

## **PART 1 - GENERAL**

### **1.1 WORK INCLUDED**

- A. Provide all labor, materials, tools, and equipment required for the complete installation of work called for in the Contract Documents.

### **1.2 DESCRIPTION OF WORK**

- A. This section includes minimum requirements for the following:
  - 1. Circuit Breakers
  - 2. Branch Circuit Panelboards
  - 3. Distribution Panelboards
  - 4. Disconnect Switches
  - 5. Enclosed Circuit Breakers
  - 6. Transient Voltage Surge Suppression (TVSS)
  - 7. Low Voltage Fuses

### **1.3 QUALITY ASSURANCE**

- A. All low voltage power distribution equipment shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the Contract Documents shall be subject to the control and approval of the Owner's Representative. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed. Where "approved equal" is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.
- B. Materials and installation practices specified herein shall comply with the latest applicable requirements of:
  - 1. The following Articles of the National Electric Code (NFPA 70)
    - a) 240 - Overcurrent Protection
    - b) 285 - TVSS
    - c) 404 - Switches
    - d) 408 - Switchboards and Panelboards
  - 2. The following National Electrical Manufacturers Association (NEMA) Standards:
    - a) NEMA AB 1 - Molded Case Circuit Breakers and Molded Case Switches
    - b) NEMA PB 1 - Panelboards
    - c) NEMA PB 1.1 - Instructions for Safe Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or less.
    - d) NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
    - e) NEMA 250 - Enclosures for Electrical Equipment
    - f) NEMA LS1-1992 (R2000) Guidelines

3. The following American National Standards Institute (ANSI) standards:
  - a) ANSI/IEEE C12.1 Code for Electric Metering
  - b) IEEE C62.41.1-2002, C62.41.2-2002 and C62.45-1992
  - c) IEEE C62.1, C62.11 and C62.34
  
4. The following U.L. Standards:
  - a) UL 50 - Enclosures for Electrical Equipment
  - b) UL 67 - Panelboards
  - c) UL 96 - Standard for Safety for Lightning Protection Components
  - d) UL 98 - Enclosed and Dead-Front Switches
  - e) UL 489 - Molded Case Circuit Breakers and Circuit Breaker Enclosures
  - f) UL 857 - Underwriters Busway Standard
  - g) UL 943 - Standard for Ground Fault Circuit Interrupters
  - h) UL 1283 - Electromagnetic Interference Filters
  - i) UL 1449 - TVSS

#### **1.4 SUBMITTALS**

- A. Provide five (5) sets or electronic files of product data including voltage, current, interrupting rating, and enclosure type for the following:
  1. Thermal Magnetic Molded Case Circuit Breakers
  2. Electronic Trip Molded Case Circuit Breakers
  3. Electronic Trip Insulated Case Circuit Breakers
  4. Branch Circuit Panelboards
  5. Distribution Panelboards
  6. Computer Grade Panelboards
  7. Disconnect switches.
  8. Enclosed circuit breakers.
  9. Transient Voltage Surge Suppression (TVSS).
  10. Low voltage fuses.

#### **1.5 MINOR MODIFICATIONS**

- A. Provide modifications to circuit breaker rating plug, fuse sizes, lug sizes, circuit breaker trip rating within the frame size at no additional cost, until shop drawings are reviewed and submitted.
  
- B. For projects with emergency generator provide a breaker coordination study indicating breakers provided in the submittal properly coordinate to code. Provide change in breaker styles in submittal at no additional costs.

#### **1.6 FIELD SUPERVISION**

- A. Provide field supervision and start-up by a qualified representative of the equipment manufacturer. Provide certification that the equipment has been installed in accordance with the manufacturer's requirements.

#### **1.7 INSTRUCTION BOOKS**

- A. Provide three [3] copies of instruction books for all switchboards. Include in the Operation and Maintenance Manuals required in this Specification. Instruction books shall include the following:
1. Blow-up diagrams of equipment with a listing of components.
  2. Description of available accessories.
  3. Recommended spare parts list.
  4. Directions for receiving, installation, care and maintenance of equipment.

