

## **DIVISION 26 – ELECTRICAL**

### **26 00 00 ELECTRICAL**

#### **26 01 00 Operation and Maintenance of Electrical Systems**

- 26 01 10 Operation and Maintenance of Medium-Voltage Electrical Distribution
- 26 01 20 Operation and Maintenance of Low-Voltage Electrical Distribution
- 26 01 26 Maintenance Testing of Electrical Systems
- 26 01 30 Operation and Maintenance of Facility Electrical Power Generating and Storing Equipment
- 26 01 40 Operation and Maintenance of Electrical and Cathodic Protection Systems
- 26 01 50 Operation and Maintenance of Lighting
  - 26 01 50.51 Luminaire Relamping
  - 26 01 50.81 Luminaire Replacement

#### **26 05 00 Common Work Results for Electrical**

- 26 05 13 Medium-Voltage Cables
  - 26 05 13.13 Medium-Voltage Open Conductors
  - 26 05 13.16 Medium-Voltage, Single- and Multi-Conductor Cables
- 26 05 19 Low-Voltage Electrical Power Conductors and Cables
  - 26 05 19.13 Undercarpet Electrical Power Cables
- 26 05 23 Control-Voltage Electrical Power Cables
- 26 05 26 Grounding and Bonding for Electrical Systems
- 26 05 29 Hangers and Supports for Electrical Systems
- 26 05 33 Raceway and Boxes for Electrical Systems
- 26 05 36 Cable Trays for Electrical Systems
- 26 05 39 Underfloor Raceways for Electrical Systems
- 26 05 43 Underground Ducts and Raceways for Electrical Systems
- 26 05 46 Utility Poles for Electrical Systems
- 26 05 48 Vibration and Seismic Controls for Electrical Systems
- 26 05 53 Identification for Electrical Systems
- 26 05 73 Overcurrent Protective Device Coordination Study

#### **26 06 00 Schedules for Electrical**

- 26 06 10 Schedules for Medium-Voltage Electrical Distribution
- 26 06 20 Schedules for Low-Voltage Electrical Distribution
  - 26 06 20.13 Electrical Switchboard Schedule
  - 26 06 20.16 Electrical Panelboard Schedule
  - 26 06 20.19 Electrical Motor-Control Center Schedule
  - 26 06 20.23 Electrical Circuit Schedule
  - 26 06 20.26 Wiring Device Schedule
- 26 06 30 Schedules for Facility Electrical Power Generating and Storing Equipment
- 26 06 40 Schedules for Electrical and Cathodic Protection Systems
- 26 06 50 Schedules for Lighting
  - 26 06 50.13 Lighting Panelboard Schedule
  - 26 06 50.16 Lighting Fixture Schedule

#### **26 08 00 Commissioning of Electrical Systems**

## **26 09 00 Instrumentation and Control for Electrical Systems**

- 26 09 13 Electrical Power Monitoring and Control
- 26 09 23 Lighting Control Devices
- 26 09 26 Lighting Control Panelboards
- 26 09 33 Central Dimming Controls
  - 26 09 33.13 Multichannel Remote-Controlled Dimmers
  - 26 09 33.16 Remote-Controlled Dimming Stations
- 26 09 36 Modular Dimming Controls
  - 26 09 36.13 Manual Modular Dimming Controls
  - 26 09 36.16 Integrated Multipreset Modular Dimming Controls
- 26 09 43 Network Lighting Controls
  - 26 09 43.13 Digital-Network Lighting Controls
  - 26 09 43.16 Addressable Fixture Lighting Control
- 26 09 61 Theatrical Lighting Controls

## **26 10 00 MEDIUM-VOLTAGE ELECTRICAL DISTRIBUTION**

### **26 11 00 Substations**

- 26 11 13 Primary Unit Substations
- 26 11 16 Secondary Unit Substations

### **26 12 00 Medium-Voltage Transformers**

- 26 12 13 Liquid-Filled, Medium -Voltage Transformers
- 26 12 16 Dry-Type, Medium -Voltage Transformers
- 26 12 19 Pad-Mounted, Liquid-Filled, Medium -Voltage Transformers

### **26 13 00 Medium-Voltage Switchgear**

- 26 13 13 Medium-Voltage Circuit Breaker Switchgear
- 26 13 16 Medium-Voltage Fusible Interrupter Switchgear
- 26 13 19 Medium-Voltage Vacuum Interrupter Switchgear

### **26 18 00 Medium-Voltage Circuit Protection Devices**

- 26 18 13 Medium-Voltage Cutouts
- 26 18 16 Medium-Voltage Fuses
- 26 18 19 Medium-Voltage Lightning Arresters
- 26 18 23 Medium-Voltage Surge Arresters
- 26 18 26 Medium-Voltage Reclosers
- 26 18 29 Medium-Voltage Enclosed Bus
- 26 18 33 Medium-Voltage Enclosed Fuse Cutouts
- 26 18 36 Medium-Voltage Enclosed Fuses
- 26 18 39 Medium-Voltage Motor Controllers

## **26 20 00 LOW-VOLTAGE ELECTRICAL TRANSMISSION**

### **26 21 00 Low-Voltage Overhead Electrical Power Systems**

### **26 22 00 Low-Voltage Transformers**

- 26 22 13 Low-Voltage Distribution Transformers
- 26 22 16 Low-Voltage Buck-Boost Transformers

26 22 19 Control and Signal Transformers

**26 23 00 Low-Voltage Switchgear**

26 23 13 Paralleling Low-Voltage Switchgear

**26 24 00 Switchboards and Panelboards**

26 24 13 Switchboards

26 24 16 Panelboards

26 24 19 Motor-Control Centers

**26 25 00 Enclosed Bus Assemblies**

**26 26 00 Power Distribution Units**

**26 27 00 Low-Voltage Distribution Equipment**

26 27 13 Electricity Metering

26 27 16 Electrical Cabinets and Enclosures

26 27 19 Multi-Outlet Assemblies

26 27 23 Indoor Service Poles

26 27 26 Wiring Devices

26 27 73 Door Chimes

**26 28 00 Low-Voltage Circuit Protective Devices**

26 28 13 Fuses

26 28 16 Enclosed Switches and Circuit Breakers

**26 29 00 Low-Voltage Controllers**

26 29 13 Enclosed Controllers

26 29 13.13 Across-the-Line Motor Controllers

26 29 13.16 Reduced-Voltage Motor Controllers

26 29 23 Variable-Frequency Motor Controllers

**26 30 00 FACILITY ELECTRICAL POWER GENERATING AND STORING EQUIPMENT**

**26 31 00 Photovoltaic Collectors**

**26 32 00 Packaged Generator Assemblies**

26 32 13 Engine Generators

26 32 13.13 Diesel-Engine-Driven Generator Sets

26 32 13.16 Gas-Engine-Driven Generator Sets

26 32 16 Steam-Turbine Generators

26 32 19 Hydro-Turbine Generators

26 32 23 Wind Energy Equipment

26 32 26 Frequency Changers

26 32 29 Rotary Converters

26 32 33 Rotary Uninterruptible Power Units

**26 33 00 Battery Equipment**

26 33 13 Batteries

- 26 33 16 Battery Racks
- 26 33 19 Battery Units
- 26 33 23 Central Battery Equipment
- 26 33 33 Static Power Converters
- 26 33 43 Battery Chargers
- 26 33 46 Battery Monitoring
- 26 33 53 Static Uninterruptible Power Supply

#### **26 35 00 Power Filters and Conditioners**

- 26 35 13 Capacitors
- 26 35 16 Chokes and Inductors
- 26 35 23 Electromagnetic -Interference Filters
- 26 35 26 Harmonic Filters
- 26 35 33 Power Factor Correction Equipment
- 26 35 36 Slip Controllers
- 26 35 43 Static-Frequency Converters
- 26 35 46 Radio-Frequency-Interference Filters
- 26 35 53 Voltage Regulators

#### **26 36 00 Transfer Switches**

- 26 36 13 Manual Transfer Switches
- 26 36 23 Automatic Transfer Switches

### **26 40 00 ELECTRICAL AND CATHODIC PROTECTION**

#### **26 41 00 Facility Lightning Protection**

- 26 41 13 Lightning Protection for Structures
  - 26 41 13.13 Lightning Protection for Buildings
- 26 41 16 Lightning Prevention and Dissipation
- 26 41 19 Early Streamer Emission Lightning Protection
- 26 41 23 Lightning Protection Surge Arresters and Suppressors

#### **26 42 00 Cathodic Protection**

- 26 42 13 Passive Cathodic Protection for Underground and Submerged Piping
- 26 42 16 Passive Cathodic Protection for Underground Storage Tank

#### **26 43 00 Transient Voltage Suppression**

- 26 43 13 Transient-Voltage Suppression for Low-Voltage Electrical Power Circuits

### **26 50 00 LIGHTING**

#### **26 51 00 Interior Lighting**

- 26 51 13 Interior Lighting Fixtures, Lamps, And Ballasts

#### **26 52 00 Emergency Lighting**

#### **26 53 00 Exit Signs**

**26 54 00 Classified Location Lighting**

**26 55 00 Special Purpose Lighting**

- 26 55 23 Outline Lighting
- 26 55 29 Underwater Lighting
- 26 55 33 Hazard Warning Lighting
- 26 55 36 Obstruction Lighting
- 26 55 53 Security Lighting
- 26 55 59 Display Lighting
- 26 55 61 Theatrical Lighting
- 26 55 63 Detention Lighting
- 26 55 70 Healthcare Lighting

**26 56 00 Exterior Lighting**

- 26 56 13 Lighting Poles and Standards
- 26 56 16 Parking Lighting
- 26 56 19 Roadway Lighting
- 26 56 23 Area Lighting
- 26 56 26 Landscape Lighting
- 26 56 29 Site Lighting
- 26 56 33 Walkway Lighting
- 26 56 36 Flood Lighting
- 26 56 68 Exterior Athletic Lighting

*26 60 00 Unassigned*

*26 70 00 Unassigned*

*26 80 00 Unassigned*

*26 90 00 Unassigned*

SECTION 26 00 00  
ELECTRICAL

## PART 1 GENERAL

## 1.1 GENERAL

## A. Work Included:

1. This section covers general requirements applying to all sections included in Division 26, ELECTRICAL, as well as electrical work pertaining to other divisions.
2. Division 26, ELECTRICAL, covers the work necessary for the complete electrical system. Furnish materials, labor, and equipment in accordance with these Specifications and the accompanying Drawings. A brief outline of the work includes, but is not limited to the following:

<<TO BE COMPLETED BY CONSULTING ENGINEER>>

## B. Work Included in Division 26, ELECTRICAL:

<<TO BE COMPLETED BY CONSULTING ENGINEER>>

## C. Work Specified Under Other Divisions:

1. The General Conditions, Supplementary General Conditions and Division 01 General Requirements.
2. Components for heating, ventilating, air conditioning systems, including conductors for control wiring, unless specifically shown on Electrical Drawings.
3. Demolition as specified under [Section 02 40 00] and Drawings.

## D. Materials and equipment furnished and installed under other divisions with raceway and electrical conductors furnished, installed and connected under Division 26, ELECTRICAL:

1. Air Conditioning equipment
2. Ventilating system equipment
3. Electric water heaters
4. Exhaust fans
5. Motors
6. Motor heaters
7. Motor thermal protectors and any required special protector monitoring relay
8. Halon system

- E. Materials and equipment furnished, installed, under other divisions, but with raceways, conductors, and connections furnished and installed under Division 26, Electrical
1. Instrumentation and control systems indicated on the Drawings by an open hexagon symbol. Final connections at control equipment made under the supervision of control system contractor.
- F. Inspection of the Site and Existing Conditions
1. The Electrical Drawings were developed from past record drawings and information supplied by the Owner. Verify all scaled dimensions prior to submitting bids.
  2. Before submitting a bid, visit the site and determine conditions at the site and at all existing structures in order to become familiar with all existing conditions and electrical systems which will, in any way or manner, affect the work required under this Contract. No subsequent increase in Contract cost will be allowed for additional work required because of the Contractor's failure to fulfill this requirement. By submitting a bid on the work, the Contractor shall be deemed to have accepted the site conditions.
  3. Carry out any work involving the shutdown of the existing services to any piece of equipment now functioning in existing areas at such time as to provide the least amount of inconvenience to the Owner. Do such work when directed by the Engineer.
  4. After award of Contract, confer with Engineer to verify at each area of construction activity the location of existing underground utilities. Protect all existing underground utilities during construction. Pay for all required repairs without increase in Contract cost should damage to underground utilities occur during construction.
- G. Responsibility
1. The Contractor shall be responsible for:
    - a. Complete systems in accordance with the intent of these Contract Documents.
    - b. Coordinating the incoming electrical service with the electric utility company [LADWP] for providing interim service as shown on Drawings.
    - c. Coordinating the telephone service with the owners private system the telephone utility company, [General Telephone Company; Pacific Telephone Company].
    - d. Coordinating the details of facility equipment and construction for all Specification Divisions which affect the work covered under Division 26, ELECTRICAL.
    - e. Furnishing and installing all incidental items not actually shown or specified, but which are required by good practice to provide complete functional systems.

- f. Cleaning of construction area including removal of all trash and debris as a result of electrical work.
- H. Intent of Drawings
- 1. Electrical plan drawings show only general locations of equipment, devices, and raceway, unless specifically dimensioned. Field conditions, non-interference with other trades, and architectural, structural and mechanical features shall determine the exact locations. [The Contractor shall be responsible for the proper routing of raceway, subject to the approval of the Engineer.]
- I. Departures from Contract Documents
- 1. Submit to the Engineer in writing details of any necessary or proposed departures from these Contract Documents, and the reasons therefore. Submit such requests as soon as practical and within 14 calendar days after award of the Contract. Make no such departures without written approval of the Engineer.
- J. Record Drawings
- 1. As-built Contract Drawings shall be prepared by the Contractor marked with red indelible pencil on reproducible sepia to show all departures from original Drawings. Show underground cable, conduit, or duct runs dimensioned from established building lines, and all electrical work revisions. Prepare by obtaining new, clean sets of Contract Drawings from Engineer and pay all costs for same. Field marked as-built drawings shall be initialed by the Engineer or his representative.
- K. Extra Work
- 1. No extra work shall be undertaken without written approval of the Owner.
- L. Substitution of Materials and Equipment
- 1. In accordance with provisions elsewhere in these Contract Documents, manufacturers' names and catalog numbers stated herein are intended to indicate the type and quality of equipment or materials desired. Unless substitution is specifically forbidden, proposed alternatives may be submitted for approval.
  - 2. Make requests for approval of alternatives in writing to the Engineer before submittals of shop drawings. Provide sufficient material or data, including samples if requested, to allow evaluation of the proposed alternative and determination of compliance with these Contract Documents. List any proposed deviations from these Contract Documents. Advise of any reduction in cost resulting from the proposed alternative.
- M. Submittals During Construction
- 1. Provide complete manufacturers' descriptive information and shop drawings for all equipment, material, and devices furnished under Division 16, ELECTRICAL, including certified outline drawings, arrangement drawings, elementary (schematic) diagrams, interconnection and connection diagrams, in



accordance with provisions elsewhere in these Contract Documents. Provide the number of copies specified therein for the Engineer, Contractor, and Operation and Maintenance Manuals.

2. Provide certified shop drawings, literature, and requested samples showing items proposed for use, size, dimensions, capacity, special features required, schematic (elementary) control diagrams, equipment schedules, rough-in, etc., as required by the Engineer for complete review and for use during installation. Use NEMA device designations and symbols for all electric circuit diagrams submitted. Make content of schematic (elementary) connection of interconnection diagrams in accordance with the latest edition of NEMA ICS 1.
3. Check submittals for proper number of copies, adequate identification, correctness and compliance with Drawings and Specifications, and initial all copies indicating this has been done. Revise, change, and/or resubmit all submittal information until acceptable to the Engineer. Obtain Engineer's acceptance before commencing fabrication or installation of any materials or equipment.
4. Review of submittal information by the Engineer shall not relieve the Contractor from responsibility for deviations from Drawings and Specifications, unless he has in writing at time of submission requested and received written approval from the Engineer for specific deviations. Review of submittal information shall not relieve the Contractor from responsibility for errors and omissions in shop drawings or literature.
5. Manufacturer's standardized elementary diagrams will not be acceptable unless applicable portions of the diagram have been clearly identified and non-applicable portions deleted or crossed out.
6. Sequentially number submittals, with resubmittals of the same or supplementary information numbered with the original number and a "2" for the second submittal, "3" for the third submittal, etc. So mark each Drawing, brochure, catalog cut, or similar information. Mark each document with the project number, equipment or item number, and proper revision number. Include with each submittal a transmittal letter showing the following information:
  - a. Specification Section Number
  - b. Quantity of each document
  - c. Submittal number
  - d. Submittal revision
  - e. Date of transmittal
7. Make submittals in accordance with Division 01, GENERAL REQUIREMENTS and the following schedule:
  - a. Within [30] Days After Award of Contract: Preliminary general arrangement drawings, outline dimensions, weights, and descriptive literature for all major (engineered) equipment and devices furnished under Division 26, ELECTRICAL, including, but not limited to:

1. Medium voltage metal clad switchgear
  2. Secondary unit substations
  3. Uninterruptible power supply systems
- b. Within [60] Days After Award of Contract:
1. Certified arrangement drawings, outline dimensions, and weights for all major (engineered) equipment including, but not limited to:
    - (a) All items for which preliminary information is required to be submitted within 60 days after award of Contract.
    - (b) Functional description or logic diagrams for all control systems furnished under Division 26, ELECTRICAL.
    - (c) Arrangement drawings, outline dimensions, weights, and descriptive literature for all fire alarm and communication systems.
  2. Shop drawings, outline dimensions, and descriptive literature for all equipment and devices furnished under Division 26, ELECTRICAL, including, but not limited to:
    - (a) Medium voltage fuses
    - (b) Low voltage fuses
    - (c) Lighting and distribution panels
    - (d) Separately mounted circuit breakers, fused switches and nonfused disconnect switches
    - (e) Capacitors
    - (f) Rigid steel conduit
    - (g) PVC-coated rigid steel conduit
    - (h) PVC conduit
    - (i) Flexible conduit
    - (j) Wireway
    - (k) Cable tray
    - (l) Outlet and device boxes
    - (m) Pull boxes and junction boxes
    - (n) Terminal junction boxes
    - (o) Precast manholes

- (p) Precast handholes
- (q) Medium and high voltage cables and conductors; submit samples
- (r) Medium and high voltage cable terminations and connectors
- (s) Medium and high voltage cable splices
- (t) 600-volt conductors
- (u) Control and power cables for all types specified
- (v) Lighting fixtures
- (w) Standby lighting units
- (x) Lamps: fluorescent, metal halide, incandescent, high pressure sodium per Luminaire Schedule
- (y) Ballasts: fluorescent, metal halide, high pressure sodium
- (z) Lighting UPS systems (UPS-3)
- (aa) Receptacles
- (bb) Light switches
- (cc) Device plates
- (dd) Pushbuttons, Indicating Lights, Selector Switches: devices and stations
- (ee) Dry type power transformers, 0-600V primary
- (ff) Dry type shielded isolation transformers, 0-600V primary
- (gg) Medium and low voltage surge protective equipment
- (hh) Automatic transfer switches
- (ii) Manual transfer switches
- (jj) Batteries
- (kk) Battery chargers
- (ll) Penetration sealing systems
- (mm) Sound systems and components
- (nn) Communications systems and components

- (oo) Telephone terminal cabinets
  - (pp) Fire alarm systems and components
  - (qq) All material specified on Drawings
  - (rr) Uninterruptible Power Supplies UPS-1, UPS-2 per Section ???
  - (ss) Conduit and cable tray information requested under Section 16110 Raceways paragraph 1.D.
  - (tt) All field panels being provided under Division 16 as shown on Drawings
- c. Within [90] days after award of contract:
1. Certified drawings and descriptive literature for all equipment and devices furnished under Division 26, ELECTRICAL, and not previously submitted including, but not limited to:
  2. Schematic (elementary) drawings for any electrical control; and bills of material for equipment including, but not limited to:
  3. Motor control
  4. Medium voltage metal clad switchgear
  5. Secondary unit substations
  6. Control panels for fire and communication systems
  7. All miscellaneous control systems required to be furnished under Division 26, ELECTRICAL
  8. Draft copy of short circuit and protective device coordination study
  9. Connection diagrams showing all internal wiring and interconnection diagrams showing all required field wiring for the following:
  10. Medium voltage metal clad switchgear
  11. Low voltage switchgear
  12. Motor control centers
  13. Secondary unit substations
  14. Control panels for all miscellaneous systems
  15. Fire alarm and communication systems
  16. UPS systems

- N. Operations and Maintenance Manuals
1. Provide operations and maintenance manuals in accordance with provisions of General Conditions, GENERAL REQUIREMENTS, in these Contract Documents. Provide the number of copies specified therein containing:
    - a. Operation, maintenance, recommended spare parts, and renewal parts information for all equipment furnished under this section.
    - b. Set of complete, final, as-reviewed and accepted information herein required to be submitted for review following Contract award.
    - c. As-built electric circuit, equipment, and installation drawings.
    - d. Index of all equipment suppliers listing current names, addresses, and telephone numbers of those who should be contacted for service, information, and assistance.
    - e. All field and factory test results.
    - f. Information listed under individual specification items.
    - g. Complete interconnection diagrams between all instrumentation and control devices showing field wiring from numbered terminal to numbered terminal in block diagram format.
    - h. Sequence of switching operations for emergency conditions and for restoration to normal operation.
  2. Use only clean material. File under dividers with heading in accordance with Specification item title.
  3. Submit material to Engineer for review prior to delivery of the final Operations Maintenance Manuals to Owner. Make additions or changes required by the reviewer.
- O. Standards, Codes, Permits, and Regulations
1. Perform all work; furnish and install all materials and equipment in full accordance with the latest applicable rules, regulations, requirements, and specifications of the following:
    - a. Local Laws and Ordinances
    - b. State and Federal Laws
    - c. National Electrical Code (NEC)
    - d. State Fire Marshal
    - e. Underwriters' Laboratories (UL)
    - f. National Electrical Safety Code (NESC)
    - g. American National Standards Institute (ANSI)

- h. National Electrical Manufacturer's Association (NEMA)
  - i. National Electrical Contractor's Association (NECA) Standard of Installation
  - j. Institute of Electrical and Electronics Engineers (IEEE)
  - k. Insulated Cable Engineers Association (ICEA)
  - l. Occupational Safety and Health Act (OSHA)
  - m. National Electrical Testing Association (NETA)
  - n. American Society for Testing and Materials (ASTM)
  - o. City of Los Angeles Electrical Code
  - p. California Administrative Code, Title 8, Subchapter 5, Electrical Safety Orders
  - q. California General Order No. 95
  - r. California Administrative Code Titles 20 and 24 Energy Efficiency Standards for New Buildings
- 2. Conflicts, if any, that may exist between the above items will be resolved at the discretion of the Engineer by applying the most stringent requirement.
  - 3. Wherever the requirements of the Specifications or Drawings exceed those of the above items, the requirements of the Specifications or Drawings govern. Code compliance is mandatory. Construe nothing in the Contract Documents as permitting work not in compliance with these codes.
  - 4. Obtain all permits and pay all fees required by any governmental agency having jurisdiction over the work. Arrange all inspections required by these agencies. On completion of the work, furnish satisfactory evidence to the Engineer that the work is acceptable to the regulatory authorities having jurisdiction.
- P. Temporary Utilities
- 1. Refer to GENERAL REQUIREMENTS in these Contract Documents for necessary provisions for electric power required by Contractor during construction.
  - 2. Contractor may use the power and water available in the building for lighting and small tools. Toilet facilities in the building may be used by contractor personnel.
  - 3. Power is available at the location and voltage noted on the drawings. All necessary expense for connection, transformation, metering and distribution shall be borne by the Contractor. Contractor shall reimburse owner for power used at \$0.00 per kilowatt-hour.
- Q. Salvaged Material

1. Unless otherwise indicated, all material required to be removed and salvaged is the property of the Owner and shall be delivered by the Contractor for storage where directed by the Owner.

R. Guarantee

1. Materials, equipment, and workmanship shall be guaranteed in accordance with provisions of GENERAL REQUIREMENTS, in these Contract Documents.

\*\* OR \*\*

2. Materials, equipment and workmanship furnished and installed under this Division shall be guaranteed by the Contractor for a period of one (1) year, except as indicated below, from the date of acceptance of the work.
3. Extended Guarantee: The following equipment shall be guaranteed by the Contractor for a period of two (2) years from the date of acceptance of the work:
  - a. Lighting ballasts

S. Payment

1. Payment for the work in this section will be included as part of the lump sum bid amount stated in the Proposal.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT, COMMON REQUIREMENTS

A. General

1. Unless otherwise indicated, provide all first-quality, new materials and equipment, free from any defects, in first-class condition, and suitable for the space provided. Provide materials and equipment listed by UL and having label, symbol or other identifying mark of UL affixed wherever standards have been established by that agency.
2. Where two or more units of the same class of material or equipment are required, provide products of a single manufacturer. Component parts of materials or equipment need not be products of the same manufacturer.
3. All electrical equipment furnished under this contract shall be listed by a testing laboratory recognized and conforming to all the requirements of the City of Los Angeles Department of Building and Safety. In lieu of such listing the contractor must submit the equipment for approval to the electrical testing laboratory of the Department of Building and Safety. Contractor shall bear all cost and include same in his bid for obtaining this approval. Shop drawing approval by the Engineer shall not constitute a waiver of the requirements of the Department of Building and Safety.

B. Standard Products

1. Unless otherwise indicated, provide materials and equipment which are the standard products of manufacturers regularly engaged in the production of

such materials and equipment. Provide the manufacturers' latest standard design that conforms to these Specifications.

C. Equipment Finish

1. Unless noted otherwise provide materials and equipment with manufacturers' standard finish system. Provide manufacturers' standard finish color, except where specific color is indicated. If manufacturer has no standard color, finish equipment with [ANSI No. 61, light gray color].

D. Altitude

1. Provide materials and equipment suitable for installation and operation under rated conditions for elevations shown on Drawings.

E. Outdoor Equipment

1. Provide equipment and devices to be installed outdoors or in unheated enclosures capable of continuous operation within an ambient temperature range of 15 degrees F to 110 degrees F.

F. Hazardous Areas

1. Provide materials and equipment acceptable to the regulatory authority having jurisdiction for the Class, Division and Group of hazardous area indicated.

PART 3 EXECUTION

3.1 EXECUTION

A. General

1. Install materials and equipment in a workmanlike manner utilizing craftsmen skilled in the particular trade. Provide work which has a neat and finished appearance. Carry out work in accordance with NECA Standard of Installation unless otherwise specified.
2. Coordinate electrical work with Engineer, General Contractor and work of other trades to avoid conflicts, errors, delays, and unnecessary interference with operation of the plant during construction.
3. Check the approximate locations of light fixtures, electrical outlets, equipment, and other electrical system components shown on Drawings for conflicts with openings, structural members, and components of other systems and equipment having fixed locations. In the event of conflicts, notify the Engineer in writing. The Engineer's decision shall govern. Make modifications and changes required to correct conflicts.
4. Be responsible for receiving and handling of Owner furnished equipment which is to be installed under Division 26, ELECTRICAL, per the General Requirements of this Specification.

B. Protection During Construction



1. Throughout this Contract, provide protection for materials and equipment against loss or damage in accordance with provisions elsewhere in these Contract Documents. Throughout this Contract, follow manufacturers' recommendations for storage. Protect everything from the effects of weather. Prior to installation, store items in clean, dry, indoor locations. Store in clean, dry, indoor, heated locations items subject to corrosion under damp conditions, and items containing electrical insulation, such as transformers, conductors, motors, and controls. Energize all space heaters furnished with equipment. Provide temporary heating, sufficient to prevent condensation, in transformers, switchgear, switchboards, motors, and motor control centers which do not have space heaters.
2. Following installation, protect materials and equipment from corrosion, physical damage, and the effects of moisture on insulation. When equipment intended for indoor installation is installed at the Contractor's convenience in areas where it is subject to dampness, moisture, dirt, or other adverse atmosphere until completion of construction, ensure that adequate protection from these atmospheres is provided that is acceptable to the Engineer. Cap conduit runs during construction with manufactured seals. Keep openings in boxes or equipment closed during construction. Energize all space heaters furnished with equipment. Provide for all wiring of space heaters.

C. Material and Equipment

1. Follow manufacturers' installation instructions explicitly, unless otherwise indicated. Wherever any conflict arises between the manufacturers' instructions, codes and regulations, and these Contract Documents, follow Engineer's decision. Keep copy of manufacturers' installation instructions on the job site available for review at all times.
2. Use appropriate conduit and conductor entry fittings with enclosures which maintain the specified enclosure environmental capability and NEMA rating after proper installation.

D. Removal of Relocation of Materials and Equipment

1. Where existing materials and equipment are removed or relocated, remove all materials no longer used such as studs, straps, conduits, and wires. Remove or cut off concealed or embedded conduit, boxes, or other materials and equipment to a point at least 3/4-inch below the final finished surface and repair surfaces as specified herein.
2. Repair affected surfaces to conform to the type, quality, and finish of the surrounding surface in a neat and workmanlike manner and acceptable to the Engineer. Utilize skilled craftsmen of the trades involved.

E. Cutting and Patching

1. Lay out work carefully in advance. Do not cut or notch any structural member or building surface without specific approval of Engineer. Carefully carry out any cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, paving, or other surfaces required for the installation, support, or anchorage of conduit, raceways, or other electrical materials and equipment. Following such work, restore surfaces neatly to original condition. Use skilled craftsmen of the trades involved.

- F. Cleaning and Touchup Painting
1. Keep the premises free from accumulation of waste material or rubbish. Upon completion of work, remove all materials, scraps, and debris from premises and from interior and exterior of all devices and equipment. Touch up scratches, scrapes, or chips in interior and exterior surfaces of devices and equipment with finishes matching as nearly as possible the type, color, consistency, and type of surface of the original finish. If extensive damage is done to equipment paint surfaces, refinish the entire equipment in a manner that provides a finish equal to or better than the factory finish, that meets the requirements of the Specifications, and that is acceptable to the Engineer.
- G. Hazardous Areas
1. Install all materials and equipment in hazardous areas in a manner acceptable to the regulatory authority having jurisdiction for the Class, Division, and Group of hazardous area indicated.
- H. Inspection
1. Allow materials, equipment, and workmanship to be inspected at any time by the Engineer, and/or Owner or their representatives. Correct work, materials, or equipment not in accordance with these Contract Documents or found to be deficient or defective in a manner satisfactory to the Engineer.
- I. Service Continuity
1. Maintain continuity of electric service to all functioning portions of the facility or buildings during hours they are normally in use. Temporary outages will be permitted during cutover work at such times and places as can be prearranged with Engineer and the Owner. Such outages shall be kept to a minimum number and minimum length of time. Submit request for outage ten (10) work days prior to proposed date. Make no outages without prior written authorization of the Owner. Include all costs for temporary wiring and overtime work required in the Contract price. Remove all temporary wiring at the completion of the work.
- J. Short Circuit and Protective Device Coordination Study
1. Provide seven copies in hard cover three-ring binders, each including complete short circuit and protective device coordination studies complete with device coordination time-current curves for the medium and low voltage distribution systems.
  2. In the short circuit study, provide calculation methods and assumptions, the base per unit quantities selected, one-line diagrams, source impedance data including power company system characteristics, impedance diagrams, typical calculations, tabulations of calculation quantities and results, conclusions, and recommendations. Calculate short circuit interrupting and momentary (when applicable) duties for an assumed 3-phase bolted fault at each supply switchgear lineup, unit substation primary and secondary terminals, low voltage switchgear lineup, switchboard, motor control center, distribution panelboard, pertinent branch circuit panelboard, and other significant locations throughout the system. Provide a ground fault current study for the same system areas, including the associated zero sequence impedance diagram. Include in

tabulations fault impedance, X to R ratios, asymmetry factors, motor contribution, short circuit kVA, and symmetrical and asymmetrical fault currents.

3. In the protective device coordination study, provide time-current curves graphically indicating the coordination proposed for the system, centered on conventional, full-size, log-log forms. Include with each curve sheet a complete title and one-line diagram with legend identifying the specific portion of the system covered by that particular curve sheet. Include a detailed description of each protective device identifying its type, function, manufacturer, and time-current characteristics. Tabulate recommended device tap, time dial, pickup, instantaneous, and time delay settings.
4. Include on the curve sheets power company relay and fuse characteristics, system medium voltage equipment relay and fuse characteristics, low voltage equipment circuit breaker trip device characteristics, pertinent transformer characteristics, pertinent motor and generator characteristics, and characteristics of other system load protective devices. Include at least all devices down to largest branch circuit and largest feeder circuit breaker in each motor control center. Include all adjustable setting ground fault protective devices. Include manufacturing tolerance and damage bands in plotted fuse characteristics. Show transformer full load and 150, 400, or 600 percent currents, transformer magnetizing inrush, ANSI transformer withstand parameters, and significant symmetrical and asymmetrical fault currents. Terminate device characteristic curves at a point reflecting the maximum symmetrical or asymmetrical fault current to which the device is exposed.
5. Select each primary protective device required for a delta-wye connected transformer so that its characteristic or operating band is within the transformer characteristics, including a point equal to 58 percent of the ANSI withstand point to provide secondary line-to-ground fault protection. Where the primary device characteristic is not within the transformer characteristics, show a transformer damage curve. Separate transformer primary protective device characteristic curves from associated secondary device characteristics by a 16 percent current margin to provide proper coordination and protection in the event of secondary line-to-line faults. Separate medium voltage relay characteristic curves from curves for other devices by at least a 0.4-second time margin.
6. In each binder, include complete sets of individual protective device time-current characteristics on transparencies.
7. Short circuit and protective device studies may be prepared with a network analyzer, digital computer, or by written computations, but must include complete fault calculations as specified herein for each proposed and ultimate source combination. Note that source combinations may include present and future supply circuits, large motors, or generators as noted on Drawing one-lines.
8. Provide short circuit and protective device coordination studies carried out by the electrical equipment manufacturer who furnishes the switchgear or equipment for the incoming service to the Contract site or by a professional electrical engineer registered in the State of California. Provide studies prepared by persons experienced in the work. Submit qualifications of individual(s) who will perform the work for approval prior to commencement of the studies. Provide studies in conjunction with equipment submittals to verify

equipment ratings required. Submit a draft of the final study to Engineer for review prior to delivery of the final study to the Owner. Make all additions or changes as required by the reviewer.

9. Utilize equipment load data for the study obtained by the Contractor from Contract Documents, including Contract Addenda issued prior to bid opening.
  10. Include fault contribution of all existing motors in the study. Obtain all required existing equipment data. Notify the Engineer in writing of existing circuit protective devices not properly rated for new fault conditions.
- K. Implementation of Short Circuit and Protective Device Coordination Studies Results
1. The drawings and specifications indicate the general requirements for the electrical equipment being provided. Changes and additions to equipment characteristics and ratings may be suggested by the results of the short circuit and protective device coordination studies. Submit any such proposed changes and additions as a part of the study material. Necessary field settings of devices, and adjustments and minor modifications to equipment to accomplish conformance with the accepted short circuit and protective device coordination studies shall be carried out by the particular manufacturer or by the Contractor at no additional cost to the Owner.
- L. Check-Out and Start-Up
1. During check-out and start-up of the various plant systems, provide a crew of skilled craftsmen to be available for check-out and troubleshooting activities as required by the specifications. Since coordination with other crafts and contractors will often be required, the craftsmen assigned to check-out must be available outside normal working hours when necessary.
- M. Tests
1. Carry out tests specified hereinafter and as indicated under individual items of materials and equipment specified in other sections.
  2. After the electrical system installation is completed and at such time as the Engineer may indicate, conduct an operating test for approval. Demonstrate that the equipment operates in accordance with the requirements of these Specifications and Drawings. Demonstrate that protective functions are operating properly and are properly incorporated in control system, circuit breaker, and motor control center circuitry. Perform the test in the presence of the Owner, Engineer, or other authorized representative. Furnish all instruments and personnel required for the tests.
  3. Voltage: When the installation is essentially complete and the plant is in operation, check the voltage at the point of termination of the power company supply system to the project. Check voltage amplitude and balance between phases for loaded and unloaded conditions.
    - a. Record the supply voltage (all three phases simultaneous on the same graph) for 7 working days. Submit the recording with a letter of transmittal to the Owner and his authorized representative within 5 days of the date the test was taken.

- b. If an unbalance (as defined by NEMA) exceeds 1 percent, or if the voltage varies throughout the day and from loaded to unloaded conditions more than plus or minus 4 percent of nominal, make a written request to the utility, that the condition be corrected. If corrections are not made, obtain from the utility a written statement that the voltage variations and/or unbalance are within their normal standards.
4. Motor Rotation: After final service connections are made, check and correct the rotation of all motors. Coordinate rotation checks with the Engineer and the Contractor responsible for the driven equipment. Submit a written report to the Engineer for each motor verifying that rotation has been checked and corrected.
5. Equipment Line Current: Check the line current in each phase for each piece of equipment. If the power company makes adjustments to the supply voltage magnitude or balance, make the line current check after the adjustments are made. If any phase current in any piece of equipment is above the rated nameplate current, determine the cause of the problem and submit it in writing to the Engineer.
6. Load Balance: The Drawings and Specifications indicate circuiting to electrical loads and distribution equipment and the extent of load balance anticipated. Measure electrical load between phases on switchboards, panelboards, motor control centers, etc. Notify Engineer of conditions of unbalance which exceed ten percent. Verify that loads are connected per Drawings and Specifications where unbalance exceeds ten percent.

END OF SECTION

SECTION 26 05 00  
COMMON WORK RESULTS FOR ELECTRICAL

## PART 1 GENERAL

## 1.1 Work Included

- A. This section covers the work necessary to furnish, install and complete the materials specified hereinafter.

## 1.2 Related Work Specified in Other Sections

<<TO BE COMPLETED BY CONSULTING ENGINEER>>

## 1.3 Submittals During Construction

- A. Make submittals after award of Contract in accordance with [Section 26 00 00, ELECTRICAL]. Furnish descriptive literature for the following equipment or devices supplied under this section:

1. Junction and pull boxes greater than 12" in any dimension.
2. Terminal boxes
3. Telephone terminal cabinets
4. Wiring devices (each type)
5. Multi-outlet surface raceway
6. Surface raceway
7. Communication pole(s)
8. Telephone outlets
9. Device plates
10. Lighting Panelboards
11. Power Distribution Panelboards
12. Circuit breakers
13. Ground fault protector
14. Fused and unfused switches
15. Fuses
16. Pushbuttons, indicating lights, and selector switches
17. Terminal blocks 0 to 600 volts

18. Control relays
19. Reset timers
20. Elapsed time meters
21. Manual Motor Starters
22. Magnetic contactors
23. Lighting contactors
24. Capacitors
25. Transformers
26. Penetration sealing systems (Fire Stops)

## PART 2 PRODUCTS

### 2.1 Outlet and Device Boxes

- A. General: Provide boxes not less than 2 inches deep, unless shallower boxes are required by structural conditions. Do not use box extensions to provide wiring space required by the NEC. (For hollow masonry construction provide boxes of sufficient depth so that conduit knockouts or hubs are in the masonry void space.)
- B. Sheet Steel (SS) Boxes: Provide zinc-or cadmium-plated boxes of the one-piece drawn type. Install 4-inch minimum octagonal boxes for ceiling outlets, except where smaller boxes are required for the particular fixture being installed. Use concrete type boxes in poured concrete slabs. Provide 4-inch by 4-inch minimum boxes for switches and receptacles. Provide plaster rings where required.
- C. Cast Steel (CS) Boxes: Provide boxes of case ferrous metal with gasketed, watertight, cast ferrous metal covers and stainless steel screws. Provide boxes with threaded conduit hubs and cast mounting lugs where lugs are required. (Where designated to be NEMA 4X provide bases with 40 mil PVC coating.) Use Crouse-Hinds, Appleton, or Robroy Type FS or FD boxes, or equal.

### 2.2 Junction and Pull Boxes

- A. Utilize NEMA 3R watertight enclosures for outdoor or wet locations and where subscript WP is indicated at the box location on the Drawings.
- B. Where outlet boxes are used as junction or pull boxes, use materials as specified under OUTLET AND DEVICE BOXES.
- C. Where larger sheet steel boxes are required, utilize boxes of code-gauge, galvanized steel with full-access screw covers mounted with corrosion-resistant machine screws.
- D. Where larger cast metal boxes are required, use neoprene gasketed, watertight boxes with hinged, case metal full-access covers, stainless steel cover hardware, and drilled and tapped conduit entrances. Use Crouse-Hinds Series W, O.Z./Gedney Series Y boxes, or equal. For below grade conduit, use Crouse-Hinds Type WJBF,

O.Z./Gedney Series YR, or equal, minimum size 8 inches by 6 inches. For hazardous areas, use boxes applicable for the location and hazardous atmosphere present.

- E. Where larger nonmetallic boxes are required, they shall be gasketed, watertight, corrosive resistant, and have a hinged, full-access screw cover. The hinge and machine screws shall be stainless steel. The box and cover shall be of high-impact strength fiberglass-reinforced polyester material with stability to high heat and ultra violet rays. The boxes shall have conduit hubs and any required mounting lugs. The minimum size shall be 7 inches by 10 inches by 6-1/2 inches deep. Use Crouse-Hinds Type NJB boxes, or equal.
- F. Use concrete boxes of reinforced cast concrete, 10 inches by 17 inches minimum inside dimensions, Brooks Products, Inc., No. 3-1/2T, Quikset W.17, or equal. Mark cast iron cover, ELECTRICAL, TELEPHONE, or as shown on the Drawings.
- G. Use special boxes where indicated on the Drawings.

### 2.3 Terminal Junction Boxes (TJB)

- A. Provide hinged-cover terminal junction boxes of the required type and size where indicated. Utilize NEMA 1 enclosures for indoor dry locations. Utilize NEMA 3R watertight enclosures, as described under JUNCTION AND PULL BOXES, for outdoor or wet locations and where subscript WP is indicated at the box location on the Drawings. Provide terminal blocks with a separate connection point for each conductor entering or leaving the box. Provide 25 percent spare terminal points. Paint interior surfaces with white enamel or lacquer. Label all terminal blocks with plastic tags.

### 2.4 Wiring Devices

#### A. Switches:

1. General Use Switches: Provide specification grade, totally-enclosed, ac type, quiet tumbler switches meeting NEMA WD 1 performance standards and Federal Specification W-S-896E, and capable of control 100 percent tungsten filament and fluorescent lamp loads. Use switches rated at 20 amps, 120/277 volts. Provide operating handles colored ivory in office areas, and brown in all other areas. Switches shall have screw terminals.
2. Weatherproof Switches: Use switches as specified mounted in a cast metal box with gasketed, weatherproof device plate as specified.
3. Switches with Pilot Lights: Provide switches as specified with 125-volt, neon light with red jewel, or lighted toggle which is lighted when the switch in ON.
4. Acceptable Manufacturers: Bryant, General Electric, Hubbell, Pass and Seymour, or equal.

#### B. Receptacles:

1. Single and Duplex: Provide specification grade receptacles meeting NEMA WD 1 performance standards and Federal Specification W-C-596, and having a contact arrangement such that contact is made on two sides of each inserted



blade without detent. Use two-pole, three-wire Isolated ground type receptacles rated [15] [20] amps, 125 volts, NEMA Configuration [5-15R] [5-20R], and with screw type wire terminals suitable for No. [12] [10] AWG. Provide high strength thermoplastic bases colored ivory in offices, [red for emergency,] orange for conditioned power,] and brown in all other areas. Acceptable manufacturers: Bryant, General Electric, Hubbell, Pass and Seymour or equal.

2. Weatherproof Receptacles: Receptacles shall be specified above mounted in a cast metal box with gasketed, weatherproof device plate as specified below.
  3. Ground Fault Circuit Interrupter (GFCI) Receptacles: Provide duplex specification grade GFCI receptacles tripping at 5 milliamps; rated [15] [20] amps, 120 volts, NEMA Configuration [5-20R]; and capable of interrupting 1,000 amps without damage. Use units meeting NEMA WD 1, fitting standard sized outlet boxes, having No. 12 AWG copper TW insulated pigtails, having provision for testing, and ivory in color. Use standard model where ground fault protection is needed at an individual location. Use feed-thru model where ground fault protection is specified for "downstream" conventional receptacles. Provide receptacles accepting standard device plates. Acceptable manufacturers: Pass and Seymour, Square D, General Electric, or equal.
  4. Special Purpose Receptacles: Provide receptacles of the type, rating, and number of poles indicated or required for the anticipated purpose.
- C. Multi-outlet Surface Raceway System: Provide Plugmold 2000, Walker Duct 2GW, or equal, with three wire grounding receptacles on indicated 12-inch centers. Provide an insulated grounding conductor to each receptacle. Wherever a two-circuit, three-wire supply to a multi-outlet system is indicated, wire alternate outlets to each circuit and make receptacle color alternate ivory-black. Utilize gray raceway with black receptacles.
- D. Surface Raceway System: Surface non-metallic raceway shall be used for telephone station circuits where noted on the plans. Provide raceway and all system components which are UL listed and exhibit nonflammable self extinguishing characteristics, tested to comparable specifications of UL 94V-O. The raceway shall consist of a two-piece construction utilizing a separate base and a separate removable cover section to allow access to the wiring. Both base and cover are to be manufactured of rigid natural PVC compounds. The base shall have a smooth texture, natural in color; the cover, matte texture, ivory in color. The overall dimensions of the base and cover when assembled shall be 2-1/4"W x 11/16"D. A full complement of fittings must be available including, but not limited to, extension boxes, 90° elbows, tees, fixture boxes and device boxes. All fittings shall match the ivory color of the raceway cover. Acceptable Manufacturers: Wiremold series 2300 B & C, or equal.
- E. Communication Pole: Provide single compartment steel poles with a minimum material thickness of 0.030", a cross section of 2-1/8" x 2-1/8", and ivory finish. Furnish unwired and without outlets. Acceptable Manufacturers: Wiremold 25TC-4 or equivalent.
- F. Telephone Outlets: Provide empty outlet boxes and cover plates conforming to the requirements of the telephone company where telephone outlets are indicated.

