

16010.1**DESCRIPTION**

The General Conditions, Supplementary General Conditions, Alternates and Addenda, applicable drawings and the Technical Specifications herein shall apply to the providing and construction of a complete electrical system under the requirements of this Division 16.

16010.1.1**RELATED WORK AND REFERENCED SECTIONS**

Section 01300 - Submittals
Section 02200 - Trench Excavation and Backfill
Section 16050 - Basic Materials and Methods
Section 16150 - Electrical Control Devices
Section 16210 - Lighting Fixtures
Section 16400 - Service and Distribution System

16010.1.2**SCOPE**

- A. The Work required under this Section consists of the Electrical General Requirements and related items necessary to complete the Work indicated within the Contract Documents.
- B. This Section describes procedures and incidental items of Work relating to Electrical Division 16.
- C. The drawings are diagrammatic, intended to indicate the general scope and location of the Work to be installed and are not to be considered as complete in every detail. The Contractor shall install all Work indicated and/or specified herein, complete in every way to perform the function (s) intended without additional cost.
- D. Plans and Specifications are complementary; whatever is called for in either shall be as called for in both. In the event Work is called for in more than one place and is of conflicting requirements, the right shall be reserved to require the installation of the larger or the more expensive.

16010.1.3**CONTRACT DOCUMENTS**

- A. Contract documents consist of drawings, specifications, and other documents issued by the Engineer. Each is complementary and requirements shown, written or reasonably inferable there-from on one is considered as written, shown and implied in all.
- B. Electrical drawings are diagrammatic, but shall be followed as closely as actual construction and Work of other Contractors will permit. Runs to panels from outlets referred to as "home runs" are indicated, by pointing in the general direction of panels. Contractor shall continue such circuits to the panels as though the routes were completely indicated.
- C. Deviations from the Drawings required to make Work of this Contract conform to Building as constructed, or as to Work of other contractors or subcontractors, shall be made by the Contractor at his expense. The Engineer reserves the right to make minor changes in the location of equipment and outlets without additional charges.
- D. The Contractor shall familiarize himself with the architectural and mechanical plans. The Contractor shall perform all Work and provide all material required by the electrical Contractor shown under these and all other sections of the plans and specifications.

16010.1.4 SUBMITTALS

All submittals shall meet the requirements of Section 01300 of these Specifications.

16010.1.4.1 SHOP DRAWINGS – Submittal of shop drawings shall be as follows:

- A. Submittal of shop drawings shall meet the requirements of Section 01300 of these Specifications.
- B. Shop drawings shall be submitted within fifteen (15) days after the award of contract.
- C. Shop drawing shall include functional and descriptive literature of the particular item furnished complete with dimensional drawings, rough-in and installation instructions, knock-out locations, hangers or mounting devices, etc., as required for the proper checking and installation of the equipment. Catalog sheets without any reference made to the particular item will not be acceptable. All special features called for in the Contract Documents shall be noted. Where performance test results of a product design are called for in the technical sections of these specifications, test data sheets shall be provided with the shop drawing submittal.
- D. Shop drawings shall be submitted for all switch gear, motor control centers, motor starters, control panels, telemonitoring panels, alarms, electrical controls, electrical instrumentation, communication devices and circuitry, lighting fixtures, and equipment anchors and supports for seismically supported components.
- E. In connection with seismic restraint requirements, shop drawings are required for all equipment anchors, supports, and seismic restraints. Submittals shall include weights, dimensions, load/deflection data, centers of gravity, standard connections, manufacturer's recommendations, and behavior problems (vibration, thermal, expansion, etc.) associated with equipment so that the final design can be properly reviewed.
- F. Three preliminary sets shall be submitted to the Architect/Engineer for their review. Following review, two sets will be returned to the Contractor for correction. After corrections have been made, the formal six sets of the corrected shop drawings shall be submitted for final review and distribution.
- G. Each shop drawing required under this or other sections of Division 16 shall be bound together in sets in one hard back three ring binder per set, properly indexed for the formal submittal. Binders shall be properly sized to adequately contain all of the materials to be placed therein and shall be labeled to identify the Owner, the name of the job, the name of the Contractor and/or any sub-contractor (s), and any other pertinent information.

16010.1.4.2 MATERIALS LIST - A materials list including manufacturer, type, size, model number and other properties shall be submitted for all raceway, conduit, fittings, support materials, wire, cable, junction boxes, and wiring devices, including boxes for weather proof devices.

16010.1.4.3 EQUIPMENT/INSTRUMENT LIST - Equipment/Instrument list(s) including manufacturer, type, size, model number and other properties shall be submitted for all equipment and instruments.

16010.1.4.4 OPERATION AND MAINTENANCE MANUAL – The Contractor, or electrical subcontractor, shall assemble and deliver to the Owner an operation and maintenance (O&M) manual for the electrical systems furnished and installed in connection with the Work. O&M manuals shall be as follows:

- A. Number of copies shall be as specified in Section 01300 or as required in the Special

Provisions or by the Engineer or the Owner. The O&M manual shall be reviewed and approved prior to the final inspection.

- B. Each copy of the O&M manual shall be bound in a hard-backed binder. The front of each binder shall have the following information printed on it by silk screen process:

OPERATION AND MAINTENANCE MANUAL
FOR
(PROJECT NAME)
(SPECIFIC SYSTEM NAME AND/OR LOCATION, as appropriate)
(OWNER'S NAME)

- C. Each copy shall contain a master index at the beginning of the manual showing all items included.
- D. A separate section for each different type of item of equipment or information furnished shall be provided. Use plastic tab indexes for all sections of the book.
- E. The first section of the manual shall consist of the names, addresses and telephone numbers of the Mechanical Engineer, Electrical Engineer, General Contractor, Electrical Contractor.
- F. Descriptive literature (manufacturer's catalog cuts and other data) of each manufactured item shall be included. Literature shall show capacities and size of equipment used and shall be marked indicating each specific item with all applicable data underlined.
- G. Operating instructions shall, at a minimum, include:
1. General description of the electrical system.
 2. Where applicable, a step-by-step procedure to follow in putting each piece of electrical equipment in operation.
 3. Provide diagram for the electrical control system showing the wiring of all related electrical control items, such as fuses, interlocks, electrical switches and relays.
 4. Test results of all items requiring testing as called for in the technical section of specifications.
- H. Maintenance instructions shall, at a minimum, include:
1. Manufacturer's maintenance instructions for each piece of electrical equipment installed in the project. Instructions should include installation instructions, parts numbers and lists, operation instructions of equipment, name of vendor, and maintenance and lubrication instructions.
 2. A summary list of each piece of electrical equipment requiring lubrication, showing the name of the equipment, location, type and frequency of lubrication.
 3. A complete list of all electrical equipment used indicating name, model, serial number and nameplate data of each item, together with number and name of each system with which the item is associated.
- I. An approved copy of the manual shall be used during final inspection and shall be left with the Owner for its use and disposition.

16010.1.4.5 OTHER INFORMATION - Other information shall be provided as required by the Engineer.

16010.2 MATERIALS

All equipment and materials shall be as specified, new, of the best quality and free from defects. Each type of equipment or material shall be the same make and quality.

16010.2.1 UNDERWRITERS LABORATORIES

All equipment, materials, and devices shall be approved by Underwriters Laboratories, Inc. (UL). Custom designed items shall be fabricated using UL approved materials. All custom panels shall bear the UL label certifying UL-508 standards.

16010.2.2 MATERIALS AND EQUIPMENT TO BE SUPPLIED

The Contractor or electrical Subcontractor shall provide all materials, equipment, and any other fittings or devices required for a complete and finished installation. Materials and equipment shall be as shown on the Drawings and/or as called for in these Specifications, including the Special Provisions if any, unless otherwise approved, in writing, by the Engineer.

16010.2.3 APPROVAL OF SUBSTITUTIONS

Equipment and materials are designated by one or more manufacturer's name brands or numbers. It is not the intent of the Specifications to exclude other equipment or materials that equal the standard of those specified. If the Bidder, in its bid, desires to use equipment or materials other than those specified, the Bidder must obtain written approval from the Engineer in this regard at least seven (7) calendar days prior to bidding. Submit complete data, including detailed specifications and drawings with written request in duplicate. Samples may be requested if deemed necessary. Certificates of compliance with specifications or a list of all exceptions to the specifications shall be included with request.

16010.2.4 STORAGE OF EQUIPMENT AND MATERIALS

- A. The Contractor shall be responsible for the proper transportation, unloading, storage, and holding of all electrical systems, materials, and equipment until they are installed in the Work, and accepted by the Owner. This shall include responsibility for damage, loss, theft, and pilferage.
- B. Materials and equipment shall be handled and stored in accordance with the manufacturer's and/or supplier's instructions. Packaged items shall be stored in original, undamaged condition with manufacturer's seals and labels intact. Materials and equipment shall be stored in a neat and orderly condition at all times and allowing for easy access for inspection.

16010.2.5 RACEWAYS AND FITTINGS

The manufacturer shall be Republic Steel, Triangle, National, Carlon, Allied or approved equal. All conduits shall be in accordance with the requirements of the National Electric Code (NEC) and applicable local codes. Steel conduit shall be in accordance with recommendations of the latest edition of American Iron and Steel Institute "Design Manual on Steel Electric Raceways."

A. RIGID GALVANIZED STEEL CONDUIT (RGS)

1. Shall be USAS C80.1, zinc-coated by hot-dip galvanizing or sheradizing with additional enamel or lacquer coating.
2. Fittings shall be threaded type and of the same material as the conduit.
3. Unless otherwise noted, rigid metallic conduit shall be used for underground runs, under slab runs, and where runs are placed in concrete. It shall also be used for exposed runs in mechanical rooms and for other exposed runs where the conduit is exposed to moisture, weather or mechanical injury.
4. Where rigid metallic conduit is used for underground installations, including elbows required to make sweeps in PVC conduit runs, the conduit shall be wrapped with 3m-50 10 mil pipe wrap or approved equal.

B. INTERMEDIATE METAL CONDUIT (IMC)

1. Shall be UL Standard 1242, hot-dip galvanized steel.
2. Fittings shall be threaded type and of the same material as the conduit.
3. It can be used for exposed runs in mechanical rooms and for other exposed runs where the conduit is exposed to moisture, weather or mechanical injury.
4. **This conduit shall not be used in hazardous areas.**

C. ELECTRICAL METALLIC TUBING (EMT)

1. Shall be in accordance with UL "Standard for Electrical Metallic Tubing" No. 797, galvanized mild steel with interior coat of enamel.
2. Fittings shall be steel compression type.
3. **Cast type, indenter, or set-screw type fittings shall not be used.**
4. EMT shall be used for exposed and concealed runs to lighting fixtures above 10 feet or above ceilings.
5. **Not approved for any exposed conduit runs or drops.**

D. NON-METALLIC CONDUIT (PVC)

1. Shall be PVC Schedule 40 heavy wall suitable for direct burial.
2. Fittings shall be threaded or solvent welded type of the same material as the conduit.
3. **Shall not be used above grade or embedded in concrete, except as noted specified for runs above 600 volts. PVC shall not be used where exposed or concealed in walls or floors.**
4. PVC may be used for all underground runs, except for bends exceeding 22 degrees where jacketed or wrapped rigid galvanized steel is required, and runs under concrete slabs. Runs under concrete slabs shall be embedded in earth a minimum of 4 inches below the bottom of the slab. Risers through concrete slabs shall be rigid steel or intermediate metal conduit.
5. Provide PVC to steel adapters as required.

