# SECTION 262313 - PARALLELING LOW-VOLTAGE SWITCHGEAR

Latest Update 5-6-2017 See underlined text for Edits.

(Engineer shall edit specifications and blue text in header to meet project requirements. This includes but is not limited to updating Equipment and/or Material Model Numbers indicated in the specifications and adding any additional specifications that may be required by the project. Also turn off all "Underlines".)

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section and all other sections of Division 26.

### 1.2 SUMMARY

A. This Section includes metal-clad, [low] [medium] <Insert voltage> -voltage, circuit-breaker switchgear rated [1000] [5000] [15000] V <Insert rating> and less, and associated control systems, for paralleling generators on an isolated bus and for distributing power in ac systems.

B. Related Sections include the following:

1. Division 26 Section "Electrical Power Monitoring and Control" for interfacing communication and metering requirements.

### 1.3 DEFINITIONS

A. ATS: Acceptance Testing Specifications.

B. GFCI: Ground-fault circuit interrupter.

C. HMI: Human machine interface.

### 1.4 SUBMITTALS

A. Product Data: For each type of switchgear and related equipment, include the following:

1. Technical data on features, performance, electrical characteristics, ratings, and finishes.
2. Rated capacities, operating characteristics, furnished specialties, and accessories for individual circuit breakers.

3. Features, characteristics, ratings, factory settings, and time-current characteristic curves for individual relays and overcurrent protective devices.
4. Description of sequence of operation for paralleling controls.

B. Shop Drawings: For each type of switchgear and related equipment, include the following:

1. Dimensioned plans, elevations, sections, and details, including requi"RED" clearances and service space around equipment. Include the following:

   a. Tabulation of installed devices with features and ratings.
   b. Enclosure types and details.
   c. Outline and general arrangement drawing showing dimensions, shipping sections, and weights of each assembled section.
   d. Floor plan drawing showing locations for anchor bolts and leveling channels.
   e. Bus configuration with current rating, size, and number of conductors in each bus run, including phase, neutral, and ground conductors of main and branch buses.
   f. Short-time and short-circuit current rating of switchgear assembly.
   g. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
   h. Nameplate legends.
   i. Mimic-bus diagram.

2. Wiring Diagrams: For switchgear, paralleling control system, and related equipment, include the following:

   a. Power, signal, and control wiring.
   b. Schematic control diagrams.
   c. Diagrams showing connections of component devices and equipment.
   d. Three-line diagrams of current and future circuits showing device terminal numbers and internal diagrams.
   e. Schematic diagrams showing connections to remote devices including SCADA remote terminal unit.

C. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around switchgear where pipe and ducts are prohibited. Show switchgear layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

D. Samples: Representative portion of mimic bus with specified finish. Manufacturer's color charts showing colors available for mimic bus.

E. Qualification Data: For testing agency.

F. Source quality-control test reports.

G. Field quality-control test reports.

H. Updated mimic bus diagram reflecting field changes after final switchgear load connections have been made, for record.

I. Operation and Maintenance Data: For switchgear and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for sequence of operation.
2. Manufacturer's sample system checklists and log sheets.
3. Manufacturer's written instructions for testing and adjusting relays and overcurrent protective devices.
4. Time-current curves, including selectable ranges for each type of relay and overcurrent protective device.

## 1.5 QUALITY ASSURANCE

A. Independent 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.

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. Source Limitations: Obtain switchgear through one source from a single manufacturer.

C. Product Options: Drawings indicate size, profiles, and dimensional requirements of switchgear and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

D. 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.

E. Comply with NFPA 70.

## 1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchgear in sections of lengths that can be moved past obstructions in delivery path.

B. Store switchgear indoors in clean dry space with uniform temperature to prevent condensation. Protect switchgear from exposure to dirt, fumes, water, corrosive substances, and physical damage.

## 1.7 PROJECT CONDITIONS

A. Installation Pathway: Remove and replace building components and structures to provide pathway for moving switchgear into place.

B. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify UM fin writing no fewer than 10 days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without UM's written permission.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchgear, including clearances between switchgear and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Environmental Limitations: Rate equipment for continuous operation at indicated ampere ratings for the following conditions:

1. Ambient temperature not exceeding $104^0$F.
2. Altitude of 6600 above sea level.

## 1.8 COORDINATION

A. Coordinate layout and installation of switchgear and components with other construction that penetrates ceilings or is supported by them, including conduit, piping, equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access doors and panels.

B. Coordinate size and location of concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.9 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: 10% of each type and rating used. Include spares for [potential transformers] [control power circuits] [and] [fusible devices] <Select and insert> Fuses are specified in Division 26 Section "Fuses."
2. Indicating Lights: 10 % of each type installed.

B. Maintenance Tools: Furnish tools and miscellaneous items required for switchgear test, inspection, maintenance, and operation. Include the following:

1. [Traveling-type lifting device, rail mounted on top of switchgear] [Floor-running transport or dockable dolly with manual lifting mechanism] and all other items necessary to remove circuit breaker from housing and transport to remote location.
2. Racking handle to move circuit breaker manually between connected and disconnected positions, and a secondary test coupler to permit testing of circuit breaker without removal from switchgear.

1.10 WARRANTY/GUARANTEE

A. See Division 26 Specification Section "Basic Electrical Requirements' for warranty and guarantee requirements.

**PART 2 - PRODUCTS**

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified.

2.2 GENERATOR PARALLELING MONITOR AND CONTROL SYSTEM

A. Available Manufacturers:

1. Caterpillar; Engine Div.
2. Emerson; ASCO Power Technologies, LP.

3. GE Zenith Controls.
4. Onan Corp.; Cummins Inc.; Industrial Business Group.
5. Russelectric.

B. Control and Monitoring Panel: Provide a control and monitoring panel that allows the operator to view status and control operation of respective generator. Provide panel with the following features and characteristics:

1. Basis of Design is Cummins Power Command

2. Paralleling Control Features

a. Microprocessor based control

b. AC Metering: both analog (% Load, Hz, AC Volts, % Amperes) and RMS digital metering (Ac Amps, AC Volts, HZ, KW, KWH, Power Factor)

c. Generator Protection with Alarm and Status Indication

d. Engine Protection with Alarm and Status Indication

e. LED Alphanumeric Display: Two (2) lines, sixteen (16) characters per line

f. Amp Sentry™ for Paralleling Protection

1) Amp Senrty™ Protective Features:

a) Generator Set Overload
b) Alternator Overcurrent
c) Alternator Short Circuit
d) Fail to Synchronize
e) Circuit Breaker Fail to Close
f) High and Low AC Voltage
g) Reverse Power
h) Under Frequency
i) Loss of Excitation
j) Phase Rotation

g. Single membrane, dust–tight control face with gasket enclosure

h. Standard Emergency Stop

i. Genset "Run/Off/Auto" Selector Switch

j. Voltage Regulator

k. Isochronous Governor Control

l. Isochronous Paralleled Load Sharing

m. Breaker Control Push-Buttons

n. Automatic Synchronizer – Voltage and Phase Matching

o. Permissive Synchronizing Check Relay

p. Smart Starting Control System – Fuel Ramping, Cold Starting, reduced Black Smoke

q. Battery Monitoring System – Weak Battery Indication

r. Engine start and stop (cool-down) time relays

s. Self Test Diagnostics

t. Service Diagnostic RS232 Port

u. Customer auxiliary contacts & NFPA 110 alarm relays

v. Master First Start Sensor

3. User Interface MCM 3320

a. User Buttons: The user interface includes (2) fixed action buttons and (4) soft keys buttons. The action of the soft key buttons changes to meet the requirements of each screen. Key Actions will meet or exceed actions defined by Cummins Power Command user interface.

b. Pop-Ups: The operator panel will display pop-ups, including the fault number and short description, when a fault becomes active. The fault number is read from the fault logic and the corresponding fault description is displayed from a table.

c. LED Indicators: The MCM 3320 operator panel has (6) LED indicators. Colors, flashing frequency, and conditions to turn them on, off and to make them blink are indicated below:

1) Utility Parallel LED (Location 1), Color: “GREEN”

2) Lockout LED (Location 2) Color: “RED”

3) Warning LED (Location 3) Color: “YELLOW”

4) Remote Start LED (Location 4) Color: “GREEN”

5) Auto LED (Location 5) Color: "GREEN"

6) Manual LED (Location 6) Color: "YELLOW"

d. HMI 211 Bar Graphs: One dedicated to the utility source and one to the genset bus. The Bar Graphs provide the following readings for each source:

1) L1 Current Percent

2) L2 Current Percent

3) L3 Current Percent

4) Total KW Percent

5) Power Factor

6) Frequency Percent

7) L1 L2 Voltage Percent

8) L2 L3 Voltage Percent

9) L3 L1 Voltage Percent

e. AUX-101, AUX-102 Load Add/Shed Modules

1) These modules provide the relay outputs and switch position inputs for controlling and monitoring up to six (6) load feed breakers or ATS'. The modules communicate with the MCM 3320.

2) Connect to CT's on "Generator" circuit breaker incoming and on Utility circuit breaker incoming.

4. Generator Metering: 1% accuracy class or better

a. Ammeter, Voltmeter, Frequency Meter, Wattmeter, Kilowatt-Hour Meter and Power Factor Meter

1) For three-phase and four-wire systems, indicate line-to-line and line-to-neutral conditions on voltmeter.

2) Provide switches or other provisions to allow reading of both generator and bus voltages and frequencies from this metering set.

b. Synchroscope and "Generator Set Synchronized" indication:

1) Provide LED indication of synchronization

2) Provide 360-degree analog movement synchroscope

c. Engine run-time meter, start counter, rpm meter, and battery voltage meter.

d. Engine oil temperature gage and engine coolant temperature gage

5. Generator Protective and Control Devices: Solid-state industrial relays, integrated microprocessor-based control devices, and other accessories and devices located either in generator control and monitoring panel or in switchgear control section to provide the following features and functions:

a. Kilowatt Load Sharing Control:

1) Operates engine governor during synchronizing and provides isochronous load sharing when paralleled

2) Allows generator set to ramp up to kilowatt load level signal by system master controller

b. Load-Demand Governing Control:

1) Causes generator set to ramp down to zero load when signaled to shut down in load-demand mode

2) Causes generator set to ramp up to a proportional share of total bus load

c. Kilovolt Ampere rating Load Sharing Control:

1) Operates alternator excitation system while generator is paralleled

2) Causes sharing of reactive load among all generator sets to within 1 percent of equal levels without voltage drop

d. Sync-Check and Paralleling Monitor and Control:

1) Monitors and verifies that generator set has reached 90 percent of nominal voltage and frequency before closing to bus

2) Prevents out-of–phase paralleling if two or more generator sets reach operating conditions simultaneously, by sending "inhibit" signal to sets not designated by system as "first to close to bus"

3) Recognizes failure of "first-to-close" generator set and signals system paralleling to continue

4) Prevents out-of-phase closure to bus due to errant manual or automatic operation of synchronizer

e. Synchronizer Control:

1) Adjusts engine governor to match voltage, frequency, and phase angle of paralleling bus

2) Maintains generator-set voltage within 1% of bus voltage, and phase angle within twenty (20) electrical degrees of paralleling bus for 0.5 seconds before circuit-breaker closing

3) Provides "fail-to-synchronize time delay" adjustable from ten (10) seconds to one hundred twenty (120) seconds; with field selectivity to either initiate alarm or shut down generator set on failure condition

f. Reverse Power Monitor and Control:

1) Prevents sustained reverse power flow in generator set

2) Trips generator circuit breaker and initiates generator shutdown when reverse power condition exceeds 10 percent of generator sets kilowatt for three seconds

g. Phase Rotation Monitor and Control:

1) Verifies generator set and paralleling bus phase rotation match prior to closing paralleling circuit breaker

h. Electronic Alternator Overcurrent Alarm and shutdown Control:

1) Monitors current flow at generator-set output terminals

2) Initiates alarm when load current on generator set is more than 110 % of rated current for more than sixty (60) seconds

3) Provides overcurrent shutdown function matched to thermal damage curve of alternator. Provide without instantaneous-trip function

i. Electronic Alternator Short-Circuit Protection:

1) Provides shutdown when load current is more than 175 percent of rated current and combined time/current approaches thermal damage cure of alternator. Provide without instantaneous-trip function

j. Loss of Excitation Monitor:

1) Initiates alarm when sensing loss of excitation to alternator while paralleled to system bus

k. Generator-Set Start Contacts: redundant system, 10 A at 32-VDC

l. Cool-Down Time Delay Control: Adjustable, 0-600 seconds

m. Start Time-Delay Control: Adjustable, 0-300 seconds

n. Paralleling Circuit-Breaker Monitor and Control:

1) Monitors circuit-breaker auxiliary contacts

2) Initiates fault signal if circuit breaker fails to close within adjustable time-delay period (0.5 to 15 seconds)