## G. Device Plates:

1. General
  - a. Provide plates fitting closely and tightly to the box on which they are to be installed. On surface-mounted boxes, provide plates which do not extend beyond the sides of the box unless the plates do not have sharp corners or edges.
  - b. Provide single piece plates. Sectional type device plates will not be permitted.
  - c. Use plate material compatible with the box material such that galvanic corrosion of the plate and/or box does not occur.
2. Plastic: Provide plates manufactured of [high abuse nylon] [plastic] with a minimum of 0.10-inch wall thickness. Plates shall be the same color as receptacle or toggle switch with which they are mounted.
3. Metal (M) Plates: Provides specification grade, one-piece, 0.040-inch nominal minimal thickness, No. [302] [430] satin finish stainless steel device plates with oval-head, matching mounting screws.
4. Industrial Covers: Provide 1/2-inch raised industrial covers manufactured of zinc-or cadmium-plated steel with rounded corners. Covers shall not extend beyond box perimeter.
5. Engraved Plates: Where device titles are indicated, provide device plates engraved with the designated titles. Provide engraved letters, numbers, or characters 1/8-inch high with filler of red color.
6. Cast Metal (CM) Plates: Provide cast metal device plates of malleable ferrous metal or copper-free aluminum with gaskets and stainless steel screws with oval heads.
7. Weatherproof (WP) Plates:
  - a. Where weatherproof receptacles are designated, the receptacle shall be installed in the specified box with a gasketed, weatherproof, cast metal or stainless steel cover plate with individual cap over each receptacle opening and stainless steel mounting screws. Utilize plates with caps held tightly closed with stainless steel springs when receptacle is not in use. Acceptable manufacturers: General Electric, Bryant, Hubbell, Sierra, Pass and Seymour, Crouse-Hinds, Bell, or equal.
  - b. Where weatherproof switches are designated, the switch shall be installed in the specified box with a gasketed, weatherproof, cast metal cover plate incorporating an external operator for the internal switch and with stainless steel mounting screws. Acceptable manufacturers and types: Crouse-Hinds DS-181 or DS-185, Appleton FSK-1VTS or FSK-1VS, or equal.

## 2.5 Lighting and Power Distribution Panelboards

- A. General:
1. Provide circuit breaker panelboards meeting standards established by UL, NEMA PB 1, and the NEC. Where used for service entrance equipment, provide panels U.L. labeled for that use. Furnish panels with fully rated short circuit current equipment rating [or with U.L. labeled series rating]. Provide panels rated for connection to an electric system having an available amperes rms symmetrical short circuit current of [10,000 amperes at 208Y/120 volts and 14,000 amperes at 480Y/277 volts] [as indicated on the drawings]. Provide panelboards and circuit breakers suitable for use with 75 degrees C wire at full NEC 75 degrees C ampacity.
- B. Cabinets:
1. Furnish boxes large enough to provide a minimum wiring gutter space on both sides and top and bottom of 4 inches by 4 inches minimum. Provide flush or surface-mounted boxes as indicated manufactured with reinforced steel frame and code-gauge, hot-dip galvanized sheet steel. [Provide boxes without manufactured knockouts.] Utilize front trim the same size as the box for surface-mounted panelboards. Provide sheet steel fronts finished with a prime coat of rust inhibitor and the manufacturer's standard baked enamel or lacquer finish and utilizing adjustable clamps as the means for fastening the front to the boxes. Utilize fronts having door with concealed hinges and flush type lock and catch device. Provide multipoint locking devices for all doors over 30 inches in height. Key all locks alike, and furnish two milled type keys with each lock. Door and trim shall be manufactured of No. 12 gauge steel. Furnish a metal directory frame welded onto door interior with transparent plastic face and enclosed directory card, typed with panel circuit designations. Furnish an engraved, laminated plastic nameplate, screwed (no adhesives) to the cabinet exterior face indicating the panel designation, service voltage, phases and ampere rating. Nameplates shall be black with a white core.
- C. Interiors:
1. Utilize panel boards interiors that are factory assembled complete with circuit breakers as indicated. Furnish circuit breakers in positions where diagram or schedule indicates SPARE. Furnish only complete provisions for future circuit breakers where diagram or schedule indicates SPACE, and cover the resulting opening in the cabinet front with an easily removable metal cover. Utilize panel boards with interiors designed so that circuit breakers can be replaced without disturbing adjacent circuit breakers or without removing the main bus. Mount main circuit breaker so nameplate information is visible without removal of trim or covers.
  2. Provide copper bus bars fully sized throughout their length. Aluminum bus is not acceptable. Make complete provisions for mounting future circuit breakers throughout the full length of the bus provide regardless of the number of units and spaces called for. Provide all machining, drilling, or tapping required to add or change circuit breakers in the future. Bolt together and rigidly support bus bars and connection straps on molded insulators. Bus shall provide for bolt-on circuit breakers.
  3. Furnish an insulated neutral bus bar where indicated rated [the same] [twice the] rating as the phase bus bars and having at least one [two] terminal screw

for each branch circuit. [Furnish an Isolated Plated Copper Ground Bus where indicated on the drawings]. Furnish a plated copper ground bus bar installed on the panelboard frame, bonded to the box, and containing at least one terminal screw for each circuit. Provide solderless main lugs for main, neutral, and ground bus bars. Provide lugs and connections points on phase, neutral, and ground buses suitable for copper conductors.

D. Circuit Breakers:

1. Furnish indicating type molded circuit breakers providing ON/OFF and TRIPPED positions of the operating handle. Furnish thermal magnetic, quick-make, quick-break circuit breakers which are noninterchangeable in accordance with the NEC. Do not use tandem or dual circuit breakers in normal single-pole spaces. Do not use single-pole circuit breakers with handle ties where multipole circuit breakers are indicated. Utilize multipole circuit breakers designed so that an overload on one pole automatically causes all poles to open. Provide circuit breakers meeting requirements of NEMA AB 1. Install bolt-on circuit breakers in all panelboards. Provide circuit breaker handle padlocking provisions where indicated or required by codes.
2. Where ground fault interrupter (GFI) circuit breakers are indicated or required by the NEC, provide a unit containing a conventional thermal magnetic trip and a ground fault sensor rated to trip the circuit breaker in approximately 0.025 second for a 5-milliampere ground fault (UL Class A sensitivity). Utilize a ground fault sensor having the same rating as the circuit breaker and having a push-to-test button.

E. Acceptable Manufacturers: Benjamin, General Electric, Square D, Westinghouse, or approved equivalent.

2.6 Circuit Breakers, Individual, 0 to 600 Volts

- A. Mount individual circuit breakers in NEMA 1, industrial use enclosure unless otherwise indicated. Provide NEMA 3R enclosure for circuit breakers mounted outdoors and wherever the subscript WP is indicated on the Drawings. Provide circuit breakers with handles that can be locked in the OFF position. Interlock enclosure and circuit breaker to prevent opening the cover with the circuit breaker in the ON position.
- B. Provide quick-make, quick-break, thermal magnetic circuit breakers of the indicating type showing ON/OFF and TRIPPED positions of the operating handle. Do not use single-pole circuit breakers with handle ties where multipole circuit breakers are indicated. Utilize multipole circuit breakers designed so that an overload on one pole automatically causes all poles to open.
- C. Provide circuit breakers meeting the requirements of NEMA AB 1 and having a minimum interrupting rating of 30,000 amps rms symmetrical at 480 volts. Where circuit breakers are used as service entrance equipment, provide units UL labeled for that use. Provide circuit breakers suitable for use with 75 degrees C wire at full NEC 75 degrees C ampacity.

2.7 Fused Switches, Individual, 0 to 600 Volts

- A. Mount individual fused switches in NEMA 1, industrial use enclosures unless otherwise indicated. Provide NEMA 3R enclosure for fused switches mounted outdoors and wherever the subscript WP is indicated on the Drawings. Provide fused switches that can be locked in the OFF position. Interlock enclosure and switch to prevent opening the cover with the switch in the ON position.
  - B. Provide fused switches which are quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type having external marking clearly indicating ON and OFF positions. Provide fuses of the current ratings indicated and typed specified herein. Utilize fuse mountings that reject Class H fuses and will accept only the current-limiting fuses specified. Provide fused switches meeting the requirements of NEMA KS 1 and UL listed for application to a system having an available short circuit current of 200,000 amps rms symmetrical.
  - C. Where fused switches are used as service entrance equipment, provide units UL labeled for that use. Provide switches suitable for use with 75 degrees C wire at full NEC 75 degrees C ampacity.
- 2.8 Nonfused Switches, Individual, 0 to 600 Volts
- A. Mount individual switches in NEMA 1, industrial use enclosure unless otherwise indicated. Provide NEMA 3R enclosure for switches mounted outdoors and wherever the subscript WP is indicated on the Drawings. Provide switches that can be locked in the OFF position. Interlock enclosure and switches to prevent opening the cover with the switch in the ON position.
  - B. Provide switches which are quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type having external marking clearly indicating ON and OFF positions. Furnish switches meeting the requirements of NEMA KS 1. Provide switches suitable for use with 75 degrees C wire at full NEC 75 degrees C ampacity.
- 2.9 Fuses, 0 to 600 Volts
- A. Provide a complete set of current-limiting fuses wherever fuses are indicated. Supply a set of six spare fuses of each type and each current rating installed. Utilize fuses that fit mountings specified with switches and which provide features rejecting Class H fuses. Provide the following types:
    - 1. For 0- to 600-volt motor and transformer circuits, 0 to 600 amps, UL Class RK-1 with time delay, Bussmann Type LPS-RK, Shawmut Type A6D-R, or equal.
    - 2. For 0- to 250-volt motor and transformer circuits, 0 to 600 amps, UL Class RK-1 with time delay, Bussmann Type LPN-RK, Shawmut Type A2D-R, or equal.
    - 3. For 0- to 600-volt feeder and service circuits, 0 to 600 amps, UL Class RK-1, Bussmann Type KTS-R, Shawmut Type A6K-R, or equal.
    - 4. For 0- to 250-volt feeder and service circuits, 0 to 600 amps, UL Class RK-1, Bussmann Type KTN-R, Shawmut Type A2K-R, or equal.
    - 5. For 0- to 600-volt feeder and service circuits, 601 to 6,000 amps, UL Class L. Bussmann Type KRP-C, Shawmut Type A4BY, or equal.
- 2.10 Pushbuttons, Indicating Lights, and Selector Switches

- A. For non-hazardous, indoor, dry locations, including motor control centers, control panels, and individual stations, provide heavy-duty, oiltight type pushbuttons, indicating lights, selector switches, and stations for these devices. Utilize General Electric Type CR 104P, or equivalent by Square D, Cutler-Hammer, or other acceptable manufacturer.
- B. For non-hazardous, outdoor, or normally wet locations, or where otherwise indicated, provide heavy-duty corrosion-resistant, watertight type pushbuttons, indicating lights, or selector switches mounted in NEMA 3R watertight enclosures. Provide special gasketing required to make complete station watertight. Utilize Square D Type SK, or equivalent by General Electric, Cutler-Hammer, or other manufacturers.
- C. Provide devices meeting the requirements of NEMA ICS 2, and having individual, extra large nameplates indicating their specific function. Provide pushbutton stations with laminated plastic nameplates indicating the drive they control. Provide contacts with NEMA designation rating A600. Install provisions for locking pushbuttons and selector switches in the OFF position wherever lockout provisions are indicated.
- D. Utilize selector switches having gloved-hand operating levers. Make all indicating lights transformer push-to-test type. Provide ON or START pushbutton colored black. Provide OFF or STOP pushbuttons colored red.

#### 2.11 Terminal Blocks 0 to 600 Volts

- A. Provide 600-volt terminal blocks for termination of all control circuits entering or leaving equipment, panels, or boxes. Provide screw clamp compression, dead front barrier type terminal blocks with current bar providing direct contact with wire between the compression screw and yoke. Provide yoke, current bar, and clamping screw constructed of high strength and high conductivity metal. Utilize yoke that guides all strands of wire into the terminal. Utilize current bar providing dependable vibration-proof connection. Supply terminals constructed to allow connection of wire without any special preparation other than stripping. Rail mount individual terminals to create a complete assembly and provide terminals constructed such that jumpers can be installed with no loss of space on terminal or rail.
- B. Size all terminal block components to allow insertion of all necessary wire sizes and types. Supply terminal blocks with marking system allowing the use of preprinted or field-marked tags. Supply UL approved terminal blocks manufactured by Weidmuller, Ideal, Electrovert, or equal.

#### 2.12 Control Relays

- A. Provide magnetic control relays, NEMA Class A600 (600 volts, 10 amps continuous, 7,200VA make, 720VA break), industrial control type with field convertible contracts, and meeting the requirements of NEMA ICS 2. Provide Cutler-Hammer Type M-600, General Electric Type CR120B, or equal.
- B. Where time delay relays are specified or required, unless otherwise noted, provide magnetic control relays with a pneumatic timer attachment adjustable from 5 to 180 seconds (minimum) and field convertible from ON delay to OFF delay and vice-versa. Provide Agastat 7000 series or equal.
- C. Where latching (mechanically held) relays or motor thermal detector relays are specified, provide magnetic control relays with mechanical latch attachment with

unlatching coil and coil clearing contacts. Utilize an attachment allowing easy manual latching and unlatching.

#### 2.13 Reset Timers

- A. Provide synchronous motor-driven reset timers with a solenoid-operated clutch and suitable for semiflush panel mounting. Utilize timers with time range indicated and 10-amp, 120-volt contacts. Provide Eagle Signal Bulletin 125 timers, Automatic Timing and Controls Bulletin 305 timers, or equal.

#### 2.14 Spring Wound Timers

- A. Provide spring wound timers without a "hold" position switchable for flush mounting in a standard switch box. Utilize timers with time range indicated and 20-amp, 120-volt contacts. Use ivory dial in office area and brown dial with metal plate in industrial locations. Provide Intermatic FD Series, FF Series, or equal.

#### 2.15 Elapsed Time Meters

- A. Provide synchronous motor-driven, elapsed time meters, 0 to 99,999.9 hours range, nonreset type, suitable for semiflush, panel mounting. Provide General Electric Type 240, 2-1/2 inch Big Look unit, Eagle Signal Bulletin 705 unit, or equal.

#### 2.16 Manual Motor Starters

- A. Provide general-purpose Class A manually operated, full-voltage controllers with integral thermal overload unit, [red pilot light] and [toggle][push button] operator for the induction horsepower indicated. Mount controllers in NEMA 1, industrial use enclosures unless otherwise indicated.

#### 2.17 Magnetic Contactors

- A. Provide contactors of the NEMA sizes indicated. Mount contactors in NEMA 1, industrial use enclosures unless otherwise indicated. Utilize contactors manufactured and rated in accordance with NEMA ICS 2. Provide control circuit fusing as shown.

#### 2.18 Magnetic Lighting Contactors

- A. Provide mechanically held lighting contactors of the current ratings indicated. Mount contactors in NEMA 1, industrial use enclosures unless otherwise indicated. Provide coil-clearing contacts on mechanically held units. Utilize contactors manufactured and rated in accordance with NEMA ICS 2.

#### 2.19 Capacitors

- A. Provide industrial capacitors of the voltage and kilovar rating indicated. Utilize enclosed, indoor, dustproof, 3-phase capacitor units containing internally mounted, indicating type, high interrupting-capacity, current-limiting fuses and discharge resistors. Supply units meeting requirements of NEC and listed by UL. Units containing PCB dielectric fluid will not be acceptable.
- B. Kilovar ratings of capacitors connected to individual motor circuits were selected based on expected motor power factor. Check motor nameplate and manufacturer's

power factor and no-load current data for the actual motor being installed. Reduce capacitor kVAR, if required, so that the size does not exceed any motor manufacturer's recommended maximum size. If motor manufacturer makes no such recommendation, reduce capacitor kVAR, if required, so that the size does not exceed the value required to raise the motor no-load power factor to 0.95 lagging.

- C. Provide suitable hangers or mounting brackets wherever wall or ceiling mounting is indicated.
- D. Acceptable manufacturers are General Electric, Westinghouse, or equal.

#### 2.20 Dry type Small Power Transformers (0 to 600 Volt Primary)

- A. Provide self-cooled, two-winding, dry type transformers of the ratings indicated and built in accordance with the latest IEEE, ANSI, and NEMA standards. Utilize units with manufacturer's 220 degrees C insulation class and 80 degrees C temperature rise. For ratings 3 to 25 kVA single-phase and 3 to 15 kVA 3-phase, provide units with core and coils completely enclosed in a nonventilated, NEMA 3R weatherproof enclosure. Utilize encapsulated windings on single-phase units 0 to 25 kVA. On all transformers 3 kVA and larger, provide units with at least four, 2-1/2 percent, full-capacity voltage taps; two above and two below normal voltage rating. On units 75 kVA and larger, provide an impedance of 4.5 percent minimum.

Provide copper windings for units 25 kVA and above.

- B. Supply units where sound levels determined by tests in accordance with NEMA and ANSI standards do not exceed:
  - 1. 40 decibels for 0 to 9 kVA
  - 2. 45 decibels for 10 to 50 kVA
  - 3. 50 decibels for 50 to 150 kVA
  - 4. 55 decibels for 151 to 300 kVA
  - 5. 60 decibels for 301 to 500 kVA
- C. For transformers 30 kVA and larger, equip units with integral vibration isolators completely isolating the core and coil assembly from the transformer enclosure. For smaller transformers, provide integral vibration isolators or install external vibration isolators which isolate the entire unit from the structure on which it is mounted. Utilize only integral or external vibration isolators which are rated for the weight of the transformer and provide 99 percent isolation efficiency at the fundamental frequency of sound emitted by the transformer.
- D. Acceptable Manufacturers: General Electric, Hevi-Duty, Sorgel, Tierney, Westinghouse, or equal.

#### 2.21 Dry Type, Shielded Isolation Transformers (0 600 Volt Primary)

- A. General: Supply dry type transformers providing electrical isolation and noise suppression between the electrical supply system and the critical load. Supply transformers of the ratings and connections indicated, built in accordance with



current IEEE, ANSI, NEMA, and UL standards in a general purpose indoor enclosure. Provide units having four full-capacity primary winding taps, two above and two below rated voltage. Provide units with manufacturer's standard insulation system and temperature rise. Provide copper windings on all units.

B. Isolation and Noise Suppression:

1. Provide units including core and coils having two foil type electrostatic shields, one located between the primary and secondary windings, and the other located between the core and the secondary winding. Provide a ground lead from each shield out into the unit enclosure.
2. Supply isolation transformers with electrical noise attenuation and other characteristics as follows:

Common mode attenuation	120 dB
Transverse mode attenuation	20 dB
Impedance	4.3 percent, maximum
Reactance	Minimum 3 percent; maximum 4.2 percent
Regulation, no-load to full-load	Plus or minus 1.2 percent
Output distortion	None added

PART 3 EXECUTION

3.1 Outlet and Devices Boxes

- A. General: Provide a box suitable for the conditions encountered at each outlet in the wiring or raceway system and sized in accordance with the NEC. Use the following types unless otherwise indicated or accepted.
- B. Steel Raceway System:

<u>Locations</u>	<u>Box Type</u>
Exterior Locations, with:	
Exposed Raceway	Cast steel
Concealed Raceway	Cast steel
Concrete Encased Raceways Class I, II or III	Cast steel
Hazardous Areas	Approved, steel
Interior Dry Locations, with:	
Exposed Rigid Conduit	Cast steel
Other Exposed Raceway	Sheet steel
Concealed Raceway	Sheet steel
Concrete Encased Raceways	Sheet steel
Lighting Circuits, Ceiling Portion	Sheet steel

Class I, II or III Hazardous Areas	Approved, steel
Interior Damp or Wet Locations, with:	
Exposed Raceway	Cast steel
Concealed Raceway	Cast steel
Concrete Encased Raceways	Sheet steel
Lighting Circuits, Ceiling Portion	Sheet steel
Class I, II or III Hazardous Areas	Approved, steel

C. Installation:

1. Mount boxes at the following heights unless otherwise indicated on the drawings (heights are to the centerline of the box):

Wall switches	42 inches above floor
Thermostats	42 inches above floor
Wall mounted telephone	18 inches above floor, outlets 6 inches above counter tops, unless otherwise indicated
Convenience receptacles:	
Indoor Office, general use areas, halls, etc.	Flush device plate bottom or side with top of the splashback on counter tops; 6 inches above counter tops without splashback; 18 inches above floor unless otherwise indicated
Industrial areas, machine shops, warehouses, workshops, etc.	42 inches above floor unless otherwise indicated
Outdoors, all areas	42 inches above finished grade
Multioutlet assembly	Above counters or tables; see architectural details

Special purpose receptacles

18 inches  
above floor or as  
indicated on drawings

2. Where above heights do not suit the building construction or finish, locate boxes where directed by the Owner.
3. Locations indicated are approximate. Study the Drawings in relation to spaces and equipment surrounding each outlet. When necessary, with the approval of the Owner, relocate outlets to avoid interference with mechanical equipment or structural features. Locate all light fixture outlets in a symmetrical pattern according to the room layout unless otherwise indicated.
4. Mount all boxes plumb and level.
5. Install boxes in a secure, substantial manner supported independently of conduit by attachment to the building structure or a structural member. Fasten boxes directly with wood screws on wood, bolts and expansion shields on concrete or brick, toggle bolts on hollow masonry units, and machine screws or welded, threaded studs on steel work. Utilize plated mounting hardware.
6. Provide flush lighting fixtures with separate junction boxes when required by the fixture terminal temperature. Where boxes support fixtures, provide proper means of attachment with adequate strength.
7. Open no more knockouts in sheet steel boxes than are actually required. Seal any unused openings in any type box.

### 3.2 Junction and Pull Boxes

#### A. General:

1. Where indicated on the Drawings, and where necessary to terminate, tap-off, or redirect multiple conduit runs, provide and install appropriately designed junction boxes. Furnish and install pull boxes where necessary in the raceway system to facilitate conductor installation. Provide pull boxes to limit conduit runs to no more than the equivalent of three right-angle bends unless accepted by the Engineer.

#### B. Types to be Provided:

1. Use boxes of the types listed for specific locations under OUTLET AND DEVICE BOXES.
2. Do not use outlet boxes as junction boxes and pull boxes.

#### C. Installation:

1. Make all boxes accessible. Do not install boxes in finished areas unless accepted by the Engineer. Mount all boxes plumb and level.
2. Install boxes in a secure, substantial manner, supported independently of conduit by attachment to the building structure or a structural member. Fasten boxes directly with wood screws on wood, bolts and expansion shield on

concrete or brick, toggle bolts on hollow masonry unit, and machine screw or welded threaded studs on steel work. Utilize plated mounted hardware in industrial areas.

3.3 Wiring Devices

- A. Switches: Mount switches at the heights indicated under OUTLET AND DEVICE BOXES. Mount switches for switch operation in the vertical position.
- B. Receptacles: Mount receptacles at heights indicated under OUTLET AND DEVICE BOXES. Mount receptacles with grounding slot up except where horizontal mounting is indicated, in which case mount with neutral slot up.
  - 1. Special Purpose Receptacles: Locate special purpose receptacles where shown. Install and mount the receptacles in accordance with the manufacturer's instructions and the applicable codes.
- C. Surface Raceway System: Locate surface raceway systems where shown and install in accordance with the manufacturer's instructions.
- D. Device Plates:
  - 1. Types to be Provided:

<u>Locations</u>	<u>Plate Type</u>
Interior office, general use areas, halls, etc.	[Plastic][Metal]
Industrial areas, machine shops, warehouses, workshops, etc.	Galvanized Metal
Outdoor or indoor damp	Weatherproof
Hazardous areas	Approved Cast Metal
Special purpose devices	Engraved

- 2. Installation: Securely fasten device plates to switch or receptacle boxes of the wiring device contained therein. Install device plates vertically or horizontally with an alignment tolerance of 1/16 inch.

3.4 Lighting and Distribution Panelboards

- A. Mount panelboards securely where indicate, plumb, in-line, and square with walls. Unless otherwise indicate, mount panelboard with top of its cabinet approximately 6 feet above the floor. Provide a typewritten circuit directory under a metal-framed transparent plastic cover inside each panelboard.

3.5 Engraving and Marking

- A. In addition to nameplates required for governing codes for switchboards, panelboards, transformers, etc., all other control devices switches, circuit breakers, starters, relays, etc. shall be labeled to indicate function or use.
  - B. Attach all nameplates with rivets or drive screws. Use of adhesive only is not acceptable.
  - C. Control devices on switchboards, distribution panels or motor control centers shall have engraved nameplates.
  - D. Circuits on panelboards shall be labeled with a typed directory mounted in a holder provided on inside and with embossed plastic strip type adhesive labels mounted adjacent to control devices.
  - E. Panelboards shall be labeled as follows:
    - 1. "WARNING 277/480 VOLTS", orange with white core.
    - 2. "WARNING 277/480 VOLTS", black with white core.
    - 3. "CRITICAL SOURCE", yellow with white core.
    - 4. "EMERGENCY SOURCE", red with white core.
  - F. Individual disconnect switches, circuit breakers and motor starters in finished areas on interior or exterior of building shall have engraved nameplates. Control devices in mechanical rooms may be labeled by means of paint stenciling with a contrasting paint color. Stencil figures shall be 3/8" high unless otherwise required.
  - G. Flush mounted control devices with stainless steel or plastic plates shall have plate engraved with 3/16" high block type characters filled with black enamel.
  - H. Attached engraved nameplates shall be of laminated black and white nameplate stock with 3/16" high characters cut through the black exposing the white. Plates shall have beveled edges.
- 3.6 Engraving and Marking
- A. Install new nameplates on all panels per Paramount standard nomenclature. Minimum nameplate size is 2" x 4" with 1/8" high lettering. See attached Exhibit 16050-A for specific nomenclature. Nameplates shall be fastened to equipment with screws.

END OF SECTION

SECTION 26 05 13  
MEDIUM VOLTAGE CABLES

## PART 1- GENERAL

## 1.1 RELATED DOCUMENTS

&lt;&lt; TO BE COMPLETED BY CONSULTING ENGINEER&gt;&gt;

## 1.2 SUMMARY

- A This Section includes cables and related splices, terminations, and accessories for medium voltage electrical distribution systems.

## 1.3 DEFINITIONS

&lt;&lt; TO BE COMPLETED BY CONSULTING ENGINEER&gt;&gt;

## 1.4 APPLICABLE STANDARDS

&lt;&lt; TO BE COMPLETED BY CONSULTING ENGINEER&gt;&gt;

## 1.5 SUBMITTALS

- A Product Data: For each type of cable indicated. Include splices and terminations for cables and cable accessories.
- B Samples: 16-inch lengths of each type of cable indicated.
- C Qualification Data: For Installer.
- D Material Certificates: For each cable and accessory type, signed by manufacturers.
- E Source quality-control test reports.
- F Field quality-control test reports.

## 1.6 QUALITY ASSURANCE

- A Installer: Engage a cable splicer, trained and certified by splice material manufacturer, to install, splice, and terminate medium-voltage cable.
- B Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
- C Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- D Source Limitations: Obtain cables and accessories through one source from a single manufacturer.
- E Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

## 1.7 PROJECT CONDITIONS

- A Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by university or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
1. Written notification must be provided to University no fewer than 14 days in advance of proposed interruption of electrical service.
  2. Do not proceed with interruption of electric service without University's written permission.

## PART 2- PRODUCTS

## 2.1 MANUFACTURERS

- A Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cables: Okonite Company (The).
  2. Cable Splicing and Terminating Products and Accessories:
    - a. \*Preferred: Thomas & Betts Corporation/Elastimold
    - b. Engineered Products Company.
    - c. G&W Electric Company.
    - d. RTE Components; Cooper Power Systems, Inc.
    - e. Scott Fetzer Co. (The); Adalet.
    - f. 3M; Electrical Products Division.

## 2.2 CABLES

- A Cable Type: MV105.
- B Comply with UL 1072, AEIC CS 8, ICEA S-93-639, and ICEA S-97-682.
- C Conductor: Copper.
- D Conductor Stranding: Concentric lay, Class B.
- E Strand Filling: Conductor interstices are filled with impermeable compound.
- F Conductor Insulation: Ethylene-propylene rubber.
1. Voltage Rating: 15 kV.
  2. Insulation Thickness: 133 percent insulation level.
- G Shielding: Copper tape, helically applied over semiconducting insulation shield.
1. Circuit Identification: Color-coded tape (black, red, blue) under the metallic shielding.

## 2.3 SOLID TERMINATIONS

- A Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class is equivalent to that of cable. Include shield ground strap for shielded cable terminations.
1. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief tube; multiple, molded-silicone rubber, insulator modules; shield ground strap; and compression-type connector.
  2. Class 1 Terminations: Heat-shrink type with heat-shrink inner stress control and outer nontracking tubes; multiple, molded, nontracking skirt modules; and compression-type connector.
  3. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief shield terminator; multiple-wet-process, porcelain, insulator modules; shield ground strap; and compression-type connector.
  4. Class 1 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, compression-type connector, and end seal.
  5. Class 2 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, and compression-type connector. Include silicone-rubber tape, coldshrink- rubber sleeve, or heat-shrink plastic-sleeve moisture seal for end of insulation whether or not supplied with kits.
  6. Class 3 Terminations: Kit with stress cone and compression-type connector.

## 2.4 SEPARABLE INSULATED CONNECTORS

- A Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.
- B Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.
- C Dead-Break Cable Terminators: Elbow-type unit with 600-A continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.
- D Dead-Front Terminal Junctions: Modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two-, three-, or four-terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer's standard accessory stands, stainless-steel mounting brackets, and attaching hardware.
1. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.
  2. Portable Feed-Through Accessory: Two-terminal, dead-front junction arranged for removable mounting on accessory stand of stationary terminal junction.
  3. Grounding Kit: Jumpered elbows, portable feed-through accessory units, protective caps, test rods suitable for concurrently grounding three phases of feeders, and carrying case.
  4. Standoff Insulator: Portable, single dead-front terminal for removable mounting on accessory stand of stationary terminal junction. Insulators suitable for fully insulated isolation of energized cable-elbow terminator.
- E Tool Set: Shotgun hot stick with energized terminal indicator, fault-indicator test tool, and carrying case.

## 2.5 ARC-PROOFING MATERIALS



- A Tape for First Course on Metal Objects: 10-mil thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.
- B Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3 inch thick, compatible with cable jacket.
- C Glass-Cloth Tape: Pressure-sensitive adhesive type, 1/2 inch wide.

## 2.6 SOURCE QUALITY CONTROL

- A Test and inspect cables according to ICEA S-94-649 before shipping.
- B Test strand-filled cables for water-penetration resistance according to ICEA T-31-610, using a test pressure of 5 psig.

## PART 3 – EXECUTION

### 3.1 INSTALLATION

- A Install cables according to IEEE 576.
- B Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values
  - 1. Where necessary, use manufacturer-approved pulling compound or lubricant that will not deteriorate conductor or insulation.
  - 2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips that will not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.
- C Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.
- D Support cables according to [Section 26 05 00 "Common Work Results for Electrical."]
- E Install "buried-cable" warning tape 12 inches above cables.
- F In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit and support cables at intervals adequate to prevent sag.
- G Install cable splices at pull points and elsewhere as indicated; use standard kits.
- H Install terminations at ends of conductors and seal multiconductor cable ends with standard kits.
- I Install separable insulated-connector components as follows:
  - 1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.
  - 2. Portable Feed-Through Accessory: Three.
  - 3. Standoff Insulator: Three.
- J Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, cable tray, direct burial, or termination materials. In addition to arcproofing tape manufacturer's written instructions, apply arc proofing as follows:

1. Clean cable sheath.
  2. Wrap metallic cable components with 10-mil pipe-wrapping tape.
  3. Smooth surface contours with electrical insulation putty.
  4. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
  5. Band arc-proofing tape with 1-inch- wide bands of half-lapped, adhesive, glass-cloth tape 2 inches o.c.
- K Seal around cables passing through fire-rated elements according to [Section 07 84 13 "Penetration Firestopping."]
- L Install fault indicators on each phase where indicated.
- M Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.
- N Identify cables according to Section 26 05 53 "Identification for Electrical Systems."
- 3.2 FIELD QUALITY CONTROL
- A Testing: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.
- B Testing: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
- C Perform the following field tests and inspections and prepare test reports:
1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
  2. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.
- D Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 26 05 13

SECTION 26 05 19  
LOW VOLTAGE CABLES

PART 1 GENERAL

1.1 Work Included:

- A. This section covers the work necessary to furnish and install, complete electrical conductor systems.

1.2 Submittals During Construction

- A. Submittals during construction shall be made in accordance with [Division 1, GENERAL REQUIREMENTS, and] Section # ELECTRICAL - GENERAL PROVISIONS. In addition, the following specific information shall be provided:
- B. Certification of Cable Splicer: Prior to making splices or termination, submit names of cable splicer along with a certification of 5 years minimum cable splice experience with the type of cables and terminations specified. Submit certification for each splicer by the manufacturer that the splicer has attended and passed a course in the use of the manufacturer's kits.
- C. Submit certified report of factory tests performed in accordance with AEIC CS-3 for approval prior to shipment of cable from the factory. Provide original copy of the X-Y corona discharge plot with the certification.
- D. Installation test reports.

1.3 Quality Assurance

- A. Each cable splicer may be required to make an approved dummy splice in the presence of the University's representative in accordance with the manufacturer's instructions. The contractor shall furnish all tools, materials and supplies necessary for the dummy splices.

1.4 Conductor Color Coding

- A. For power conductors, provide all single conductors and individual conductors of multiconductor power cables with integral insulation pigmentation of the designated colors, except conductors larger than No. 6 AWG may be provided with color coding by wrapping the conductor at each end and at all accessible locations with vinyl tape. Where this method of color coding is used, wrap at least six full overlapping turns of tape around the conductor covering an area 1-1/2 to 2 inches wide at a visible location.
- B. Phase A, B, and C implies the direction of positive phase rotation.
- C. Use the following colors unless directed otherwise by the Owner or Engineer. Verify color coding with Owner prior to construction.

<u>System</u>	<u>Conductor</u>	<u>Color</u>
All Systems	Equipment Grounding	Green

240/120 Volts 1-Phase, 3-Wire	Grounded Neutral One Hot Leg Other Hot Leg	White Black Red
208Y/120 Volts 3-Phase, 4-Wire	Grounded Neutral Phase A Phase B Phase C	White Black Red Blue
480Y/277 Volts 3-Phase, 4-Wire	Grounded Neutral Phase A Phase B Phase C	Gray Brown Orange Yellow

PART 2 PRODUCTS

2.1 Conductors

A. Single Conductors 600 Volts and Below:

1. Unless otherwise indicated, provide stranded conductors, except provide solid conductors where No. 10 AWG and No. 12 AWG are designated for branch circuit power wiring.
2. Utilize only conductors meeting applicable requirements of NEMA WC 3, WC 5, WC 7, and ICEA S-19-81, S-61-402, and S-66-524.
3. Provide conductors with Type THHN/THWN insulation.
4. Provide copper conductors. Unless noted otherwise, conductor sizes indicated are based on copper conductors. Do not provide conductors smaller than those indicated. No aluminum conductors shall be allowed.

B. Control and Instrumentation Cable: Use Belden 6760 #18 AWG copper shielded twisted pair with #20 AWG copper drain wire.

C. Conductor Arc and Fireproofing Materials: Use Scotch Brand 77 or Plymouth Plyarc 30 arc and fireproofing tape, Scotch Brand 69 or Plymouth Plyglass cloth electrical tape, or equal.

D. Equipment Grounding Conductors:

1. Provide stranded copper conductors, as indicated or as required by NEC, for equipment grounding.
2. Provide conductors with green Type TW insulation with a minimum thickness of 2/64 inch.
3. Provide equipment grounding conductors in all [PVC] conduits sized as required by NEC table 250-95 whether indicated on the drawings or not.

## PART 3 EXECUTION

## 3.1 General

- A. Do not exceed cable manufacturer's recommendations for maximum pulling tensions and minimum bending radii. Where pulling compound is used, use only UL listed compound compatible with the cable outer jacket and with the raceway involved.
- B. Tighten all screws and terminal bolts using torque type wrenches and/or drivers to tighten to the inch-pound requirements of the NEC and UL.
- C. Where single conductors and cables in manholes, handholes, vaults, cable trays, and other indicated locations are not wrapped together by some other means such as arc and fireproofing tapes, bundle throughout their exposed length all conductors entering from each conduit with nylon, self-locking, releasable, cable ties placed at intervals not exceeding 18 inches on centers.

## 3.2 Conductors 600 Volts and Below

- A. Provide conductor sizes indicated on Drawings.
- B. Place no more than one conductor in any single-barrel pressure connection. Use crimp connectors with tools by same manufacturer and/or UL listed for connectors of all stranded conductors.
- C. Soldered mechanical joints insulated with tape will not be acceptable.
- D. Vinyl plastic insulating tape for wire and cable splices and terminations shall be flame retardant, 7-mil thick minimum, rated for 90 degrees C minimum meeting the requirements of UL 510.
- E. Provide terminals and connectors acceptable for the type of material used.
- F. Arrange wiring in cabinets, switchgear, electrical equipment neatly cut to proper length, remove surplus wire, and bridle and secure in an acceptable manner.
- G. Terminate control wiring with methods consistent with terminals provided, and in accordance with terminal manufacturer's instructions. Where terminals provided will accept such lugs, terminate all control and instrumentation wiring with insulated compression lugs, Thomas & Betts Sta-Kon, or equal.
- H. For terminals designed to accept only bare wire compression terminations, use only stranded wire, and terminate only one wire per terminal. Tighten all terminal screws with torque screwdriver to recommended torque values.
- I. Attach compression lugs with a tool specifically designed for that purpose which provides a complete, controlled crimp where the tool will not release until the crimp is complete. Use of plier type crimpers is not acceptable.
- J. Cap spare conductors and conductors not terminated with UL listed end caps.
- K. Where conductors pass through holes or over edges in sheet metal, remove all burrs, chamfer all edges, and install bushings and protective strips of insulating material to protect the conductors.

- L. For conductors that will be connected by others, provide at least 6 feet spare conductor in freestanding panels and at least 2 feet spare in other assemblies. Provide more spare conductor in any particular assembly where it is obvious that more conductor will be needed to reach the termination point.

### 3.3 Control and Instrumentation Cables Below 600 Volts

- A. Do not splice without permission of the Engineer. Locate splices, when permitted, only in readily accessible cabinets or junction boxes using terminal strips.
- B. Maintaining the integrity of shielding of instrumentation cables is essential to the operation of the control systems. Take special care in cable installation to ensure that grounds do not occur because of damage to the jacket over the shield.

### 3.4 Conductor ARC and Fireproofing Tapes

- A. Use arc and fireproofing tapes on all 5 kV single conductors throughout their entire exposed length in all manholes, handholes and vaults.
- B. Wrap together as a single cable all conductors entering from each conduit.
- C. Follow tape manufacturer's installation instructions. Secure the arc and fireproofing tape at frequent intervals with bands of the specified glass cloth electrical tape. Make each band of at least two wraps of tape directly over each other.

### 3.5 Field Tests

- A. Conductors Under 600 Volts:
  - 1. Perform insulation resistance testing of all power and control circuits below 600 volts with a 500-volt megger, applied for 1 minute.
  - 2. Measure the insulation resistance of each circuit phase-to-phase and phase-to-ground.
  - 3. Minimum acceptable value for insulation resistance is 1 megohm or as approved by the Engineer.
  - 4. Disconnect equipment that might be damaged by this test. Perform tests with all other equipment connected to the circuit.
  - 5. Prepare a written test report of the results and submit to the Engineer prior to final inspection.

END OF SECTION

SECTION 26 05 26  
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

## PART 1 GENERAL

## 1.1 Work Included

- A. This section covers the work necessary to furnish and install, complete, the electrical grounding system.

## 1.2 Referenced Standards

- A. Section 26 05 53 Identification

## 1.3 Submittals During Construction

- A. Submittals during construction shall be made in accordance with Section 26 00 00, ELECTRICAL.

## 1.4 Ground Resistance Test Report

- A. Upon completion and before final acceptance of work, submit the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding system and soil condition at the time the measurements were take.

## PART 2 PRODUCTS

## 2.1 Ground Rods

- A. Provide copper-clad ground rods not less than  $3/4$  [1] inch in diameter, 10 feet long driven full length into the earth. Special requirements shall be as shown and as specified herein. Ground rod clamps shall be cast bronze body providing high pressure contact between rod and ground wire, Copperwelt Type AB, Burndy GKP or equal.

## 2.2 Ground Conductors

- A. Provide insulated or bare grounding conductors of the size shown on Drawings and as specified in Section CONDUCTORS for locations and applications indicated.

## 2.3 Ground Connections

- A. For below grade connections, provide exothermic-welded type of connectors as manufactured by Cadweld, Thermoweld, or equivalent, or compression type connectors designed for this special purpose as manufactured by Burndy, Thomas and Betts, or equivalent.
- B. Above ground connectors shall be bronze. To connect copper or copperweld conductor to pad type terminal, use bolted, compression, or Cadweld fitting. Use grounding terminals on equipment where provided. Use the bolted type for connecting to steel structures and equipment.

## PART 3 EXECUTION

## 3.1 General

- A. Except where specifically indicated otherwise, ground all exposed noncurrent-carrying metallic parts of electrical equipment, raceway systems, and transformer electrostatic shields and the neutral of all wiring systems in strict accordance with the NEC, state, and other applicable laws and regulations.
- B. Where grounding conductors are shown, bond the wires to metallic enclosures at each end and to all intermediate metallic enclosures. Connect grounding conductors to all grounding bushings on raceways. Where any equipment contains a ground bus, extend and connect grounding conductors to that bus. Connect the enclosure of the equipment containing the ground bus to that bus. Run ground conductors inside conduits enclosing the power conductors.
- C. Make connections of any grounding conductors to motors 10 hp and above or circuits 20 amps or above by a solderless terminal and a 5/16-inch minimum bolt tapped to the motor frame or equipment housing. Ground connections to smaller motors or equipment may be made by fastening the terminal to a connection box. Connect junction boxes to the equipment grounding system with grounding clips mounted directly on the box or with 3/8-inch machine screws. Completely remove all paint, dirt, or other surface coverings at grounding conductor connection points so that good metal-to-metal contact is made.
- D. Ground shields of any shielded power cable at each splice or termination in accordance with recommendations of the splice or termination manufacturer.
- E. Ground metal sheathing and any exposed metal vertical structural elements of buildings. Ground metal fences enclosing electrical equipment. Bond any metal equipment platforms which support electrical equipment to that equipment. Provide good electrical contact between metal frames and railings supporting pushbutton stations, receptacles, instrument cabinets, etc., and raceways carrying circuits to these devices.
- F. Bond any interior exposed metal piping system including water, gas and any other metal piping system which may become energized to the service equipment grounding electrode with a continuous unspliced copper conductor sized in accordance with NEC Table 250-94.

## 3.2 Grounding Electrodes:

- A. Provide cone pointed driven ground rods driven full depth plus 6 inches, installed where indicated to provide a resistance to ground as tested by standard methods does not exceed 5 ohms.
- B. Install sufficient ground rods in addition to those indicated so that resistance to ground does not exceed 5 ohms unless otherwise accepted. Where more than one rod is required, install rods at least 3 feet apart.

## 3.3 Ground Connections



- A. Unless shown otherwise, make connections of grounding conductors to ground rods at the upper end of the rod with a compression connector if located above ground, or by exothermic weld if the connection point is below finished grade.
  - B. In manholes, and handholes make connections to ground rods 4 to 6 inches above the floor with connections of grounding conductors fully visible and accessible.
  - C. When making thermite welds, wire brush or file the point of contact to a bare metal surface. Use thermite welding cartridges and molds in accordance with the manufacturer's recommendations. After welds have been made and cooled, brush slag from the weld area and thoroughly clean the joint.
  - D. For compression connectors, use homogeneous copper, anti-corrosion, surface treatment compound at connectors in accordance with connector manufacturer's recommendations. Use connectors of proper size for conductors and ground rods specified. Use connector manufacturer's compression tool.
  - E. Notify owner's representative prior to backfilling any ground connections.
- 3.4 Substation/Switchgear Grounding
- A. Provide bare copper cable not smaller than No. 4/0 AWG not less than 24 inches below grade connecting the indicated ground rods. Substation transformer neutral connections shall not be smaller than No. 1/0 AWG.
  - B. Extend the ground connections to the [wire mesh] [reinforcing steel] of the concrete pads. [Connect ground connections, to 20 feet minimum of one or more concrete pad reinforcing steel bar(s) not less than 1/2 inch diameter.] [Provide a concrete-encased electrode consisting of 20 feet of bare copper conductor not smaller than No. [4] AWG.]
  - C. Fence and equipment connections shall not be smaller than No. 4 AWG. Ground fence at each gate post and cornerpost and at intervals not exceeding 10 feet. Bond each gate section to the fence post through a 1/8 inch by 1 inch flexible braided copper strap and clamps.
- 3.5 Field Tests
- A. Test in the Engineer's presence the ground resistance of the grounding system. Ground resistance shall not exceed five (5) ohms. Utilize fall of potential method to determine ground resistance. Measure no less than 48 hours after rainfall.
  - B. Provide copies of reports of all grounding system tests for inclusion in Operation and Maintenance Manuals and for review by the Engineer.

END OF SECTION

SECTION 26 05 33  
RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

## PART 1 GENERAL

## 1.1 Work Included

- A. This section covers the work necessary to furnish and install, complete, electrical raceway systems.

## 1.2 General

- A. Raceway sizes are minimum allowable based upon NEC requirements when using THWN/THHN or the cable insulation indicated. Contractor may increase conduit size at contractor's discretion and at no additional cost to Owner to facilitate cable pulling.

## 1.3 Submittals

- A. Make submittals in accordance with Section 26 00 00, Electrical - General Provisions. Furnish descriptive literature for the following equipment or devices supplied under this section:

1. Rigid steel conduit
2. PVC-coated rigid steel conduit
3. PVC conduit
4. Plastic utilities duct
5. Electrical metallic tubing
6. Flexible metal conduit
7. Cable tray
8. Wireway
9. Precast manholes
10. Precast handholes
11. Warning tape
12. Raceway tags

## PART 2 MATERIALS

## 2.1 Rigid Steel Conduit

- A. Use rigid steel conduit, including bushings, couplings, elbows, nipples, and other fittings, galvanized by hot-dipping, or sherardizing process both inside and out and meeting the requirements of ANSI C80.1, ANSI C80.4, UL, and the NEC. Electro galvanizing is not permitted.

## 2.2 PVC-Coated Rigid Steel Conduit

- A. Use PVC coated conduit and all fittings consisting of galvanized rigid steel conduit meeting the requirements of NEMA RN 1, UL, and the NEC, and a PVC coating 40 mils nominal thickness bonded to the metal. Provide fittings with overlapping pressure sealing sleeves. Use PVC coated conduit suitable for conductors with 75 degrees C insulation.

## 2.3 PVC Schedule 40 Conduit

- A. Use rigid PVC Schedule 40 conduit, UL listed for concrete-encased, underground direct burial, concealed and direct sunlight exposed use, and UL listed and marked for use with conductors having 90 degrees C insulation. Use conduits meeting the requirements of NEMA TC 2, Federal Specification W-C-1094, UL, NEC and ASTM specified tests for intended use. Use only conduit with a factory formed bell on one end. Conduit that requires the use of couplings for straight runs will not be acceptable.