## **PART 2 - PRODUCTS**

### **2.1 CIRCUIT BREAKERS**

- A. General
1. Molded case circuit breakers shall be constructed of a glass reinforced insulating material. All current carrying components shall be completely insulated and isolated from the outside of the circuit breaker.
  2. Provide an over-center, trip-free handle to provide quick-make, quick-break contact action.
  3. Provide multi-pole breakers with common trip.
  4. When the circuit breaker has tripped, the handle shall move to a position between the "on" and "off" positions. Provide a visual indication that the circuit breaker has tripped.
  5. The ampere rating shall be clearly marked on the face of the circuit breaker.
  6. Any series rated fuse/circuit breaker installations shall be UL listed as recognized component combinations. Provide a permanent label at the Series rated device reading "Caution - Series Rated System. \_\_\_\_\_A available". Provide identical replacement of equipment".
  7. Make provisions to add circuit breaker handle locks.
  8. Circuit breakers shall have voltage, ampere, and interrupting ratings as called for on the Panelboard Schedule.
  9. Circuit breakers shall be plug-on.
  10. Design make: Squared NQOD(250V), E Frame (480V).
- B. Thermal Magnetic Molded Case Branch Circuit Breakers
1. Permanent trip unit containing individual thermal and magnetic trip elements.
  2. Thermal trip unit shall be long time, non-adjustable, thermal overload trip.

3. Magnetic trip unit shall be instantaneous, electro-magnetic trip. Magnetic trip unit shall be adjustable for all frame sizes 225 amperes and larger.
4. Interchangeable rating plugs shall be provided for all frame sizes 400 amperes and larger.
5. 60°C terminal temperature rating for circuit breakers rated 125 amperes or below.
6. 75°C terminal temperature rating for circuit breakers rated above 125 amperes.
7. All 20 and 30 ampere, single pole circuit breakers shall be UL listed for switching duty.
8. Circuit breakers shall be plug-on I-Line type distribution circuit breakers are acceptable.
9. Circuit breakers rated 250 amperes and below shall be UL listed HACR type.
10. Where ground fault circuit breakers are required, provide a shunt trip circuit breaker with a zero sequence sensing ground fault module.
11. Design Make: Square D, I-Line (600 volt)
12. Acceptable Manufacturers:
  - a) Square D
  - b) General Electric
  - c) Westinghouse/Cutler Hammer
  - d) Siemens ITE
  - e) Approved Equivalent

C. Standard Function Electronic Trip Molded Case Circuit Breakers

1. Microprocessor based true RMS sensing current sensing device with accuracy to the thirteenth harmonic.
2. Sensor frame and rating plug size shall be as indicated on the Panelboard Schedule.
3. UL listed to carry 80% of the ampere rating continuously.
4. Provide the following time/current response adjustments:
  - a) Long Time Pickup
  - b) Long Time Delay
  - c) Short Time Pickup
  - d) Short Time Delay (I<sup>2</sup>t IN only)
  - e) Instantaneous Pickup

5. Provide a means to cover the trip unit adjustments in accordance with NEC Article 240-6(c).
6. Provide trip indication for overload, short circuit, and ground fault trips.
7. Tripping system shall be equipped with an externally accessible test port for use with a Universal Test Set. Disassembly of the circuit breaker shall not be required for testing.
8. Design Make: Square D LX, MX, NX, PX
9. Acceptable Manufacturers:
  - a) Square D
  - b) General Electric
  - c) Westinghouse
  - d) Siemens ITE
  - e) Approved Equivalent

## **2.2 120/208 VOLT BRANCH CIRCUIT PANELBOARDS**

- A. 240 Volt AC rated, with amperes as shown on plans. Main circuit breaker or main lugs as noted.
- B. Copper bus bars with high dielectric thermoplastic insulators.
- C. Provide continuous current ratings, short circuit current ratings, branch circuit breakers, main circuit breaker or main lugs, and flush or surface trims as called for on the Panelboard schedule.
- D. Service entrance rated per panelboard schedules.
- E. Provide nameplate on each panelboard indicating voltage, current, phase, wire, and short circuit rating.
- F. 100% rated neutral of the same material as the main bus. Panelboards shall be marked for non-linear load applications.
- G. Provide ground bus of the same material as the main bus.
- H. Interior trim shall be dead front construction, with pre-formed metal twist-outs covering unused mounting space.
- I. Enclosures shall be nominal 20" wide by 6" deep, galvanized steel construction with removable endwalls and knockouts.
- J. Fronts
  1. Surface or flush mounted as called for on the Panelboard Schedule.
  2. ANSI 49 gray electrodeposited enamel.
  3. Fronts shall be one piece with door, and hinged to the enclosure.

