
- B. Install NEMA 12 boxes in dry, dusty or dirty, non-hazardous, non-corrosive areas indoors.
- C. Install NEMA 4X boxes in corrosive areas outdoors and indoors.

3.2 Provide pull and junction boxes where shown on the drawings, and where required for changes in direction, at junction points, and to facilitate wire pulling. Provide additional boxes as required so that wire and cable manufacturer's maximum recommended pulling tensions are not exceeded.

3.3 Size boxes in accordance with NEC unless larger boxes are indicated.

3.5 Identify each pull and junction box.

- A. Identify each pull and junction box.
- B. Identify using paint pen markers.
- C. Markings shall be placed on the box cover and shall identify source and circuit number[s].
- D. Where more than one conduit enters and / or leaves a box, markings shall be placed directly on the conduit within six inches of the box.

END OF SECTION 16301

SECTION 16302 - WIRING DEVICE BOXES

PART 1 - GENERAL

1.1 ELECTRICAL GENERAL PROVISIONS

- A. Provisions of Section 16100 - Electrical General Provisions shall be made an integral part of this section.

PART 2 - PRODUCTS

2.1 FLUSH-MOUNTED WALL BOXES

- A. Material: Sheet metal, zinc coated or cadmium plated inside and out.
- B. Size:
 - 1. Single gang boxes: 4" high x 4" wide.
 - 2. Multi-gang boxes: 4" high, length as required for number of gangs.
- C. Box depth shall be a minimum of 2-1/8 inches deep where wall construction permits. Where wall construction dictates, depth may be 1-1/2 inches.
- D. Device support trim shall be raised to match thickness of the wall materials concealing the box.
- E. Gang boxes shall be one piece. Provide permanently installed barriers between adjacent switches used to control 277 volt circuits.
- F. Boxes installed in masonry construction shall be fabricated specifically for such application. They shall be of squared corner construction and shall have no openings through which mortar or water can enter the box.

2.2 SURFACE-MOUNTED BOXES

- A. Materials: Cast, copper-free aluminum
- B. Finish: Grey epoxy powder

2.3 PLATES

- A. Provide cover or device plates for outlet boxes as follows unless otherwise noted.
- B. Flush type: Stainless steel
- C. Surface type: Cast, copper-free aluminum, in-use type with 4 1/2" cord space when closed.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Install sheet metal boxes for flush-mounted applications.
- B. Install cast boxes for surface-mounted applications.

3.2 INSTALLATION

- A. For boxes flush mounted in finished walls.
 - 1. Install boxes so that face of device support trim falls flush with or slightly behind the face of the wall.
 - 2. 3/16 Inch maximum gaps allowed for noncombustible walls.
 - 3. Adjust location of outlets in masonry or tile construction to occur in the nearest joint to the height specified.
- B. Support all boxes to maintain alignment and rigidity.
- C. Clean boxes of all foreign matter prior to installation of wiring or devices.

END OF SECTION 260534

SECTION 16400 - UNDERGROUND DUCTS

PART 1 - GENERAL

1.1 ELECTRICAL GENERAL PROVISIONS

- A. Provisions of Section 16100 - Electrical General Provisions shall be made an integral part of this section.

1.2 REFERENCES

- A. NEMA Publication: TC 8 Extra Strength PVC Plastic Utilities Duct for Underground Installation.
- B. American Society for Testing and Materials -- ASTM
- C. American Association of State Highway and Transportation Officials - AASHTO
- D. All excavation shall be unclassified regardless of material encountered.

PART 2 - PRODUCTS

2.1 Underground ducts shall be one of the following types:

2.3 Type PVC-40 shall meet requirements of NEMA Publication No. TC 8.

2.3 Concrete encasement shall meet requirements of Section 03300 - Cast-in-Place Concrete.

2.4 Reinforcing steel shall meet requirements of Section 03300 - Cast-in-Place Concrete.

2.5 Buried utility warning marker tape shall be "Identoline Underground Warning Tape" as manufactured by W. H. Brady Industrial Products Division or equal by Panduit or Thomas & Betts. The tape shall have the phrase "CAUTION BURIED ELECTRIC LINE" repetitively printed along its entire length.

2.6 Backfill material shall be free of debris, roots, frozen materials, organic matter, rock larger than 6 inches in any dimension, or other harmful matter.

PART 3 - EXECUTION

3.1 GENERAL

- A. Thoroughly clean the ducts before using or laying .
- B. The arrangement of the ducts shall be as indicated on the drawings.
- C. Solvent weld the joints between each section of plastic duct.

3.2 CONCRETE-ENCASED DUCT BANKS, REINFORCED

- A. Excavation
 - 1. Excavate 6 inches below bottom of duct bank for first concrete pour.
 - 2. Keep excavations free of water while work is being performed.

3. Where underground streams or springs are found, provide temporary drainage and notify Engineer.
- B. Encasement placement, first pour
1. Place lower portion of rebar cage.
 2. Place first concrete pour
- C. Duct installation
1. Lay duct lines to a consistent grade generally paralleling the average contour of the finished grade of earth. Lay in such a manner as to avoid bellies and humps in the runs.
 3. Duct joints may be placed side by side horizontally; however, stagger joints at least 6 inches vertically.
 4. Make joints in accordance with manufacturer's recommendations for the particular duct. Make joints watertight.
 5. Install base and intermediate spacers and tie downs in sufficient numbers to maintain duct spacing.
 6. Make changes in direction of runs exceeding a total of 10 degrees, either vertical or horizontal, with long sweep bends having a minimum radius of curvature of 25 feet, except that manufactured bends may be used at the ends of the run.
 7. Install upper portion of rebar cages.
 8. After the duct line has been completed, pull a flexible mandrel not less than 12 inches long, having an appropriate diameter through each duct, after which pull a brush with stiff bristles through each duct. Pulling of the mandrel shall be witnessed by Engineer .
 9. Plug ends of ducts until cables are installed. Leave plugs in spare ducts.
- D. Encasement placement, second pour:
1. When ready for but before making the second pour, request inspection by Engineer.
 2. Place concrete. Exercise care when puddling to avoid air pockets and to avoid damaging ducts.
- E. Backfill
1. Backfill trench with earth fill. Backfill shall be placed by hand, uniformly on the duct or duct bank and compacted in layers not exceeding 6 inches. Do not backfill on muddy or frozen soil, or with muddy or frozen soil. Compact each layer of backfill to the required density.
 2. Install buried utility marker tape above each ductbank 1 foot below finished grade full length of the ductbank.

