2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NFPA 70**, and list and label as complying with UL 1561**.

B. Provide transformers that are constructed to withstand seismic forces specified in Section 260548.16 "Seismic Controls for Electrical Systems."

C. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.

1. One leg per phase.
2. Core volume shall allow efficient transformer operation at 10 percent above the nominal tap voltage.
3. Grounded to enclosure.

D. Coils: Continuous windings except for taps.

1. Coil Material: **Copper**.
2. Internal Coil Connections: Brazed or pressure type.
3. Terminal Connections: **Bolted**.

E. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.

F. Enclosure: **Ventilated**.

1. NEMA 250, **Type 3R**: Core and coil shall be encapsulated within resin compound **using a vacuum-pressure impregnation process** to seal out moisture and air.
2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.
3. Wiring Compartment: Sized for conduit entry and wiring installation.
4. Finish: Comply with NEMA 250.

a. Finish Color: **ANSI 61 gray** weather-resistant enamel.

G. Taps for Transformers 3 kVA and Smaller: **None**.

H. Taps for Transformers 7.5 to 24 kVA: **One 5 percent tap above and one 5 percent tap below normal full capacity**.

I. Taps for Transformers 25 kVA and Larger: **Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity**.

J. Insulation Class, Smaller Than 30 kVA: 180 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.

K. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of **150** deg C rise above 40 deg C ambient temperature.

L. Grounding: Provide ground-bar kit or a ground bar installed on the inside of the transformer enclosure.

M. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.

1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor, without exceeding the indicated insulation class in a 40 deg C maximum ambient and a 24-hour average ambient of 30 deg C.
2. Indicate value of K-factor on transformer nameplate.
3. Unit shall comply with requirements of DOE 2016 efficiency levels when tested according to NEMA TP 2 with a K-factor equal to one.

N. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.

1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
2. Include special terminal for grounding the shield.

O. Neutral: Rated 200 percent of full load current for K-factor-rated transformers.

P. Low-Sound-Level Requirements: Maximum sound levels when factory tested according to IEEE C57.12.91, as follows:

1. 9.00 kVA and Less: **40**dBA.
2. 9.01 to 30.00 kVA: **45**dBA.
3. 30.01 to 50.00 kVA: **45 dBA for K-factors of 1, 4, and 9**.
4. 50.01 to 150.00 kVA: **50 dBA for K-factors of 1, 4, and 9**.
5. 150.01 to 300.00 kVA: **55 dBA for K-factors of 1, 4, and 9**.
6. 300.01 to 500.00 kVA: 6**0 dBA for K-factors of 1, 4, and 9**.
7. 500.01 to 700.00: **62 dBA for K-factors of 1, 4, and 9**.
8. 700.01 to 1000.00: **64 dBA for K-factors of 1, 4, and 9**.

2.4 IDENTIFICATION

A. Nameplates: Engraved, laminated-acrylic or melamine plastic signs for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."

B. Nameplates: Self-adhesive label for each distribution transformer. Self-adhesive labels are specified in Section 260553 "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.

1. Resistance measurements of all windings at rated voltage connections and at all tap connections.
2. Ratio tests at rated voltage connections and at all tap connections.

3. Phase relation and polarity tests at rated voltage connections.
4. No load losses, and excitation current and rated voltage at rated voltage connections.
5. Impedance and load losses at rated current and rated frequency at rated voltage connections.
6. Applied and induced tensile tests.
7. Regulation and efficiency at rated load and voltage.
8. Insulation-Resistance Tests:

    a. High-voltage to ground.
    b. Low-voltage to ground.
    c. High-voltage to low-voltage.

9. Temperature tests.

B. Factory Sound-Level Tests: **Conduct prototype sound-level tests on production-line products**.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

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 requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Environment: Enclosures shall be rated for the environment in which they are located. Covers for NEMA 250, Type 4X enclosures shall not cause accessibility problems.

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

3.2 INSTALLATION

A. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

B. Construct concrete bases according to project plans and anchor floor-mounted transformers according to manufacturer's written instructionsand requirements in Section 260529 "Hangers and Supports for Electrical Systems."

1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

C. Secure transformer to concrete base according to manufacturer's written instructions.

D. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.

E. Remove shipping bolts, blocking, and wedges.

3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections.

E. Small (Up to 167-kVA Single-Phase or 500-kVA Three-Phase) Dry-Type Transformer Field Tests:

1. Visual and Mechanical Inspection.

    a. Inspect physical and mechanical condition.
    b. Inspect anchorage, alignment, and grounding.
    c. Verify that resilient mounts are free and that any shipping brackets have been removed.
    d. Verify the unit is clean.
    e. Perform specific inspections and mechanical tests recommended by manufacturer.
    f. Verify that as-left tap connections are as specified.
    g. Verify the presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:

    a. Measure resistance at each winding, tap, and bolted connection.
    b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: the value of the index shall not be less than 1.0.
    c. Perform turns-ratio tests at all tap positions. Test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If test fails, replace the transformer.
    d. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

F. Large (Larger Than 167-kVA Single Phase or 500-kVA Three Phase) Dry-Type Transformer Field Tests:

1. Visual and Mechanical Inspection:

    a. Inspect physical and mechanical condition.
    b. Inspect anchorage, alignment, and grounding.
    c. Verify that resilient mounts are free and that any shipping brackets have been removed.
    d. Verify the unit is clean.
    e. Perform specific inspections and mechanical tests recommended by manufacturer.
    f. Verify that as-left tap connections are as specified.
    g. Verify the presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:

    a. Measure resistance at each winding, tap, and bolted connection.
    b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: the value of the index shall not be less than 1.0.
    c. Perform power-factor or dissipation-factor tests on all windings.
    d. Perform turns-ratio tests at all tap positions. Test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If test fails, replace the transformer.
    e. Perform an excitation-current test on each phase.
    f. Perform an applied voltage test on all high- and low-voltage windings to ground. See IEEE C57.12.91, Sections 10.2 and 10.9.
    g. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

G. Remove and replace units that do not pass tests or inspections and retest as specified above.

H. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.

1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.

2. Perform two follow-up infrared scans of transformers, one at four months and the other at 11 months after Substantial Completion.
3. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

I. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 262213

SECTION 262313 - PARALLELING LOW-VOLTAGE SWITCHGEAR

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.

1.2 SUMMARY

A. Section Includes: Metal-enclosed, low-voltage, circuit-breaker switchgear rated 600 V and less, and associated monitoring and control systems for paralleling standby generators on an isolated bus and for distributing electrical power.

B. As applied to the TBPPs this switchgear is to be used when aggregating together two or more TBPPs to arrive at a given kW output. This aggregation will be for paralleling two or three TBPPs to the same emergency supply bus.

C. Related Requirements:

1. Section 263213.16 "Gaseous Emergency Engine Generators"
2. Section 263373 “BESS”

1.3 DEFINITIONS

A. ATS: Acceptance Testing Specification.

B. DDC: Direct digital control.

C. Legally Required: As used in this Section, it shall have the same meaning as used in NFPA 70.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of paralleling low-voltage switchgear.

1. Include technical data on features, performance, electrical characteristics, ratings, and finishes for programmable logic controllers, instrumentation, control devices, monitoring devices, **SCADA interface devices, Ethernet interface,** and display components.
2. Include rated capacities, operating characteristics, furnished specialties, factory settings, and accessories for individual circuit breakers.
3. Include time-current characteristic curves for overcurrent protective devices.

B. Shop Drawings: For each type of paralleling low-voltage switchgear.

1. Include dimensioned plans, elevations, sections, details, shipping sections, weights of each assembled section, and required clearances and service space around equipment.
2. Include tabulation of installed devices with features and ratings.
3. Include enclosure types and details.
4. Detail locations for anchor bolts **and leveling channels**.
5. Show 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.
6. Indicate short-time and short-circuit current rating of switchgear assembly.
7. Include features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
8. Detail nameplate legends.
9. Include mimic-bus diagram.
10. Include three-line power wiring diagrams for paralleling low-voltage switchgear, generators, and related equipment showing device terminal numbers.
11. Include point-to-point schematic control, monitoring, and alarm wiring diagrams showing internal component terminal numbers.
12. Include point-to point schematic control, monitoring, and alarm wiring diagrams for external components indicating terminal numbers for the following:

    a. Engine generators.
    b. Transfer switches.
    c. Other load-control devices.
    d. Elevator controller in each elevator bank.
    e. DDC system for HVAC controller.
    f. SCADA remote terminal unit.

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

D. Delegated-Design Submittal: For paralleling low-voltage switchgear.

1. Include design calculations, signed and sealed by a qualified professional engineer, for selecting seismic restraints and for structural analysis of outdoor enclosures, including wind loading.

E. Sequence of Operation: Description of sequence of operation for paralleling controls in automatic, manual, system test, and peak-shaving modes.

1. Include the following in the description of the automatic-mode sequence of operation:

    a. Programmed sequence of initial generator starting and connection of generators to the isolated paralleling bus, including a description of how the proposed design complies with the requirements for redundancy.
    b. Programmed sequence of transferring loads to the isolated paralleling bus based on operator-adjustable preset priorities and preset loads. Include initial load settings.
    c. Programmed sequence of starting and stopping generators based on actual real-time measured loads.
    d. Programmed sequence of sending a load-shed signal to transfer switches**[, and to other devices]** when the generator frequency does not return to the normal frequency within the adjustable time period.

e. Programmed sequence of stopping generators based on no transfer switch or other device sending a start signal.

2. Include the following in the description of the system testing mode sequence of operation:

   a. Load.
   b. No load.

3. Include in the description, the manual-mode sequence of operation showing that the manual mode fulfills the requirement to permit the operator at the paralleling low-voltage switchgear to accomplish all automatic, system test, and peak-shaving functions.
4. Paralleling Low-Voltage Switchgear Redundancy: Identify any single points of failure.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Floor plans showing dimensioned layout, required working clearances, and required area above and around paralleling low-voltage switchgear where pipe and ducts are prohibited.
2. Switchgear layout and relationships between components and adjacent structural and mechanical elements.
3. Support locations, type of support, and weight on each support. Indicate field measurements.

B. Qualification Data: For testing agency.

C. Source quality-control reports.

D. Field quality-control reports.

E. Sample Warranty: For manufacturer's special warranty.

1.6 CLOSEOUT SUBMITTALS

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

B. Operation and Maintenance Data: For paralleling low-voltage switchgear and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

   a. Manufacturer's written instructions for sequence of operation.
   b. Manufacturer's system checklists, maintenance schedule, and maintenance log sheets complying with NFPA 110.
   c. Manufacturer's written instructions for testing and adjusting relays.
   d. Time-current curves, including selectable ranges for each type of overcurrent protective device.

1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Control Power Fuses: **Six** of each type and rating used. Include spares for the following:

a. Potential transformers.
b. Control power circuits.

2. Indicating Lights: **Six** of each type installed.
3. Draw-out Circuit Breakers: One of each type and rating used for circuit breaker in the paralleling low-voltage switchgear.

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

1. **Floor-running transport or dockable dolly with manual lifting mechanism** and all other items necessary to remove circuit breaker from housing and transport it to remote location.
2. Racking handle to move circuit breaker manually between connected and disconnected positions.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.9 DELIVERY, STORAGE, AND HANDLING

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

B. Store paralleling low-voltage switchgear indoors in clean dry space with uniform temperature to prevent condensation.

1.10 FIELD CONDITIONS

A. Installation Pathway: Remove and replace building components and structures to provide pathway for moving paralleling low-voltage 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 **Construction Manager** and **Owner** no fewer than five days in advance of proposed interruption of electrical service.

2. Do not proceed with interruption of electrical service without **Construction Manager's** and **Owner's** written permission.

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

1. Ambient temperature not exceeding **122 deg F (50 deg C).**
2. Altitude of 6600 feet above sea level.

1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace paralleling equipment that fails in materials or workmanship within specified warranty period.

1. Warranty Period: **Two** year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

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

C. The multiple-generator paralleling monitoring and control panel in the paralleling low-voltage switchgear shall monitor and control the following standby power system components:

1. Paralleling low-voltage switchgear.
2. Engine generators.
3. Transfer switches.
4. Other load-control devices.
5. Distribution circuit breakers in paralleling low-voltage switchgear.

D. Sequence of Operation for Normal Conditions:

1. Paralleling low-voltage switchgear, including controlled generators**, controlled circuit breakers,** and transfer switches, shall be in the automatic position and ready to operate on loss of power or other designated initiation conditions.
2. Each single-generator monitoring and control system has not received a "start" signal from the following:

a. Transfer switch.
b. Multiple-generator paralleling monitoring and control system.
c. Aggregation switchboard shall be energized through grid forming BESS systems from the aggregated TBPPs. All BESS systems shall be prior synchronized to form an aggregated output equal to the rating of the aggregated TBPPs.

E. Sequence of Operation for Loss of Normal Power Conditions:

1. System ATS shall transfer to already energized aggregation switchboard.

2. ATS shall send start signal to each engine generator in the aggregated TBPP.

3. On receiving a start signal, each single-generator monitoring and control system shall start engine generators and achieve rated voltage and frequency.

4. Black-Start Control: Prevent out-of-phase paralleling. After selecting the first generator to achieve 90 percent rated voltage and frequency, inhibit the connection of generator-controlled circuit breakers to the isolated paralleling bus, then close the circuit breaker connecting the first generator to the isolated paralleling bus.

    a. Comply with requirements in Section 263213 "Engine Generators" for selection of the first engine generator to connect to the isolated paralleling bus.

5. Each single-generator paralleling monitoring and control system synchronizes its associated engine generator and allows closure of respective generator paralleling low-voltage circuit breakers to the isolated paralleling bus. On closure to isolated paralleling bus, each engine generator assumes its proportional share of total load.
6. Failure of an Engine Generator to Synchronize: If engine generator fails to synchronize, sound an alarm after a preset time delay, but continue to attempt to synchronize the engine generator until signaled to stop by manual operation.

F. Load-Demand Sequence of Operation:

1. With load-demand sequence of operation activated, controller continuously monitors total isolated paralleling bus load.
2. If isolated paralleling bus load is below preset limits and after a preset time delay, demand controller shuts down engine generators in predetermined order until minimum number of sets are operating. Set preset limits, predetermined order, and preset time delay, as well as choose manual operation, from human-machine interface.
3. On sensing available isolated paralleling bus capacity diminished to set point, controller starts and closes engine generators to isolated paralleling bus to accommodate load.

G. Individual Transfer Switch Return to Normal Condition Sequence of Operation: Enable individual transfer switches to return to normal power when normal power is available at the transfer switch.
1. When transfer is complete ATS sends stop signal to all generators.
2. BESS to remain energized and on isolated emergency bus.

H. System Test Sequence of Operation:

1. Configure tests to comply with NFPA 110, Level 1 testing requirements for each generator. Automatically generate NFPA 110, Level 1 reports.
2. Single-generator test.
3. Multiple-generator test.
4. Start generators manually, by generator exerciser on user-defined schedule.
5. Engine generator(s) start and achieve rated voltage and frequency.