3) Trips open and locks out paralleling circuit breaker upon paralleling circuit breaker failure to close, until manually reset

6. Engine Protection and Local Annunciation:

a. Provide annunciation and shutdown control modules for alarms indicated

b. Provide visual alarm status indicator and alarm horn with silence/acknowledge push button on generator control and monitoring panel

c. Provide dry-contact output for remote monitoring of the generator common alarm output in the ION 7650 meter

d. Provide Generator Run Status to provide a dry-contact output for remote date and time stamp of generator start and stop in the Ion 7650 meter

e. Annunciate the following conditions:

1) Status Light Only (Non-latching)

a) Generator engine control switch not in auto (“RED”)
b) Generator engine control switch in auto (“GREEN”)
c) Emergency mode (“RED”)

d) Generator circuit breaker closed ("RED")
e) Generator circuit breaker open ("GREEN")
f) Engine stopped ("GREEN")
g) Engine running ("RED")
h) Engine cool-down ("AMBER")

2) Pre-Alarm, Light and Horn (Non-latching)

a) Pre-high coolant temperatures ("AMBER")
b) Pre-low oil pressure ("AMBER")
c) Low coolant temperature ("AMBER")
d) Engine low battery ("AMBER")
e) Engine low fuel ("AMBER")
f) Generator fails to synchronize ("AMBER")

3) Shutdown Alarm, Light and Horn (Latching)

a) Engine over-crank ("RED")
b) Engine over-speed ("RED")
c) Engine low oil pressure ("RED")
d) Engine high coolant temperatures ("RED")
e) Engine low coolant level ("RED")
f) Engine remote emergency shutdown ("RED")
g) Generator circuit breaker tripped ("RED")
h) Generator loss of excitation ("RED")
i) Generator reverse power ("RED")
j) Generator under-voltage ("RED")
k) Generator over-voltage ("RED")
l) Generator under-frequency ("RED")
m) Generator over-frequency ("RED")

f. Sequence of Operation:

1) Refer to Sequence of Operations on drawings for additional information and protective sequence

2) Existing building management system will initiate Demand Response Mode start and stop. At end of Demand Response Mode initiate normal engine cooling sequence

C. Individual Generator Control and Monitoring Panel: Provide each generator with a control and monitoring panel that allows the operator to view status and control operation of respective generator. Provide panel with the following features and characteristics:

1. Generator Metering: 1% accuracy class or better.

a. Ammeter, Voltmeter, Frequency Meter, Wattmeter, Kilowatt-Hour Meter, and Power Factor Meter:

1) For three-phase and four-wire systems, indicate line-to-line and line-to-neutral conditions on voltmeter.
2) Provide switches or other provisions to allow reading of both generator and bus voltages and frequencies from this metering set.

b. Synchroscope and "Generator Set Synchronized" Indication:

1) Provide lamp or LED indication of synchronization.
2) Provide 360-degree analog movement synchroscope.

c. Engine run-time meter, start counter, rpm meter, and battery voltage meter.
d. Engine oil temperature gage and engine coolant temperature gage.
e. Digital Fuel Tank Monitoring Control Panel as manufactured by Pryco, Inc.

2. Generator Protective and Control Switches: Provide oil-tight, industrial-grade switches in generator control and monitoring panel.

a. Mode Selector Switch (Run/Off/Auto):

1) "Run" mode to start and accelerate unit to rated speed and voltage, but not close paralleling circuit breaker.
2) "Off" mode to prevent generator from starting or to immediately shutdown generator if running.
3) "Auto" mode to allow generator to start on receipt of remote start signal.

b. Circuit-Breaker Trip/Close Switch: Interlocked with system control so that circuit-breaker closure is impossible unless the following occurs:

1) Mode selector switch is in "Run" position.
2) Generator set is synchronized with system bus.

c. Control/reset push button with flashing lamp to indicate generator is locked out due to fault condition.
d. Lamp test push button to simultaneously test all lamps on panel.
e. Control Panel Illumination: DC lamps to illuminate panel when lighting from surrounding environment is not available.
f. Emergency Stop Push Button: "RED" mushroom-head switch maintaining its position until manually reset.
g. Voltage and Frequency Raise/Lower Switches:

1) Allow plus/minus 5% adjustment when generator set is operating but not paralleled.

3. Generator Protective and Control Devices: Solid-state industrial relays, integrated microprocessor-based control devices, and other accessories and devices located either in generator control and monitoring panel or in switchgear control section to provide the following features and functions:

a. Kilowatt Load Sharing Control:

1) Operates engine governors during synchronizing and provides isochronous load sharing when paralleled.
2) Allows generator set to ramp up to kilowatt load level signaled by system master controller.

b. Load-Demand Governing Control:

1) Causes generator set to ramp down to zero (0) load when signaled to shut down in load-demand mode.
2) Causes generator set to ramp up to a proportional share of total bus load.

c. Kilovolt Ampere Rating Load Sharing Control:

1) Operates alternator excitation system while generator set is paralleled.
2) Causes sharing of reactive load among all generator sets to within 1 percent of equal levels without voltage drop.

d. Sync-Check and Paralleling Monitor and Control:

1) Monitors and verifies that generator set has reached 90% of nominal voltage and frequency before closing to bus.
2) Prevents out-of-phase paralleling if two or more generator sets reach operating conditions simultaneously, by sending "inhibit" signal to sets not designated by system as "first to close to bus."
3) Recognizes failure of "first-to-close" generator set and signals system paralleling to continue.
4) Prevents out-of-phase closure to bus due to errant manual or automatic operation of synchronizer.

e. Synchronizer Control:

1) Adjusts engine governor to match voltage, frequency, and phase angle of paralleling bus.

2) Maintains generator-set voltage within 1% of bus voltage, and phase angle within twenty (20) electrical degrees of paralleling bus for 0.5 seconds before circuit-breaker closing.
3) Provides "fail-to-synchronize time delay" adjustable from ten (10) seconds to one hundred twenty (120) seconds; with field selectivity to either initiate alarm or shut down generator set on failure condition.

f. Reverse Power Monitor and Control:

1) Prevents sustained reverse power flow in generator set.
2) Trips generator circuit breaker and initiates generator set shutdown when reverse power condition exceeds 10% of generator set kilowatt for three seconds.

g. Phase Rotation Monitor and Control:

1) Verifies generator set and paralleling bus phase rotation match prior to closing paralleling circuit breaker.

h. Electronic Alternator Overcurrent Alarm and Shutdown Control:

1) Monitors current flow at generator-set output terminals.
2) Initiates alarm when load current on generator set is more than 110 % of rated current for more than sixty (60) seconds.
3) Provides overcurrent shutdown function matched to thermal damage curve of alternator. Provide without instantaneous-trip function.

i. Electronic Alternator Short-Circuit Protection:

1) Provides shutdown when load current is more than 175 percent of rated current and combined time/current approaches thermal damage curve of alternator. Provide without instantaneous-trip function.

j. Loss of Excitation Monitor:

1) Initiates alarm when sensing loss of excitation to alternator while paralleled to system bus.

k. Generator-Set Start Contacts: Redundant system, 10 A at 32-V dc.

l. Cool-Down Time-Delay Control: Adjustable, 0 to 600 seconds.

m. Start Time-Delay Control: Adjustable, 0 to 300 seconds.

n. Paralleling Circuit-Breaker Monitor and Control:

1) Monitors circuit-breaker auxiliary contacts.