F. COMPACTION

1. Compact each layer of fill or backfill to not less than the following percentages of the maximum density at optimum moisture content as determined by ASTM D 698 (AASHTO T-99).
 2. 100 percent beneath and within 25 feet of buildings and structures, including those shown for future construction.
 3. 95 percent beneath pavements, walks, and road shoulders, including those shown for future construction.
 4. 90 percent in other unpaved areas.
- B. Compact soil materials using equipment suitable for materials to be compacted and work area locations. Use power-driven hand tampers for compacting materials adjacent to structures.

END OF SECTION 16543

SECTION 16401 - UNDERGROUND PULL BOXES

PART 1 - GENERAL

1.1 ELECTRICAL GENERAL PROVISIONS

- A. Provisions of Section 16100 - Electrical General Provisions shall be made an integral part of this section.

1.2 DESCRIPTION

- A. This section specifies pull boxes used in underground duct systems.

PART 2 - PRODUCTS

2.1 Underground pull boxes shall have the following features:

- A. Constructed of polymer concrete consisting of an aggregate matrix bound together with a polymer resin.
- B. Internal reinforcement provided by means of steel, fiberglass or a combination of the two.
- C. Physical specifications:
 - 1. Compressive strength: 9,000 psi tested in accordance with ASTM C-109 at a load rate between 28,000 lbs to 41,000 lbs per minute.
 - 2. Flexural strength: 6,000 psi tested in accordance with ASTM D-790.
 - 3. Tensile strength: 800 psi tested in accordance with ASTM C-496.
 - 4. Accelerated service: Tested in accordance with Procedure E, ASTM D-756.
 - 5. Water absorption: Tested in accordance with ASTM D-570, Section 5, 6.1 and 6.6.
 - 6. Impact resistance: 72 lbs / ft in accordance with ASTM D-2444 using a AC@ cup.
 - 7. Skid resistance: 0.5 coefficient of friction in accordance with ASTM C-1028.
 - 8. Flammability test: Tested in accordance with ASTM D-635.
 - 9. Ultraviolet exposure: Tested in accordance with ASTM G-53 using a U.V.A. 340 bulb.
 - 10. Chemical resistance: Tested in accordance with ASTM D-543, Section 7, Procedure 1 using the following chemicals: sodium chloride 5%; sodium carbonate 0.1N; hydrochloric acid 0.2N; acetic acid 5%; transformer oil per ASTM D-543; sulfuric acid 0.1N; sodium sulfate 0.1N; sodium hydroxide 0.1N; kerosene per ASTM D-543.D-635.
- D. Boxes and covers shall be grey.
- E. Covers
 - 1. Bolted to box using stainless steel bolts.
 - 2. The logo "ELECTRICAL" shall be permanently impressed into cover.

- F. Minimum test load rating: 15,000 lbs distributed over a 10" x 10" area with a minimum test load of 22,568 lbs. Design shall be for use in driveways, parking lots and off roadway applications where subject to occasional, non-deliberate heavy vehicles.
- H. Acceptable manufacturers
 - 1. CDR Systems Corporation
 - 2. Quazite Division of MMFG
- I. Unit sizes shall be as indicated on the drawings.

PART 3 - EXECUTION

- 3.1 Provide units as shown on drawings. Provide additional units as required so that wire and cable manufacturer's maximum recommended pulling tensions are not exceeded.
- 3.2 Locate units approximately where shown on the drawings. The exact location shall be determined after careful consideration of other utilities, grading, and paving.
- 3.3 Install units on 8" deep gravel bed for drainage.
- 3.4 In paved areas, set the top of the unit cover flush with the finished surface of the paving.
- 3.5 In unpaved areas, set the top of the unit cover approximately 2 inch above the finished grade.
- 3.6 Install concrete collar ring around unit per manufacturer's instructions.

END OF SECTION 16401

SECTION 16500 - DRY TYPE TRANSFORMERS

PART 1 - GENERAL

1.1 ELECTRICAL GENERAL PROVISIONS

- A. Provisions of Section 16100 - Electrical General Provisions shall be made an integral part of this section.

1.2 DESCRIPTION

- A. Transformer ratings and special features shall be as indicated on drawings.

1.3 REFERENCES

- A. NEMA Publications
 - 1. ST 1 Specialty Transformers.
 - 2. ST 20 Dry-type Transformers for General Applications.
 - 3. TP 1 Guide for Determining Energy Efficiency for Distribution Transformers
 - 4. TR 27 Commercial, Institutional, and Industrial Dry-type Transformers.
- B. UL Standard 506 Specialty Transformers.

PART 2 - PRODUCTS

2.1 GENERAL:

- A. Transformers shall be continuously rated, isolating type for 60 hertz service unless otherwise indicated.
- B. Windings shall be copper
- C. Transformers shall meet or exceed the requirements of NEMA TP-1 for energy efficient transformers.