6. Failure of Engine Generator to Start: After expiration of overcrank time delay, engine generator shuts down and alarm is initiated.
7. Black-Start Control: Prevent out-of-phase paralleling. After selecting first generator to achieve 90 percent rated voltage and frequency, inhibit connection of generator-controlled circuit breakers to isolated paralleling bus, then close circuit breaker connecting first generator to isolated paralleling bus. Each single-generator paralleling monitoring and control system synchronizes its associated engine generator and allows closure of respective generator paralleling low-voltage circuit breakers to the isolated paralleling bus. On closure to isolated paralleling bus, each engine generator assumes its proportional share of total load.
8. Failure of Engine Generator to Synchronize: If engine generator fails to synchronize, sound alarm after preset time delay, but continue to attempt to synchronize engine generator until signaled to stop by manual operation.
9. Manually select or automatically preselect whether test is a load or no-load test. If test is a load test, manually select or automatically preselect loads to be transferred according to schedule or by adjustable time delays at transfer switches. After generators are connected to isolated paralleling bus, transfer loads by sending signal to load-add relay that is connected to input for "remote transfer to generator source" of transfer switch controller or to other devices.
10. After adjustable period of time the system, allow engine generators to optimize down to only the required number to be online to avoid wet stacking. Set stopping and starting sequences through human-machine interface panel device and allow settings based on manual priorities or by engine run time.
11. On sensing available bus capacity diminished to set point, controller starts and closes engine generators to the isolated paralleling bus to accommodate load.
12. After system test is completed, transfer loads back to normal power with transfer switches. Shut down system using sequence in automatic mode.
13. If there is an outage during this mode of operation, automatically change to requirements specified in "Sequence of Operation for Loss of Normal Power Conditions" Paragraph, send load-shed signals to lower-priority loads until load is below generator capacity, signal any engine generator that is not currently operating to start, and cancel system test.

I. Comply with NFPA 110 for the following:

1. Emergency: EPSS Level 1, Type 10.
2. Legally Required Standby: EPSS Level 1, Type 60.
3. Optional Standby: EPSS **[Level 1] [Level 2]**, **[Type 10] [Type 60] [Type 120] [Manual]**.

J. Comply with NFPA 99 for healthcare applications.

2.2 MULTIPLE-GENERATOR PARALLELING MONITORING AND CONTROL SYSTEM

A. Source Limitations: Obtain paralleling low-voltage switchgear from same manufacturer as required **transfer switches and engine generators**.

B. Components and Devices: Factory mounted in a **metal-enclosed, paralleling low-voltage switchgear**.

1. Paralleling Low-Voltage Switchgear Door-Mounted Control Devices: Industrial, oil-type devices.

2. Indicator Lamps: High-intensity digital display.

C. Control Power for Multiple-Generator Monitoring and Control System: Supplied from 24-V dc starting batteries of engine generators.

1. Isolate each battery bank to prevent failure of one battery from disabling entire system.
2. Include, if necessary, separate control power battery system rated 24-V dc for equipment unable to accept voltage drop that occurs during engine cranking.

D. Multiple-generator monitoring and control system auto/manual selector switch.

E. Full-Color, Touch-Screen, Human-Machine Interface Device:

1. Minimum viewing area of **60 sq. in. (387 sq. cm)** shall be configurable in either U.S. standard or SI (metric) units.
2. Main Menu: Include date, time, and system status messages. Configure screens so that no screen is more than three touches from any other screen.

    a. Individual engine generator data shall be accessed at the paralleling low-voltage switchgear from the **main menu and each single-generator paralleling monitoring and control system**.

3. One-Line Diagram: Depicting system configuration and system status by screen animation, screen colors, text messages, or pop-up indicators.

    a. Conditions for Engine Generators, Buses, and Paralleling Circuit Breakers: Energized or de-energized.
    b. Engine Generator Modes:

        1) Auto.
        2) Lockout.
        3) Reset.
        4) Off.
        5) Cool down.
        6) Test off line.
        7) Test on load.

    c. Engine Generator Status: Normal, warning, shutdown, or load-demand stop.
    d. Paralleling Circuit-Breaker Status: Open, closed, or tripped.
    e. Bus Conditions: Energized or de-energized.
    f. Percent load.

4. AC metering screen for isolated paralleling bus shall display the following:

    a. Phase, volts, and amperes.
    b. Kilowatts.
    c. Kilovolt amperes.
    d. Kilovolt-ampere rating.
    e. Power factor.
    f. Frequency.
    g. Kilowatt hour.

h. Kilowatt demand.
i. Real-time trend chart for system kilowatts and volts updated on not less than one-second intervals.
j. A minimum of one historical trend chart for total system loads with intervals no shorter than five minutes and a minimum duration of four hours.
k. Percent of available capacity of the engine generators that are operating in parallel on the bus.

5. Engine Generator Monitoring and Control Screen:

   a. Control:

      1) Engine generator manual start/stop control (functional only when the paralleling low-voltage switchgear mounted control switch is in "Auto" position).
      2) Engine generator alarm reset.
      3) Manual paralleling and circuit-breaker enable/inhibit controls.
      4) Engine function and timer settings.
      5) System function, testing, and timer settings.
      6) Engine generator optimization settings: automatically determine the priority of the engine generators based on engine run time and number of engine starts or manually assign engine priorities.

   b. Status and Alarms:

      1) Power Metering: Watts, volt-ampere reactive, power factor, frequency, amperes, and voltage.
      2) Engine run hours.
      3) Engine status.
      4) Number of generator circuit-breaker operations.
      5) Replicate status and alarms from each single-generator paralleling monitoring and control panel.

6. Dual, Three-Phase, Metering Screen: Graphical analog (270 electrical degree) metering representation with digital display. Display two generators at the same time or one generator and the isolated paralleling bus at the same time. Display graphical synchroscope when one generator and the isolated paralleling bus are selected.

   a. True rms, three-phase voltage, amperes, kilowatts, kilovolt amperes, kilovolt-ampere reactive, power factor, and frequency parameters.
   b. Engine battery voltage display.

7. Password-Protected System Control Screen:

   a. System Test Modes: Test with load/test without load/normal/retransfer time-delay override.
   b. Test with Load: Starts and synchronizes engine generators on isolated paralleling bus; all loads are transferred to the isolated paralleling bus.
   c. Test without Load: Starts and synchronizes engine generators on isolated paralleling bus but does not transfer loads to the isolated paralleling bus.

d. Time adjustments for retransfer time delay, transfer time delay, system time delay on stopping, and system time delay on starting.

8. Load-Demand Control Screen: Monitors total load on the isolated paralleling bus and controls number of engine generators running so that capacity tracks load demand.

   a. Load-Demand Control: Enable/disable.
   b. Set engine generator shutdown sequence.
   c. Load-Demand Pickup Set Point: Adjustable from 90 to 40 percent in 5 percent increments.
   d. Load-Demand Dropout Set Point: Adjustable from 20 to 70 percent in 5 percent increments.

9. Alarm Summary and Run Report Screen:

   a. Lists most recent alarm conditions and status changes.
   b. Lists a minimum of the most recent 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 engine generators.
   d. Lists generator circuit position and status.
   e. Access to trend all monitored automatic transfer switches.
   f. **16-gigabyte** hard-disk space for storing the database file for multiple-generator paralleling monitoring and control panel trending and event logging. Trend and log data at a resolution of one second. If hard drive is full, overwrite in a first-in-first-out procedure.

      1) Trend up to eight monitored points simultaneously.

10. Load Status and Control Screen: Displays status of automatic transfer switches connected to the system for 6 transfer switches, and other controlled devices.

    a. Automatic transfer switch connected to normal.
    b. Automatic transfer switch connected to emergency.
    c. Engine start indication.
    d. Transfer Switch Power Metering Function: Total kilowatt, three-phase current, and three-phase voltage.
    e. Automatic Transfer Switch Load Priority: Ability to change priorities of automatic transfer switches (password protected).
    f. Display name, status, and priority of each load block (whether on or off) and the total load of that block.

11. Automated email messages shall be transmitted when shutdowns occur and shall include time and date of alarm.
12. Based on either the number operations or the time since the last maintenance, suggest maintenance period for generator (run hours), controlled circuit breaker (number of operations), and transfer switches (number of transfers).
13. Status and Alarm Screen:

a. Visual alarm status indicator and alarm horn with silence and acknowledge push button.
b. Status, Light Only:

1) "SYSTEM NOT IN AUTO" (red).
2) Running Status: Display engine generator number and running-status light (green).
3) Load-demand mode (green).
4) System test (green).
5) Remote system start (red).
6) Monitoring of Each Transfer Switch:

a) Normal source available for each (green).
b) Connected to normal (green).
c) Generator source available (green).
d) Connected to generator source (green).

c. Status Light and Alarm:

1) Isolated paralleling bus under frequency (red).
2) Isolated paralleling bus over frequency (red).
3) Auxiliary power failure (red).
4) Emergency start signal power failure (red).
5) Load-Shed Level Status: Displays load number and red load-shed, status light.
6) Generator Alarm Status: Displays generator number and red "Check Generator" status light.
7) Controller malfunction (red).
8) Check station battery (red).
9) Isolated paralleling bus overload (red).
10) System not in auto (red).
11) Main tank, low fuel (amber)
12) Main tank, high fuel (amber).
13) Main tank, fuel leak (red).

F. Remote Monitoring: Replicate human-machine interface monitoring functions **at remote computer terminal**.

G. Remote Monitoring of Status and Alarms: Replicate human-machine interface status and alarms at DDC system for HVAC via isolated contacts.

2.3 METAL-ENCLOSED, CIRCUIT-BREAKER SWITCHGEAR (600 V AND LESS)

A. Source Limitations: Obtain paralleling low-voltage switchgear from same manufacturer as required for **transfer switches and engine generators**.

B. Description: Factory assembled and tested, and complying with IEEE C37.20.1 and UL 1558.

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

D. Nominal System Voltage: Per project plans wire, 60 Hz.

E. Isolated Paralleling Bus: Per project plans.

1. Phase-, Neutral-, and Ground-Bus Materials:

   a. Phase **and Neutral** Bus: **Copper, tin plated**.
   b. Ground Bus: Copper**, tin** plated; minimum size 1/4 by 2 inches (6 by 50 mm).

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

   a. Uniform capacity for horizontal and vertical bus.
   b. Neutral Bus: **100** percent of phase-bus ampacity, except as indicated
   c. Supports and Bracing for Buses: Adequate strength for indicated short-circuit currents.

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

G. 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.

   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.

   e. Neutral Disconnect Link: Bolted, uninsulated, 1/4-by-2-inch (6-by-50-mm) 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 (0.08 mm), minimum.
      2) Bolted Bus Joints: Insulate with secure joint covers that can easily be removed and reinstalled.

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

H. Circuit Breakers: Comply with IEEE C37.13, IEEE C37.16, and IEEE C37.17.

1. Ratings: As indicated on project plans 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.

3. Stored-Energy Mechanism: Electrically charged, with optional manual charging **and operation counter**.
4. Trip Devices:

    a. Solid-state, overcurrent trip-device system consisting of one or two current transformers or sensors per phase, and a release mechanism.
    b. Functions: Long-time-delay, short-time-delay, and instantaneous-trip functions, independent of each other in both action and adjustment.
    c. Temperature Compensation: Ensures accuracy and calibration stability from minus 5 to plus 40 deg C.
    d. Time-Current Characteristics: Field adjustable.
    e. Current Adjustability: Dial settings and rating plugs on trip units or sensors on circuit breakers, or a combination of these methods.
    f. Long-Time- and Short-Time-Delay Functions: Three bands, minimum; marked "minimum," "intermediate," and "maximum."
    g. Pickup Points: Five minimum, for long-time- and short-time-trip functions. Equip short-time-trip function for switchable I-squared-t operation.
    h. Pickup Points: Five minimum, for instantaneous-trip functions.
    i. 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.

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

5. 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.
6. 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.

a. Interlocks: Prevent movement of circuit breaker to or from connected position when it is closed.
b. Circuit-Breaker Positioning:

1) 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.
2) An open circuit breaker may be manually withdrawn to a position for removal from the structure with the door open.
3) Status for connection devices for different positions includes the following:

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

7. 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.
8. Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism.
9. Operating Handle: One for each circuit breaker capable of manual operation.

a. Generator Paralleling Circuit Breakers: Interlocked with system control so that circuit breaker does not close unless mode selector switch is in "Auto" position and engine generator is synchronized with the isolated paralleling bus.

10. Electric Close Button: One for each electrically operated circuit breaker.

a. Generator Paralleling Circuit Breakers: Interlocked with system control so that circuit breaker does not close unless mode selector switch is in "Auto" position and engine generator is synchronized with the isolated paralleling bus.

11. Mechanical Interlocking of Circuit Breakers: Uses a mechanical tripping lever or equivalent design and electrical interlocks.
12. Key Interlocks: Arranged so keys are attached at devices indicated. Mountings and hardware are included where future installation of key-interlock devices is indicated.
13. Undervoltage Trip Devices: Instantaneous, with adjustable pickup voltage.
14. Undervoltage Trip Devices: Adjustable time-delay and pickup voltage.
15. Shunt-Trip Devices:

a. 24-V dc for generator paralleling circuit breakers and for distribution paralleling switchgear circuit breakers.
b. Where indicated.

16. 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.

I. Metering:

1. Type and Locations:

a. Isolated Paralleling Bus: **Multifunction digital-metering monitor;** on door of separate metering compartment.
b. TBPP Circuit Breakers: **Multifunction digital-metering monitor;** on circuit-breaker door.

2. Instrument Transformers:

a. Comply with IEEE C57.13.
b. Potential Transformers: Secondary-voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
c. Current Transformers:

1) Burden and accuracy class suitable for connected relays, meters, and instruments.
2) Size for the maximum momentary current amperage based on calculation or the momentary rating of the circuit breaker protecting the conductor.
3) Include shorting-type terminal blocks.

3. Multifunction Digital-Metering Monitor:

a. Microprocessor-based unit suitable for three- or four-wire systems.
b. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
c. Switch-selectable digital display with the following features:

1) Phase Currents, Each Phase: Plus or minus 1 percent.
2) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
3) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
4) Three-Phase Real Power: Plus or minus 2 percent.
5) Three-Phase Reactive Power: Plus or minus 2 percent.
6) Power Factor: Plus or minus 2 percent.
7) Frequency: Plus or minus 0.5 percent.
8) Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
9) Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

d. Communications module suitable for remote monitoring of meter quantities and functions.
e. Mounting: Display and control unit that is flush or semi-recessed mounted in instrument compartment door.

J. Relays: Comply with IEEE C37.90, integrated digital type; with test blocks and plugs.

1. Functions: <**Insert functions**>.
2. Characteristics: <**Insert characteristics**>.

K. Door-Mounted Control Components: Industrial-type oiltight devices and digital-display indicator lamps.

L. Control Power Supply:

1. Control power transformer shall supply 120-V ac control circuits from the generator source through secondary disconnect devices.
2. Include a control power transformer for each generator paralleling switchgear circuit breaker connected to the generator side of the circuit breaker.
3. Include a control power transformer for each distribution paralleling switchgear circuit breaker.
4. Dry-type transformers shall be in separate compartments for units larger than 3 kVA, including primary and secondary fuses.
5. Two control power transformers in separate compartments with necessary interlocking relays; each transformer shall be connected to line side of associated main circuit breaker.

    a. Secondary windings shall be connected through relay(s) to control bus to effect an automatic transfer scheme.
    b. Secondary windings shall be connected through an internal automatic transfer switch to paralleling switchgear control power bus.

6. Control Power Fuses: Primary and secondary fuses shall provide current-limiting and overload protection.

M. Control Wiring:

1. Factory installed, complete with bundling, lacing, and protection.
2. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.
3. Conductors shall be sized according to NFPA 70 for duty required.

N. Provision for Future Devices: Equip compartments with rails, mounting brackets, supports, necessary appurtenances, and bus connections.

O. Identification: Comply with requirements in Section 260553 "Identification for Electrical Systems" for electrical identification devices and installation.

1. Identify units, devices, controls, and wiring.
2. Mimic Bus: Continuous mimic bus, applied to front of paralleling low-voltage 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 paralleling low-voltage switchgear sections to which applied, to produce a concise visual presentation of principal paralleling 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.