4. Provide cylindrical tumbler type lock with catch and spring loaded stainless steel door pull. All locks shall be keyed alike.
  5. Provide a clear plastic directory card holder on the inside of the door.
- K. Design Make: Square D "NQOD"
- L. Acceptable Manufacturers
1. Square D "NQOD"
  2. General Electric "A" Series
  3. Cutler Hammer "CH"
  4. Siemens ITE "Sentron S1"
  5. Approved Equivalent

### **2.3 277/480 VOLT BRANCH CIRCUIT PANELBOARDS**

- A. 480 Volt AC rated, ampere rating as shown on plans. Main circuit breaker or main lug as noted.
- B. Copper bus bars with high dielectric thermoplastic insulators.
- C. Provide continuous current ratings, short circuit current ratings, branch circuit breakers, main circuit breaker or main lugs, and flush or surface trims as called for on the Panelboard schedule.
- D. Provide nameplate on each panelboard indicating voltage, current, phase, wire, and short circuit rating.
- E. Provide ground bus of the same material as the main bus.
- F. Interior trim shall be dead front construction, with pre-formed metal twist-outs covering unused mounting space.
- G. Enclosures shall be nominal 20" wide by 6" deep, galvanized steel construction with removable endwalls and knockouts.
- H. Fronts
  1. Surface or flush mounted as called for on the Panelboard Schedule.
  2. ANSI 49 gray electrodeposited enamel.
  3. Fronts shall be one piece with door, and hinged to the enclosure.
  4. Provide cylindrical tumbler type lock with catch and spring loaded stainless steel door pull. All locks shall be keyed alike.
  5. Provide a clear plastic directory card holder on the inside of the door.
- I. Design Make: Square D "NF"
- J. Acceptable Manufacturers

1. Square D "NF"
2. General Electric "AE" Series
3. Cutler Hammer "CH"
4. Siemens ITE "Sentron S2"
5. Approved Equivalent

## 2.4 DISTRIBUTION PANELBOARDS

- A. 600 Volt rated, 400 amperes. Main circuit breaker.
- B. 600 ampere and smaller: Copper bus bars with high dielectric polyester insulators.
- C. Provide continuous current ratings, short circuit current ratings, branch circuit breakers, main circuit breaker or main lugs, and flush or surface trims as called for on the Panelboard schedule.
- D. Service entrance rated.
- E. Provide nameplate on each panelboard indicating voltage, current, phase, wire, and short circuit rating.
- F. 100 % rated neutral of the same material as the main bus. Panelboards shall be marked for non-linear load applications.
- G. Provide ground bus of the same material as the main bus.
- H. Interior trim shall be dead front construction.
- I. Enclosures shall be galvanized steel construction with removable endwalls and knockouts. If design make equipment is not used, verify enclosure will fit in space allotted.
- J. Fronts
  1. Surface mounted.
  2. ANSI 49 gray electrodeposited enamel.
  3. Fronts shall be one piece with door, and hinged to the enclosure where possible.
  4. Provide cylindrical tumbler type lock with three point latch. All locks shall be keyed alike.
  5. Provide a clear plastic directory card holder on the inside of the door.
- K. Design Make: Square D "I-Line"
- L. Acceptable Manufacturers:
  1. Square D "I-Line"
  2. General Electric "Spectra"