E. FLEXIBLE LIQUID-TIGHT CONDUIT

1. Shall be galvanized steel, liquid-tight, with moisture and oil- proof extruded PVC cover.
2. Fittings shall be liquid-tight, compression type.
3. Approved for flexible connections to equipment, items or instruments subject to vibration such as motors, fans, pumps, dry transformers, etc.
4. **Flexible Liquid-tight conduit shall not be less than 18 inches in length and not more than 3 feet in length.**

- F. FLEXIBLE STEEL CONDUIT
1. Shall be galvanized steel.
 2. Fittings shall be compression type of the same material as the conduit.
 3. Shall be used for lighting fixture runs above drop ceiling grid systems or other devices required or approved by NEC or as requested or approved by the Engineer. (Install ground conductor per NEC in runs over 6 feet in length.)
- G. PVC COATED CONDUIT
1. Rigid Steel conduit coated with a minimum of 40 mil of PVC coating shall be used in all corrosive areas or where required by NEC or the Engineer.
 2. **All fittings, boxes, support materials, clamps, etc., used with PVC coated conduit shall be PVC coated in a like manner.**
 3. Wiring devices shall be corrosion resistant UL rated in corrosive areas requiring PVC coated conduit.
- H. WALL AND FLOOR SLEEVES
1. Shall be galvanized sheet steel or pipe.
- I. CLAMPS
1. Shall be galvanized malleable iron one-hole straps, beam clamps or other approved device with necessary bolts and expansion shields.
 2. **Perforated metal straps shall not be used.**
- J. CONDUIT SIZES
1. Shall be as indicated on the drawings.
 2. **Shall not be smaller than 3/4 inch exposed or 1 inch buried conduit unless otherwise specifically approved by the Engineer.**
- K. CONDUIT BUSHINGS
1. For conduit 1-1/4 inch and larger use OZ type BLG or SBLG with Lay-in-Lug.
 2. Use Lay-in-Lug bushings on multiple conduit entrances to enclosures or gutters.
 3. Bonding bushings shall be used on conduits containing service entrance conductors.
- L. ENTRANCE SEALS
1. Provide and install OZ entrance seals on all conduits entering building below grade.
- M. RACKS AND SUPPORTS
1. Conduit support racks, Unistrut supports and fittings, etc., shall be hot-dipped galvanized, except in corrosive areas where the supports and fittings must be PVC coated.
 2. **Painted metal supports are not allowed.**
- N. PULL BOXES
1. Pull boxes, which are required for proper conduit installation, shall be sized according to the requirements of Article 370 of the NEC.
 2. Condulet type pull boxes shall be cast type with threaded hubs

O. OUTLET/JUNCTION BOXES

1. Boxes shall be provided in the wiring or raceway systems wherever required for routing/pulling of wires, making connections and mounting of devices or fixtures.
2. Boxes in exposed conduit runs shall be cast metal condulets with threaded hubs. **Non-metallic boxes are not allowed.**
3. Each box shall be metal and shall have the volume required by the National Electrical Code for the number of conductors enclosed in the box. Boxes for mounting lighting fixtures shall not be less than 4 inch octagonal or 4 inch square except that smaller boxes may be installed as required by fixture configuration, as approved. Boxes in the raceway system shall not be less than 1-1/2 inches deep, except where shallower boxes required by structural conditions are approved.
4. Boxes for other than lighting fixture outlets shall not be less than 4 inches square.
5. Boxes in concealed conduit runs shall be equipped with tile extension rings, device mounting straps and accessories required for the purpose of the outlet.

16010.2.6

A. CONDUCTORS

1. Shall be of the type, size, and locations as shown on the Drawings and meet the requirements of the latest addition of the National Electric Code (NEC).
2. Shall be soft-annealed coated copper in accordance with ASTM B33 or B189.
3. Conductors No. 10 and smaller shall be solid copper for lighting circuits only, all other circuits shall be stranded copper.
4. All conductors shall be THHN/THWN copper rated at 600 volts, unless otherwise noted.
5. **Aluminum conductors will not be allowed.**

B. GROUNDING CABLE

1. Shall be as called out on the drawings and per NEC. (Grounding lugs shall be the clamp type made of high conductivity copper alloy and shall be provided for all equipment to be grounded.)

16010.2.7

SPLICES, TAPS AND TERMINATIONS

- A. Splices, taps and terminations made in interior damp or wet locations, corrosive atmosphere locations or exterior boxes above or below grade shall be covered with 3M heat shrinkable ITCSN series sleeves or end caps or Raychem equal as approved by the Engineer.
- B. All splices shall require approval by the Engineer.

16050.2.1

SAFETY SWITCH DISCONNECTS

- A. Provide disconnect switches where shown and required by NEC as specified herein.
- B. Type: Heavy duty, manual, single throw, fusible or non-fusible as indicated.
- C. Rating: 600 volt, ampere size as noted or as required for load served.
- D. Enclosure: Nema 4, Gasketed stainless steel or as called out in equipment schedule on drawings.
- E. Fuses: Switches shall be equipped with Type "R" fuse clips factory installed. Fuses shall

be dual element type RK5 of size as noted.

- F. Non-Fusible Switches: For equipment 2 horsepower and smaller, shall be horsepower rated; toggle switch type; quantity of poles and voltage rating as indicated. For equipment larger than 2 horsepower, switches shall be the same as fusible type.

16050.2.2 JUNCTION BOXES

- A. Junction or pull boxes, which are required but not shown, shall be sized according to requirement of the most current NEC.
- B. Condulet type junction boxes shall be cast metal with threaded hubs, unless otherwise specified on the drawings.

16050.2.3 WIRE DEVICES

- A. Switches: 20 ampere, 120/277 volt, toggle type. Single pole used as designation for entire series - double pole, 3-way, 4-way or lock type. Hubbell #1221, Bryant #1221, Leviton #1221. Switch and pilot shall be Hubbell #1221-PL or Leviton #1221-PL. Double pole toggle switch shall be Hubbell #1222-2.
- B. Ground Fault Interrupter Receptacles: 20 ampere, 125 volt, NEMA 5-20R, gray color. Leviton #6398.
- C. Receptacles: 20 ampere, 125 volt, NEMA 5-20R, gray color for locations where indicated. Hubbell #5352, Bryant #5352, or Leviton #5352.
- D. All devices shall be gray in color.
- E. Special receptacles other than those listed above shall be as designated on the drawings.
- F. Device Plates:
- 1) For surface mounted boxes plates shall be stainless steel suitable for use on cast metal device boxes, condulet FS and FD types. Shall be complete with gaskets and approved for wet locations.
 - 2) For flush boxes in finished areas, plates shall be stainless steel. Gang plates shall be one-piece.

16010.3 CONSTRUCTION REQUIREMENTS

Unless notified otherwise, the Contractor responsible for the electrical Work shall perform all electrical work in accordance with the Drawings and with these Specifications.

16010.3.1 CODES, PERMITS, LICENSES AND STANDARDS

- A. PERMITS AND LICENSES - The Contractor shall secure all permits and licenses required in connection with this work.
- B. CODES AND STANDARDS - All work, labor, and equipment shall conform to applicable State and Local Codes and Standards and the applicable sections of the latest revisions of the following:
- American Society for Testing and Materials (ASTM)

- National Fire Protection Association, National Electrical Code (NEC)
- Insulated Power Cable Engineers Association (IPCEA)
- Underwriters Laboratories Inc. (UL)
- American Steel and Iron Institute, "Design Manual on Steel Electrical Raceways"
- National Electrical Manufacturer's Association (NEMA)
- American National Standards Institute (ANSI)
- Institute of Electrical and Electronic Engineers (IEEE)
- International Building Code (IBC)
- International Fire Code (IFC)
- Sheet Metal and Air Conditioning Contractors National Association (SMACNA)

Conflicts between any of the above referenced codes and standards and between any of them and these Specifications and/or the Project Drawings shall be resolved by complying with the more stringent requirements.

16010.3.2 SAFETY

- A. REGULATIONS - The Contractor's work shall conform to the Associated General Contractors of America, Inc. *Manual of Accident Prevention in Construction* and shall comply with all current regulations of the Occupational Safety and Health Act (OSHA) as required for work identified on the Drawings or in these Specifications.
- B. SAFETY GUARDS - All equipment, which the Contractor furnishes and installs, shall be provided with appropriate safety guards for prevention of accidents. The Contractor shall provide and maintain any other necessary construction required to secure safety of life or property, including the maintenance of sufficient lights to secure such protection.

16010.3.3 DIAGRAMMATIC DRAWINGS

- A. The electrical drawings are diagrammatic, intended to indicate the general scope and locations of the work to be installed and are not to be considered as complete in every detail. The Contractor shall install all work indicated and/or specified herein, complete to perform the function intended without additional cost.
- B. The electrical drawings are diagrammatic, however, they shall be followed as closely as actual construction and work of other contractors will permit. Runs to panels from outlets, referred to as "home runs", are indicated on the drawings by arrows pointing in the general direction of panels. Contractor shall continue such circuits to the panels as though the routes were completely indicated. Deviations from drawings required to make the work of this Contract conform to building as constructed, or as to work of other contractors, shall be made at the Contractor's expense. The Engineer reserves the right to make minor changes in the location of equipment and outlets without additional charges.

16010.3.4 SITE EXAMINATION

Examination of the site shall be made by the Contractor, who shall compare it with the drawings and specifications and satisfy himself as to the conditions under which the work is to be performed. The Contractor shall, at such time, ascertain and check all conditions which may affect its work. No allowance shall subsequently be made in the Contractor's behalf for any extra expenses to which the Contractor may be put due to failure or neglect on its part to make such examination and determination of the condition.

16010.3.5 SUPERVISION

- A. A competent foreman or superintendent, approved by the Owner's Representative, shall be at the site at all times to receive instructions and shall have the proper authority to act on behalf of the Contractor. The Contractor shall verify dimensions given on the electrical drawings and report any errors or inconsistencies to the Engineer before commencing the work. The Engineer or its representative will interpret the meaning of the Drawings and Specifications where questions arise.
- B. Contractor shall assign persons to be in direct charge of work who are thoroughly experienced in the types of construction work specified herein. All labor shall be performed in a workmanlike manner by skilled workmen under the supervision of competent foremen.

16010.3.6 WORKMANSHIP

Workmanship shall be in accordance with the best present-day construction methods and shall be neat and orderly throughout the project.

16010.3.7 COORDINATION OF CONSTRUCTION

- A. The Contractor shall coordinate work with other contractors, subcontractors, the Owner, and the Engineer to assure orderly and expeditious progress of work. The Contractor shall select order/sequence of work and establish schedule of working hours for construction, all subject to review and direction by the Owner.
- B. This Contractor shall be held solely responsible for the proper installation of its work. The Contractor shall arrange with the proper contractors for the installation of anchors and other embedded devices, and for the leaving of required chases, openings, etc., and shall do all cutting and patching made necessary by its failure or neglect to make such arrangements with others. Any cutting or patching done by this Contractor shall be subject to the directions of the Engineer and shall not be started until approval has been obtained.
- C. All cutting, welding or drilling of concrete or structural members shall be properly reinforced and patched to match as nearly as possible the surrounding work. Before cutting, welding or drilling any concrete or structural member, the Contractor shall secure the approval of the Engineer. Where deemed appropriate by the Engineer, in the case of gross negligence pertaining to this issue, the Engineer reserves the right to back-charge the Contractor for the Engineers associated costs.

16010.3.8 INSTALLATION**RACEWAY AND FITTINGS**

- A. **STANDARDS**
 - 1. All conduit to be installed in accordance with the requirements of the National Electrical Code, latest addition.
 - 2. Steel conduit to be installed in accordance with recommendations of American Iron and Steel Institute "Design Manual on Steel Electrical Raceways", latest addition.
 - 3. PVC coated, "Plastic-Bond-Red", conduit installed in accordance with instructions in Robroy Plastic -Bond installation manual.
- B. **ELECTRICAL CONTINUITY**

All metallic conduit systems shall be electrically continuous throughout.

C. MOISTURE

1. All conduit raceway systems shall be essentially moisture tight.
2. Conduit drainage shall be accomplished by sloping conduits towards manholes or boxes.
3. Where pockets cannot be avoided in exposed conduits, provide drainage fittings or weep holes. Weep holes drilled through the walls of any conduit or fitting shall not produce burrs on the inside or outside surface.

D. ALIGNMENT OF EXPOSED CONDUIT

Install conduit runs parallel or at right angles to lines of structure.