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

1. Features for Each Compartment or Group of Compartments:
    a. Space heater operating at one-half or less of rated voltage, sized to prevent condensation.

b. Louvers equipped with insect and rodent screen and filter; arranged to permit air circulation while excluding insects, rodents, and exterior dust.
c. Hinged front door with locking provisions.
d. Interior light with switch.
e. Weatherproof ground-fault circuit-interrupter duplex receptacle.
f. Power for air conditioning, heaters, lights, and receptacles to be provided from control power transformer.

Q. Access: Fabricate enclosure with hinged, rear cover panels to allow access to rear interior of paralleling low-voltage switchgear.

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

S. Accessories:

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

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

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

V. Storage for Manual: Rack or holder, near the operating instructions, for a copy of maintenance manual.

2.4 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate paralleling low-voltage switchgear, with **generators and transfer switches**, according to operation of functions and features specified.

B. Paralleling low-voltage switchgear, with **generators and transfer switches**, will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, where paralleling low-voltage switchgear will be installed for compliance with installation tolerances, required clearances, and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Comply with applicable portions in NECA 400.

B. Equipment Mounting:

1. Install paralleling low-voltage switchgear on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations as specified on the project plans.

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

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Section 260553 "Identification for Electrical Systems."

B. Diagrams and Instructions:

1. Frame and mount under clear acrylic plastic on front of paralleling low-voltage switchgear.

a. Operating Instructions: Printed basic instructions for paralleling low-voltage 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. Comply with grounding and bonding requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

B. Comply with wire and cable requirements in Section 260519 "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.

3. Inspect paralleling switchgear installation, including wiring, components, connections, and equipment. **Test and adjust components and equipment.**
4. Verify that electrical control wiring installation complies with manufacturer's submittal by means of point-to-point continuity testing.
5. Complete installation and startup checks according to manufacturer's written instructions.

B. Testing Agency: **Owner will engage** a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform the following tests and inspections:

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. AC generators and emergency systems.
    b. Switchgear.
    c. Circuit breakers.
    d. Instrument transformers.
    e. Metering and instrumentation.
    f. Ground-fault systems.

2. Perform NFPA 100 tests for Type 1 essential power systems.

E. Paralleling low-voltage switchgear will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. Infrared Scanning: After Substantial Completion, but not more than 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 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.

H. Test sequence of operation step by step for each mode.

3.6 ADJUSTING

A. Set field-adjustable, electronic circuit-breaker trip characteristics according to results specified in Section 260573 "Overcurrent Protective Device Coordination Study."

B. Set field-adjustable, electronic circuit-breaker trip characteristics.

3.7 CLEANING

A. On completion of installation, inspect interior and exterior of paralleling low-voltage 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 paralleling low-voltage switchgear, according to manufacturer's written instructions, throughout periods when paralleling switchgear environment is not controlled for temperature and humidity within manufacturer's stipulated service conditions.

3.9 DEMONSTRATION

A. **Engage a factory-authorized service representative to train** Owner's maintenance personnel to adjust, operate, and maintain paralleling low-voltage switchgear.

END OF SECTION 262313

SECTION 262416 - PANELBOARDS

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.

1.2 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Load centers.

1.3 DEFINITIONS

A. ATS: Acceptance testing specification.

B. GFCI: Ground-fault circuit interrupter.

C. GFEP: Ground-fault equipment protection.

D. HID: High-intensity discharge.

E. MCCB: Molded-case circuit breaker.

F. SPD: Surge protective device.

G. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of panelboard.

1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details.
2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.

3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
4. Detail bus configuration, current, and voltage ratings.
5. Short-circuit current rating of panelboards and overcurrent protective devices.
6. Include evidence of NRTL listing for series rating of installed devices.
7. Include evidence of NRTL listing for SPD as installed in panelboard.
8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
9. Include wiring diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Panelboard Schedules: For installation in panelboards. **Submit final versions after load balancing.**

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Keys: **Two** spares for each type of panelboard cabinet lock.
2. Circuit Breakers Including GFCI and GFEP Types: **Two** spares for each panelboard.

1.8 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to **NEMA PB 1**.

1.10 FIELD CONDITIONS

A. Environmental Limitations (Interior locations):

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

a. Ambient Temperature: Not exceeding **minus 22 deg F (minus 30 deg C)** to plus 104 deg F (plus 40 deg C).
b. Altitude: Not exceeding 6600 feet (2000 m).

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet (2000 m).

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

1. Notify **Construction Manager and Owner** no fewer than **two** days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without **Construction Manager's and Owner's** written permission.
3. Comply with NFPA 70E.

1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.

1. Panelboard Warranty Period: **18** months from date of Substantial Completion.

B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace SPD that fails in materials or workmanship within specified warranty period.

1. SPD Warranty Period: **Five** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARDS AND LOAD CENTERS COMMON REQUIREMENTS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

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

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Comply with NEMA PB 1.

E. Comply with NFPA 70.

F. Enclosures: **Surface**-mounted, dead-front cabinets.

1. Rated for environmental conditions at installed location.
   a. Outdoor Locations: NEMA 250, **Type 3R**.

2. Height: 84 inches (2.13 m) maximum.
3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Trims shall cover all live parts and shall have no exposed hardware.
4. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
5. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
6. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
7. Finishes:

   a. Panels and Trim: **Steel and galvanized steel**, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
   b. Back Boxes: **Galvanized steel**.
   c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.

G. Incoming Mains:

1. Location: **Convertible between top and bottom**.
2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.

H. Phase, Neutral, and Ground Buses:

1. Material: **Tin-plated aluminum**.

   a. Plating shall run entire length of bus.
   b. Bus shall be fully rated the entire length.

2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.

3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
4. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.

I. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: **Hard-drawn copper, 98 percent conductivity**.
2. Terminations shall allow use of 75 deg C rated conductors without derating.
3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
4. Main and Neutral Lugs: **Mechanical** type, with a lug on the neutral bar for each pole in the panelboard.
5. Ground Lugs and Bus-Configured Terminators: **Mechanical** type, with a lug on the bar for each pole in the panelboard.
6. Feed-Through Lugs: **Mechanical** type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
7. Subfeed (Double) Lugs: **Mechanical** type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
8. Gutter-Tap Lugs: **Mechanical** type suitable for use with conductor material and with matching insulating covers. Locate at same end of bus as incoming lugs or main device.
9. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.

J. NRTL Label: Panelboards or load centers shall be labeled by an NRTL acceptable to authority having jurisdiction for use as service equipment with one or more main service disconnecting and overcurrent protective devices. Panelboards or load centers shall have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.

K. Future Devices: Panelboards or load centers shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

1. Percentage of Future Space Capacity: **Five** percent.

L. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.

1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to **ASCE/SEI 7**.

1. 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."

B. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD **Type 1**.

2.3 POWER PANELBOARDS

A. Panelboards: NEMA PB 1, distribution type.

B. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than **36 inches (914 mm)** high, provide two latches, keyed alike.

C. Mains: **Circuit breaker**.

D. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: **Bolt-on circuit breakers.**

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: **Bolt-on circuit breakers**.

2.4 LOAD CENTERS

A. Load Centers: Comply with UL 67.

B. Mains: **Circuit breaker**.

C. Branch Overcurrent Protective Devices: Plug-in circuit breakers, replaceable without disturbing adjacent units.

D. Doors: Concealed hinges secured with flush latch with tumbler lock; keyed alike.

E. Conductor Connectors: Mechanical type for main, neutral, and ground lugs and buses.

2.5 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. MCCB: Comply with UL 489, with **interrupting capacity** to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers:

a. Inverse time-current element for low-level overloads.
b. Instantaneous magnetic trip element for short circuits.
c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

2.6 IDENTIFICATION

A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.

B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.

C. Circuit Directory: Directory card inside panelboard door, mounted in **metal frame with transparent protective cover**.

1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

2.7 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.

B. Receive, inspect, handle, and store panelboards according to **NEMA PB 1.1**.

C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.

D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Comply with NECA 1.

C. Install panelboards and accessories according to [**NECA 407**] [**NEMA PB 1.1**].

D. Equipment Mounting:
   1. Attach panelboard to the vertical finished or structural surface behind the panelboard.

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

F. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

G. Mount top of trim **90 inches (2286 mm)** above finished floor unless otherwise indicated.

H. Mount panelboard cabinet plumb and rigid without distortion of box.

I. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

J. Mount surface-mounted panelboards to steel slotted supports **5/8 inch (16 mm)** in depth. Orient steel slotted supports vertically.

K. Install overcurrent protective devices and controllers not already factory installed.

   1. Set field-adjustable, circuit-breaker trip ranges.
   2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.

L. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.

M. Install filler plates in unused spaces.

N. Arrange conductors in gutters into groups and bundle and wrap with wire ties **after completing load balancing**.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads **after balancing panelboard loads**; incorporate Owner's final areas designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

E. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Acceptance Testing Preparation:

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

D. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers stated in NETA ATS, Paragraph 7.6 Circuit Breakers. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
c. Instruments and Equipment:

1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

E. Panelboards will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges **as indicated**.

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Architect of effect on phase color coding.

1. Measure loads during period of normal facility operations.
2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by the Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
4. Tolerance: Maximum difference between phase loads, within a panelboard, shall not exceed 20 percent.

3.6 PROTECTION

A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 262416

SECTION 262726 - WIRING DEVICES

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.

1.2 SUMMARY

A. Section Includes:

1. Straight-blade convenience
2. Toggle switches.
3. Wall plates.

1.3 DEFINITIONS

A. BAS: Building automation system.

B. EMI: Electromagnetic interference.

C. GFCI: Ground-fault circuit interrupter.

D. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

E. RFI: Radio-frequency interference.

F. SPD: Surge protective device.

G. UTP: Unshielded twisted pair.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

C. Samples: One for each type of device and wall plate specified, in each color specified.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

PART 2 - PRODUCTS

2.1 GENERAL WIRING-DEVICE REQUIREMENTS

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:

1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
2. Devices shall comply with the requirements in this Section.

D. Devices for Owner-Furnished Equipment:

1. Receptacles: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

E. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 STRAIGHT-BLADE RECEPTACLES

A. Duplex Convenience Receptacles: 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

2.3 GFCI RECEPTACLES

A. General Description:

1. 125 V, 20 A, straight blade, **feed**-through type.
2. Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, UL 943 Class A, and FS W-C-596.
3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.

B. Duplex GFCI Convenience Receptacles:

2.4 TOGGLE SWITCHES

A. Comply with NEMA WD 1, UL 20, and FS W-S-896.

B. Switches, 120/277 V, 20 A:

1. Single Pole:

2.5 WALL PLATES

A. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: **Steel with white baked enamel, suitable for field painting.**
3. Material for Unfinished Spaces: **Galvanized steel**.
4. Material for Damp Locations: **Cast aluminum** with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant**, die-cast aluminum** with lockable cover.

2.6 FINISHES

A. Device Color:

1. Wiring Devices Connected to Normal Power System: **Almond** unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Emergency Power System: **Red**.
3. SPD Devices: Blue.
4. Isolated-Ground Receptacles: **Orange**.

B. Wall Plate Color: For plastic covers, match device color.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.

3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:

    a. Cut back and pigtail, or replace all damaged conductors.
    b. Straighten conductors that remain and remove corrosion and foreign matter.
    c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles **down**, and on horizontally mounted receptacles to the **right**.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

H. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 GFCI RECEPTACLES

A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

3.3 IDENTIFICATION

A. Comply with Section 260553 "Identification for Electrical Systems."

B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with **black**-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.4 FIELD QUALITY CONTROL

A. Test Instruments: Use instruments that comply with UL 1436.

B. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

C. Perform the following tests and inspections.

1. In healthcare facilities, prepare reports that comply with recommendations in NFPA 99.
2. Test Instruments: Use instruments that comply with UL 1436.
3. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

D. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

E. Test straight-blade for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz. (115 g).

F. Wiring device will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

END OF SECTION 262726

SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Nonfusible switches.
   2. Molded-case circuit breakers (MCCBs).
   3. Enclosures.

1.3 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

   1. Enclosure types and details for types other than NEMA 250, Type 1.
   2. Current and voltage ratings.
   3. Short-circuit current ratings (interrupting and withstand, as appropriate).
   4. Include evidence of a nationally recognized testing laboratory (NRTL) listing for series rating of installed devices.
   5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
   6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in **PDF and** electronic format.

B. Shop Drawings: For enclosed switches and circuit breakers.

   1. Include plans, elevations, sections, details, and attachments to other work.
   2. Include wiring diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
b. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in **PDF and** electronic format.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.8 FIELD CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
2. Altitude: Not exceeding 6600 feet (2010 m).

1.9 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: **One** year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

2.2 GENERAL REQUIREMENTS

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

D. Comply with NFPA 70.

2.3 NONFUSIBLE SWITCHES

A. Type GD, General Duty shall not permitted.

B. Type HD, Heavy Duty, Three Pole, Single Throw **600**-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
4. Auxiliary Contact Kit: **One Two** NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating **120-V ac**.
5. Lugs: **Mechanical** type, suitable for number, size, and conductor material.
6. Service-Rated Switches: Labeled for use as service equipment.

2.4 MOLDED-CASE CIRCUIT BREAKERS

A. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.

B. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing

international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.

C. The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker. Circuit breakers shall be **100 percent rated**.

D. Lugs shall be suitable for **194 deg F (90 deg C) rated wire, sized according to the 167 deg F (75 deg C) temperature rating in NFPA 70**.

E. Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents.

F. Thermal-Magnetic Circuit Breakers: Inverse time-current thermal element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

G. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

H. Ground-Fault Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

2.5 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

B. Enclosure Finish: The enclosure shall be **gray baked enamel paint, electrodeposited on cleaned, phosphatized galvannealed steel (NEMA 250 Types 3R, 12)**.

C. Operating Mechanism: The circuit-breaker operating handle shall be **directly operable through the dead front trim of the enclosure (NEMA 250 Type 3R)**. The cover interlock mechanism shall have an externally operated override. The override shall not permanently disable the interlock mechanism, which shall return to the locked position once the override is released. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

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

1. Commencement of work shall indicate Installer's acceptance of the areas and conditions as satisfactory.

3.2 PREPARATION

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

1. Notify **Construction Manager** and **Owner** no fewer than five days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without **Construction Manager's** and **Owner's** written permission.
4. Comply with NFPA 70E.

3.3 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.

1. Indoor, Dry and Clean Locations: NEMA 250, **Type 1**.
2. Outdoor Locations: NEMA 250, **Type 3R**.
3. Other Wet or Damp, Indoor Locations: NEMA 250, **Type 4**.
4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

3.4 INSTALLATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

C. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Install fuses in fusible devices.

F. Comply with NFPA 70 and NECA 1.

3.5 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.

2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections.

E. Tests and Inspections for Switches:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, grounding, and clearances.
c. Verify that the unit is clean.
d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
e. Verify that fuse sizes and types match the Specifications and Drawings.
f. Verify that each fuse has adequate mechanical support and contact integrity.
g. Inspect bolted electrical connections for high resistance using one of the two following methods:

1) Use a low-resistance ohmmeter.

a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.
i. Verify correct phase barrier installation.
j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.

2. Electrical Tests:

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.

b. Measure contact resistance across each switchblade fuseholder. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
e. Perform ground fault test according to NETA ATS 7.14 "Ground Fault Protection Systems, Low-Voltage."

F. Tests and Inspections for Molded Case Circuit Breakers:

1. Visual and Mechanical Inspection:

a. Verify that equipment nameplate data are as described in the Specifications and shown on the Drawings.
b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, grounding, and clearances.
d. Verify that the unit is clean.
e. Operate the circuit breaker to ensure smooth operation.
f. Inspect bolted electrical connections for high resistance using one of the two following methods:

1) Use a low-resistance ohmmeter.

a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

g. Inspect operating mechanism, contacts, and chutes in unsealed units.
h. Perform adjustments for final protective device settings in accordance with the coordination study.