2.2 ENCLOSURE

- A. Enclosures shall be metallic, suitable for indoor or outdoor installation, as applicable, and rodent proof.
- B. The structure shall be a rigid, self-supporting, completely metal-enclosed structure

2.3 TAPS: The primary shall have two 2.5% full capacity taps above and four 2.5% full capacity taps below rated voltage.

2.4 INSULATION: Insulation systems shall be 220 degrees C (150 degrees C rise) for 37.5 KVA and above, single phase, or 30 KVA and above, three phase units.

2.5 Audible sound levels shall not exceed the following:

| | |
|---------------|-------|
| 15 - 50 KVA | 45 dB |
| 51 - 150 KVA | 50 dB |
| 151 - 300 KVA | 55 dB |
| 301 - 500 KVA | 60 dB |

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Securely mount transformers at location indicated on drawings.
- B. Install floor-mounted transformers on concrete housekeeping pads.
- C. Mount transformers so that vibrations are not transmitted to the structural parts of building.

3.2 CONNECTION: Make conduit connections with flexible conduit.

3.3 GROUNDING

- A. Ground the transformer case and the electrostatic shield via a full size, grounding electrode conductor.
- B. Bond the transformer neutral to the grounding electrode conductor.

3.4 WARNING SIGNAGE conforming to NFPA 70E shall be installed on the equipment.

END OF SECTION 16500

SECTION 16501 - PANELBOARDS

PART 1 - GENERAL

1.1 ELECTRICAL GENERAL PROVISIONS

- A. Provisions of Section 16100 - Electrical General Provisions shall be made an integral part of this section.

1.2 RELATED SECTION

- A. Section 16507 - Surge Protective Devices (SPD's)

PART 2 - PRODUCTS

2.1 GENERAL

- A. Panelboards shall be of dead front construction utilizing thermal magnetic circuit breakers and shall conform to the requirements established by UL, NEMA and the NEC, except where modified herein. Each shall be suitable for its intended application as scheduled, considering voltage, phase, frequency and intended service. All panelboards shall be UL listed and shall be so labeled.
- B. Panels known as "loadcenters" will not be accepted.
- C. Panelboards shall consist of cabinet or back box, bus assembly, circuit breakers, trim, and all accessories as indicated and required. All characteristics shall be as shown or scheduled on the drawings.

2.2 CABINETS

- A. Cabinets or back boxes shall be fabricated from galvanized or equivalent rust resistant sheet steel of thickness to meet code requirements.
- B. Cabinet depths shall be the manufacturer's standard except where specific requirements indicate otherwise.
- C. Gutter space shall meet UL and NEC requirements.

2.3 BUS

- A. The bus assembly shall consist of copper or aluminum bus structure, secured and arranged to receive breakers as indicated.
- B. All bussing shall be designed in accordance with UL standards to suit the loading requirements as scheduled and shall be braced to withstand mechanical stresses created by faults of magnitude equivalent to the rating of breakers to be installed.
- C. Bus assembly shall include main lugs and main breakers where indicated. Arrangement shall also include double row construction of breakers and allowance for breaker replacement from the front without disturbing adjacent units or main bus connections. Bus and mounting pan shall be designed so that circuit breakers may be changed or added without additional machining, drilling or tapping.
- D. Connections to aluminum bus bars shall have special coating, such as plating or inhibiting compound, to prevent electrolysis. Belleville washers shall be used to prevent cold flow.

- E. Phase and neutral bus supports shall be insulated.
 - F. Construction shall be such that the bus will not be exposed upon removal of trim.
 - G. Provisions shall be included for adjustment of bus assembly and breakers for some vertical alignment and front-to-back position without removal of the assembly.
 - H. All panelboards shall be provided with solid neutrals, where indicated on the drawings.
 - I. Ground bars with lugs shall be provided on all panelboards.
 - J. Space where shown in panel schedules designates space for future protective devices and shall include bus and support components.
- 2.4 CIRCUIT BREAKERS: Circuit breakers shall as specified in Section 16505 - Molded Case Circuit Breakers.
- 2.5 PANELBOARD FRONTS
- A. Panelboard fronts shall be of cold rolled steel in accordance with gauges required by code.
 - B. Trim shall be fastened to box by means of clamps which indicate their position from the front. Trim clamps shall be concealed to present a flat smooth appearance. The use of screws engaging holes in the box flange for fastening trim will not be acceptable.
 - C. Doors
 - 1. Doors shall be fastened to trim by flush concealed hinges.
 - 2. Doors shall be equipped with a flush type combination catch and keyed lock. Two milled type keys shall be provided with each panel, and all locks shall be keyed alike.
 - 3. Doors shall be equipped with a neat directory frame secured to the inside of the door.
 - E. Trim and doors shall be properly cleaned and finished with one rust-inhibiting priming coat and a finish coat of light gray enamel, ANSI Z55.1-1967 No. 61. All circuits shall be identified as specified hereinafter.
- 2.6 MINIMUM SHORT CIRCUIT RATING
- A. The minimum short circuit rating for the panelboard shall be the rating of the device within the assembly having the lowest short circuit rating.
 - B. Maximization of selective tripping coordination is the intent of this design. Use of series rated equipment will not be approved.
- 2.8 ACCEPTABLE MANUFACTURERS
- A. Cutler-Hammer / Westinghouse
 - B. General Electric
 - C. Siemens
 - D. Square D

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install SPD's where indicated on drawings. Mounting: Bolt to wall such that top of enclosure is 72 inches above finished floor.
- B. Arrange and number circuits exactly as indicated in drawing schedules. If circuit arrangement does not match schedules, Contractor will be back-charged for the cost incurred by the Engineer in editing schedules for As-Built Drawings.
- C. Identify each conduit leaving surface mounted panelboards.
 - 1. Identify using paint pen markers.
 - 2. Markings shall identify load name and circuit number[s].
 - 3. Place markings within six inches of the enclosure.
- D. Type entries on directory cards completely and accurately. Equip each circuit breaker with an identification label (as recommended by manufacturer) showing circuit number served. Numbers on identification labels shall match respective circuit numbers on directory cards.