E. FIELD CUTS AND THREADS

1. Field cuts shall be made square, threads clean and sharp.
2. Remove burrs, sharp or rough edges by reaming.
3. Before couplings or fittings are attached, apply a coat of red lead or zinc chromate to male threads of RGS or IMC conduit, also apply these coatings or other special compound recommended by the manufacturer of the conduit where the conduit protective coating is damaged.
4. PVC coated conduit system requires male threads on conduit, elbows and nipples and all female threads on fittings or conduit couplings to be protected by application of a urethane coating.
5. **Care must be taken to assure that concrete surfaces are protected from cutting oil, any/all damage will be the responsibility of the Contractor.**

F. BENDS

1. Uniform, whether job-fabricated or made with standard fittings or boxes.
2. Do not dent or flatten conduit
3. Conduit installation should be installed symmetrically insofar as practicable.
4. Unless approved otherwise, bends larger than 1-1/4 inch shall be factory made.
5. Bends in exposed conduit shall be symmetrical insofar as practicable.
6. Do not expose bends at floor or ceiling.

G. LOCATION

1. Conduit routing is generally shown in schematic fashion, unless dimensioned or noted to the contrary.
2. Contractor is responsible to route conduits as required to connect equipment or devices.
3. Vertical risers, equipment and device locations are approximately as indicated on the drawings. Contractor shall coordinate installation of conduit with structure and equipment.
4. Contractor is responsible to coordinate conduit installation with other contractors installations, in the event of conflict, field routed conduit shall be moved at the Contractors expense.
5. Conduit shall be located a minimum 6 inches away from steam, hot water, or other hot surface. Protect from heat, as Engineer approved, if the 6 inch separation is impracticable.
6. Diagonal installation is not permitted.

H. BURIED/EMBEDDED CONDUIT

1. Buried conduit shall be a minimum of 30 inches below finished grade, sloped toward manholes or pull boxes.
2. RGS conduit installed underground, or used in PVC runs for sweeps 22 degrees or larger, must be wrapped with 3M-50 10 mil pipe wrap, approved asphalt compound or approved equal.
3. Mid-run weep holes and gravel drainage pockets will not be permitted.
4. Conduits embedded in concrete or masonry shall be securely held in place during concrete placement and construction operations.
5. In concrete floors, conduit shall be set before pouring of concrete begins. Conduit shall be routed in a direct line, with bends as long as possible, with 2 inches minimum from conduit to bottom of slab and maximum conduit size of 2 inch, unless otherwise approved.
6. Non-metallic conduits above 600 Volts shall be encased in red concrete covered by a minimum of 2 inches on all sides.

I. WALL PENETRATIONS

1. Penetrations through exterior building walls to be by core drilling and providing appropriate conduit entrance seals.
2. Openings through existing partitions shall be provided at Contractor's expense. Holes through masonry construction shall be drilled with suitable core drilling machine.
3. All work is to be performed neatly.
4. Patches shall match original material in composition and appearance.
5. Provide fire seals as detailed or required by NEC where a fire rated wall or partition is penetrated.
6. A template shall be provided by the Contractor to hold conduit groups terminating together or passing through fire walls or floors.
7. In walls and partitions, conduit shall be installed vertically. If vertical installation is impracticable, the Engineer shall approve horizontal installation for each location.

J. EXPANSION FITTINGS

1. Install expansion fittings in all conduit runs crossing structural expansion joints and in all straight conduit runs exceeding 75 feet in length.

K. CONDUIT ENDS

1. Insulating bushings shall be installed at open conduit ends, terminating in panels, control centers, consoles or other similar locations.
2. Plug space around cables with oakum and/or an approved sealing compound where conduits enter switchboards, cabinets or similar locations.
3. Cap or plug all spare conduit ends to prevent the entrance of foreign material.

L. CONDUIT CONNECTIONS

1. At cabinets and boxes use double locknuts and insulating bushings for rigid conduit.
2. At cable tray securely clamp conduit to tray and install insulating bushings.
3. Install insulated grounding bushings with lay-in ground lugs where metallic conduit terminates in non-metallic manholes or pullboxes.
4. Flexible conduit for connection to movable/vibrating equipment shall be liquid-tight, sealtite as manufactured by Anaconda Metal Hose Company, or approved equal, utilizing approved liquid-tight fittings.

M. SUPPORTS

1. Hangers and supports shall be galvanized or PVC coated.
2. Hangers generally are not detailed, but must be adequate to support combined weight of conduit. Rigid fastenings are to spaced at a maximum of 6 feet.
3. Clamps will be galvanized malleable iron one-hole straps, beam clamps or other approved device with necessary bolts, washers and expansion shields.
4. **Perforated metal straps shall not be used.**
5. Adjustable hangers shall be used to support horizontal runs only, use trapeze hangers for parallel runs of conduit. Install u-bolts or other approved clamping device at each end and at each elbow. Install clamp every third intermediate hanger for each conduit.

N. CONDUIT CLEANING

1. Contractor is to clean and swab the inside of conduits, by mechanical means, to remove foreign materials and moisture before conductors are installed.

O. SPARE CONDUITS

1. Spare conduits shall have a nylon pulling line installed for future installation of cables.
2. Recessed panels shall have three 1 inch spare conduits in the wall space stubbed-out above ceiling and three 1 inch spare conduits stubbed under the floor.
3. Spare conduits shall be capped.

CONDUCTOR INSTALLATION**A. BENDING RADII**

1. Not to be less than permitted by ICEA and/or NEC.

B. SUPPORTS IN VERTICAL RUNS

1. To be in accordance with NEC requirements.

C. SPLICING

1. Will be permitted only with Engineers approval, and will be held to an absolute minimum.
2. Permitted only in junction boxes or similar accessible locations.
3. Cover with heat shrinkable sleeves to make moisture proof and corrosive resistant.
4. No splicing of instrument or control wiring shall be allowed without specific approval, by the Engineer.

D. CONNECTORS

1. Solderless compression or mechanical type will be utilized where screw does not bear directly on the wire.
2. Apparatus lugs, conductor, and coat shall be thoroughly cleaned with suitable oxidation inhibiting compound prior to connection.
3. Retaining cup washers shall be used where solid wire is used at terminal blocks.
4. Compression type connectors shall be installed using ratchet type crimping tools that will not release until full compression has been achieved.
5. Dies for the crimping tools shall be matched to the connector and approved for use

- by the Engineer and the connector manufacturer.
6. Twist on type, Scotch-lok or approved equal, connectors shall be restricted to the connection of lighting fixture wires only.

E. POWER CABLES

All power cables will be installed in strict accordance with the manufacturers instruction, and in conformance with NEC.

F. CONNECTIONS

All apparatus lugs shall be tandem single or multi-barrel lugs as detailed/required.

G. CONDUCTOR PULLING

1. Use pulling grips or eyes.
2. Firmly mount pulling reels on portable stand and secure against displacement
3. Use an approved by the Engineer commercial pulling compound for lubrication.
4. Monitor and do not exceed cable-pulling tension as specified by the cable manufacturer.

H. COLOR CODING

1. Single phase service – use white for neutral conductor, and black for ungrounded conductors.
2. Three phase service - feeder and branch conductors shall be color coded as follows

120/208 Volt

277/480 Volt

- | | |
|---------------------------|---------------|
| a. Phase A – Black | Brown |
| b. Phase B – Red | Orange |
| c. Phase C – Blue | Yellow |
| d. Neutral – White | Grey |
| e. Ground – Green or Bare | Green or Bare |

3. Coding shall be by insulation color or minimum 1 inch band of colored tape.
4. Green covering of conductors shall be solely for grounding.

I. PHASING

1. Where common neutral is run for two or three circuits, phase conductors shall be connected to breakers in the panel, which are connected to different phase legs.
2. Home runs may be combined at the option of the Contractor, providing not more than three circuits are installed in one conduit, unless otherwise approved by the Engineer.

J. SERVICE SYSTEMS

1. Incoming service systems shall be grounded at two points with the main water service at the entrance point ground to the building and to driven ground rods as indicated on the Standard Detail Drawing.
2. Jumpers shall be provided around water meters and any dielectric sections of pipe.
3. Size shall be as indicated on the Drawings and/or as required by NEC.
4. Connections shall be accessible for inspection.
5. Neutral conductor connection to grounding electrode conductor shall be at the main

- service enclosure only.
6. Type of equipment and details of installation shall be verified with Power Company representatives.
 7. Metering equipment shall be provided as indicated on the Drawings or as required by these Specifications.

16010.3.9 INSTALLATION OF POWER AND CONTROLS TO EQUIPMENT

Contractor shall provide all power and control wiring required for the work of other trades as described on the drawings and in the specifications, except where the furnishing and installing of such wiring is specified elsewhere. Connect cord sets to Owner furnished equipment and make connections to all electric power consuming equipment whether furnished under contract or by Owner.

16010.3.10 TEMPORARY ELECTRIC SERVICE DURING CONSTRUCTION

- A. The Project Contractor is responsible for all project electrical work unless otherwise noted. The Contractor shall be aware, however, that some or all of the project electrical work may be performed by the Owner and/or an independent electrical contractor. The division of work to be performed by others may be indicated on the drawings, or may be as called for by the Engineer. But, the Contractor shall be responsible to review the Drawings and consult with the Engineer, to determine if its scope is less than one hundred percent of all project electrical work. The Contractor shall also be responsible to coordinate and schedule its work with that of the Owner or independent electrical contractor, and to leave its installations ready, with the connecting wires coiled, for the Owner or independent contractor to connect to or to terminate as necessary, thereby ensuring the most efficient completion of the project by all parties.
- B. The Contractor or electrical subcontractor doing the work shall provide temporary power, complete with metering and wiring, for lighting and power outlets for construction tools and equipment. This contractor will make arrangements with the local power company for temporary electrical service connections for construction power.
- C. No attempt shall be made herein to specify construction power requirements for equipment in detail. However, all temporary wiring shall meet NEC, Article 305, requirements. The service shall be provided with a main disconnect, and all power receptacles shall be, or be protected by, appropriately rated GFI single-pole devices.
- D. At completion of the Project, or sooner if directed, the temporary power supply shall be disconnected and removed from the construction site.
- E. During construction, if it becomes necessary to shut down power to a critical item of equipment or process, the Contractor or electrical subcontractor shall provide the necessary wiring and a portable generator or other source of electric power to keep such critical equipment or process in operation.

16010.3.11 SEISMIC RESTRAINT

- A. The appropriate Seismic Zone Classification will be provided on the Drawings or in the Special Provisions. All electrical equipment shall be securely anchored and seismically braced in accordance with the regulations contained in the most recently adopted edition of the IBC and with the *SMACNA Guidelines for Seismic Restraints of Electrical Systems* as they pertain to the Seismic Zone Classification given.
- B. Units mounted and secured directly to structures shall be provided with connectors of

sufficient strength to meet the restraining criteria.

- C. All electrical equipment which is to be securely anchored (hard mounted) to the building or structure shall have supports designed to withstand lateral and vertical "G" loadings equal to or greater than IBC requirements and SMACNA guidelines for the given seismic zone.

16010.3.12 LABELING OF J-BOX COVERS

All J-Box covers shall be labeled with information showing the voltage and the circuit number in reference to each home run pulled through that J-Box and a particular run of conduit. The Contractor shall continue such circuits to the panels as though the routes were completely indicated.

16010.3.13 REPAIR OF WORK

- A. The work shall be carefully laid out in advance and where cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings or other surfaces is necessary for the proper installation, support, or anchorage of the conduit raceways or other electrical work, this work shall be carefully done. Any damage to building, piping or equipment shall be repaired by skilled mechanics of the trades involved, at no additional cost to the Owner.
- B. Penetrations within fire rated wall assemblies shall be appropriately repaired and replaced to full integrity of the designed fire resistance of the wall.

16010.3.14 TESTING

On completion of the work, the installation shall be tested free from all grounds and short circuits. Normal feeders, circuits, and service entrance conductors with wire size #2 and larger shall be tested for leakage phase-to-ground and phase-to-phase prior to energizing the electrical system. The Contractor shall submit a written report to the Engineer showing methods used and readings taken. Voltage applied for testing shall not exceed two times normal operating voltage.

16010.3.15 GUARANTEE/WARRANTY

- A. The following guarantee is a part of the specification and shall be binding on the part of the Contractor:

"The Contractor guarantees that this installation is free from defects. The Contractor agrees to replace or repair, to the satisfaction of the Owner's Representative, any part of this installation which may fail or be determined unacceptable within a period of one (1) year after final acceptance."

- B. Electrical systems and equipment shall not be considered acceptable for substantial completion until they have performed in service continuously without malfunction for at least ten (10) days.