2) Initiates fault signal if circuit breaker fails to close within adjustable time-delay period (0.5 to 15 seconds).

3) Trips open and locks out paralleling circuit breaker upon paralleling circuit breaker failure to close, until manually reset.

4. Engine Protection and Local Annunciation:

a. Provide annunciation and shutdown control modules for alarms indicated.

b. Provide visual alarm status indicator and alarm horn with silence/acknowledge push button on generator control and monitoring panel.

c. Provide dry-contact output for remote monitoring of the generator common alarm output in the Ion 7650 meter

d. Provide Generator Run Status to provide a dry-contact output for remote date and stamp of generator start and stop in the Ion 7650 meter

e. Annunciate the following conditions:

1) Status, Light Only (Non-latching):

a) Generator engine control switch not in auto (“RED”).
b) Generator engine control switch in auto (“GREEN”).
c) Emergency mode (“RED”).
d) Generator circuit breaker closed (“RED”).
e) Generator circuit breaker open (“GREEN”).
f) Engine stopped (“GREEN”).
g) Engine running (“RED”).
h) Engine cool-down (“AMBER”).

2) Pre-Alarm, Light and Horn (Non-latching):

a) Pre-high coolant temperature (“AMBER”).
b) Pre-low oil pressure (“AMBER”).
c) Low coolant temperature (“AMBER”).
d) Engine low battery (“AMBER”).
e) Engine low fuel (“AMBER”).
f) Generator fails to synchronize (“AMBER”).

3) Shutdown Alarm, Light and Horn (Latching):

a) Engine over-crank ("RED").
b) Engine over-speed ("RED").
c) Engine low oil pressure ("RED").
d) Engine high coolant temperature ("RED").
e) Engine low coolant level ("RED").
f) Engine remote emergency shutdown ("RED").
g) Generator circuit breaker tripped ("RED").
h) Generator loss of field ("RED").
i) Generator reverses power ("RED").
j) Generator under-voltage ("RED").
k) Generator over-voltage ("RED").
l) Generator under-frequency ("RED").
m) Generator over-frequency ("RED").

D. Sequence of Operation:

1. Refer to Sequence of Operations on drawings for additional information and protective sequence

2. Existing building management system will initiate Demand Response Mode start and stop. At end of Demand Response Mode initiate normal engine cooling sequence

E. Master Control System and Monitoring Equipment: Paralleling and monitoring equipment, components, and accessories for multiple generators with the following features and characteristics:

1. Components and devices shall be mounted in a separate enclosure.

2. Paralleled System Metering: 1 percent accuracy class or better to monitor total output of generator bus.

a. Ammeter, voltmeter, frequency meter, wattmeter, kilowatt-hour meter, power factor meter, kilovolt ampere, kilovolt ampere rating, and kilowatt demand meters.

1) For three-phase/four-wire systems, indicate line-to-line and line-to-neutral conditions on voltmeter.
2) Display all functions on the HMI device.

3. Full-Color HMI Device: Touch screen with minimum viewing area of sixty (60) square inches.

a. Allows operator to monitor and control the complete system of paralleled generator sets.
b. Screens shall include the following:

1) Main Menu: Include date, time, and system status messages with screen push buttons to access one-line diagram, system controls, load controls, alarms, bus metering, and individual generator-set data.
2) One-Line Diagram Screen: Depicting system configuration and system status by screen animation, screen colors, text messages, or pop-up indicators. Indicate the following minimum system conditions:

    a) Generator sets, buses, and paralleling circuit breakers energized/de-energized.
    b) Generator-set mode (run/off/auto).
    c) Generator-set status (normal/warning/shutdown/load-demand stop).
    d) Paralleling circuit-breaker status (open/closed/tripped).
    e) Bus conditions (energized/de-energized).
    f) Provide access to other screens.

3) AC Metering Screen: Displays the following minimum meter data for the paralleling bus:

    a) Phase volts and amperes, kilowatt, kilovolt ampere, kilovolt ampere rating, power factor, frequency, kilowatt hour, and kilowatt demand.
    b) Real-time trend chart for system kilowatts and volts updated on not less than one-second intervals.
    c) A minimum of one historical trend chart for total system loads with intervals no shorter than five (5) minutes and a minimum duration of four (4) hours.

4) Generator-Set Control Screen: Provides control over individual generator sets from master system control panel. Includes the following minimum functions:

    a) Generator manual start/stop control (functional only when generator-set mounted control switch is in "Auto" position).
    b) Generator-set alarm reset.
    c) Manual paralleling and circuit-breaker controls.

5) Generator-Set Data Display Screen: Provide the following minimum parameters:

    a) Engine speed, oil pressure and temperature, coolant temperature, and engine operating hours.
    b) Three-phase voltage and current, kilowatt, power factor, and kilowatt hour.

c) Generator control switch position and paralleling circuit-breaker position.
d) All generator-set alarms.

6) System Control Screen: Password protected and with the following minimum functions:

a) System Test Modes: Test with load/test without load/normal/retransfer time-delay override.
b) Test with Load: Starts and synchronizes generator sets on paralleling bus; all loads are transferred to bus.
c) Test without Load: Starts and synchronizes generator sets on paralleling bus but does not transfer loads to bus.
d) Time adjustments for retransfer time delay, transfer time delay, system time delay on stopping, and system time delay on starting.

7) Load-Demand Control Screen: Monitors total load on system bus and controls number of generator sets running so that capacity tracks load demand.

a) Load-Demand Control: On/off.
b) Load-Demand Pickup Set Point: Adjustable from 90% to 40% in 5% increments.
c) Load-Demand Dropout Set Point: Adjustable from 20% to 70% in 5% increments.