3.2 WARNING SIGNAGE conforming to NFPA 70E shall be installed on the equipment.

To calculate arc flash energy, assume that available fault current is the minimum short circuit rating shown on the panel schedule.

END OF SECTION 16501

SECTION 16502 - WIRING DEVICES

PART 1 - GENERAL

1.1 ELECTRICAL GENERAL PROVISIONS

- A. Provisions of Section 16100, Electrical General Provisions, shall be made an integral part of this section.

1.2 REFERENCES

- A. National Electrical Manufacturers Association (NEMA) Publications.

1. WD 1 General Purpose Wiring Devices.
2. WD 3 Alternating-current General Use Snap Switches.

- B. Underwriters Laboratories (UL) Publications

1. UL 20 General-use Snap Switches.
2. UL 943 Ground-fault Circuit Interrupters.

PART 2 – PRODUCTS

2.1 GENERAL:

- A. Furnish and install wiring devices at all locations shown on the drawings, complete with all mounting devices and other appurtenances where required. All wiring devices shall be the product of a single manufacturer except as specifically stated otherwise. The catalog numbers of the devices herein specified are based on those of Bryant Electric Co. However, equal devices as manufactured by General Electric, Leviton, or Hubbell will be acceptable.

- B. Wiring device color shall be grey.

2.2 AC GENERAL USE SNAP SWITCHES

- A. Switches for control of lighting circuits shall be specification grade, full size, heavy duty, composition enclosed, AC type, rated for 20 amperes at 120-277 volts, Nos. 4901-G, 4902-G, 4903-G and 4904-G. Standard, competitive, residential grade and interchangeable line switches will not be acceptable.

2.3 RECEPTACLES

- A. All single convenience receptacles shall be specification grade, back and side wired, three wire grounding type with U-shaped slotted ground, straight blades, catalog numbers as follows:

1. 20 amperes, 2P3W, 125 volts, Cat. No. 5361-G.
2. 20 amperes, 2P3W, 250 volts, Cat. No. 5461-G.
3. 30 amperes, 2P3W, 125 volts, Cat. No. 9530-FR.
4. 30 amperes, 2P3W, 250 volts, Cat. No. 9630-FR.

- B. Duplex convenience receptacles shall be the ground fault interrupter type having the following features:
1. UL listed: UL 943 Class A
 2. Configuration: Duplex, NEMA 5-20R
 3. Trip current sensitivity: 5 milliamperes plus or minus 1 milliampere
 4. Trip speed: 0.025 second maximum for a fault of 264 milliamperes
 5. Electronic amplifier protection: 6000 volt transients, ringwave configuration
 6. Withstand rating: 2000 amperes
 7. Operating temperature range: minus 35 to plus 66 degrees C
 8. Front-accessible test and reset push buttons
 9. Color shall match non-ground fault, duplex, convenience receptacles.
 10. Manufacturer and type: Bryant GFR53FT series or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install AC, general-use snap switches for switching lighting or other branch circuit loads as indicated on the drawings. Where adjacent to doors, coordinate with architectural drawings to ensure switches are installed on strike side of door.
1. Locate centerline at the height of 48" above finished floor.
 2. Long dimension of switches shall be vertical unless otherwise indicated.
- B. Install receptacles as indicated on the drawings with grounding pole up.
1. Locate centerline at the height of 18" above finished floor unless otherwise indicated.
 2. Long dimension of receptacles shall be vertical unless otherwise indicated or required.
 3. It is intended that each receptacle be equipped with ground fault interrupters. Do not use the feed thru feature to protect downstream equipment.

END OF SECTION 16502

SECTION 16503 - SAFETY SWITCHES

PART 1 - GENERAL

1.1 ELECTRICAL GENERAL PROVISIONS

- A. Provisions of Section 16100 - Electrical General Provisions shall be made an integral part of this section.

1.2 REFERENCES: NEMA PUBLICATION

- A. KS 1 Enclosed Switches

PART 2 - PRODUCTS

2.1 SAFETY SWITCHES

- A. Safety switches shall be the enclosed heavy duty type (Type HD) with quick-make, quick-break mechanism and external padlockable operating handle.
- C. Safety switches shall be rated for 240 or 600 volts as applicable. They shall be horsepower rated when used in motor circuits.
- D. Safety switches shall be:
 - 1. Fusible or non-fusible, as indicated on drawings.
 - 2. Single-phase circuits: two-pole
 - 3. Three-phase circuits: three pole
 - 4. Single throw unless otherwise indicated on the drawings.

2.2 ENCLOSURES: Enclosures shall be NEMA 12 indoors and NEMA 4X outdoors unless otherwise indicated on drawings.

2.4 ACCEPTABLE MANUFACTURERS

- A. Cutler-Hammer / Westinghouse
- B. General Electric
- C. Siemens
- D. Square D

PART 3 - EXECUTION

3.1 APPLICATION: Provide safety switches where indicated on the drawings or required by NEC.

3.2 INSTALLATION

- A. Mount safety switches securely between 3 and 6 foot levels above floor unless otherwise indicated on the drawings.

B. Furnish fuses for fusible switches of the size indicated on the drawings.

3.3 WARNING SIGNAGE conforming to NFPA 70E shall be installed on each switch.

END OF SECTION 16503

SECTION 16504 - FUSES

PART 1 - GENERAL

1.1 ELECTRICAL GENERAL PROVISIONS

- A. Provisions of Section 16100 - Electrical General Provisions shall be made an integral part of this section.