16010.3.16 DEFECTIVE EQUIPMENT

If equipment fails to conform to the Specifications or to operate satisfactorily, the Owner will have the right to operate said equipment until defects are corrected. The Owner will have the right to operate rejected equipment until it is replaced, without cost for depreciation use or wear. The Contractor shall remove defective equipment from operation for examination, adjustment, alteration, or change only at times approved by Owner.

16010.3.17 CLEAN-UP

- A. As the work progresses, and on a daily basis, the Contractor shall remove from the premises and surrounding streets, alleys, etc., all rubbish and debris resulting from its operations and shall leave all equipment and material furnished by the Contractor absolutely clean and ready for use.
- B. In addition, the Contractor shall periodically remove all debris and waste in order to maintain safe working and operating conditions, and shall dispose of the same in an approved manner. At the completion of work, The Contractor shall remove all its rubbish, tools, scaffolds and surplus materials from and about the site, leaving its work clean and the areas ready for occupancy.

16010.3.18 AS-BUILT DRAWINGS

Blue line white prints of drawings will be furnished by the Engineer, on which the Contractor shall accurately and neatly mark, in colored pencil, all changes or deviations from the drawings as such changes are made in the work. These drawings shall be reviewed with the Engineer on a timely basis, not to exceed at least once each month. Failure to keep as-built drawings up to date shall be cause for withholding monthly or final payment.

16010.3.19 FINAL INSPECTION AND ACCEPTANCE

The Contractor shall notify the Engineer when work is considered to be complete, in full operating condition, and ready for final inspection. The Engineer, after determining that the installation is ready for final inspection, will conduct the final inspection and tests as are deemed necessary to determine that the provisions of the specifications are satisfied. The Owner will not accept work nor make final payment to the Contractor until Engineer has certified that the work of the Contractor is complete and in conformance with the specifications and guarantees.

16010.4 METHOD OF MEASUREMENT**16010.4.1 NO SEPARATE MEASUREMENT**

Separate measurement shall NOT be made for furnishing or installing electrical systems, components, materials required to be installed within the pay limits for a building or enclosure identified in the Bid schedule to be furnished by the Contractor.

16010.4.2 SEPARATE MEASUREMENT

- A. **NEW BUILDINGS** – Separate measurement shall be made for installation of electrical systems, components, and materials, required for a building or enclosure shown on the Drawings and as called for in these Specifications and identified in the Bid Schedule, when such electrical systems, components, and materials are identified and listed in the Bid Schedule.
- B. **ALTERNATE POWER SYSTEMS** -- Provide standby generator, battery charger, block heater, remote start and operation, power plug/receptacle, automatic transfer switch, manual transfer switch, grounding, conduit, conductors, and fuel supply, as shown on the Drawings, and as defined in the applicable sections of the Specifications for a complete and functioning system.
- C. **EXISTING BUILDINGS** -- Separate measurement will be made for installation of electrical systems, components, and materials, required to be installed or replaced in an existing building or enclosure, as shown on the Drawings and as called for in these Specifications,

when such electrical systems, components, and materials are identified and listed in the Bid Schedule.

- D. **MOBILIZATION & EQUIPMENT** – Provide mobilization and demobilization vehicles and equipment necessary to perform all electrical work as shown on Drawings and Specifications.

16010.5 BASIS OF PAYMENT

16010.5.1 No separate payment shall be made for furnishing or installing electrical systems, components, or materials required to be installed within the pay limits for a building or enclosure identified in the BID schedule to be furnished by the Contractor.

16010.5.2 When electrical systems, components, or materials are measured for a new building or enclosure as shown on the Bid Schedule, separate payment will be made as listed in specification 16400.

16010.5.3 When initial installation or replacement of electrical systems, components, or materials is made in an existing building as shown on the Bid Schedule, the accepted quantity will be paid for at the contract price listed below:

PAY ITEM	UNIT
New Buildings	Lump Sum
Alternate Power Systems	Lump Sum
Existing Building	Lump Sum
Mobilization & Equipment	Lump Sum

16100.1 DESCRIPTION

Furnish and install buried cable for electrical controls and service of the size and location as shown on the Drawings and specified herein.

16100.1.1 RELATED WORK

Section 02200 - Trench Excavation and Backfill
Section 02222 - Pipe Installation
Section 16010 - Electrical General Requirements

16100.2 MATERIALS**16100.2.1 CABLE**

Shall be the size and type as shown on the Drawings or Special Provisions. All cable shall comply with the requirements of the National Electrical Code and shall be specifically manufactured for direct burial.

16100.3 CONSTRUCTION REQUIREMENTS

All buried cable shall be installed as shown on the Drawings and in accordance with the requirements of the National Electric Code and Section 16010.

16100.4 METHOD OF MEASUREMENT**16100.4.1 NO SEPARATE MEASUREMENT**

Separate measurement will not be made when buried electrical cable is a component of another item listed in the Bid Schedule.

16100.4.2 SEPARATE MEASUREMENT

Measurement of buried cable shall be made using a tape measure or other accurate measuring device to determine the number of lineal feet of cable installed and accepted as identified in the Bid Schedule.

16100.5 BASIS OF PAYMENT**16100.5.1 NO SEPARATE PAYMENT**

Separate payment will not be made for buried electrical cable installed and accepted as a component of another item listed in the Bid Schedule.

16100.5.2 SEPARATE PAYMENT

The accepted quantity, when shown as an item in the Bid Schedule, will be paid for at the contract unit price for:

PAY ITEM	UNIT
Buried Cable (<i>size, type</i>)	Lineal Foot

16150.1 GENERAL**16150.1.1 QUALITY ASSURANCE**

- A. Comply with NFPA 70 requirements for electrical materials and installation.
- B. Provide products and components which have been UL listed and labeled, including UL marks indicating special type usage whenever applicable.

16150.2 PRODUCTS**16150.2.1 CONTACTORS**

- A. Acceptable Manufacturers:
 - 1. Allen-Bradley Co.
 - 2. Eaton Corp/Power Distribution Div.
 - 3. General Electric Co. (GE Supply)
 - 4. Square D Co.
 - 5. Siemens
 - 6. Or Approved Equal
- B. Provide starters with thermal overload protection on each phase utilizing interchangeable melting alloy, Class 20 (trip in 20 seconds or less when carrying a current equal to 600 percent of its current rating) overload heaters, or solid state overloads designed with class 20 trip capabilities, sized in field for full load current rating indicated on each motor nameplate.
- C. Manual Motor Starter: Quick-make, quick-break trip free toggle or pushbutton operating mechanism; provisions for positive padlocking in OFF position.
- D. Magnetic Motor Starter: Non-reversing or reversing, as indicated; manual reset overload relay with reset button on face of enclosure; full voltage starting; control transformer of sufficient capacity to handle operating coil and associated controls, integral with each starter; 120 volts control circuit, fuse protected; equipped with pilot light.

16150.2.2 RELAYS

- A. Acceptable Manufacturers:
 - 1. Siemens
 - 2. Allen-Bradley Co.
 - 3. IDEC Systems & Controls Corp.
 - 4. Potter & Brumfield
 - 5. Square D Co.
 - 6. Or Approved Equal

16150.2.3 CONTROL PANELS

- A. Acceptable Manufacturers:
 - 1. Allen-Bradley Co.
 - 2. Eaton Corp/Power Distribution Div.
 - 3. Siemens
 - 4. Square D Co.

5. Or Approved Equal
- B. Provide factory fabricated oil-tight pushbuttons, selector switches, pilot (indicating) lights, and pushbutton stations.
 1. Fabricate pushbutton stations for vertical or horizontal mounting, as indicated, and with button and light arrangements, as indicated on drawings.
- C. Pushbuttons: Momentary or maintained contacts, as indicated; contacts rated 10 amps continuous carrying current, 600 volts AC; quick-make, quick-break, snap action operating mechanism.
- D. Selector Switches: Rotary type; two or three position control, as indicated; legend plate with markings as indicated.

16150.2.4 CIRCUIT AND MOTOR DISCONNECTS

- A. Acceptable Manufacturers:
 1. Eaton Corp/Power Distribution Div.
 2. Allen-Bradley Co.
 3. Siemens Corp/Electrical Apparatus Div.
 4. Square D Co.
 5. General Electric Co. (GE Supply)

16150.3 METHOD OF MEASUREMENT**16150.3.1 NO SEPARATE MEASUREMENT**

Separate measurement shall NOT be made for furnishing or installing electrical systems, components, materials required to be installed within the pay limits for a building or enclosure identified in the Bid schedule to be furnished by the Contractor.

16150.4 BASIS OF PAYMENT

16150.4.1 No separate payment shall be made for furnishing or installing electrical systems, components, or materials required to be installed within the pay limits for a building or enclosure identified in the BID schedule to be furnished by the Contractor.

16150.4.2 When electrical systems, components, or materials are measured for a new building or enclosure as shown on the Bid Schedule, separate payment will be made as listed in specification 16400.

SPECIAL PROVISIONS**ELECTRICAL FIXTURES****SECTION
16210SP****16210.1 DESCRIPTION**

The Contractor shall provide and install all lighting systems for the Project, complete with lamps, brackets, hangers, mounting devices, ballasts, lighting contactors, and all other miscellaneous components required to complete the lighting system as shown on the Drawings and in accordance with these Specifications.

16210.1.1 RELATED WORK

Section 16010 - Electrical General Requirements and section 16050 - Basic Materials and Methods.

16210.1.2 SUBMITTALS

Shop drawings shall be submitted for all light fixtures in accordance with Section 1300 of these Specifications.

A. Acceptable Lighting Manufacturers

1. Hubbell
2. Lithonia
3. Thomas

B. Other lighting manufacturers may be submitted as approved equals, but must be approved by the ENGINEER or OWNER

16210.2 DEFINITIONS AND MATERIALS**16210.2.1 LIGHTING FIXTURE TYPES AND SIZES**

Shall be as designated on the Drawings or as otherwise required by the Special Provisions. All work, equipment, and materials shall be in accordance with UL "Standards for Electric Lighting Fixtures", No. 57, and the NEC (National Electric Code). All fixtures and associated equipment shall have a minimum 1 year full replacement warranty.

16210.2.2 INCANDESCENT FIXTURES

Shall be complete with medium base socket, all hardware required for installation, and lamps. Lamps shall be medium base, inside frosted, general purpose, or the project type as referenced in the electrical schedule.

A. Hazardous Location, Class 1 Div. 1 and 2, Group C and D Class II Div. 1 and 2 Groups E, F, and G Class III. UL Listed 844

1. Fixtures must meet all requirements as stated in the National Electric Code for hazardous locations.
2. Fixture housing shall be constructed of corrosion resistant, cast aluminum with epoxy powder coat finish. Fixture base shall have threaded hubs.
3. Glass globe shall be a heat and impact resistant prismatic glass globe with a die cast aluminum guard with an epoxy powder coat finish to match fixture housing.

B. Vapor tight/Rough service type Incandescent Fixtures

1. Fixture housing shall be constructed of corrosion resistant, cast aluminum with epoxy powder coat finish. Fixture base shall have threaded hubs.
2. Glass globe shall be a gasketed heat and impact resistant prismatic glass globe with a die cast aluminum guard with an epoxy powder coat finish to match fixture housing.

C. Flood, Spot, or Area type Incandescent Fixtures

1. Fixture housing/base shall be constructed of heavy duty die cast aluminum with epoxy powder coat finish. Finish shall be dark bronze unless otherwise stated on the drawings. Fixture must be suitable for vertical or horizontal mounting. Mounting back plate must have gasketed seal and shall be UL listed for damp locations.
2. Lamp holders shall be constructed of the same materials as the fixture housing/base. Lamp holder sockets shall be porcelain type with medium type lamp bases. Lamp holder color shall match that of the housing/base. Lamp holders shall be UL listed for damp locations.
3. Motion sensor and Photo Cell color shall match that of the housing/base. Coverage Zone shall be a minimum of 270° with a detection range no less than 100 feet. Sensors shall include but not be limited to dusk to dawn operation, power and test mode, manual override, sensitivity and time adjustment, and adjustable photo cell control. Motion sensor shall be UL listed for damp locations.