## 2.4 Plastic Utilities Duct

- A. Use rigid PVC plastic utilities duct, UL listed for concrete-encased, underground direct burial, concealed and direct sunlight exposed use, and UL listed and marked for use with conductors having 90 degrees C insulation. Use conduits meeting the requirements of NEMA TC 6 for Type EB; TC 8 for Type DB; TC 10 for Type B, C or D; UL, NEC and ASTM specified tests for intended use. Use only conduit with a factory formed bell on one end. Conduit that requires the use of couplings for straight runs will not be acceptable.

## 2.5 Electrical Metallic Tubing (EMT)

- A. Electrical Metallic Tubing (EMT) shall conform to U.L. Standard 797. Use tubing of high grade steel with exterior protective coating of zinc, applied by the electrogalvanized process. EMT shall be dipped in chromic acid bath to chemically form a corrosion-resistant protective coating of zinc chromate over galvanized surface.

## 2.6 Flexible Metal Conduit

- A. Flexible Metal Conduit shall be U.L. listed manufactured from single strip steel galvanized on all four sides prior to conduit fabrication. Flexible aluminum and flexible light-weight steel conduit will not be allowed. Use liquid tight flexible metal conduit consisting of galvanized steel flexible conduit covered with an extruded PVC jacket.

## 2.7 Raceway Fittings

- A. Fittings for Uncoated and PVC Coated-Rigid Steel Conduit:
  - 1. Use insulated throat bushings of metal with integral plastic bushings rated for 105 degrees C. For insulated throat bushings for rigid steel conduit, use Thomas & Betts Nylon Insulated Metallic Bushings, or O.Z. Gedney Type B.
  - 2. Use Myers Scru-Tite hubs for rigid steel conduit.

3. Use conduit bodies for rigid steel conduit of metal and sized as required by the NEC (NFPA 70-1987). Use Appleton Form 35 threaded Unilets; Crouse-Hinds Mark 9 or Form 7 threaded condulets; Killark Series O Electrolets; or equivalent, for normal conduit bodies for rigid steel conduit. Where conduit bodies for rigid steel conduit are required to be approved for hazardous (classified) locations, use conduit bodies manufactured by Appleton, Crouse-Hinds, Killark or equivalent.
  4. Use only couplings for rigid steel conduit supplied by the conduit manufacturer. Do not use setscrew type couplings, bushings, elbows, nipples, and other fittings.
- B. Fittings for PVC Conduit: Use UL listed PVC couplings, bushings, elbows, nipples, and other fittings manufactured in accordance with NEMA TC-3, UL, NEC and ASTM specified tests for intended use.
  - C. Fittings for Plastic Utilities Duct: Use UL listed couplings, bushings, elbows, nipples, and other fittings manufactured in accordance with NEMA TC-9, UL, NEC and ASTM specified tests for intended use.
  - D. Fittings for Electrical Metallic Tubing: Fittings for Electrical Metallic Tubing: Fittings for electrical metallic tubing (EMT) for sizes 1/2" through 1" shall be either "drive-on," "push-on" or wrench tightened compression type which shall provide pull-on force resistance and electrical continuity as required by U.L. Standard 514. Drive-on fittings shall contain grips which engage the conduits as the fitting is forced on. No indenting fittings or adjustable set screw type fittings shall be used. Fittings for EMT larger than 1" shall be compression type.
  - E. Fittings for Flexible Conduit: Use insulated throat connectors with an integral plastic bushing rated for 105 degrees C, and of the long design type extending outside of the box or other device at least 2 inches.
  - F. Fittings for Liquid-Tight Flexible Conduit: Use liquid-tight fittings which provide positive ground continuity. Include ground conductor. Manufacturer "Sealtite Flexible" Type "UA" Columbia "Flex-Seal" Type "XL", or equal, with Appleton Flexible fittings, Series "ST", T & B 5200 Series, Steel City M 111 Series, or equal.
- 2.8 Surface Metal Raceways
- A. Two-piece construction consisting of a formed rectangular trough and snap-on cover plate. Trough shall be 0.060 inch thick sheet of steel and cover plate shall be 0.04 inch thick steel. Trough shall be 4-3/4 inch high by 3-9/16 inch deep, unless otherwise noted.
  - B. Metal device plates and fittings.
  - C. All metal shall be galvanized.
  - D. Bake enamel finish, ANSI-61 gray.
  - E. Manufacturer's Wiremold Walker Parkersburg, or equal.
- 2.9 Manholes and Handholes

- A. Provide manholes and handholes precast with 28-day, 3000 psi minimum compressive strength concrete and designed for AASHTO H-20 loading. Minimum dimensions for manholes and handholes are shown on the Drawings. Increase these dimensions as required by use of extension sections to accommodate the several raceway entrances at their required elevations.
  - B. Slope floors toward drain points, leaving no pockets or other nondraining areas. Provide drainage outlet or pump sump at the low point of the floor constructed with a heavy, cast iron, slotted or perforated hinged cover, and 4-inch minimum outlet and outlet pipe. Where adjoining manholes or handholes have common walls, provide a drain in only one manhole. In each common wall, install a 3-inch minimum drainpipe or scupper with the invert at floor elevation.
  - C. Provide a pulling iron embedded in the concrete wall opposite each raceway entrance and one in the floor vertically below the center of the manhole or handhole cover. Utilize 3/4-inch round stock securely fastened to the overall steel reinforcement before concrete is poured.
  - D. Provide raceway entrances [as shown on the drawings] [on all four sides]. For raceways installed under this Contract, knockout panels or precast individual raceway openings may be used. On sides where no raceways are installed under this Contract, provide 12-inch high by 24-inch wide (minimum) knockout panels for future raceway installation.
  - E. Utilize heavy-duty type frames and covers made of cast iron, suitable for H-20 loading, and having machined bearing surfaces. Provide indented type covers, solid top design, with two drop handles each. On the upper side of each cover, cast or burned by welder, in integral letters no less than 2 inches high appropriate titles, ELECTRIC HIGH VOLTAGE (for above 600 volts), ELECTRIC LOW VOLTAGE (for 600 volts and below), or TELEPHONE. Field stamp covers with manhole or handhole numbers indicated on the Drawings.
  - F. Provide heavy-weight cable racks with adjustable arms and acceptable insulators for all cables in each manhole. Set adjustable inserts in the concrete walls for the attachment of racks. Do not use bolts or studs embedded in concrete for attaching racks. Set racks and inserts on not greater than 3-foot centers around the entire inside perimeter of the manhole, arranged so that all spare conduit ends are clear for future cable installation. Provide racks with a sufficient number of arms and insulators to accommodate cables for each conduit entering or leaving the manhole, including spares.
  - G. Utilize manhole and handhole hardware of steel, hot-dip galvanized after fabrication.
  - H. Manufacturers: Associated Concrete Products, Inc.; Brooks Products, Inc.; Concrete Conduit Co.; Penn-Cast Products, Inc.; or equivalent.
- 2.10 Raceway Tags
- A. Provide permanent, stainless steel markers with raceway designations pressure embossed, or engraved onto the tag. Tags relying on adhesives or taped-on markers are not acceptable. Attach tags to raceways with noncorrosive stainless steel wire.
- 2.11 Warning Tape

- A. Provide heavy-gauge, yellow plastic tape of 6-inch minimum width for use in trenches containing electric circuits. Utilize tape made of material resistant to corrosive soil. Use tape with printed warning that an electric circuit is located below the tape. Manufacturers and type: ITT Blackburn Type YT or RT; Griffolyn Co. Terra-Tape; or equivalent.

#### 2.12 Penetration Sealing Systems (Fire Stops)

- A. Where indicated or required, provide cable and raceway penetration sealant meeting UL and ASTM applicable standards and NEC Article 300-21. Sealant shall not rely on heat to expand and seal the penetration. Sealant shall remain pliable and vibration-proof to prevent cracks or spawl and break seal due to expansion or vibration of cables and raceways.
- B. The fire rating of the sealant shall equal or exceed the fire rating of the penetrated materials (1 hour minimum at corridor walls; 2 hours minimum at shafts and chases). Sealant shall be Chase Tech. Corp CTC PR-855, 3M Type CP-25 or equivalent.

#### 2.13 Moisture Sealing Material

- A. Where indicated or required, provide a two-part urethane foam sealant which when mixed will expand approximately 15 times in volume to form a dense, strong tough foam unit with a density of 3 to 4 pounds per cubic foot. Sealant shall reach 60% full strength in 8 to 10 minutes after application.

### PART 3 EXECUTION

#### 3.1 General

- A. Provide raceway systems meeting or exceeding the requirements of the NEC.

#### 3.2 Protection During Construction

- A. In addition to the requirements of the General Conditions, Division 1 General Requirements and Section 16000, Electrical - General Requirements, prior to installation, store all products specified in this section in a dry location. Following installation, protect products from the effects of moisture, corrosion, and physical damage during construction. Keep openings in conduit and tubing capped with manufactured seals during construction.

#### 3.3 Required Raceway Type for Location and Installation Method

- A. Interior exposed:
  1. Below 8 feet above finished floor, or exposed to physical damage:
    - Rigid galvanized steel
  2. Over 8 feet above finished floor, not exposed to physical damage:
    - Electrical metallic tubing (EMT)
    - Rigid galvanized steel
- B. Interior concealed:
  1. Not embedded in concrete:

Electrical metallic tubing (EMT)  
Intermediate Metal Conduit  
Rigid galvanized steel

2. Above ground, embedded in concrete walls or floors:

Rigid galvanized steel  
PVC Schedule 40 Conduit

3. Below floor, in contact with earth:

Encase in concrete. See below.  
Coat or use PVC coated rigid risers.

C. Exterior exposed:

1. Below 10 feet above finished grade, exposed to physical damage, or above 600 volt class:

Rigid galvanized steel

2. Over 10 feet above finished grade, not subject to physical damage, not above 600 volt class:

Electrical metallic tubing (EMT)  
Intermediate metal conduit  
Rigid galvanized steel

D. Concrete Encased Raceways:

Rigid galvanized steel  
PVC Schedule 40 Conduit  
Plastic Utilities Duct Type EB-[40]

E. Direct Buried Raceways:

PVC Schedule 40 Conduit  
Plastic Utilities Duct Type DB-[##]

F. Exposed Conduit in Manholes:

Rigid steel conduit unless specified otherwise on Drawings

G. Flexible Metal Conduit:

1. Flexible metal conduit shall be used for final connection to rotating or vibrating equipment. Liquid-tight flex shall be used in damp or wet locations requiring flexible connections.
2. Flexible metal conduit may be used in lengths of up to 6 feet for final connection to lighting fixtures.
3. A green insulated equipment grounding conductor shall be installed in any flexible metal conduit.

- H. Conduit for Underground Service Into a Building: Provide rigid galvanized steel from the service equipment to a point 5 feet beyond the building for underground service into building. The underground portion of the conduit shall be encased in a concrete envelope having a wall thickness of not less than 3 inches and shall be installed a minimum of 18 inches below slab or grade.

### 3.4 General Installation Requirements for Raceways

#### A. Location and Routing

1. Conceal or expose raceways as indicated. Group raceways in the same area together. Locate raceways at least 12 inches away from parallel runs of heated piping for other utility systems.
2. Run exposed raceways and raceways concealed above removable ceilings parallel or perpendicular to walls, structural members or intersections of vertical planes to provide a neat appearance. Follow surface contours as much as possible.
3. Avoid obstruction of passageways.
4. Run concealed raceways with a minimum number of bends in the shortest practical distance considering the building construction and other systems.
5. In block walls, do not run raceways in the same horizontal course with reinforcing steel.
6. In outdoor, underground, or wet locations, use watertight couplings and connections in raceways. Install and equip boxes and fittings so as to prevent water from entering the raceway.
7. Do not notch or penetrate structural members for passage of raceways except with prior written approval of the Owner and Structural Engineer.
8. Locate aboveground raceways concealed in poured concrete so that the minimum concrete covering is not less than 1-1/2 inches.
9. Except at raceway crossings, separate raceways in slabs not less than six times the raceway outside diameter.
10. Raceways installed under slabs shall be concrete encased and lie completely under the slab with no part of the horizontal run of the raceway embedded within the concrete slab. The top of the concrete envelope shall be directly under the floor slab.
11. Install raceways so that they emerge at right angles to the surface and have none of the curved portion of the bend exposed. Provide support during pouring of concrete to ensure that raceways remain in position. Provide galvanized rigid steel elbows where conduit emerges from slab or concrete.
12. Cut raceways at right angles.
13. Installation of raceway system shall be coordinated with other disciplines to assure maximum accessibility to all systems.



## B. Support:

1. Support raceways at intervals not exceeding NEC requirements unless otherwise indicated. Support individual raceways by wall brackets, strap hangers, or ceiling trapeze, fastened by wood screws to wood; toggle bolts on hollow masonry units; expansion shields or inserts on concrete or brick; and machine screws, welded thread studs, or spring-tension clamps on steelwork. Fill all unused holes or openings.
2. Fasteners attached to concrete ceiling shall be vibration and shock resistant. Holes cut to depth of more than 1-1/2 inches in reinforced concrete beams or to depth of more than 3/4 inch in concrete joints shall not cut main reinforcing bars.
3. Do not support conduit by ceiling support system. Conduit and box system must be supported independently of both tie wires supporting ceiling grid system and ceiling grid system into which ceiling panels are placed.
4. Threaded studs driven in by a powder charge and provided with lock washers and nuts may be used in lieu of expansion shields.
5. Support all raceways from structural members only. Supporting means shall not be shared between electrical raceways and mechanical piping or ducts. Do not support from pipe hangers or rods, cable tray, or other conduit or utility systems.
6. Do not weld raceways or pipe straps to steel structures. Do not use wire in lieu of pipe straps or hangers.

## C. Bends:

1. Make changes in direction of runs with symmetrical bends or cast metal fittings. Make bends and offsets of the longest practical radius.
2. Use field manufactured bends where possible. Avoid factory-made bends and offsets unless necessary.
3. Make bends in parallel on banked runs of raceways from the same center or centerline so that bends are parallel and of neat appearance. Make field bends in parallel or banked raceways if there is a change in the plane of the run and the raceways are of the same size. Make field bends with an acceptable conduit bending machine per manufacturer's recommendations.
4. Use acceptable heating methods for forming bends in PVC conduit as recommended by the manufacturer.
5. The ID of conduits shall not be reduced when making field bends.

## D. Bushing and Insulating Sleeves:

1. Where metallic conduit enters metal equipment enclosures through conduit openings, install a bonding bushing on the end of each conduit. Install a bonding jumper from the bushing to any equipment ground bus or ground pad.

2. If neither exists, connect the jumper to a lag-bolt connection to the metallic enclosure.
  3. Use manufacturer's standard insulating sleeves in all metallic conduits terminating at an enclosure.
- E. Expansion Joints:
1. Provide suitable expansion fittings that maintain conduit electrical conductivity for raceways crossing expansion joints in structures or concrete slabs. Provide for the high rate of thermal expansion and contraction of PVC conduit by providing PVC expansion joints as recommended by the manufacturer and as required. For rigid steel conduit use OZ-Gedney Type DX or equivalent.
- F. Penetrations:
1. Seal the interior of all raceways entering structures at the first box or outlet with oakum or suitable expandable compound to prevent the entrance in the structure of gases, liquids, or rodents.
  2. Where an exterior raceway enters a structure through a concrete roof or a membrane waterproofed wall or floor, provide an acceptable, malleable iron, watertight, entrance sealing device. When there is no raceway concrete encasement specified or indicated, provide such a device having a gland type sealing assembly at each end with pressure bushings which may be tightened at any time. When there is raceway concrete encasement specified or indicated, provide such a device with a gland type sealing assembly on the accessible side. Securely anchor all such devices into the masonry construction with one or more integral flanges. Secure membrane waterproofing to such devices in a permanently watertight manner.
  3. Sleeves for electrical conduit passing through walls or slabs shall be placed before concrete is poured. Where conduits pass through suspended floor slabs, sleeves shall be standard weight, galvanized steel pipe extending 2" above finished floor level. Sleeves at other locations shall be either light weight galvanized steel pipe or galvanized sheet steel. Clearance between conduit and sleeves shall be not less than 1/2".
  4. Conduits passing through floor slabs at grade level will not require sleeves, and shall be placed with tops of couplings at floor level. Wherever conduits pass through roof or outer walls, piercing the waterproofing, base flashing and counter flashing shall be provided to maintain waterproofing seal.
  5. Dry pack with non-shrink grout around raceways that penetrate concrete walls, floors, or ceilings aboveground, or use one of the methods specified for underground penetrations.
  6. Where raceways penetrate fire-rated walls, floors or ceilings, fire stop openings around electrical penetrations to maintain the fire-resistance rating equal to the barrier being penetrated.
- 3.5 Installation Requirements for Underground Direct Burial and Concrete-encased Raceways
- A. General

1. Coordinate installation of underground raceways with other outside and building construction work. Maintain existing outside utilities in operation.
  2. Remove entirely and properly reinstall all raceway installations not in compliance with these requirements.
  3. Provide a minimum cover of 2 feet over low voltage and 3 feet over high voltage underground raceways unless otherwise indicated.
  4. Do not backfill underground direct burial and concrete-encased raceways until they have been inspected by the Engineer, Owner or their representative.
  5. Warning Tapes: Bury warning tapes approximately 18 inches above all underground conduit runs or duct banks. Align parallel to and within 12 inches of the centerline of runs.
- B. Separation and Support:
1. Separate parallel runs of two or more raceways in a single trench with preformed, nonmetallic spacers designed for the purpose. Install spacers at intervals not greater than that specified in the NEC for support of the type raceways used, and in no case greater than 10 feet.
  2. Support raceways installed in fill areas to prevent accidental bending until backfilling is complete. Tie raceways to supports, and raceways and supports to the ground, so that raceways will not be displaced when concrete encasement or earth backfill is placed.
- C. Arrangement and Routing:
1. Arrange multiple conduit runs substantially in accordance with any details shown on the Drawings. Locate underground conduits where indicated on the Drawings and graded to the elevations shown.
  2. Make minor changes in location or cross-section as necessary to avoid obstructions or conflicts. Where raceway runs cannot be installed substantially as shown because of conditions not discoverable prior to digging of trenches, refer the condition to the Engineer for instructions before further work is done.
  3. Where other utility piping systems are encountered, maintain a 12-inch minimum vertical separation between raceways and other systems at crossings. Maintain a 12-inch minimum separation between raceways over couplings in other piping systems. Refer conflicts with these requirements to the Engineer for instructions before further work is done.
  4. In multiple conduit runs, stagger raceway coupling locations so that couplings in adjacent raceways are not in the same transverse line.
- D. Direct Earth Burial Conduit Zone Backfill Installation:
1. Backfill material for the conduit zone of direct burial conduit trenches may be selected from the excavated material if it is free from roots, foreign material, and oversized particles. Use material with 3/4-inch maximum particle size and suitable gradation for satisfactory compaction. Remove material if necessary to meet these requirements.

2. Imported 3/4-inch minus gravel or sand may be used in lieu of material from the excavation.
3. After conduits have been properly installed, backfill the trench with specified material placed around the conduits and carefully tamped around and over them with hand tampers. Final, tamped conduit cover shall be inches minimum.

E. Concrete Encasement:

1. Encase underground conduits in slurry as indicated below:
  - a. Low voltage: Use 1 sack mix slurry. Maintain a minimum 3 inch envelope around all conduits.
  - b. High voltage: Use 6 sack mix (C6) slurry with 5 pounds of red oxide per cubic yard. Maintain a minimum 3 inch envelope around all conduits. Backfill from top of C6 encasement to finish grade shall be 1 sack mix slurry.
2. Maintain a grade of a least 4 inches per 100 feet, either from one manhole or pull box to the next, or from a high point between them, depending on the surface contour.
3. Hold conduits for concrete-encased raceways securely in place by acceptable window type spacer supports. Where, in the opinion of the Engineer, ground conditions are such as to require concrete forms, install forms constructed of materials and in a manner acceptable to the Engineer. No variations greater than 1/2 inch in 50 feet will be permitted from a straight line.
4. Envelopes may be poured directly against the sides of trenches if the cut is clean, even, and free of loose material. Remove loose material from trenches before and during pouring of concrete to ensure sound envelopes. Carefully spade slurry during pouring to eliminate all voids under and between raceways and honeycombing of the exterior surface.
5. Do not use power-driven tampers or agitators unless they are specifically designed for the application, in order to ensure that the watertight integrity of the raceways is maintained.
6. Generally, pour an entire slurry envelope in one continuous pour. Where more than one pour is necessary, terminate each pour in a sloped plane, and insert 3/4-inch reinforcing rod dowels extending into the slurry 18 inches minimum on each side of the joint. Obtain Engineer's approval for the number and location of dowels.

3.6 Manholes and Handholes

- A. Install manholes and handholes where shown on the drawings. Provide excavation, shoring, bracing, backfilling, grading, etc., in accordance with requirements specified elsewhere in these contract documents.
- B. Do not install manholes or handholes until final conduit grading, including field changes necessitated by underground interferences, has been determined. Set frames to final grades as required.

- C. Make installation so that raceways enter manholes or handholes at nearly right angles and as near as possible to one end of a wall, unless otherwise indicated.
- D. Install one ground rod in each manhole and handhole. Connect all noncurrent-carrying metal parts in the manhole and any metallic raceway grounding bushings to this ground rod with No. 4/0 bare copper ground conductor and approved ground clamp and as required per NEC.

### 3.7 Preparation for Pulling in Conductors:

- A. Do not install crushed or deformed raceways. Avoid traps in raceways where possible. Take care to prevent the lodging of concrete, dirt, or trash in raceways, boxes, fittings, and equipment during the course of construction. Make raceways entirely free of obstructions or replace them. Ream all raceways, remove burrs, and clean raceway interior before introducing conductors or pull wires.
- B. Immediately after installation, plug or cap all raceway ends with water-tight and dust-tight seals until the time for pulling in conductors.
- C. For concrete-encased raceways, after the concrete envelope has set, pull a mandrel of a diameter approximately 1/4 inch less than the raceway inside diameter, through each raceway. Then pull a bristle brush through each raceway to remove debris.

### 3.8 Empty Raceways

- A. Certain raceways will have no conductors pulled in as part of the Contract. Identify with tags at each end and at any intermediate pull point the origin and destination of each such empty raceway. Where a raceway has been identified with a name (number) in the Raceway Schedule, use that name on the tag in lieu of origin and destination. Provide a removable permanent cap over each end of each empty raceway. Provide a 3/8" nylon pull cord in each empty raceway.

### 3.9 As-Built Conduit Drawings

- A. At the completion of Contract, provide as-built conduit Drawings showing location and depth of all conduits. Measure conduit locations from permanently fixed readily discernable landmarks such as building corners, columns, manhole centerline, etc.

END OF SECTION

SECTION 26 05 36  
CABLE TRAYS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 GENERAL

- A. Work Included: This section covers the work necessary to furnish and install, complete cable tray systems.
- B. General: INSTRUCTIONS TO BIDDERS, INFORMATION FOR BIDDERS, GENERAL CONDITIONS and Section 26 00 00, ELECTRICAL contain information and requirements that apply to the work specified herein.
- C. Related Work Specified and Performed Under Other Sections:  
  
<<TO BE COMPLETED BY CONSULTING ENGINEER>>
- D. Submittals: Make submittals in accordance with Section 26 00 00, ELECTRICAL. Furnish descriptive literature for the following equipment or devices supplied under this section:
  - 1. Cable Tray
  - 2. Elbows
  - 3. Tees
  - 4. Crosses
  - 5. Risers
  - 6. Reducers
  - 7. Expansion Joints
  - 8. Barrier Strips
  - 9. Bonding Jumpers
  - 10. Hangers
  - 11. Supports
  - 12. Cable Dropouts
  - 13. Covers
- E. Cable Tray Design Submittals: Provide for all cable tray, complete detailed shop drawings, calculations, and descriptive information. Provide NEC cable tray fill calculations using actual cables proposed to be used. Increase size of trays as required to meet NEC requirements. Include proposed NEMA load/span designation and how it was selected. Include proposed support span length and pounds-per-foot actual and future cable loading at all locations, along with safety factor used. Show location and magnitude of maximum simple beam deflection of tray for the loading specified. Show location of all cable tray supports. Provide layout drawings and list of accessories being provided. Show location of all floor or wall penetrations dimensioned from building column lines or other appropriate baseline. Provide detailed tray routing and section plans for review prior to construction.

PART 2 PRODUCTS

2.1 MATERIALS

## A. General

1. Provide [steel] [aluminum] cable tray meeting the requirements of NEMA VE-1.
2. Ladder type straight sections shall be 12'-0" long and shall be of the width [indicated on the drawings.] [as required to provide planned cable capacity.]
3. Fittings shall have the same load carrying capacity as straight sections. Fittings shall be [12"] [24"] [[36"] radius unless otherwise indicated on the drawings.

## B. Material and Construction

1. Provide steel ladder type cable tray constructed of hot-dipped galvanized after fabrication (to ASTM A 123-84, formerly ASTM A 386, Class B2) finish. [Provide louvered tray covers where indicated.] [Provide PVC coated steel or epoxy painted tray where indicated.]

\*\* OR \*\*

2. Provide aluminum ladder type cable tray with side rails constructed of 6063-T6 or 6061-T6 aluminum alloy and rungs constructed of type 6063-T6 aluminum alloy. Finish shall be natural. Provide louvered tray covers where indicated.
3. Where slopes or horizontal bends of trays are not at standard NEMA angles, use adjustable connectors. Use combinations of fittings and adjustable connectors to prevent angle from exceeding cable bending radius. If dimensions require to be changed, obtain Engineer's written approval.
4. Provide cable tray with outward facing side rails. Cable support surface on top of rungs shall be flattened. Inside of tray shall not have flanges or other projections. Full access to the contents of cable tray shall be available.
5. Provide cable tray with the next higher NEMA class designation for the proposed support span length and working load adequate for the actual cable installed plus a 20 percent additional weight allowance for future cables plus a 250-pound concentrated static load applied between the side rails at midspan, all with a safety factor of 2.0.

## C. Grounding

1. Provide cable tray suitable for use as a grounding conductor in accordance with the NEC and UL. Supply ground conductor clamps and bonding jumpers for each section elbow, tee, cross, and reducer sized for the ground conductor indicated.

## D. Accessories

1. Provide all elbows, tees, crosses, risers, reducers, expansion joints, barrier strips, bonding jumpers, hangers, supports, conduit clamps, cable clamps,

box connectors, cable dropouts, and other accessories as indicated or as required for a complete system.

2. Provide expansion joints per NEMA VE 1 for the following maximum temperature extremes:
  - a. Minimum temperature: 35°F
  - b. Maximum temperature: 115°F
3. Provide all top level trays in stacks and single runs with raised peaked ventilated covers with heavy duty hold down clamps on 3'-0" maximum centers.
4. All steel cable trays and covers shall be furnished from the manufacturer with a painted finish of ANSI-49 gray epoxy or PVC coated.

### PART 3 EXECUTION

#### 3.1 EXECUTION

##### A. General

1. Provide raceway systems meeting or exceeding the requirements of the NEC.
2. Install cable trays in strict accordance with the recommendations contained in the Application Information Section of NEMA VE 1 and tray manufacturer's recommendations.
3. Assemble cable trays so that joints are not made at support brackets. Install trays so as to be level, straight, and true to line or grade within plus or minus 1/8 inch in 10 feet and within an accumulative maximum of 1/2 inch. Make vertical structures plumb within a tolerance of 1/8 in.
4. Install cable trays and troughs to leave no exposed raw edges.

##### B. Support

1. Support cable tray at intervals not exceeding NEC requirements unless otherwise indicated. Support cable tray by wall brackets or ceiling trapeze, fastened by expansion shields on concrete, and machine screws or welded thread studs on steelwork, and lag screws into wood.
2. Threaded studs driven in by a powder charge and provided with lock washers and nuts may be used in lieu of expansion shields.
3. Support and brace tray for seismic zone 4 installation.

##### C. Cable Installation

1. Support all control cables, either single or multiple conductor, entering the bottom of control boards with suitable clamps.
2. Gather all wires and cables in the trays together in bundles, if a combination of two or more multiple-conductor cables and/or single



conductors are in the run. Determine the grouping and number of wires in each bundle in the field, mainly with consideration to physical locations of the routing and destination of the wires. Provide barriers as noted on Drawings.

3. Use nylon cable ties for bundling with a spacing between tie points of approximately 8 feet.
  4. Do all bundling and clamping before the end terminations are connected.
  5. As far as practicable, lay the wire parallel and straight in the tray. Provide barriers in cable trays where indicated. Separate all cables of different systems in the same cable tray with barriers.
  6. Securely fasten all wires, cables, and bundles to the tray with nylon cable straps, or other specified means, to maintain their relative positions in the trays. On horizontal runs, install the fastenings at a maximum interval of 20 feet. On vertical runs, the maximum interval shall be 5 feet.
  7. Stencil 2-inch high designations on all cable trays, using an oil base type of paint, in locations designated by the Engineer or as shown on Drawings. Designations shall be as shown in Raceway Schedule.
- D. As-Built Drawings: At the completion of Contract, provide as-built cable tray drawings showing location and elevation of all cable trays complete with conduit and tray identification system. Submit as-built Drawings to Engineer for review and make all corrections and changes to Drawings, as directed by the Engineer. Provide Engineer with reproducible scaled Drawings showing all changes and revisions issued by Contract Addendum and Change Orders.

END OF SECTION

SECTION 26 05 53  
IDENTIFICATION FOR ELECTRICAL SYSTEMS

## PART 1 – GENERAL

## 1.1 RELATED DOCUMENTS

&lt;&lt;TO BE COMPLETED BY CONSULTING ENGINEER&gt;&gt;

## 1.2 SUMMARY

- A. This section includes identification of electrical materials, equipment, and installations. It includes requirements for electrical identification components including but not limited to the following:

1. Buried electrical line warnings.
2. Identification labeling for raceways, cables, and conductors
3. Operational instruction signs.
4. Warning and caution signs.
5. Equipment labels and signs.

## 1.3 SUBMITTALS

&lt;&lt;TO BE COMPLETED BY CONSULTING ENGINEER&gt;&gt;

## 1.4 QUALITY ASSURANCE

&lt;&lt;TO BE COMPLETED BY CONSULTING ENGINEER&gt;&gt;

## PART 2 – PRODUCTS (NOT APPLICABLE)

## PART 3 – EXECUTION

## 3.1 GENERAL

- A. Lettering and Graphics: Coordinate names, abbreviations, colors, and other designations used in electrical identification work with corresponding designations specified or indicated on the drawings. Provide numbering, lettering, and colors as approved in submittals and as required by Code.
- B. Provide identification devices in accordance with manufacturer's written instructions and requirements of the NEC.
- C. Sequence of Work: Where identification is to be applied to surfaces that require finish, install identification after completion of finish work.

## 3.2 ELECTRICAL IDENTIFICATION PROCEDURES

- A. Nameplates – General:

1. Provide laminated, engraved plastic nameplates with  $\frac{3}{8}$  inch high letters for all switchgear, switchboards, motor control centers, transfer switches, panelboards, signal system equipment cabinets, and terminal cabinets. Provide similar nameplates with  $\frac{3}{8}$  inch high letters for transformers, time switches, individually mounted breakers, switches and controls, switchboards, and motor center branch devices. Attach nameplates to gear with sheet metal screws. Adhesive mounted nameplates are not acceptable. Refer to single line diagrams and schedules for actual designations and circuit numbers that apply to this project.
2. Include nameplate schedule on shop drawing submittals.
3. Indicate on Gear Nameplates:
  - a. Line 1: Equipment designation
  - b. Line 2: Primary voltage, phase, number of wires.
    - 1) In addition, include KVA rating for substations, transformers, and generators
    - 2) In addition, include Amperes for switchgear and panelboards
  - c. Line 3:
    - 1) For single feeder supply, indicate source feeder.
    - 2) For two feeder supply, indicate normal source and standby source feeders.
    - 3) For Automatic Transfer Switch, indicate normal and emergency source feeders.
  - d. Line 4: (where applicable)
    - 1) Secondary equipment: indicate voltage, phase, number of wires, Amperes.
    - 2) For Automatic Transfer Switch, indicate priority number.
  - e. Example #1:  
  
SUBSTATION SS6A,  
4.16KV, 3 PH, 3 WIRE 1500/1680/1932 KVA  
NORMAL SOURCE B6, STANDBY SOURCE A1  
480/277, 3 PH, 4 WIRE SECONDARY
  - f. Example #2:  
  
ATS-EQ1  
480V, 3 PH, 4 WIRE, 600A  
NORMAL SOURCE MSS-6, EMERGENCY SOURCE ESS-3  
PRIORITY NO. 3

4. Indicate equipment and/or equipment controlled and designation on component nameplates. Examples:
    - a. Switchboard Breaker: CKT 3 – PANEL H3
    - b. Motor Switch: TOILET EXHAUST FAN EC-3
    - c. Submeter: KWHR SUBMETER AIR CONDITIONING
    - d. Time-Switch: TSA – PARKING LIGHTS (served from Panel A)
    - e. Fire Alarm Terminal Cabinet: FIRE ALARM SYSTEM 24V DC
  5. Install panelboard nameplates behind panel door in public areas and on panel face in equipment rooms.
- B. Nameplate Color Schedule:
1. Over 600V: Brown letters on white label.
  2. 277 through 600V: Orange letters on white label.
  3. 120 through 240V: Black letters on white label.
  4. Emergency System: White letters on red label.
  5. Devices Connected ahead of Service Mains and Substation Secondary Mains: Letter color as per switchboard voltage on Yellow label.
  6. Fire Alarm System: Black letters on red label.
  7. Communication or Signal Systems: White letters on black label. Identify system and voltage.
  8. Building Control System: White letters on green label.
- C. Stenciled Designations: Provide readily visible block letter stenciled designations for the following with  $\frac{3}{8}$  inch high minimum letters on background of contrasting colors as outlined under Nameplate Color Schedule (above). Fabricate stencils of brass and deliver to Owner on completion of work. Obtain receipt and include in maintenance manual.
1. Junction and pull boxes of signal and communication systems identifying system and voltage.
  2. Lighting Outlet and Junction Boxes: Identify voltage and circuits contained within box.
  3. 480V Outlet and Junction Boxes: 480V. Identify circuit(s).
  4. Each 10 foot length of medium voltage conduit, exposed or in accessible ceiling space and associated junction and pull boxes: DANGER HIGH VOLTAGE

5. Feeder conduit runs on 25 foot centers and on both sides of wall and floor penetrations, where visible from floor and above demountable ceilings. Indicate circuit designation and number on all feeders. Indicate system on all signal and communications system conduit sized 1½ inch and larger.

D. Labels:

1. Provide label, in addition to UL label, for each switchgear, switchboard, panelboard, transfer switch, and motor control center indicating the short circuit rating of the gear as constructed and the minimum rating of devices allowable. Submit with shop drawings.
2. At all 120V outlet locations, provide labels with panel and circuit information using a P-touch or similar label maker with minimum ½" tape. For normal power, label shall be black letters on white tape. For emergency power, label shall be white letters on red tape.
3. At all fusible devices, either individually mounted or part of gear, provide a label (as supplied by fuse manufacturer) or nameplate inside each switch cover, indicating specific type of fuse required for replacement.

E. Emergency System:

1. Identify all enclosures per Article 700 of the NEC
2. Paint junction box covers and covers of multi-outlet assemblies red.
3. Use visibly red receptacles and devices. Alternately, engrave plates "EMERGENCY SYSTEM" and fill in with red enamel.

F. Conduit and Conductors:

1. Tag feeders at panels, switchboards, pull boxes, manholes and other accessible enclosures, indicating source, voltage, circuit number, and conductor ampere rating. Tags to be readily readable after installation.
2. Identify medium voltage conductors with phase and circuit number.
3. In exterior or wet locations, and for medium voltage conductors in all locations, provide 1½ inch diameter brass discs engraved or embossed with 3/16 inch minimum high letters and tied with No. 16 AWG galvanized wire.
4. In interior dry locations, provide metal or laminated plastic discs as above, attached with nylon cord.
5. Tag exposed ends of conduit stubs indicating system, name of panel, switchboard, etc., of origin and conduit size.
6. Identify all branch circuit system conductors with pre-marked self-adhesive, wrap around cloth wire markers, indicating circuit number and name of panel, cabinet, etc, or origin, at panelboards, motor control centers, switchboards, isolated power panels,

terminal cabinets, wireways, junction boxes and at all outlet boxes containing more than one neutral wire.

7. Identification Format Example:

- |    |                              |   |                      |
|----|------------------------------|---|----------------------|
| a. | Switchboard Feeder           | - | MSA-1 480/277V 225A  |
| b. | Transformer Subfeeder        | - | T1 208/120V 380A     |
| c. | Transfer Switch Subfeeder    | - | ATS-1 480V 800A      |
| d. | Bus Duct Feeder              | - | BDA-3 208/120V 600A  |
| e. | Substation Feeder            | - | DBA-1 480/277V 1200A |
| f. | Panel Branch Circuit         | - | A1-10                |
| g. | Motor Control Center Circuit | - | MCCA-4 480V          |

8. Underground Electrical Line Identification: Install line marker for underground wiring, both direct-burial and in raceway. During trench backfilling, for underground power, signal, and communication lines, install continuous underground plastic line marker, located directly above line 6 to 8 inches below finished grade. Where multiple lines installed in a common trench or concrete envelope do not exceed an overall width of 16 inches, install a single line marker.

9. Provide, above underground conduits stubbed for future use, engraved flush bronze marker anchored in 4 inch square by 12 inch deep concrete block, flush with grade, indicating system, conduit size and point of origin.

10. Paint Fire Alarm System J-boxes and pullboxes red and provide label: "Fire Alarm System".

G. Identify Raceways of Certain Systems with Color Banding: Band exposed or accessible raceways of the following systems for identification. Bands shall be painted with colors indicated below. Make each color band 2 inch wide, completely encircling conduit, and place adjacent bands of two-color markings in contact, side by side. Install bands at changes in direction, at penetrations of walls and floors, and at 10 foot maximum intervals in straight runs. Apply the following colors:

1. Fire Alarm Systems: Red.
2. Fire Suppression Supervisory and control System: Red and Yellow
3. Mechanical and Electrical Supervisory System: Green and White
4. Telephone System: Green and Yellow

- H. Conductor Color Coding: provide color coding for secondary service, feeder, and branch circuit conductors throughout the project secondary electrical system as follows:

<u>208/120 Volts</u>	<u>Phase</u>	<u>480/277 Volts</u>
Black	A	Brown
Red	B	Orange
Blue	C	Yellow
White	Neutral	Gray
Green	Ground	Green

- I. Use conductors with color factory-applied the entire length of the conductors except as follows:
1. The following field-applied color coding methods may be used in lieu of factory-coded wire for sizes larger than No. 10 AWG:
    - a. Apply colored, pressure-sensitive plastic tape in half-lapped turns for a distance of 6 inches from terminal points and in boxes where splices or tape are made. Apply the last two laps of tape with no tension to prevent possible unwinding. Use 1 inch wide tape in colors as specified. Do not obliterate cable identification markings by taping. Tape locations may be adjusted slightly to prevent such obliteration.
    - b. In lieu of pressure-sensitive tape, colored cable ties may be used for color identification. Apply three ties of specified color to each wire at each terminal or splice point starting 3 inches from the terminal and spaced 3 inches apart. Apply with a special tool or pliers, tighten for snug fit, and cut off excess length.
    - c. Color coded conductors of cables used in communication and signal systems and control conductors in line and low voltage control panels, motor control centers, and supervisory panels. Use white for grounded conductors and green for equipment ground, exclusively.
- J. Devices: Engrave on each device plate with 3/16 inch high block letters with black enamel where noted and as follows:
1. Lock switch and switch with pilot light – device controlled.
  2. Switch for fan, motor unit heater – equipment controlled.
  3. Switch where lights or equipment are out of sight – identify area or equipment controlled.
  4. Switches in gangs of three or more – identify areas or equipment switched.
  5. Receptacles over 150V to ground and/or 30A and higher rating – voltage and ampere rating.
  6. Isolated Ground Receptacles – Isolated Ground.
  7. Where wording is not indicated, allow for ten letters per device and use wording as directed.

8. For switch cabinets engrave each device or provide engraved nameplate.
- K. Warning Signs: Conform with the latest edition of the NEC. Provide No. 18 AWG steel, white porcelain enameled signs with 1 inch high letters to read "DANGER! – HIGH VOLTAGE, AUTHORIZED PERSONNEL ONLY!". Post on doors or entries to all rooms or areas containing equipment rated over 600V and on front of such equipment enclosures. Provide similar signs with 1 inch high black letters in all electrical and signal rooms and closets reading "ELECTRICAL (or SIGNAL) ROOM – NO STORAGE PERMITTED". Submit shop drawings.
- L. Panel Schedules: Provide typewritten panel schedules on inside of panel doors behind clear plastic. Indicate as-built quantity and type of outlets served as well as general location of outlets or fixtures and/or item of equipment served.
- M. Diagrams and Posted Signs:
1. For switchboards with bus rating 1000A or greater, and for substations, provide a bus diagram framed and mounted behind clear plastic indicating bus configuration and rating, devices, ground fault detectors, standby generator connection, and switchboard components. Submit diagram for review with shop drawings.
  2. For signal and communication systems, provide block wiring and location diagram mounted behind clear plastic and posted at system control location or as directed. Submit diagram for review with shop drawings.
  3. For medium voltage switchgear, provide a single line bus diagram air brush painted in contrasting color across the front face of the switchgear indicating all components within cubicles including lightning arresters, metering, etc.
  4. For all main electrical rooms, and/or as directed by Owner, provide a single line diagram framed and mounted behind clear plastic indicating as-built system configuration and distribution.

END OF SECTION



SECTION 26 09 33  
CENTRAL DIMMING CONTROLS

## PART 1 GENERAL

## 1.1 GENERAL

- A. Work Included: Provide, install, and test an architectural lighting dimming system as specified herein for the areas indicated on the drawings and load schedule(s).
- B. System Description: System shall consist of factory pre-assembled dimming cabinets, low voltage control stations and/or interface panels, occupancy (motion) sensors, and solid-state high frequency fixture packs (where applicable). Additional items may also be required and are described herein and/or shown on the drawings.
- C. Submittals: Shall include all mechanical and electrical notes and construction details for both dimming panels and controls. Include a dimming load schedule which indicates a clear understanding of the actual loads per circuit, which circuits are on their respective control zones, which circuits are on emergency (if applicable), and the corresponding circuit numbers (per the electrical drawings). Include an interconnection diagram showing a detail of each control, which zones are on that control, the interconnect wiring between controls and dimming panels(s), and the dimming panel(s). Provide one diagram per each dimming panel location. Block diagrams involving cross-referencing to catalog specification/application sheets will not be acceptable. Include catalog literature with performance specifications which indicate compliance to the specifications herein.
1. Manufacturer shall provide any additional information or demonstrations as required by specifier to demonstrate conformance with Part 2 of this specification. All demonstrations are to be at a location, time, and in a manner chosen by the specifier.
  2. Manufacturer shall substantiate conformance to the specifications by supplying a document indicating equipment submitted meets or exceeds each line item in the specification, or exceptions taken.
- D. Quality Assurance
1. Manufacturer: Company specializing in architectural lighting control systems with a minimum of 10 years continuous experience in manufacturing such equipment.
  2. The entire dimming system shall be listed by U.L. and shall bear a U.L. label on each dimming panel. Additionally, each dimming, non-dimming, or motor module shall be specifically listed by U.L. for control of the type of load (i.e., incandescent, low voltage, fluorescent, neon/cold-cathode, HID, motor). All occupancy (motion) sensors shall be U.L. listed and bear a U.L. label on devices.

## PART 1 PRODUCTS

## 1.1 MATERIALS

- A. Acceptable manufacturers
1. Lutron Electronics Company, Inc. or Owner approved equivalent.
  2. The listing of a manufacturer as "acceptable" does not imply automatic approval. It is the sole responsibility of the electrical contractor to ensure that any price quotations received and submittals made are for dimming systems which meet or exceed the specifications included herein.
- B. Dimming Cabinets
1. Cabinets shall be wall or floor mounted NEMA-1 grade, constructed of sheet steel plates not less than #14 U.S. gauge. Contractor shall reinforce wall as required for wall-mounted panels.
  2. Cabinets shall be completely pre-wired by the manufacturer. The contractor shall be required to provide input feed wiring, load wiring, and control wiring which terminates to a set of clearly marked low voltage terminals. No other wiring or assembly by the contractor shall be permitted.
  3. Cabinets shall contain input and output circuit breakers to provide primary line side protection and outgoing branch circuit protection for each dimming module. Circuit breakers shall be designed to trip within 9 msec after a 400A surge. Circuit breakers shall contain a visual trip indicator and shall be rated at 10,000 AIC (120V) or 14,000 AIC (277V).
  4. Cabinets shall contain current carrying terminals with factory installed brass or copper jumpers. These jumpers will enable power to completely bypass the dimmer modules for temporary power during installation and any future service work. Bypass jumpers shall be clearly and permanently labeled and shall be re-usable at any time. Low voltage control signal methods of bypass shall not be acceptable. Alternatively, the contractor may provide a switch panel with a specification grade SPST switch wired in parallel with each dimming module. Provide one switch per module with a capacity equal to the input breaker rating of the dimmer module. Engrave each switch wall plate NORMAL in the switch open position, and BYPASS in the switch closed position. Provide details of this switch panel with the dimming system submittals.
  5. Cabinets shall be cooled exclusively by means of free convection, unaided by fans, in an ambient temperature range of 0°C (32°F) to 40°C (104°F). To provide the utmost in reliability, cabinets which normally use cooling fans must have their capacity derated accordingly, and as such may require either larger panels or a greater number of panels than shown on the drawings. All additional labor and material costs due to requiring additional panels shall be included in the electrical contractor's bid. Alternatively fans may be used with the following additional provisions:
- C. Service Contract
1. The manufacturer shall provide a service contract beginning from the day the standard warranty ends until 10 years from the date of purchase. The service contract shall provide for bi-annual replacement of all fans and annual cleaning of all filters by a factory service technician. A label not

less than 3" X 5" shall be affixed to each dimming panel and shall clearly state that the panel is covered by an extended service contract on these items, with appropriate spaces for logging the service work performed.

2. Provide a copy of the service contract, as well as a copy of the label described above, with the other information required for submission purposes.
3. Cost for the above service contract to be included in the base bid.