1.2 SCOPE: Provide fuses in accordance with this specification unless specifically shown otherwise on the drawings.

1.4 REFERENCES

- A. American National Standards Institute (ANSI) Publication: C97.1 Low Voltage Cartridge Fuses 600 Volts or Less.
- B. Underwriters Laboratories, Inc. (UL) Standards: 198E Class R Fuses.

PART 2 - PRODUCTS

2.1 FUSES

- A. General: All fuses shall be non-renewable type.
- B. Class R: Fuses for motor circuit protection, when not otherwise indicated on drawings, shall be UL 198E Class RK1 with time delay, 200,000 AIC, 250 and 600 volts as applicable, moderate degree current limiting.

2.2 ACCEPTABLE MANUFACTURERS

- A. Bussman
- B. Reliance
- C. Mersen (formerly Ferraz Shawmut)

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install fuses where indicated on drawings.
- B. At each point of fuse application, fuse all ungrounded conductors.
- C. Install on the outside of the door of each fusible switch an engraved phenolic nameplate stating fuse ampere rating, manufacturer, and type.

3.2 PROVIDE 10 percent spare fuses (or three, whichever is greater) of each size and type installed.

END OF SECTION 16504

SECTION 16505 - MOLDED CASE CIRCUIT BREAKERS (MCCB)

PART 1 - GENERAL

1.1 ELECTRICAL GENERAL PROVISIONS

- A. Provisions of Section 16100 - Electrical General Provisions shall be made an integral part of this section.

1.3 REFERENCES

- A. NEMA AB 1 1993 - (National Electrical Manufacturers Association) Molded Case Circuit Breakers and Molded Case Switches
- B. UL 489 - (Underwriters Laboratories Inc.) Molded Case Circuit Breakers and Circuit Breaker Enclosures
- C. UL 943 - Standard for Ground Fault Circuit Interrupters

- 1.4 SCOPE: This section applies to all MCCB whether individually enclosed or installed in panelboards.

- 1.5 SUBMITTALS: Provide outline drawings with dimensions, and ratings for voltage, amperage and maximum interruption. Include instructions for identification and receiving inspection, circuit breaker mounting, trip unit functions and adjustments, trouble shooting, accessories and wiring diagrams.

1.6 QUALIFICATIONS

- A. To be considered for approval, the manufacturer shall furnish products listed by Underwriters Laboratories Incorporated (UL), or testing firm acceptable to the authority having jurisdiction as suitable for application specified.
- B. The overcurrent protection device manufacturing facility shall be Registered by Underwriters Laboratories Inc. to the International Organization for Standardization ISO 9000 Series Standards for quality.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Cutler-Hammer / Westinghouse
- B. General Electric
- C. Siemens
- D. Square D

2.2 GENERAL

- A. Circuit breakers shall be constructed using glass reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.
- B. Circuit breakers shall have an over center, trip free, toggle operating mechanism which will provide quick-make, quick-break contact action. The circuit breaker shall have common tripping of all poles.

- C. The circuit breaker handle shall reside in a tripped position between ON and OFF to provide local trip indication. Circuit breaker escutcheon shall be clearly marked ON and OFF in addition to providing International I/O markings.
- D. The maximum ampere rating and UL or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker.
- E. Circuit breakers shall be equipped with UL Listed electrical accessories as noted on the associated drawing.
- F. Provide hardware for locking handle in the ON and OFF position where shown on drawings, regardless of location and size.
- G. All circuit breakers shall be UL Listed for reverse connection without restrictive line and load markings and be suitable for mounting in any position
- H. Circuit breakers shall be fixed construction with factory installed mechanical lugs. All circuit breakers shall be UL Listed to accept field installable / removable lugs (except Quick Lag type). Lug body shall be bolted in place; snap in design is not acceptable. All lugs shall be UL Listed to accept solid (not larger than #8 AWG) and/or stranded copper and aluminum conductors. Quick Lag breakers shall be the bolt-on type.
- I. Minimum short circuit rating
 - A. The minimum short circuit rating for a breaker shall be its stand-alone rating.
 - B. Maximization of selective tripping is the intent of this design. Use of series rated equipment will not be approved.

2.3 THERMAL-MAGNETIC CIRCUIT BREAKERS

- A. Circuit breakers shall have a permanent trip unit containing individual thermal and magnetic trip elements in each pole.
- B. Thermal trip elements shall be factory preset and sealed. Circuit breakers shall be true rms sensing and thermally responsive to protect circuit conductor(s) in a 40° C ambient temperature.
- C. Circuit breaker frame sizes above 100 amperes shall have a single magnetic trip adjustment located on the front of the circuit breaker (except type Q2, Q2H and Q2-H).

2.4 ELECTRONIC TRIP CIRCUIT BREAKERS

- A. Circuit breaker trip system shall be a microprocessor-based true rms sensing design with sensing accuracy through the thirteenth (13th) harmonic. Sensor ampere ratings shall be as indicated on the drawings.
- B. The integral trip system shall be independent of any external power source and shall contain no less than industrial grade electronic components.
- C. The ampere rating of the circuit breaker shall be determined by the combination of an interchangeable rating plug, the sensor size and the long-time pickup adjustment on the circuit breaker. The sensor size, rating plug and adjustment positions shall be clearly marked on the face of the circuit breaker. Circuit breakers shall be UL Listed to carry 80% of their ampere rating continuously.