16210.2.3**FLUORESCENT FIXTURES**

Shall be provided complete with Class "P" high power factor, electronic type ballast with a -20°F temperature rating, together with all miscellaneous hardware and lamps. Ballast shall be CBM certified, ETL rated, with maximum sound level equivalent to General Electric Company Sound Rating "A". Lamps shall be cool white unless otherwise required on the Drawings.

A. Surface Mount Damp or Wet Location Type Fluorescent Fixtures

1. Fixture housing must be constructed of impact resistant, UV stabilized, reinforced polyester fiberglass housing.
2. Diffuser must be shatter resistant 15% acrylic standard with high impact 50% DR acrylic diffuser available. Diffuser must have stainless steel, corrosion resistant, cam action latches.
3. Gasketing between diffuser and housing must provide a continuous seal

B. Surface Mount Standard Dry Location Fluorescent Fixture

1. Fixture housing must be constructed of die-formed, cold rolled steel finished with baked white enamel.
2. Diffuser must be wrap around type acrylic prismatic with sonic welded, injection molded, luminous ends. Side prisms shall be linear with bottom prisms being pyramidal. Diffuser support shall be continuous and interlocking.

C. Recessed or Troffer type Fluorescent Fixtures

1. Fixture housing must be constructed of die formed, cold rolled steel finished with baked white enamel. The fixtures shall have hemmed sides to provide smooth edges for easy handling during installation.
2. Fixture door frame shall be steel with flush mitered corners and painted to match fixture housing. Fixture door must be reversible, in that the door may be hinged from either side.
3. Diffuser shall be an acrylic #12 pattern at a minimum of .140" thick.
4. Fixture shall have dual ballast with optional two level controls with either all on/off, or partial on/off capabilities. All fluorescent fixtures shall be capable of having battery backup capabilities on fixture designated on drawings.

D. High-Bay Type Fluorescent Fixtures

1. Fixture housing shall be 20 gauge channel construction with high gloss baked white enamel finish.
2. Fixture characteristics shall have but not be limited to task light distribution, minimum ambient temp. of 0° F and maximum ambient temp of 104° F with polished chrome type reflector with open optics. Fixture shall consist of 2 electronic ballasts, 120-277V with minimum starting temperature of 0° F (-18° C) with 6 lamps (lamp included) with end caps. Fixture mounting shall be suspended type and shall not be mounted within 12 inches of ceiling. Fixture shall have optional two level controls with either all on/off, or partial on/off capabilities.
3. Fixture shall have minimum 1/2 inch conduit and wire entry, and wire-form hangers, allthread, or hook type mount assemblies.

16210.2.4**HIGH INTENSITY DISCHARGE FIXTURES**

Shall be ballast type, complete with all miscellaneous hardware and lamps. Photocells shall be used as required on the Drawings. Ballast shall be constant wattage, high power factor type with a minimum of class H insulation, and shall be 100% factory tested. Ballast shall be multi tap type (120, 208, 240, 277, and 480V) Lamps shall be inside frosted and of the wattage indicated.

A. High-Bay and Low-Bay Type HID Fixtures

1. Fixture housing shall be die cast aluminum with white polyester powder finish and shall be rated for heavy duty service. Electrical components shall be heat sunked to ballast housing for cooler operation. Housing shall be threaded for 3/4 inch conduit for pendant type mounting.
2. Fixture reflector shall be high efficiency, anodized, fluted aluminum, and shall have but not be limited to, gasketed clear tempered glass with Stainless steel hinge and tool-less latch assembly.

SPECIAL PROVISIONS

ELECTRICAL FIXTURES

**SECTION
16210SP**

3. Fixture socket shall be a porcelain, vertically oriented mogul base socket with copper alloy nickel plated screw shell with center contact, UL listed at 1500W, 600V, 4kV pulse rated.

16210.2.5 HIGH PRESSURE SODIUM FIXTURES

High-pressure sodium and metal halide fixtures shall be suitable for all burning positions as specified for each type of luminaries.

A. Wall Pack type Fixtures

1. Fixture housing shall be corrosion resistant, die cast aluminum rated for heavy duty service, UL listed for wet locations, and shall have corrosion resistant external hardware with stainless steel slotted hex head fasteners. Unless otherwise noted on drawings, external finish shall be dark bronze corrosion resistant polyester powder finish. Back housing shall consist of sealable 3/4 inch threaded wiring access in top, with removable 3/4 knockout in back. Fixture shall be provided with gasket to provide seal from fixture to wall and shall be capable of mounting on any non combustible vertical surface.
2. Fixture reflector shall be polished anodized aluminum. Lens shall be prismatic borosilicate glass, sealed and gasketed.
3. Fixture ballast shall be multi tap (120, 208, 240, 277, and 480V) high reactance, high power factor, copper wound and 100% factory tested and UL listed.
4. Fixture socket shall be porcelain, horizontally oriented socket with copper alloy nickel plated screw shell with center contact, UL listed at 700W, 600V, medium base and 1500W, 600V, mogul base, each 4kV pulse rated.

16210.2.6 EMERGENCY AND EMERGENCY EXIT FIXTURES

Shall be UL listed for applications requiring general purpose emergency lighting and exit signage. UL 924, NFPA 101, NFPA 70-NEC and OSHA Illumination Standards, and shall be rated for indoor damp locations.

A. Emergency light fixture.

1. Fixture housing must be constructed of impact resistant, scratch resistant, corrosion proof, UV resistant with a UL94V-0 flame rating. Fixture must have the capability of being mounted vertically as well as horizontally.
2. Fixture lamp heads shall be adjustable using a 5 watt minimum krypton type lamp and must meet the Life Safety Code for minimum luminance.
3. Fixture shall have dual voltage capabilities (120 – 277V), and shall have visible test button pilot light with status indicator light.
4. Fixture battery shall be a sealed maintenance free lead calcium battery, which shall provide a minimum 90 minute run time, with an automatic current limiting charger which shall recharge after battery has discharged.

B. Emergency Exit Lights and Unit Combination Lighting

1. Fixture housing must be injection molded, flame retardant, high impact thermoplastic with a universal j-box pattern for easy mounting on walls and must have ceiling mount capabilities as well. Housing shall have fully assembled single face with extra faceplate for conversion to double face if necessary.
2. Fixture lamps shall be high output with a minimum of 5 watt. Lamp heads shall have a full range of adjustment capabilities.
3. Fixture shall have dual voltage capabilities (120 – 277V), and shall have visible test button pilot light with status indicator light.
4. Fixture battery shall be a sealed maintenance free lead calcium battery, which shall provide a minimum 90 minute run time, with an automatic current limiting charger which shall recharge after battery has discharged.

16210.3 CONSTRUCTION REQUIREMENTS

16210.3.1 Fixtures and related materials shall be installed as neatly as possible in the locations shown on the Drawings. The Contractor shall coordinate the exact locations with structure, equipment, and other devices as approved by the Engineer and/or the Owner. Mounting heights shall be as indicated on the Drawings.

16210.3.2 Conductors serving light fixtures mounted on ceiling grid or drop type ceilings, where conductors are above ceiling construction, shall be enclosed in a minimum 1/2 inch EMT conduit or 1/2 inch steel flex. All flex shall not exceed 6 feet in length and shall have a ground conductor sized per the N.E.C. and light fixture manufacturer requirements. 3/8 inch steel flex will only be allowed with Troffer type fluorescent fixtures that come from the fixture manufacturer with a 3/8 inch steel flex fixture whip. All flex must be connected to a junction box attached to the building structure, with flex being supported per the N.E.C. Fixture locations shall be coordinated with ceiling system. Fixtures shall be securely fastened to the ceiling framing members, and building structure per local governing seismic requirements.

16210.3.3 Surface mounted type fixtures must be mounted over an approved junction box which is either recessed or surface mounted in walls or ceilings. If required by light fixture manufacturer, light fixtures may be mounted to structure, using a mounting system which must be approved by the ENGINEER.

16210.4 METHOD OF MEASUREMENT

16210.4.1 Provide all lighting fixtures, beacons, emergency lighting, conduit, sweeps, support members, enclosures, lamps, conductors, switches, and appurtenances as shown on the drawings and as defined in the applicable sections the specifications required for a complete and functioning system.

16210.5 BASIS OF PAYMENT

SPECIAL PROVISIONS

ELECTRICAL FIXTURES

**SECTION
16210SP**

- 16210.5.1 No separate payment shall be made for furnishing or installing electrical systems, components, or materials required to be installed within the pay limits for a building or enclosure identified in the BID schedule to be furnished by the Contractor.
- 16210.5.2 When electrical systems, components, or materials are measured for a new building or enclosure as shown on the Bid Schedule, separate payment will be made as listed below.
- 16210.5.3 When initial installation or replacement of electrical systems, components, or materials is made in an existing building as shown on the Bid Schedule, the accepted quantity will be paid for at the contract price listed below:

PAY ITEM	UNIT
Light Fixtures, Associated Equipment and Controls	Lump Sum

16400.1 GENERAL

16400.1.1 APPLICABLE SECTIONS

The General Conditions, Supplementary General Conditions, Special Conditions, Alternates and addenda, applicable drawings and the technical specifications herein shall apply to all work under this Division 16.

16400.1.2 SCOPE

Provide all operations, methods, labor and equipment and provide and install all materials and incidentals necessary for the completion of the work as specified herein or included on the drawings.

16400.1.3 WORK INCLUDED

- A. Electrical work required for this work is shown on the drawings and includes, but is not necessarily limited to:
1. Complete new electrical distribution system for power and lighting as shown.
 2. Complete system of raceways and outlets for Control and all other auxiliary systems of this Division 16. Unless noted otherwise, the equipment and wiring of these auxiliary systems will be furnished and installed under their respective sections; however, the conduit raceway systems will be furnished and installed under this Section 16400.
 3. All excavating, backfilling, compacting, and grading required for the installation of all work covered under this Division 16.
- B. Shall furnish and install all component parts of all the systems required for their safe and proper operation, whether or not specifically mentioned or noted on the drawings, except those items or articles which are specifically noted hereinafter as being supplied otherwise.
- C. Perform all trenching and backfilling required in connection with the work of this section in strict accordance with the provisions of Division 02000 of these specifications.
- D. Provide all required electrical connections and service to items described in all other sections of these specifications. Provide all those services outlined in other divisions of the specifications as being done by the electrical sub-contractor.

16400.1.4 RELATED WORK SPECIFIED ELSEWHERE:

Section 16010 - Electrical General Requirements
Section 16410 - Fuses
Section 16483 - Variable Frequency Drives
Section 16485 - VFD Long Lead

16400.2 PRODUCTS

16400.2.1 DISTRIBUTION PANELBOARDS

- A. Distribution panelboards shall be factory assembled dead front, wall mounted as scheduled and braced for the indicated ampere rms symmetrical with equipment, bussing

connections, circuit breakers and all similar components indicated on the drawings or required for proper completion. Each breaker shall have an etched micarta nameplate secured by two cadmium plated screws. Nameplates shall indicate equipment served as shown in schedule. Busses shall be copper of a maximum current density of 1000 amperes per inch and shall be equipped with uninsulated equipment ground bus. Three phase, 4-wire panels shall have full capacity neutral bus.

- B. All floor mounted panels shall be mounted on a **4" housekeeping pad** and therefore to comply with NEC, the operating handles of switches and breakers shall be no more than 6'-2" above the bottom of the panel.
- C. Distribution panel boards shall be wall mounted as indicated in schedules. For access to wiring gutters, panel shall be door within door construction. Shall be Square D, I-Line or equal of Siemens I.T.E., Cutler Hammer/Westinghouse or General Electric.

16400.2.2 BRANCH CIRCUIT PANELBOARDS

- A. Branch circuit panelboards shall be Square D for the scheduled voltage, 3 phase, 4 wire operation or equal of Siemens, or General Electric. Shall be equipped with bolt-on breakers. Minimum width shall be 20 inches. Minimum depth shall be 5.75 inches. Panel trims shall be of the door within door construction.
- B. Busses shall be copper.
- C. Branch circuit breakers shall be provided per schedules on drawings. All multi-pole breakers shall be common trip.
- D. Doors shall be complete with corrected circuit schedule on inside. Panels shall be NEMA 3R type construction.