2. Electrical Tests:

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar

connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.

b. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.

c. Perform a contact/pole resistance test. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.

d. Perform insulation resistance tests on all control wiring with respect to ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid state components, follow manufacturer's recommendation. Insulation resistance values shall be no less than two megohms.

e. Determine the following by primary current injection:

1) Long-time pickup and delay. Pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
2) Short-time pickup and delay. Short-time pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
3) Ground-fault pickup and time delay. Ground-fault pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
4) Instantaneous pickup. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances.

f. Test functionality of the trip unit by means of primary current injection. Pickup values and trip characteristics shall be as specified and within manufacturer's published tolerances.

g. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of the shunt trip and close coils shall be as indicated by manufacturer.

h. Verify correct operation of auxiliary features such as trip and pickup indicators; zone interlocking; electrical close and trip operation; trip-free, anti-pump function; and trip unit battery condition. Reset all trip logs and indicators. Investigate units that do not function as designed.

i. Verify operation of charging mechanism. Investigate units that do not function as designed.

3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

4. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit

breaker. Remove front panels so joints and connections are accessible to portable scanner.

b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.

c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

G. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

H. Prepare test and inspection reports.

1. Test procedures used.
2. Include identification of each enclosed switch and circuit breaker tested and describe test results.
3. List deficiencies detected, remedial action taken, and observations after remedial action.

3.7 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

END OF SECTION 262816

SECTION 263100 - PHOTOVOLTAIC COLLECTORS

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.

1.2 SUMMARY

A. Section Includes:

1. PV system description.
2. Manufactured PV units.
3. PV module framing.
4. PV array construction.
5. Inverters.
6. System overcurrent protection.
7. Mounting structures.

1.3 DEFINITIONS

A. CEC: California Energy Commission.

B. ETFE: Ethylene tetrafluoroethylene.

C. FEP: Fluorinated ethylene propylene.

D. IP Code: Required ingress protection to comply with IEC 60529.

E. MPPT: Maximum power point tracking.

F. PTC: PVUSA Test Condition. Commonly regarded as a "real-world" measure of PV output. See below for definition of "PVUSA."

G. PV: Photovoltaic.

H. PVUSA: Photovoltaics for Utility Systems Applications.

I. STC: Standard Test Conditions defined in IEC 61215.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for PV panels.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For PV modules.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly.
4. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For manufacturer's special materials and workmanship warranty and minimum power output warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For PV modules to include in operation and maintenance manuals.

1.7 WARRANTY

A. Manufacturer's Special Warranty: Manufacturer agrees to repair or replace components of PV modules that fail in materials or workmanship within specified warranty period.

1. Manufacturer's materials and workmanship warranties include, but are not limited to, the following:

   a. Faulty operation of PV modules.
   b. Linear Power Performance Warranty

2. Warranty Period:
   a. Twenty Five years on materials and workmanship from date of Substantial Completion.
   b. Thirty years on linear power performance

B. Manufacturer's Special Minimum Power Output Warranty: Manufacturer agrees to repair or replace components of PV modules that fail to exhibit the minimum power output within specified warranty period. Special warranty, applying to modules only, applies to materials only, on a prorated basis, for period specified.

1. Manufacturer's minimum power output warranties include, but are not limited to, the following warranty periods, from date of Substantial Completion:

a. Specified minimum power output to **80** percent or more, for a period of 30 years.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Hazardous Locations: FM Global approved for NFPA 70, Class 1, Division 2, Group C and Group D.

2.2 PV CAPACITIES AND CHARACTERISTICS

A. Minimum Electrical Characteristics:

1. Rated Open-Circuit Voltage: 39.6 V dc.
2. Maximum System Voltage: 1500 V dc.
3. Maximum Power at Voltage (Vpm): 33.4 V dc.
4. Short-Circuit Temperature Coefficient: .045% /deg C>.
5. Rated Short-Circuit Current (Isc): 16 amps.
6. Rated Operation Current (Imp): 14.98 amps.
7. Maximum Power at STC (Pmax): 500 watts.

2.3 PV SYSTEMS DESCRIPTION

A. Interactive PV System: Collectors connected in parallel to the TBPP main bus and BESS; and capable of providing power for Project and supplying power to a distributed network.

1. A module array sized as noted on the project plans to generate a total nominal rated output as noted on the project plans.
2. System Components:

a. PV modules.
b. Array frame.
c. BESS interactive inverter. BESS to be grid forming.
d. Overcurrent protection, disconnect, and rapid shutdown devices.
e. Mounting structure.
f. System kW/kWh meter.
g. DC combiner boxes.

B. System shall be a Stand Alone PV system: Collectors connected to provide power to Project dc and ac loads through an energy storage system.

2.4 MANUFACTURED PV UNITS

A. Cell Materials: N-Type TOPCon Technology

B. Module Construction:

1. Nominal Size: 44.6 inches (800 mm) wide by 77.2 inches (1600 mm) long.
2. Weight: 51.4 lb (19.4 kg).

C. Front Panel: Fully tempered glass.

D. Backing Material: Tempered glass.

E. Frame: Anodized aluminum

F. Bypass Diode Protection: Internal.

G. Junction Box:

1. Size: 1.56 by 3.96 by 0.52 inch (39.6 by 100.6 by 13.2 mm).
2. Fully potted, vandal resistant.
3. IP Code **IP68**.
4. Flammability Test: UL 1703.

H. Output Cabling:
1. Quick, multiconnect, polarized connectors.

I. Series Fuse Rating: 25 amp.

2.5 PV MODULE FRAMING

A. PV laminates mounted in anodized extruded-aluminum frames.

1. Entire assembly UL listed for electrical and fire safety, according to UL 1703, and complying with IEC 61215.
2. Frame strength exceeding requirements of certifying agencies in subparagraph above.
3. Finish: Anodized aluminum.

a. Alloy and temper recommended by framing manufacturer for strength, corrosion resistance, and application of required finish.
b. Color: As indicated by manufacturer's designations.

2.6 PV ARRAY CONSTRUCTION

A. Framing:

1. Material: **Extruded aluminum**.
2. Maximum System Weight: Less than 4 lb/sq. ft. (19.53 kg/sq. m).
3. Raceway Cover Plates **Aluminum**.

2.7 INVERTER

A. Inverter Type: String.

B. Inverter size: AC output wattage as noted on project plans.

C. Control Type: Maximum power point tracker control.

D. Inverter Electrical Characteristics:
   1. Inverter shall have elecrtrical ratings as listed for its size and are similar to those manufactured by SMA, SolarEdge, Chint (CPS), or equal.

E. Operating Conditions:

   1. Operating Ambient Temperatures: Minus 4 to plus 122 deg F (20 to plus 50 deg C).
   2. Storage Temperature: Minus 40 to plus 122 deg F (minus 40 to plus 50 deg C).
   3. Relative Humidity: Zero to 95 percent, noncondensing.

F. Enclosure:

   1. NEMA **Type 3R minimum**.
   2. Enclosure Material: **Steel**.
   3. Cooling Methods:
      a. Passive cooling.

   4. Protective Functions:

      a. AC over/undervoltage.
      b. AC over/underfrequency.
      c. Ground overcurrent.
      d. Overtemperature.
      e. AC and dc overcurrent.
      f. DC overvoltage.

   5. Standard LCD, four lines, 20 characters, with user display and on/off toggle switch.

G. Disconnects: Rated for system voltage and conductor.

H. Regulatory Approvals:

   1. IEEE 1547.1.
   2. IEEE 1547.3.
   3. UL 1741.

2.8 SYSTEM OVERCURRENT PROTECTION

A. Fuses: Per project plans requirements.

B. Circuit Breakers: Per project plans requirements.

2.9 MOUNTING STRUCTURES

A. Rack Mounts per project plans.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrate areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Do not begin installation until mounting surfaces have been properly prepared.

C. If preparation of mounting surfaces is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

D. Examine modules and array frame before installation. Reject modules and arrays that are wet, moisture damaged, or mold damaged.

E. Examine roofs, supports, and supporting structures for suitable conditions where PV system will be installed.

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

3.2 INSTALLATION

A. Comply with NECA 1.

B. Coordinate layout and installation of PV panels with [**roof**] [**support**] assembly and other construction.

C. Support PV panel assemblies independent of supports for other elements such as roof and support assemblies, enclosures, vents, pipes, and conduits. Support assembly to prevent twisting from eccentric loading.

D. Install PV [**inverters,**] [**energy storage,**] [**charge controller,**] [**rapid shutdown,**] [**and**] [**system control**] in locations indicated on Drawings.

E. Install weatherseal fittings and flanges where PV panel assemblies penetrate exterior elements such as walls or roofs. Seal around openings to make weathertight. See Section 079200 "Joint Sealants" for materials and application.

F. Seismic Restraints: Comply with requirements for seismic-restraint devices specified in Section 260548.16 "Seismic Controls for Electric Systems."

G. Wiring Method: Install cables in raceways.

H. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.3 CONNECTIONS

A. Coordinate PV panel cabling to equipment enclosures to ensure proper connections.

B. Coordinate installation of utility-interactive meter with utility.

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

D. Make splices, terminations, and taps that are compatible with conductor material **and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors**.

END OF SECTION 263100

SECTION 263213.16 - GASEOUS EMERGENCY ENGINE GENERATORS

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.

1.2 SUMMARY

A. Section includes packaged engine generators for emergency use with the following features:

1. **Natural gas with LP backup** engine.
2. Gaseous fuel system.
3. Control and monitoring.
4. Generator overcurrent and fault protection.
5. Generator, exciter, and voltage regulator.
6. Outdoor acoustic modified engine generator enclosure.
7. Engine driven radiator.
8. Vibration isolation devices.
9. Finishes.

B. Related Requirements:
1. Section 263600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine generators.

1.3 DEFINITIONS

A. EPS: Emergency power supply.

B. EPSS: Emergency power supply system.

C. LP: Liquid petroleum.

D. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Include thermal damage curve for generator.
3. Include time-current characteristic curves for generator protective device.

4. Include fuel consumption in cubic feet per hour (CFH) at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
5. Include generator efficiency at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
6. Include airflow requirements for cooling and combustion air in cubic feet per minute (CFM) at 0.8 power factor, with air-supply temperature of 95. Provide Drawings indicating requirements and limitations for location of air intake and exhausts.
7. Include generator characteristics, including, but not limited to, kilowatt rating, efficiency, reactances, and short-circuit current capability.

B. Shop Drawings:

1. Include plans and elevations for engine generator and other components specified.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Identify fluid drain ports and clearance requirements for proper fluid drain.
4. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and supported equipment. Include base weights.
6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for EPS equipment and functional relationship between all electrical components.
7. Include drawings for propane tanks and supports, if used.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For **manufacturer**.

B. Seismic Qualification Data: Certificates, for engine generator, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: With engine and generator mounted on rails, identify center of gravity and total weight, **supplied enclosure, silencer,** and each piece of equipment not integral to the engine generator, 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.

C. Source Quality-Control Reports: Including, but not limited to, the following:

1. Certified summary of prototype-unit test report.
2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.

4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
5. Report of sound generation.
6. Report of exhaust emissions showing compliance with applicable regulations.
7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.

D. Field quality-control reports.

E. Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
b. Operating instructions laminated and mounted adjacent to generator location.
c. Training plan.

1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.
4. Tools: Each tool listed by part number in operations and maintenance manual.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

B. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.9 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 2 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain packaged engine generators and auxiliary components from single source from single manufacturer.

B. Acceptable manufacturers shall be those whose final, fully assembled packaged gaseous engine generator product meets or exceeds all performance requirements as specified herein for gaseous emergency engine generators.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Engine generator housing, engine generator, batteries, battery racks, silencers, sound attenuating equipment, accessories, and components shall withstand the effects of earthquake motions determined according to **ASCE/SEI 7 level 4**.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."
2. Shake-table testing shall comply with ICC-ES AC156. Testing shall be performed with all fluids at worst-case normal levels.
3. Component Importance Factor: **1.0**.

B. B11 Compliance: Comply with B11.19.

C. NFPA Compliance:

1. Comply with NFPA 37.
2. Comply with NFPA 70.
3. Comply with NFPA 99.
4. Comply with NFPA 110 requirements for Level **1** EPSS.

D. UL Compliance: Comply with UL 2200.

E. Engine Exhaust Emissions: Comply with EPA Tier **2 for non-road SI engine** requirements and applicable state and local government requirements.

F. Noise Emission: Comply with **applicable state and local government requirements** for maximum noise level due to sound emitted by engine generator, including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation. See silencer requirements in paragraph 2.4 in this specification. See enclosure requirements in paragraph 2.10 of this specification.

G. Environmental Conditions: Engine generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: **5 to 104 deg F .**
2. Altitude: Sea level to **3000 feet**. Generator rated output shall be at the stated elevation.

H. Unusual Service Conditions: Engine generator equipment and installation are required to operate under the following conditions:

1. **High salt-dust content in the air due to sea-spray evaporation when installed within 50 miles of the coast.**

2.3 ENGINE GENERATOR ASSEMBLY DESCRIPTION

A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

C. EPSS Class: Engine generator shall be classified as **Class 48** according to NFPA 110.

D. Service Load: 10 kW/12.5kVA.

E. Power Factor: **0.8,** lagging.

F. Frequency: 60 Hz.

G. Voltage: 120/240V ac.

H. Phase: Single-phase, three-wire.

I. Induction Method: **Turbocharged**.

J. Governor: Adjustable isochronous, with speed sensing.

K. Mounting Frame: Structural-steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.

1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and engine generator center of gravity.

L. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries**.**
2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

M. Engine Generator Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage, from no load to full load.
2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency, from no load to full load.
4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
8. Start Time: Comply with NFPA 110, **Type 10**, system requirements.

N. Engine Generator Performance for Sensitive Loads:

1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.

    a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.

2. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage, from no load to full load.
3. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.
4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency, from no load to full load.
5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
6. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.
7. Output Waveform: At no load, harmonic content, measured line to neutral, shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
8. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.

9. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.

    a. Provide permanent magnet excitation for power source to voltage regulator.

10. Start Time: Comply with NFPA 110, **Type 10**, system requirements.

O. Parallel Engine Generators:

1. Automatic reactive output power control and load sharing between engine generators operated in parallel.
2. Automatic regulation, automatic connection to a common bus, and automatic synchronization, with manual controls and instruments to monitor and control paralleling functions.
3. Protective relays required for equipment and personnel safety.
4. Paralleling suppressors to protect excitation systems.
5. Reverse power protection.
6. Loss of field protection.

2.4 ENGINE

A. Fuel: **Natural gas with LP backup**.

B. Rated Engine Speed: 1800 rpm.

C. Lubrication System: Engine or skid mounted.

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

D. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity and with UL 499.

E. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine generator mounting frame and integral engine-driven coolant pump.

1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
2. Size of Radiator: Adequate to contain expansion of total system coolant, from cold start to 110 percent load condition.
3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant-system pressure for engine used. Equip with gage glass and petcock.
4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.

5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, UV-, and abrasion-resistant fabric.

    a. Rating: 50-psig maximum working pressure with coolant at 180 deg F, and non collapsible under vacuum.
    b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

F. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 25 dB at 500 Hz.
2. Sound level measured at a distance of 25 feet from exhaust discharge after installation is complete shall be **78** dBA or less.