3. Cutler Hammer "Pow-R-Line"
4. Siemens ITE "Sentron S4 or S5"
5. Approved Equivalent

## **2.5 DISCONNECT SWITCHES**

- A. Three pole, single throw, or as called for on the drawings.
- B. Quick-make, quick-break switch operating mechanism.
- C. Heavy-duty, current rating as called for on the drawings, voltage rating as required by the equipment served.
- D. All current carrying parts shall be plated to resist corrosion.
- E. Lugs shall be removable and rated for 75°C temperature rating.
- F. Switch blades shall be visible when the switch is in the open position and the door is open.
- G. Switch shall be padlockable in the OFF and ON positions.
- H. Provide fusible switches with rejection type fuse holders and fuses as indicated on the plans or as per equipment requirements.
- I. Provisions for a field installable electrical interlock.
- J. Provide external override mechanism to open the disconnect switch door without opening the disconnect switch.
- K. Enclosure shall be steel with gray baked enamel paint.
- L. Provide NEMA type enclosures as called for on the drawings.
- M. NEMA type 1 enclosures shall be equipped with knockouts.
- N. Design Make: Square D
- O. Acceptable Manufacturers:
  1. Square D
  2. General Electric
  3. Cutler Hammer
  4. Siemens
  5. Approved Equivalent

## **2.6 ENCLOSED CIRCUIT BREAKERS**

- A. Circuit breakers shall be as specified in section 2.1.
- B. Ratings as indicated on plans and as required by the installation.

- C. Short Circuit Withstand ratings of the assembly shall be equal to that of the circuit breaker.
- D. Provide NEMA rated enclosure as called for on the drawings, and as required by the environment.
- E. Externally operable handle, with provisions for padlocking in the OFF and On position.
- F. Gray baked enamel finish except for stainless steel, NEMA 4X enclosures.
- G. Knockouts at the top and bottom of NEMA 1 enclosures.
- H. Design Make: Square D
- I. Acceptable Manufacturers:
  - 1. Square D
  - 2. General Electric
  - 3. Cutler Hammer
  - 4. Siemens
  - 5. Approved Equivalent

## **2.7 TRANSIENT VOLTAGE SURGE SUPPRESSION (TVSS)**

- A. Electrical Requirements
  - 1. The MCOV of the TVSS shall be greater than 115% of nominal voltage. The system's maximum continuous operating voltages shall be in compliance with test and evaluation procedures outlined in NEMA LS 1-1992 (R2000), paragraphs 2.2.6 and 3.6.
  - 2. The unit shall provide protection in all modes. WYE systems: Line-Neutral, Line-Ground, Line-Line and Neutral-Ground; Delta systems: Line-Line and Line-Ground
  - 3. Operating frequency range shall be 47 to 63 Hertz.
- B. The maximum single-pulse surge current capacity per mode shall be verified through testing at an independent third party testing facility and shall be conducted per NEMA LS-1-1992 (R2000). The unit shall be tested in all modes at rated surge currents and all tested modes shall be from the same test sample. This test shall include all components of the system, including disconnects (if applicable) and fusing as a completed assembly. Individual component testing, module testing only, or subsystem testing of the unit for compliance with this section will not be acceptable. Testing that causes damage to the device, fuse operation, or voltage clamping performance degradation by more than 10% is not acceptable. The rated single pulse surge current capacity shall be as 200kA per mode
- C. The product shall be repetitive surge current capacity tested in every mode utilizing a 1.2 x 50  $\mu$ sec, 20 KV open circuit voltage, 8 x 20  $\mu$ sec, 10 KA short circuit

current Category C3 bi-wave at one minute intervals without suffering either performance degradation or more than +10% deviation of clamping voltage at the specified surge current, for 13,000 repetitive C3 strikes per mode.

- D. The unit's clamping voltages shall be in compliance with test and evaluation procedures outlined in NEMA LS-1-1992 (R2000), paragraphs 2.2.10 and 3.10. Maximum clamping voltages for the unit are as follows:
- E. The UL 1449 Second Edition listed suppressed voltage ratings are listed in the following tables as assigned by Underwriters Laboratories utilizing the test procedure described in section 4.3 of this document titled UL 1449 Second Edition Suppression Voltage Performance Testing.

System Voltage	Mode	B3 Ringwave	B3/C1 Comb. Wave	C3 Comb. Wave	UL 1449 Second Edition
120/240	L-N	300 / 350	400/425	625/750	400/400
	L-G	375 / 425	400/475	625/800	500/500
120/208	N-G	325 / 325	450/450	725/725	500/500
	L-L	375 / 475	750/825	925/1225	700/700
277/480	L-N	525 / 575	850/875	1100/1200	800/800
	L-G	825 / 850	825/875	1050/1200	1000/1000
	N-G	675 / 675	875/875	1200/1200	900/900
	L-L	625 / 725	1625/1700	1925/2175	1500/1500

- F. The unit shall include a high frequency filter and shall be UL 1283 listed as an Electromagnetic Interference Filter. The unit's EMI-RFI noise rejection or attenuation values shall be in compliance with test and evaluation procedures outlined in NEMA LS-1-1992 (R2000), paragraphs 2.2.11 and 3.11.