8) Manual Load Control Screen: Allows operator to manually add or delete generator sets from paralleled system in response to system load parameters.

a) Indication of system available in kilowatts and amperes.
b) Control functions allow manual addition/removal of generator sets on system, and activation of load-shed/load-restore functions.

9) Load-Add/Load-Shed Sequence Screen: Password protected and with the following minimum functions:

a) Assigns "load-add sequence priority" to each load control relay with designation for relay operation after a set number of generator sets are online.
b) Assigns "load-shed sequence priority" to each load control relay with designation for relay operation depending on number of generator sets online.

10) Alarm Summary and Run Report Screen:

a) Lists most recent alarm conditions and status changes.
b) Lists a minimum of the most recent thirty two (32) alarm conditions by name and time/date; acknowledges alarm conditions with time/date.
c) For each start signal, lists start time and date, stop time and date, maximum kilowatt and ampere load on system during run time, and start and stop times of individual generator sets.

4. Solid-State System Status Panel:

a. Provides visual alarm status indicator and alarm horn with silence/acknowledge push button.
b. Annunciates the following conditions:

1) Status, Light Only:

a) Running Status: Display generator set number and "GREEN" running-status light.
b) Load demand mode ("GREEN").
c) Priority Load Status: Display load number and "GREEN" on-status light.
d) System test ("GREEN").
e) Remote system starts ("RED").
f) Normal source available ("GREEN").
g) Connected to normal ("GREEN").
h) Generator source available ("GREEN").
i) Connected to generator source ("GREEN").

2) Status, Light and Alarm:

a) Load-Shed Level Status: Displays load number and "RED" load-shed, status light.
b) Generator Alarm Status: Displays generator number and "RED" "Check Generator" status light.
c) Controller malfunction ("RED").
d) Check station battery ("RED").
e) Bus over-load ("RED").
f) System not in auto ("RED").

F. Description of System Operation:

1. Loss of Normal Power:

a. System receives "start" signal; all generator sets start and achieve rated voltage and frequency.
b. System closes the first generator set achieving 90% of rated voltage to paralleling bus.
c. "Priority load add" controls prevent overloading of system.
d. Remaining generator sets switched to synchronizers that control and then allow closure of generator sets to paralleling bus.
e. On closure to paralleling bus, each generator set assumes its proportional share of total load.

2. Failure of a Generator Set to Start or Synchronize:

a. After expiration of over-crank time delay, generator set shuts down and alarm is initiated.
b. Priority controller prevents overload of system bus.
c. Manual override of priority controller at HMI allows addition of low-priority load to bus.
d. Bus overload monitor protects bus from manual overloading.

3. Bus Overload:

a. On bus overload, load-shed control initiates load shedding.
b. If bus does not return to normal frequency within adjustable time period, additional load continues to be shed until bus returns to normal frequency.
c. Loads shed can be reconnected to bus only by manual reset at HMI.

4. Load-Demand Mode:

a. With "load-demand" function activated, controller continuously monitors total bus load.
b. If bus load is below preset limits for fifteen (15) minutes, demand controller shuts down generator sets in predetermined order until minimum number of sets are operating.
c. On sensing available bus capacity diminished to set point, controller starts and closes generator sets to bus to accommodate load.

5. Return to Normal Power:

a. Process starts on removal of start signals from system.
b. When no load remains on paralleling bus, all generator breakers open, go through cool-down period, and shut down.
c. If start signal is received during cool-down period, one generator set is reconnected to bus, and system operation follows that of "loss of normal power."

2.3 MANUFACTU"RED" UNITS

A. Description: Factory assembled and tested and complying with IEEE C37.20.1.

B. Ratings: Suitable for application in 3-phase, 60-Hz, solidly grounded neutral system.

C. Indoor Enclosure Material: Steel.

D. Outdoor Enclosure Fabrication Requirements: Galvanized steel, weatherproof; integral structural-steel base frame with factory-applied asphaltic undercoating.

1. Provide each compartment or group of compartments with the following features:

a. Structural design and anchorage adequate to resist loads imposed by a one hundred twenty five (125) mph wind.
b. Space heater operating at one-half or less of rated voltage, sized to prevent condensation.
c. Louvers equipped with insect and rodent screen and filter; arranged to permit air circulation while excluding insects, rodents, and exterior dust.
d. Hinged front door with locking provisions.
e. Interior light with switch.
f. Weatherproof GFCI duplex receptacle.
g. Power for heaters, lights, and receptacles to be provided [by control power transformer] [as indicated] <Insert type>.

2. Provide weatherproof internal aisle construction with the following features:

a. Common internal aisle of sufficient width to permit protective-device withdrawal, disassembly, and servicing in aisle.
b. Aisle access doors with exterior padlocking provisions and interior panic latches.
c. Aisle space heaters operating at one-half or less of rated voltage, thermostatically controlled.
d. Vapor-proof fluorescent aisle lights with low-temperature ballasts, controlled by wall switch at each entrance.
e. GFCI duplex receptacles, a minimum of two, located in aisle.
f. Aisle ventilation louvers equipped with insect and rodent screen and filter; arranged to permit air circulation while excluding insects, rodents, and exterior dust.

E. Access: Fabricate enclosure with hinged, rear cover panels to allow access to rear interior of switchgear.

F. Finish: Manufacturer's standard gray finish over a rust-inhibiting primer on phosphatizing-treated metal surfaces.

G. Phase-, Neutral-, and Ground-Bus Materials: Extend full length of switchgear.

1. Phase [and Neutral] Bus: [Copper, silver plated at connection points] [Copper, tin plated] [Aluminum, tin plated]. <Insert type>
2. Ground Bus: Copper [, silver] [, tin] <Insert type> plated; minimum size one quarter (1/4) inch by two (2) inches.

H. Switchgear Components: Incorporate components as indicated on Drawings.

1. Instrument Transformers: Comply with IEEE C57.13.

   a. Potential Transformers: See Division 26 Section "Electrical Monitoring and Control".
   b. Current Transformers: See Division 26 Section "Electrical Monitoring and Control".

2. Multifunction Digital-Metering Monitor: See Division 26 Section "Electrical Monitoring and Control":

3. Relays: Comply with IEEE C37.90, integrated digital type; with test blocks and plugs.
4. Provision for Future Devices: Equip compartments with rails, mounting brackets, supports, necessary appurtenances, and bus connections.
5. Control Power Supply: Control power transformer supplies 120-V control circuits through secondary disconnect devices. Include the following features:

   a. Dry-type transformers, in separate compartments for units larger than 3 kVA, including primary and secondary fuses.
   b. Two control power transformers in separate compartments with necessary interlocking relays; each transformer connected to line side of associated main circuit breaker.