16400.2.3 DRY TYPE TRANSFORMERS

- A. General Purpose Dry-Type Transformers: (Under 600 volts)
 - 1) General: Furnish and install at locations shown on the drawings dry-type two winding power transformers for general power and lighting applications indicated. Transformers shall be UL listed and bear the required Listing Mark.
 - 2) Electrical Rating: Shall be 60 hertz of sizes, phases, high voltage and low voltage as scheduled on the drawings. Each transformer, unless specifically noted otherwise, shall have six (6) 2-1/2% full capacity taps, two above and four below nominal voltage in the high voltage winding. Temperature Classification: Each transformer shall utilize an insulation system that has been properly temperature classified and approved by Underwriters' Laboratories. Unless specifically noted otherwise, the insulation classification shall be 220 C with 150 C winding temperature rise in accordance with Underwriters' Laboratories specification UL506. Windings shall be copper.
 - 3) Load Rating:
 - a. Each transformer supplied to this specification shall be capable of operating at 100% of nameplate rating (NPR) continuously while in an ambient temperature not exceeding 40°C and shall be capable of meeting the daily overload requirements of ANSI Standard C57.96 as stated in the following chart:

PERMISSIBLE ONCE DAILY OVERLOADS WITH NORMAL LIFE MAINTAINED			
Peak Load Following and Followed by a Constant Load of			
Peak Load Time (Hours)	90% NPR	70% NPR	50% NPR
1/2	162% NPR	185% NPR	200% NPR
1	138% NPR	148% NPR	152% NPR
2	123% NPR	128% NPR	133% NPR
4	113% NPR	115% NPR	118% NPR
8	106% NPR	107% NPR	108% NPR

NPR = Nameplate Rating

- b. Transformer loaded in accordance with this paragraph shall be capable of long service life under the thermal conditions specified. There shall be no need for derating.
- 4) Sound Rating: Each transformer shall have sound levels equal or lower than those established in the latest revision of ANSI Standard C89 as shown in the following chart:

Transformer Rating KVA	Maximum Sound Level Decibels
10-50	45
51-150	50
150-300	55

- 5) Other Requirements: The following requirements shall be in accordance with Underwriters' Laboratories specification UL506:
- a. Enclosure:
 - (i) Ventilation openings
 - (ii) Corrosion resistance
 - (iii) Cable bending space
 - (iv) Grounding provisions
 - (v) Surface temperature rise
 - (vi) Wiring compartment temperature rise
 - (vii) Terminations
- 6) Test Requirements:
- a. Each transformer furnished to this specification shall be subjected to the following production tests:
 - (i) Applied potential

- (ii) Induced potential
- (iii) No load losses
- (iv) Voltage ratio
- (v) Polarity
- (vi) Continuity

b. The manufacturer shall have performed the following additional tests on units identical to the design type being furnished to this specification. Proof of performance of these lists in the form of test data sheets shall be provided as part of the shop drawing submittal.

- (i) Sound levels
- (ii) Temperature rise tests
- (iii) Full-load losses
- (iv) Regulation
- (v) Impedance

7) Shop Drawings: Submit shop drawing for review prior to delivery to job site.

16400.3 EXECUTION

16400.3.1 INSTALLATION OF GROUNDING SYSTEM

- A. The conduit system and neutral conductor of the wiring system shall be grounded to the cold water pipe having a continuous path to earth in compliance with grounding provisions as outlined in the NEC. Point of connection to the water system shall be as near as practicable to the service entrance. Provide bonding jumper same size as system ground to provide ground continuity from customer's side of metallic lines service entrance and street side of metallic mains. The neutral and ground shall be connected together at the main service switch only.
- B. Where the water main is not metallic, delete water pipe ground requirements and provide a concrete encased electrode consisting of a 20-foot length of #3/0 bare copper conductor tied to the steel reinforcing bars and encased within a concrete footing. This footing shall be in direct contact with earth and located near the main panel.
- C. The Contractor shall also install a made electrode ground system consisting of copperclad rods spaced not closer than six feet apart. Grounding conductors and connections to ground rods shall be protected from damage and shall be placed to avoid disconnect by unauthorized personnel. Interconnect with water pipe ground system.
- D. The equipment grounding system shall be such that all metallic structures, enclosures, raceways, junction boxes, outlet boxes, cabinets, machine frames, portable equipment and other conductive items in close proximity with the electrical circuits operate continuously at ground potential and provide a low impedance path for the possible ground fault currents. The system shall comply with the National Electrical Code, modified as indicated on the drawings or specifications and as hereinafter specified to incorporate a maximum 25 ohms ground resistance. Grounding connections shall be accessible for inspection.
- E. The distributions system shall be provided with a separate equipment grounding conductor for each single or three-phase feeder, each branch circuit with a multi-pole protective device and each single phase receptacle and motor circuit as indicated. The required grounding conductor shall be installed in the common raceway with the related phase and/or neutral conductors. Single-phase branch circuits required for lighting, shall

consist of phase and neutral conductors installed in common metallic conduit which shall serve as the grounding conductor. Conduit equipment connections utilized in conjunction with the above single-phase branch circuits shall be provided with suitable bonding jumpers connected to approved grounding type bushings. Single-phase branch circuits and all branch circuits installed in flexible conduits shall be provided with a separate grounding conductors as hereinbefore specified for the multi-pole branch circuits.

16400.3.2 INSTALLATION OF PANELS

- A. Installation: Unless otherwise indicated on the drawings, install wall panels with the top of the trim 6'-0" above the finished floor. Panels located in equipment rooms and wire closets shall be surface mounted. Floor mounted panels shall be provided with a 4" concrete housekeeping pad. Floor mounted panels shall be anchored to floor at all four corners and to wall or structural member at top for seismic restraint.
- B. Directories: Mount a typewritten directory behind glass or plastic on the inside of each panel door. On the directory, show the circuit number and complete description of all outlets with specific locations on each circuit. In addition, provide a typewritten label inside door showing source of power to panel both as to feeder switch, panel designation and location within buildings.

16400.3.3 GENERAL PURPOSE DRY TYPE TRANSFORMERS

General purpose dry transformers shall be mounted on floor at locations shown on drawings. Each shall be anchored to floor by means of a minimum of four 1/2" x 6" anchor bolts grouted in existing concrete floor.

16400.3.4 TESTING

- A. General: Upon completion of this portion of the work, test all parts of the electrical system in the presence of the Engineer Owner's Representative.
- B. Test Requirements: All systems shall test free from short circuits and grounds, shall be free from mechanical and electrical defects, and shall show an insulation resistance between phase conductors and ground of not less than that required by the National Electrical Code.

16400.3.5 FINAL INSPECTION

- A. This Division 16 contractor's job foreman shall be present at the final inspection of the work by the Owner.
- B. Electrical job foreman shall have pad and pencil to list all deficient items noted. Corrections and adjustments of deficient items shall be done after the inspection, not during.
- C. See Section 16050 for other requirements for final inspection.

16400.4 METHOD OF MEASUREMENT

- 16400.4.1 SERVICE ENTRANCE. Provide all conduit, sweeps, support members, transformer pads, grounding equipment, breakers, disconnects, enclosures, conductors, and appurtenances as required by the local utility, and as shown on the drawings and as defined in the applicable sections of the specifications required for a complete and fully functioning system.

- 16400.4.2 **GROUNDING SYSTEM.** Provide all grounding conductors, connections, ground rods, ground wells, and associated appurtenances and as shown on the drawings, and as defined in the applicable sections of the specifications.
- 16400.4.3 **POWER PANEL (PP) OR MOTOR CONTROL CENTER (MCC).** Provide all conduit, sweeps, pull boxes, power panels, motor starters, motor savers, motor control center, transient voltage surge suppressor (TVSS), support members, grounding equipment, breakers, disconnects, enclosures, conductors, and appurtenances as shown on the drawings and as defined in the applicable sections of the specifications required for a complete and functioning system.
- 16400.4.4 **DRY TYPE TRANSFORMERS.** Provide dry type transformer and appurtenances as shown on the drawings and as defined in the applicable sections of the specifications required for a complete and functioning system.
- 16400.4.5 **LIGHTING PANEL (LP).** Provide all conduit, sweeps, support members, grounding equipment, breakers, disconnects, enclosures, conductors, switches, receptacles, and appurtenances as shown on the drawings and as defined in the applicable sections the specifications required for a complete and functioning system.
- 16400.5 BASIS OF PAYMENT**
- 16400.5.1 No separate payment shall be made for furnishing or installing electrical systems, components, or materials required to be installed within the pay limits for a building or enclosure identified in the BID schedule to be furnished by the Contractor.
- 16400.5.2 When electrical systems, components, or materials are measured for a new building or enclosure as shown on the Bid Schedule, separate payment will be made as listed below.
- 16400.5.3 When initial installation or replacement of electrical systems, components, or materials is made in an existing building as shown on the Bid Schedule, the accepted quantity will be paid for at the contract price listed below:

PAY ITEM	UNIT
Service Entrance	Lump Sum
Grounding System	Lump Sum
Power Panel or Motor Control Center	Lump Sum
Dry Type Transformers	Lump Sum
Lighting Panel (LP)	Lump Sum

16410.1 GENERAL**16410.1.1 ACCEPTABLE MANUFACTURERS**

- A. Manufacturer: Bussmann.
- B. Other acceptable manufacturer: Gould Shawmut, Littlefuse.
- C. All fuses shall be of one manufacturer. Fuses shall have a 200,000 ampere RMS symmetrical interrupting rating unless noted otherwise.

16410.1.2 FUSE TYPES AND RATINGS

- A. Fuses from 0 to 600 ampere for each circuit serving a single motor shall be UL Class RK5 dual-element Low Peak, LPN-RK (250 volt).
- B. All other fuses in the 0 to 600 ampere range shall be UL Class J, dual-element, time delay, low peak, LPJ-SP (250 volt).
- C. Fuses larger than 600 ampere shall be UL Class L with time delay, Hi Cap, KRP-C.

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16483.1 GENERAL

16483.1.1 RELATED DOCUMENTS

- A. The drawings and general provisions of this contract, including general and supplementary conditions and division 16 specification sections, apply to work of this section.
- B. Information contained on the drawings and/or schedules shall detail the additional specific requirements for the Variable Frequency Drive (VFD) system equipment.

16483.1.2 SCOPE OF WORK

- A. It is the intent of this specification to set the minimum acceptable requirements for the design, construction, installation, commissioning and vendor support requirements for the VFD systems herein specified.
- B. The VFD Vendor should supply to the control panel vendor VFD systems for integration into the individual control panel systems. The VFD vendor should coordinate all necessary documentation, accessories, mounting hardware, etc. for a complete and operable system. The installation, of the control panel system, will be performed by the Owner. The VFD vendor should coordinate system start-up and commissioning with the Owner as herein described.

16483.1.3 CODES AND STANDARDS

- A. Equipment supplied under this specification shall conform to the latest applicable codes and standards of the following:
 - 1. NEC - (NFPA 70) - National Electric Code.
 - 2. ANSI/NEMA ICS 6 - Enclosures for Industrial Controls and Systems.
 - 3. NEMA AB 1 - Molded Case Circuit Breakers.
 - 4. NEMA ICS 2 - Industrial Control Devices, Controllers, and Assemblies.
 - 5. ANSI C37 - Standards for Circuit Breakers, Switchgear, Relays, Substations and Fuses.
 - 6. ANSI C57 - Distribution, Power, and Regulating Transformers. (includes Reactors)
- B. The fully assembled VFD system shall carry the UL label certifying UL-508 standards. An equivalent safety-labeling program by ETL or CSA documenting compliance with these industry standards shall be acceptable.

16483.1.4 ACCEPTABLE SUPPLIERS

- A. The following VFD manufacturer's equipment have been pre-approved to meet the products section of this specification:
 - 1. Mitsubishi Electronics America, Inc., by Energy Management Corp
 - 2. Magnatek GPD by QED
 - 3. EMS G3+ by Control Industries, Inc.
 - 4. Allen Bradley
 - 5. Siemens
 - 6. Eaton/Cutler Hammer

Note: It is the intent for the VFD manufacturer to provide a VFD that will convert the provided 120/240V single phase power to the needed 240V 3 phase power for the new 20HP well pump. The VFD manufacturer will ensure the VFD is sized accordingly to handle these requirements. Also the functionality of the VFD must meet that of the various pump manufacturer/suppliers requirements for this project. It will be the responsibility of the Contractor to ensure the coordination from all parties involved i.e. Pump Manufacturer, VFD Manufacturer takes place.