G. Air-Intake Filter: **Heavy** duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

H. Starting System: **24**V electric, with negative ground.

1. Components: Sized so they are not damaged during a full engine-cranking cycle, with ambient temperature at maximum specified in "Performance Requirements" Article.
2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: **As required by NFPA 110 for system level specified**.
4. Battery: **Lead acid** with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least **three times** without recharging.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 50 deg F regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.
7. Battery Stand: Factory-fabricated, two-tier metal with acid-resistant finish designed to hold the quantity of battery cells required and to maintain the arrangement to minimize lengths of battery interconnections.
8. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
9. Battery Charger: Current-limiting, automatic-equalizing and float-charging type designed for **lead-acid** batteries. Unit shall comply with UL 1236 and include the following features:

    a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
    b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 to 140 deg F to prevent overcharging at high temperatures and undercharging at low temperatures.

c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.5 GASEOUS FUEL SYSTEM

A. Natural Gas Piping: Comply with project requirements.

B. LP Gas Piping: Comply with project requirements.

C. Gas Train: Comply with NFPA 37.

D. Tanks: Comply with requirements for propane storage containers.

E. Engine Fuel System:

1. **Natural Gas with LP Gas Backup**, Vapor-Withdrawal System:

a. Carburetor.
b. Secondary Gas Regulators: One for each fuel type, with atmospheric vents piped to building exterior.
c. Fuel-Shutoff Solenoid Valves: NRTL-listed, normally closed, safety shutoff valves; one for each fuel source.

2. Fuel Filters: One for each fuel type.
3. Manual Fuel Shutoff Valves: One for each fuel type.
4. Flexible Fuel Connectors: Minimum one for each fuel connection.
5. LP gas flow adjusting valve.
6. Fuel change gas pressure switch.

2.6 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of engine generator. When mode-selector switch is switched to the on position, engine generator starts. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

B. Manual Starting System Sequence of Operation: Switching On-Off switch on the generator control panel to the on position starts engine generator. The off position of same switch initiates

engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

C. Provide minimum run-time control set for **15** minutes, with override only by operation of a remote emergency-stop switch.

D. Comply with UL 508A.

E. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the engine generator. Mounting method shall isolate the control panel from engine generator vibration. Panel shall be powered from the engine generator battery.

F. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel. Panel shall be powered from the engine generator battery.

G. Configuration: Operating and safety indications, protective devices, basic system controls, engine gages, instrument transformers, generator disconnect switch or circuit breaker, and other indicated components shall be grouped in a combination control and power panel. Control and monitoring section of panel shall be isolated from power sections by steel barriers. Panel shall be powered from the engine generator battery. Panel features shall include the following:

1. Wall-Mounting Cabinet Construction: Rigid, self-supporting steel unit complying with NEMA ICS 6.
2. Switchboard Construction: Freestanding unit complying with Section 262413 "Switchboards." Power bus shall be copper. Bus, bus supports, control wiring, and temperature rise shall comply with UL 891.
3. Switchgear Construction: Freestanding unit complying with Section 262300 "Low-Voltage Switchgear."

H. Control and Monitoring Panel:

1. Digital controller with integrated LCD display, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup.
2. Instruments: Located on the control and monitoring panel and viewable during operation.

    a. Engine lubricating-oil pressure gage.
    b. Engine-coolant temperature gage.
    c. DC voltmeter (alternator battery charging).
    d. Running-time meter.
    e. AC voltmeter **connected to a phase selector switch**.
    f. AC ammeter **connected to a phase selector switch**.
    g. AC frequency meter.
    h. Generator-voltage adjusting rheostat.

3. Controls and Protective Devices: Controls, shutdown devices, and common visual alarm indication as required by NFPA 110 for Level **1**] system, including the following:

    a. Cranking control equipment.
    b. Run-Off-Auto switch.

c. Control switch not in automatic position alarm.
d. Overcrank alarm.
e. Overcrank shutdown device.
f. Low water temperature alarm.
g. High engine temperature pre-alarm.
h. High engine temperature.
i. High engine temperature shutdown device.
j. Overspeed alarm.
k. Overspeed shutdown device.

l. Coolant low-level alarm.
m. Coolant low-level shutdown device.
n. Coolant high-temperature prealarm.
o. Coolant high-temperature alarm.
p. Coolant low-temperature alarm.
q. Coolant high-temperature shutdown device.
r. EPS load indicator.
s. Battery high-voltage alarm.
t. Low-cranking voltage alarm.
u. Battery-charger malfunction alarm.
v. Battery low-voltage alarm.
w. Lamp test.
x. Contacts for local and remote common alarm.
y. Remote manual-stop shutdown device.
z. Air shutdown damper alarm when used.
aa. Air shutdown damper shutdown device when used.
bb. Generator overcurrent-protective-device not-closed alarm.

I. Connection to Datalink:

1. A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication.
2. Provide connections for datalink transmission of indications to remote data terminals via **Ethernet**.

J. Common Remote Panel with Common Audible Alarm: Comply with NFPA 110 requirements for Level **1** systems. Include necessary contacts and terminals in control and monitoring panel. Remote panel shall be powered from the engine generator battery.

K. Remote Alarm Annunciator: Comply with NFPA 99. An LED indicator light labeled with proper alarm conditions shall identify each alarm event, and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface mounting type to suit mounting conditions indicated.

1. Overcrank alarm.
2. Coolant low-temperature alarm.
3. High engine temperature pre-alarm.
4. High engine temperature alarm.
5. Low lube oil pressure alarm.

6. Overspeed alarm.
7. Low coolant level alarm.
8. Low-cranking voltage alarm.
9. Contacts for local and remote common alarm.
10. Audible-alarm silencing switch.
11. Air shutdown damper when used.
12. Run-Off-Auto switch.
13. Control switch not in automatic position alarm.
14. Lamp test.
15. Low-cranking voltage alarm.
16. Generator overcurrent-protective-device not-closed alarm.

L. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator unless otherwise indicated.

M. Remote Emergency-Stop Switch: Wall mounted unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.7 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.

1. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.

B. Generator Circuit Breaker: Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.

1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
2. Trip Settings: Selected to coordinate with generator thermal damage curve.
3. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
4. Mounting: Adjacent to or integrated with control and monitoring panel.

C. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other engine generator protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector performs the following functions:

1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other engine generator malfunction alarms. Contacts shall be available for load shed functions.
2. Under single- or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.

3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the engine generator.
4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

D. Ground-Fault Indication: Comply with NFPA 70 Article 700, "Emergency System" signals for ground fault.

1. Indicate ground fault with other engine generator alarm indications.
2. Trip generator protective device on ground fault.

2.8 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H or Class F.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required. Provide **12** lead alternator.

E. Range: Provide **broad** range of output voltage by adjusting the excitation level.

F. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

G. Enclosure: Dripproof.

H. Instrument Transformers: Mounted within generator enclosure.

I. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified and as required by NFPA 110.

1. Adjusting Rheostat on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.
2. Maintain voltage within **20** percent on one step, full load.
3. Provide anti-hunt provision to stabilize voltage.
4. Maintain frequency within **5** percent and stabilize at rated frequency within **two** seconds.

J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

L. Subtransient Reactance: **12** percent, maximum.

2.9 OUTDOOR ENGINE GENERATOR ENCLOSURE

A. Description: Vandal-resistant, sound-attenuating, weatherproof steel housing, wind resistant up to 100 mph. Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.

1. Sound Attenuation Level: To reduce noise level to 70db at 23 feet from genset enclosure.

B. Description: Prefabricated or pre-engineered, galvanized-steel-clad, integral structural-steel-framed, acoustically attenuated, enclosure; erected on concrete foundation or provided assembled with genset.

C. Structural Design and Anchorage: Comply with ASCE/SEI 7 for wind loads up to 100 mph.

D. Seismic Design: Comply with seismic requirements in Section 260548.16 "Seismic Controls for Electrical Systems."

E. Provide smoke detector in enclosure; mounted according to NFPA 72.

F. Hinged Doors: With padlocking provisions.

G. Space Heater: Thermostatically controlled and sized to prevent condensation.

H. Lighting: Provide weather-resistant **LED** lighting with **30 fc** average maintained.

I. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine generator components.

J. Muffler Location: **Within** enclosure.

K. Engine-Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for two hours or 100% continuous for 48 hours with ambient temperature at top of range specified in system service conditions.

1. Louvers: Fixed-engine, cooling-air inlet and discharge. Stormproof and drainable louvers prevent entry of rain and snow.
2. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.
3. Ventilation: Provide temperature-controlled exhaust fan interlocked to prevent operation when engine is running.

L. Interior Lights with Switch: Factory-wired, vaporproof luminaires within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.

1. AC lighting system and connection point for operation when remote source is available.
2. DC lighting system for operation when remote source and generator are both unavailable.

M. Convenience Outlets: Factory-wired, GFCI. Arrange for external electrical connection.

2.10 VIBRATION ISOLATION DEVICES

A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

1. Material: **Standard neoprene** separated by steel shims.

B. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.

2.11 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.12 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine generator using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.

B. Project-Specific Equipment Tests: Before shipment, factory test engine generator and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:

1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
2. Test generator, exciter, and voltage regulator as a unit.
3. Full-load run.
4. Maximum power.
5. Voltage regulation.
6. Transient and steady-state governing.
7. Single-step load pickup.
8. Safety shutdown.
9. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
10. Report factory test results within 10 days of completion of test.

PART 3 - EXECUTION - THIS IS SITE SPECIFIC

3.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine generator performance.

B. Examine roughing-in for piping systems and electrical connections to verify actual locations of connections before packaged engine generator installation.

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

3.2 PREPARATION

A. 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 **Construction Manager** and **Owner** no fewer than five working days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without **Construction Manager's** and **Owner's** written permission.

3.3 INSTALLATION

A. Comply with NECA 1 and NECA 404.

B. Comply with packaged engine generator manufacturers' written installation and alignment instructions and with NFPA 110.

C. Equipment Mounting:

1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in project plans.
2. Coordinate size and location of concrete bases for packaged engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

D. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

E. Cooling System: Pre-piped as part of packaged engine generator system.

F. Exhaust System: Pre-piped as part of packaged engine generator system.

G. Drain Piping: Pre-piped as part of packaged engine generator system.

H. Gaseous Fuel Piping:

1. Natural gas piping, valves, and specialties for gas distribution are to be provided for the pipe size and gas volume requqired.
2. LP gas piping, valves, and specialties for gas piping are to be provided for the pipe size and gas volume required.

I. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.

B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.

C. Connect cooling-system water piping to engine generator and **radiator** with flexible connectors.

D. Connect engine exhaust pipe to engine with flexible connector.

E. Gaseous Fuel Connections:

1. Connect fuel piping to engines with a gate valve and union and flexible connector.
2. Install manual shutoff valve in a remote location to isolate gaseous fuel supply to the generator.
3. Vent gas pressure regulators outside enclosure a minimum of 60 inches (1500 mm) from any building openings.

F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Provide a minimum of one 90-degree bend in flexible conduit routed to the engine generator from a stationary element.

H. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

3.5 IDENTIFICATION

A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."

B. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections **with the assistance of a factory-authorized service representative**.

E. Tests and Inspections:

1. Perform tests recommended by manufacturer and each visual and mechanical inspection and electrical and mechanical test listed in first two subparagraphs below, as specified in NETA ATS. Certify compliance with test parameters.

    a. Visual and Mechanical Inspection:

        1) Compare equipment nameplate data with Drawings and the Specifications.
        2) Inspect physical and mechanical condition.
        3) Inspect anchorage, alignment, and grounding.
        4) Verify that the unit is clean.

    b. Electrical and Mechanical Tests:

        1) Perform insulation-resistance tests according to IEEE 43.

            a) Machines Larger Than 200 hp (150 kW): Test duration shall be 10 minutes. Calculate polarization index.
            b) Machines 200 hp (150 kW) or Less: Test duration shall be one minute. Calculate the dielectric-absorption ratio.

        2) Test protective relay devices.
        3) Verify phase rotation, phasing, and synchronized operation as required by the application.
        4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
        5) Perform vibration test for each main bearing cap.
        6) Conduct performance test according to NFPA 110.
        7) Verify correct functioning of the governor and regulator.

2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.

    a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
    b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
    c. Verify acceptance of charge for each element of the battery after discharge.
    d. Verify that measurements are within manufacturer's specifications.

4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.

6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg (120 kPa). Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
7. Exhaust Emissions Test: Comply with applicable government test criteria.
8. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
9. Harmonic-Content Tests: Measure harmonic content of output voltage at 25 and 100 percent of rated linear load. Verify that harmonic content is within specified limits.
10. Noise Level Tests: Measure A-weighted level of noise emanating from engine generator installation, including engine exhaust and cooling-air intake and discharge, at **four** locations **25 feet (8 m) from edge of the generator enclosure**, and compare measured levels with required values.

F. Coordinate tests with tests for transfer switches and run them concurrently.

G. Test instruments shall have been calibrated within the past 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.

H. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.

I. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.

J. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

K. Remove and replace malfunctioning units and [**retest**] [**reinspect**] as specified above.

L. Retest: Correct deficiencies identified by tests and observations, and retest until specified requirements are met.

M. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

N. Infrared Scanning: After Substantial Completion, but not more than 60 days after final acceptance, perform an infrared scan of each power wiring termination and each bus connection while running with maximum load. Remove all access panels, so terminations and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 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 terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.7 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include **12** months' full maintenance by skilled employees of manufacturer's authorized service representative. Include quarterly preventive maintenance and exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Parts shall be manufacturer's authorized replacement parts and supplies.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

END OF SECTION 263213.16

SECTION 263373 - BATTERY ENERGY STORAGE SYSTEM (BESS)

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Battery energy storage system (BESS).

1.02 RELATED REQUIREMENTS

A. Section 262713.16 - Power Quality Meters

Section 263713 - Low-Voltage Microgrid Energy Management System

1.03 ABBREVIATIONS AND ACRONYMS

A. BESS: Battery energy storage system.
B. BMS: Battery management system.
C. HVAC: Heating, ventilation, and air conditioning.
D. IEC: International Electrotechnical Commission.
E. IEEE: Institute of Electrical and Electronics Engineers.
F. kWh: Kilowatt hour.
G. kW: Kilowatt.
H. LFP: Lithium ferrophosphate/lithium-ion iron phosphate.
I. NEC: National Electrical Code.
J. PCS: Power conversion system.
K. SOC: State of charge.
L. UL: Underwriters Laboratories.

1.04 DEFINITIONS

A. C Rate: Power/energy capacity.

1.05 REFERENCE STANDARDS

A. ASCE 7 - Minimum Design Loads and Associated Criteria for Buildings and Other Structures; Most Recent Edition Cited by Referring Code or Reference Standard.
B. ICC (IBC) - International Building Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
C. IEC 61800-3 - Adjustable Speed Electrical Power Drive Systems - Part3: EMC Requirements and Specific Test Methods for PDS and Machine Tools; 2022.
D. IEEE 693 - Recommended Practice for Seismic Design of Substations; 2018.
E. ISO 9001 - Quality Management Systems — Requirements; 2015, with Amendment (2024).
F. ISO 12944-5 - Paints and Varnishes – Corrosion Protection of Steel Structures by Protective Paint Systems – Part 5: Protective Paint Systems; 2019.

G. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2020.

H. NFPA 69 - Standard on Explosion Prevention Systems; 2024.

I. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

J. NFPA 855 - Standard for the Installation of Stationary Energy Storage Systems; 2023.

K. UL 1642 - Lithium Batteries; Current Edition, Including All Revisions.

L. UL 1741 - Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources; Current Edition, Including All Revisions.

M. UL 1973 - Batteries for Use in Stationary and Motive Auxiliary Power Applications; Current Edition, Including All Revisions.

N. UL 9540 - Energy Storage Systems and Equipment; Current Edition, Including All Revisions.

O. UL 9540A - Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems; Current Edition, Including All Revisions.

1.06 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation Meeting: Review material selections and installation procedures with manufacturer's representative and affected installers.

B. Scheduling: Do not schedule functional demonstration testing until operational readiness testing is complete and associated report and certification have been submitted.