D. Dimming Modules

1. Silicon thyristors shall be used to control the power furnished to the loads. The complete load current shall be carried by these devices. They shall be capable of withstanding surges, without impairment to performance, of 6000V, 3000A as specified by IEEE Std. 587-1980. In addition, under fully-loaded operating conditions, all devices shall operate at a minimum 20°C safety margin below the component temperature rating.
2. A positive air gap relay shall be employed with each dimmer to ensure that the load circuits are open when the "off" function is selected at a control station. Use of semiconductors to accomplish this result shall not be acceptable. These relays need not be integral to the dimming module but must be integral to the dimming cabinet. Dimming manufacturer shall provide and warrant both the relays and the necessary control interface(s) as part of the dimming system.
3. All dimming modules shall be voltage regulated so that "10% change in line voltage shall cause no more than + 3% change in output voltage.
4. All dimming modules shall provide a smooth and continuous Square Law dimming curve throughout the entire dimming range.
5. All dimmers designed for use with inductive loads shall include the following additional features:
  - a. The maximum allowable asymmetry in the load waveform shall be "1 VDC.
  - b. The dimmer shall incorporate circuitry to prevent the lights from momentarily "flashing" when the dimmer is turned on or off.
6. Quantities and sizes of each type of dimmer module shall be provided to control each type of load shown on the load schedule and/or the drawings.

E. Incandescent and Low Voltage - Magnetic Transformer

1. Filtering shall be provided in each dimmer so that current rise time shall be at least 350 micro sec. at 50% rated dimmer capacity as measured from 10-90% of the load current waveform at 90° conduction angle, and at no point rise faster than 30mA/micro sec. Manufacturers should note that additional filters may be required to meet this specification. These filters need not be integral to the dimming module, but must be integral to the dimming cabinet.

2. Modules shall provide a dimming range from 100% to 0% (blackout). Minimum light levels shall be user adjustable in order to compensate for different loading of each dimmer module.
- F. Florescent: Hi-lume - Solid-State Dimming Ballast
1. Florescent modules shall be rated to control 430mA rapid start (3',4'), 800mA high output (3', 4', 8'), or 265mA T-8 (3',4',5') lamps @ 120VAC. Module shall be rated to control 430mA rapid start (4' only) @ 277 VAC. All lamps on the same circuit must have the same current rating (i.e., 800mA), but may be different lengths,. Ballasts for fluorescent fixtures must be Lutron Hi-lume "OSPCU" series. See fixtures schedule for specific ballast model numbers. The dimming performance shall be as follows:
    - a. Dimming range from 100% to 1% light output.
    - b. One- and two-lamp ballasts track evenly, with no perceptible difference in light levels for the same type lamps.
    - c. Different lamp lengths on the same circuit track evenly, with no perceptible difference in light levels for the same type lamps.
    - d. Ballasts shall be inaudible with no apparent humming or buzzing at any point in the dimming range.
    - e. Standard lamps must be used. Energy-saver krypton-fill lamps are not acceptable. Where applicable, knife-edge lamp sockets should be used.
    - f. No electrical noise shall be generated which could interfere with any other properly installed electrical equipment.
    - g. Minimum light levels shall be user-adjustable in order to compensate for different loading of each dimmer module. A 0% control input from any control station shall turn the respective dimmer "off" completely.
- G. Controls
1. Controls shall be low voltage type as specified here and as listed below and/or shown on the drawings. Controls shall use low voltage Class II wiring, electrically isolated from power wiring by means of a U.L. Listed Class II transformer. A separate set of terminals shall be provided for each control station termination at the dimming panel and/or interface panels.
  2. Faceplates shall be machined from a single piece of 1/8" thick metal base (minimum). Unless noted elsewhere, finish shall be clear brushed aluminum. Brass bronze, or chrome controls (unless specified otherwise) shall be machined using a single piece of solid brass. Painted controls shall be painted by manufacturer to exactly match architect's sample. Paint shall be a polyurethane enamel type equal to Polane™ in quality.

3. Faceplates shall attach to the wallbox using no visible means of attachment. To prevent unauthorized faceplate removal, set screws through the edge of the faceplate shall securely hold the faceplate to the switchbox. Alternately, controls shall be mounted in an enclosure with a locking translucent cover. Paint enclosure per architect's sample.
  4. Controls shall be engraved with appropriate zone and/or scene descriptions, furnished to the manufacturer prior to fabrication. Size and style of engraving type shall be determined by the architect. Any silk-screened borders, logos, graduations, etc., shall use a graphic process that chemically bonds the graphics to the metal faceplate, resisting removal by scratching, cleaning, etc.
  5. All control stations shall provide power-failure memory. Should power be interrupted to the control station and subsequently returned, the lights will come back on the same levels set prior to the power interruption. Restoration to some other default level is not acceptable, unless specifically noted elsewhere.
- H. Preset Control Systems
1. Each flush-mount unit shall consist of four touch-buttons to provide scene selection. LEDs to indicate lighting levels of each zone and electronic fade between each scene. Fade rate for all zones shall be adjusted from 0 to 60 seconds by one adjustment at the control. A fifth touch-button shall switch off the system. The entire present section shall be concealed behind a smoked translucent flush-mounted window which shall appear black except for the illuminated potentiometers in the active scene. Unit shall be capable of add-on interface to external equipment, providing electrical isolation, without modification of the backbox unit, or mounting of an additional panel.
  2. Provide remote preset activator control containing only the same four-scene activating buttons with LEDs and "off" button as specified above, as shown on the drawings.
  3. Provide entrance control station(s) containing an "on" button with LED and an "off" button as specified above, as shown on the drawings.
- I. Quality Control
1. All components used in the dimming system shall be inspected following Military Standard 105D or equivalent.
  2. Dimming module main power semiconductors shall be 100% tested at a case temperature of 100°C and with rated voltage applied for a minimum of 48 hours.
  3. The completely assembled dimming system shall be operated at full-rated load for a minimum of five hours before shipment.
  4. Finished system shall be fully tested for proper operation of all control functions per system approved submittals.

5. Submittals shall include certification by the manufacturer of the successful completion of the tests described in paragraphs above.

PART 2 EXECUTION

2.1 EXECUTION

A. Installation

1. The system shall be installed utilizing complete manufacturer's shop drawings and in accordance with these specifications.
2. Upon completion of the installation and prior to removal of the bypass jumpers, the contractor shall completely test all line voltage power and low voltage control wiring for continuity and accuracy of connections. The jumpers shall remain in place until all loads have been fully tested and found to be free of miswires, short circuits, or other wiring defects.

B. System Check-Out

1. Upon completion of the installation, the system shall be completely checked out by a factory-trained engineer. The check-out will be performed upon notification by the contractor that the system installation is complete and that all loads have been tested live for continuity and freedom from defects and that all control wiring has been connected and checked for proper continuity.
2. Upon completion of the system check-out, the engineer shall demonstrate the operation of the system to appropriate owner's representatives.

C. Warranty and Warranty Service

1. Manufacturer shall provide full one (1) year warranty and second year service contract on system.
2. Warranty/Service Contract coverage shall begin from date of system start-up. Warranty/Service Contract service shall be performed by a factory-trained engineer.

END OF SECTION

SECTION 26 11 16  
SECONDARY UNIT SUBSTATIONS

PART 1 GENERAL

1.1 Section Includes

- A. This specification covers an indoor secondary unit substation complete from the incoming switch line terminals to the outgoing switchboard load terminals. All equipment shall be new and manufactured by a company regularly engaged in the fabrication of such equipment. Units shall be painted ANSI 61 for indoor service.

1.2 Related Sections

- A. Section 26 05 53 Identification

1.3 Applicable Standards

- A. The publications listed below form a part of this specification to the extent referenced. The latest revision of each publication shall be applied.

- B. American National Standards Institute (ANSI) Publications:

C2	National Electrical Safety Code (NEC)
C37.20.3	Metal-Enclosed Interrupter Switchgear
C37.47	Distribution Fuse Disconnecting Switches, Fuse Supports, and Current-Limiting Fuses
C57.12.01	Dry-Type Distribution and Power Transformers Including Those With Solid Cast and/or Resin-Encapsulated Windings, Standard General Requirements for
C57.12.50	Ventilated Dry-Type Distribution Transformers, 1 to 500 kVA, Single Phase, and 15 to 500 kVA Three Phase, with High-Voltage 601 to 34 500 Volts, Requirements for
C57.12.56	Test Procedure for Thermal Evaluation of Insulation Systems for Ventilated Dry-Type Power and Distribution Transformers
C57.12.59	Guide for Dry-Type Transformer Through-Fault Current Duration
C57.12.70	Terminal Markings and Connections for Distribution and Power Transformers
C57.12.91	Test Code for Dry-Type Distribution and Power Transformers
C57.13	Standard Requirements for Instrument Transformers

C57.96	Guide for Loading Dry-Type Distribution and Power Transformers
C57.98	Guide for Transformer Impulse Tests
Z35.1	Specifications for Accident Prevention Signs
Z55.1	Gray Finished for Industrial Apparatus and Equipment

C. National Electrical Manufacturers Association (NEMA) Publications:

AB-1	Molded Circuit Breakers
CC-1	Electric Power Connectors for Substations
LI-1	Industrial Laminated Thermosetting Plastics
PB-2	Dead-Front Distribution Switchboards
PB-2.1	Safe Handling, Installation, Operation and Maintenance of Switchboards
ST-20	Dry Type Transformers for General Applications

D. National Fire Protection Association (NFPA) Publications:

70-1987	National Electrical Code
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E. Underwriters Laboratories, Inc. (UL) Publications:

467	Grounding and Bonding Equipment
489	Molded-Case Circuit Breakers and Circuit Breaker Enclosures
891	Dead-Front Switchboards
1562	Transformers, Distribution, Dry-Type-Over 600 Volts

1.4 Quality Control

- A. Design tests required for certification of conformance to ANSI, NEMA or UL requirements may be required for review by the engineer at the option of the owner. Design tests need not be performed on the actual equipment being submitted but must have been performed on a sample or other unit representative of the specific construction techniques which are utilized.
- B. The following factory tests shall be made on all primary switches, although not necessarily in the order listed. All tests shall be in accordance with the latest revision of ANSI C37.20.3 and/or UL standards:
  - 1. A dielectric withstand test in shall be made between each phase and ground with all switching devices closed and phases not under test grounded.



2. Mechanical tests shall be performed to verify the integrity of all operating mechanisms and interlocks.
3. The grounding of instrument transformer cases or frames, as applicable, shall be checked with a low potential source.
4. Control wire continuity and correctness shall be verified by actual electrical operation of the control component or individual circuit continuity checks with electrical instruments.
5. Control wire insulation shall be tested with the application of 1500 V, 60 Hz for 1 minute after circuit grounds have been disconnected for the test. Sensitive or electronic equipment shall be disconnected for the test.
6. Polarity tests shall be performed to verify that instrument transformers have been correctly connected.

Results of the above tests shall be submitted with final drawings in the form of certified test reports. Third party certification is not required.

- C. The following factory tests shall be made on the transformer although not necessarily in the order listed. All tests shall be in accordance with the latest revision of ANSI Test Code C57.12.91, NEMA ST-20, and/or UL 1562.

1. Resistance measurements of all windings on the rated voltage connection and at the tap extremes.
2. Ratio tests on the rated voltage connection and on all tap connections.
3. Polarity and phase-relation tests on the rated voltage connections.
4. No-load loss at rated voltage on the rated voltage connection.
5. Exciting current at rated voltage connection.
6. Impedance and load loss at rated current on the rated voltage connection.
7. Temperature Test or tests shall be made. Tests shall not be required when there is available a record of a temperature test on an essentially duplicate unit. When a transformer is supplied with auxiliary cooling equipment to provide more than one KVA rating, temperature tests as listed above shall be made on the lowest KVA OA rating and the highest KVA FA rating.
8. Applied potential test.
9. Induced potential tests.

Results of the above tests including no load loss data shall be submitted with final drawings in the form of certified test reports.

- D. The following factory tests shall be made on the secondary switchboard, although not necessarily in the order listed. All tests shall be in accordance with the latest revision NEMA PB-2 and/or UL 891:

1. A dielectric withstand test of 1000 VDC shall be made between each phase and ground with all switching devices closed and phases not under test grounded.
2. The grounding of instrument transformer cases or frames, as applicable, shall be checked with a low potential source.
3. Control wire continuity and correctness shall be verified by actual electrical operation of the control component or individual circuit continuity checks with electrical instruments.
4. Control wire insulation shall be tested with the application of 1000 VDC after circuit grounds have been disconnected for the test. Sensitive or electronic equipment shall be disconnected for the test.
5. Polarity tests shall be performed to verify that instrument transformers have been correctly connected.

Results of the above tests shall be submitted with final drawings in the form of certified test reports. Third party certification is not required.

#### 1.5 Submittals for Approval

- A. Manufacturers Data: Submit six (6) copies of manufacturers data for the following components:
  1. Load Interrupter Switch
  2. Primary Fuses
  3. Arresters
  4. Transformer
  5. Low Voltage Circuit Breaker
  6. Instruments and Meters
  7. Instrument Transformers
  8. Control Component Devices
- B. Shop Drawings: Submit six (6) copies of shop drawings for the secondary unit substation including the following:
  1. Overall dimensions, front view, sectional views, conduit entrance location(s), equipment access requirements and weights.
  2. Bus arrangements including dimensions and ampere ratings of all bus bars, including ground bus.
  3. Load interrupter switch type and interrupting rating.
  4. Transformer nameplate diagram.

5. Type and spacing of bus supports.
6. Maximum short circuit bracing.
7. Circuit breaker type, interrupting rating, instrument transformers and meters.
8. Elementary diagrams and wiring diagrams having their terminals identified, and indicating the internal wiring for each item of equipment and the interconnection between the items.
9. One line diagram.
10. Details of bus connections.
11. Anchoring instructions to meet UBC Seismic Zone 4 requirements.
12. Instrument transformers and meters.
13. Proposed nameplate schedule.
14. Itemized and coded bill of material.

Before shipment, all shop drawings shall be approved by the Engineer.  
Shipping splits shall be approved in writing.

- C. Certified tests reports: Submit six (6) copies of certified tests reports for the following:

1. Transformer
2. Switchgear Factory Tests
3. Paint qualification test in accordance with ANSI C37.20.3 section 5.2.8

Before shipment all certified test reports shall be approved by the Engineer.

- D. Operating and Maintenance Instructions: Furnish 3 copies of maintenance, instructional literature and renewal parts data bound in a loose leaf notebook. Notebook shall contain but not be limited to the following:

1. Load Interrupter Switch
2. Primary Fuses
3. Arresters
4. Instruments and Meters
5. Instrument Transformers
6. Control Component Devices
7. Meters (each type)

- 8. Transformer
- 9. Circuit Breakers

1.6 Warranty

- A. Equipment shall be warranted for either 18 months from date of shipment or 12 months from date of energizing, whichever comes first.

PART 2 PRODUCTS

2.1 Load Interrupter Switch

- A. The primary fused switch shall consist of deadfront, completely metal enclosed free standing structure(s) containing interrupter switches and fuses of the number, rating and type noted on the drawings or specified herein. All switches shall meet or exceed all applicable ANSI C37.47 requirements.
- B. Acceptable manufacturers are Square D or Westinghouse.
- C. The load interrupter switches shall be quick-make, quick-break three pole, gang operated, with stored energy operation. Each switch shall have the following minimum rating:

System Voltage	2.4 KV 3 phase, 3 wire
Maximum Design Voltage	5 KV
Basic Impulse Level	60 KV
Amperes Continuous	600 Amperes
Amperes Interrupting	600 Amperes
Momentary (Switch Closed, 10 cycle)	40,000 Amps. Asym.
Fault Close	40,000 Amps. Asym.

- D. A manual over toggle type stored energy spring mechanism shall be supplied to provide opening and closing action of the switch. The speed of opening and closing the switch shall be independent of the operator, and it shall be impossible to tease the switch into any intermediate position.
- E. The interrupter switch shall have separate main and make/break contacts to provide maximum endurance for fault close and load interrupting duty. The switch assembly shall have insulating barriers between phase and between outer phases and the enclosure.
- F. The following features shall be supplied on every three pole, two position open-closed switch:
  - 1. A high impact viewing window that permits full view of the position of all three switch blades through the closed door.
  - 2. A fuse access door interlocked with the switch so that:
    - a. The switch must be opened before access to the fuses is possible.
    - b. The door must be closed before the switch can be closed.

3. A grounded metal barrier in front of every switch to prevent inadvertent contact with any live part, yet allow for a full-view inspection on the switch blade position.
  4. Provision for padlocking the switch in the open or closed position.
  5. Permanent "Open-Closed" switch position indicators.
- G. Install three (3) glow type high voltage indicators on the line side of each duplex switch mounted to be visible through the viewing window.
- H. Fuses
1. Fault protection shall be furnished by fuses. Fuses shall be [Westinghouse type CLE, 250E, 2750V] [Shawmut type CS-3, 250E, 5500V] maximum design rating and 50,000 ampere symmetrical interrupting rating. Furnish three spare fuses for each fuse switch in a holder mounted on the inside of the fuse access door.
  2. Fuse clips shall be either Westinghouse "V-block" or other engineer approved equivalent.
- I. Bus Construction
1. One two hole NEMA pad per phase shall be provided with crimp type cable terminals suitable for copper cable of the number and sizes indicated on the drawings. Sufficient vertical space shall be supplied for contractor supplied electrical stress relief termination system. Provide a cable support rack for contractor installed cables.
  2. All bus shall be copper and be mounted on NEMA rated glass polyester insulators. All bussing shall be braced for the maximum available fault current.
  3. All bolted current carrying connections shall be fastened with two (2) bolts. All hardware used at bolted connections shall be [high tensile strength and plated] hex head, silicone bronze with Bellville type spring washers. All washers shall be plated.
- J. Enclosure
1. Enclosure construction shall universal frame type using deformed, welded and bolted members. Barriers between sections or compartments shall be formed with tightly fitting steel sheets, removable as necessary for access, but without exposing circuits in adjacent compartments. All hardware shall be hex head, high strength steel. Slotted heads are not allowed. Plastic or similar plugs shall not be used to cover holes. Where required, use plated carriage bolts to close pre-fabricated holes.
  2. All enclosing covers and doors shall be fabricated from not less than 11-gauge steel. All holes shall be neatly punched and edges and corners of sheets shall be rounded and sharp projections ground off before finishing. To facilitate installation and maintenance of cables and bus, rear hinged padlockable doors shall be supplied. Rear doors shall be bolted closed with a minimum of three (3) 3/8-inch self-captured bolts.

3. Outdoor units shall be NEMA 3R and have a sloped drip-proof roof. Each switch cubicle shall have a single, full length, flanged front door over the switch and fuse assembly and shall be equipped with two (2) rotary latch type padlockable handles. Use of three point latch assemblies is not acceptable. Door shall be hinged on the opposite side of the switch operator to provide clear access for operation.
  4. All openings shall be screened to prevent the entrance of small animals, and barred to inhibit the entrance of dirt, dust, etc. Doors shall be gasketed. A minimum of one 250 watt, 120 volt space heater shall be provided in each cubicle. Power for the space heater(s) shall be furnished [from a separate source] [from a control power transformer as indicated] and controlled by a thermostat.
  5. All enclosing and supporting steel shall be painted utilizing an initial phosphatizing cleaning treatment, followed by an epoxy primer coat and epoxy final finish coat baked on to a total of three mils average thickness for interior surfaces and five mils average thickness for exterior surfaces. Paint color shall be in accordance with ANSI Z55.1 and as specified under paragraph 1.1.
- K. Arresters: 3 KV intermediate class surge arresters shall be provided connected at the incoming terminations and securely grounded to the metal structure.
- L. Instruments, Relays and Control Component Devices
1. Small wiring and terminal blocks within the switch shall be furnished as necessary. Use type SIS stranded wire for all control and instrumentation circuits. Terminate wires with compression type ring terminals, Thomas & Betts "Sta-kon" or equivalent. All groups of control wires shall be labeled with wire markers and all wires leaving the switch shall be provided with terminal blocks. Terminal blocks shall be strap screw type rated 600 V, 30A minimum with numbering strips. Use of compression type or sectional terminal blocks is not acceptable. Enclose all low voltage equipment in a separate wireway segregated from the high voltage compartment by a removable cover.
  2. Install key interlocks on duplex switches such that only one access door can be opened at a time, and only if both switches are open. Provide a warning sign which states: "Caution - Load side of switch and fuses may be energized unless both switches are open".
  3. Install a zero sequence 50/5 ratio current transformer for the incoming cable of each duplex switch. Current transformer shall conform to ANSI C57.13 requirements.
  4. Connect current transformer to a 0-1 ampere full scale panel meter.
  5. Shunt panel meter with separate push-to-read button. Provide an
  6. Install one set each N/O and N/C contacts on each duplex switch operator and wire to a terminal block in the low voltage wireway. Secondary Distribution Switchboard

## 2.2 Transformer

A. The transformer shall be of explosion resistant, fire-resistant, air insulated, dry type construction, cooled by the natural circulation of air through the windings. Connections between the primary device and the transformer shall be bus, and between the transformer and secondary shall be flexible shunts to busway. Transformer enclosure shall be ventilated, NEMA 2, drip-proof, with lifting holes. All ventilation openings shall be protected against falling dirt.

B. Transformer windings shall be constructed of copper.

C. The ratings of the transformer shall be as follows or as shown on the drawings:

KVA Rating	:	750 AA
Impedance	:	5.75% +/-7-1/2%
HV	:	2400 V DELTA
HV BIL	:	60 KV
HV Taps	:	2 - 2-1/2% full capacity above and below nominal
LV	:	208/120 V Wye
LV BIL	:	10 KV

Approved manufacturers are Square D and ABB.

D. Transformer shall be cooled by natural Air convection (AA).

E. The electrical insulation system shall utilize Class H material in a fully rated 220°C system. Transformer design temperature rise shall be based on a 30°C average ambient over a 24 hour period with a maximum of 40°C. Solid insulation in the transformer shall consist of inorganic materials such as porcelain, glass fiber, electrical grade glass polyester or Nomex. All insulating materials must be rated for continuous 220°C duty. The insulation between the high and low voltage coils shall be more than sufficient for the voltage stress without the need of a varnish.

F. The core/coil assembly shall be impregnated with (VPI) with a pre-catalyzed resin. The assembly shall be installed on vibration-absorbing pads.

G. The transformer cores are to be constructed of high grade, non-aging silicon steel laminations with high magnetic permeability, and low hysteresis and eddy current losses. Magnetic flux densities are to be kept well below the saturation point. The core laminations shall be clamped together with heavy, structural steel bars or angles.

H. The transformer shall be supplied in a knockdown case design, for ease in fitting through limited openings, and shall be of heavy gauge sheet steel construction, equipped with removable panels for access to the core and coils. Equip enclosure with provisions for lifting. Construct base with structural steel members to allow skidding or rolling in any direction. The wiring compartment shall be suitable for conduit entry and shall meet bending radius requirements to accommodate wire sizes as indicated on the plans.

I. Provide a winding temperature indicator consisting of three high-accuracy thermistor sensors, installed directly on the winding at the hottest spot, and a digital readout.

- J. Transformer shall include: Diagram instruction plate, provisions for lifting and jacking, removable case panel for access to high voltage strap type connector taps for de-energized tap changing; two ground pads.
- K. The transformer shall be designed to meet the sound level standards for dry-type transformers as defined in NEMA ST-20.
- L. An engraved nameplate shall be mounted on the front of the transformer enclosure per the legend at the end of this section.

### 2.3 Secondary Switchboard

- A. Furnish a dead front type, completely metal enclosed, self-supporting structure independent of wall supports. Voltage rating shall be 208Y/120V, 3 phase, 4 wire. It shall consist of the required number of vertical sections bolted together to form one rigid switchboard. The sides shall be covered with removable bolt-on plates. All edges of front cover panels shall be formed. Sheet steel shall be 12 gauge minimum thickness unless proof of conformance to UL 891 rigidity requirements can be submitted. Identify any sheet components constructed of less than 12 gauge steel.
- B. Equipment shall comply with the latest applicable standards of NEMA PB2 and UL 891, and shall comply with all NEC and UL requirements for service entrance and a UL service entrance label shall be provided. Los Angeles City Test Lab Certification is acceptable in lieu of UL labeling.
- C. Small wiring, necessary fuse blocks and terminal blocks within the switchboard shall be furnished as required. All groups of control wires shall be labeled with wire markers and all wires leaving the switchboard shall be provided with terminal blocks having suitable numbering strips. All control devices shall be provided with engraved plastic nameplates black with white core, attached with two screws.
- D. Switchboard shall be provided with adequate lifting means and shall be capable of being rolled or moved into installation position and bolted directly to the floor without the use of floor sills.
- E. All power connections shall be bused from incoming to outgoing line terminals. Use of cable is not allowed. All bus bars shall be copper with silver-plated copper bolted connections at joints. The bus bars shall be of sufficient size to limit the temperature rise to 65°C rise at the ampere rating indicated on the drawing based on UL tests, and rated to withstand thermal stresses and mechanical forces exerted during short circuit conditions when directly connected to a power source having an available fault current of 30,000 amperes symmetrical at rated voltages. Provide full capacity neutral.
- F. A ground bus shall be furnished firmly secured to each vertical section structure and shall extend the entire length of the switchboard. The neutral bus shall be grounded to the ground bus with a bus conductor sized per UL and NEC requirements. An incoming ground lug shall be furnished. One ground lug for each feeder circuit shall also be supplied.
- G. All hardware used at bolted connections shall be of high strength, hex head, grade 5 steel with Bellville type spring washers. All bolts and washers shall be plated. Slotted head screws are not allowed.



- H. All hardware used on conductors shall be high-tensile strength and plated. All terminals shall be compression type suitable for copper cable of sizes indicated for 75°C cable.
- I. The manufacturer shall supply, upon request, test results to confirm that the switchgear has been tested to substantiate designs according to applicable NEMA and UL Standards. The tests shall verify the performance of the short circuit bracing and temperature rise of the bus assembly, the suitability of the enclosure venting and rigidity. In addition, each switchgear assembly shall be factory tested in accordance with the latest revision of NEMA PB-2 and/or UL 891.
- J. Front Accessible Switchboard:
1. Switchboards where shown shall be equal to Westinghouse POW-R-LINE C or Square D I-Line front accessible. All vertical sections without uniform depths shall align rear as shown on the drawings. Switchboard shall be constructed for placement against the wall.
  2. All internal devices shall be removable from the front and shall be panel mounted with the necessary line and load connections front accessible. All bus connections shall be accessible from the front. Nuts shall face top or front as applicable to allow access for torquing.
  3. Mount devices so manufacturer type, catalog number, ampere rating and interrupting rating are visible without removing panels or covers.
  4. Provide padlocking provisions for each circuit breaker.
- K. Customer Metering: Provide a separate customer metering compartment with front hinged door and include the following:
1. Current Transformers.
  2. Fused potential disconnecting means for metering as shown on the drawing. Use GE Class J pullout fuse blocks. Supply one set of spare fuses.
  3. Square D Power Logic based metering package with digital readout capable of displaying the following data:
    - a. Amperes in each phase
    - b. Voltage - Phase-to-phase and
    - c. Phase-to-neutral
    - d. Megawatts
    - e. Megavars
    - f. Power factor
    - g. Frequency
    - h. Megawatt demand

- i. Megawatt hours
  4. Equip Power Logic with RS-485 output for external communications.
  5. Westinghouse Flexitest Switch, 10 total poles, 4 potential, 6 current, Style Number 129A514G01. Wire switch to short current transformers to allow removal of metering package.
  6. Two (2) D-MON digital electronic kilowatt-hour/demand meters wired as indicated on the drawings, complete with pulse initiator for external communication.
  7. Provide control power to transformer temperature indicator, if required. Use GE Class J pullout fuse blocks. Supply one set of spare fuses.
- L. Overcurrent Devices:
1. Main protective devices shall be fixed mounted molded case breaker with 1600 ampere, 100% continuous rated frame with 1600 ampere trip ratings.
  2. Individually fixed mounted feeder protective devices shall be molded case breaker type with frame and trip rating as shown on the drawings.
  3. Devices shall have a minimum interrupting rating of 30,000 amperes at 240 volts.
- M. Molded Case Breakers
1. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism tripping of the breaker shall be clearly indicated by handle position. Contacts shall be non-welding silver alloy and arc extinction shall be accomplished by means of arc chutes.
  2. Breakers 150 amperes and below shall be thermal-magnetic trip with inverse time current characteristics and shall be Westinghouse Series C or Square D I-Line. Breakers with 250 and 400 amperes frame shall be Westinghouse Series C or Square D I-Line with either thermal-magnetic or solid state trip.
  3. Breakers with 600 amperes frame and above shall be Westinghouse Seltronic or Square D Standard Micrologic with solid-state trip unit and flux transfer shunt trip. Breakers shall have trip rating plugs with ratings as indicated on the drawings. Rating plugs shall be interlocked so they are NOT interchangeable between frames and interlocked such that a breaker cannot be latched with the rating plug removed.
    - a. Trip unit shall have adjustable short time setting with a fixed instantaneous override for circuit protection. Main breakers shall be provided with additional short delay trip time adjustment for increased system coordination.
    - b. Breakers shall have built-in test points for testing long delay, and instantaneous functions of the breaker by means of a 120 volt operated test kit.

4. Where indicated on the drawings, circuit breakers shall be UL listed and labeled for 100% application per NEC.

#### 2.4 Paint

- A. All enclosing and supporting steel of the unit substation shall be painted utilizing an initial phosphatizing cleaning treatment, followed by an epoxy primer coat and epoxy final finish coat baked on to a total of three mils average thickness for interior surfaces and five mils average thickness for exterior surfaces. Paint color shall be as specified under paragraph 1.1.

#### 2.5 Nameplates and Signs

- A. Provide all safety and warning signs in accordance with ANSI Z35.1 and as required by the NEC, NESC and any local codes.
- B. Furnish Master Nameplate giving voltage, ampere rating, short circuit rating, manufacturer's name, general order number and item number.
- C. An engraved lamincoid nameplate shall be provided to identify all switches, transformers, circuit breakers, instruments, door mounted devices and control equipment. Construct nameplate of 1/16 inch engraving lamincoid with letters machine engraved through black facing to white opaque core unless otherwise indicated. All nameplates shall have a 1/64-inch bevel on front edges. Nameplates shall be fastened with a minimum of two (2) stainless steel screws, not adhesive. Letter size shall be 1/4-inch high for unit identification and 1/8-inch high for device identification unless otherwise indicated. (See nameplate legend at end of section.)
- D. Provide mimic bus manufactured of anodized red aluminum, 1/4-inch wide, fastened with flat head recessed stainless steel screws on 4 inch centers.

#### 2.6 Concrete

- A. Concrete shall have a 28 day compressive strength of 3000 PSI. Provide ASTM C 33 aggregate, size No. 67. Provide a 5 percent air entrainment. The maximum chloride content shall not exceed one percent.
- B. Slump shall be 1 inch minimum, 3 inches maximum. Maximum allowable slump may be increased to 5 inches for concrete utilizing either fly ash, pozzolan, or ground slag for 20 to 25 percent, minimum, of the total cementitious material.

#### 2.7 Reinforcement

- A. Wire mesh shall be 6-inch by 6-inch No. 6, W2.9/W2.9 steel.
- B. Reinforcing bar shall be No. 4 steel.

### PART 3 EXECUTION

#### 3.1 General

- A. Install equipment in strict accordance with ANSI C2, NEMA PB 2.1, NFPA 70, shop drawings and manufacturer's instructions and recommendations.

- 3.2 Grounding
- A. Grounding shall be as specified in Section 16452, "Grounding."
- 3.3 Foundation for Equipment
- A. Mount unit substation on a concrete housekeeping slab. Unless otherwise indicated, the slab shall be at least 8 inches thick with 12 inch footing the perimeter of the slab. Slab shall extend a minimum of 8 inches beyond the equipment. Slab shall be placed on 6-inch thick, well compacted gravel base. The top of the slab shall be approximately 6 inches above existing finished grade level. Edges shall have 1 inch chamfer.
- B. [Reinforce the slab with 6- by 6- inch No. 6 wire mesh placed uniformly at the center of the slab.] [Reinforce the slab with No. 4 steel reinforcing bar place on 12 inch centers in both directions.] [Dowel slab to existing surface with No. 4 steel reinforcing bars on 24" centers in both directions.]
- C. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil- resistant caulking or sealant. Cut off and bush conduits 3 inches above slab surface. [Concrete work shall be as specified in Section 03300, "Cast-In-Place Concrete"] [Section 03302, "Cast-In-Place Concrete (Minor Construction)"].
- 3.4 Mounting
- A. Secure equipment to slab with anchor bolts or other means suitable for Seismic Zone 4 requirements. Install equipment plumb and in longitudinal alignment with pad or wall.
- 3.5 Field Tests and Inspections
- A. Perform in accordance with the manufacturer's recommendations and the latest referenced standards. Perform work in a careful and safe manner so as not to endanger personnel or equipment.
- B. Compare actual connections with wiring diagrams. Promptly bring any discrepancies to the attention of the engineer.
- C. Inspect all equipment and devices for damage or maladjustment caused by shipping or installation.
- D. Verify the tightness of all bolted connections with a torque wrench in accordance with manufacturer's recommended values. Mark each bolt with a permanent marker after torque is verified.
- E. Perform an insulation resistance test at 1000 VDC on low voltage switchgear prior to connecting flexible shunts to transformer. Disconnect fuses to heater and metering circuits prior to the performance of the test. Minimum insulation resistance shall be 10,000,000 ohms.
- F. Perform an insulation resistance test on the transformer as follows:
1. Primary to Secondary and Ground: 2500 VDC, 1000 Megohms minimum

2. Secondary to Primary and Ground: 1000 VDC, 100 Megohms minimum

3.6 Cleaning and Touch-Up

- A. After the equipment is installed, clean area of all dirt and debris.
- B. Touch up all scratches, mars, dents or other surface damage incurred during shipment or installation of equipment.
- C. Supply one can of touch-up paint to owner.

END OF SECTION

SECTION 26 11 16.01  
 SECONDARY UNIT SUBSTATION - EXTERIOR

PART 1 GENERAL

1.1 Description

- A. This specification covers [a] [an outdoor] secondary unit substation complete from the incoming line terminals to the outgoing line terminals. Equipment supplied includes a primary disconnect switch, [high fire point] liquid filled distribution transformer, and secondary distribution switchboard. All equipment shall be new and manufactured by a company regularly engaged in the fabrication of such equipment.
- B. Outdoor primary and secondary equipment shall be of NEMA 3R weatherproof construction, rodent proof and shall contain 120V space heaters. Outdoor liquid transformer unit shall include suitable outdoor paint finish and tank undercoating.
- C. Units shall be painted ANSI 61 for indoor service or ANSI 49 for outdoor service.

1.2 Applicable Standards

- A. The publications listed below form a part of this specification to the extent referenced. The latest revision of each publication shall be applied.

B. American National Standards Institute (ANSI) Publications:

C37.20	Switchgear Assemblies Including Metal Enclosed Bus
C37.47	Distribution Fuse Disconnecting Switches, Fuse Supports, and Current-Limiting Fuses
C39.1	Electrical Analog Instruments
C57.12.00	Liquid-Immersed Distribution, Power and Regulating Transformers, Standard General Requirement for
C57.12.13	Standard Requirements for Instrument
C57.12.90	Test Code for Liquid-Immersed Distribution, Power and Regulating Transformers and Guide for Short-Circuit Testing of Distribution and Power Transformers
C57.92	Loading Mineral-Oil-Immersed Overhead and Pad-Mounted Distribution Transformers Rated 500 KVA and Less with 65°C or 55°C Winding Rise, Guide for
Z55.1	Gray Finished for Industrial Apparatus and Equipment

C. American Society for Testing and Materials (ASTM) Publications:

D 92	Flash and Fire Points by Cleveland Open Cup
D 117	Electrical Insulating Oils of Petroleum Origin
D 877	Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
D 3487	Mineral Insulating Oil Used in Electrical Apparatus

D. National Electrical Manufacturers Association (NEMA) Publications:

AB-1	Molded Circuit Breakers
LA-1	Surge Arresters
PB-2	Dead-Front Distribution Switchboards
PB-2.1	Safe Handling, Installation, Operation and Maintenance of Switchboards
SG-5	Power Switchgear Assemblies
210	Secondary Unit Substations

E. National Fire Protection Association (NFPA) Publications:

70-1987	National Electrical Code
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F. Underwriters Laboratories, Inc. (UL) Publications:

467	Grounding and Bonding Equipment
489	Molded-Case Circuit Breakers and Circuit Breaker Enclosures
891	Dead-Front Switchboards
1437	Electrical Analog Instruments

1.3 Warranty

- A. Equipment shall be warranted for either 18 months from date of shipment of 12 months from date of energizing, whichever comes first.

1.4 Factory Tests

- A. The following factory tests shall be made on all transformers, although not necessarily in the order listed. All tests shall be in accordance with the latest revision of ANSI Test Code C57.12.90 and/or NEMA TR1:

1. Resistance measurements of all windings on the rated voltage connection and at the tap extremes.
  2. Ratio tests on the rated voltage connection and on all tap connections.
  3. Polarity and phase-relation tests on the rated voltage connections.
  4. No-load loss at rated voltage on the rated voltage connection.
  5. Exciting current at rated voltage on the rated voltage connection.
  6. Impedance and load loss at rated current on the rated voltage connection.
  7. Temperature Test or tests shall be made. Tests shall not be required when there is available a record of a temperature test on an essentially duplicate unit. When a transformer is supplied with auxiliary cooling equipment to provide more than one KVA rating, temperature tests as listed above shall be made on the lowest KVA OA rating and the highest KVA FA rating.
  8. Applied potential test.
  9. Induced potential tests.
  10. Results of the above tests including no load loss data shall be submitted with final drawings in the form of certified test reports.
- B. The following factory tests shall be made on all switchgear or switchboards, although not necessarily in the order listed. All tests shall be in accordance with the latest revision NEMA PB-2 and/or UL 891:
1. A dielectric withstand test of 1000 VDC shall be made between each phase and ground with all switching devices closed and phases not under test grounded.
  2. The grounding of instrument transformer cases or frames, as applicable, shall be checked with a low potential source.
  3. Control wire continuity and correctness shall be verified by actual electrical operation of the control component or individual circuit continuity checks with electrical instruments.
  4. Control wire insulation shall be tested with the application of 1000 VDC after circuit grounds have been disconnected for the test. Sensitive or electronic equipment shall be disconnected for the test.
  5. Polarity tests shall be performed to verify that instrument transformers have been correctly connected.
  6. Results of the above tests shall be submitted with final drawings in the form of certified test reports. Third party certification is not required.

#### 1.5 Submittals



- A. Manufacturers Data: Submit six (6) copies of manufacturers data for the following components:
1. Load Interrupter Switch
  2. Primary Fuses
  3. Liquid Filled Transformer
  4. Low Voltage Circuit Breaker
  5. Lightning Arresters
- B. Shop Drawings: Submit six (6) copies of shop drawings for the secondary unit substation including the following:
1. Overall dimensions, front view, sectional views, conduit entrance location(s), and weight.
  2. Bus arrangements including dimensions and ampere ratings of all bus bars, including neutral and ground bus.
  3. Details of bus connections.
  4. Type and spacing of bus supports.
  5. Maximum short circuit bracing.
  6. Circuit breaker type and interrupting rating
  7. Instrument transformers, control switches and meters.
  8. Elementary diagrams and wiring diagrams having their terminals identified, and indicating the internal wiring for each item of equipment and the interconnection between the items.
  9. One line diagram.
  10. Before shipment, all shop drawings shall be approved by the Engineer. Shipping splits shall be approved in writing.
- C. Seismic Bracing: Submit six (6) copies of site specific mounting details and methods for seismic bracing prepared and signed by a structural engineer registered in the state of California.
- D. Certified tests reports: Submit six (6) copies of certified tests reports for the following:
1. Liquid Filled Transformer
  2. Switchgear
  3. Before shipment all certified test reports shall be approved by the Engineer.

E. Operating and Maintenance Instructions: Furnish 3 copies of maintenance, instructional literature and renewal parts data bound in a loose leaf notebook. Notebook shall contain but not be limited to the following:

1. Load Interrupter Switch
2. Meters (each type).
3. Control switches (each type).
4. Transformer
5. Fuses
6. Heaters
7. Thermostat
8. Circuit Breakers

PART 2 PRODUCTS

2.1 Load Interrupter Switch

- A. The primary fused switch shall consist of deadfront, completely metal enclosed free standing structure(s) containing interrupter switches and fuses of the number, rating and type noted on the drawings or specified herein. All switches shall meet or exceed all applicable NEMA, ANSI and IEEE Standards.
- B. Acceptable manufacturers are Square D or Westinghouse.
- C. The load interrupter switches shall be quick-make, quick-break three pole, gang operated, with stored energy operation. Each switch shall have the following minimum rating:

System Voltage	2.4 KV 3 phase, 3 wire
Maximum Design Voltage	5 KV
Basic Impulse Level	60 KV
Amperes Continuous	600 Amperes
Amperes Interrupting	600 Amperes
Momentary (Switch	
Closed, 10 cycle)	40,000 Amps. Asym.
Fault Close	40,000 Amps. Asym.

- D. A manual over toggle type stored energy spring mechanism shall be supplied to provide opening and closing action of the switch. The speed of opening and closing the switch shall be independent of the operator, and it shall be impossible to tease the switch into any intermediate position.
- E. The interrupter switch shall have separate main and make/break contacts to provide maximum endurance for fault close and load interrupting duty. The switch assembly shall have insulating barriers between phase and between outer phases and the enclosure.

- F. The following features shall be supplied on every three pole, two position open-closed switch:
1. A high impact viewing window that permits full view of the position of all three switch blades through the closed door.
  2. A fuse access door interlocked with the switch so that:
    - a. The switch must be opened before access to the fuses is possible.
    - b. The door must be closed before the switch can be closed.
    - c. A grounded metal barrier in front of every switch to prevent inadvertent contact with any live part, yet allow for a full-view inspection on the switch blade position.
    - d. Provision for padlocking the switch in the open or closed position.
    - e. Permanent "Open-Closed" switch position indicators.
- G. Fault protection shall be furnished by fuses. Fuses shall be Westinghouse type CLE, 250E, 2750V maximum design rating and 50,000 ampere symmetrical interrupting rating. Furnish three spare fuses.
- H. One two hole NEMA pad per phase shall be provided for attaching contractor supplied crimp type cable terminals suitable for copper cable of the number and sizes indicated on the drawings. Sufficient vertical space shall be supplied for contractor supplied electrical stress relief termination system.
- I. All bus shall be copper and be mounted on NEMA rated glass polyester insulators. All bussing shall be braced for the maximum available fault current. All hardware used at bolted connections shall be hex head, Grade 5 steel with Bellville type spring washers. All bolts and washers shall be plated.
- J. Enclosure construction shall be of the universal frame type using deformed, welded and bolted members. All enclosing covers and doors shall be fabricated from not less than 11-gauge steel. Plastic or similar plugs shall not be used to cover holes. To facilitate installation and maintenance of cables and bus, rear hinged padlockable doors shall be supplied. All hardware shall be hex head, high strength steel. Slotted head screws are not allowed.
- K. Each switch cubicle shall have a single, full length, flanged front door over the switch and fuse assembly and shall be equipped with two (2) rotary latch type padlockable handles.
- L. Outdoor units shall have a sloped drip-proof roof. All openings shall be screened to prevent the entrance of small animals, and barriered to inhibit the entrance of dirt, dust, etc. Doors shall be gasketed. A minimum of one 250 watt, 120 volt space heater shall be provided in each cubicle. Power for the space heater shall be furnished the switchgear/low voltage switchboard.
- M. All enclosing and supporting steel shall be painted utilizing an initial phosphatizing cleaning treatment, followed by an epoxy primer coat and epoxy final finish coat baked on to a total of three mils average thickness for interior surfaces and five mils

average thickness for exterior surfaces. Paint color shall be as specified under paragraph 1.1.

- N. Small wiring and terminal blocks within the switch shall be furnished as necessary. All groups of control wires shall be labeled with wire markers and all wires leaving the switch shall be provided with terminal blocks having suitable numbering strips. Enclose all low voltage equipment in a separate wireway segregated from the high voltage compartment by a removable cover.
- O. A nameplate shall be mounted on the front door of the switch cubicle. Provide a plastic mimic bus 1/4 inch wide fastened with flat head recessed screws on 4 inch centers.
- P. 3 KV intermediate class surge arresters shall be provided connected at the incoming terminations and securely grounded to the metal structure.
- Q. The manufacturer shall supply, upon request, test results to confirm that the switch has been tested to substantiate designs according to applicable ANSI and NEMA Standards. The tests shall verify not only the performance of the switch and integrated switch-fuse assembly, but also the suitability of the enclosure venting, rigidity and bus bracing. In addition, each switch shall be factory tested in accordance with ANSI Standards.
- R. Install key interlocks on duplex switches such that only one access door can be opened at a time, and only if both switches are open. Provide a warning sign which states: "Caution - Load side of switch and fuses may be energized unless both switches are open."
- S. Install key interlock between switch and PLM receptacle such that plug cannot be inserted or removed unless switch is open. Provide a warning sign which states: "Caution - Switch must be open before inserting or removing PLM."

2.2 LIQUID FILLED TRANSFORMER

- A. The transformer unit supplied shall consist of a HV flange and a LV flange. Connections between the primary device and transformer shall be cable, and between the transformer and secondary shall be flexible bus braid.
  - 1. The ratings of the transformer shall be as follow:
 

KVA Rating	:	750/862/966 OA/FA/FA
Impedance	:	5.75%+/-7-1/2%
HV	:	2400 V DELTA
HV BIL	:	45 KV
HV Taps	:	2 - 2-1/2% full capacity above and below nominal
LV	:	480 V Wye
LV BIL	:	30 KV
- B. The unit shall be copper wound (alternate for aluminum), Mineral oil filled and shall be constructed in accordance with the applicable portions of the latest editions of ANSI C57.12.00, C57.12.13, C57.12.27, and the N.E.C.

- C. Acceptable manufacturers are ASEA Brown Boveri, Baltau Standard, General Electric, or Square D.
- D. The transformer shall carry its continuous rating with average winding temperature rise by resistance that shall not exceed 55 degrees C, based on average ambient of 30 degrees C over 24 hours with a maximum of 40 degrees C. The insulation system shall allow an additional 12% KVA output at 65 degrees C average winding temperature rise by resistance, on a continuous basis, without any decrease in normal transformer life.
- E. Transformer shall include fans and auxiliary equipment necessary for automatic temperature controlled forced air cooling to obtain an additional 15% capacity.
- F. The transformer shall be designed to carry short time emergency overloads in accordance with ANSI C57.92 and NEMA TR 98 as applicable. Duration and magnitude of designed withstand capacity shall be as outlined in ANSI C57.12 and the latest draft of the IEEE Short Circuit Test Code.
- G. Substation features and accessories shall include de-energized tap changer with cover mounted, externally operated, padlockable handle; combination drain and filter valve and sampling device; manual gas pressure test connection; one inch filling plug and filter press connection in cover; dial type top liquid thermometer with alarm contacts; magnetic liquid level gauge; provisions for lifting; provisions for jacking; base designed for skidding or rolling in two directions; pressure relief device; ground pad; stainless steel instruction nameplate; pressure/vacuum gauge; welded-on main tank cover with handhole in cover; cooling fans and auxiliary control equipment.
- H. All high voltage winding shall have epoxy insulation.
- I. The main transformer tank and attached components shall be sealed and designed to withstand pressure 25% greater than the required operating design value without permanent deformation. Construction shall consist of carbon steel plate reinforced with external sidewall braces. All seams and joints shall be continuously welded. Adequate gas space shall be provided to limit internal pressure due to normal load cycle operation.
- J. Each radiator assembly shall be individually welded and receive a quality control pressurized check for leaks. The entire tank assembly shall receive a similar leak test before tanking. A final six hour leak test shall be performed after the transformer is tanked, welded and completed to ensure that there are no leaks before shipment.
- K. Transformer shall be painted utilizing an initial phosphatizing cleaning treatment, followed by an epoxy primer coat baked on to a total of five mils average thickness. Paint color shall be as specified under paragraph 1.1.