- D. The following time/current response adjustments shall be provided. Each adjustment shall have discrete settings and shall be independent of all other adjustments.
1. Long Time Pickup
 2. Long Time Delay
 3. Short Time Pickup
 4. Short Time Delay
 5. Instantaneous Pickup
 6. Ground Fault Pickup
 7. Ground Fault Delay
 8. Energy-reduction maintenance switch
- E. A means to seal the trip unit adjustments in accordance with NEC Section 240-6(b) shall be provided.
- F. Local visual trip indication for overload, short circuit and ground fault trip occurrences shall be provided.
- G. Long Time Pickup indication to signal when loading approaches or exceeds the adjusted ampere rating of the circuit breaker shall be provided.
- I. The trip system shall include a long-time memory circuit to sum the time increments of intermittent overcurrent conditions above the pickup point. Means shall be provided to reset the long-time memory circuit during primary injection testing.
- J. Circuit breakers shall be equipped with back-up thermal and magnetic trip system.
- J. Circuit breaker trip system shall be equipped with an externally accessible test port for use with a Universal Test Set. Disassembly of the circuit breaker shall not be required for testing. Test set shall be capable of verifying the operation of all trip functions with or without tripping the circuit breaker.
- K. Provide one Universal Test Set.
- 2.5 ENCLOSURES: Enclosures for individually enclosed MCCB shall be NEMA 4X.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install MCCB's in panelboards and individually-enclosed as indicated on the drawings.
- B. Individually enclosed MCCB's:
1. Install securely.
 2. Install so that the breaker handle is 6'-0" above the floor.
- 3.2 Adjust circuit breaker pick-up level and time delay settings to values indicated in the Power System Analysis.
- 3.3 WARNING SIGNAGE conforming to NFPA 70E shall be installed on each individually-enclosed MCCB.

END OF SECTION 16505

SECTION 16506 - MOTOR STARTERS**PART 1 - GENERAL****1.1 ELECTRICAL GENERAL PROVISIONS**

- A. Provisions of Section 16100 - Electrical General Provisions shall be made an integral part of this section.

1.2 SCOPE

- A. This section specifies starters shown on the drawings individually mounted; i.e., not an integral part of a piece of mechanical equipment.

1.3 REFERENCES: NEMA PUBLICATIONS

- A. ICS 1 General Standards for Industrial Control and Systems.
- B. ICS 2 Standards for Industrial Control Devices, Controllers, and Assemblies.
- C. ICS 6 Enclosures for Industrial Controls and Systems.

PART 2 - PRODUCTS**2.1 GENERAL**

- A. Starters shall be NEMA-rated. IEC-rated equipment will not be accepted.
- B. Starters and associated devices shall have NEMA 12 enclosures.
- C. Starters shall disconnect all un-grounded circuit conductors.
- D. Starters shall have 75°C - rated line and load lugs.

2.2 MANUAL STARTERS

- A. Overload:
 - 1. Thermal overload protection shall be trip-free and the hand reset type. Overload relays shall be Class 10.
 - 2. Each ungrounded phase or motor lead shall have overload protection in its starter.
 - 3. Overload relays in outdoor starters shall be ambient compensated.
 - 4. Elements sized upon nameplate running amperes of the actual motor installed.

2.3 MAGNETIC STARTERS

- A. General
 - 1. Starters shall be electro-mechanical.

2. Overload:
 - a. Thermal overload protection shall be trip-free and the hand reset type. Overload relays shall be Class 10.
 - b. Each ungrounded phase or motor lead shall have overload protection in its starter.
 - c. Overload relays in outdoor starters shall be ambient compensated.
 - d. Manual reset in cover
 - e. Elements sized upon nameplate running amperes of the actual motor installed.
3. Control voltage shall be 120 volts obtained from neutral run from power source to the starter. Ungrounded control wiring shall be fused within the starter.

2.4 ACCEPTABLE MANUFACTURERS:

- A. Allen-Bradley
- B. Cutler-Hammer / Westinghouse
- C. Furnas
- D. General Electric
- E. Siemens
- F. Square D

PART 3 - EXECUTION

3.1 GENERAL

- A. When motors are supplied with characteristics different from those indicated on the drawings, starters, feeders, overloads, disconnects, and associated devices of the correct size, type, and rating shall be provided.
- B. Provide full-voltage starters unless otherwise indicated.

3.2 INSTALLATION

- A. Install in accordance with manufacturer's printed instructions.
- B. Mounting: Install so that top of enclosure is 72 inches above finished floor.

- 3.3 WARNING SIGNAGE conforming to NFPA 70E shall be installed on each individually-enclosed, magnetic motor starter.

END OF SECTION 16506

SECTION 16507 - SURGE PROTECTIVE DEVICES (SPD'S)

PART 1 – GENERAL

1.1 ELECTRICAL GENERAL PROVISIONS

- A. Provisions of Section 16100 - Electrical General Provisions shall be made an integral part of this section.

1.2 SCOPE: Furnish and install the surge protective device (SPD) equipment having the electrical characteristics, ratings, and modifications as specified herein and as shown on the drawings.

1.3 RELATED SECTION

- A. Section 262416 - Panelboards

1.4 REFERENCES: SPD units and all components shall be designed, manufactured, and tested in accordance with the latest applicable UL Standard (ANSI/UL 1449 3RD Edition).

1.6 QUALIFICATIONS

- A. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly.
- B. For the equipment specified herein, the manufacturer shall be ISO 9001 or 9002 certified.
- C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
- D. The SPD shall be compliant with the Restriction of Hazardous Substances (rohs) Directive 2002/95/EC.

1.7 DELIVERY, STORAGE AND HANDLING

- A. Handle and store equipment in accordance with manufacturer's instructions.
- B. Include one copy of manufacturer's instructions with the equipment at time of shipment.
- C. Operation and Maintenance Manuals: Ship operation and maintenance manual with each SPD shipped.