      1) Secondary windings connected through relay(s) to control bus to effect an automatic transfer scheme.
      2) Secondary windings connected through an internal automatic transfer switch to switchgear control power bus.

   c. Control Power Fuses: Primary and secondary fuses provide current-limiting and overload protection.
   d. Fuses are specified in Division 26 Section "Fuses."

6. Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:

   a. Flexible conductors for No. 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.
   b. Conductors sized according to NFPA 70 for duty required.

I. Identification: Electrical identification devices and installation requirements are specified in Division 26 Section "Identification for Electrical Systems."

1. Identify units, devices, controls, and wiring.
2. Mimic Bus: Continuous mimic bus, applied to front of switchgear, arranged in one-line diagram format, using symbols and lettered designations consistent with approved mimic-bus diagram.

   a. Mimic-bus segments coordinated with devices in switchgear sections to which applied, to produce a concise visual presentation of principal switchgear components and connections.
   b. Medium: Painted graphics, as selected by Architect.
   c. Color: Contrasting with factory-finish background; as selected by Architect from manufacturer's full range.

J. Control Battery System:

1. System Requirements: Battery shall have number of cells and ampere-hour capacity based on an initial specific gravity of 1.210 at $25^0$C with electrolyte at normal level and minimum ambient temperature of $13^0$C. Cycle battery before shipment to guarantee rated capacity on installation. Arrange battery to operate ungrounded.
2. Battery: Lead-calcium type in sealed, clear plastic or glass containers, complete with electrolyte, fully charged, and arranged for shipment with electrolyte in cells. Limit weight of each container to not more than 70 lb and cells per container to not more than 3. System batteries shall be suitable for service at an ambient temperature ranging from minus $18^0$C to $25^0$C. Limit variation of current output to 0.8 percent for each degree below $25^0$C down to minus $8^0$C.
3. Rack: Two-step rack with electrical connections between battery cells and between rows of cells; include two flexible connectors with bolted-type terminals for output leads. [Rate battery rack, cell supports, and anchorage for seismic requirements.]
4. Accessories:

   a. Thermometers with specific-gravity correction scales.
   b. Hydrometer syringes.
   c. Set of socket wrenches and other tools required for battery maintenance.
   d. Wall-mounting, nonmetallic storage rack fitted to store above items.
   e. Set of cell numerals.

5. Charger: Static-type silicon rectifier equipped with automatic regulation and provision for manual and automatic adjustment of charging rate. Unit shall automatically maintain output voltage within 0.5 % from no load to rated charger output current, with ac input-voltage variation of plus or minus 10 % and input-frequency variation of plus or minus 3 Hz. Other features of charger include the following:

a. DC ammeter.
b. DC Voltmeter: Maximum error of 5% at full-charge voltage; operates with toggle switch to select between battery and charger voltages.
c. Ground Indication: Two (2) appropriately labeled lights to indicate circuit ground, connected in series between negative and positive terminals, and with midpoint junction connected to ground by normally open push-button contact.
d. Capacity: Sufficient to supply steady load, float-charge battery between 2.20 and 2.25 V per cell and equalizing charge at 2.33 V per cell.
e. Charging-Rate Switch: Manually operated switch provides for transferring to higher charging rate. Charger operates automatically after switch operation until manually reset.
f. AC power supply is 120 V, 60 Hz, subject to plus or minus 10 % variation in voltage and plus or minus 3-Hz variation in frequency. After loss of ac power supply for any interval, charger automatically resumes charging battery. Charger regulates rate of charge to prevent damage due to overload and to prevent fuses or circuit breakers from opening.
g. Protective Feature: Current-limiting device or circuit, which limits output current to rating of charger but does not disconnect charger from either battery or ac supply; protects charger from damage due to overload, including short circuit on output terminals.
h. Electrical Filtering: Reduces charger's audible noise to less than 26 dB.

## 2.4 METAL-CLAD, CIRCUIT-BREAKER SWITCHGEAR (1000 V AND LESS)

A. Manufacturers:

1. ABB Inc.
2. Cutler-Hammer; Eaton Corporation.
3. General Electric Company.
4. Siemens Energy & Automation, Inc.
5. Square D; Schneider Electric.

B. Description: Factory assembled and tested, and complying with IEEE C37.20.1.

C. Nominal System Voltage: 480/277 V, 4 wire, 60 Hz.

D. Main-Bus Continuous: [4000] [3200] [2000] [1600] <Insert rating> A.

E. Short-Time and Short-Circuit Current: Match rating of highest-rated circuit breaker in switchgear assembly.

F. Switchgear Fabrication:

1. Bus isolation barriers shall be arranged to isolate line bus from load bus at each main and tie circuit breaker.
2. Circuit-breaker compartments shall be equipped to house drawout-type circuit breakers and shall be fitted with hinged outer doors.
3. Auxiliary Compartments: Match and align with basic switchgear assembly. Include the following:

    a. Bus transition sections.
    b. Pull sections.
    c. Hinged front panels for access to accessory and blank compartments.
    d. Pull box on top of switchgear for extra room for pulling cable; with removable top, front, and side covers; and ventilation provisions adequate to maintain air temperature in pull box within same limits as switchgear.

        1) Set pull box back from front to clear circuit-breaker lifting mechanism.
        2) Bottom: Insulating, fire-resistive material with separate holes for cable drops into switchgear.
        3) Cable Supports: Arranged to ease cabling and adequate to support cables indicated, including those for future installation.

4. Bus bars connect between vertical sections and between compartments. Cable connections are not permitted.

    a. Main Phase Bus: Uniform capacity the entire length of assembly.
    b. Neutral Bus: 100 % of phase-bus ampacity, except as indicated. [Equip bus with pressure-connector terminations for outgoing neutral conductors] [Include braces for neutral-bus extensions for busway feeders].
    c. Vertical Section Bus Size: Comply with IEEE C37.20.1, including allowance for spare circuit breakers and spaces for future circuit breakers.
    d. Supports and Bracing for Buses: Adequate strength for indicated short-circuit currents.
    e. Neutral Disconnect Link: Bolted, uninsulated, one quarter (1/4) inch by two (2) inch copper bus, arranged to connect neutral bus to ground bus.
    f. Provide for future extensions from either end of main phase, neutral, and ground bus by means of predrilled bolt-holes and connecting links.
    g. Bus-Bar Insulation: Individual bus bars wrapped with factory-applied, flame-retardant tape or spray-applied, flame-retardant insulation.