### 2.3 Secondary Distribution Switchboard

- A. Furnish a dead front type, completely metal enclosed, self-supporting structure independent of wall supports. Voltage rating shall be [480Y/277V] [208Y/120V], 3 phase, 4 wire. It shall consist of the required number of vertical sections bolted together to form one rigid switchboard. The sides and rear shall be covered with removable bolt-on plates. All edges of front cover panels shall be formed.

- B. Equipment shall comply with the latest applicable standards of NEMA PB2 and UL 891, and shall comply with all NEC and UL requirements for service entrance and a UL service entrance label shall be provided. Los Angeles City Test Lab Certification is acceptable in lieu of UL labeling.
- C. Small wiring, necessary fuse blocks and terminal blocks within the switchboard shall be furnished as required. All groups of control wires shall be labeled with wire markers and all wires leaving the switchboard shall be provided with terminal blocks having suitable numbering strips.
- D. Switchboard shall be provided with adequate lifting means and shall be capable of being rolled or moved into installation position and bolted directly to the floor without the use of floor sills.
- E. All bus bars shall be copper with silver-plated copper bolted connections at joints. The bus bars shall be of sufficient size to limit the temperature rise to 65 degree C rise at 1200 amperes based on UL tests, and rated to withstand mechanical forces exerted during short circuit conditions when directly connected to a power source having an available fault current of [30,000 amperes symmetrical at rated voltages][as indicated on the drawings]. Provide full capacity neutral. Include provisions for future extension of main bus. (See Alternate 2).
- F. A ground bus shall be furnished firmly secured to each vertical section structure and shall extend the entire length of the switchboard. An incoming ground lug shall be furnished. One ground lug for each feeder circuit shall also be supplied.
- G. All hardware used at bolted connections shall be of high strength, hex head, [grade 5 steel] [silicone bronze] with Bellville type spring washers. All bolts and washers shall be plated. Slotted head screws are not allowed.
- H. All hardware used on conductors shall be high-tensile strength and plated. All terminals shall be compression type suitable for copper cable of sizes indicated for 75 degree C cable.
- I. Front and Rear Accessible Switchgear:
  - 1. Switchboards where shown shall be equal to Westinghouse POW-R-LINE C or Square D I-Line front and rear accessible. All vertical sections shall align front and rear with uniform depth as shown on the drawings. Switchboard shall be constructed for placement away from walls with required NEC clearances.
  - 2. All internal devices, except the main disconnect, shall be removable from the front and shall be panel mounted with the necessary line and load connections front accessible. The main device and its connections shall be rear accessible. All bus connections not accessible from the front shall be accessible from the rear. Nuts shall face top, front (or rear as applicable to allow access for torquing).
- J. Customer Metering: Provide a separate customer metering compartment with front hinged door and include the following:
  - 1. Current Transformers.

2. Potential transformers including primary and secondary protection with disconnecting means for metering as shown on the drawing.
3. Westinghouse IQ Data Plus II Microprocessor based metering package with digital readout capable of displaying the following data:
  - Amperes in each phase
  - Voltage - Phase-to-phase and Phase-to-neutral
  - Megawatts
  - Megavars
  - Power factor
  - Frequency
  - Megawatt demand
  - Megawatt hours]
4. Equip IQ Data Plus with PONI Card for external communications.
5. Westinghouse Flexitest Switches.
6. Voltmeter with phase selector switch.
7. Ammeter with phase selector switch.
8. Control Power Transformer, including primary and secondary [disconnecting device and overcurrent protection] [pullout fuse block] [circuit breaker], shall be connected ahead of the main circuit breaker for control power to the primary switch heater, secondary switchgear heaters(s) and [future] transformer fans. A separate [disconnecting device] shall be provided for each load. Transformer shall be adequately sized for above loads.
 

\*\*\* or \*\*\*
9. Control power [disconnecting device and overcurrent protection] [pullout fuse block] [circuit breaker], shall be connected ahead of the main circuit breaker for the primary switch heater, secondary switchgear heaters(s) and [future] transformer fans. A separate device shall be provided for each load.
- K. Instruments: Indicating switchboard style with 2% accuracy meeting ANSI C39.1 and UL 1437. Instruments shall be 4 inches square with 250-degree scale.
- L. Instrument Control Switches: Provide rotary cam-operated type with positive means of indicating contact positions. Switches shall have silver-to-silver contacts enclosed in a protective cover which can be removed to inspect the contacts.
- M. Overcurrent Devices:
  1. Main protective device shall be fixed mounted molded case breaker [with \_\_\_\_\_ ampere, 100% continuous rated frame with \_\_\_\_\_ ampere trip ratings] [100% continuous rated frame with frame and trip ratings as shown on the drawings].
  2. Individually fixed mounted feeder protective devices shall be molded case breaker type with frame and trip rating as shown on the drawings.

3. Devices shall have a minimum interrupting rating of [30,000] [42,000] amperes at [480] [240] volts.

N. Molded Case Breakers

1. Protective devices as shown shall be molded case circuit breakers providing complete circuit overcurrent protection by having inverse time and instantaneous tripping characteristics.
2. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism tripping of the breaker shall be clearly indicated by handle position. Contacts shall be non-welding silver alloy and arc extinction shall be accomplished by means of arc chutes.
3. Breakers 150 amperes and below shall be thermal-magnetic trip with inverse time current characteristics and shall be Westinghouse Series C or Square D breakers with 250 and 400 amperes frame shall be Westinghouse Series C or Square D with either thermal-magnetic or solid state trip.
4. Breakers with 600 amperes frame and above shall be Westinghouse Seltronic or Square D Micrologic with solid-state trip unit and flux transfer shunt trip. Breakers shall have trip rating plugs with ratings as indicated on the drawings. Rating plugs shall be interlocked so they are NOT interchangeable between frames and interlocked such that a breaker cannot be latched with the rating plug removed.
5. Trip unit shall have adjustable short time setting with a fixed instantaneous override for circuit protection. Main breakers shall be provided with additional short delay trip time adjustment for increased system coordination.
6. Breakers shall have built-in test points for testing long delay, and instantaneous [and ground fault] functions of the breaker by means of a 120 volt operated test kit.
7. Breaker mounting shall be made so rating data can be visible without removing any covers or trim.
8. Breakers, where indicated on the drawings, shall be UL listed and labeled for 100% application per NEC.

O. Nameplates: Engraved nameplates shall be furnished for all mains and feeder circuits with designation as indicated on the drawings in the following nameplate schedule. Furnish Master Nameplate giving voltage, ampere rating, short circuit rating, manufacturer's name, general order number and item number. All nameplates shall be screw on. Adhesive fastening is not acceptable.

P. Enclosures: Enclosures shall be of NEMA 3R outdoor construction as shown on the drawings. Outdoor enclosures shall be non-walk-in and provided with space heaters and adjustable thermostat. Doors shall be gasketed. All openings shall be sealed with carriage bolts. Use of snap-in plastic or metal plugs is not allowed.

1. Sections 36-inches wide or less shall have a single, full length, flanged front door.



2. Sections over 36-inches wide shall have double, full length, flanged front doors.
  3. Doors shall be equipped with three-point spring-loaded overtoggle roller type latches with padlockable handles.
  4. All doors shall meet UL 891 stiffness requirements.
- Q. Paint: All enclosing and supporting steel of the switchboard shall be painted utilizing an initial phosphatizing cleaning treatment, followed by an epoxy primer coat and epoxy final finish coat baked on to a total of three mils average thickness for interior surfaces and five mils average thickness for exterior surfaces. Paint color shall be as specified under paragraph 1.1.
- 2.4 Conductor Lugs
- A. Conductor lugs shall be two hole long barrels style manufactured of high-conductivity tin plated copper.
- 2.5 Concrete
- A. Concrete shall have a 28 day compressive strength of 3000 PSI. Provide ASTM C 33 aggregate, size No. 67. Provide a 5 percent air entrainment. The maximum chloride content shall not exceed one percent.
  - B. Slump shall be 1 inch minimum, 3 inches maximum. Maximum allowable slump may be increased to 5 inches for concrete utilizing either fly ash, pozzolan, or ground slag for 20 to 25 percent, minimum, of the total cementitious material.
- 2.6 Reinforcement
- A. Wire mesh shall be 6-inch by 6-inch No. 6, W2.9/W2.9 steel.
  - B. Reinforcing bar shall be No. 4 steel.
- PART 3 EXECUTION
- 3.1 General
- A. Install equipment in strict accordance with ANSI C2, NEMA PB 2.1, NFPA 70, shop drawings and manufacturer's instructions and recommendations.
- 3.2 Grounding
- A. Grounding shall be as specified in Section 16452, "Grounding."
- 3.3 Foundation for Equipment
- A. Mount unit substation on a concrete housekeeping slab. Unless otherwise indicated, the slab shall be at least 8 inches thick with 12 inch footing the perimeter of the slab. Slab shall extend a minimum of 8 inches beyond the equipment. Slab shall be placed on 6-inch thick, well compacted gravel base. The top of the slab shall be approximately 6 inches above existing finished grade level. Edges shall have 1 inch chamfer.

- B. [Reinforce the slab with 6- by 6- inch No. 6 wire mesh placed uniformly at the center of the slab.] [Reinforce the slab with No. 4 steel reinforcing bar place on 12 inch centers in both directions.] [Dowel slab to existing surface with No. 4 steel reinforcing bars on 24" centers in both directions.]
- C. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil- resistant caulking or sealant. Cut off and bush conduits 3 inches above slab surface. [Concrete work shall be as specified in Section 03300, "Cast-In-Place Concrete"] [Section 03302, "Cast-In-Place Concrete (Minor Construction)"]

#### 3.4 Mounting

- A. Secure equipment to slab with anchor bolts or other means suitable for Seismic Zone 4 requirements. Install equipment plumb and in longitudinal alignment with pad or wall.

#### 3.5 Field Tests and Inspections

- A. Perform in accordance with the manufacturer's recommendations and the latest referenced standards. Perform work in a careful and safe manner so as not to endanger personnel or equipment.
- B. Compare actual connections with wiring diagrams. Promptly bring any discrepancies to the attention of the engineer.
- C. Inspect all equipment and devices for damage or maladjustment caused by shipping or installation.
- D. Verify the tightness of all bolted connections with a torque wrench in accordance with manufacturer's recommended values. Mark each bolt with a permanent marker after torque is verified.
- E. Perform an insulation resistance test at 1000 VDC on low voltage switchgear prior to connecting flexible shunts to transformer. Disconnect fuses to heater and metering circuits prior to the performance of the test. Minimum insulation resistance shall be 10,000,000 ohms.
- F. Perform an insulation resistance test on the transformer as follows:
  - 1. Primary to Secondary and Ground: 2500 VDC, 1000 Megohms minimum
  - 2. Secondary to Primary and Ground: 1000 VDC, 100 Megohms minimum

#### 3.6 Touch-Up

- A. After the equipment is installed, touch up all scratches, mars, dents or other surface damage incurred during shipment or installation of equipment.
- B. Supply one can of touch-up paint to owner.

END OF SECTION

SECTION 26 11 16.02  
 SECONDARY UNIT SUBSTATIONS - INDOOR

PART 1 GENERAL

1.1 GENERAL

- A. Work Included: This section covers the work necessary to install the customer furnished indoor substation as indicated on the drawings and specified herein.
- B. Related Work Specified and Performed Under Other Sections:
- C. Submittals During Construction: Submittals during construction shall be made in accordance with Section 16000 ELECTRICAL - GENERAL PROVISIONS. In addition, the following specific information shall be provided:
  - 1. Provide six (6) copies of certified reports on all tests.
- D. Standards: The secondary unit substation shall be handled and installed in accordance with the following standards:
 

ANSI	C2	National Electrical Safety Code
ASTM	C-33	Concrete Aggregates
NEMA	PB 2.1	General Instructions for Proper Handling, Installation, Operation and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less
NFPA	70	National Electrical Code
UL	467	Grounding and Bonding Equipment
- E. Tests: Perform the acceptance tests as specified herein. Provide a certified report on all tests.

PART 1 PRODUCTS

1.1 MATERIALS

- A. Equipment Furnished by Owner: The following equipment shall be provided by the owner:
  - 1. Primary Load Break Disconnect Switches: Two (2) 5 kV, 3 pole, 200 A, NEMA 1 indoor, complete with fuses.
  - 2. Dry Type Transformer: 500 kVA, 2400-208Y/120V
  - 3. Secondary Switchboard: 1600 A, 3 phase, 4 wire, NEMA 1 indoor.
- B. Concrete:
  - 1. Concrete shall have a 28 day compressive strength of 3000 PSI. Provide ASTM C 33 aggregate, size No. 67. Provide a 5 percent air entrainment. The maximum chloride content shall not exceed one percent.

2. Slump shall be 1 inch minimum, 3 inches maximum. Maximum allowable slump may be increased to 5 inches for concrete utilizing either fly ash, pozzolan, or ground slag for 20 to 25 percent, minimum, of the total cementitious material.
- C. Reinforcement:
1. Wire Mesh shall be 4-inch x 4-inch on center, W1.4/W1.4 minimum wire size.
  2. Reinforcement bar shall be #4 steel, ASTM A 615, Grade 40.

## PART 2 EXECUTION

### 2.1 INSTALLATION

- A. General: Install equipment in strict accordance with ANSI C2, NEMA PB 2.1, NFPA 70, shop drawings and manufacturer's instructions and recommendations.
- B. Foundation for Equipment: Mount unit substation on a concrete housekeeping slab sized as shown on the drawings. Reinforce the slab with [wire mesh] [reinforcement bar placed 12 inches on center in both directions] placed uniformly at the center of the slab.] The top of the slab shall be approximately 4 inches above existing finished floor and level. Edges shall have 1/2 inch chamfer.
- C. Mounting: Secure equipment to slab with anchor bolts or other means suitable for Seismic Zone 4 requirements. Drill through new housekeeping pad and fasten equipment into existing floor using expansion shields. Install equipment plumb and in longitudinal alignment with pad or wall.
- D. Field Tests and Inspections: Perform in accordance with the manufacturer's recommendations and the latest referenced standards. Perform work in a careful and safe manner so as not to endanger personnel or equipment.
1. Compare actual connections with wiring diagrams. Promptly bring any discrepancies to the attention of the engineer.
  2. Inspect all equipment and devices for damage or maladjustment caused by shipping or installation.
  3. Verify the tightness of all bolted connections with a torque wrench in accordance with manufacturer's recommended values. Mark each bolt with a permanent marker after torque is verified.
  4. Perform an insulation resistance test at 1000 VDC on low voltage switchgear prior to connecting flexible shunts to transformer. Disconnect fuses to heater and metering circuits prior to the performance of the test. Minimum insulation resistance shall be 10,000,000 ohms.
  5. Perform an insulation resistance test on the transformer as follows:
    - a. Primary to Secondary and Ground: 2500 VDC, 1000 Megohms minimum
    - b. Secondary to Primary and Ground: 1000 VDC, 100 Megohms minimum

- E. Touch-up: After the equipment is installed, touch up all scratches, mars, dents or other surface damage incurred during shipment or installation of equipment.

END OF SECTION

SECTION 26 12 00  
MEDIUM VOLTAGE TRANSFORMERS

## PART 1 – GENERAL

## 1.1 RELATED DOCUMENTS

&lt;&lt;TO BE COMPLETED BY CONSULTING ENGINEER&gt;&gt;

## 1.2 SUMMARY

- A This Section includes the following types of transformers with medium-voltage primaries
  1. Liquid-filled distribution and power transformers.
- B Units shall be painted ANSI 61 for indoor service or ANSI 49 for outdoor service.

## 1.3 DEFINITIONS

&lt;&lt;TO BE COMPLETED BY CONSULTING ENGINEER&gt;&gt;

## 1.4 APPLICABLE STANDARDS

&lt;&lt;TO BE COMPLETED BY CONSULTING ENGINEER&gt;&gt;

## 1.5 SUBMITTALS

- A Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, location of each field connection, and performance for each type and size of transformer indicated.
- B Shop Drawings: Diagram power wiring.
- C Coordination Drawings: Floor plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved
  1. Underground primary and secondary conduit stub-up location.
  2. Dimensioned concrete base, outline of transformer, and required clearances.
  3. Ground rod and grounding cable locations.
  4. Clearance requirements for maintenance and compliance with NEC.
- D Manufacturer Seismic Qualification Certification: Submit certification that transformer assembly and components will withstand seismic forces defined in [Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems."] Include the following:
  1. Basis for Certification
    - a. Indicate whether withstand certification is based on actual test of assembled components or on calculation.
    - b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
  2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- E Qualification Data: For testing agency.

- F Source quality-control test reports.
  - G Field quality-control test reports.
  - H Follow-up service reports.
  - I Operation and Maintenance Data: For transformer and accessories to include in emergency, operation, and maintenance manuals.
- 1.6 QUALITY ASSURANCE
- A Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
    - 1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
  - B Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- 1.7 FACTORY TESTS
- A All tests shall be in accordance with the latest revision of ANSI Test Code C57.12.90 and/or NEMA TR 1.
- 1.8 DELIVERY, STORAGE, AND HANDLING
- A Equipment shall be protected from damage during delivery and handling.
  - B Store transformers protected from damage, weather and so condensation will not form on or in units. Provide temporary heating according to manufacturer's written instructions.
- 1.9 PROJECT CONDITIONS
- A Service Conditions: IEEE C37.121, usual service conditions except for the following:
    - 1. Exposure to seismic shock or to abnormal vibration, shock, or tilting.
- 1.10 COORDINATION
- A Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
  - B Coordinate installation of louvers, doors, spill retention areas, and sumps. Coordinate installation so no piping or conduits are installed in space allocated for medium-voltage transformers except those directly associated with transformers.
- 1.11 WARRANTY
- A Equipment shall be warranted for 12 months from the date of Final Acceptance.

## PART 2- PRODUCTS

## 2.1 MANUFACTURERS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ASEA Brown Boveri
  2. Baltau Standard
  3. General Electric
  4. Cutler Hammer
  5. Square D
  6. Acme Electric Corporation; Power Distribution Products Division.
  7. Cooper Industries; Cooper Power Systems Division.
  8. Federal Pacific Transformer Company; Division of Electro-Mechanical Corp.
  9. Virginia Transformer
  10. Siemens Energy & Automation, Inc.

## 2.2 PAD-MOUNTED, LIQUID-FILLED TRANSFORMERS

- A Description: Copper wound, pad-mounted, 2-winding transformers. Stainless-steel tank base, cabinet, and sills. HV flange and LV flange. All copper. Constructed in accordance with the applicable portions of the latest editions of ANSI C57.12.13, ANSI C57.12.26, IEEE C57.12.00.  
Duration and magnitude of designed withstand capacity shall be as outlined in ANSI C57.12 and the latest draft of the IEEE Short Circuit Test Code.
- B Ratings: Multiple kVA ratings. 5.75% +/- 6.5% impedance. HV -[4.8kV][12.48kV]. LV - [480][408/277V][120/208V].
- C Basic Impulse Level Nominal Primary Voltage 5kV: 75kV [for UPC]  
Basic Impulse Level Nominal Primary Voltage 15kV: 110 kV. [for HSC]
- D Insulating Liquid: Less flammable, mineral oil filed [edible-seed-oil based], and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic.
- E Insulation Temperature Rise: 55 degrees C when operated at rated kVA output in a 40 degrees C ambient temperature. Transformer shall be rated to operate at rated kilovolt ampere in an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C without loss of service life expectancy. The insulation system shall allow an additional 12% kVA output at 65 degrees C average winding temperature rise by resistance, on a continuous basis, without any decrease in normal transformer life.
- F High voltage windings: Epoxy insulation.
- G Temperature Control: Transformer shall include fans and auxiliary equipment necessary for automatic temperature controlled forced air cooling to obtain an additional 15% capacity.



- H Full-Capacity Voltage Taps: Four 2.5 percent taps, 2 above and 2 below rated high voltage; with externally operable tap changer for de-energized use and with position indicator and pad-lockable handle.
- I High-Voltage Switch: 600A, make-and-latch rating of 10-kA RMS, symmetrical, arranged for radial feed with 3-phase, 2-position, gang-operated, load-break switch that is oil immersed in transformer tank with hook-stick operating handle in primary compartment.
- J Primary Fuses: 150-kV fuse assembly with fuses complying with IEEE C37.47. Rating of current-limiting fuses shall be 50-kA RMS at specified system voltage.
1. Current-limiting type in dry-fuse holder wells, mechanically interlocked with liquid-immersed switch in transformer tank to prevent disconnect under load.
  2. Internal liquid-immersed cartridge fuses.
  3. Bay-O-Net liquid-immersed fuses that are externally replaceable without opening transformer tank.
  4. Bay-O-Net liquid-immersed fuses in series with liquid-immersed current-limiting fuses. Bay-O-Net fuses shall be externally replaceable without opening transformer tank.
  5. Bay-O-Net liquid-immersed current-limiting fuses that are externally replaceable without opening transformer tank.
- K High-Voltage Terminations and Equipment: Dead front with universal-type bushing wells for dead-front bushing-well inserts, complying with IEEE 386 and including the following:
1. Bushing-Well Inserts: One for each high-voltage bushing well.
  2. Surge Arresters: Dead-front, elbow-type, metal-oxide-varistor units.
  3. Portable Insulated Bushings: Arranged for parking insulated, high-voltage, load-break cable terminators; one for each primary feeder conductor terminating at transformer.
- L Accessories
1. Combination Drain and Filer Valve: 1 inch, with sampling device.
  2. Dial-type top liquid thermometer.
  3. Magnetic liquid-level gage.
  4. Pressure-vacuum gage.
  5. Pressure Relief Device: Self-sealing with an indicator.
  6. Mounting provisions for low-voltage current transformers.
  7. Mounting provisions for low-voltage potential transformers.
  8. Busway terminal connection at low-voltage compartment.
  9. Cooling fans
  10. Auxiliary control equipment
  11. Alarm contacts for gages and thermometer listed above.
- M Painting: Paint color shall be green or grey.
- N [Transformers shall be K rated as shown on the single line diagrams.]

### 2.3 IDENTIFICATION DEVICES

- A Nameplates: Engraved, laminated-plastic or metal nameplate for each transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 26 05 53 "Identification for Electrical Systems."

### 2.4 SOURCE QUALITY CONTROL

- A Factory Tests: Perform design and routine tests according to standards specified for components. Conduct transformer tests according to IEEE C57.12.90.
- B Factory Tests: Perform the following factory-certified tests on each transformer
  1. Resistance measurements of all windings on rated-voltage connection and on tap extreme connections.
  2. Ratios on rated-voltage connection and on tap extreme connections.
  3. Polarity and phase relation on rated-voltage connection.
  4. No-load loss at rated voltage on rated-voltage connection.
  5. Excitation current at rated voltage on rated-voltage connection.
  6. Impedance and load loss at rated current on rated-voltage connection and on tap extreme connections.
  7. Applied potential.
  8. Induced potential.
  9. Temperature Test
    - a. If transformer is supplied with auxiliary cooling equipment to provide more than one rating, test at lowest kilovolt-ampere Class OA or Class AA rating and highest kilovolt-ampere Class OA/FA or Class AA/FA rating.
    - b. Temperature test is not required if record of temperature test on an essentially duplicate unit is available.
  10. Owner will witness all required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.

### PART 3- EXECUTION

#### 3.1 EXAMINATION

- A Examine areas and conditions for compliance with requirements for medium-voltage transformers.
- B Examine roughing-in of conduits and grounding systems to verify the following:
  1. Wiring entries comply with layout requirements.
  2. Entries are within conduit-entry tolerances specified by manufacturer and no feeders will have to cross section barriers to reach load or line lugs.
- C Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.
- D Verify that ground connections are in place and that requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.
- E Proceed with installation only after unsatisfactory conditions have been corrected.

#### 3.2 INSTALLATION

- A Install transformers on concrete bases.
  1. Anchor transformers to concrete bases according to manufacturer's written instructions, seismic codes at Project, and requirements in [Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems."]

2. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit and 4 inches high.
  3. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in [Section 03 30 00 "Cast-in-Place Concrete."]
  4. Install dowel rods to connect concrete bases to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
  5. Install epoxy-coated anchor bolts, for supported equipment, that extend through concrete base and anchor into structural concrete floor.
  6. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  7. Tack-weld or bolt transformers to channel-iron sills embedded in concrete bases. Install sills level and grout flush with floor or base.
- B Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.
- 3.3 IDENTIFICATION
- A Identify field-installed wiring and components and provide warning signs as specified in Section 26 05 53 "Identification for Electrical Systems."
- 3.4 CONNECTIONS
- A Primary Device and Transformer: Connections shall be cable or copper flexible braid.
- B Transformer and Secondary Device: Connections shall be copper flexible braid.
- C All connections shall be with copper wire.
- D Ground equipment according to [Section 26 05 26 "Grounding and Bonding for Electrical Systems."]
- E Connect wiring according to [Section 26 05 19 "Low Voltage Electrical Power Conductors and Cables."] [Section 26 05 13 "Medium Voltage Cables."]
- 3.5 FIELD QUALITY CONTROL
- A Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B Perform the following field tests and inspections and prepare test reports
1. After installing transformers but before primary is energized, verify that grounding system at substation is tested at specified value or less.
  2. After installing transformers and after electrical circuitry has been energized, test for compliance with requirements.
  3. Testing shall include IR scanning of all electrical connections once energized. Test report shall include digital and thermal photographs of all scans including equipment that is both abnormal and normal.
  4. Perform visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.

5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C Remove and replace malfunctioning units and retest as specified above.
- D Test Reports: Prepare written reports to record the following:
1. Test procedures used.
  2. Test results that comply with requirements.
  3. Test results that do not comply with requirements and corrective actions taken to achieve compliance with requirements.
- 3.6 FOLLOW-UP SERVICE
- A Voltage Monitoring and Adjusting: If requested by the Owner, perform the following voltage monitoring after Substantial Completion but not more than six months after Final Acceptance
1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at secondary terminals of each transformer. Use voltmeters with calibration traceable to National Institute of Science and Technology standards and with a chart speed of not less than 1 inch per hour. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from nominal value by more than plus or minus 5 percent during test period, is unacceptable.
  2. Corrective Actions: If test results are unacceptable, perform the following corrective actions, as appropriate
    - a. Adjust transformer taps.
    - b. Prepare written request for voltage adjustment by electric utility.
  3. Retests: After corrective actions have been performed, repeat monitoring until satisfactory results are obtained.
  4. Report: Prepare written report covering monitoring and corrective actions performed.

END OF SECTION 26 12 00

SECTION 26 13 16  
 MEDIUM VOLTAGE FUSIBLE INTERRUPTER SWITCHGEAR  
 (AIR INSULATED)

PART 1 GENERAL

1.1 Specification Includes

- A. This specification covers air interrupter switches and switchgear complete from the incoming line terminals to the outgoing line terminals. All equipment shall be new and manufactured by a company regularly engaged in the fabrication of such equipment.
- B. Outdoor equipment shall be of NEMA 3R weatherproof construction, rodent proof and shall contain 120V space heaters. Units shall be painted ANSI 49 for outdoor service.
- C. The equipment shall be listed by UL, be approved by the City of Los Angeles Test Lab, or certified by an independent test laboratory acceptable to the City of Los Angeles prior to shipment.

1.2 Applicable Standards

- A. The publications listed below form a part of this specification to the extent referenced. The latest revision of each publication shall be applied.
- B. American National Standards Institute (ANSI) Publications:
  - C2 National Electrical Safety Code (NESC)
  - C37.20.3 Metal-Enclosed Interrupter Switchgear
  - C37.47 Distribution Fuse Disconnecting Switches, Fuse Supports, and Current-Limiting Fuses
  - C57.13 Standard Requirements for Instrument Transformers
  - Z35.1 Specifications for Accident Prevention Signs
  - Z55.1 Gray Finished for Industrial Apparatus and Equipment
- C. National Electrical Manufacturers Association (NEMA) Publications:
  - CC-1 Electric Power Connectors for Substations
  - LI-1 Industrial Laminated Thermosetting Plastics
- D. National Fire Protection Association (NFPA) Publications:
  - 70-1987 National Electrical Code (NEC)
- E. Underwriters Laboratories, Inc. (UL) Publications:

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Grounding and Bonding Equipment

## 1.3 Warranty

- A. Equipment shall be warranted for either 18 months from date of shipment or 12 months from date of energizing, whichever comes first.

## 1.4 Design Tests

- A. The manufacturer shall supply, upon request, design test results to confirm that the switch has been tested to substantiate designs according to applicable ANSI, NEMA and UL Standards. The tests shall verify not only the performance of the switch and integrated switch-fuse assembly, but also the suitability of the enclosure venting, rigidity, bus bracing and painting system. In addition, each switch shall be factory tested in accordance with ANSI and UL Standards.

## 1.5 Factory Tests

- A. The following factory tests shall be made on all switchgear, although not necessarily in the order listed. All tests shall be in accordance with the latest revision of ANSI C37.20.3 and/or UL standards:
  - 1. A dielectric withstand test shall be made between each phase and ground with all switching devices closed and phases not under test grounded.
  - 2. Mechanical tests shall be performed to verify the integrity of all operating mechanisms and interlocks.
  - 3. The grounding of instrument transformer cases or frames, as applicable, shall be checked with a low potential source.
  - 4. Control wire continuity and correctness shall be verified by actual electrical operation of the control component or individual circuit continuity checks with electrical instruments.
  - 5. Control wire insulation shall be tested with the application of 1500 V, 60 Hz for 1 minute after circuit grounds have been disconnected for the test. Sensitive or electronic equipment shall be disconnected for the test.
  - 6. Polarity tests shall be performed to verify that instrument transformers have been correctly connected.
- B. Results of the above tests shall be submitted with final drawings in the form of certified test reports. Third party certification is not required.

## 1.6 Submittals

- A. Manufacturers Data: Submit six (6) copies of manufacturers data for the following components:
  - 1. Load Interrupter Switch
  - 2. Primary Fuses

3. Arresters
  4. High Voltage Connector (PLM)
  5. Instruments and Meters
  6. Instrument Transformers
  7. Control Component Devices
  8. Heaters
  9. Thermostats
- B. Shop Drawings: Submit six (6) copies of shop drawings for the secondary unit substation including the following:
1. Overall dimensions, front view, sectional views, conduit entrance location(s) and weight.
  2. Anchoring instructions to meet UBC Seismic Zone 4 requirements.
  3. Bus arrangements including dimensions and ampere ratings of all bus bars, including ground bus.
  4. Type and spacing of bus supports.
  5. Maximum short circuit bracing.
  6. Load interrupter switch type and interrupting rating.
  7. Instrument transformers and meters.
  8. Proposed nameplate schedule.
  9. Itemized and coded bill of material.
  10. Elementary diagrams and wiring diagrams having their terminals identified, and indicating the internal wiring for each item of equipment and the interconnection between the items.
  11. One line diagram.
  12. Details of bus connections.
- C. Before shipment, all shop drawings shall be approved by the Engineer. Shipping splits shall be approved in writing.
- D. Certified tests reports: Submit six (6) copies of certified tests reports for the following:
1. Switchgear Factory Tests
  2. Paint qualification test in accordance with ANSI C37.20.3 section 5.2.8.

- E. Before shipment all certified test reports shall be approved by the Engineer.
- F. Operating and Maintenance Instructions: Furnish 3 copies of maintenance, instructional literature and renewal parts data bound in a loose leaf notebook. Notebook shall contain but not be limited to the following:
  - 1. Load Interrupter Switch
  - 2. Primary Fuses
  - 3. Arresters
  - 4. High Voltage Connector (PLM)
  - 5. Instruments and Meters
  - 6. Instrument Transformers
  - 7. Control Component Devices
  - 8. Heaters
  - 9. Thermostats

PART 2 PRODUCTS

2.1 Load Interrupter Switch

- A. The primary fused switch shall consist of deadfront, completely metal enclosed free standing structure(s) containing interrupter switches and fuses of the number, rating and type noted on the drawings or specified herein. All switches shall meet or exceed all applicable ANSI C37.47 requirements.
- B. Acceptable manufacturers are Square D or Westinghouse.
- C. The load interrupter switches shall be quick-make, quick-break three pole, gang operated, with stored energy operation. Each switch shall have the following minimum rating:

System Voltage	2.4 KV 3 phase, 3 wire
Maximum Design Voltage	15 KV
Basic Impulse Level	60 KV
Amperes Continuous	600 Amperes
Amperes Interrupting	600 Amperes
Momentary (Switch	
Closed, 10 cycle)	40,000 Amps. Asym.
Fault Close	40,000 Amps. Asym.

- D. A manual over toggle type stored energy spring mechanism shall be supplied to provide opening and closing action of the switch. The speed of opening and closing the switch shall be independent of the operator, and it shall be impossible to tease the switch into any intermediate position.
- E. The interrupter switch shall have separate main and make/break contacts to provide maximum endurance for fault close and load interrupting duty. The switch assembly



shall have insulating barriers between phase and between outer phases and the enclosure.

- F. The following features shall be supplied on every three pole, two position open-closed switch:
1. A high impact viewing window that permits full view of the position of all three switch blades through the closed door.
  2. A fuse access door interlocked with the switch so that:
    - a. The switch must be opened before access to the fuses is possible.
    - b. The door must be closed before the switch can be closed.
  3. A grounded metal barrier in front of every switch to prevent inadvertent contact with any live part, yet allow for a full-view inspection on the switch blade position.
  4. Provision for padlocking the switch in the open or closed position.
  5. Permanent "Open-Closed" switch position indicators.
- G. Install three (3) glow type high voltage indicators on the line side of each duplex switch mounted to be visible through the viewing window.

## 2.2 Fuses

- A. Fault protection shall be furnished by fuses. Fuses shall be Westinghouse type CLE, 250E, 2750V maximum design rating and 50,000 ampere symmetrical interrupting rating. Furnish three spare fuses for each fuse switch in a holder mounted on the inside of the fuse access door.
- B. Fuse clips shall be either Westinghouse "V-block" or other engineer approved equivalent.

## 2.3 Bus Construction

- A. One two hole NEMA pad per phase shall be provided with crimp type cable terminals suitable for copper cable of the number and sizes indicated on the drawings. Sufficient vertical space shall be supplied for contractor supplied electrical stress relief termination system. Provide a cable support rack for contractor installed cables.
- B. All bus shall be copper and be mounted on NEMA rated glass polyester insulators. All bussing shall be braced for the maximum available fault current.
- C. All bolted current carrying connections shall be fastened with two (2) bolts. All hardware used at bolted connections shall be [high-tensile strength and plated] hex head, silicone bronze with Bellville type spring washers. All washers shall be plated.

## 2.4 Enclosure

- A. Enclosure construction shall universal frame type using deformed, welded and bolted members. Barriers between sections or compartments shall be formed with tightly

## Medium Voltage Fusible Interrupter Switchgear

fitting steel sheets, removable as necessary for access, but without exposing circuits in adjacent compartments. All hardware shall be hex head, high strength steel. Slotted heads are not allowed. Plastic or similar plugs shall not be used to cover holes. Where required, use plated carriage bolts to close pre-fabricated holes.

- B. All enclosing covers and doors shall be fabricated from not less than 11-gauge steel. All holes shall be neatly punched and edges and corners of sheets shall be rounded and sharp projections ground off before finishing. To facilitate installation and maintenance of cables and bus, rear hinged padlockable doors shall be supplied. Rear doors shall be bolted closed with a minimum of three (3) 3/8-inch self-captured bolts.
- C. Outdoor units shall be NEMA 3R and have a sloped drip-proof roof. Each switch cubicle shall have a single, full length, flanged front door over the switch and fuse assembly and shall be equipped with two (2) rotary latch type padlockable handles. Use of three point latch assemblies is not acceptable. Door shall be hinged on the opposite side of the switch operator to provide clear access for operation.
- D. All openings shall be screened to prevent the entrance of small animals, and barred to inhibit the entrance of dirt, dust, etc. Doors shall be gasketed. A minimum of one 250 watt, 120 volt space heater shall be provided in each cubicle. Power for the space heater(s) shall be furnished [from a separate source] [from a control power transformer as indicated] and controlled by a thermostat.
- E. All enclosing and supporting steel shall be painted utilizing an initial phosphatizing cleaning treatment, followed by an epoxy primer coat and epoxy final finish coat baked on to a total of three mils average thickness for interior surfaces and five mils average thickness for exterior surfaces. Paint color shall be in accordance with ANSI Z55.1 and as specified under paragraph 1.1.

## 2.5 Nameplates and Signs

- A. Provide all safety and warning signs in accordance with ANSI Z35.1 and as required by the NEC, NESC and any local codes.
- B. An engraved lamincoid nameplate shall be provided to identify all switches, door mounted devices and control equipment. Construct nameplate of 1/16 inch engraving lamincoid with letters machine engraved through black facing to white opaque core unless otherwise indicated. All nameplates shall have a 1/64-inch bevel on front edges. Nameplates shall be fastened with a minimum of two (2) stainless steel screws, not adhesive. Letter size shall be 1/4-inch high for unit identification and 1/8-inch high for device identification unless otherwise indicated. See nameplate legend at end of section.
- C. Provide mimic bus manufactured of anodized red aluminum, 1/4-inch wide, fastened with flat head recessed stainless steel screws on 4 inch centers.

## 2.6 Arresters

- A. 3 KV intermediate class surge arresters shall be provided connected at the incoming terminations and securely grounded to the metal structure.

## 2.7 High voltage connector

- A. Provide a switchgear mounted PLM portable cable receptacle rated 500 amperes at 7,500 volts maximum. Receptacle shall be socket type with female contacts. Provide a cover interlock for socket and cover/insulator assembly. Receptacle shall be a catalog number SFG-375-A-BB-R as manufactured by Adalet-PLM.
- B. Support connector on a mounting shelf manufactured of 11-gauge minimum formed steel. Provide adequate bracing to support weight of external connector and cable without deforming shelf or switch enclosure.
- C. Install kirk-key interlock between switch and PLM receptacle such that plug cannot be inserted or removed unless switch is open. Tether key to switch with vinyl covered stainless steel cable. Provide a warning sign which states: "Caution - Switch must be open before inserting or removing PLM"

## 2.8 Instruments, Relays and Control Component Devices

- A. Small wiring and terminal blocks within the switch shall be furnished as necessary. Use type SIS stranded wire for all control and instrumentation circuits. Terminate wires with compression type ring terminals, Thomas & Betts "Sta-kon" or equivalent. All groups of control wires shall be labeled with wire markers and all wires leaving the switch shall be provided with terminal blocks. Terminal blocks shall be strap screw type rated 600 V, 30A minimum with numbering strips. Use of compression type or sectional terminal blocks is not acceptable. Enclose all low voltage equipment in a separate wireway segregated from the high voltage compartment by a removable cover.
- B. Install key interlocks on duplex switches such that only one access door can be opened at a time, and only if both switches are open. Provide a warning sign which states: "Caution - Load side of switch and fuses may be energized unless both switches are open".
- C. Install a zero sequence 50/5 ratio current transformer for the incoming cable of each duplex switch. Current transformer shall conform to ANSI C57.13 requirements.
- D. Connect current transformer to a 0-1 ampere full scale panel meter.
- E. Shunt panel meter with separate push-to-read button. Provide an
- F. Install one set each N/O and N/C contacts on each duplex switch operator and wire to a terminal block in the low voltage wireway.

## PART 3 EXECUTION

### 3.1 General

- A. Install equipment in strict accordance with ANSI C2, NFPA 70, shop drawings and manufacturer's instructions and recommendations.

### 3.2 Grounding

- A. Grounding shall be as specified in Section 16452, "Grounding."

### 3.3 Foundation for Equipment

- A. Mount unit substation on a concrete housekeeping slab. Unless otherwise indicated, the slab shall be at least 8 inches thick with 12 inch footing the perimeter of the slab. Slab shall extend a minimum of 8 inches beyond the equipment. Slab shall be placed on 6-inch thick, well compacted gravel base. The top of the slab shall be approximately 6 inches above existing finished grade level. Edges shall have 1 inch chamfer.
  - B. [Reinforce the slab with 6- by 6- inch No. 6 wire mesh placed uniformly at the center of the slab.] [Reinforce the slab with No. 4 steel reinforcing bar place on 12 inch centers in both directions.] [Dowel slab to existing surface with No. 4 steel reinforcing bars on 24" centers in both directions.]
  - C. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil- resistant caulking or sealant. Cut off and bush conduits 3 inches above slab surface. [Concrete work shall be as specified in Section 03300, "Cast-In-Place Concrete"] [Section 03302, "Cast-In-Place Concrete (Minor Construction)"].
- 3.4 Mounting
- A. Secure equipment to slab with anchor bolts or other means suitable for Seismic Zone 4 requirements. Install equipment plumb and in longitudinal alignment with pad or wall.
- 3.5 Field Tests and Inspections
- A. Perform in accordance with the manufacturer's recommendations and the latest referenced standards. Perform work in a careful and safe manner so as not to endanger personnel or equipment.
  - B. Compare actual connections with wiring diagrams. Promptly bring any discrepancies to the attention of the engineer.
  - C. Inspect all equipment and devices for damage or maladjustment caused by shipping or installation.
  - D. Verify the tightness of all bolted connections with a torque wrench in accordance with manufacturer's recommended values. Mark each bolt with a permanent marker after torque is verified.
- 3.6 Touch-Up
- A. After the equipment is installed, touch up all scratches, mars, dents or other surface damage incurred during shipment or installation of equipment.
  - B. Supply one can of touch-up paint to owner.

END OF SECTION

SECTION 26 22 13  
LOW VOLTAGE TRANSFORMERS

PART 1 GENERAL

1.1 GENERAL

- A. Work Included: This specification covers an indoor type transformer. All equipment shall be new and manufactured by a company regularly engaged in the fabrication of such equipment.
  - 1. The equipment shall be either UL labeled or shall be approved by the City of Los Angeles Test Lab prior to shipment.
  - 2. Units shall be painted ANSI 61 for indoor service.
- B. General: Instructions to bidders, information for bidders, and specification 16000, electrical general provisions contain information and requirements that apply to the work specified herein.
- C. Intent of Drawings: Electrical plan drawings are diagrammatic in nature and show general location and sizes of equipment unless dimensioned. Manufacturer will be responsible for constructing equipment to meet with the space requirements available. Transformer must be able to fit through limited openings.
- D. Applicable Standards: The publications listed below form a part of this specification to the extent referenced. The latest revision of each publication shall be applied.
  - 1. American National Standards Institute (ANSI) Publications:
 

C57.12.01	Dry-Type Distribution and Power Transformers Including Those With Solid Cast and/or Resin-Encapsulated Windings, Standard General Requirements for
C57.12.50	Ventilated Dry-Type Distribution Transformers, 1 to 500 kVA, Single Phase, and 15 to 500 kVA Three Phase, with High-Voltage 601 to 34 500 Volts, Requirements for
C57.12.56	Test Procedure for Thermal Evaluation of Insulation Systems for Ventilated Dry-Type Power and Distribution Transformers
C57.12.59	Guide for Dry-Type Transformer Through-Fault Current Duration
C57.12.70	Terminal Markings and Connections for Distribution and Power Transformers
C57.12.91	Test Code for Dry-Type Distribution and Power Transformers

- C57.96 Guide for Loading Dry-Type Distribution and Power Transformers
- C57.98 Guide for Transformer Impulse Tests
- Z55.1 Gray Finished for Industrial Apparatus and Equipment
- 2. National Electrical Manufacturers Association (NEMA) Publications:
  - ST-20 Dry Type Transformers for General Applications
- 3. National Fire Protection Association (NFPA) Publications:
  - 70-1987 National Electrical Code
- 4. Underwriters Laboratories, Inc. (UL) Publications:
  - 467 Grounding and Bonding Equipment  
1562 Transformers,  
Distribution, Dry-Type-Over 600 Volts
- E. Warranty: Equipment shall be warranted for either 18 months from date of shipment or 12 months from date of energizing, whichever comes first.
- F. Factory Tests: The following factory tests shall be made on the transformer although not necessarily in the order listed. All tests shall be in accordance with the latest revision of ANSI Test Code C57.12.91, NEMA TR1, and/or UL 1562.
  - 1. Resistance measurements of all windings on the rated voltage connection and at the tap extremes.
  - 2. Ratio tests on the rated voltage connection and on all tap connections.
  - 3. Polarity and phase-relation tests on the rated voltage connections.
  - 4. No-load loss at rated voltage on the rated voltage connection.
  - 5. Exciting current at rated voltage on the rated voltage connection.
  - 6. Impedance and load loss at rated current on the rated voltage connection.
  - 7. Temperature Test or tests shall be made. Tests shall not be required when there is available a record of a temperature test on an essentially duplicate unit. When a transformer is supplied with auxiliary cooling equipment to provide more than one KVA rating, temperature tests as listed above shall be make on the lowest KVA OA rating and the highest KVA FA rating.
  - 8. Applied potential test.
  - 9. Induced potential tests.

Results of the above tests including no load loss data shall be submitted with final drawings in the form of certified test reports.
- G. Design Tests: Design tests required for certification of conformance to ANSI, NEMA or UL requirements may be required for review by the engineer at the option of the owner. Design tests need not be performed on the actual equipment being submitted but must have been performed on a sample or other unit representative of the specific construction techniques which are utilized.
- H. Submittals:

1. Manufacturers Data: Submit six (6) copies of manufacturers data for the transformer.
2. Shop Drawings: Submit six (6) copies of shop drawings including the following:
  - a. Overall dimensions, front view, equipment access requirements, and conduit entrance location(s)
  - b. Type and spacing of supports.
  - c. Nameplate diagram
  - d. Details of connections

Before shipment, all shop drawings shall be approved by the Engineer.

3. Certified tests reports: Submit six (6) copies of certified tests reports for the following:
  - a. Transformer
  - b. Transformer Design Tests

Before shipment all certified test reports shall be approved by the Engineer.

4. Operating and Maintenance Instructions: Furnish 3 copies of maintenance, instructional literature and renewal parts data bound in a loose leaf notebook.