16483.2 PRODUCT

16483.2.1 GENERAL

- A. This portion of the specification outlines the overall fabrication, performance and functional requirements of VFDs supplied for positive speed control of standard NEMA design B induction motors.
- B. It is the intent of this section to specify non-proprietary designs and hardware that assure modern "state of the art" equipment which provides a high level of performance and reliability for the greatest long term, total value to the owner.

16483.2.2 SYSTEM DESCRIPTION

- A. The VFD system shall be supplied as a complete package produced by a single manufacturer regularly engaged in the production of same and who maintains full system support responsibility. The VFD functionality must conform to that which is described on the drawings, and that which has been described in section 16483.1.4.
 - 1. The VFD system manufacturer shall integrate all components and equipment required to conform to these specification features and functions as a single UL (or equivalent) labeled system. Vendors providing equipment requiring panel shop or job site modifications or additions that would not be valid under the original equipment manufacturer's (OEM's) safety labeling will not be acceptable.
 - 2. Pre-integrated equipment shall include but not be limited to incoming line reactors, rectifier units, inverter units, control circuitry, operator interfaces, protective equipment, and other accessories and auxiliary items necessary to meet the highest standards for the type of service specified herein.

16483.2.3 CONSTRUCTION

A. SPACE AND ENVIRONMENT:

- 1. All VFD system components shall be housed in the Motor Control Center shown on the drawings, and shall not exceed the size allotments specified on the drawings nor shall any portion of the system exceed a height of 90 inches. Entry shall be provided for incoming line and load cables as required or as shown on the drawings.
- 2. VFD systems mounted inside Motor Control Center shall be properly ventilated and sized to operate continuously at the specified job site elevation in an ambient environment of 0°C to 40°C, 0-90% RH.

B. SUPPLY POWER:

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1. All components of the VFD system shall be selected to operate continuously without any system trip or damage based on the nominal power specifications and requirements shown on the drawings or schedules. The above conditions must be maintained under the following expected variations:
 - a. Plus or minus 10% voltage fluctuation.
 - b. Plus or minus 3% frequency variation (5% if served by a back-up generator).
 - c. Distorted voltage waveform with up to 7% total voltage harmonic distortion.
2. The VFD system shall employ voltage sag ride-through coordination under normal operating (average load) conditions to prevent nuisance trips with the following utility interruptions (based on preliminary IEEE working group P1346 data):
 - a. 0% voltage for 1 cycle.
 - b. 60% voltage for 10 cycles.
 - c. 87% voltage continuous.

C. DEVICES and WIRING:

1. The VFD system shall employ door mounted industrial control operator devices, programming unit, and other devices per the layout shown on the drawings and as required to meet all functional and feature requirements of this specification. Operator pilot lights, switches and pushbuttons (if required) shall be industrial oil tight industry standard devices. Cabinet shall accommodate all control/instrumentation components as detailed on drawings.
2. Control voltages shall be 120 volts or less supplied by machine tool type transformers employing both primary and secondary fusing. VFD control transformer VA sizes shall be increased by 10% or as necessary to accommodate external impedance when plans show connections to external safety interlocks or other control devices.
3. The VFD system factory wiring shall be permanently marked with hot emboss stamping or an equivalent marking system. All devices shall be labeled and identified with correct setting selections. All component identification and wiring shall be documented in the operation and maintenance manual.

D. LOAD:

1. The VFD system shall be capable of starting and continuously driving the specified maximum motor load as identified on the drawings and schedules. A constant torque load shall be assumed for drive sizing purposes.

2. VFDs driving variable torque loads shall be programmed to optimize load patterns which maximize system efficiency and minimize motor heating and stresses. VFDs driving constant torque or other loads shall be programmed to optimize load patterns for system or process performance as required.
3. All VFD systems shall have an overload capacity of a minimum of 120% for one minute.

E. EFFICIENCY AND POWER FACTOR:

1. The VFD solid state converter and inverter power switching components and control shall be selected to achieve 95% efficiency or better at full load and full speed. Other auxiliary devices required on the drawings or in these specifications including filters, line reactors, cooling or heating devices etc. shall be of a design to optimize efficiency as intended under this specification.
2. The displacement power factor (as measured at the input to the VFD system) shall be 95% or better across the operational speed range.

F. PROTECTION:

1. Short circuit protection shall be provided to the VFD system through an externally operated, door interlocked fused disconnect, circuit breaker or motor circuit protector (MCP) rated at 65,000 AIC minimum. The door interlock handle must be capable of being locked off to meet NEC.
2. Overcurrent protection shall be provided in the VFD system through electronic motor overload (MOL) circuits with instantaneous trip, inverse time trip, and current limit functions. These shall be adjustable and optimized for the application.
3. In addition to the overcurrent protection above, the VFD system shall provide over and under-voltage protection, over-temperature protection, ground fault protection, and control or microprocessor fault protection. These protective circuits shall cause an orderly shutdown of the VFD, provide indication of the fault condition, and require a manual reset (except under-voltage) before restart. Under-voltage from a power loss shall be set to automatically restart after return to normal. The history of the previous three faults shall remain in memory for future review.
4. External protective faults including safeties or motor over-temperature may be interfaced to the VFD system and annunciated if shown on the drawings.

G. SYSTEM CONTROLS AND INTERFACE TERMINATIONS:

1. If shown on the drawings, the VFD system may require integrated transducers, controllers, sequencers, bypass methods, filters and communication interfaces among others. Such devices (shown on the drawings as part of the VFD system) shall be completely pre-integrated requiring the owner to make only the typical field connections required as customer connections.
2. Items shown on the drawings or schedules as "future" shall be available from the VFD system manufacturer in kit form for future owner integration into the VFD system.

3. The VFD system customer terminations shall be clearly identified with terminal numbers and a permanent-wiring diagram located in the VFD system enclosure.

16483.2.4 FEATURES

- A. The VFD interface keypad shall be mounted to control panel face and hard-wired to the VFD unit. This device shall annunciate VFD faults and operating conditions as described herein in a "real English" format without the use of codes. This unit shall provide the VFD user function interface as described herein. The following operator control and indication features shall be provided standard (unless shown differently on the drawings) as part of each VFD system:
 1. Frequency (speed) indication.
 2. Motor voltage indication.
 3. Motor current indication.
 4. VFD run indication.
 5. VFD fault and diagnostic indication.
- B. The following customer connections and interface terminations shall be provided standard (unless shown differently on the drawings) as part of each VFD system:
 1. VFD remote start/stop connection.
 2. External safeties connection.
 3. VFD run annunciation.
 4. VFD fault annunciation.
 5. VFD speed reference input connection (4-20mA or as shown on drawings).
- C. The following parameter adjustments shall be available at the VFD key pad to tune the VFD system:
 1. Minimum and maximum speeds.
 2. Acceleration and deceleration times.
 3. Over-current trip point.
 4. Current limit response to overload.
 5. Maximum base motor voltage.
 6. Input speed reference signal gain and bias.
 7. Output speed reference signal gain and bias.
- D. The VFD shall be capable of starting into a rotating motor at any speed.

- E. The VFD shall auto restart after a power failure.
- F. For maintenance purposes, the VFD system shall be capable of starting, stopping, and running with stable operation with the motor completely disconnected (no load).
- G. Each VFD system shall be provided with a series line reactor.

16483.3 EXECUTION

16483.3.1 EQUIPMENT PROTECTION AND STORAGE

- A. The VFD system manufacturer shall furnish written instructions for the unloading, storing, handling, installation and any special considerations to keep the equipment free from damage prior to the authorized commissioning start-up.
- B. The VFD systems shall be received, unloaded, stored, protected and installed into the control panels by the Control Panel Vendor.
- C. This Vendor shall inspect the VFD systems upon delivery and store them in a clean, dry space and as per the manufacturer's requirements. The VFD system electrical contractor shall maintain the factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

16483.3.2 INSTALLATION

- A. Properly sized overload elements, fuses, circuit breakers, etc. shall be installed and verified for actual motor and circuit protection.
- B. Required interlock wiring and connections between the VFD system, and safety devices shall be the responsibility of the Control Panel Vendor.

16483.3.3 SYSTEM COMMISSIONING AND CERTIFICATION

- A. The VFD system start-up shall be performed by a service technician or engineer certified by the manufacturer. The following adjustments and tests shall be performed as a minimum with certified copies included in the maintenance and operation manual:
 - 1. Verify that the input voltage is within the manufacturer's specification tolerances.
 - 2. Verify that the motor rotation is correct in all modes of operation.
 - 3. Verify all operator devices, programming and monitoring functions to be fully operational.
 - 4. Verify operation of all field signal control connections.
 - 5. Measure and record system output voltage and current at 50% and 100% speed. Tune the output voltage to correspond to motor nameplate rating at full speed. Check full load current measurements against nameplate data.
 - 6. Make all parameter adjustments to tune and optimize the VFD system to the application. Record all configuration values as part of this report.

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7. Make any/all other applicable tests with recorded results recommended by the VFD vendor.
- B. Owner training shall be provided for each model and type of VFD system provided. Training shall consist of both classroom and actual equipment hands-on training. The training shall be certified on the approved form and included in the operation and maintenance manuals.

16483.3.4 DOCUMENTATION

- A. The operation and maintenance manuals shall consist of the following instructions and information:
 1. Unloading, handling, installation, and special consideration instructions.
 2. Operating functional descriptions and operating instructions.
 3. Bill of materials with all spare parts ordering information and availability.
 4. Start-up and system commissioning reports.
 5. Training certification.

16483.3.5 WARRANTY

- A. The VFD system vendor shall supply a complete parts and labor warranty (including travel expenses) for 1 year from the date of start-up or 1.5 years from the date of shipment (whichever comes first).
 1. The warranty shall cover the entire VFD system including power devices, controllers, filters etc. enclosed as part of the system package.
 2. For equipment or components manufactured by other than the complete VFD system manufacturer, (which comprises more than 25% of the cost of the VFD system), the original equipment manufacturer shall be identified with its nearest office and warranty obligation.
- B. In place of the one-year warranty, a two-year warranty/service contract shall be quoted as an option at bid time. This service contract shall be renewable in two-year increments thereafter. The service contract shall be executable by the owner, at the fixed bid price anytime during the first 6 months of operation after start-up.
 1. The extended warranty/service contract shall include necessary repairs or loaner replacement assuring complete restoration of operation within 24 hours from the time a service call is requested. A \$100.00 per day penalty shall be applied for failure to comply after the acknowledged service request.
 2. The extended warranty/service contract shall include job site visits twice yearly to inspect, clean, tune (optimize parameters) and repair (if necessary) each VFD system supplied under this contract.
 3. The extended warranty/service contract shall include basic orientation and operator training review with the owner's designated personal as part of this visit.

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4. The extended warranty/service contract shall include a 200% performance bond in the owner's favor for the term of the service contract.

16483.3.6 METHOD OF MEASUREMENT

16483.3.6.1 Measurement of the completed, functioning, and accepted VFD system will be made by the "Lump Sum" as shown on the Bid Schedule.

16483.4 BASIS OF PAYMENT

16483.4.1 The accepted quantities will be paid for at the contract unit price for:

PAY ITEM	UNIT
VFD's	Lump Sum

16400.1 GENERAL**16400.1.1 APPLICABLE SECTIONS**

The General Conditions, Supplementary General Conditions, Special Conditions, Alternates and addenda, applicable drawings and the technical specifications herein shall apply to all work under this Division 16.

16400.1.2 SCOPE

Provide all operations, methods, labor and equipment and provide and install all materials and incidentals necessary for the completion of the work as specified herein or included on the drawings.

16400.1.3 WORK INCLUDED

- A. Electrical work required for this work is shown on the drawings and includes, but is not necessarily limited to:
 - 1. Complete new electrical distribution system for power and lighting as shown.
 - 2. Complete system of raceways and outlets for Control and all other auxiliary systems of this Division 16. Unless noted otherwise, the equipment and wiring of these auxiliary systems will be furnished and installed under their respective sections; however, the conduit raceway systems will be furnished and installed under this Section 16400.
 - 3. All excavating, backfilling, compacting, and grading required for the installation of all work covered under this Division 16.
- B. Shall furnish and install all component parts of all the systems required for their safe and proper operation, whether or not specifically mentioned or noted on the drawings, except those items or articles which are specifically noted hereinafter as being supplied otherwise.
- C. Perform all trenching and backfilling required in connection with the work of this section in strict accordance with the provisions of Division 02000 of these specifications.
- D. Provide all required electrical connections and service to items described in all other sections of these specifications. Provide all those services outlined in other divisions of the specifications as being done by the electrical sub-contractor.