1.07 SUBMITTALS

A. Provide sufficient information to determine compliance with Contract Documents. Identify submittal data with specific equipment tags and/or service descriptions to which they pertain. Identify specific model numbers, options, and features of equipment proposed.

B. Indicate deviations from Contract Documents with reference to corresponding drawing or specification number and written justification for deviation.

C. Product Data: Provide manufacturer's standard catalog pages and data sheets, including physical data, electrical performance, electrical characteristics, and connection requirements.

D. Shop Drawings: Indicate enclosure dimensions, shipping section dimensions, weights, foundation requirements, required clearances, location and size of each field connection, and mounting and installation instructions.
   1. Structural calculations.
   2. Inspection and test plan.

E. Operational Readiness Report:
   1. Document test results, including assumptions, conditions, allowances, and corrections made.
   2. Provide listing of field modifications and adjustments made including settings/parameters not identified as factory defaults within equipment’s operations and maintenance manual documentation.
   3. Include certification, signed by Contractor and manufacturer's representative, that equipment and associated system have been installed, configured, and tested in accordance with manufacturer’s recommendations, conforms to requirements of Contract Documents, and is ready for operation.

F. Functional Demonstration Testing Report: Document test results, including assumptions, conditions, allowances, and corrections made.

G. Manufacturer's qualification statement.

H. Operation and Maintenance Data:
   1. Provide detailed information on system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.
      a. Include contact information for parts stocking location closest to Owner.
      b. Identify critical spare parts associated with long lead times and/or those critical to unit operation.
      c. Identify maintenance spare parts required to regularly perform scheduled equipment maintenance including, but not limited to, consumable parts required to be exchanged during scheduled maintenance periods.

I. Project Record Documents:
   1. Construction, installation, schematic, and wiring diagrams updated to as-installed and commissioned state.
   2. Configured settings/parameters for adjustable components updated to as-installed and commissioned state, noted if different from factory default.

J. Specimen Warranty: Statement of standard warranty and extended warranty options/costs.

K. Executed warranty.

L. Maintenance Materials: Furnish the following for Owner's use in maintenance of project:
   1. Spare Parts: For each type and size of unit installed.
      a. Provide minimum spare parts recommended by manufacturer.
      b. Fuses: **One set**] of each type of power and control fuse installed within equipment.
      c. Package and mark spare parts for long-term storage. Provide separate anti-static containers for printed circuit boards.
   2. Tools: Manufacturer-specific special tools required to install, remove, test, and maintain equipment components.
      a. Equipment Configuration Software: PC-based or smart mobile device application; provide **one** of each different communication interface cable required to connect computer/device for configuration and programming.
      b. Electronic Configuration Files: For future upload into replaced/repaired components, in media format acceptable by Owner.

1.08 QUALITY ASSURANCE

A. Comply with the following:
   1. NFPA 70.
   2. NFPA 855.
   3. Requirements of local authorities having jurisdiction.
   4. Applicable local codes.

B. Manufacturer Qualifications:
   1. Certified in accordance with ISO 9001 with applicable quality assurance system regularly reviewed and audited by third-party registrar. Develop and control manufacturing, inspection, and testing procedures under guidelines of quality assurance system.
   2. Service, repair, and technical support services available 24 hours per day, 7 days per week from manufacturer or their representative.

C. Product Listing Organization Qualifications: Organization recognized by OSHA as Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.09 DELIVERY, STORAGE, AND HANDLING

A. Prior to delivery to project site, verify suitable storage space is available to store materials in well-ventilated area protected from weather, moisture, soiling, extreme temperatures, humidity, and corrosive atmospheres.

B. Protect materials during delivery and storage and maintain within manufacturer's written storage requirements. At minimum, store indoors in clean, dry space with uniform temperature to prevent condensation and protect electronics from potential damage from electrical and magnetic energy.

C. Deliver materials to project site in supplier's or manufacturer's original wrappings and containers, labeled with supplier's or manufacturer's name, material or product brand name, and equipment tag number or service name as identified in Contract Documents.

D. Inspect products and report concealed damage or violation of delivery, storage, and handling requirements to Owner.

E. Provide crane for handling of up to 20 ft BESS or as required.

F. Energize/charge BESS within 2 weeks after delivery to project site.

1.10 FIELD CONDITIONS

A. Maintain field conditions within manufacturer's required service conditions during and after installation.

1.11 WARRANTY

A. Manufacturer Warranty:
   1. Provide manufacturer warranty for defects in material and workmanship for 3 years, including performance guarantee, labor, and parts. Complete forms in Owner's name and register with manufacturer.
   2. Offer warranty extension for coverage through year 4 for customers that enable remote support.
   3. Offer warranty extension for coverage through year 10 for additional cost.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. See approved list of manufacturers.

2.02 BATTERY ENERGY STORAGE SYSTEMS (BESS)

A. BESS sizing based on project requirements for TBPP size being installed. See project plans.

B. BESS Ratings/Configurations: As indicated on drawings.

C. Provide battery energy storage system (BESS) units factory assembled in non-walk-in, outdoor-rated only enclosure including but not limited to power conversion system (PCS), lithium-ion iron phosphate/lithium ferrophosphate (LFP) batteries, output isolation transformer, factory-installed local BESS controller for communication with microgrid controls, UPS for control backup, HVAC system, fire alarm system, gas detection and ventilation system, and factory-installed internal electrical connections.

D. Listed as complying with UL 9540.

E. Seismic Qualification:
   1. Provide independent third-party analysis and certification in accordance with ICC (IBC)/ASCE 7 and IEEE 693, using importance factor of 1.0.

F. Fire Safety:
   1. UL 9540 certification, which includes UL 9540A large fire battery open rack tests.
   2. Dry pipe sprinkler system, requiring first responder water connection.
   3. Heat, smoke, and gas sensors.
   4. Active ventilation explosion prevention system complying with NFPA 69.

G. Electromagnetic Compatibility: IEC 61800-3.

H. Operation Temperature Range: From minus 4 to 122 degrees F (minus 20 to 50 degrees C).

I. HVAC:
   1. Factory-installed packaged HVAC unit, wall mounted, with integral thermostat and disconnect.
   2. Capacity: Maintain enclosure interior temperature to battery manufacturer requirements with outside design temperature of minus 4 degrees F (minus 20 degrees C) or 122 degrees F (50 degrees C).

J. Total Harmonic Distortion:
   1. Output Current THD (I): 2 percent, maximum.
   2. Output Voltage THD (V): 3 percent, maximum.

K. Power Conversion System:
   1. Rated Power:
      a. 7 ft BESS: 60 kW and 90 kW models available.
      b. 20 ft BESS: 250 kW, 375 kW, and 500 kW models available.
   2. AC Output Voltage:
      a. 7 ft BESS: 480 VAC (plus/minus 10 percent), 3 phase, 4 wire.
      b. 20 ft BESS: 400 VAC (plus/minus 10 percent), 3 phase, 4 wire.
   3. Grid Frequency: 60 Hz, plus/minus 2.5 Hz.
   4. DC Bus Voltage Range:
      a. 7 ft BESS: 350-750 VDC.
      b. 20 ft BESS: 600-900 VDC.
   5. Control: Droop, virtual synchronous generation, isochronous.
   6. Overload Capability:
      a. 7 ft BESS: 100-110 percent unlimited; 110-120 percent for 10 minutes; 120-150 percent for 200 milliseconds.
      b. 20 ft BESS: 105-115 percent for 10 minutes; 115-125 percent for 1 minute; 125-150 percent for 200 milliseconds.
   7. Current Imbalance: 100 percent.
   8. Certifications:
      a. UL 1741, UL 1741 SA, UL 1741 SB, and UL 1741 CRD.
      b. California Energy Commission PCS/BESS listed.
   9. Four-Quadrant Inverters: Capable of grid-tie and grid-forming operation.

L. Batteries:
   1. Chemistry: Lithium-ion iron phosphate/lithium ferrophosphate (LFP).
   2. Nominal Capacity:
      a. Cell: 100 Ah.
      b. Battery Module: 400 Ah.
   3. Nominal Energy:
      a. Cell: 0.32 kWh.
      b. Battery Module: 20.5 kWh.
   4. Voltage Range:

a. Cell: 2.8-3.6 V.
b. Battery Module: 44.8-57.6 V.

5. Optimize capacity, energy, and voltage range for racks for configuration.
6. C-Rate: 0.5C.
7. Rated Life: 6,000 cycles, 15-20 years; dependent on application and temperature.
8. Certifications:
   a. UL 1642.
   b. UL 1973.
   c. UL 9540A.
   d. United Nations Manual of Tests and Criteria, Section 38.3 (UN 38.3).

M. Power Quality Meters (20 ft BESS Only):

N. Communications:
1. Protocol: Modbus TCP.
2. Ethernet Port: Copper RJ45, maximum 328 feet (100 m).
3. Data logging.

O. Enclosure – Size depends on project requirements:
1. Environmental Rating: NEMA 250, Type 3R.
2. Corrosion Resistance: ISO 12944-5, Class C3.
3. Dimensions:
   a. Wall mount BESS: 4 ft tall by 2.5 ft wide by 12 in deep
   b. 7 ft BESS: 6.9 feet (2.1 m) long by 4.2 feet (1.3 m) deep by 7.7 feet (2.4 m) high.
   c. 20 ft BESS: 19,.9 feet (6.1 m) long by 8 feet (2.4 m) deep by 9,5 feet (2.9 m) high.
4. Weight (Battery Loaded):
   a. 7 ft BESS: Up to 4.96 tons (4.5 mt), depending on configuration.
   b. 20 ft BESS: Up to 26.08 tons (23.7 mt), depending on configuration.

2.03 SOURCE QUALITY CONTROL

A. Perform factory functional testing and first parameter adjusting.

B. Identify BESS with label indicating inspection/testing agency and date of service.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine equipment exterior and interior for damage, including but not limited to, structure, moisture, and mildew.

B. Examine for conditions detrimental to completion of work.

3.02 INSTALLATION

A. Install equipment in accordance with manufacturer's written instructions.

3.03 FIELD QUALITY CONTROL

A. Manufacturer Services: Provide services of manufacturer's field representative to perform functional testing, commissioning, and first parameter adjusting.
   1. Include necessary material, equipment, labor, and technical supervision.
   2. Replace damaged or malfunctioning equipment and report discrepancies or installation issues.
   3. Identify BESS with label indicating inspection/testing agency and date of service.

B. Operational Readiness Testing:
   1. Inspect and test equipment and associated systems for conformance to Contract Documents, including equipment manufacturer's recommendations, and readiness for operation.
      a. Visually inspect for physical damage and proper installation.
      b. Perform tests in accordance with manufacturer's instructions.
      c. Perform tests to verify compliance with Contract Documents.
      d. Perform tests to verify equipment is ready for operation.
      e. Touch-up paint chips and scratches with manufacturer-supplied paint.

3.04 CLOSEOUT ACTIVITIES

A. Functional Demonstration Testing: Demonstrate proper operation of equipment and associated systems to Owner's designated representative, observing and documenting compliance with Contract Documents.

B. Training:
   1. Train Owner's personnel on operation and maintenance of system.
      a. Accommodate minimum of **four** attendees.
      b. Provide not less than **one** session with **four hours** of classroom and hands-on training.
      c. Training Reference: **Use submitted operations and maintenance manuals**.
      d. Instructor: Factory-trained manufacturer's representative.
      e. Location: Project site.
   2. Provide sufficient time and detail in each session to cover the following at minimum:
      a. Operation theory.
      b. Major equipment components.
      c. Equipment operation.
      d. Equipment configurations.
      e. Maintenance, troubleshooting, and repair.
      f. Component-level parts replacement.

3.05 MAINTENANCE

A. Service Plan: Provide separate maintenance contract to Owner**, as proposal in addition to base bid,** for service and maintenance of BESS for **two years** from date of Substantial Completion.
   1. Annual Preventative Maintenance Visit: Perform inspection of equipment and environment and submit report documenting results with recommendations.

3.06 PROTECTION

A. Protect installed equipment from subsequent construction operations.

END OF SECTION 263373

SECTION 263600 - TRANSFER SWITCHES

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.

1.2 SUMMARY

A. Section includes **automatic** transfer switches rated 600 V and less.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for transfer switches.
2. Include rated capacities, operating characteristics, electrical characteristics, and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, details showing minimum clearances, conductor entry provisions, gutter space, and installed features and devices.
2. Include material lists for each switch specified.
3. Single-Line Diagram: Show connections between transfer switch, power sources, and load.
4. Riser Diagram: Show interconnection wiring between transfer switches, annunciators, and control panels.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For **manufacturer-authorized service representative**.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Features and operating sequences, both automatic and manual.
b. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications:

1. Member company of NETA.

a. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.7 FIELD CONDITIONS

A. 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:

1. Notify **Construction Manager and Owner**] no fewer than five days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without **Construction Manager's and Owner's** written permission.

1.8 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of transfer switch or transfer switch components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: **Two years** from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NEMA ICS 1.

C. Comply with NFPA 99.

D. Comply with NFPA 110.

E. Comply with UL 1008 unless requirements of these Specifications are stricter.

F. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.

G. Tested Fault-Current Closing and Short-Circuit Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.

1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.
2. Short-time withstand capability for **three** cycles.

H. Repetitive Accuracy of Solid-State Controls: All settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

I. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.62. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

J. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism. Switches for emergency or standby purposes shall be mechanically and electrically interlocked in both directions to prevent simultaneous connection to both power sources unless closed transition.

K. Service-Rated Transfer Switch:

1. Comply with UL 869A and UL 489.
2. Provide terminals for bonding the grounding electrode conductor to the grounded service conductor.
3. In systems with a neutral, the bonding connection shall be on the neutral bus.
4. Provide removable link for temporary separation of the service and load grounded conductors.
5. Surge Protective Device: Service rated.
6. Ground-Fault Protection: Comply with UL 1008 for **normal bus**.

L. Neutral Switching: Where four-pole switches are indicated, provide **neutral pole switched simultaneously with phase poles**.

M. Neutral Terminal: Solid and fully rated unless otherwise indicated.

N. Heater: Equip switches exposed to outdoor temperatures and humidity, and other units indicated, with an internal heater. Provide thermostat within enclosure to control heater.

O. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.

P. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, by color-code or by numbered or lettered wire and cable **shrinkable sleeve** markers at terminations.

Color-coding and wire and cable markers are specified in Section 260553 "Identification for Electrical Systems."

1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
4. Accessible via **front** access.

Q. Enclosures: General-purpose NEMA 250, **Type 3R** complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.2 CONTACTOR-TYPE AUTOMATIC TRANSFER SWITCHES

A. Comply with Level 1 equipment according to NFPA 110.

B. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are unacceptable.
2. Switch Action: Double throw; mechanically held in both directions.
3. Contacts: Silver composition or silver alloy for load-current switching. Contactor-style automatic transfer-switch units, rated 600 A and higher, shall have separate arcing contacts.
4. Conductor Connectors: Suitable for use with conductor material and sizes.
5. Material: **Hard-drawn copper, 98 percent conductivity**.
6. Main and Neutral Lugs: **Mechanical** type.
7. Ground Lugs and Bus-Configured Terminators: **Mechanical** type.
8. Ground bar.
9. Connectors shall be marked for conductor size and type according to UL 1008.

C. Automatic Open-Transition Transfer Switches: Interlocked to prevent the load from being closed on both sources at the same time.

1. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.

D. Automatic Closed-Transition Transfer Switches: Connect both sources to load momentarily. Transition is controlled by programming in the automatic transfer-switch controller.

1. Fully automatic make-before-break operation when transferring between two available power sources.
2. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.
3. Initiation of No-Interruption Transfer: Controlled by in-phase monitor and sensors confirming both sources are present and acceptable.

    a. Initiation occurs without active control of generator.
    b. Automatic transfer-switch controller takes active control of generator to match frequency, phase angle, and voltage.

c. Controls ensure that closed-transition load transfer closure occurs only when the two sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.