PART 1 PRODUCTS

1.1 MATERIALS

A. The transformer shall be of explosion resistant, fire-resistant, air insulated, dry type construction, cooled by the natural circulation of air through the windings. Connections between the primary device and the transformer shall be cable, and between the transformer and secondary shall be cable. Transformer enclosure shall be ventilated, NEMA 2, drip-proof, with lifting holes. All ventilation openings shall be protected against falling dirt.

B. The ratings of the transformer shall be as follows or as shown on the drawings:

KVA Rating	:	500 AA
Impedance	:	5.75%+/-7-1/2%
HV	:	2400 V DELTA
HV BIL	:	30 KV
HV Taps	:	2 - 2-1/2% full capacity above and below nominal
LV	:	208/120 V Wye
LV BIL	:	10 KV

Approved manufacturers are ITC, Square D and ABB.

C. Transformer shall be cooled by natural Air convection (AA).

- D. The electrical insulation system shall utilize Class H material in a fully rated 220°C system. Transformer design temperature rise shall be based on a 30°C average ambient over a 24 hour period with a maximum of 40°C. Solid insulation in the transformer shall consist of inorganic materials such as porcelain, glass fiber, electrical grade glass polyester or Nomex. All insulating materials must be rated for continuous 220°C duty. The insulation between the high and low voltage coils shall be more than sufficient for the voltage stress without the need of a varnish.
- E. The core/coil assembly shall be impregnated with non-hygroscopic, thermo-setting varnish and cured to reduce hotspots and seal out moisture. The assembly shall be installed on vibration-absorbing pads.
- F. The transformer cores are to be constructed of high grade, non-aging silicon steel laminations with high magnetic permeability, and low hysteresis and eddy current losses. Magnetic flux densities are to be kept well below the saturation point. The core laminations shall be clamped together with heavy, structural steel bars or angles.
- G. The transformer shall be supplied in a knockdown case design, for ease in fitting through limited openings, and shall be of heavy gauge sheet steel construction, equipped with removable panels for access to the core and coils. Equip enclosure with provisions for lifting. Construct base with structural steel members to allow skidding or rolling in any direction. The wiring compartment shall be suitable for conduit entry and shall meet bending radius requirements to accommodate wire sizes as indicated on the plans.
- H. Provide a winding temperature indicator consisting of three high-accuracy thermistor sensors, installed directly on the winding at the hottest spot, and a digital readout.
- I. Transformer shall include: Diagram instruction plate, provisions for lifting and jacking, removable case panel for access to high voltage strap type connector taps for de-energized tap changing; two ground pads.
- J. The transformer shall be designed to meet the sound level standards for dry-type transformers as defined in NEMA TR1.
- K. An engraved nameplate shall be mounted on the front of the transformer enclosure. See Section 26 05 53 Identification for more information.

## PART 2 EXECUTION

### 2.1 INSTALLATION

- A. Installation will be by owner's contractor.

END OF SECTION



SECTION 26 24 13  
SWITCHBOARDS

PART 1 GENERAL

1.1 Section Includes

- A. This specification covers an indoor distribution switchboard complete from the incoming switch line terminals to the outgoing load terminals. All equipment shall be new and manufactured by a company regularly engaged in the fabrication of such equipment. Units shall be painted ANSI 61 for indoor service.

1.2 Related Sections

- A. Section 26 05 53 Identification
- B. Section 26 27 13 Electricity Metering (Low Voltage Distribution Equipment)

1.3 Applicable Standards

- A. The publications listed below form a part of this specification to the extent referenced. The latest revision of each publication shall be applied.

- B. American National Standards Institute (ANSI) Publications:

C2	National Electrical Safety Code (NEESC)
C12	Code for Electricity Metering
C39.1	Requirements for Electrical Analog Indicating Instruments
C57.12	Requirements for Instrument Transformers
Z35.1	Specifications for Accident Prevention Signs
Z55.1	Gray Finished for Industrial Apparatus and Equipment

- C. National Electrical Manufacturers Association (NEMA) Publications:

AB-1	Molded Circuit Breakers
LI-1	Industrial Laminated Thermosetting Plastics
PB-2	Dead-Front Distribution Switchboards
PB-2.1	Safe Handling, Installation, Operation and Maintenance of Switchboards
260	Safety Labels for Padmounted Swtichgear and Transformers Sited in Public Areas

- D. International Electrical Testing Association (NETA)

ATS                      Acceptance Testing Specifications for Electrical Power  
Distribution Equipment

E. National Fire Protection Association (NFPA) Publications:

70-1987                  National Electrical Code

F. Underwriters Laboratories, Inc. (UL) Publications:

467                        Grounding and Bonding Equipment

489                        Molded-Case Circuit Breakers and Circuit Breaker  
Enclosures

891                        Dead-Front Switchboards

1.4 Quality Control

A. Design tests required for certification of conformance to ANSI, NEMA or UL requirements may be required for review by the engineer at the option of the owner. Design tests need not be performed on the actual equipment being submitted but must have been performed on a sample or other unit representative of the specific construction techniques which are utilized.

B. The following factory tests shall be made on the secondary switchboard, although not necessarily in the order listed. All tests shall be in accordance with the latest revision NEMA PB-2 and/or UL 891:

1. A dielectric withstand test of 1000 VDC shall be made between each phase and ground with all switching devices closed and phases not under test grounded.
2. The grounding of instrument transformer cases or frames, as applicable, shall be checked with a low potential source.
3. Control wire continuity and correctness shall be verified by actual electrical operation of the control component or individual circuit continuity checks with electrical instruments.
4. Control wire insulation shall be tested with the application of 1000 VDC after circuit grounds have been disconnected for the test. Sensitive or electronic equipment shall be disconnected for the test.
5. Polarity tests shall be performed to verify that instrument transformers have been correctly connected.
6. Results of the above tests shall be submitted with final drawings in the form of certified test reports. Third party certification is not required.

1.5 Submittals for Approval

A. Manufacturers Data: Submit six (6) copies of manufacturers data for the following components:

1. Low Voltage Circuit Breaker
  2. Instruments and Meters
  3. Instrument Transformers
  4. Control Component Devices
- B. Shop Drawings: Submit six (6) copies of shop drawings for the secondary unit substation including the following:
1. Overall dimensions, front view, sectional views, conduit entrance location(s), equipment access requirements and weights.
  2. Bus arrangements including dimensions and ampere ratings of all bus bars, including ground bus.
  3. Type and spacing of bus supports.
  4. Maximum short circuit bracing.
  5. Circuit breaker type, interrupting rating, instrument transformers and meters.
  6. Elementary diagrams and wiring diagrams having their terminals identified, and indicating the internal wiring for each item of equipment and the interconnection between the items.
  7. One line diagram.
  8. Details of bus connections.
  9. Anchoring instructions to meet UBC Seismic Zone 4 requirements.
  10. Instrument transformers and meters.
  11. Proposed nameplate schedule.
  12. Itemized and coded bill of material.
  13. Before shipment, all shop drawings shall be approved by the Engineer. Shipping splits shall be approved in writing.
- C. Certified tests reports: Submit six (6) copies of certified tests reports for the following:
1. Switchgear Factory Tests
  2. Paint qualification test in accordance with ANSI C37.20.3 section 5.2.8
  3. Before shipment all certified test reports shall be approved by the Engineer.
- D. Operating and Maintenance Instructions: Furnish 3 copies of maintenance, instructional literature and renewal parts data bound in a loose leaf notebook. Notebook shall contain but not be limited to the following:

1. Instruments and Meters
  2. Instrument Transformers
  3. Control Component Devices
  4. Meters (each type)
  5. Circuit Breakers
- 1.6 Regulatory
- A. Conform to the requirements of NFPA 70.
  - B. Products: Listed and classified by Underwriters Laboratories, Inc. or a testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.
- 1.7 Warranty
- A. Equipment shall be warranted for either 18 months from date of shipment or 12 months from date of energizing, whichever comes first.
- PART 2 PRODUCTS
- 2.1 Description
- A. Furnish a dead front type, completely metal enclosed, self-supporting structure independent of wall supports. Voltage rating shall be [480Y/277] [208Y/120] volts, 3 phase, [4 wire] [3 wire]. It shall consist of the required number of vertical sections bolted together to form one rigid switchboard. The sides shall be covered with removable bolt-on plates. All edges of front cover panels shall be formed. Sheet steel shall be 12 gauge minimum thickness unless proof of conformance to UL 891 rigidity requirements can be submitted. Identify any sheet components constructed of less than 12 gauge steel.
  - B. Equipment shall comply with the latest applicable standards of NEMA PB2 and UL 891, and shall comply with all NEC and UL requirements for service entrance and a UL service entrance label shall be provided. Los Angeles City Test Lab Certification is acceptable in lieu of UL labeling.
- 2.2 Construction
- A. Switchboard shall be provided with adequate lifting means and shall be capable of being rolled or moved into installation position and bolted directly to the floor without the use of floor sills.
  - B. All power connections shall be bused from incoming to outgoing line terminals. Use of cable is not allowed. All bus bars shall be copper with silver-plated copper bolted connections at joints. The bus bars shall be of sufficient size to limit the temperature rise to 65°C rise at the ampere rating indicated on the drawing based on UL tests, and rated to withstand thermal stresses and mechanical forces exerted during short circuit conditions when directly connected to a power source having an available fault

current of 50,000 amperes symmetrical at rated voltages. Provide full capacity neutral.

- C. A ground bus shall be furnished firmly secured to each vertical section structure and shall extend the entire length of the switchboard. The neutral bus shall be grounded to the ground bus with a bus conductor sized per UL and NEC requirements. An incoming ground lug shall be furnished. One ground lug for each feeder circuit shall also be supplied.
- D. All hardware used at bolted connections shall be of high strength, hex head, grade 5 steel with Bellville type spring washers. All bolts and washers shall be plated. Slotted head screws are not allowed.
- E. All hardware used on conductors shall be high-tensile strength and plated. All terminals shall be compression type suitable for copper cable of sizes indicated for 75°C cable.
- F. The manufacturer shall supply, upon request, test results to confirm that the switchgear has been tested to substantiate designs according to applicable NEMA and UL Standards. The tests shall verify the performance of the short circuit bracing and temperature rise of the bus assembly, the suitability of the enclosure venting and rigidity. In addition, each switchgear assembly shall be factory tested in accordance with the latest revision of NEMA PB-2 and/or UL 891.
- G. Small wiring, necessary fuse blocks and terminal blocks within the switchboard shall be furnished as required. All groups of control wires shall be labeled with wire markers and all wires leaving the switchboard shall be provided with terminal blocks having suitable numbering strips. All control devices shall be provided with engraved plastic nameplates black with white core, attached with two screws.
- H. Front Accessible Switchboard:
  - 1. Switchboards where shown shall be equal to Westinghouse POW-R-LINE C or Square D I-Line front accessible. All vertical sections without uniform depths shall align rear as shown on the drawings. Switchboard shall be constructed for placement against the wall.
  - 2. All internal devices shall be removable from the front and shall be panel mounted with the necessary line and load connections front accessible. All bus connections shall be accessible from the front. Nuts shall face top or front as applicable to allow access for torquing.
  - 3. Mount devices so manufacturer type, catalog number, ampere rating and interrupting rating are visible without removing panels or covers.
  - 4. Provide padlocking provisions for each circuit breaker.

2.3 Customer Metering – See Section 26 27 13

2.4 Overcurrent Devices

- A. Main protective devices shall be fixed mounted molded case breaker with 1600 ampere, 100% continuous rated frame with 1600 ampere trip ratings.

- B. Individually fixed mounted feeder protective devices shall be molded case breaker type with frame and trip rating as shown on the drawings.
- C. Devices shall have a minimum interrupting rating of 30,000 amperes at 240 volts.
- D. Molded Case Breakers
  - 1. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism tripping of the breaker shall be clearly indicated by handle position. Contacts shall be non-welding silver alloy and arc extinction shall be accomplished by means of arc chutes.
  - 2. Breakers 150 amperes and below shall be thermal-magnetic trip with inverse time current characteristics and shall be Westinghouse Series C or Square D I-Line. Breakers with 250 and 400 amperes frame shall be Westinghouse Series C or Square D I-Line with either thermal-magnetic or solid state trip.
  - 3. Breakers with 600 amperes frame and above shall be Westinghouse IMPAC Standard Micrologic with solid-state trip unit and flux transfer shunt trip. Breakers shall have trip rating plugs with ratings as indicated on the drawings. Rating plugs shall be interlocked so they are NOT interchangeable between frames and interlocked such that a breaker cannot be latched with the rating plug removed.
    - a. Trip unit shall have adjustable short time setting with a fixed instantaneous override for circuit protection. Main breakers shall be provided with additional short delay trip time adjustment for increased system coordination.
    - b. Breakers shall have built-in test points for testing long delay, and instantaneous functions of the breaker by means of a 120 volt operated test kit.
  - 4. Where indicated on the drawings, circuit breakers shall be UL listed and labeled for 100% application per NEC.

## 2.5 Paint

- A. All enclosing and supporting steel of the unit substation shall be painted utilizing an initial phosphatizing cleaning treatment, followed by an epoxy primer coat and epoxy final finish coat baked on to a total of three mils average thickness for interior surfaces and five mils average thickness for exterior surfaces. Paint color shall be as specified under paragraph 1.1.

## 2.6 Nameplates and Signs

- A. See Section 26 05 13 Identification
- B. Provide all safety and warning signs in accordance with ANSI Z35.1 and as required by the NEC, NESC and any local codes.
- C. Furnish Master Nameplate giving voltage, ampere rating, short circuit rating, manufacturer's name, general order number and item number.

- D. An engraved lamicoïd nameplate shall be provided to identify all switches, transformers, circuit breakers, instruments, door mounted devices and control equipment. Construct nameplate of 1/16 inch engraving lamicoïd with letters machine engraved through black facing to white opaque core unless otherwise indicated. All nameplates shall have a 1/64-inch bevel on front edges. Nameplates shall be fastened with a minimum of two (2) stainless steel screws, not adhesive. Letter size shall be 1/4-inch high for unit identification and 1/8-inch high for device identification unless otherwise indicated. (See nameplate legend at end of section.)
- E. Provide mimic bus manufactured of anodized red aluminum, 1/4-inch wide, fastened with flat head recessed stainless steel screws on 4 inch centers.

## 2.7 Concrete

- A. Concrete shall have a 28 day compressive strength of 3000 PSI. Provide ASTM C 33 aggregate, size No. 67. Provide a 5 percent air entrainment. The maximum chloride content shall not exceed one percent.
- B. Slump shall be 1 inch minimum, 3 inches maximum. Maximum allowable slump may be increased to 5 inches for concrete utilizing either fly ash, pozzolan, or ground slag for 20 to 25 percent, minimum, of the total cementitious material.

## 2.8 Reinforcement

- A. Wire mesh shall be 6-inch by 6-inch No. 6, W2.9/W2.9 steel.
- B. Reinforcing bar shall be No. 4 steel.

## PART 3 EXECUTION

### 3.1 General

- A. Install equipment in strict accordance with ANSI C2, NEMA PB 2.1, NFPA 70, shop drawings and manufacturer's instructions and recommendations.

### 3.2 Grounding

- A. Grounding shall be as specified in Section 16452, "Grounding."

### 3.3 Foundation for Equipment

- A. Mount unit substation on a concrete housekeeping slab. Unless otherwise indicated, the slab shall be at least 8 inches thick with 12 inch footing the perimeter of the slab. Slab shall extend a minimum of 8 inches beyond the equipment. Slab shall be placed on 6-inch thick, well compacted gravel base. The top of the slab shall be approximately 6 inches above existing finished grade level. Edges shall have 1 inch chamfer.
- B. [Reinforce the slab with 6- by 6- inch No. 6 wire mesh placed uniformly at the center of the slab.] [Reinforce the slab with No. 4 steel reinforcing bar place on 12 inch centers in both directions.] [Dowel slab to existing surface with No. 4 steel reinforcing bars on 24" centers in both directions.]

- C. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil- resistant caulking or sealant. Cut off and bush conduits 3 inches above slab surface. [Concrete work shall be as specified in Section 03300, "Cast-In-Place Concrete"] [Section 03302, "Cast-In-Place Concrete (Minor Construction)"].

#### 3.4 Mounting

- A. Secure equipment to slab with anchor bolts or other means suitable for Seismic Zone 4 requirements. Install equipment plumb and in longitudinal alignment with pad or wall.

#### 3.5 Field Tests and Inspections

- A. Perform in accordance with the manufacturer's recommendations and NETA ATS, Section 7.1. Perform work in a careful and safe manner so as not to endanger personnel or equipment.
- B. Compare actual connections with wiring diagrams. Promptly bring any discrepancies to the attention of the engineer.
- C. Inspect all equipment and devices for damage or maladjustment caused by shipping or installation.
- D. Verify the tightness of all bolted connections with a torque wrench in accordance with manufacturer's recommended values. Mark each bolt with a permanent marker after torque is verified.
- E. Perform an insulation resistance test at 1000 VDC on low voltage switchgear prior to connecting flexible shunts to transformer. Disconnect fuses to heater and metering circuits prior to the performance of the test. Minimum insulation resistance shall be 10,000,000 ohms.
- F. Perform an insulation resistance test on the transformer as follows:
  - 1. Primary to Secondary and Ground: 2500 VDC, 1000 Megohms minimum
  - 2. Secondary to Primary and Ground: 1000 VDC, 100 Megohms minimum

#### 3.6 Cleaning and Touch-Up

- A. After the equipment is installed, clean area of all dirt and debris.
- B. Touch up all scratches, mars, dents or other surface damage incurred during shipment or installation of equipment.
- C. Supply one can of touch-up paint to owner.

END OF SECTION



SECTION 26 24 19  
MOTOR CONTROL CENTERS

## PART 1 GENERAL

## 1.1 GENERAL

## A. Work Included:

1. This section covers the work necessary to furnish and install, complete, motor control equipment. Provide each motor with a suitable controller and devices that will perform the functions specified and required for the respective motors.
2. Motor horsepower ratings and enclosures shown are what is expected. This information is for guidance only and does not limit the equipment size. Notify the Engineer when motors furnished differ from the expected ratings indicated, make the necessary adjustments to wiring, conduit, disconnect devices, motor starters, branch circuit protection, and other affected material or equipment to accommodate the motors actually installed as directed by the Engineer at no additional cost to City. Provide revised Drawings for review prior to construction.

## B. General:

1. Make like items of equipment provided there under the end products of one manufacturer in order to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer's service.

## C. Related Work Specified Under Other Divisions:

1. Components for heating, ventilating, air conditioning systems, including conductors for control wiring, unless specifically shown on Electrical Drawings.
2. Demolition unless specifically shown on electrical drawings.

## D. Materials and Equipment Furnished and Installed Under Other Divisions with Raceway and Electrical Conductors Furnished, Installed, and Connected Under Division 16, Electrical:

1. Air conditioning equipment
2. Ventilating system equipment
3. Electric water heaters
4. Exhaust fans
5. Motors
6. Motor heaters
7. Motor thermal protectors and any required special protector monitoring relay
8. Elevator equipment

## E. Submittals During Construction: Make submittals after award of Contract in accordance with Section 16000, Electrical - General Provisions. In addition, provide the following specific information:

1. One-line diagrams
2. Elementary diagram
3. Connection diagrams
4. Interconnection diagrams
5. Protective device time-current characteristics on conventional-sized transparencies. For all protective devices, a copy is to be included with shipping package.
6. Operational description
7. Installation instructions, complete with instructions for anchoring, to meet UBC Zone 4 requirements
8. Maintenance instructions
9. Spare parts list
10. Test reports

## PART 1 PRODUCTS

### 1.1 MATERIALS

#### A. Motor Control, General:

1. Provide each motor with a suitable controller and devices that will function as specified for the respective motors and meeting NEMA ICS 2, the NEC, and UL.
2. Provide each motor controller with thermal overload protection in all ungrounded phases. Use protection consisting of thermal overload relays meeting NEMA ICS 2 which are sensitive to motor current and mounted within the motor controller, or a combination of thermal protectors embedded within the motor windings and controller-mounted overload relays, as indicated. Use overload protection devices of the inverse-time-limit type.
3. Provide controller-mounted overload relays of the manual-reset type with externally operated reset button when used without motor thermal protectors; when used in conjunction with thermal protectors, provide the automatic reset type. Select and install overload relay heaters after the actual nameplate full-load current rating of the motor has been determined.
4. If power factor correction capacitors are indicated to be connected on the load side of the overload relays, incorporate the resulting reduction in line current in the selection of overload relay heaters.
5. Install and connect any required thermal protector monitoring relay provided by motor manufacturer in motor-control circuit and provide manual reset function. Fuse thermal-protector circuits according to the manufacturer's recommendations.

B. Manually Operated Starters, Fractional Horsepower: Provide starters meeting NEMA ICS 2 with the enclosures shown, rated 1 hp at single-phase, ac voltages of 115 and 230 volts, and with thermal overload protection, and toggle or pushbutton operation. Provide for locking in the OFF position.

C. Manually Operated Starters, Integral Horsepower: Provide starters meeting NEMA ICS 2 of the horsepower rating, voltage, number of phases, and enclosure shown and with thermal overload protection, and pushbutton or toggle switch operation. Provide for locking in the OFF position. Provide running overcurrent protection.

- D. Full Voltage Magnetic Starters: Provide starters meeting NEMA ICS 2, Class A, with the rating and enclosure shown.
1. Non-Reversing Starters
    - a. Across-the-line magnetic starters for motors up to 100 HP., 600 Volts, shall be built and tested in accordance with the latest NEMA standards.
    - b. Starters shall be equipped with three overload relays. Overload should be block-type with a push-to-test feature. An isolated, field mountable alarm contact should be available. Starter shall provide for field installation of up to 3 NO and 4 NC auxiliary contacts in addition to the hold-in interlock.
  2. Reversing Starters
    - a. Reversing magnetic starters for motors up to 100 HP., 600 volts, shall be built and tested in accordance with the latest NEMA standards.
    - b. Starters shall be equipped with three overload relays. Overload should be block-type with push-to-test feature. An isolated, field-mountable alarm contact should be available. Starter shall provide for field installation of up to 4 NO and 4 NC auxiliary contacts in addition to the normal interlocks.
  3. Two Speed Starters
    - a. Starters shall be equipped with three overload relays. Overload should be block-type with a push-to-test feature. An isolated, field-mountable alarm contact should be available. Starter shall provide for field installation of up to 4 NO and 4 NC auxiliary contacts in addition to the normal interlocks.
  4. Combination Non-Reversing Starters
    - a. Across-the-line combination starters for motors up to 100 HP, 600 volts, shall be [non-fusible disconnect switch], [fusible disconnect switch], [motor circuit protector], [or motor circuit protector with current limiter]. They shall be built in accordance with the latest NEMA standards.
    - b. For non-reversing and reversing starters, provide current limiters in series with the MCP motor circuit protector. It is specifically designed for motor circuits, permitting combination starter application to 100,000 ampere fault capacity systems when combined with the MCP. Coordination with the MCP provides minimum downtime by allowing the MCP to clear the more frequent low level faults with the current limiter operating only at the higher levels. This coordination also prevents single-phasing should the current limiter operate. Each phase of the limiter has a built in trip indicator to immediately show when a fault has blown the current limiter.

c. Starters shall be equipped with three overload relays. Overload should be block-type with a push-to-test feature. An isolated, field-mountable alarm contact should be available. Starter shall provide for field installation of up to 3 NO and 4 NC auxiliary contacts in addition to the hold-in interlock.

d. Operating handle shall always remain connected to the breaker or switch. The operating handle shall not be mounted in the door of the enclosure, but to the side of the door for safe "stand-aside" operation. Position of operating handle will indicate On, Off or Tripped condition of switch or circuit breaker.

e. Interlock provisions shall prevent unauthorized opening or closing of the starter door with the disconnect in the On position.

5. Combination Reversing Starters

a. Reversing combination starters for motors up to 100 HP, 600 volts, shall be non-fusible disconnect switch, fusible disconnect switch, motor circuit protector, or motor circuit protector with current limiter. They shall be built in accordance with the latest NEMA standards.

b. Starters shall be equipped with three overload relays. Overload should be block-type with a push-to-test feature. An isolated, field-mountable alarm contact should be available. Starter shall provide for field installation of up to 4 NO and 4 NC auxiliary contacts in addition to the normal interlocks.

c. Operating handle shall always remain connected to the breaker or switch. The operating handle shall not be mounted in the door of the enclosure, but to the side of the door for safe "stand-aside" operation. Position of operating handle will indicate On, Off, or Tripped condition of switch or circuit breaker.

d. Interlock provisions shall prevent unauthorized opening or closing of the starter door with the disconnect in the On position.

E. Control Power Transformers: Supply individual control power transformers for each starter and contactor. The transformers shall have sufficient capacity to serve the connected load and limit voltage regulation to 10 percent during contact or pickup. Fuse one side of the secondary winding and ground the other side. Provide primary, current limiting fuses where fuses are shown on Drawings, or where required by applicable codes and standards.

F. Motor Control Centers:

Provide motor control centers and components meeting the requirements of the latest revised NEMA and UL standards and the following requirements, unless otherwise indicated:

1. Motor Control Center(s) shall be UL labeled and shall have been tested in a high power laboratory to prove adequate mechanical and electrical capabilities. All major components shall have been individually design tested and guaranteed by the manufacturer. Wiring shall be NEMA Class [I] [II], Type [A] [B] [C].

2. The type of enclosure shall be in accordance with NEMA Standards for [Type 1A with gasketed doors] [Type 12 Dust-tight and drip-proof] [Type 3R non-walk-in] [Type 3R walk-in]. All enclosing sheet steel, wireways and unit doors shall be gasketed.
3. The Motor Control Center(s) shall be 600 volt class suitable for operation on a three phase, 60 Hertz system. The system operating voltage and number of wires shall be as indicated on the drawings.
4. Equipment shall meet the applicable NEMA, ANSI and UL standards.
5. Structure Arrangement
  - a. Structures shall be totally enclosed deadfront, free standing assemblies. They shall be 90 inches high and [16 inches] [21 inches] deep for front mounted units. Structures shall contain a horizontal wireway at the top, isolated from the horizontal bus and shall be readily accessible through a hinged cover. Adequate space for conduit and wiring to enter the top or bottom shall be provided without structural interference.
  - b. Compartments for mounting control units shall be incrementally arranged such that not more than six size 1 starters can be mounted within each vertical structure. Guide rails shall be provided.
  - c. A vertical wireway with minimum of 35 square inches of cross sectional area shall be adjacent to each vertical unit and shall be covered by a hinged door. Wireways shall contain steel rod cable supports.
6. Bus Arrangement
  - a. Each structure shall contain a main horizontal [aluminum] [copper] bus, with minimum ampacity of 600 amperes or rated as shown on the drawings. Vertical busses feeding unit compartments shall be copper and shall be securely bolted to the horizontal main bus. All joints shall be front accessible for ease of maintenance. The vertical bus shall have a minimum rating of 300 amperes for front mounted units and 600 amperes for back-to-back mounted units.
  - b. The vertical bus shall be completely isolated and insulated by means of a labyrinth design barrier. It shall effectively isolate the vertical busses to prevent any fault generated gases to pass from one phase to another. Vertical bus shall be braced for 100,000 amperes.

\*\* or \*\*
  - c. Isolation of the vertical bus compartment from the unit compartment shall be by means of a full height insulating barrier. This barrier shall be a single sheet of glass reinforced polyester with cutouts to allow the unit stabs to engage the vertical bus. Provide snap-in covers for all unused openings.

d. Busses shall be braced for [65,000] [100,000] amperes RMS symmetrical.

7. Unit Construction

a. All full voltage starter units through NEMA size 5 shall be of the drawout type. Drawout provisions shall include a positive guide rail system and stab shrouds to absolutely ensure alignment of stabs with the vertical bus. Drawout units shall have a tin-plated stab assembly for connection to the vertical bus. No wiring to these stabs shall extend into the bus compartment. Interior of all units shall be painted white for increased visibility. Units shall be equipped with side-mounted, pressure pull-apart type control terminal blocks rated 480 volts. Knockouts shall be provided for the addition of future terminal blocks. In addition, a master terminal block, when Type C wiring is specified, shall be drawout and shall be located in the bottom wireway, readily accessible through a hinged cover.

b. All drawout units shall be secured by a spring loaded quarter turn indicating type fastening device located at the top front of the unit. Each unit compartment shall be provided with an individual front door.

c. An operating mechanism shall be mounted on the primary disconnect of each starter unit. It shall be mechanically interlocked with the unit door to prevent access unless the disconnect is in the OFF position. A defeater shall be provided to bypass this interlock. With the door open, an interlock shall be provided to prevent inadvertent closing of the disconnect. A second interlock shall be provided to prevent removal or re-insertion of the unit while in the ON position. Padlocking facilities shall be provided to positively lock the disconnect in the OFF position with from one to three padlocks with the door open or closed. In addition, means shall be provided to padlock the unit in a partially withdrawn position with the stabs free of the vertical bus.

d. Combination starter units shall be full voltage non-reversing, unless shown otherwise, and shall utilize motor circuit protectors (MCP). Each combination unit shall be rated [65,000] [100,000] AIC symmetrical at 480V. The MCP shall provide adjustable magnetic protection and be provided with pin insert to stop magnetic adjustment at 1300% motor nameplate full load current to comply with NEC requirements. All MCP combination starter units shall have a "tripped" position on the unit disconnect and a push-to-test button on the HMCP. Type MCP motor circuit protectors shall include transient override feature for motor inrush current.

\*\* or \*\*

e. Combination starter units shall be full voltage non-reversing, unless shown otherwise utilizing fusible switches. Fusible switches shall be quick make, quick break and shall

accept Class R dimension fuses and the combination shall safely interrupt 100,000 amperes.

f. Linestarters shall be electrically operated, electrically held, three pole assemblies with arc extinguishing characteristics and shall have silver-to-silver renewable contacts. They shall have provisions for a total of eight NO or eight NC auxiliary contacts. The overload relay assembly shall be of the thermal bimetallic type. Overload relays shall be reset from outside the enclosure by means of an insulated button. The overload relay shall have a built-in push-to-test button.

g. Solid-state reduced voltage starters shall be provided where scheduled. Starters to 75 HP shall be plug-in type design with through-the-door heat sink. Starters from 100 HP to 400 HP shall be fixed mounted with the enclosure designed to provide for heat removal from the motor control center. Starters shall be of the six SCR full-wave rectifier design and shall provide for adjustable voltage ramp to control starting torque. Starters shall be equipped with an automatic load sensing circuit which shall minimize motor power consumption and line voltage limit during periods of high line voltage.

h. Adjustable Frequency controllers shall be provided where scheduled. Controllers shall be for variable torque loads unless otherwise indicated on the drawings. Controllers for variable torque loads shall be rated a minimum of 110% overcurrent for one minute. Controllers for all other type loads shall be rated a minimum of 150% overcurrent for one minute. All controllers shall be combination type and shall include options as specified.

i. Each starter shall be equipped with a fused control power transformer, two indicating lights, HOA selector switch, and two NO contacts, unless otherwise scheduled on the drawings. Device panel to have space to accommodate six oil-tite pilot-control devices or indicating ammeters, voltmeters, or elapsed time meters.

j. Individual feeder breakers shall have a minimum interrupting capacity of 65,000 AIC at rated voltage or as scheduled on the drawings.

k. Individual feeder switches shall be quick-make, quick-break gang operated type utilizing Class R fuse clips. The fused switch shall have a 100,000 AIC at rated voltage.

8. Microprocessor Metering System

- a. IQ Data
- b. IQ Data Plus II
- c. IQ Generator

9. Incoming Mains: Incoming [cable] [busway] shall terminate within the control center on a [main lug] [main breaker] termination point. Main lug terminations shall have adequate dedicated space for the type and size of cable used and the lugs shall be [standard mechanical screw]

[compression type] with antiturn feature. Main breakers, if required, shall be as scheduled on the drawings and be [molded case] [insulated case, 100% rated, stored energy device].

10. Finish: The control center shall be given a phosphatizing pretreatment. The paint finish shall be an anionic, thermoset acrylic. Manufacturer's standard color shall be used.

11. Nameplates: Each unit will have 1.0 x 2.5 inch hot stamped nameplate. The lettering shall be white 3/16 inch high, in a black background.

G. Acceptable Manufacturers:

1. General Electric, 8000 Line; Square D, Model 5; Westinghouse, Five Star; or Engineer approved equivalent.

## PART 2 EXECUTION

### 2.1 EXECUTION

A. General: Perform work in a workmanlike manner with craftsmen skilled in the particular trade. Provide work presenting a neat and finished appearance.

B. Installation:

1. Install equipment in strict accordance with submittal drawings and manufacturer's recommendations. Install motor control centers in accordance with NEMA ICS 2.3 as a minimum. Secure motor control centers rigidly to mounting pads with welds, or other acceptable means to meet UBC Seismic Zone 4 importance factor 1 requirements. Grout mounting channels provided with motor control into the mounting pads.
2. Provide a qualified, factory-trained representative to supervise installation, final adjustment, and initial energization of this equipment. Make this representative available for as long as his services are required, but in any case for a period of 5 days minimum. At the end of installation and adjustment, provide certification signed by this representative that the equipment has been properly installed and tested, and is ready for energization.
3. Retighten to NEMA standards all current-carrying bolted connections and all support framing and panels.
4. Field adjust the trip settings of all motor starter magnetic trip only circuit breakers. Adjust to approximately 11 times motor rated current. Determine motor rated current from motor nameplate following installation. In the selection of overload relay heaters, allow for motor current reduction where power factor correction capacitors are installed on the load side of the overload heaters. Prepare a typed tabulation of motor name, motor horsepower, nameplate full load current, measured load current, heater catalog number, protective device, trip setting, and include copy in the Operations and Maintenance Manual. Attach to the tabulation a copy of the starter manufacturer's overload heater selection tables, including only the tables for the particular starters provided.



5. After the equipment is installed, touch up any scratches, marks, etc., incurred during shipment or installation of equipment. If required by the Engineer because of undue amount of scratches, repaint the entire assembly.
- C. Field Tests:
1. Functional Test: Prior to energizing the MCC, inspect all equipment for proper alignment, proper connection, and satisfactory performance per Manufacturer's installation instructions. The following electrical tests shall also be performed.
  2. Electrical Tests:
    - a. Insulation tests:
      - (1) Measure insulation resistance of each bus section phase to phase and phase to ground for one (1) minute.
      - (2) Measure insulation resistance of each starter section phase to phase and phase to ground with the starter contacts closed and the protective device open.
      - (3) Measure insulation resistance of each control circuit with respect to ground.
      - (4) Minimum insulation resistance shall be 1 megohms.
    - b. Motor overload units shall be tested by injecting primary current through overload unit and monitoring trip time. Verify proper overload heater for each motor per manufacturer's heater tables.
    - c. Perform operational tests by initiating control devices to affect proper operation.
    - d. Perform contact and insulation tests of circuit breakers per manufacturers instructions.
    - e. Verify all remote controls and indication to insure operation consistent with design control schematic drawings.
    - f. Perform insulation tests using a 1,000 volts D.C. Megger on wire and bus.
    - g. Check the connections of all equipment for proper phase rotation.
    - h. At the completion of all tests, provide Engineer with clean copies of all field test reports, listing readings and field test procedure utilized.

END OF SECTION

SECTION 26 27 13  
ELECTRICITY METERING

## PART 1 GENERAL

## PART 2 PRODUCTS

## 2.1 MANUFACTURERS

## A. Cutler-Hammer

## 2.2 MICROPROCESSOR-BASED METERING EQUIPMENT

## A. IQ DP-4000 (Detailed Specification)

1. Where indicated on the drawings provide a digital line Meter Monitor and Protection<sup>1</sup> (MM&P) device equal to Cutler-Hammer type Westinghouse IQ DP-4000 having the features and functions specified below. The MM&P shall be UL listed, CUL and CE certified and also meet ANSI Standard C37.90.1 for surge withstand.
2. The MM&P shall provide direct reading metered or calculated values of the items listed below and shall auto range between Units, Kilo-units and Mega-units for all metered values. Accuracy indicated below to be a percentage of the full scale of the device.
  - a. AC amperes in each phase, +/- 0.3% accuracy
  - b. AC voltage, phase-to-phase, phase-to-neutral, +/- 0.3% accuracy
  - c. Watts, +/- 0.6% accuracy
  - d. Vars, +/- 0.6% accuracy
  - e. VA, +/- 0.6% accuracy
  - f. Power factor, 1.0% (+/- 1 digit) accuracy
  - g. Frequency, +/- 0.1 Hz accuracy
  - h. Watt Demand (5-, 10-, 15-, 20-, 25-, 30-, 45-, 60-minute interval programmable or from utility synchronizing pulse)
  - i. Watt hours, +/- 0.6% accuracy
  - j. Var hours, +/- 0.6% accuracy
  - k. VA hours, +/- 0.6% accuracy
  - l. %THD measures through 31st harmonic
3. The MM&P shall display minimum and maximum values of the following metered parameters:

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<sup>1</sup> This designation to be used on the drawings

- a. Voltage, line-to-line, line-to-neutral
  - b. Current, per phase
  - c. Power, watts, Vars and VA
  - d. Power factor, displacement and apparent
  - e. Frequency
4. The MM&P shall also display peak percent THD and demand parameters.
  5. The MM&P shall monitor and display positive and negative Watts, Vars and power factor. The sign convention shall be selectable between mathematical or power engineer's convention. The MM&P shall display net energy at the device and shall display reverse, forward and net energy via the communications port.
  6. The following adjustable protective alarm features shall be provided. Alarm shall be communicated via the communications port<sup>1</sup>[or by Form C relay output contacts. Each relay shall be programmable to operate as latched or unlatched (self-resetting), and programmable to operate in mode 1 (energized) or mode 2 (de-energized) when the trigger occurs].
    - a. Voltage phase loss, if any phase RMS is less than 50% of the nominal line voltage
    - b. Current phase loss, if the smallest phase value is less than 1/16 of the largest phase value
    - c. Line voltage phase unbalance, selectable from 5 to 40% of nominal in 5% increments
    - d. Voltage phase reversal
    - e. Overvoltage, selectable from 105 to 140% in 5% increments
    - f. Undervoltage, selectable from 95 to 60% in 5% increments
    - g. Time delay (adjustable from 0 to 20 seconds in 1 second intervals) for overvoltage, undervoltage and phase unbalance trip and alarm settings
  7. Input ranges of the MM&P shall accommodate external current transformers with ratios from 5/5 Amperes through 5/12,800 Amperes. Provide external current transformers with rating as indicated on the drawing or sized for incoming service. The 600-volt and below voltage power module shall be detachable from the chassis. Three (3) in-line fuses shall protect the MM&P from current overloads. Potential transformer shall be self included and fused up to 600 volts. Above 600 volts, provide fused external potential transformers.
  8. The display face shall be membrane type and rated suitable for NEMA 3R and NEMA 12 mounting. The MM&P shall have a durable six-digit LED display screen. The display

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<sup>1</sup> Note to Spec Writer—Optional

screen and LEDs shall indicate two (2) alarm conditions. The cause of a trip or alarm shall be indicated in the display window.

9. The MM&P shall have an operating temperature range of -20 degrees C to 70 degrees C, and 0 to 95% relative humidity non-condensing.
10. A neutral terminal shall be provided and wired for 4-wire, grounded systems.
11. In the event of an alarm condition, a built-in reset button shall allow a manual reset of the MM&P. The MM&P shall also be capable of being remotely reset via its communication port. The MM&P shall have the capability for resetting watt-hours, VAR-hours, VA-hours, Minimum/Maximum values, and demand.
12. The MM&P control power shall be capable of being supplied from the monitored incoming line without the need for a separate AC supply control circuit or separate remote power source (96- to 264-volt AC or 100- to 350-volt DC).
13. The MM&P shall have non-volatile memory and not require battery back-up in the event of a power failure. The MM&P shall retain all pre- set parameters, accumulated watt-hours, and watt demand.
14. <sup>2</sup>Provide an input/output block and modifications to provide the following:
  - a. The MM&P shall offer a load shed feature which activates the pulse initiator relay when a user selected parameter exceeds a pre-programmed range.
  - b. Synchronizing pulse input shall be provided, and when activated, shall override the preset watt demand interval and let the utility control the demand window.
  - c. Outputs shall have separate trip and alarm contacts with ratings of 10 amperes at 115/240-volt AC or 30-volt DC resistive. The contacts shall be Form C (NO/NC). In addition, provide a separate Form C (NO/NC) contact to provide a kilowatt-hour pulse output. The pulse shall be KYZ type.
15. <sup>3</sup>[Provide] [Make provisions for] an addressable communication card capable of transmitting all data, including trip data over a compatible two-wire local area network to a central personal computer for storage and/or printout. The network shall also be capable of transmitting data in RS232c format via a translator module.

B. IQ DP-4000 (Condensed Specification)

1. Where indicated on the drawings provide a digital line Meter Monitor and Protection<sup>4</sup>(MM&P) device equal to Cutler-Hammer type :Westinghouse IQ DP-4000 having the features and functions specified below. The MM&P shall consist of a single microprocessor-based unit capable of monitoring and displaying the functions listed below with the accuracy indicated; the MM&P shall auto range between Units, Kilo-units and Mega-units. The MM&P shall provide the adjustable protection functions indicated and the capability to communicate data via twisted pair network. The MM&P shall be UL listed, CUL and CE certified and also meet ANSI Standard C37.90.1 for surge withstand.

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<sup>2</sup> Note to Spec Writer--Optional

<sup>3</sup> Note to Spec Writer—Select one

<sup>4</sup> This designation to be used on the contract drawings

METERED VALUES	ALARM FUNCTIONS
(Accuracy % Full Scale)	
AC Phase Amperes +/- (0.3%)	Voltage Phase Loss
AC Phase Voltage +/- (0.3%)	(less than 50% RMS)
Watts +/- (0.6%)	Current Phase Loss
VA +/- (0.6%) (1/16 largest phase)	
Vars +/- (0.6%)	Phase Voltage Unbalance
Power Factor (+/- 1 digit)	(5 to 40% -- 5% steps)
Frequency +/- (0.1 Hz)	Phase Voltage Reversal
Watt-hours +/- (0.6%)	Overvoltage
VAR-hours +/- (0.6%)	(105 to 140% -- 5% steps)
VA-hours +/- (0.6%)	Undervoltage (95 to 60% -- 5% steps)
Watt Demand with	Time Delay for Overvoltage,
10-, 15-, 20-, 25-, 30-,	Undervoltage, and Phase
45-, 60-min interval)	Unbalance (0 to 20 sec. –
%THD (through 31st harmonic)	1-sec. steps)
Voltage -- min./max.	
Current-- min./max.	
Power-- min./max.	
Power Factor -- min./max.	
Frequency -- min./max.	
Peak % THD	
Peak Demand	

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2. Input ranges of the MM&P shall accommodate external current transformers with ranges from 5/5 through 12,800/5 amperes. Provide external current transformers with rating as indicated on the drawing or sized for incoming service. Potential transformers shall be self included and fused up to 600 volts. Above 600 volts, provide fused external potential transformers.
  3. Control power shall be capable of being supplied from the monitored incoming AC line without the need for a separate AC supply control circuit or separate remote power source (96- to 264-volt AC or 100- to 350-volt DC) where shown on the drawings.
  4. <sup>5</sup>Provide the following features:
    - a. Synchronizing pulse input shall be provided, and when activated, shall override the preset watt demand interval and let the utility control the demand window.
    - b. Load shed feature which activates the pulse initiation relay when a user selected parameter exceeds a pre-programmed range.
    - c. Outputs shall have separate Form C (NO/NC) trip and alarm contacts with ratings of 10 amperes at 115/240-volt AC or 30- volt DC resistive. In addition, provide a separate Form C (NO/NC) contact to provide a programmable kilowatt-hour pulse output.
  5. <sup>6</sup>[Provide] [Make provisions for] an addressable communication card capable of transmitting all data, including trip data over a compatible two-wire local area network to a central personal computer for storage and/or printout. The network shall also be capable of transmitting data in RS232c format via a translator module.

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<sup>5</sup> Note to Spec. Writer-Select one

<sup>6</sup> Note to Spec. Writer- Optional

## C. IQ Analyzer

1. Where indicated on the drawings provide a digital line Meter Analyzer and Protection (MA&P) device equal to Cutler-Hammer type Westinghouse IQ Analyzer having the features and functions specified below. <sup>7</sup>The MA&P shall be UL listed, CSA certified and also meet ANSI Standard C37.90.1 for surge protection.
2. The MA&P shall provide direct reading metered or calculated values of the items listed below and shall auto range between Units, Kilo-units and Mega-units for all metered values. <sup>8</sup>[The device shall be capable of displaying the frequency distribution in graphic form and shall be capable of displaying the Wave Form in graphic form.] The device shall be capable of displaying multiple parameters at once, including two (2) user-configurable custom screens displaying any seven (7) of the parameters listed. Indicator LED shall always remain active to display device status for safety and troubleshooting purposes. Time, date, software version, and network address shall also be displayed. Accuracy indicated below to be of read or calculated values based on full scale.
  - a. AC Current (Amperes) in A, B, and C phase, 3-Phase Average, Neutral (N) and Ground (G). Accuracy +/- 0.2% (provide neutral and ground current transformer)
  - b. AC Voltage (Volts) for A-B, B-C, and C-A, Phase Average, A-N, B-N, and C-N, Average Phase to N, and N to G. Accuracy +/- 0.2%
  - c. Real Power (WATTS), Reactive Power (VARs), Apparent Power (VA), for each phase and system. Accuracy +/- 0.4%. Forward/Reverse indication shall be provided.
  - d. Real Energy (WH), Reactive Energy (VARH), Apparent Energy (VAH) for each phase and system. Accuracy +/- 0.4%. Forward/Reverse indication shall be provided.
  - e. Frequency (HERTZ) Accuracy +/-0.4%
  - f. Demand values for System Current (AMPERES), System Real Power (WATTS), System Reactive Power (VARs), and System Apparent Power (VA)
  - g. Power Factor for both Displacement only 60-cycle fundamental WATTS to VA and Apparent total WATTS to total VARs including harmonics for A, B, and C phase and system. Accuracy +/- 0.8%
  - h. Current Percent Total Harmonic Distortion (THD) in A, B, and C phase and N
  - i. Voltage percent THD in A-B, B-C, and C-A phase, A-N, B-N and C-N
  - j. K-Factor (sum of the squares of harmonic currents times the square of their harmonic numbers)
  - k. Transformer Derating Factor (1.414 divided by the Crest Factor)
  - l. Crest Factor (ratio of peak current to RMS current)

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<sup>7</sup> The designation to be used on the drawings

<sup>8</sup> Note to Spec. Writer - Optional

3. The MA&P shall provide the following advanced analysis features:
  - a. Trend Analysis Screens displaying the minimum and maximum values for each metered value, with all parameters time stamped to 1-second resolution.
  - b. Demand Analysis screens displaying present demand and peak demands for current (phase A, B, C, N, and G) and power (system real (kW), reactive (kVAR), and apparent (kVA). Peak demands shall display time and date stamped to within 1-second resolution. Demand Window Selection for metered demand values shall be selectable either as:
    1. A user selectable fixed window (programmable from 1 to 60 minutes)
    2. Sliding window method with programmable 1 to 60 minute subintervals, for power (kW, kVAR, kVA) demand only
    3. Initiated from a synch pulse for power (kW, kVAR, kVA) demand only
    4. Communication signal initiated from a Cutler-Hammer type Westinghouse IMPACC network master computer.
  - c. Harmonic Analysis Screens shall be capable of being function key triggered to capture a high-speed wave form of two (2) cycles of data sampled at 128 samples per cycle, simultaneously recording current in A, B, and C phases, N, and G as well as all voltages A-B, B-C, and C-A phases, A-N, B-N, C-N, and N-G. Data captured shall include the magnitude (% of the fundamental) and the direction of harmonic source (phase angle) for all odd and even multiples of fundamentals from 1st through the 50th.
  - d. Event/Alarm Analysis Screens shall display data recorded for up to ten (10) event/alarm conditions. The initiation level of the declaration of an event/alarm condition shall be field programmable for all measured parameters. For each event/alarm a description of the event/alarm, date, and time of event/alarm shall be recorded (10 ms resolution). In addition, a capture shall be made of all metered values available and all current and voltage distortion information available on the Harmonic Analysis Screens.
  - e. The MA&P shall be capable of transmitting all data at time of the event via communications to a personal computer for creating and displaying wave forms. In addition, the Event/Alarm Analysis Screens shall be capable of being initiated from an energized discrete input circuit, or through the communications port.
  - f. Event/Alarm Condition Levels shall be capable of being triggered by up to 7 of any of 61 conditions when the programmed threshold is exceeded. All shall have programmable time delays from 0.1 to 60 seconds except voltage disturbance which shall be programmable from 0 to 3600 cycles.