PART 2 – PRODUCTS

2.1 VOLTAGE SURGE SUPPRESSION – GENERAL

- A. Electrical Requirements
 1. Unit Operating Voltage – Refer to drawings for operating voltage and unit configuration.
 2. Maximum Continuous Operating Voltage (MCOV) – The MCOV shall not be less than 115% of the nominal system operating voltage.
 3. The suppression system shall incorporate thermally protected metal-oxide varistors (MOV's) as the core surge suppression component for the service entrance and all other distribution

levels. The system shall not utilize silicon avalanche diodes, selenium cells, air gaps, or other components that may crowbar the system voltage leading to system upset or create any environmental hazards.

4. Protection Modes – The SPD must protect all modes of the electrical system being utilized. The required protection modes are indicated by bullets in the following table:

| Configuration | Protection Modes | | | |
|--------------------|------------------|-----|-----|-----|
| | L-N | L-G | L-L | N-G |
| Wye | ● | ● | ● | ● |
| Delta | N/A | ● | ● | N/A |
| Single Split Phase | ● | ● | ● | ● |
| High Leg Delta | ● | ● | ● | ● |

5. Nominal Discharge Current (I_n) – All SPD’s applied to the distribution system shall have a 20ka I_n rating regardless of their SPD Type (includes Types 1 and 2) or operating voltage. SPD’s having an I_n less than 20ka shall be rejected.
6. ANSI/UL 1449 3rd Edition Voltage Protection Rating (VPR) – The maximum ANSI/UL 1449 3rd Edition VPR for the device shall not exceed the following:

| MODES | 208Y/120 | 480Y/277 | 600Y/347 |
|---------------|----------|----------|----------|
| L-N; L-G; N-G | 700 | 1200 | 1500 |
| L-L | 1200 | 2000 | 3000 |

B. SPD Design

1. The SPD’s shall be maintenance free and shall not require any user intervention throughout its life. SPD’s containing items such as replaceable modules, replaceable fuses, or replaceable batteries shall not be accepted. SPD’s requiring any maintenance of any sort such as periodic tightening of connections shall not be accepted. SPD’s requiring user intervention to test the unit via a diagnostic test kit or similar device shall not be accepted.
2. Balanced Suppression Platform: The surge current shall be equally distributed to all MOV components to ensure equal stressing and maximum performance. The surge suppression platform must provide equal impedance paths to each matched MOV. Designs incorporating replaceable SPD modules shall not be accepted.
3. Electrical Noise Filter: Each unit shall include a high-performance EMI/RFI noise rejection filter. Noise attenuation for electric line noise shall be up to 50 db from 10 khz to 100 mhz using the MIL-STD-220A insertion loss test method. Products unable able to meet this specification shall not be accepted.
4. Internal Connections: No plug-in component modules or printed circuit boards shall be used as surge current conductors. All internal components shall be soldered, hardwired with connections utilizing low impedance conductors.
5. Monitoring Diagnostics: Each SPD shall provide the following integral monitoring options:
 - a. Protection Status Indicators: Each unit shall have a green / red solid-state indicator light that reports the status of the protection on each phase.
 - (1) For wye configured units, the indicator lights must report the status of all protection elements and circuitry in the L-N and L-G modes. Wye configured units shall also contain an additional green / red solid-state indicator light that reports the status of the protection elements and circuitry in the N-G mode.

- SPD's that indicate only the status of the L-N and L-G modes shall not be accepted.
- (2) For delta configured units, the indicator lights must report the status of all protection elements and circuitry in the L-G and L-L modes.
 - (3) The absence of a green light and the presence of a red light shall indicate that damage has occurred on the respective phase or mode. All protection status indicators must indicate the actual status of the protection on each phase or mode. If power is removed from any one phase, the indicator lights must continue to indicate the status of the protection on all other phases and protection modes. Diagnostics packages that simply indicate whether power is present on a particular phase shall not be accepted.
- b. Remote Status Monitor: The SPD must include Form C dry contacts (one NO and one NC) for remote annunciation of its status. Both the NO and NC contacts shall change state under any fault condition.
 - c. Audible Alarm and Silence Button: The SPD shall contain an audible alarm that will be activated under any fault condition. There shall also be an audible alarm silence button used to silence the audible alarm after it has been activated.
 - d. Surge Counter: The SPD shall be equipped with an LCD display that indicates to the user how many surges have occurred at the location. The surge counter shall trigger each time a surge event with a peak current magnitude of a minimum of $50 \pm 20A$ occurs. A reset pushbutton shall also be standard, allowing the surge counter to be zeroed. The reset button shall contain a mechanism to prevent accidental resetting of the counter via a single, short-duration button press. In order to prevent accidental resetting, the surge counter reset button shall be depressed for a minimum of 2 seconds in order to clear the surge count total. The ongoing surge count shall be stored in non-volatile memory. If power to the SPD is completely interrupted, the ongoing count indicated on the surge counter's display prior to the interruption shall be stored in non-volatile memory and displayed after power is restored. The surge counter's memory shall not require a backup battery in order to achieve this functionality.
6. Overcurrent Protection: The unit shall contain thermally protected MOV's. These thermally protected MOV's shall have a thermal protection element packaged together with the MOV in order to achieve overcurrent protection of the MOV. The thermal protection element shall disconnect the MOV(s) from the system in a fail-safe manner should a condition occur that would cause them to enter a thermal runaway condition.
 6. Fully Integrated Component Design: All of the SPD's components and diagnostics shall be contained within one discrete assembly. SPD's or individual SPD modules that must be ganged together in order to achieve higher surge current ratings or other functionality shall not be accepted.
 7. Safety Requirements
 - a. The SPD shall minimize potential arc flash hazards by containing no user serviceable / replaceable parts and shall be maintenance free. SPD's containing items such as replaceable modules, replaceable fuses, or replaceable batteries shall not be accepted. SPD's requiring any maintenance of any sort such as periodic tightening of connections shall not be accepted. SPD's requiring user intervention to test the unit via a diagnostic test kit or similar device shall not be accepted.