4. Failure of power source serving load initiates automatic break-before-make transfer.

E. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.

F. Manual Switch Operation: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.

G. Electric Switch Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternative Source." Switch shall be capable of transferring load in either direction with either or both sources energized.

H. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval shall be adjustable from 1 to 30 seconds.

I. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

J. Automatic Transfer-Switch Controller Features:

1. Controller operates through a period of loss of control power.
2. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage shall be adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
4. Time Delay for Retransfer to Normal Source: Adjustable from zero to 30 minutes, and factory set for 10 minutes. Override shall automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.

    a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
    b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.

9. Transfer Override Switch: Overrides automatic retransfer control so transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
12. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
13. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods shall be adjustable from 10 to 30 minutes. Factory settings shall be for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:

    a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
    b. Push-button programming control with digital display of settings.
    c. Integral battery operation of time switch when normal control power is unavailable.

2.3 TRANSFER SWITCH ACESSORIES

A. Bypass/Isolation Switches:

1. Source Limitations: Same manufacturer as transfer switch in which installed.
2. Comply with requirements for Level 1 equipment according to NFPA 110.
3. Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Include the following features for each combined automatic transfer switch and bypass/isolation switch:
    a. Provide means to make power available to transfer-switch control circuit for testing and maintenance purposes.
    b. Transition: Provide **open**-transition operation when transferring between power sources.
    c. Legend: Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.
    d. Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors.

B. Remote Annunciator System:

1. Source Limitations: Same manufacturer as transfer switch in which installed.
2. Functional Description: Remote annunciator panel shall annunciate conditions for indicated transfer switches.
3. Annunciation panel display shall include the following indicators:

    a. Sources available, as defined by actual pickup and dropout settings of transfer-switch controls.

b. Switch position.
c. Switch in test mode.
d. Failure of communication link.

4. Annunciator Panel: LED-lamp type with audible signal and silencing switch.

a. Indicating Lights: Grouped for each transfer switch monitored.
b. Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.
c. Mounting: Flush, modular, steel cabinet unless otherwise indicated.
d. Lamp Test: Push-to-test or lamp-test switch on front panel.

2.4 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect components, assembled switches, and associated equipment according to UL 1008. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

B. Prepare test and inspection reports.

1. For each of the tests required by UL 1008, performed on representative devices, for **emergency** systems. Include results of test for the following conditions:

a. Overvoltage.
b. Undervoltage.
c. Loss of supply voltage.
d. Reduction of supply voltage.
e. Alternative supply voltage or frequency is at minimum acceptable values.
f. Temperature rise.
g. Dielectric voltage-withstand; before and after short-circuit test.
h. Overload.
i. Contact opening.
j. Endurance.
k. Short circuit.
l. Short-time current capability.
m. Receptacle withstand capability.
n. Insulating base and supports damage.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Floor-Mounting Switch: Anchor to floor by bolting.

1. Install transfer switches on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified on the project plans.
2. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.

3. Provide workspace and clearances required by NFPA 70.

B. Annunciator and Control Panel Mounting: Surface mounted on wall unless otherwise indicated.

C. Identify components according to Section 260553 "Identification for Electrical Systems."

D. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

E. Comply with NECA 1.

3.2 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to generator sets, control, and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

B. Wiring Method: Install cables in raceways and cable trays except within electrical enclosures. Conceal raceway and cables except in unfinished spaces.

1. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

F. Connect twisted pair cable according to Section 260523 "Control-Voltage Electrical Power Cables."

G. Connect twisted pair cable according to Section 271513 "Communications Copper Horizontal Cabling."

H. Route and brace conductors according to manufacturer's written instructions**.** Do not obscure manufacturer's markings and labels.

I. Brace and support equipment according to Section 260548.16 "Seismic Controls for Electrical Systems."

J. Final connections to equipment shall be made with liquidtight, flexible metallic conduit no more than 18 inches (457 mm) in length.

3.3 FIELD QUALITY CONTROL

A. Testing Agency: **Owner will engage** a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections **with the assistance of a factory-authorized service representative**:

1. After installing equipment, test for compliance with requirements according to NETA ATS.
2. Visual and Mechanical Inspection:

    a. Compare equipment nameplate data with Drawings and Specifications.
    b. Inspect physical and mechanical condition.
    c. Inspect anchorage, alignment, grounding, and required clearances.
    d. Verify that the unit is clean.
    e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
    f. Verify that manual transfer warnings are attached and visible.
    g. Verify tightness of all control connections.
    h. Inspect bolted electrical connections for high resistance using one of the following methods, or both:

        1) Use of low-resistance ohmmeter.
        2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data.

    i. Perform manual transfer operation.
    j. Verify positive mechanical interlocking between normal and alternate sources.
    k. Perform visual and mechanical inspection of surge arresters.
    l. Inspect control power transformers.

        1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
        2) Verify that primary and secondary fuse or circuit-breaker ratings match Drawings.
        3) Verify correct functioning of drawout disconnecting contacts, grounding contacts, and interlocks.

3. Electrical Tests:

    a. Perform insulation-resistance tests on all control wiring with respect to ground.
    b. Perform a contact/pole-resistance test. Compare measured values with manufacturer's acceptable values.
    c. Verify settings and operation of control devices.
    d. Calibrate and set all relays and timers.
    e. Verify phase rotation, phasing, and synchronized operation.
    f. Perform automatic transfer tests.
    g. Verify correct operation and timing of the following functions:

        1) Normal source voltage-sensing and frequency-sensing relays.
        2) Engine start sequence.

3) Time delay on transfer.
4) Alternative source voltage-sensing and frequency-sensing relays.
5) Automatic transfer operation.
6) Interlocks and limit switch function.
7) Time delay and retransfer on normal power restoration.
8) Engine cool-down and shutdown feature.

4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.

   a. Check for electrical continuity of circuits and for short circuits.
   b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
   c. Verify that manual transfer warnings are properly placed.
   d. Perform manual transfer operation.

5. After energizing circuits, perform each electrical test for transfer switches stated in NETA ATS and demonstrate interlocking sequence and operational function for each switch at least three times.

   a. Simulate power failures of normal source to automatic transfer switches and retransfer from emergency source with normal source available.
   b. Simulate loss of phase-to-ground voltage for each phase of normal source.
   c. Verify time-delay settings.
   d. Verify pickup and dropout voltages by data readout or inspection of control settings.
   e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
   f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for one pole deviating by more than 50 percent from other poles.
   g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

6. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.

   a. Verify grounding connections and locations and ratings of sensors.

D. Coordinate tests with tests of generator and run them concurrently.

E. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

F. Transfer switches will be considered defective if they do not pass tests and inspections.

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

H. Prepare test and inspection reports.

I. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

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

3.4 DEMONSTRATION

A. **Engage a factory-authorized service representative to train** Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment.

B. Training shall include testing ground-fault protective devices and instructions to determine when the ground-fault system shall be retested. Include instructions on where ground-fault sensors are located and how to avoid negating the ground-fault protection scheme during testing and circuit modifications.

C. Coordinate this training with that for generator equipment.

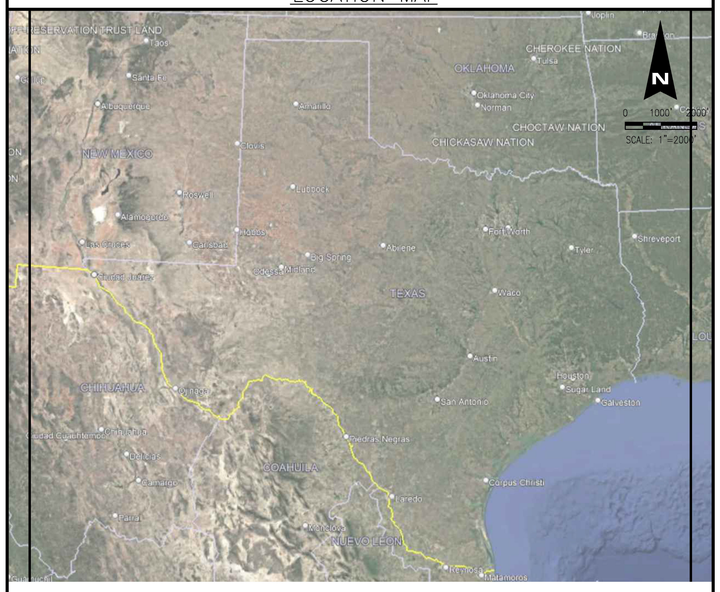
END OF SECTION 263600

PUBLIC UTILITY COMMISSION OF TEXAS
TEXAS BACKUP POWER PACKAGES
FOR CRITICAL FACILITIES
10kW

INDEX OF DRAWINGS

SHEET No.	TITLE	REV NO.	DATE
T0.01	TITLE SHEET	0	01/21/2025
E1.01	LEGENDS AND ABBREVIATIONS	0	01/21/2025
E1.02	GENERAL SPECIFICATIONS	0	01/21/2025
E2.01	ONE LINE DIAGRAM	0	01/21/2025
E3.01	10KW TBPP LAYOUT	0	01/21/2025
E4.01	ELECTRICAL SIGNAGE DETAILS	0	01/21/2025

LOCATION MAP



LOCATED IN THE STATE OF TEXAS

NOTIFICATIONS

Texas 811 Know what's below. Call before you dig.

SUMMARY

TEXAS BACKUP POWER PACKAGES (TBPP) ARE TO BE DEVELOPED IN ACCORDANCE WITH PLANS HEREIN. THEY ARE TO BE USED IN ISLAND MODE ONLY TO PROVIDE BACKUP POWER TO CRITICAL FACILITIES IN THE EVENT OF AN ELECTRICAL POWER OUTAGE. THE TBPPs ARE TO BE SUITABLE FOR INSTALLATION THROUGHOUT THE STATE OF TEXAS. THE PLANS HEREIN ARE FOR THE DEVELOPMENT OF THE TBPPS AND ARE NOT SPECIFIC TO ANY PARTICULAR SITE OR LOCATION WITHIN THE STATE OF TEXAS.

FOR ELECTRICAL ONLY

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Patrick Engineering Inc.
55 East Monroe
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Chicago, IL 60603
TEL: (312) 201-7900
FAX: (312) 220-0722
www.rina-us.org
PROFESSIONAL DESIGN FIRM
LICENSE NO. 184000409-0014

Owner/Client:

Scale: 1"=2000'

Sheet Size: ARCH D 24"x36"

Designed:	AMH
Drawn:	LAB
Checked:	DJS
Approved:	DJS

Rev. No.	Date	Description
A	01/21/2025	ORIGINAL ISSUE

ISSUES & REVISIONS

THE INFORMATION CONTAINED ON THESE DRAWINGS IS FOR USE ON THIS PROJECT ONLY

STATE OF TEXAS
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LICENSED PROFESSIONAL ENGINEER

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Project: TEXAS BACKUP POWER PACKAGE
PUBLIC UTILITY COMMISSION OF TEXAS

Sheet Title: COVER SHEET

Date: 01/21/2025 Proj. No: 22483.005

PROJECT PHASE

XXXX

Sheet No: T0.01

Sheet of

Revision No.: 0

FILE NAME: P:\Jobs\Public Utility Commission of Texas (PUCT)\22483.005 Backup Power Package Design\11_Drawings\11.3_Electrical\10kW\01.01 Electrical Cover Sheet.dwg LAYOUT NAME: T0.01 PLOTTED: Tuesday, January 21, 2025 - 11:18am USER: AHS04

FIRE ALARM SYMBOLS

SYMBOL		DESCRIPTION
WALL	CEILING	
		KNOX BOX
GAP		GENERATOR REMOTE ANNUNCIATOR PANEL
FAAP		FIRE ALARM ANNUNCIATOR PANEL
FACP		FIRE ALARM CONTROL PANEL

ELECTRICAL LIGHTING SYMBOLS

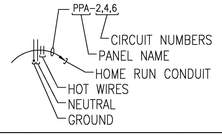
SYMBOL		DESCRIPTION
WALL	CEILING	
		DOWN LIGHT OR WALL WASH LIGHTING FIXTURE
		FLUORESCENT LIGHTING FIXTURE
EM	EM	EMERGENCY FLUORESCENT LIGHTING FIXTURE
NL	NL	NIGHT LIGHTING FLUORESCENT FIXTURE
EM	EM	DOWN LIGHT OR WALL WASH LIGHTING FIXTURE CONNECTED TO EMERGENCY LIGHTING SYSTEM
		BATTERY EMERGENCY LIGHTING UNIT, TWO-WAY THROW, UL APPROVED. WALL MOUNTED 1'-0" BELOW CEILING OR MAX OF 8'-0" AFF. CEILING MOUNTED-RECESSED IN CEILING
		BATTERY EMERGENCY LIGHTING UNIT, TWO-WAY THROW, UL APPROVED. WALL MOUNTED 1'-0" BELOW CEILING OR MAX OF 8'-0" AFF. SINGLE HEAD EXTENDED THROUGH WALL.
		BATTERY EMERGENCY LIGHTING UNIT, SINGLE HEAD ONE-WAY THROW
		EXIT SIGN (TYPE AS NOTED ON EXIT SIGN LEGEND)
S_{OS}	OS	OCCUPANCY SENSOR
TC		TIME CLOCK
S_b		SINGLE POLE TOGGLE SWITCH +42" AFF, LOWERCASE LETTER DENOTES LIGHTING CONTROL
S_{3W}		3-WAY TOGGLE SWITCH +42" AFF
S_{4W}		4-WAY TOGGLE SWITCH +42" AFF
S_M		MOMENTARY CONTACT SWITCH +42" AFF
S_K		KEY OPERATED SINGLE POLE TOGGLE SWITCH
S_D		DIMMER SWITCH +42" AFF
S_P		TOGGLE SWITCH W/ PILOT NEON LIGHT +42" AFF

NOTE:
1. THIS IS A COMPOSITE LIST AND ALL SYMBOLS MAY NOT BE USED ON THIS PROJECT.
2. SEE LIGHTING FIXTURE SCHEDULE FOR LIGHTING FIXTURE TYPE DESCRIPTIONS AND PLANS FOR FIXTURE TYPE TAGS.