#### Voltage Disturbances

1. Undervoltage/sag -- A-B, B-C, A-C  
(selectable from 50 to 100%)
2. Undervoltage/sag--A-N, B-N, C-N  
(selectable from 50 to 100%)

3. Overvoltage/swell-- A-B, B-C, A-C  
(selectable from 100 to 150%)
4. Overvoltage/swell-- A-N, B-N, C-N  
(selectable from 100 to 150%)  
If time delay is programmed, any disturbance lasting two (2) cycles (less if magnitude is sufficient to effect RMS readings) shall trigger voltage disturbance event/alarm.

Maximum Threshold Exceeded

- 5-24 Present THD (2-1000) or Magnitude of THD for:  
-Current Phases A, B, C  
-Voltage A-B, B-C, C-A  
-Voltage A-N, B-N, C-N
- 25-31 Demand  
-Current Phases A, B, C, Average  
-System Power-watts, vars, VA
- 32 Voltage -- Neutral to Ground
- 33-34 Current -- Neutral or Ground

Minimum or Maximum Threshold Exceeded

- 33-40 Current Phases A, B, C
- 41-46 System Power-watts, vars, VA
- 47-49 Frequency High, Low, High or Low
- 50-53 System Power Factor  
-Displacement Minimum and Maximum  
-Apparent Minimum and Maximum

Voltage Phase Unbalance

- 54-55 Voltage Line-to-Line or Line-to-Neutral

Current Phase Unbalance

- Current comparison between Phases A, B, C

Discrete Input Energized

- 57-59 Input 1, 2, 3

IMPACC Communication

- Remote command through communications port

Manual Capture

- 61 Manual capture from pushbutton at device

4. The MA&P shall be capable of receiving the following inputs:
  - a. Instrument transformers: Input ranges of the MA&P shall accommodate external current transformers with ranges from 10,000/5 through 5/5 amperes. Provide external current transformers for each phase, neutral and ground circuit with rating as indicated on the drawing or sized for incoming service or associated feeder. MA&P shall be capable of overranging up to eight (8) times nominal current rating. Potential transformers shall be self included and fused for up to 600 volts with potential connections suitable for 3-phase 120-volt, 208/220/240-volt, 380/416-volt, 460/575-volt. Above 600 volts, provide fused external potential transformers for up to 500 kV.



- b. Control Power: The MA&P control power shall be capable of being supplied from the monitored incoming AC line up to 600 volts without the need for a separate AC control circuit unless a separate 120- or 240-volt source is indicated on the drawings. The device shall also be capable of being supplied from a separate control power source when indicated on the drawings (input range of 96 to 264 volts AC or 100 to 350 volts DC).
- c. Dry Contacts: Three (3) dry discrete input contacts shall be capable of being monitored which may be programmed by the user to perform any of the following functions. The status of the input contacts shall be locally displayable and accessible through the communications port.
  1. Trigger an Event/Alarm Analysis including Harmonic Analysis information for display on the device and information for Wave Form Analysis and display at a personal computer.
  2. Act as a synchronizing pulse input to synchronize demand windows with a utility provided synchronizing pulse.
  3. Actuate a relay output.
  4. Reset a relay output, peak demand, Minimum/Maximum, or Event Analysis records.
5. Furnish Relay Output Contacts with four Form C (NO/NC) relay output contacts which shall be capable of being independently programmed for the following functions:
  - a. Act as a kWH, kVARH, or kVAH pulse initiator output.
  - b. Actuate on one (1) or more Event/Alarm conditions, including discrete inputs and Communication Command signal. Each relay contact shall be capable of being set for Auto or Manual Reset with 0- to 30-minute release delay in one second increments. Relay contacts programmed to actuate on undervoltage shall also have a programmable 0- to 30-minute delay on power-up for transfer applications.
6. Furnish one (1) 0 to 20 mA analog input and three (3) 0 to 20 mA outputs. The input values shall be capable of being displayed on the device as a percentage and shall also be accessible throughout the communications port. Each analog output shall be programmable to reflect a phase current, voltage, power, demand, %THD, power factor, or system frequency.
7. The device shall be fully programmable from the faceplate, including alarm relay and power quality (e.g., harmonic distortion) settings. Programming shall be password protected.
8. <sup>9</sup>[Provide] [Make provisions for] an addressable communication card capable of transmitting all data, remotely controlling and programming the MA&P over a compatible two-wire local area network to a central personal computer for storage, analysis, display, and printout. The network shall also be capable of transmitting data in RS232c format via a translator module. The following minimum functions shall be available through communications at the personal computer with appropriate Windows-based software:

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<sup>9</sup> Note to Spec. Writer – Select one

- a. Monitoring and trending of all locally displayed values and device status
- b. Initiating an Event/Alarm
- c. Retrieving Event/Alarm information
- d. Retrieving Harmonic Analysis/Wave Form Analysis information including construction of the Harmonic Profile to graphically display simultaneously the relative magnitudes of the multiples of the fundamental frequency for both current and voltage of a given phase
- e. Retrieving Harmonic wave form analysis information for display of eight-cycle wave shapes of all simultaneously recorded current (phase A, B, C, N, and G) and voltages L-L and N-G
- f. Activating relay output contacts
- g. Programming device configuration and setpoints
- h. Synchronizing device clocks to within 30 milliseconds (for demand windows and time stamping).

D. IQ. Data

1. Where indicated on the drawings, provide a digital line Meter Monitor <sup>10</sup>(MM) device equal to Cutler-Hammer type Westinghouse IQ Data, having the features and functions specified below. The MM shall consist of a single microprocessor-based unit, capable of monitoring and displaying simultaneously current in each phase and voltage, phase-to-phase as well as phase-to-neutral on 4-wire systems. The MM shall auto range between units and kilo-units. The MM accuracy shall be 1% of read values. The MM shall have the capability to communicate data via twisted pair network. The MM shall be UL recognized and CSA certified.
2. Input ranges of the MM shall accommodate external current transformers with ranges from 25/5 through 5,000/5 amperes. Provide three (3) external current transformers with rating as indicated on the drawing or sized for incoming service. Potential transformers shall be self included and fused up to 600 volts. Above 600 volts, provide fused external potential transformers. Potential and current transformer ratios shall be field settable with DIP switches. The preset DIP switch settings shall be retained through a power failure.
3. The MM control power shall be capable of being supplied from the monitored incoming AC line without the need for a separate AC supply control circuit.
4. The display face shall be membrane-type and rated suitable for NEMA 3R and NEMA 12 mounting. The MM shall have two (2) durable 4-digit LED display screens. The MM shall have separate step buttons for changing through the voltage and current displays.
5. <sup>11</sup>[Provide] [Make provisions for] an addressable communication card capable of transmitting all data over a compatible two-wire local area network to a central personal computer for storage and/or printout. The network shall also be capable of transmitting data in RS232c format via a translator module.

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<sup>10</sup> This designation to be used on the drawings

<sup>11</sup> Note to Spec. Writer – Select one

## E. IQ Generator

1. Where indicated on the drawings, provide a digital line Generator Meter Monitor<sup>12</sup> (GMM) device equal to Cutler-Hammer type Westinghouse IQ Generator having the features and functions specified below. The device shall consist of a single microprocessor- based unit capable of monitoring and displaying simultaneously current in each phase, voltage phase-to-phase as well as phase-to-neutral on 4-wire systems, and frequency. The device accuracy shall be 1% of read values for current and voltage and 0.5% for frequency. The device shall have the capability to communicate data via twisted pair network. The device shall be UL recognized and CSA certified.
2. Input ranges of the device shall accommodate external current transformers with ranges from 25/5 through 5,000/5 amperes. Provide three (3) external current transformers with rating as indicated on the drawing or sized for incoming service. Potential transformers shall be self included and fused up to 600 volts. Above 600 volts, provide fused external potential transformers. Potential and current transformer ratios shall be field settable with DIP switches. The preset DIP switch settings shall be retained through a power failure.
3. The GMM control power shall be capable of being supplied from the monitored incoming AC line without the need for a separate AC supply control circuit.
4. The display face shall be membrane-type and rated suitable for NEMA 3R and NEMA 12 mounting. The device shall have three (3) durable 4-digit LED display screens. The device shall have separate step buttons for changing through the voltage and current displays.
5. <sup>13</sup>[Provide] [Make provisions for] an addressable communication card capable of transmitting all data over a compatible two-wire local area network to a central personal computer for storage and/or printout. The network shall also be capable of transmitting data in RS232c format via a translator module.

## F. IQ Energy Sentinel

1. Where shown on the drawings, supply a UL listed microprocessor- based Sub Metering Module<sup>14</sup> (SMM), Cutler-Hammer type Westinghouse IQ ENERGY SENTINEL or approved equal having the specified features. The SMM shall be available to directly attach to 150-ampere, 250-ampere and 400-ampere frame Molded Case Circuit Breakers equivalent to Cutler-Hammer type Westinghouse Series C or shall be panel or din-rail mountable where Cutler-Hammer type Westinghouse Series C breakers are not used. Where required for use with a circuit greater than 400A, a Universal type SMM for use with external current transformers shall be supplied. The SMM shall be suitable for use with single-phase 120/240-volt or 3-phase 208Y/120- volt or 480Y/277-volt AC systems where shown on the drawings.
2. The SMM, when utilized with its associated circuit breaker and connected via twisted pair network to the monitoring system Central Energy Display (CED) and/or computer, shall be capable of providing the following information in Units, Kilo-units or Mega-units as applicable:

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<sup>12</sup> This designation to be used on the drawings

<sup>13</sup> Note to Spec. Writer – Select one

<sup>14</sup> This designation to be used on the contract drawings

- a. WATTS
  - b. Present Watt Demand (5-, 10-, 15-, 30-, or 60-minute window)
  - c. Peak Watt Demand (same window as Present Watt Demand)
  - d. Watt-hours.
3. Accuracy of the SMM shall be +/- 1% of the Breaker Frame rating through a range of 0.1 to 1.25 of the Breaker Frame rating. The SMM shall be suitable for 60-cycle power systems with a Power Factor of from 90-degree lagging to 30-degree leading.
  4. Communications capability shall be provided to transmit information over a local area network at 9,600 baud. The communications network shall be noise immune to 60-cycle power and utilize a non-polarized shielded twisted pair of #18 wires.
  5. Each SMM shall include all of the following features:
    - a. When used with a 125, 250, or 400A Cutler-Hammer type Westinghouse Series C circuit breaker, have the same width and depth dimensions as its associated molded case breaker along with integral voltage stabs for mounting it directly to the circuit breaker. Device to include built-in neutral and communications terminals and transmit LED.
    - b. For circuits 400A and less, include three (3) built-in integral doughnut current transformers, suitable for having the load side cables passed through and being directly connected to the circuit breaker terminals without decreasing the code required bending space. For loads greater than 400A, provide three (3) current transformers.
    - c. Be powered directly from the monitored circuit and shall not need any separate control power source.
    - d. Include integral DIP switches for establishing its own address for the monitoring system.

## 2.1 MICROPROCESSOR-BASED METERING EQUIPMENT-- DISPLAY UNITS

### A. Central Energy Display

1. Where shown on the drawings supply a UL recognized Central Energy Display<sup>15</sup>(CED), Cutler-Hammer type Westinghouse CED or approved equal device for monitoring and displaying the information from the Sub Metering Modules (SMM), Cutler-Hammer type Westinghouse IQ Energy Sentinels or approved equal and Meter Monitor & Protection (MM&P) devices, Cutler-Hammer type Westinghouse IQ DP-4000 or approved equal. The CED shall be a microprocessor-based, self-contained device suitable for door mounting and shall perform the below listed functions. Each CED shall have provisions for a communications module to provide for remote computer monitoring up to 10,000 feet away.
2. The CED shall be capable of monitoring and displaying parameters of up to 50 SMMs and up to eight (8) Meter Monitor & Protection (MM&P) devices. There shall be separate step-up and step-down buttons to select specific SMMs or MM&P devices by

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<sup>15</sup> This designation to be used on the contract drawings

means of a device address in a display window. In addition to the device address, a user programmed, custom descriptive name for each remote device shall be displayed. The following parameters shall be displayed on a front NEMA 12 membrane faceplate for each remote device as it is selected:

- a. Energy Consumption (kilowatt-hours)
  - b. Peak Power Demand (kilowatts)
  - c. Present Power Demand (kilowatts)
  - d. Group readings -- The CED shall have the ability to sum the energy, peak power demand and present power demand readings for up to eight (8) user-selected device groups.
  - e. Status of each remote device -- active, inactive or no response
  - f. Historical alarm log
  - g. Date and time.
3. The CED shall be capable of being programmed to alarm for any of the following conditions:
- a. Whenever the value and time duration of a peak demand exceeds the user programmed maximum for both individual SMMs and groups of SMMs
  - b. On inactive SMM or loss of response from a SMM.
4. The user shall have the option at setup of deciding whether or not a security code is needed to access the acknowledgment for alarms and resetting of alarms. The alarms shall also be a capable of being acknowledged and reset by remote computer over the twisted pair network.
5. The CED shall have the following features:
- a. The CED shall be self-learning and poll its subnetwork and store the addresses of the SMMs and MM&Ps on the network. This shall be done automatically after the unit is turned on for the first time or shall be capable of being operator started for re-polling in the program mode. A custom description for each device on the subnetwork shall be capable of being entered and displayed in an 8-digit alphanumeric window.
  - b. The microprocessor shall have non-volatile memory and shall retain the addresses, types and description of devices during an AC power loss that have been previously stored in memory during the learn mode.
  - c. The CED shall have a real-time clock which is battery-backed.
  - d. The CED shall be suitable for 50- or 60-cycle, 240-volt or 120- volt control power (10 VA maximum power consumption).
  - e. The CED shall be suitable for operating conditions from 0 degrees C to 70 degrees C with a Humidity of 0 to 95% Relative Humidity non-condensing.

- f. Alarm contacts shall be rated 10 amperes at 250-volt AC resistive, or 30 volts DC 1/3 hp at 125 or 250 volts AC.
6. The CED shall have the following communications capability:
    - a. Communications to the various subnetwork devices shall be over a single twisted pair of conductors, with communications speed field selectable at either 1,200 or 9,600 baud for distances up to 10,000 feet.
    - b. <sup>16</sup>[Provide] [Make provisions only] for the addition of a CED communications module which will allow the CED to communicate with a remote master at either 1,200 or 9,600 baud. Communications modules shall be available for either communicating to a remote computer or programmable controller over Cutler-Hammer type Westinghouse IMPACC system, or over RS232c protocol.
- B. Assemblies Electronic Monitor II
1. Where indicated on the drawings, provide an Assemblies Electronic Monitor <sup>17</sup>(AEM), Cutler-Hammer type Westinghouse AEM II or equal. The AEM shall be microprocessor-based, self-contained device (NEMA 3R/12 faceplate) suitable for door mounting and shall perform the following listed functions. Each assembly shall have provisions for a communications module to provide for remote computer monitoring up to 10,000 feet.
  2. Monitor and display parameters of up to 40 circuit breakers equipped with microprocessor-based Digitrip RMS 700/800/810/910 trip units. Communications over the local area network shall be field dip switch selectable at either 1,200 or 9,600 baud. There shall be separate step up and step down buttons to select specific breakers by means of a breaker address in a display window. Parameters locally displayed at the AEM for each breaker and shall also be capable of being communicated via twisted pair to a remote personal computer and shall include:
    - a. Customized field programmable circuit breaker designation.
    - b. LEDs shall indicate circuit breaker status -- TRIPPED, OPEN, CLOSED, and NO RESPONSE.
    - c. Indicate cause of trip --"Long Delay," "Short Delay," "Instantaneous," "Ground," "Override/Discriminator," or "Communications Network."
    - d. LED shall also indicate circuit breaker high-load alarm when current exceeds 85% of LDPU setting for at least 40 seconds.
    - e. Current in each phase and ground, power in megawatts, peak power demand, energy used in megawatt hours, breaker trip unit in test mode, long delay pickup (overload in progress), missing or defective rating plug, unit failed RAM/ROM check, negative power, cause of circuit breaker trip, circuit breaker address, and trip buffers with real-time stamp data shall be shown in display window selected by means of membrane-type pushbuttons.
  3. The AEM shall be capable of transmitting via the twisted pair network to a remote computer in addition to the locally displayed parameters the following additional circuit breaker parameters:

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<sup>16</sup> Note to Spec. Writer – Select one

<sup>17</sup> This designation to be used on the contract drawings

- a. Circuit breaker type
  - b. Current rating of circuit breaker trip rating plug.
4. The program directing the functions and trip buffer data shall be permanently stored in the AEM so there is no need to reload data after an AC power loss. In addition, the addresses of breakers, type of devices and descriptions shall be stored in memory during an initial learn mode and shall be retained during an AC power loss.
  5. The AEM shall have a built-in alarm relay with Form C contacts rated 10 amperes resistive at 115 Vac for remote alarm, as well as an alarm LED. An ACK/Reset pushbutton shall be provided to acknowledge the alarm as well as de-energize the alarm relay, change the alarm LED from flashing to steady on, and stop cycling the alarmed breakers. The alarm data shall be stored in AEM memory and displayed whenever the alarm breaker address is selected. The alarm data shall be purged from memory only after the ACK/Reset pushbutton has been depressed again after the breaker trip unit is reset.
  6. The AEM shall be operated from 120-volt, single-phase input.
  7. The AEM shall have a "Help" button function which shall scroll English explanations in the alphanumeric window for any condition or abbreviations.
  8. <sup>18</sup>[Provide] [Make provisions for] an addressable communication card capable of transmitting all data, including trip data over a compatible two-wire local area network to a central personal computer for storage and/or printout. ~Provide date and time stamping for all breaker operations. Reprogramming of the AEM shall not be required when adding a communication module. The network shall also be capable of transmitting data in RS232c format via a translator module.
- C. Breaker Interface Module
1. Where indicated on the drawings, provide a Breaker Interface Module (BIM) Cutler-Hammer type Westinghouse BIM or equal. The BIM shall be a microprocessor-based, self-contained device (NEMA 3R/12 faceplate) suitable for door mounting and shall perform the following listed functions. Each assembly shall have provisions for a communications module to provide for remote computer monitoring up to 10,000 feet.
  2. Monitor and display parameters of up to 50 circuit breakers equipped with microprocessor-based trip units; Cutler-Hammer Westinghouse type Digitrip RMS 810, 910, OPTIM, and/or IQ energy sentinels. Communications over the local area network shall be 9,600 baud. There shall be separate step up and step down buttons to select specific breakers by means of a breaker address in a display window. Parameters locally displayed at the BIM for each device shall also be capable of being communicated via twisted pair to a remote personal computer and shall include:
    - a. Phase Current
    - b. Energy
    - c. Present Demand Watts
    - d. Peak Demand Watts

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<sup>18</sup> Note to Spec. Writer – Select one

- e. Average Demand Current
  - f. Cause and Magnitude of trip
  - g. Trip history
  - h. Percent Total Harmonic Distortion (THD) for each phase
  - i. Percent Harmonic Content for each phase (1st through 27th harmonic)
  - j. Custom Circuit Description.
3. Where applicable, the BIM shall be capable of transmitting the following parameters:
    - a. Waveform Analysis
    - b. Power Factor
    - c. Breaker Curves.
  4. LEDs shall indicate circuit breaker status -- TRIPPED, OPEN, CLOSED, and NO RESPONSE.
  5. Indicate cause of trip -- "Long Delay," "Short Delay," "Instantaneous," "Ground," "Override/Discriminator," or "Communications Network".
  6. LED shall also indicate circuit breaker high-load alarm when current exceeds 85% of LDPU setting for at least 40 seconds.
  7. The program directing the: functions and trip buffer data shall be permanently stored in the BIM so there is no need to reload data after an AC power loss. In addition, the addresses of breakers, type of devices and descriptions shall be stored in memory during an initial learn mode and shall be retained during an AC power loss.
  8. The BIM shall have a built-in alarm relay with Form C contacts rated 10 amperes resistive at 277 Vac for remote alarm, as well as an alarm LED. An ACK/Reset pushbutton shall be provided to acknowledge the alarm as well as de-energize the alarm relay, change the alarm LED from flashing to steady on, and stop cycling the alarmed breakers. The alarm data shall be stored in BIM memory and displayed whenever the alarm breaker address is selected. The alarm data shall be purged from memory only after the ACK/Reset pushbutton has been depressed again after the breaker trip unit is reset.
  9. The BIM shall be operated from 120-volt or 240-volt, single-phase input.
  10. The BIM shall have a "Help" button function which shall scroll English explanations in the alphanumeric window for any condition or abbreviations.
  11. <sup>19</sup>[Provide] [Make provisions for] an addressable communication card capable of transmitting all data, including trip data over a compatible two-wire local area network to a central personal computer for storage and/or printout. Provide date and time stamping for all breaker operations. Reprogramming of the AEM shall not be required

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<sup>19</sup> Note to Spec. Writer – Select One



when adding a communication module. The network shall also be capable of transmitting data in RS232c format via a translator module.

- D. ADVANTAGE Central Monitoring Unit (CMU)
1. Where shown on the drawing, provide a Cutler-Hammer type Westinghouse Advantage Central Monitoring Unit (CMU) or approved equal. The CMU shall be a microprocessor-based, self-contained device (NEMA 3R/12 faceplate) suitable for door mounting and shall perform the following listed functions. Each assembly shall have provisions for a communications module to provide for remote computer monitoring up to 10,000 feet.
  2. Monitoring and display parameters of up to 99 Cutler-Hammer type Westinghouse Advantage starters or contactors equipped with product operated network interface card (PONI), or Cutler-Hammer type Westinghouse IQ 500 solid-state overload relays. Communications over the local area network shall be 9,600 baud. Parameters locally displayed at the CMU for each starter and overload relay shall also be capable of being communicated via twisted pair to a remote personal computer. Information displayed at the CMU shall include the following:
    - a. Status--ON, OFF, TRIPPED, NO RESPONSE
    - b. Standard address
    - c. Three-phase current
    - d. Control voltage
    - e. Overload condition (alarm)
    - f. Cause of device trip
    - g. Operations count
    - h. Run time
    - i. Set points
    - j. Starter description and identification.
  3. When used with the remote communications option, the CMU shall pass data to a computer from Advantage starters, contactor, and overload relays-IQ 500. The master or the host network's baud rate (speed of upper network passing data to a computer) shall be independent of the CMU's subnetwork baud rate. The master or host network's baud rate shall be established via the PONI communications module, while the CMU's subnetwork baud rate shall be switch selectable on the rear of the CMU.
  4. The program directing the functions of the CMU shall be permanently stored in the CMU. There shall be no need to reload data after AC power loss.
  5. The addresses, types of devices and descriptions shall be stored in memory during the learn mode and shall also be retained throughout a power loss. Unless there has been a change, it shall not be necessary to re-enter the learn mode after a power loss.

6. CMU shall have an 8-digit alphanumeric display to monitor active data, trip data or set points which are available from the individual Motor Control devices. CMU shall have three (3) LEDs to indicate which group of data is being displayed, as selected through membrane-type alphanumeric pushbuttons by the user. CMU shall have a 2-digit alphanumeric display to indicate the address of the control device, for which data is being displayed. CMU shall have membrane type push- buttons to allow the user to step up or down to select the control device to be displayed. CMU shall have two additional LEDs at the top of the CMU to indicate that the CMU is operational and when there is an "alarm" status on one of the motor control devices. CMU shall have an "acknowledge/reset" membrane-type pushbutton to permit the user to reset the CMU following a motor control device trip.
7. The CMU shall be operated from 120-volt, single-phase input.
8. The CMU shall have a "Help" button function, which shall scroll English explanations in the alphanumeric window for any condition or abbreviations.
9. Provide data and time-stamping for all starter/contactor operations. Reprogramming of the CMU shall not be required when adding a communication module.
10. <sup>20</sup>[Provide] [Make provisions for] an addressable communication card capable of transmitting all data, including trip data over a compatible two-wire, local area network to a central personal computer for storage and or printout. The network shall also be capable of transmitting data in RS232c format via a translator module.

## 2.2 TEMPERATURE MONITORING EQUIPMENT

### A. Universal RTD Module

1. Where indicated on the drawings, provide an electronic Resistance Temperature Detector Module <sup>21</sup>(RTDM) for use with associated Motor Protective Relay (MPR) or as a standalone device to monitor motor temperature. The RTDM shall be equal to Cutler-Hammer type Westinghouse Universal RTD module having the following specified features and functions. The RTDM shall be UL recognized, CSA certified and also meet appropriate ANSI standards.
2. The RTDM shall be capable of monitoring RTDs of the 3-lead type or 2-lead type as provided by the motor manufacturer. The RTDM shall be capable of monitoring up to eleven (11) RTD inputs of four function groups as follows: six (6) for motor windings, two (2) for motor bearings, two (2) for load bearings and one (1) auxiliary input. The RTDM shall be field DIP switch programmable to accept any of the following types of RTD inputs:
  - a. 10-ohm copper
  - b. 100-ohm platinum
  - c. 100-ohm nickel
  - d. 120-ohm nickel.

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<sup>20</sup> Note to Spec. Writer – Select One

<sup>21</sup> This designation to be used on the contract drawings

It shall be possible to field select a different type RTD for each of the four function groups.

3. The RTDM shall operate from 120-volt AC power (+15%, -15%), 50 hz or 60 hz. Power consumption with communication card shall be 7 volt- amperes. Provide appropriate control power transformer when RTDM is located in motor starter assembly or appropriate 120-volt circuit when located at the motor.
4. The RTDM shall be suitable for location at the MPR or at the motor as indicated on the drawings. The RTD module, when located at the motor shall be capable of transmitting all temperature information to the MPR over 3 conductor shielded cable up to a maximum distance of 500 feet or via a fiber-optic link up to a maximum distance of 400 feet. Contractor to provide shielded cable or fiber-optic link, as shown on the drawings, or as recommended by the manufacturer.
5. The RTDM shall be suitable for operating temperatures from 0 to 70 degrees C and suitable for humidity of 0 to 95% RH non-condensing. It shall be in a NEMA 1 enclosure approximately 8 inches by 5 inches by 2 inches without communication module.
6. When the drawings indicate the RTDM is utilized for monitoring temperature only, without an MPR device, a communication module shall be supplied which jacks into the RTDM and shall be capable of communicating temperature information up to 10,000 feet over a twisted pair network to a remote master control station.

### PART 3 EXECUTION

#### 3.1 Installation of IQ Meters

- A. Wire shall be 2 pair 18 AWG stranded individually and overall shield type PLTC/ITC cable (P/N W118-02ISOSTC/L31802) installed from the new meter location to either the main telephone backboard or the nearest existing meter location.
- B. Conduit shall be a minimum of ¾”.
- C. All devices shall be interconnected in a series (daisy chain) configuration.

END OF SECTION

SECTION 26 32 13  
ENGINE GENERATORS

## PART 1 GENERAL

## 1.1 GENERAL

## A. General

1. The requirements specified as general requirements of this project shall apply to and govern the work under CSI Division 1 except where indicated in the following articles. Specific attention is directed to [Division 25 and 26 - Mechanical and Electrical Requirements].

## B. Work Included

1. Provide all labor, materials, and equipment to furnish, install, and place in operation the power generation system in accordance with the contract documents and manufacturer's drawings and installation instructions. These specifications also describe requirements for the design, fabrication, and testing of the power system.

## C. The installation of the power generation system shall include, but is not limited to the following:

1. Engine-driven generator set
2. Control system
3. Cooling system
4. Fuel supply and storage system
5. Generator set accessories
6. Mounting system
7. System control

## D. Related Work

1. All applicable specifications under this contract shall be considered.
  - a. Basic Mechanical Requirements
  - b. Expansion Compensation
  - c. Supports and Anchors
  - d. Vibration isolation
  - e. Piping insulation
  - f. Equipment Insulation
  - g. Ductwork Insulation
  - h. Fire Protection
  - i. Plumbing and Piping
  - j. Underfloor ducts
  - k. Cable trays
  - l. Wires and cables
  - m. Wire connections/devices
  - n. Panelboards
  - o. Circuit Breakers
  - p. Motor Starter

E. System Description

1. The electric power generating system shall have a site capability of [ ], power factor, 480 volts, Wye connected, three phase, 4 wire, 60 hertz. This power shall be applied for Standby operation.

F. System Loads

1. The system load shall include:

Single Phase Loads

	line-line	line-neutral (gnd)
Phase 1	kW	kW
Phase 2	kW	kW
Phase 3	kW	kW

Three Phase Loads

Lighting	kW	
Other Non-motor		kW @ PF
Nonlinear		Eff
Pulse		Bat Recharge
		UPS
		kW

Var Freq Motors

Motors

Start	Start	Seq	Size	Volt Dip %
		Comment		

G. System Function

1. The generator set shall include the capability of automatically controlling generator set operation. After starting, the unit will attain rated speed and voltage, and accept rated load. Generator set speed shall be controlled by the engine governor, while generator output voltage regulation shall be a function of the generator automatic voltage regulator. Manual adjustment of generator speed and voltage shall be provided on the generator control panel.

H. Single Generator Set

1. The generator set start-stop sequence shall be initiated manually or automatically by closing or opening of a contact. The control system shall automatically engage the cranking motor, sense engine starting speed, disengage the motor, and arm the engine protection circuit.
2. The set shall immediately shut down in the event of overspeed, low oil pressure, high water temperature and overcrank. Cause of shutdown shall be indicated by a light annunciator. System logic shall prevent restart until fault is cleared. There shall be a provision for manual shutdown.

I. Site Conditioned, Diesel

1. The operating environment of the power generating system shall be:

Altitude \_\_\_\_\_ 1000 ft.  
 Engine room temperature, max \_\_\_\_\_ 110 EF  
 Outside temperature, min \_\_\_\_\_ 32 EF  
 Installation description. \_\_\_\_\_ Enclosure  
 Fuel type \_\_\_\_\_ Diesel  
 Cooling System Type \_\_\_\_\_ Radiator, Blower fan, engine mounted  
 Fuel Tank \_\_\_\_\_ 8 hours, skid mounted

J. System Performance, General

1. The power generating system shall conform to the following performance criteria:

- a. Rating - Engine brake horsepower shall be sufficient to deliver full rated generator set kW/KVA when operated at rated rpm and equipped with all engine-mounted parasitic and external loads such as radiator fans and power generators regardless of ambient temperature.
- b. Conditions - The rating shall be based on SAE J1349 conditions of 100kPa (29.61 in Hg) and 25EC (77EF). The rating shall also apply at ISO 3046/1, DIN 6271, and BS 5514 standard conditions.
- c. Fuel - Diesel engines shall be able to deliver rated power when operating on No. 2 diesel fuel having 35 degree API (16EC or 60EF) specific gravity.
- d. Fuel Consumption - Diesel fuel rates shall be based on fuel having a low heating value (LHV) of 42,780 kJ/kg (18,390 Btu/lb) when used at 29EC (85EF) and weighing 838.9 g/l (7.001 lbs/US gal).
- e. Start Time and Load Acceptance - Engines shall start, achieve rated voltage and frequency, and be capable of accepting load within 10 seconds.
- f. Block Load Acceptance - Transient response shall conform to ISO 8528 requirements.

K. Quality Assurance

- 1. The complete power generation system, shall be assembled by one manufacturer who has been regularly engaged in the production of complete generating systems for at least thirty (30) years. All components shall have been designed to achieve optimum physical and performance compatibility and prototype tested to prove integrated design capability. The complete system shall have been factory fabricated, assembled, and production tested.
- 2. Acceptable manufacturers are:

- a. Caterpillar
- b. ONAN
- c. Kohler
- d. Cummins

L. Responsibility

1. The responsibility for performance to this specification shall not be divided among individual component manufacturers, but must be assumed solely by the primary manufacturer. This includes generating system design, manufacture, test, and having a local supplier responsible for service, parts, and warranty for the total system. This responsibility includes all necessary coordination with the supplier of the automatic transfer switch.

M. Prototype Tests

1. The system manufacturer must be able to certify that engine, generator, controls, and switchgear have been tested as complete systems of representative engineering models (not on equipment sold).

N. Production Tests

1. The system manufacturer shall perform post production tests on the generator set supplied. A certified report of these tests shall be available when requested at the time of the generator set order. The test shall be made on the complete system.

O. Drawings/Schematics

1. All installation drawings and wiring diagrams for the generator set, controls, and switchgear must conform to a common format.

P. References

1. This specification includes applicable considerations of:  
  
American Society of Mechanical Engineers (ASME)  
Association of British Generating Set Manufacturers (ABGSM)  
British Standards Institution (BS)  
Diesel Engine Manufacturers Association (DEMA)  
Electrical Generating Systems Association (EGSA)  
Deutsches Institut fuer Normung (DIN)  
International Electrotechnical Commission (IEC)  
International Standards Organization (ISO)  
Institute of Electrical and Electronics Engineers (IEEE)  
National Electrical Code (NEC)  
National Electric Manufacturers Association (NEMA)  
National Fire Protection Association (NFPA)  
Occupational Safety and Health Act (OSHA)  
Society of Automotive Engineers (SAE)  
United States Military Standards for Generators and Controls (MIL-STD)  
Verband Deutscher Elektrotechniker (VDE)

Q. Submittals

1. Submittals for approval shall be made in accordance with Division 1. Submittals shall include but not be limited to:
  - a. Component List - A breakdown of all components and options including switchgear.
  - b. Technical Data - Manufacturer produced generator set specification or data sheet identifying make and model of engine and generator, and including relevant component design and performance data.
2. Engine:
  - Type, aspiration, compression ratio, and combustion cycle
  - Bore, stroke, displacement, and number of cylinders
  - Engine lubricating oil capacity
  - Engine coolant capacity without radiator
  - Engine coolant capacity with radiator
  - Coolant pump external resistance (maximum)
  - Coolant pump flow at maximum resistance
3. Generator:
  - Model
  - Frame
  - Insulation class
  - Number of leads
  - Weight, total
  - Weight, rotor
  - Air flow
4. At rated voltage:
  - Efficiency at 0.8 power factor for 50 % load, 75 % load and 100% load
  - Time constants, short circuit transient (T'D)
  - Time constants, armature short circuit (TA)
  - Reactance, subtransient - direct axis (X"D)
  - Reactance, transient - saturated (X'D)
  - Reactance, synchronous - direct axis (XD)
  - Reactance, negative sequence (X2)
  - Reactance, zero sequence (X0)
  - Fault current, 3 phase symmetrical
  - Fault current single phase to ground
  - Decrement curve for 3 phase and single phase to ground
5. Radiator:
  - Model
  - Type
  - Fan drive ratio
  - Coolant capacity, radiator
  - Coolant capacity, radiator and engine
  - Weight, dry and wet



- 6. System:
  - Dimensions: length  
 width  
 height
  - Weight: dry  
 wet
  
- 7. Transient response of frequency and voltage for the generator set [and, if units are operating in parallel,] for the total system when imposing block load changes of:
  - 0 - 25%
  - 0 - 50%
  - 0 - 75%
  - 0 - 100%
  - 100 - 0%
  - 75 - 0%
  - 50 - 0%
  - 25 - 0%
  
- 8. Auxiliary Equipment - Specification or data sheets, including switchgear, transfer switch, vibration isolators, and day tank.
  
- 9. Drawings - General dimensions drawings showing overall generator set measurements, mounting location, and interconnect points for load leads, fuel, exhaust, cooling and drain lines.
  
- 10. Wiring Diagrams - Wiring diagrams, schematics and control panel outline drawings published by the manufacturer in Joint Industrial Council (JIC) format for controls and switchgear showing interconnected points and logic diagrams for use by contractor and owner.
  
- 11. Warranty Statements - Warranty verification published by the manufacturer.
  
- 12. Service - Location and description of supplier's parts and service facility including parts inventory and number of qualified generator set service personnel.
  
- R. Service and Warranty
  - 1. The manufacturer shall have a local authorized dealer who can provide factory trained servicemen, the required stock of replacement parts, technical assistance, and warranty administration.
  
- S. Warranty Administration
  - 1. The manufacturer's authorized dealer shall be capable of administering the manufacturer's and dealer's warranty for all components supplied by the selling dealer (who may or may not be the same as the servicing dealer).

## T. Warranty Terms

1. The manufacturer's and dealer's standard warranty shall in no event be for a period of less than one (1) year from date of initial start-up of the system and shall include repair parts, labor, reasonable travel expense necessary for repairs at the jobsite, and expendables (lubricating oil, filters, antifreeze, and other service items made unusable by the defect) used during the course of repair. Running hours shall not be a limiting factor for the system warranty by either the manufacturer or servicing dealer. Submittals received without written warranties as specified will be rejected in their entirety.

## U. Parts Availability

1. The generator set supplier shall have sufficient parts inventory to maintain over the counter availability of at least 90% of any required parts.

## PART 1 PRODUCTS

## 1.1 PRODUCTS

- A. The following articles and paragraphs are intended to define a power generation system of proven type and design, of current production, and with all components commercially available.

1. Engine

- a. The engine shall be a stationary, liquid cooled, 1800 rpm, four-cycle design, vertical in-line or V-type, with Dry exhaust manifolds. It shall have 8 cylinders with minimum displacement of 34.5 liters and be manufactured in the United States.

2. Engine Equipment

- a. The engine shall be equipped with air filters, fuel filters and pressure gauge, lubricating oil cooler, filters, and pressure gauge, water pump and temperature gauge, service hour meter, flywheel, and flywheel housing when applicable.

3. Lubrication System

- a. The lubrication oil pump shall be a positive displacement type that is integral with the engine and gear driven from the engine gear train. The system shall incorporate full flow filtration with bypass valve to continue lubrication in the event of filter clogging.

- b. The bypass valve must be integral with the engine filter base or receptacle. Systems where bypass valves are located in the replaceable oil filter are not acceptable. Pistons shall be oil cooled by continuous jet spray to the underside or inside of the crown and piston pin.

4. Diesel Fuel System
  - a. The fuel system shall be integral with the engine. It shall consist of fuel filter, transfer pump, injection pumps, lines, and nozzles. The transfer pump shall deliver fuel under low pressure to individual injection pumps - one for each cylinder.
  - b. The injection pumps shall be driven from the camshaft and simultaneously controlled by a rack and pinion assembly that is hydraulically actuated by signals from the engine governor. The pumps shall be of a variable displacement type to alter the volume of fuel delivered to the spray nozzles according to load demand.
  - c. The nozzles shall inject fuel directly into the cylinder in the optimum spray pattern for efficient combustion.
5. Fuel/Water Separator
  - a. A fuel/water separator shall protect the fuel system from water damage.
6. Fuel Cooler
  - a. Fuel shall be piped from the filter/water separators to the intake of the engine fuel pump, and then to the engine. Excess fuel shall be piped through the fuel cooler and returned to the fuel tank with less than 60 kPa restriction. The fuel cooler shall be capable of exchanging heat rejected at full load with the cooling medium, including 10% reserve to accommodate fouling.
7. Fuel Priming Pump
  - a. A manual fuel priming pump shall facilitate priming and bleeding air from the system.
8. Fuel Lines
  - a. Flexible fuel lines between engine and fuel supply shall be installed to isolate vibration.
9. Fuel Tank
  - a. A dual wall base mounted fuel tank shall be provided. The tank shall incorporate a fuel gauge and a low fuel level alarm contact. Fuel leak detector and audible alarm shall be provided between the inner and outer tank. Fuel tank shall be UL approved and bear the UL label. Tank capacity shall provide for 8 hours operation at full output at site condition.

10. Governor
  - a. The engine governor shall control engine speed and transient load response within commercial and ISO 8528 tolerances. It will be selected, installed, and tested by the generator set manufacturer.
  - b. The engine governor shall be a Woodward 8290 Electronic Speed Control with 24 volt DC Electric Actuator. Speed droop shall be 0 (isochronous) from no load to full rated load. Steady state frequency regulation shall be +/- 0.25%. Speed shall be sensed by a magnetic pickup off the engine flywheel ring gear. A provision for remote speed adjustment shall be included.
11. Radiator, Engine Mounted
  - a. Heat rejected to the engine jacket water shall be discharged to the atmosphere through a close coupled radiator. The radiator shall be sized to cool the engine continuously while operating at full rated load and at site conditions. It shall be a folded core design consisting of individually replaceable core assemblies sealed between the top and bottom tank and which can be replaced individually at the job site.
  - b. The cooling system shall tolerate at least 172.4 kPa (25 PSI) static head. Coolant temperature shall be internally regulated to disconnect external cooling systems until operating temperature is achieved.
12. Fan and Belt Guarding
  - a. The fan, fan drive, and fan belts shall be covered with 14 gauge punched steel mesh guarding for personnel protection. The guarding shall conform to IEC 34-5, ISO and OSHA standards.
13. Blower Fan
  - a. The radiator cooling fan shall be a blower type driven from the engine. Air shall be drawn from the engine side and exhausted through the radiator core.
14. Inlet Air System
  - a. The engine air cleaner shall be engine mounted with dry element requiring replacement no more frequently than 250 operating hours or once each year. 2906 cfm.
15. Turbocharging
  - a. Only single stage turbocharging shall be allowed. The turbocharger shall be of the axial turbine type driven by engine exhaust gases and direct connected to a compressor supplying engine combustion air.

16. Aftercooling
- a. Aftercooler core air surfaces shall be coated with a corrosion inhibitor to minimize oxidation.
17. Exhaust System
- a. The engine exhaust system shall be installed to discharge combustion gases quickly and silently with minimum restriction. System including silencer shall be designed for minimum restriction, and in no case shall backpressure exceed 6.7kPa.
  - b. Heavy walled piping such as Schedule 40 is preferred, with radii of 90E bends at least 1 1/2 times the pipe diameter. Piping shall be installed with 229 mm (9 in) minimum clearance from combustible material or incorporate appropriate insulation and shielding.
  - c. Piping shall be supported and braced to prevent weight or thermal growth being transferred to the engine and flexible expansion fittings provided to accommodate thermal growth. Support dampers and springs shall be included where necessary to isolate vibration.
  - d. Long runs of pipe shall be pitched away from the engine and water traps installed at the lowest point. Exhaust stacks shall be extended to avoid nuisance fumes and odors, and outlets cut at 45E to minimize noise.
18. Exhaust Noise Control
- a. The exhaust silencer shall be sized and supplied by the engine supplier. It shall be mounted on top of the engine enclosure to minimize noise and condensation, and pitched away from the engine. A provision for draining moisture shall be included.
  - b. The silencer shall provide the commercial level of attenuation while imposing no more than 6.7 kPa restriction.
19. Emissions
- a. The generator set must meet the South Coast Air Quality Management District requirements. Contractor or engine manufacturer should secure the permit.
20. Wiring and Conduit
- a. Engine and generator control wiring shall be multi-strand annealed copper conductors encased by cross-linked polyethylene insulation resistant to heat, abrasion, oil, water, antifreeze, and diesel fuel. Wiring shall be suitable for continuous use at 120EC (250EF) with insulation not brittle at

-50EC (-60EF). Each cable will be heat stamped throughout the entire length to identify the cable's origin and termination. Cables shall be enclosed in nylon flexible conduit which is slotted to allow easy access and moisture to escape. Reusable bulkhead fittings will attach the conduit to generator set mounted junction boxes.

21. Electric Starting System
  - a. The engine starting system shall include 24 volt DC starting motor, starter relay, and automatic reset circuit breaker to protect against butt engagement. The system shall be capable of starting a properly equipped engine within 10 seconds at ambient temperatures greater than 22EC (70EF).
22. Jacket Water Heater
  - a. Jacket water heater(s) shall be provided to maintain coolant temperature of 32E C (90EF) while the engine is idle. Heaters shall accept 120, 240 or 480 volt AC single phase power and include adjustable thermostats.
23. Batteries
  - a. Batteries for starting and control shall be selected and supplied by the generator set manufacturer. They shall be a heavy duty SLI lead acid type with thru-partition connectors, and housed in a hard rubber or polypropylene case with provision for venting.
  - b. Starting batteries shall be sized considering specific application requirements of engine oil viscosity, ambient starting temperature, control voltage, overcharging and vibration.
  - c. Batteries shall be located as close to the starting motor as practical, away from spark sources, and permit easy inspection and maintenance.
  - d. Battery warranty shall be the responsibility of the generator set manufacturer. A low battery voltage indicating alarm and audible alarm shall be provided.
24. Alternator
  - a. An engine mounted belt driven battery charging alternator shall be installed with an automatic voltage regulator. It shall be suitable for heavy duty applications with a rating and ampacity compatible with the battery system.
25. Instrumentation - Engine Mounted
  - a. The engine mounted instrument panel shall consist of a shock-mounted formed and welded enclosure primed for coastal environment and finished in semigloss black enamel. Metric/English marked gauges with minimum 63.5 mm

(2.5 in) diameter dial face shall be mounted in a brushed stainless steel face panel with pressure instruments piped to bulk head connections in the enclosure bottom. Gauges shall include: engine oil pressure, oil filter differential, fuel pressure, jacket water temperature and electric service meter.

b. Temperature and pressure gauges shall be non-vented with interior filled with argon gas. Gauges shall resist water entry under 22.5 kPa (3.25 psi) pressure. Provision shall be made in the panel for three additional gauges.