16400.1.4 RELATED WORK SPECIFIED ELSEWHERE:

Section 16010 - Electrical General Requirements
Section 16410 - Fuses
Section 16483 - Variable Frequency Drives
Section 16485 - VFD Long Lead

16400.2 PRODUCTS**16400.2.1 DISTRIBUTION PANELBOARDS**

- A. Distribution panelboards shall be factory assembled dead front, wall mounted as scheduled and braced for the indicated ampere rms symmetrical with equipment, bussing

connections, circuit breakers and all similar components indicated on the drawings or required for proper completion. Each breaker shall have an etched micarta nameplate secured by two cadmium plated screws. Nameplates shall indicate equipment served as shown in schedule. Busses shall be copper of a maximum current density of 1000 amperes per inch and shall be equipped with uninsulated equipment ground bus. Three phase, 4-wire panels shall have full capacity neutral bus.

- B. All floor mounted panels shall be mounted on a **4" housekeeping pad** and therefore to comply with NEC, the operating handles of switches and breakers shall be no more than 6'-2" above the bottom of the panel.
- C. Distribution panel boards shall be wall mounted as indicated in schedules. For access to wiring gutters, panel shall be door within door construction. Shall be Square D, I-Line or equal of Siemens I.T.E., Cutler Hammer/Westinghouse or General Electric.

16400.2.2 BRANCH CIRCUIT PANELBOARDS

- A. Branch circuit panelboards shall be Square D for the scheduled voltage, 3 phase, 4 wire operation or equal of Siemens, or General Electric. Shall be equipped with bolt-on breakers. Minimum width shall be 20 inches. Minimum depth shall be 5.75 inches. Panel trims shall be of the door within door construction.
- B. Busses shall be copper.
- C. Branch circuit breakers shall be provided per schedules on drawings. All multi-pole breakers shall be common trip.
- D. Doors shall be complete with corrected circuit schedule on inside. Panels shall be NEMA 3R type construction.

16400.2.3 DRY TYPE TRANSFORMERS

- A. General Purpose Dry-Type Transformers: (Under 600 volts)
 - 1) General: Furnish and install at locations shown on the drawings dry-type two winding power transformers for general power and lighting applications indicated. Transformers shall be UL listed and bear the required Listing Mark.
 - 2) Electrical Rating: Shall be 60 hertz of sizes, phases, high voltage and low voltage as scheduled on the drawings. Each transformer, unless specifically noted otherwise, shall have six (6) 2-1/2% full capacity taps, two above and four below nominal voltage in the high voltage winding. Temperature Classification: Each transformer shall utilize an insulation system that has been properly temperature classified and approved by Underwriters' Laboratories. Unless specifically noted otherwise, the insulation classification shall be 220 C with 150 C winding temperature rise in accordance with Underwriters' Laboratories specification UL506. Windings shall be copper.
 - 3) Load Rating:
 - a. Each transformer supplied to this specification shall be capable of operating at 100% of nameplate rating (NPR) continuously while in an ambient temperature not exceeding 40°C and shall be capable of meeting the daily overload requirements of ANSI Standard C57.96 as stated in the following chart:

PERMISSIBLE ONCE DAILY OVERLOADS WITH NORMAL LIFE MAINTAINED			
Peak Load Following and Followed by a Constant Load of			
Peak Load Time (Hours)	90% NPR	70% NPR	50% NPR
1/2	162% NPR	185% NPR	200% NPR
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4	113% NPR	115% NPR	118% NPR
8	106% NPR	107% NPR	108% NPR

NPR = Nameplate Rating

- b. Transformer loaded in accordance with this paragraph shall be capable of long service life under the thermal conditions specified. There shall be no need for derating.
- 4) Sound Rating: Each transformer shall have sound levels equal or lower than those established in the latest revision of ANSI Standard C89 as shown in the following chart:

Transformer Rating KVA	Maximum Sound Level Decibels
10-50	45
51-150	50
150-300	55

- 5) Other Requirements: The following requirements shall be in accordance with Underwriters' Laboratories specification UL506:
- a. Enclosure:
 - (i) Ventilation openings
 - (ii) Corrosion resistance
 - (iii) Cable bending space
 - (iv) Grounding provisions
 - (v) Surface temperature rise
 - (vi) Wiring compartment temperature rise
 - (vii) Terminations
- 6) Test Requirements:
- a. Each transformer furnished to this specification shall be subjected to the following production tests:
 - (i) Applied potential

- (ii) Induced potential
- (iii) No load losses
- (iv) Voltage ratio
- (v) Polarity
- (vi) Continuity

b. The manufacturer shall have performed the following additional tests on units identical to the design type being furnished to this specification. Proof of performance of these lists in the form of test data sheets shall be provided as part of the shop drawing submittal.

- (i) Sound levels
- (ii) Temperature rise tests
- (iii) Full-load losses
- (iv) Regulation
- (v) Impedance

7) Shop Drawings: Submit shop drawing for review prior to delivery to job site.

16400.3 EXECUTION

16400.3.1 INSTALLATION OF GROUNDING SYSTEM

- A. The conduit system and neutral conductor of the wiring system shall be grounded to the cold water pipe having a continuous path to earth in compliance with grounding provisions as outlined in the NEC. Point of connection to the water system shall be as near as practicable to the service entrance. Provide bonding jumper same size as system ground to provide ground continuity from customer's side of metallic lines service entrance and street side of metallic mains. The neutral and ground shall be connected together at the main service switch only.
- B. Where the water main is not metallic, delete water pipe ground requirements and provide a concrete encased electrode consisting of a 20-foot length of #3/0 bare copper conductor tied to the steel reinforcing bars and encased within a concrete footing. This footing shall be in direct contact with earth and located near the main panel.
- C. The Contractor shall also install a made electrode ground system consisting of copperclad rods spaced not closer than six feet apart. Grounding conductors and connections to ground rods shall be protected from damage and shall be placed to avoid disconnect by unauthorized personnel. Interconnect with water pipe ground system.
- D. The equipment grounding system shall be such that all metallic structures, enclosures, raceways, junction boxes, outlet boxes, cabinets, machine frames, portable equipment and other conductive items in close proximity with the electrical circuits operate continuously at ground potential and provide a low impedance path for the possible ground fault currents. The system shall comply with the National Electrical Code, modified as indicated on the drawings or specifications and as hereinafter specified to incorporate a maximum 25 ohms ground resistance. Grounding connections shall be accessible for inspection.
- E. The distributions system shall be provided with a separate equipment grounding conductor for each single or three-phase feeder, each branch circuit with a multi-pole protective device and each single phase receptacle and motor circuit as indicated. The required grounding conductor shall be installed in the common raceway with the related phase and/or neutral conductors. Single-phase branch circuits required for lighting, shall

consist of phase and neutral conductors installed in common metallic conduit which shall serve as the grounding conductor. Conduit equipment connections utilized in conjunction with the above single-phase branch circuits shall be provided with suitable bonding jumpers connected to approved grounding type bushings. Single-phase branch circuits and all branch circuits installed in flexible conduits shall be provided with a separate grounding conductors as hereinbefore specified for the multi-pole branch circuits.

16400.3.2 INSTALLATION OF PANELS

- A. Installation: Unless otherwise indicated on the drawings, install wall panels with the top of the trim 6'-0" above the finished floor. Panels located in equipment rooms and wire closets shall be surface mounted. Floor mounted panels shall be provided with a 4" concrete housekeeping pad. Floor mounted panels shall be anchored to floor at all four corners and to wall or structural member at top for seismic restraint.
- B. Directories: Mount a typewritten directory behind glass or plastic on the inside of each panel door. On the directory, show the circuit number and complete description of all outlets with specific locations on each circuit. In addition, provide a typewritten label inside door showing source of power to panel both as to feeder switch, panel designation and location within buildings.

16400.3.3 GENERAL PURPOSE DRY TYPE TRANSFORMERS

General purpose dry transformers shall be mounted on floor at locations shown on drawings. Each shall be anchored to floor by means of a minimum of four 1/2" x 6" anchor bolts grouted in existing concrete floor.

16400.3.4 TESTING

- A. General: Upon completion of this portion of the work, test all parts of the electrical system in the presence of the Engineer Owner's Representative.
- B. Test Requirements: All systems shall test free from short circuits and grounds, shall be free from mechanical and electrical defects, and shall show an insulation resistance between phase conductors and ground of not less than that required by the National Electrical Code.

16400.3.5 FINAL INSPECTION

- A. This Division 16 contractor's job foreman shall be present at the final inspection of the work by the Owner.
- B. Electrical job foreman shall have pad and pencil to list all deficient items noted. Corrections and adjustments of deficient items shall be done after the inspection, not during.
- C. See Section 16050 for other requirements for final inspection.

16400.4 METHOD OF MEASUREMENT

- 16400.4.1 SERVICE ENTRANCE. Provide all conduit, sweeps, support members, transformer pads, grounding equipment, breakers, disconnects, enclosures, conductors, and appurtenances as required by the local utility, and as shown on the drawings and as defined in the applicable sections of the specifications required for a complete and fully functioning system.

- 16400.4.2 **GROUNDING SYSTEM.** Provide all grounding conductors, connections, ground rods, ground wells, and associated appurtenances and as shown on the drawings, and as defined in the applicable sections of the specifications.

- 16400.4.3 **POWER PANEL (PP) OR MOTOR CONTROL CENTER (MCC).** Provide all conduit, sweeps, pull boxes, power panels, motor starters, motor savers, motor control center, transient voltage surge suppressor (TVSS), support members, grounding equipment, breakers, disconnects, enclosures, conductors, and appurtenances as shown on the drawings and as defined in the applicable sections of the specifications required for a complete and functioning system.

- 16400.4.4 **DRY TYPE TRANSFORMERS.** Provide dry type transformer and appurtenances as shown on the drawings and as defined in the applicable sections of the specifications required for a complete and functioning system.

- 16400.4.5 **LIGHTING PANEL (LP).** Provide all conduit, sweeps, support members, grounding equipment, breakers, disconnects, enclosures, conductors, switches, receptacles, and appurtenances as shown on the drawings and as defined in the applicable sections the specifications required for a complete and functioning system.

- 16400.5 BASIS OF PAYMENT**

- 16400.5.1 No separate payment shall be made for furnishing or installing electrical systems, components, or materials required to be installed within the pay limits for a building or enclosure identified in the BID schedule to be furnished by the Contractor.

- 16400.5.2 When electrical systems, components, or materials are measured for a new building or enclosure as shown on the Bid Schedule, separate payment will be made as listed below.

- 16400.5.3 When initial installation or replacement of electrical systems, components, or materials is made in an existing building as shown on the Bid Schedule, the accepted quantity will be paid for at the contract price listed below:

PAY ITEM	UNIT
Service Entrance	Lump Sum
Grounding System	Lump Sum
Power Panel or Motor Control Center	Lump Sum
Dry Type Transformers	Lump Sum
Lighting Panel (LP)	Lump Sum

16410.1 GENERAL**16410.1.1 ACCEPTABLE MANUFACTURERS**

- A. Manufacturer: Bussmann.
- B. Other acceptable manufacturer: Gould Shawmut, Littlefuse.
- C. All fuses shall be of one manufacturer. Fuses shall have a 200,000 ampere RMS symmetrical interrupting rating unless noted otherwise.

16410.1.2 FUSE TYPES AND RATINGS

- A. Fuses from 0 to 600 ampere for each circuit serving a single motor shall be UL Class RK5 dual-element Low Peak, LPN-RK (250 volt).
- B. All other fuses in the 0 to 600 ampere range shall be UL Class J, dual-element, time delay, low peak, LPJ-SP (250 volt).
- C. Fuses larger than 600 ampere shall be UL Class L with time delay, Hi Cap, KRP-C.