        1) Sprayed Insulation Thickness: 3 mils, minimum.
        2) Bolted Bus Joints: Insulate with secure joint covers that can easily be removed and reinstalled.

5. Circuit-Breaker Terminals for Cable Connections: Silver-plated copper bus extensions equipped with pressure connectors for conductors.

G. Circuit Breakers: Comply with IEEE C37.13.

1. Ratings: As indicated for continuous, interrupting, and short-time current ratings for each circuit breaker; voltage and frequency ratings same as switchgear.
2. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:

   a. Normal Closing Speed: Independent of both control and operator.
   b. Slow Closing Speed: Optional with operator for inspection and adjustment.
   c. Sto"RED"-Energy Mechanism: [Manually charged] [Electrically charged, with optional manual charging] <Insert charge type> .
   d. Operation counter.

3. Trip Devices: Solid-state, overcurrent trip-device system consisting of one (1) or two (2) current transformers or sensors per phase, a release mechanism, and the following features:

   a. Functions: Long-time-delay, short-time-delay, and instantaneous-trip functions, independent of each other in both action and adjustment.
   b. Temperature Compensation: Ensures accuracy and calibration stability from minus $5^0$C to plus $40^0$C.
   c. Field-adjustable, time-current characteristics.
   d. Current Adjustability: Dial settings and rating plugs on trip units or sensors on circuit breakers, or a combination of these methods.
   e. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."
   f. Pickup Points: Five (5) minimum, for long-time- and short-time-trip functions. Equip short-time-trip function for switchable $I^2t$ operation.
   g. Pickup Points: Five (5) minimum, for instantaneous-trip functions.
   h. Ground-fault protection with at least three short-time-delay settings and three trip-time-delay bands; adjustable current pickup. Arrange to provide protection for the following:

      1) Three-wire circuit or system.
      2) Four-wire circuit or system.
      3) Four-wire, double-ended substation.

   i. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.

4. Auxiliary Contacts: For interlocking or remote indication of circuit-breaker position, with spare auxiliary switches and other auxiliary switches required for normal circuit-breaker operation, quantity as indicated. Each consists of two Type "a" and two Type "b" stages (contacts) wired through secondary disconnect devices to a terminal block in stationary housing.

5. Drawout Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in connected, test, and disconnected positions. Include the following features:

   a. Interlocks: Prevent movement of circuit breaker to or from connected position when it is closed.
   b. Circuit-Breaker Positioning: An open circuit breaker may be racked to or from connected, test, and disconnected positions only with the associated compartment door closed, unless live parts are covered by a full dead-front shield. An open circuit breaker may be manually withdrawn to a position for removal from the structure with the door open. Status for connection devices for different positions includes the following:

      1) Test Position: Primary disconnect devices disengaged, and secondary disconnect devices and ground contact engaged.
      2) Disconnected Position: Primary and secondary devices and ground contact disengaged.

6. Arc Chutes: Readily removable from associated circuit breaker when it is in disconnected position; arranged to permit inspection of contacts without removing circuit breaker from switchgear.
7. Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism.
8. Operating Handle: One (1) for each circuit breaker capable of manual operation.
9. Electric Close Button: One (1) for each electrically operated circuit breaker.
10. Mechanical Interlocking of Circuit Breakers: Uses a mechanical tripping lever or equivalent design and electrical interlocks.
11. Key Interlocks: Arranged so keys are attached at devices indicated. Mountings and hardware are included where future installation of key-interlock devices is indicated.
12. Undervoltage Trip Devices: Instantaneous, with adjustable pickup voltage.
13. Undervoltage Trip Devices: Adjustable time-delay and pickup voltage.
14. Shunt-Trip Devices: Where indicated.
15. Indicating Lights: To indicate circuit breaker is open or closed, for main and bus tie circuit breakers interlocked either with each other or with external devices.

H. Accessories: Furnish tools and miscellaneous items required for circuit-breaker and switchgear tests, inspections, maintenance, and operation.

1. Racking handle to manually move circuit breaker between connected and disconnected positions.
2. Portable test set for testing all functions of circuit-breaker, solid-state trip devices without removal from switchgear.
3. Relay and meter test plugs suitable for testing switchgear meters and switchgear class relays.

I. Circuit-Breaker Removal Apparatus: Portable, floor-supported, roller-base, elevating carriage arranged for moving circuit breakers in and out of compartments.

J. Circuit-Breaker Removal Apparatus: Overhead-circuit-breaker lifting device, track mounted at top front of switchgear and complete with hoist and lifting yokes matching each size of drawout circuit breaker installed.

K. Spare-Fuse Cabinet: Identified and compartmented steel box or cabinet with lockable door.

L. Storage for Manual: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

## 2.5 METAL-CLAD, MEDIUM-VOLTAGE, CIRCUIT-BREAKER SWITCHGEAR

A. Manufacturers:

1. ABB, Inc.
2. Cutler-Hammer; Eaton Corporation.
3. General Electric Company.
4. Siemens Energy & Automation, Inc.
5. Square D; Schneider Electric.

B. Comply with IEEE C2 and IEEE C37.20.3.

C. Comply with IEEE C37.20.7. Provide arc-resistant switchgear, Type [1] [2] [1C] [2C] <Insert number>.

D. System Voltage: [4.16 kV nominal; 4.76 kV maximum] [13.8 kV nominal; 15 kV maximum] <Insert other voltage>.

E. Nominal Interrupting-Capacity Class: [500] [750] [1000] <Insert number> MVA.

F. Ratings: Comply with IEEE C37.04.

1. Main-Bus Continuous: [1200] [2000] [3000] <Insert number> A.

G. Circuit Breakers: Three-pole, single-throw, electrically operated, drawout-mounting units using three individual, vacuum-sealed interrupter modules; include the following features:

1. Designed to operate at rated voltage to interrupt fault current within its rating within three cycles of trip initiation. For systems with X/R ratio of 17 or less, transient voltage during interruption shall not exceed twice the rated line-to-ground voltage of system.
2. Contact-Wear Indicator: Readily accessible to field maintenance personnel.

3. Minimum of six Type A and six Type B spare contacts.
4. Interchangeability: Circuit breakers are interchangeable with vacuum circuit breakers of same current and interrupting ratings.

    a. Current Rating of Main Circuit Breaker: 2000 A.
    b. Continuous Current Rating of Tie Circuit Breaker: 2000 A.
    c. Continuous Current Rating of Feeder Circuit Breaker: 1200 A.