26. Generator

a. The generator shall be rated for Standby service at [ ], three phase, 4 wire, 60 Hz, 1800 rpm.

b. The generator shall be capable of withstanding and supplying a three phase load of 300% rated current for 10 seconds, and sustaining 150% of continuous load current for 2 minutes with field set for normal rated load excitation.

c. It shall exhibit less than 5% waveform deviation at no load.

d. Generator shall be of 2/3rd pitch with its windings braced to withstand the phase to ground fault in a solidly grounded neutral system.

e. Generator efficiencies shall be calculated according to IEC 34-2 Section 4, with all I<sup>2</sup>R losses corrected to 115EC.

27. Generator Specifications

a. The generator shall be designed, manufactured and identified according to the following specification:

Type_____	Brushless
Number of leads_____	10
Insulation class_____	155EC
Connection_____	Wye
Construction_____	Single Bearing
Heat rise_____	130.0EC

b. Efficiency (at 0.8 pf) as minimum

rated load %	load kW	efficiency %
50	450	94.40
75	675	94.40
100	900	93.90

28. Structure
- a. The generator shall be close coupled, drip proof and guarded, constructed to NEMA 1 and IP 22 standards, single bearing, salient pole, revolving field, synchronous type with amortisseur windings in the pole faces of the rotating field.
29. Mechanical Design - Single Bearing
- a. The generator housing shall be one piece and mount directly to the engine flywheel housing without bolted adapters. Engine torque shall be transmitted through flexible steel plates to the generator rotor. The generator ventilating fan shall mount to the engine flywheel and act as a pressure plate to secure the flexible plates.
  - b. The rotor assembly shall demonstrate 150% overspeed capability at 170EC for 2 hours. Rotor dynamic, two plane balance shall not exceed 0.002 inch peak to peak amplitude at operating speed. All rotating components shall be secured with SAE Grade 8 hardware.
30. Windings
- a. Thermal Class 200 magnet wire as described by NEMA Magnet Wire Standard MW 1000, Section MW 35-C, shall be used for rotor and stator windings. The windings shall consist of copper magnet wire coated with an underlay of polyester (amide)(imide) resins and a superimposed heavy coat of polyamideimide resins. All winding insulation materials shall be Class H in accordance with BS and IEEE standards. No materials shall be used which support fungus growth, and shall be impervious to oil, dirt, and fumes encountered in diesel and natural gas engine operating environments.
31. Windings - Low Voltage
- a. The revolving field coils shall be precision wet layer wound with epoxy based material applied to each layer of magnet wire. Stator shall have at least two dips and bakes using Class H impregnating varnish. Basic lightning impulse insulation level (BIL) shall not be less than 3 kV. Windings shall be tested at 3000 volts AC.
32. Operating Environment
- a. The generator shall be designed to operate in a sheltered drip-proof environment.
33. Excitation
- a. The generator exciter shall be brushless with the circuit consisting of a three-phase armature and a three-phase full wave bridge rectifier mounted on the rotor shaft. Surge



suppressors shall be included to protect the rotating diodes from voltage spikes.

34. Exciter - Permanent Magnet

a. The permanent magnet excitation system shall derive excitation current from a pilot exciter mounted on the rotor shaft. It shall enable the generator to sustain 300% of rated current for ten seconds during a fault condition.

35. Voltage Regulator

a. The automatic voltage regulator shall maintain generator output voltage by controlling the current applied to the exciter field of the generator.

b. The regulator shall be a totally solid state design which includes electronic voltage buildup and overcurrent protection. It shall incorporate 1:1 volts per Hertz characteristics with the regulated voltage a linear function proportional to frequency over a 30 to 70 Hz range.

c. The regulator shall be suitable for mounting within or external to the generator assembly, and have provision for remote voltage level control.

d. The regulator shall sense two line - to - line phases of generator output voltage and exhibit the following characteristics:

- (1) Generator output voltage maintained within +/- 1% of rated value for any load variation between no load and full load.
- (2) Generator output voltage drift no more than +/-0.5% of rated value at constant temperature.
- (3) Generator output voltage drift no more than +/- 2% of rated value over ambient operating temperature range of -40@C to 70@ C.
- (4) Telephone Influence Factor (TIF) of less than 50.
- (5) Electronic Interference/Radio Frequency Interference (EMI/RFI) suppressed to commercial standards.
- (6) The regulator shall include the following features:
- (7) Voltage level rheostat shall provide generator output voltage adjustment of -25% to +10% of nominal.
- (8) Gain adjustment shall provide output voltage compensation for changes in load or frequency.

(9) At full throttle engine starting, output voltage shall not overshoot more than 5% of its rated value, with respect to the volts/Hz curve. Response time shall be less than 20 milliseconds.

e. Protection shall be provided against loss of voltage sensing and long term overcurrent conditions. The overcurrent protection function shall automatically reset when the regulator is de-energized. The regulator shall not be damaged or result in unsafe operation when subjected to open or shorted input due to sensing loss, or a short to ground or adjacent conductor.

f. The regulator module shall be potted sufficiently to operate in environments not directly exposed to water. All electrical connections shall be through labeled screw terminals.

36. Mounting

a. The engine and generator shall be assembled to a common base by the engine-generator manufacturer. The generator set base shall be designed and built by the engine-generator manufacturer to resist deflection, maintain alignment, and minimize resonant linear vibration.

37. Mounting Base - Standby Package

a. The base shall be constructed of formed steel members with minimum 6 mm thickness. Corners shall be squared to provide rodent/bird proof joint when enclosure is added. Provision shall be made for four corner lifting. It shall incorporate flexible fuel lines, external oil and coolant drains, and external crankcase fumes disposal hose. Support cross members shall add rigidity and allow installation of vibration isolators between base and generator set. [Preferable the skid shall be bolted to the concrete pad. Manufacturer to supply the sole plates.] Generous space for ground stub-ups between the members shall be provided. The base shall include bottom mounting holes and be compatible with the fuel tank sized to support 8 hours of fuel at full load. The fuel tank shall be UL approved.

38. Enclosure - Standby Package, Basic

a. The enclosure shall offer protection as specified by OSHA from all moving parts of the engine, generator and generator coupling. It shall be constructed to allow full access to the engine for maintenance without exposing personnel to any moving machinery. Radiator and radiator fan assembly shall be totally enclosed with lockable door over the radiator cap. The radiator shall be sized to accommodate any resulting air flow restrictions. Provision shall be made for a duct flange or perforated metal grill to protect the radiator core.

b. Louvers shall allow sufficient air flow to allow full load operation of the generator set. The louvers shall be twisted to deflect water and direct noise downward. The enclosure shall satisfy NEMA 12 and IEC IP22 requirements for drip proof construction acceptable for outside installation when doors are in place.

c. The enclosure shall be fitted to the generator set base. Corners shall be formed and welded to assure strength and rigidity. Sheet metal of 2.0 mm minimum thickness shall have no burrs or sharp edges. Inside and outside surfaces shall be finished with a baked high performance enamel. Exposed fasteners shall be minimized with all hardware zinc plated.

39. Controls, Protection, and Mounting

a. The controls, protection, and monitoring systems of the generator set and its operation shall be the responsibility of the generator set manufacturer. All subsystem components, interfaces, and logic shall be compatible with engine mounted devices.

40. Automatic Start-Stop Control

a. The control panel shall be shock mounted on the skid. Do not mount the control panel on top of the generator. The 24 volt DC system shall be used for the logic system.

b. Control: Generator voltage level rheostat and ammeter/voltmeter phase selector switch shall be mounted on the panel door. The engine start-stop switch shall be door mounted and include positions for off/reset, manual, automatic, and stop.

c. Shutdowns/Annunciation: The generator set shall shut down and individual red lights shall signal operational faults of high water temperature, low oil pressure, overspeed, and overcrank.

d. Monitor: Monitoring devices shall include AC voltmeter, AC ammeter, ammeter/voltmeter phase select switch, frequency meter, electric hourmeter battery voltage, oil pressure gauge, and water temperature gauge.

e. Safety Devices: ISO red emergency stop pushbutton shall be provided, and all controls, annunciation, and monitors labeled with ISO symbols.

41. Cycle Cranking

a. A cycle crank timer shall provide five 10 second cranking periods separated by 10 second rest periods.

42. Engine Cooldown

a. A cool down timer shall provide an adjustable 0-30 minute engine running period before shutdown after removal of load.

43. Alarm Module

a. NFPA-110 requirements for the alarm panel shall be satisfied by a 24 volt DC alarm module mounted in the panel and including red indicating lights and silencable alarm horn to enunciate alarm conditions for high and low coolant temperature, low oil pressure, low DC voltage, and system not in automatic. Low fuel level, battery charger malfunction, and engine inlet air damper closed alarms shall be available to accept remote switch inputs. The alarm module shall remain operational for a battery voltage of 16V - 26 volts.

44. Overcurrent Protection - Generator Set Mounted

a. The main line overcurrent protection shall be achieved by using 3 current transformers on the 3 phases plus a three phase Basler BEI time overcurrent relay to shut the engine off. The relay curve shall be moderately inverse and follow the generator damage line. Relay shall be set by the generator manufacturer.

PART 2 EXECUTION

2.1 EXECUTION

- A. The following articles and paragraphs are intended to define acceptable procedures and practices of inspecting, installing, and testing the generator set and associated equipment.
- B. Predelivery Inspection
  - 1. A predelivery inspection must be performed by the system manufacturers' local dealer at the dealer's facility to insure no damage occurred in transit and all genset components, controls, and switchgear are included as specified herein. Owner representative to be advised of inspection 7 days ahead of time.
- C. Predelivery Testing
  - 1. Prior to delivery and acceptance, the generator set shall be tested to show it is free of any defects and will start automatically and carry full load. This testing shall be performed at the facility of the system manufacturer's authorized local dealer.
  - 2. The testing shall be done on dry type, resistive load banks capable of definite and precise incremental loading. Salt water brine tanks or load banks requiring water as a source of cooling will not be allowed.
  - 3. The load banks shall not be dependent on the generator control instruments to read amperage and voltage on each phase. Rather, the test instrumentation will serve as a check of the generator set meters.

4. Load bank testing shall be done in the presence of the owner's engineer or his appointed representative. Testing shall be for a minimum of four (4) hours under full load. Load bank testing to be priced as a separate line item for owners decision.
  5. All consumables necessary for testing shall be furnished by the bidder. Any defects which become evident during the test shall be corrected by the bidder at his own expense prior to shipment to the jobsite.
- D. Installation
1. The installation shall be performed in accordance with shop drawings, specifications, and the manufacturer's instructions. Generator shall be test started using the autotransfer switch. Voltage and frequency variations shall be within the manufacturer's claimed tolerance for loading and load rejection.
- E. Orientation
1. The system manufacturer's authorized dealer shall provide a complete orientation for the owner's engineering and maintenance personnel. Orientation shall include both classroom and hands-on instruction. Topics covered shall include control operation, schematics, wiring diagrams, meters, indicators, warning lights, shutdown system and routine maintenance.
- F. Service Manuals and Parts Books
1. The system manufacturer's authorized local dealer shall furnish one copy each of the manuals and books listed below for each unit under this contract:
    - a. OPERATING INSTRUCTIONS - with description and illustration of all switchgear controls and indicators and engine and generator controls.
    - b. PARTS BOOKS - that illustrate and list all assemblies, subassemblies and components, except standard fastening hardware (nuts, bolts, washers, etc.).
    - c. PREVENTATIVE MAINTENANCE INSTRUCTIONS - on the complete system that cover daily, weekly, monthly, biannual , and annual maintenance requirements and include a complete lubrication chart.
    - d. ROUTINE TEST PROCEDURES - for all electronic and electrical circuits and for the main AC generator.
    - e. TROUBLESHOOTING CHART - covering the complete generator set showing description of trouble, probable cause, and suggested remedy.

- f. RECOMMENDED SPARE PARTS LIST - showing all consumables anticipated to be required during routine maintenance and test.
  - g. WIRING DIAGRAMS AND SCHEMATICS - showing function of all electrical components.
2. All manuals and books described above shall be contained in rigid plastic pouches.

END OF SECTION

SECTION 26 32 13.01  
PACKAGED ENGINE GENERATOR SYSTEMS

## PART 1 GENERAL

## 1.1 Work Included

- A. This section covers the work necessary to furnish and install, complete, packaged engine generator systems.
- B. Each generator system shall consist of one engine, one generator, and one exciter mounted, assembled and aligned on one base; and other necessary ancillary equipment that may be mounted separately. Each system shall be environmentally suitable for the location and shall be the manufacturer's standard product offered in catalogs for commercial and industrial use.

## 1.2 Section Includes

- A. Packaged engine generator set
- B. Remote radiator
- C. Heat exchanger
- D. Exhaust silencer and fittings
- E. Fuel fittings and day tank
- F. Remote control panel
- G. Battery and charger
- H. Weatherproof enclosure

## 1.3 Products Furnished But Not Installed in This Section

- A. Section 15484 - Fuel Oil Piping: Installation of day tank
- B. Section 15510 - Hydronic Piping: Installation of exhaust silencer, and fittings
- C. [Section 15755 - Heat Exchangers: Installation of [remote radiator.] [heat exchanger.]]

## 1.4 References

- A. ASME B15.1 - Mechanical Power Transmission Apparatus
- B. 29 CFR 1910 - Occupational Safety and Health Standards
- C. NEMA AB1 - Molded Case Circuit Breakers
- D. NEMA MG1 - Motors and Generators
- E. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)

- F. NFPA 30 - Flammable and Combustible Liquids Code
- G. NFPA 37 - Installation and Use of Stationary Combustion Engines and Gas Turbines
- H. NFPA 70 - National Electrical Code
- I. NFPA 99 - Health Care Facilities
- J. NFPA 101 - Life Safety Code
- K. NFPA 110 - Emergency and Standby Power Systems
- L. UL 142 - Steel Above Ground Tanks for Flammable and Combustible Liquids
- M. UL 489 - Molded-Case Circuit Breakers and Circuit Breaker Enclosures

#### 1.5 Submittals

- A. Submit under provisions of Section [01300.] [16000.] [\_\_\_\_\_.]
- B. Shop Drawings: Indicate electrical characteristics and connection requirements. Show plan and elevation views with overall and interconnection point dimensions, base mounting details, anchor bolt template, recommended clearances for maintenance and operation, fuel consumption rate curves at various loads, block load transient response, ventilation and combustion air requirements, electrical diagrams including schematic and interconnection diagrams.
- C. Installation Drawing: Provide a 1/4-inch scale plan drawing of the generator system installation utilizing actual equipment dimensions showing all accessories and coordination with other trades.
- D. Product Data: Provide data showing dimensions, weights, ratings, interconnection points, and internal wiring diagrams for engine, generator, control panel, battery, battery rack, battery charger, exhaust silencer, vibration isolators, [day] tank, and [remote] radiator.
- E. Seismic Calculations: Provide anchoring and vibration isolation details and calculations prepared by a structural engineer registered in the state of California.
- F. Test Reports: Indicate results of performance testing.
- G. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.
- H. Manufacturer's Certificate: Certify that Products meet or exceed specified requirements.
- I. Manufacturer's Field Reports: Indicate procedures and findings.

#### 1.6 Operation and Maintenance Data

- A. Submit under provisions of Section [01700.] [16000.] [\_\_\_\_\_.]



- B. Operation Data: Include instructions for normal operation.
  - C. Maintenance Data: Include instructions for routine maintenance requirements, service manuals for engine and [day] tank, oil sampling and analysis for engine wear, and emergency maintenance procedures.
- 1.7 Quality Assurance
- A. Perform Work in accordance with NFPA 110.
  - B. Maintain [one copy] [[\_\_\_\_] copies] of document on site.
- 1.8 Qualifications
- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum [three] [\_\_\_\_\_] years [documented] experience[, and with service facilities within [100] [\_\_\_\_\_] miles of Project].
  - B. Supplier: [Authorized] [Franchised] distributor of specified manufacturer with minimum [three] [\_\_\_\_\_] years documented experience.
- 1.9 Regulatory Requirements
- A. Conform to requirements of NFPA 37, NFPA 70, NFPA 110, and NFPA 101.
  - B. Furnish Products listed and classified by [Underwriters Laboratories] [testing firm acceptable to authority having jurisdiction] as suitable for purpose specified and indicated.
  - C. Apply for, obtain and pay for all necessary South Coast Air Quality Management District (SCAQMD) certificates and permits including those required by the Owner. The engine shall be pre-certified by the SCAQMD for emergency use.
- 1.10 Pre-Installation Conference
- A. Convene [one] [\_\_\_\_\_] week prior to commencing work of this Section, under provisions of Section [01039.] [16000.] [\_\_\_\_\_.]
- 1.11 Delivery, Storage, and Handling
- A. Deliver, store, protect and handle products to site under provisions of Section [01600.] [16000.] [\_\_\_\_\_.]
  - B. Accept unit on site on skids. Inspect for damage.
  - C. Protect equipment from dirt and moisture by securely wrapping in heavy plastic.
- 1.12 Maintenance Service
- A. Furnish service and maintenance of engine generator for [one] [\_\_\_\_\_] year from Date of Substantial Completion. Include two (2) visits to site and all required materials.
- 1.13 Maintenance Materials

- A. Provide maintenance materials under provisions of Section [01700.] [16000.] [\_\_\_\_\_].
- B. Furnish one set of specialty tools required for preventative maintenance of the engine generator system. Package tools in adequately sized metal tool box.

1.14 Extra Materials

- A. Furnish under provisions of Section [01700.] [16000.] [\_\_\_\_\_].
- B. Provide [two] [\_\_\_\_\_] of each fuel, oil and air filter element under provisions of Section [01700.] [01750.] [16000.] [\_\_\_\_\_].

PART 2 PRODUCTS

2.1 Manufacturers

- A. [\_\_\_\_\_] Model [\_\_\_\_\_].
- B. [\_\_\_\_\_] Model [\_\_\_\_\_].
- C. [\_\_\_\_\_] Model [\_\_\_\_\_].
- D. Substitutions: Under provisions of Section [01600.] [\_\_\_\_\_].

2.2 Package Engine Generator System

- A. Description: NFPA 110, engine generator system to provide source of power for Level [1] [2] [1 and 2] applications [, and conforming to NFPA 99].
- B. System Capacity: [\_\_\_\_\_] kW, [\_\_\_\_\_] kVA at elevation of [\_\_\_\_\_] feet ([\_\_\_\_\_] m) above sea level, [continuous] [standby] rating using [engine-mounted radiator] [remote radiator] [city water cooling] [engine mounted heat exchanger].
- C. Load Characteristics:
  - 1. \_\_\_\_\_ Three-phase non-linear
  - 2. \_\_\_\_\_ Three-phase motors
  - 3. \_\_\_\_\_ Three-phase lighting and other load
  - 4. \_\_\_\_\_ Single-phase unbalanced load
- D. Performance:
  - 1. Max Step Load: [25] 50 [75] [100] percent of unit rating
  - 2. Maximum Voltage Deviation: [10] 15 [25] percent of unit rating
  - 3. Maximum Frequency Deviation: [3] 5 [10] Hertz
  - 4. Maximum Transient Voltage Recovery Time: [2] 3 [5] seconds

5. Maximum Transient Frequency Recovery Time: [2] 3 [5] seconds
  6. Maximum Starting Time to Rated Voltage and Frequency: 10 seconds
  7. Motor Starting Capability: 2.7 kVA per rated kW
  8. Maximum Motor Starting Voltage Deviation: 35 percent of unit rating
  9. Maximum Motor Starting Frequency Deviation: 5 Hertz
- E. Seismic: Zone 4
- F. Emissions: Comply with South Coast Air Quality Management District Rule 1110.2, "Emissions from Gaseous- and Liquid-Fueled Internal Combustion Engines."
- G. Safety: Provide devices designed and installed to comply with the following requirements:
1. Power
  2. Electrical installations: Conform to NFPA 70.
  3. Operator protection: Guard fan blades in accordance with 29 CFR 1910, Part 1910.212(a)(5).

### 2.3 Engine

- A. Type: [Water-cooled] [Air-cooled] inline or V-type, [four stroke cycle] [two stroke cycle], [compression ignition Diesel] [electric ignition] internal combustion engine.
- B. Rating: Sufficient to operate under 10 percent overload for one hour in an ambient of [90] [\_\_\_\_] degrees F ([32] [\_\_\_\_] degrees C. at elevation of [\_\_\_\_] feet ([\_\_\_\_] m.)
- C. Fuel System: [No. 2 fuel oil.] [Propane.] [Natural gas.] [Propane and natural gas dual fuel system with automatic changeover.] Conform to NFPA 30 and NFPA 37.
- D. Lubrication System: Positive displacement oil pump integral with engine and gear driven from the engine drive train, with full flow filtration and engine mounted bypass valve.
- E. Engine speed: [1200] [1800] [\_\_\_\_\_] rpm.
- F. Governor: Isochronous electronic type to maintain engine speed within 0.25 percent steady state, and 0.5 from no load to full load, transient response as indicated under paragraph entitled "Performance." Equip governor with means for manual operation and adjustment.
- \*\* or \*\*
- G. Governor: Droop type to maintain engine speed within 0.5 percent steady state, and 5 percent from no load to full load, transient response as indicated under paragraph entitled "Performance." Equip governor with means for manual operation and adjustment.

- H. Safety Devices: Engine shutdown on high water temperature, low oil pressure, overspeed, and engine overcrank. Limits as selected by manufacturer.
- I. Engine Starting: DC starting system with positive engagement, number and voltage of starter motors in accordance with manufacturer's instructions. Include remote starting control circuit, with MANUAL-OFF-REMOTE selector switch on engine-generator control panel, and crank limiting device to protect the starting system.
- J. Engine Jacket Heater: Thermal circulation type water heater with integral thermostatic control, sized to maintain engine jacket water at 90 degrees F (32 degrees C), and suitable for operation on [120] [\_\_\_\_] volts AC.
- K. Radiator: Radiator using glycol coolant, with blower type fan, sized to maintain safe engine temperature in ambient temperature of 110 degrees F (43 degrees C). Radiator air flow restriction 0.5 inches of water (1.25 Pa) maximum.
- L. Turbocharger: Axial turbine type driven by engine exhaust gases and directly connected to a single-stage compressor supplying engine combustion air. Use of multi-stage turbocharging is prohibited.
- M. Engine Accessories: Fuel filter, fuel transfer pump, fuel priming pump, intake air filter, lube oil filter, lube oil level sight glass, lube oil cooler, gear-driven water pump. Include fuel pressure gauge, water temperature gauge, and lube oil pressure gauge on engine/generator control panel.
- N. Mounting: Provide unit with suitable spring-type vibration isolators and mount on structural steel base.

#### 2.4 Generator

- A. Generator: NEMA MG1, [single] [three] phase, [four] [six] pole, reconnectible brushless synchronous generator with brushless exciter.
- B. Rating: [\_\_\_\_] kW, [\_\_\_\_] kVA, at [0.8] [\_\_\_\_] power factor, [240/120] [208Y/120] [480Y/277] volts, [60] [\_\_\_\_] Hz at [1200] [1800] [\_\_\_\_\_] rpm with 25 percent overspeed capability.
- C. Insulation Class: H
- D. Temperature Rise: [105 degrees C Continuous.] [130 degrees C Standby.]
- E. Enclosure: NEMA MG1, open drip proof.
- F. Excitation System: Rotor shaft mounted permanent magnet pilot exciter and brushless exciter consisting of three-phase armature and three-phase full wave bridge rectifier with surge suppression. Excitation system shall be capable of supporting 300 percent of rated output current for 10 seconds for selective tripping of downstream protective devices.
- G. Voltage Regulation: Include generator-mounted volts per hertz exciter-regulator to match engine and generator characteristics, with voltage regulation plus or minus 1 percent from no load to full load. Include manual controls to adjust voltage droop, voltage level (plus or minus 5 percent) and voltage gain.

## 2.5 Accessories

- A. [Remote Radiator: [Horizontal] [Vertical] discharge remote radiator, selected and sized by engine generator manufacturer to match engine cooling capacity, and suitable for operation at elevation of [\_\_\_\_] feet ([\_\_\_\_] M) in an ambient air temperature of [\_\_\_\_] degrees F ([\_\_\_\_] degrees C). Fan motor voltage: [480] [\_\_\_\_] volts, [single] [three] phase.]
- B. Heat Exchanger: Engine or base-mounted heat exchanger and expansion tank of type and capacity recommended by engine manufacturer. Include solenoid shut-off valve for installation on the cooling water inlet under Section 15755, and connected to open when engine runs.
- C. Day Tank: Dual wall [25] [100] [\_\_\_\_] gallon day tank unit with dual integral pumps and level control. Include flexible fuel line connections, fuel pump, fuel gauge, check valve, leak alarm contact, low level fuel alarm contact, high fuel level alarm contact, and indicating lights. Operate pump with motor rated [120] [\_\_\_\_] volts AC. Conform to NFPA 30 and NFPA 37.
- D. Skid-Mounted Fuel Tank: UL 142 listed double wall [\_\_\_\_] gallon steel tank, with fuel gauge, low fuel level alarm, leak detector, indicating lights, audible alarm, lockable fill cap, fuel line check valve and fittings for fuel supply, return, fill and vent. Provide sufficient stub-up space to allow bottom conduit entry to generator and controls. Conform to NFPA 30 and NFPA 37.
- E. Exhaust Silencer: [Residential] [Critical] type silencer, with rain cap, muffler companion flanges and flexible stainless steel exhaust fitting, sized in accordance with engine manufacturer's instructions.
- F. Batteries: Heavy duty, diesel starting type lead-acid storage batteries, [170] [\_\_\_\_] ampere-hours minimum capacity. Match battery voltage to starting system. Include necessary cables and clamps.
- G. Battery Tray: Treated for electrolyte resistance, constructed to contain spillage.
- H. Battery Charger: Dual rate current limiting type designed to float at 2.17 volts per cell and equalize at 2.33 volts per cell. Include overload protection, full wave rectifier, DC voltmeter and ammeter, and 120 volts AC fused input. Provide wall-mounted enclosure to meet NEMA 250, Type 1 requirements. Install inside engine generator weather-protective enclosure.
- I. Line Circuit Breaker: NEMA AB 1 and UL 489, molded case circuit breaker on generator output with integral thermal and instantaneous magnetic trip in each pole, sized in accordance with NFPA 70. Include battery-voltage operated shunt trip, connected to open circuit breaker on engine failure. Unit mount in enclosure to meet NEMA 250, Type 1 requirements.
- J. Engine-Generator Control Panel: NEMA 250, Type 1 [generator mounted] [free-standing] [remote wall mounted] control panel enclosure with engine and generator controls and indicators. Include the following equipment and features:
  - 1. Output voltage adjustment

2. Indicator lamps, one each for low oil pressure, high water temperature, overspeed, and overcrank
3. Lamp test switch
4. Engine off/manual/automatic selector switch
5. Engine running time meter
6. Water temperature gauge
7. Oil pressure gauge
8. Auxiliary Relay: 3PDT, operates when engine runs, with contact terminals prewired to terminal strip

\*\* or \*\*

- K. Engine-Generator Control Panel: NEMA 250, Type 1 [generator mounted] [free-standing] [remote wall mounted] control panel enclosure with engine and generator controls and indicators. Include the following equipment and features:
1. Frequency Meter: 45-65 Hz. range, 3.5 inch (89 mm) dial
  2. AC Output Voltmeter: 3.5 inch (89mm) dial, 2 percent accuracy, with phase selector switch
  3. AC Output Ammeter: 3.5 inch (89 mm) dial, 2 percent accuracy, with phase selector switch
  4. Output voltage adjustment
  5. Indicator lamps, one each for low oil pressure, high water temperature, overspeed, and overcrank
  6. Lamp test switch
  7. Engine off/manual/automatic selector switch
  8. Engine running time meter
  9. Oil pressure gauge
  10. Water temperature gauge
  11. Auxiliary Relay: 3PDT, operates when engine runs, with contact terminals prewired to terminal strip
  12. Additional visual indicators and alarms as required by NFPA 110
  13. Remote Alarm Contacts: Pre-wire SPDT contacts to terminal strip for remote alarm functions [required by NFPA 110.] [as specified.]

L. Remote Annunciator Panel: [Surface] [Flush] mounted panel with [brushed stainless steel] [painted finish, [\_\_\_\_\_] color]. Provide alarm horn, and indicators and alarms as follows:

1. Low oil pressure (alarm)
2. High water temperature (alarm)
3. Overcrank (alarm)
4. Overspeed (alarm)
5. Lamp test and horn silence switch

\*\* or \*\*

M. Remote Annunciator Panel: [Surface] [Flush] mounted panel with [brushed stainless steel] [painted finish, [\_\_\_\_\_] color]. Provide audible and visible indicators and alarms required by NFPA 110.

\*\* or \*\*

N. Remote Annunciator Panel: [Surface] [Flush] mounted panel with [brushed stainless steel] [painted finish, [\_\_\_\_\_] color]. Provide alarm horn, and indicators and alarms as follows:

1. High battery voltage (alarm)
2. Low battery voltage (alarm)
3. Low fuel (alarm)
4. System ready
5. Anticipatory-high water temperature
6. Anticipatory-low oil pressure
7. Low coolant temperature
8. Switch in off position (alarm)
9. Overcrank (alarm)
10. Emergency stop (alarm)
11. High water temperature (alarm)
12. Overspeed (alarm)
13. Low oil pressure (alarm)
14. Line power available

- 15. Generator power available
- 16. Lamp test and horn silence switch
- O. Weather-protective Enclosure: Corrosion resistant reinforced steel housing containing all system components, allowing access to control panel and service points, with lockable doors and panels. Include sufficient fixed louvers to permit operation under full load, [[\_\_\_\_\_] gallon fuel tank,] battery rack, and silencer. The enclosure shall be capable of being removed without disassembly or the engine generator or removal of components other than the exhaust system. Extend coolant and oil drains outside of the enclosure for easy maintenance. Terminate crankcase fume vents in front of radiator to prevent oil collection on radiator core.

\*\* or \*\*

- P. Walk-in Enclosure: Pre-fabricated, skid-mounted unit with engine generator, motorized air intake and exhaust louvers, controls, space heaters, and lighting fixtures. Provide 3 foot access aisle around engine-generator, with at least two doors for personnel access. Provide [7] [\_\_\_\_\_] feet ([2.25] [\_\_\_\_\_] m) clear height. Construct unit from insulated sheet metal panels to provide sound and thermal insulation.
- Q. Vibration Isolation: Provide a vibration isolation system in accordance with manufacturer's standard recommendation. Design as an integral part of the base and mounting system in accordance with the specified seismic zone.

### PART 3 EXECUTION

#### 3.1 Predelivery Testing

- A. Test the generator prior to delivery to show it is free of any defects, will start automatically and carry full load. Perform testing at the manufacturer's authorized local dealer.
- B. Perform testing in the presence of the Owner's representative including as a minimum:
  - 1. Provide cold start test giving time to nominal voltage and frequency.
  - 2. Provide full load test utilizing load bank for four hours minimum.
  - 3. Record in 20 minute intervals during four hour test:
    - a. Kilowatts
    - b. Amperes
    - c. Voltage
    - d. Coolant temperature
    - e. Room temperature
    - f. Frequency



- g. Oil pressure
    - 4. Demonstrate load pickup capability and record transient load response characteristics.
  - C. Provide at no additional cost all test equipment and consumables necessary for testing. Any defects that become evident during the test shall be corrected prior to shipment.
- 3.2 Installation
  - A. Install in accordance with manufacturer's instructions.
  - B. Install engine-generator sets on a concrete foundation as indicated. Provide vibration isolators to isolate vibrations from the engine-generator set to the foundation. Type, number, and arrangement of the isolators shall be as recommended by the manufacturer of the engine-generator set.
- 3.3 Field Quality Control
  - A. Field [inspection and] testing will be performed under provisions of Section [01400.] [16000.] [\_\_\_\_\_].
  - B. Inspect unit for physical damage. Verify nameplate rating and connections with contract documents. Inspect for proper anchorage and grounding. Verify all liquid levels, and engine cooling and fuel system integrity.
  - C. Perform phase rotation test to determine compatibility with load requirements.
  - D. Perform insulation resistance test of generator and cables.
  - E. Provide full load test utilizing portable test bank, if required, for four hours minimum. Simulate power failure including operation of transfer switch, automatic starting cycle, and automatic shutdown and return to normal.
  - F. Record in 20 minute intervals during four hour test:
    - 1. Kilowatts
    - 2. Amperes
    - 3. Voltage
    - 4. Coolant temperature
    - 5. Room temperature
    - 6. Frequency
    - 7. Oil pressure
  - G. Test alarm and shutdown circuits by simulating conditions.

- H. Provide at no additional cost all test equipment and consumables necessary for testing. Any defects that become evident during the test shall be corrected prior to project closeout.
- 3.4 Manufacturer's Field Services
- A. Prepare and start systems under provisions of Section [01400.] [16000.] [\_\_\_\_\_.]
  - B. Provide a complete orientation for the Owner's engineering and maintenance personnel. Include both classroom and hands-on instruction. Include control operation, schematics, wiring diagrams, meters, indicators, warning lights, shutdown systems and routine maintenance.
- 3.5 Adjusting
- A. Adjust work under provisions of Section [01700.] [16000.] [\_\_\_\_\_.]
  - B. Adjust generator output voltage and engine speed.
- 3.6 Cleaning
- A. Clean work under provisions of [01700.] [16000.] [\_\_\_\_\_.]
  - B. Clean engine and generator surfaces. Replace oil and fuel filters.
  - C. Clean any spilled liquids and properly dispose of all waste materials off site.
- 3.7 Demonstration
- A. Provide systems demonstration under provisions of Section [01650.] [16000.] [\_\_\_\_\_.]
  - B. Describe loads connected to [emergency] [and] [standby] system and restrictions for future load additions.
  - C. Simulate power outage by interrupting normal source, and demonstrate that system operates to provide [emergency] [and] [standby] power.

END OF SECTION

SECTION 26 36 23  
AUTOMATIC TRANSFER SWITCHES

## PART 1 GENERAL

## 1.1 GENERAL

- A. Work included: This specification covers the automatic transfer switches complete from the incoming line terminals to the outgoing line terminals. All equipment shall be new and manufactured by a company regularly engaged in fabrication of such equipment.
- B. Make like items of equipment provided hereunder the end products of one manufacturer in order to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer's service.
- C. Submittals During Construction: Make submittals after award of Contract in accordance with Section 16000, Electrical - General Provisions. In addition, provide the following specific information:
1. One-line diagrams
  2. Elementary diagram
  3. Connection diagrams
  4. Interconnection diagrams
  5. Protective device time-current characteristics on conventional-sized transparencies. For all protective devices, a copy is to be included with shipping package.
  6. Operational description
  7. Installation instructions, complete with instructions for anchoring to meet UBC Zone 4 requirements
  8. Maintenance instructions
  9. Spare parts list
  10. Test reports
- D. The ATS shall conform to the requirements of:
1. UL 1008-Standard for Automatic Transfer Switch
  2. NFPA 70-National Electrical Code, including use in emergency and standby systems in accordance with Articles 517, 700, 701 and 702
  3. NFPA 99-Essential Electrical Systems for Health Care Facilities
  4. NFPA 110-Standard for Emergency and Standby Power Systems
  5. IEEE Standard 446-IEEE Recommended Practice for Emergency and Standby power Systems (Orange Book)
  6. IEEE Standard 241-IEEE Recommended Practice for Electric Power Systems in Commercial Buildings (Gray Book)
  7. NEMA Standard ICS2-447-AC Automatic Transfer Switches
  8. IEC-Standard for Automatic Transfer Switches

- E. The ATS shall be UL listed in accordance with UL 1008 as follows:
1. Rated in amperes for total system transfer including control of motors, electric-discharge lamps, electric-heating and tungsten-filament lamp loads as referred to in Paragraph 38.13 of UL 1008.
  2. Switches rated 400 amperes and below shall be suitable for 100% tungsten-filament lamp load. Switches rated above 400 amperes shall be suitable for 30% tungsten-filament load.
  3. Overload and endurance at 480 volts AC per Tables 25.1, 25.2, 27.1 and 27.2 of UL 1008 when enclosed according to Paragraph 1.6.
  4. Temperature rise tests after the overload and endurance tests to confirm the ability of the transfer switches to carry their rated current within the allowable temperature limits.
  5. No welding of contacts. Transfer switch must be electrically operable to alternate source after short circuit withstand current tests.
  6. Dielectric tests at 1960 volts, rms, minimum after the withstand current test.
- F. In addition to the above, ATS' for use with fire pumps shall conform to the requirements of NFPA 20, Standard for Centrifugal Fire Pumps.
- G. Automatic transfer switches (ATS) with number of poles, voltage and current ratings as shown on the plans shall be provided. Each ATS shall consist of an inherently double-throw power transfer switch unit and a control module interconnected to provide complete automatic operation. The contact transfer time in either direction shall not exceed one-sixth (1/6) of a second.
- H. Where neutral conductors must be switched as shown on the plans, the ATS shall be provided with fully-rated overlapping neutral transfer contacts. The neutrals of the normal and emergency power sources shall be connected together only during the transfer and retransfer operation and remain connected together until power source contacts close on the source to which transfer or retransfer is being made. The overlapping neutral transfer contacts shall not overlap for a time duration greater than 100 milliseconds. A non-overlapping neutral transfer pole shall not be acceptable.
- I. When neutral conductors are to be solidly connected as shown on the plans, a neutral conductor terminal plate with fully-rated AL-CU pressure connectors shall be provided.
- J. Quality Assurance
1. Approved manufacturers are:
    - a. Automatic Switch Company
    - b. Russ Electric
    - c. Zenith

2. The contractor shall submit full system description and component data sheets. Deviations from this spec shall be listed and signed off by the consultant.

## PART 2 PRODUCTS

### 2.1 PRODUCTS

#### A. The Transfer Switch

1. The transfer switch unit shall be electrically operated and mechanically held. The electrical operator shall be a single-solenoid mechanism, momentarily energized. The switch shall be positively locked and unaffected by voltage variations, short circuit currents, or momentary outages so that contact pressure is maintained at a constant value and temperature rise at the contacts is minimized for maximum reliability and operating life. The switch shall be mechanically interlocked to ensure only one of two possible positions-normal or emergency.

2. All main contacts shall be silver composition. Switches rated 600 amperes and above shall have segmented, blow-on construction for high withstand current capability and be protected by separate arcing contacts. ATS' utilizing components of molded-case circuit breakers, contactors or parts thereof which have not been intended for continuous duty, repetitive switching or transfer between two active power sources are not acceptable.

3. Inspection of all contacts (movable and stationary) shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. A manual operating handle shall be provided for maintenance purposes. The handle shall permit the operator to stop the contacts at any point throughout the entire travel to properly inspect and service the contacts when required.

#### B. Microprocessor Control Module

1. The control module shall direct the operation of the transfer switch. The module's sensing and logic shall be controlled by a built-in microprocessor for maximum reliability, minimum maintenance, and inherent digital communications capability. The control module shall be connected to the transfer switch by an interconnecting wiring harness. The harness shall include a keyed disconnect plug to enable the control module to be disconnected from the transfer switch for routine maintenance.

2. The control module shall be completely enclosed with a protective cover and be mounted separately from the transfer switch unit for safety and ease of maintenance. Sensing and control logic shall be provided on plug-in printed circuit boards for maximum reliability. Interfacing relays shall be industrial control grade plug-in type with dust covers. All relays shall be identical to minimize the number of unique parts.

3. The control panel shall meet or exceed the voltage surge withstand capability in accordance with IEEE Standard 472-1974(ANSI C37.90a-1974) and the impulse withstand voltage test in accordance with the proposed NEMA Standard ICS 1-109.

C. Operation

1. Single-phase voltage sensing shall be provided for single-phase power sources and three-phase voltage sensing for three-phase power sources. Three-phase controls shall include a selector switch to enable temporary operation on single-phase power sources.

2. The voltage of each phase of the normal source shall be monitored, with pickup adjustable from 85 to 100% and dropout adjustable from 75% to 98% of pickup setting, both in increments of 1%, and shall be fully field-adjustable without the use of any tools, meters or power supplies. Repetitive accuracy of settings shall be +/- 2% or better over an operating temperature range of -20°C to 70°C. Factory set to pickup at 90% and dropout at 85%.

3. Three single-phase voltage sensing of the emergency source shall be provided, with a pickup adjustable from 85 to 100%(and dropout at 84 to 86% of pickup), and frequency sensing with pickup adjustable from 90 to 100% (and dropout at 87 to 89% of pickup). Both pickup settings shall be fully field-adjustable in 1% increments without the use of any tools, meters or power supplies. Repetitive accuracy of settings shall be +/- 2% or better over an operating temperature range of -20°C to 70°C. Factory set to pick up at 90% voltage and 95% frequency.

4. The control module shall include [four] time delays, fully field-adjustable in increments of at least 13 steps over the entire range as follows:

- a. Time delay to override momentary normal source outages to delay all transfer switch and engine starting signals. Adjustable from 0 to 6 seconds. Factory set at 1 second.
- b. Transfer to emergency time delay. Adjustable from 0 to 5 minutes. Factory set at 0 minutes, unless indicated otherwise on the plans.
- c. Retransfer to normal time delay. Time delay is automatically by-passed if emergency source fails and normal source is acceptable. Adjustable from 0 to 30 minutes and 1 hour to 8 hours. Factory set at [30] [15] minutes.
- d. Unloaded running time delay for emergency engine generator cooldown. Adjustable from 0 to 60 minutes. Factory set at [5] [10] minutes.

5. A set of DPDT gold-flashed contacts rated 10 amps, 32VDC shall be provided for a low-voltage engine start signal when the normal source fails. The start signal shall prevent dry cranking of the generator by requiring the generator to reach proper output, and to run for the duration of the cooldown setting, regardless of whether the normal

source restores before the load is transferred. Also provide a "commit/no commit to transfer" selector switch to select whether the load should be transferred to the emergency generator if the normal source restores before the generator is ready to accept the load.

6. A momentary-type test switch shall be provided to simulate a normal source failure. If held for more than 5 seconds, this switch must activate all timers, start generator and perform the transfer. There must be a label next to the test switch describing its function. A second momentary type switch shall be provided to immediately interrupt the testing, retransfer to normal and cool down the generator. This second switch will complete the manual testing sequence. Also, terminals for a remote contact which opens to signal the ATS to transfer to emergency and terminals for remote contacts which open to inhibit transfer to emergency and/or retransfer to normal shall be provided.

7. Output terminals to signal the actual availability of the normal and emergency sources, as determined by the voltage sensing pickup and dropout settings for each source, shall be provided.

8. [Four] sets of dry auxiliary contacts shall be provided rated 10 amps, 480VAC consisting of one contact closed when the ATS is connected to normal and one contact closed when the ATS is connected to emergency. Also, one set of signal lights to indicate when the ATS is connected to normal source and when the ATS is connected to emergency source shall be provided.

9. Each switch shall be furnished with an operator's manual providing installation and operating instructions.

D. Provide additional auxiliary dry contacts from the ATS to each elevator machine room:

1. One dry contact to open when normal power fails and emergency standby power becomes available and to close when normal power returns to signal elevator controllers.

2. One dry contact to open on emergency power and to close 30 to 60 seconds prior to transfer back to normal power to allow elevators to come to rest prior to normal power resumption.

E. The ATS shall be rated to withstand the available rms symmetrical short circuit current at the ATS terminals [with] [without] considering the type of overcurrent protection shown on the plans.

F. Tests and Certification

1. All production units shall be subjected to the following factory tests:

a. The complete ATS shall be tested to ensure proper operation of the individual components and correct overall sequence of operation and to ensure that the operating transfer time, voltage, frequency and time delay settings are in compliance with the specification requirements.

b. The switch shall be subjected to a dielectric strength test per NEMA Standard ICS1-109.21.

2. Upon request, the manufacturer shall provide a notarized letter certifying compliance with all of the requirements of this specification including compliance with the above codes and standards, and withstand current ratings. The certification shall identify, by serial number(s), the equipment involved. No exceptions to the specifications, other than those stipulated at the time of submittal, shall be included in the certification.

G. Configuration and Manufacturer

1. The ATS shall be furnished in a NEMA Type [1] [12] [3R] enclosure unless otherwise shown on the plans. The enclosure shall provide ample space for cable bending and routing.

2. The ATS manufacturer shall maintain a local service center capable of emergency service or routine preventive maintenance and shall offer preventive maintenance contracts. The manufacturer shall maintain records of each switch, by serial number, for a minimum of 20 years.

3. The ATS shall be an ASCO 940 with Features 1, 2B, 2E, 3A, 4B, 5, 7, 8, 9A, 9B, 14A, 14B, 17, 34A, 34B, source availability outputs and commit/no commit on transfer selector switch.

4. [Engine Generator Exerciser Timer - An engine generator exercising timer shall be built-in to the ATS control module and shall include a selector switch to select exercise with or without load transfer. The exerciser shall be solid-state and shall be programmable to enable exercise for 1 minute to 4 hours per day (in 1-minute increments) for [0 to 7 days per week] [0 to 3 days per month]. Exercise settings shall be set by pushbutton and a digital display shall be provided to indicate settings. A replaceable, built-in battery shall be provided to enable the exerciser to continue to operate for up to two weeks without external power. A built-in battery charger shall extend battery life to at least ten years. Loss of the battery shall not disable the exercise function as long as normal power is present.] [The exercising timer shall be ASCO Accessory 11C.]

5. Inphase Monitor - An inphase monitor shall be built-in to the ATS and shall control retransfer so that motor load inrush currents do not exceed normal starting currents. The monitor shall compare the phase relationship and frequency difference between the normal and emergency sources and permit transfer the first time the sources are within 15 electrical degrees and only if transfer can be accomplished within 60 electrical degrees as determined by monitoring the frequency difference. Inphase retransfer shall be accomplished if both sources are within 2 Hz of nominal frequency and 85% or more of nominal voltage. The inphase monitor shall be ASCO Accessory 27.

6. Communications Networks - A full duplex RS422 interface shall be built-in to the ATS control module to enable digital communications



with remotely-located annunciators and/or network supervisors. The digital communications interface shall be ASCO Accessory 72A.

PART 3 EXECUTION

3.1 EXECUTION

A. Installation

1. Installation shall conform to the requirements of NFPA 70 and manufacturer's recommendations.

B. Field Tests and Inspections

1. The contractor shall furnish labor, equipment, and incidentals for, and shall perform all field tests. Work affected by deficiencies shall be completely retested at the Contractor's expense. The manufacturer's factory representative shall assist the Contractor with the field test and inspection. Field tests shall include the following:

- a. Set all adjustable timers and control and protective devices.
- b. Simulate power failure and demonstrate complete ATS operation. Contractor shall show by demonstration in service that all the ATS's are in good operating condition.
- c. Conduct 15 minute load run utilizing [the building load] [portable load banks].

END OF SECTION