- b. SPD’s designed to interface with the electrical assembly via conductors shall require no user contact with the inside of the unit. Such units shall have any required conductors be factory installed.

2.2 SYSTEM APPLICATION

- A. The SPD applications covered under this section include distribution and branch panel locations, busway, motor control centers (MCC), switchgear, and switchboard assemblies. All SPD’s shall be tested and demonstrate suitability for application within ANSI/IEEE C62.41 Category C, B, and A environments.
- B. Surge Current Capacity: The minimum surge current capacity the device is capable of withstanding shall be as shown in the following table:

| Minimum surge current capacity based on ANSI / IEEE C62.41 location category | | | |
|--|---|-----------|----------|
| Category | Application | Per Phase | Per Mode |
| C | Service Entrance Locations (Switchboards, Switchgear, MCC, Main Entrance) | 250 ka | 125 ka |
| B | High Exposure Roof Top Locations (Distribution Panelboards) | 160 ka | 80 ka |
| A | Branch Locations (Panelboards, mccc, Busway) | 120 ka | 60 ka |

- C. SPD Type: All SPD’s installed on the line side of the service entrance disconnect shall be Type 1 SPD’s. All SPD’s installed on the load side of the service entrance disconnect shall be Type 1 or Type 2 SPD’s.

2.3 PANELBOARD REQUIREMENTS

- A. The SPD application covered under this section includes panelboards. The SPD units shall be tested and demonstrate suitability for application within ANSI/IEEE C62.41 Category B environments.
 - 1. The SPD shall not limit the use of through-feed lugs, sub-feed lugs, and sub-feed breaker options.
 - 2. SPD’s shall be installed immediately following the load side of the main breaker. SPD’s installed in main lug only panelboards shall be installed immediately following the incoming main lugs.
 - 3. The panelboard shall be capable of re-energizing upon removal of the SPD.
 - 4. The SPD shall be interfaced to the panelboard via a direct bus bar connection. Alternately, an SPD connected to a 30A circuit breaker for disconnecting purposes may be installed using short lengths of conductors as long as the conductors originate integrally to the SPD. The SPD shall be located directly adjacent to the 30A circuit breaker.
 - 5. The SPD shall be included and mounted within the panelboard by the manufacturer of the panelboard.
 - 6. The SPD shall be of the same manufacturer as the panelboard.
 - 7. The complete panelboard including the SPD shall be UL67 listed.

- 2.4 ENCLOSURES FOR INDIVIDUALLY MOUNTED SPD'S shall be constructed of a polymer intended for indoor use to provide a degree of protection to personal access to hazardous parts and provide a degree of protection against the ingress of solid foreign objects (falling dirt).

PART 3 – EXECUTION

- 3.1 FACTORY TESTING: Standard factory tests shall be performed on the equipment under this section. All tests shall be in accordance with the latest version of NEMA and UL standards.
- 3.2 INSTALLATION:
- A. Install all equipment per the manufacturer's recommendations and the contract drawings.
 - B. I
 - C. Install individually enclosed SPD'S in the raw water intake building and high service building
 - D. Install an SPD within Panel "MDPST".
- 3.3 WARRANTY: The manufacturer shall provide a full ten (10) year warranty from the date of shipment against any SPD part failure when installed in compliance with manufacturer's written instructions and any applicable national or local code.

END OF SECTION 16507

SECTION 16600 - LIGHTING, INTERIOR

PART 1 - GENERAL

1.1 ELECTRICAL GENERAL PROVISIONS

- A. Provisions of Section 16100 - Electrical General Provisions shall be made an integral part of this section.

- 1.2 LIGHTING FIXTURE SCHEDULE: The lighting fixture schedule lists an acceptable manufacturer and catalog numbers for each type of fixture. At Contractor's option, he may also offer an alternate based upon another manufacturer provided that the quality of the alternate is equal to or exceeds that specified.

1.5 SUBMITTALS

- A. For fixtures, submit photometrics, coefficient of utilization tables, efficiency, gage of fixture metal, lens material, thickness and style, lens frame material and hinge arrangement, and a copy of a test report by an independent testing laboratory.
- B. For each space shown to contain emergency light fixtures, provide point-by-point illumination level plots of means of egress pathway emergency lighting showing that, under emergency conditions, illumination at all points of those areas exceed 1.0 footcandle average, 0.1 footcandle minimum with a max-to-min ratio less than 40:1.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Catalog numbers given in the fixture schedules are series numbers only and may not necessarily cover all necessary appurtenances.
 - 1. Lighting fixtures shall be as indicated on drawings with applicable design features specified in this section.
 - 2. Provide integral emergency ballast where indicated on the drawings.

PART 3 - EXECUTION

- 3.1 GENERAL: Provide lamps, plates, rings, hangers, trim, and all accessories necessary for a complete and secure installation.

3.2 FIXTURE INSTALLATION

- A. Carefully examine the drawings of all disciplines so as to become acquainted with the features of the building, and the location of pipe and ductwork which would alter the location and spacing of outlets for fixtures.
- B. Adjust fixture locations as required to avoid interference with other trades or to provide maximum practical illumination for personnel areas.
- C. Lighting fixture arrangements and mounting heights shall be as indicated on the drawings. Where job conditions require arrangements or mounting heights different from those shown or specified to avoid equipment, structural features, etc., such changes in mounting height shall be as directed without additional cost to the Owner.

END OF SECTION 16600