5. Operating Mechanism: Electrically charged, mechanically and electrically trip-free, sto"RED"-energy operated.

    a. Closing speed of moving contacts to be independent of both control and operator.
    b. Design mechanism to permit manual charging and slow closing of contacts for inspection or adjustment.

        1) Control Power: 24-V dc for closing and tripping.
        2) Control Power: 120-V ac for closing and tripping.

    c. Provide shunt-trip capability independent of overcurrent trip.

H. Bus Insulation: Covered with flame-retardant insulation.

I. Test Accessories: Relay and meter test plugs.

J. Low-DC-Voltage Alarm: Switchgear shall have a monitor for dc control power voltage with a remote alarm located where indicated. Alarm shall sound if voltage falls to an adjustable value to indicate an impending battery failure. Factory set alarm value at 80 percent of full-charge voltage.

K. Grounding and Testing Device: Suitable for phasing out, testing, and grounding switchgear bus or feeder if device is installed in place of circuit breaker. Include the following:

1. Portable Grounding and Testing Device: Interchangeable with drawout-mounting, medium-voltage circuit breakers to provide interlocked electrical access to either bus or feeder; electrically operated.
2. System control cabinet permanently mounted near switchgear.
3. Portable Remote-Control Station: For grounding and testing device.
4. Control-Cabinet Coupler Cable: Of adequate length to connect device inserted in any switchgear cubicle and control cabinet.
5. Remote-Control Coupler Cable: Fifty (50) feet long to connect control cabinet and portable remote-control station.
6. Permanent Control Power Wiring: From control cabinet to power source.
7. Protective Cover: Fabricated of heavy-duty plastic and fitted to device.

8. Approval of Grounding and Testing Device System: Obtain approval of final system design from utility company and agency designated by Owner to handle future maintenance of medium-voltage switchgear.

L. Circuit-Breaker Test Cabinet: Separately mounted and containing push buttons for circuit-breaker closing and tripping, control relay, fuses, and secondary coupler with cable approximately 108 inches long. Include a set of secondary devices for operating circuit breaker if removed from switchgear and moved near test cabinet. Include provision for storage of test and maintenance accessories in cabinet.

M. Remote-Tripping Device: Wall-mounting emergency control station to open circuit breakers; located in "RED" cast-metal box with break-glass operation.

N. Bus Transition Unit: Arranged to suit bus and adjacent units.

O. Outgoing Feeder Units: Arranged to suit distribution feeders.

P. Auxiliary Compartments: Arranged to suit house meters, relays, controls, and auxiliary equipment; isolated from medium-voltage components.

Q. Key Interlocks: Arranged to effect interlocking schemes indicated.

R. Provisions for Future Key Interlocks: Mountings and hardware required for future installation of locks, where indicated.

S. Source Quality Control:

1. Before shipment of equipment, perform the following tests and prepare test reports:

   a. Production tests on circuit breakers according to ANSI C37.09.
   b. Production tests on completed switchgear assembly according to IEEE C37.20.2.

2. Assemble switchgear and equipment in manufacturer's plant and perform the following:

   a. Functional tests of all relays, instruments, meters, and control devices by application of secondary three-phase voltage to voltage circuits and injection of current in current-transformer secondary circuits.
   b. Functional test of all control and trip circuits. Connect test devices into circuits to simulate operation of controlled remote equipment such as circuit-breaker trip coils, close coils, and auxiliary contacts. Test proper operation of relay targets.

3. Prepare equipment for shipment.

a. Provide suitable crating, blocking, and supports so equipment will withstand expected domestic shipping and handling shocks and vibration.
b. Weatherproof equipment for shipment. Close connection openings to prevent entrance of foreign material during shipment and storage.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine elements and surfaces where switchgear will be installed for compliance with installation tolerances, required clearances, and other conditions affecting performance.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

A. Comply with applicable portions in NECA 400.

B. Anchor switchgear assembly to four (4) inch channel-iron embedded in concrete base and attach by bolting.

1. Sills: Select to suit switchgear; level and grout flush into concrete base.
2. Concrete Bases: Four (4) inches high, reinforced, with chamfered edges. Extend base no more than three (3) inches in all directions beyond the maximum dimensions of switchgear, unless otherwise indicated or unless required for seismic anchor support. Construct concrete bases according to Division 26 Section "Hangers and Supports for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, brackets, and temporary blocking of moving parts from switchgear units and components.

### 3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."

B. Diagrams and Instructions:

1. Frame and mount under clear acrylic plastic on front of switchgear.

a. Operating Instructions: Printed basic instructions for switchgear, including control and key-interlock sequences and emergency procedures.

b. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads.

2. Storage for Maintenance: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

## 3.4 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

## 3.5 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each switchgear bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:

1. Inspect switchgear installation, including wiring, components, connections, and equipment. Test and adjust components and equipment.
2. Verify that electrical control wiring installation complies with manufacturer's submittal by means of point-to-point continuity testing. Verify that wiring installation complies with requirements in Division 26 Sections.
3. Complete installation and startup checks according to manufacturer's written instructions.
4. Assist in field testing of equipment including pretesting and adjusting of equipment and components.
5. Report results in writing. Draft copy to be provided upon completion of testing.

C. Testing Agency: Engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.

D. 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. Perform NETA tests and inspections for each of the following NETA categories:

a. Switchgear.
b. Circuit breakers.
c. Protective relays.
d. Instrument transformers.
e. Metering and instrumentation.
f. Remote communications to campus utility management and automation servers
g. Ground-fault systems.
h. Battery systems.
i. Surge arresters.
j. Capacitors.

2. Remove and replace malfunctioning units and retest as specified above.

E. Infrared Scanning: After Substantial Completion, but not more than sixty (60) days after Final Acceptance, perform an infrared scan of each switchgear. Remove front and rear panels so joints and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear eleven (11) months after date of Substantial Completion.
2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
3. Record of Infrared Scanning: Prepare a certified report that identifies switchgear checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

## 3.6 ADJUSTING

A. Set field-adjustable, protective-relay trip characteristics according to results in Division 26 Section "Overcurrent Protective Device Coordination Study."

B. Set field-adjustable, protective-relay trip characteristics.

## 3.7 CLEANING

A. On completion of installation, inspect interior and exterior of switchgear. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair damaged finishes.

## 3.8 PROTECTION

A. Temporary Heating: Apply temporary heat to switchgear, according to manufacturer's written instructions, throughout periods when switchgear environment is not controlled for temperature and humidity within manufacturers stipulated service conditions.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchgear. Refer to Division 01 Section "Demonstration and Training" and provide a minimum of one (1) eight hour session.

END OF SECTION 262313