Frequency	50KHz	100KHz	500KHz	1MHz	5MHz	10MHz	50MHz	100MHz
Attenuation	53dB	41dB	32dB	31dB	32dB	35dB	47dB	53dB

- G. The unit shall provide an additional set of parallel connected, individually fused selenium cells, internal to the unit, which shall provide backup protection to the primary suppression devices. If subjected to an excessive overvoltage within the parameters defined below, there shall be no failure or degradation of the primary suppression elements. The suppression system shall not utilize gas tubes, spark gaps, silicon avalanche diodes or other components which might short or crowbar the line, thus leading to interruption of normal power flow to or system upset of connected loads.
- H. The unit shall be capable of withstanding temporary overvoltage events that may be encountered within the distribution system, without damaging any of the components within the TVSS, especially MOV's and other non-MOV parallel connected elements, in accordance with NEMA LS-1-1992 (R2000), section 2.2.6. The unit shall provide overvoltage protection as follows:

<b>% Overvoltage</b>	<b>160%</b>	<b>170%</b>	<b>180%</b>	<b>190%</b>	<b>195%</b>	<b>200%</b>
Line impedance of power system = 0.1 ohms						
# of cycles	1000	60	12	5	4	3.5
Line impedance of power system = 0.3 ohms						
# of cycles	>3600	300	60	20	15	11
Line impedance of power system = 0.7 ohms						
# of cycles	>3600	>3600	500	200	80	60

- I. All full magnitude transient current shall be conducted utilizing low-impedance copper bus bar. No plug-in component modules or quick-disconnect terminals shall be used in surge current-carrying paths.
- J. Overcurrent Protection
  - 1. Each MOV shall be fused such that the failure of a single MOV or the operation of a single fuse element remains isolated and does not render the entire mode, or product, deficient by more than 5%.
  - 2. All fusing must be UL-Recognized as a stand-alone fuse and shall be 200kAIC rated.
  - 3. Each fuse shall be individually sealed in a manner that eliminates cross arcing.
  - 4. All fusing shall be required to meet the single pulse surge current testing requirements of Section 3.1. It is necessary that the fuse be capable of withstanding a surge greater than the surge capacity of the element it is protecting. In no case should the fuse limit the surge capacity of the unit.
- K. The manufacturer shall provide a Ten-Year Limited Warranty from date of shipment against failure when installed in compliance with applicable national/local electrical codes and the manufacturer's installation, operation and maintenance instructions.
- L. The unit shall be supplied in a NEMA 1 metallic enclosure if mounted external to switchgear.
- M. FEATURES / OPTIONS.
  - 1. Integral Disconnect Switch.
    - a) The device shall have an optional NEMA compliant safety interlocked integral disconnect switch with an externally mounted metal manual operator.
    - b) The switch shall disconnect all ungrounded circuit conductors from the distribution system to enable testing and maintenance without interruption to the facility's distribution system.
    - c) The switch shall be rated for 600Vac.
    - d) The TVSS device shall be UL1449 Second Edition listed with the integral disconnect switch and the UL1449 Second Edition Suppression Voltage Ratings shall be provided.

- e) The integral disconnect switch shall be capable of withstanding, without failure, the published maximum surge current magnitude without failure or damage to the switch (per Section 3.1).
2. On-Line Diagnostic Monitoring:
- a) PRIMARY Monitoring Option.
    - (1) Status Indicator Lights. This monitoring shall include one set of status monitoring lights that will provide visual indication of voltage present to the TVSS for each phase of protection. The lights shall also indicate when suppressor protection has degraded to any value of less than 50%. Status indicator lights that simply indicate the presence of voltage, and provide no indication of performance will be unacceptable.
    - (2) Dual Form "C" Dry Contacts. The unit shall include 2 sets of form "C" dry contacts.

## 2.8 LOW VOLTAGE FUSES

- A. All fuses rated 600 volts and below shall be rejection type dual-element, time-delay type. Provide one complete sets of fuses for all fusible disconnect switches, plus 3 spare fuses of each size. Deliver spare fuses to the Owner and obtain receipt.
- B. Acceptable manufacturers: Fuses 600 amperes and below: Bussman Type FRN-R (300 volts), Type FRS-R (600 volts) or approved equivalent.

## PART 3 - EXECUTION

### 3.1 GENERAL

- A. Provide identification for all equipment and devices as indicated in section 261000.
- B. Provide miscellaneous bolts, washers, nuts, clips, lockwashers, hardware, etc. as required to install equipment.
- C. Unload, move, handle, set in place, install, erect, assemble, connect, and test etc. all items ad required.
- D. Provide minimum NEC working clearance for all equipment.
- E. Verify cable/lug sizes for terminations. Where a feeder is sized larger the lug provide replacement lug or power block as directed by Owner's Representative.

### 3.2 CIRCUIT BREAKERS

- A. Install circuit breakers in panelboards and switchboards as called for on the plans and as recommended by the manufacturer.

- B. Adjust circuit breaker pick-up level and time delay settings to the values required in coordination study.
- C. Submit documentation that a qualified representative from the equipment manufacturer has inspected and approved the installation.

### **3.3 BRANCH CIRCUIT AND DISTRIBUTION PANELBOARDS**

- A. Securely support all panelboard enclosures to walls unless noted otherwise. Install true and level.
- B. Install panelboards with top of the highest circuit breaker handle at 6'-6" to the centerline.
- C. Provide five empty ¾" conduits and one empty 1 ½" conduit from each flush mounted panelboard backbox to the accessible ceiling space.
- D. Make all branch circuit and feeder connections.
- E. Provide channel support between the wall and backbox for panelboards installed on outside walls.
- F. Tighten all bolt and lug connections using a torque wrench or screwdriver per the manufacturer's recommendations.
- G. Measure steady state load currents on each panelboard feeder. Rearrange branch circuits in the panelboard to balance the load within 20% of each other. Maintain proper phasing.
- H. Provide identification as required per section 261000.

### **3.4 DISCONNECT SWITCHES**

- A. Install disconnect switches in locations shown on plans. Install true and level.
- B. Tighten all bolt and lug connections using a torque wrench or screwdriver per the manufacturer's recommendations.
- C. Provide identification as required per Section 261000.
- D. Provide fuses in all fusible switches.

### **3.5 ENCLOSED CIRCUIT BREAKERS**

- A. Install disconnect switches in locations shown on plans. Install true and level.
- B. Tighten all bolt and lug connections using a torque wrench or screwdriver per the manufacturer's recommendations.
- C. Provide identification as required per section 261000

### **3.6 TRANSIENT VOLTAGE SURGE SUPPRESSOR (TVSS)**

A. DOCUMENTATION.

1. The manufacturer shall furnish with the submittal and with each unit delivered an equipment manual that details the installation, operation and maintenance instructions for the specified unit.
2. Electrical and mechanical drawings shall be provided by the manufacturer with the submittal and with each unit delivered that show unit dimensions, weights, mounting provisions, connection details and layout diagram of the unit.
3. The manufacturer shall provide data showing UL 1449 Second Edition product listing. The manufacturer shall also submit documentation showing clamping voltage data per NEMA LS 1-1992 (R2000), paragraphs 2.2.10 and 3.10.
4. Documentation from an independent test laboratory of the unit's Single Pulse Surge Current Capacity Testing shall be included in the submittal.
5. Documentation of the unit's Minimum Repetitive Surge Current Capacity Testing shall be included in the submittal.
6. A copy of the start-up test results and the factory benchmark testing results shall be supplied to the engineer and the owner for confirmation of proper system function. These results shall also clarify that the integrity of all neutral-to-ground bonds were verified through testing and visual inspection, and that all grounding bonds were observed to be in place.

**3.7 LOW VOLTAGE FUSES**

- A. Install low voltage fuses in disconnect switches as called for on the plans.
- B. Turn all spare fuses over to the Owner and obtain receipt.

**END OF SECTION**