ELECTRICAL POWER SYMBOLS

SYMBOL			DESCRIPTION
FLOOR	WALL	CEILING	
			SIMPLEX CONVENIENCE OUTLET +18" AFF (UNLESS NOTED OTHERWISE)
	WP		DUPLEX CONVENIENCE OUTLET, WEATHERPROOF
			JUNCTION BOX - SIZE AS REQUIRED - MINIMUM 4" SQUARE
	PB	PB	PULL BOX - SIZE AS REQUIRED
M	M	M	MOTOR OUTLET, HORSEPOWER AS NOTED
			DISCONNECT SWITCH - HORSEPOWER RATED, FUSED OR UNFUSED, AS REQUIRED OR NOTED. WP DENOTES WEATHERPROOF TYPE
	ATS		AUTOMATIC TRANSFER SWITCH
			UTILITY METER
			DISTRIBUTION PANEL: 208V: PROVIDE 36" FRONT CLEARANCE 480V: PROVIDE 42" FRONT CLEARANCE
			NEW PANELBOARD-SURFACE MOUNTED 208V: PROVIDE 36" FRONT CLEARANCE 480V: PROVIDE 42" FRONT CLEARANCE
			NEW PANELBOARD-RECESSED 208V: PROVIDE 36" FRONT CLEARANCE 480V: PROVIDE 42" FRONT CLEARANCE
			EMERGENCY PANEL - EM 208V: PROVIDE 36" FRONT CLEARANCE 480V: PROVIDE 42" FRONT CLEARANCE
	E		EXISTING PANEL 208V: MAINTAIN 36" FRONT CLEARANCE 480V: MAINTAIN 42" FRONT CLEARANCE
	DPM		DIGITAL POWER METERING
	SPD		SURGE PROTECTION DEVICE
			CONCEALED CONDUIT AND WIRE. RUN DASH WIRE DENOTES GROUND CONDUCTOR
			EXPOSED CONDUIT RUN. SUBMIT SHOP DWG FOR PROPOSED ROUTING.
			CONDUIT RUN (UNDERFLOOR OR UNDERGROUND)
			WIREWAY RACEWAY - SURFACE MOUNTED SAFETY SWITCHES AS NOTED ON PLANS
			FLEXIBLE CONDUIT CONNECTION
			CONDUIT ROUTED UP
			CONDUIT ROUTED DOWN
			GROUND PER CODE
	PB		EMERGENCY SHUT DOWN PUSH BUTTON (RED MUSHROOM TYPE)
	T		TRANSFORMER

ELECTRICAL IDENTIFICATIONS



ELECTRICAL RISER DIAGRAM LINETYPES

PROPOSED
EXISTING TO REMAIN ——— EXISTING TO BE REMOVED ———

E	ADJACENT TO DEVICE OR EQUIPMENT, DENOTES EXISTING TO REMAIN
X	ADJACENT TO DEVICE OR EQUIPMENT, DENOTES EXISTING TO BE REMOVED COMPLETELY, INCLUDING ALL CONDUIT AND WIRE. WHERE BOX REMAINS IN EXISTING WALL PROVIDE SUITABLE BLANK COVER.
ER	ADJACENT TO DEVICE OR EQUIPMENT, DENOTES EXISTING TO BE RELOCATED. EXTEND OR ADD WIRING AS SHOWN ON PLAN OR AS REQUIRED.
R	EXISTING DEVICE TO BE REPLACED WITH NEW
N	ADJACENT TO DEVICE OR EQUIPMENT, DENOTES NEW, WIRE SAME AS SHOWN ON PLAN.

ONE-LINE DIAGRAM SYMBOLS

SYMBOL	DESCRIPTION
PANEL NAME / AMPS / VOLTS	POWER DISTRIBUTION PANELBOARD
CONTROL PANEL / VOLTS	CONTROL PANEL
MCC XX / AMPS / VOLTS	MOTOR CONTROL CENTER
	CAPACITOR
	FUSE
	GROUND SYMBOL
	LOW VOLTAGE CIRCUIT BREAKER
	MEDIUM VOLTAGE CIRCUIT BREAKER Fxxx - DENOTES FEEDER BREAKER Uxxx - DENOTES UTILITY BREAKER Txxx - DENOTES TRANSFORMER BREAKER Gxxx - DENOTES GENERATOR BREAKER BTxx - DENOTES BUS TIE BREAKER "XX" DENOTES BUSSES BEING TIED
	NORMALLY OPEN DISCONNECT SWITCH
	NORMALLY OPEN FUSED DISCONNECT
	SEPARABLE DISCONNECTS
	NORMALLY CLOSED CONTACT
	NORMALLY OPEN CONTACT
CC	CLOSE CIRCUIT COIL
TC	TRIP CIRCUIT COIL
	TRANSFORMER WITH DELTA/WYE WIRING CONVENTION
	TRANSFORMER WITH WYE/WYE WIRING CONVENTION
	AC WIRING
M	MOTOR, HORSEPOWER AS NOTED
G	GENERATOR, RATING AS NOTED
	MOTOR STARTER
	RELAY
VFI	MEDIUM VOLTAGE VACUUM FAULT INTERRUPTER
PR	PHASE RELAY
CAP TRIP	CAPACITOR TRIP
	UTILITY POLE
SW	SWITCHGEAR
	TRANSFORMER
M	PRIMARY METER
R	RECLOSER
	SOLAR PANEL
	OPTIMIZER
	INVERTER

NOTE: THIS IS A COMPOSITE LIST AND ALL SYMBOLS MAY NOT BE USED ON THIS PROJECT.

ELECTRICAL ABBREVIATIONS

ABBREV	DESCRIPTION
A	AMPERE
AC	ALTERNATING CURRENT
A/C	AIR CONDITIONING
ACL	ACROSS THE LINE
ACS	AUXILIARY CONTACTS
AF	FUSED AMPS
AFCI	ARC FAULT CIRCUIT INTERRUPTER
AFF	ABOVE FINISHED FLOOR
AHJ	AUTHORITY HAVING JURISDICTION
AHU	AIR HANDLING UNIT
AI	ANALOG INPUT
AIC	AMPERES INTERRUPTING CAPACITY
AL	ALUMINUM
ALM	ALARM
AMP	AMPERE
ANN	ANNUNCIATOR
AO	ANALOG OUTPUT
ARCH	ARCHITECT, ARCHITECTURAL
AS	SWITCH AMPS
AT	AMPS TRIP
ATS	AUTOMATIC TRANSFER SWITCH
AVG	AVERAGE
AWG	AMERICAN WIRE GAUGE
BAL	BALLAST
BAS	BUILDING AUTOMATION SYSTEM
BESS	BATTERY ENERGY STORAGE SYSTEM
BFC	BELOW FINISHED CEILING
BGB	BUILDING GROUND BOX
BHP	BRAKE HORSEPOWER
BMNT	BASEMENT
BPS	BOLTED PRESSURE SWITCH
BR	BRANCH
BRKR	BREAKER
C	CONDUIT
CAB	CABINET
CAP	CAPACITY
CATV	CABLE TELEVISION
CB	CIRCUIT BREAKER
CCT	CIRCUIT
CCTV	CLOSED CIRCUIT TELEVISION
CEC	CHICAGO ELECTRIC CODE
CECO	COMMONWEALTH EDISON COMPANY
CLG	CEILING
CLO	CLOSET
CMB	COMBINER BOX
CO	CARBON MONOXIDE DETECTOR
COAX	COAXIAL
COMED	COMMONWEALTH EDISON COMPANY
CONN	CONNECTION
CONV	CONVENIENCE
CP	CONTROL PANEL
CT	CURRENT TRANSFORMER
CU	COPPER
C.U.	COEFFICIENT OF UTILIZATION
CUH	CABINET UNIT HEATER
DC	DIRECT CURRENT
DGR	DUPLEX GROUNDED RECEPTACLE
DIA	DIAMETER
DISC	DISCONNECT
DIST	DISTRIBUTION
DIV	DIVISION
DN	DOWN
DO	DRAWOUT
DPDT	DOUBLE POLE DOUBLE THROW
DPST	DOUBLE POLE SINGLE THROW
DS	DISCONNECT SWITCH
DT	DUST TIGHT
DWG	DRAWING
E	EXISTING TO REMAIN
EC	ELECTRICAL CONTRACTOR
EF	EXHAUST FAN
ELEC	ELECTRIC
EM	EMERGENCY
EMT	ELECTRIC METALLIC TUBING
EP	EXPLOSION PROOF
EPO	EMERGENCY POWER OFF DEVICE
EQ	EQUAL
EQUIP	EQUIPMENT
ER	EXISTING TO BE RELOCATED
ESS	ENERGY STORAGE SYSTEM
EUH	ELECTRIC UNIT HEATER
EWC	ELECTRIC WATER COOLER
EWH	ELECTRIC WATER HEATER
EX	EXISTING
F	FUSE
F&I	FURNISH AND INSTALL
FA	FIRE ALARM
FAAP	FIRE ALARM ANNUNCIATOR PANEL
FACP	FIRE ALARM CONTROL PANEL
FB	FLOORBOX
FBO	FURNISHED BY OTHERS
FCU	FAN COIL UNIT
FDC	FIRE DEPARTMENT CONNECTION
FDR	FEEDER
FIXT	FIXTURE
FLA	FULL LOAD AMPS
FLR	FLOOR
FLUOR	FLUORESCENT
FPB	FAN POWERED BOX
FPC	FIRE PUMP CONTROLLER
F.S.	FUSED SWITCH
FT	FOOT/FEET
FU	FUSE
FVNR	FULL VOLTAGE, NON REVERSING (MAGNETIC STARTER)
G	GROUND
GEN	GENERATOR
GFI	GROUND FAULT INTERRUPTER
GFP	GROUND FAULT PROTECTION
GHW	GALVANIZED HEAVY STEEL CONDUIT
GND	GROUND
GRD	GROUND
GRS	GALVANIZED RIGID STEEL CONDUIT
H	HEIGHT-MOUNTED ABOVE COUNTER
HOA	HAND-OFF-AUTO
HP	HORSE POWER
HPS	HIGH PRESSURE SODIUM
HR	HOUR
HV	HIGH VOLTAGE
HZ	HERTZ
IC	INTERRUPTING CAPACITY
IG	ISOLATED GROUND
IMC	INTERMEDIATE STEEL CONDUIT
IN	INCH(ES)
INC	INCANDESCENT
INV	INVERTER
JB	JUNCTION BOX
JPC	JOCKEY PUMP CONTROLLER
KCMIL	THOUSAND CIRCULAR MILS WIRE CROSS SECTION AREA
KO	KNOCKOUT
KVA	KILOVOLT-AMPERE
KW	KILOWATT
KWH	KILOWATT-HOUR
LB	POUND
LCP	LIGHTING CONTROL PANEL
LL	LOW LIMIT RELAY
LS	LOUD SPEAKER
LTG	LIGHTING
LV	LOW VOLTAGE
M	MOTOR
MAX	MAXIMUM
MC	MECHANICAL CONTRACTOR
MCB	MAIN CIRCUIT BREAKER
MCC	MOTOR CONTROL CENTER
MCP	MAXIMUM CIRCUIT PROTECTION
MDF	MAIN DISTRIBUTION FRAME
MECH	MECHANICAL
MED	MEDIUM
MERC	MERCURY VAPOR
MFR	MANUFACTURER
MH	MANHOLE
MIN	MINIMUM
MLO	MAIN LUGS ONLY
MOCP	MAXIMUM OVERCURRENT PROTECTION
MSB	MAIN SWITCHBOARD
MTD	MOUNTED
MTR	MOTOR
MV	MULTI-VAPOR
N	NEUTRAL
N/A	NOT APPLICABLE
NC	NORMALLY CLOSED
NEC	NATIONAL ELECTRIC CODE
NEMA	NATIONAL ELECTRICAL MANUFACTURER'S ASSOCIATION
NEUT	NEUTRAL
NF	NON-FUSED
NIC	NOT IN CONTRACT
NL	NIGHT LIGHT
NO	NORMALLY OPEN
NTS	NOT TO SCALE
O/H	OVERHEAD
OL	OVERLOAD
OPT	OPTIMIZER
P	POLE
PA	PUBLIC ADDRESS
PB	PULL BOX
PF	POWER FACTOR
PH	PHASE
PNL	PANEL
PR	PAIR
PRI	PRIMARY
PROT	PROTECTION/PROTECTIVE
PRV	POWER ROOF VENTILATOR
PT	POTENTIAL TRANSFORMER
PWR	POWER
R	RESISTANCE
RC	REMOTE CONTROL
RECP	RECEPTACLE
REQ'D	REQUIRED
RLP	RELAY LIGHTING PANEL
RT	RAINTIGHT
S	SWITCH
SC	SHORT CIRCUIT
SE	SWITCH EMERGENCY
SEC	SECONDARY
SF	SQUARE FOOT/FEET
SGR	SINGLE GROUNDED RECEPTACLE
SP	SINGLE POLE
SPD	SURGE PROTECTIVE DEVICE
SPDT	SINGLE POLE DOUBLE THROW
SPEC	SPECIFICATION
SPKR	SPEAKER
SPO	SPECIAL PURPOSE OUTLET
SPST	SINGLE POLE SINGLE THROW
SQ FT	SQUARE FOOT/FEET
SS	STAINLESS STEEL
STA	STATION
STD	STANDARD
SW	SWITCH
SWBD	SWITCHBOARD
SWGR	SWITCHGEAR
SYM	SYMMETRICAL
SYS	SYSTEM
TBPP	TEXAS BACKUP POWER PACKAGE
TTC	TERMINAL CABINET
TCP	TEMP. CONTROL PANEL
TEL	TELEPHONE
TEL CL	TELEPHONE CLOSET
TEMP	TEMPERATURE
TERM	TERMINAL
TL	TWIST LOCK
TR	TRANSFORMER
TTC	TELEPHONE TERMINAL CABINET
TV	TELEVISION
TX	TRANSFORMER
TYP	TYPICAL
UC	UNDER COUNTER
UE	UNDERGROUND ELECTRICAL
UG	UNDERGROUND
UH	UNIT HEATER
UL	UNDERWRITER'S LABORATORY
UNG	UNGROUNDED
UNO	UNLESS NOTED OTHERWISE
UPS	UNINTERRUPTIBLE POWER SOURCE
V	VOLT
VA	VOLT-AMPERE
VDT	VIDEO DISPLAY TERMINAL
VERT	VERTICAL
VFD	VARIABLE FREQUENCY DRIVE
VIF	VERIFY IN FIELD
VOL	VOLUME
VP	VAPOR PROOF
VT	VAPOR TIGHT
W	WATT
W/	WITH
WP	WEATHERPROOF
WT	WATER TIGHT
XFMR	TRANSFORMER
XR	EXISTING TO BE REMOVED
XRL	EXISTING TO BE RELOCATED
30cd	"30cd" INDICATES VISUAL STROBE LIGHT CANDELA

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Owner/Client

A	01/21/2025	ORIGINAL ISSUE
Rev. No.	Date	Description

ISSUES & REVISIONS

THE INFORMATION CONTAINED ON THESE DRAWINGS IS FOR USE ON THIS PROJECT ONLY

Project:
TEXAS BACKUP POWER PACKAGE
PUBLIC UTILITY COMMISSION OF TEXAS

Sheet Title:
LEGENDS AND ABBREVIATIONS

Date: 01/21/2025 | Proj. No: 22483.005

PROJECT PHASE

XXXX

Sheet No:
E1.01

Sheet of

Revision No.: 0

Scale:

Sheet Size: ARCH D 24"x36"

Designed: AMH
Drawn: LAB
Checked: DJS
Approved: DJS

SPECIFICATIONS

GENERAL NOTES:

THE CONTRACTOR SHALL:

1. PROVIDE ALL LABOR, MATERIALS, EQUIPMENT AND TOOLS REQUIRED FOR THE COMPLETE EXECUTION OF THE ELECTRICAL WORK AS SHOWN ON THE DRAWINGS.
2. PROVIDE ALL ADDITIONAL WORK NOT SPECIFICALLY SHOWN OR SPECIFIED YET REQUIRED TO ENSURE PROPER AND COMPLETE OPERATION OF ALL SYSTEMS, TO SATISFY THE DESIGN INTENT, AND TO COMPLY WITH ALL APPLICABLE CODES AND REGULATIONS.
3. ENSURE ALL LABOR IS PERFORMED BY EXPERIENCED PERSONS OF THE PROPER TRADE. ALL WORKMANSHIP SHALL BE FIRST CLASS, AND SHALL BE IN COMPLIANCE WITH THE SPECIFIC REQUIREMENTS OF THE CONTRACT DRAWINGS, AS WELL AS ALL APPLICABLE SAFETY CODES AND STANDARDS.
4. NOTIFY THE ENGINEER IN WRITING OF ALL DRAWING DISCREPANCIES PRIOR TO SUBMISSION OF BIDS.
5. PERFORM ALL WORK IN ACCORDANCE WITH THE LATEST ADOPTED EDITION OF THE CODES INDICATED ON T1.01, AS WELL AS THE FOLLOWING:
   - ALL LOCAL CODES, ORDINANCES, REGULATIONS;
   - THE AUTHORITY HAVING JURISDICTION.
6. ENSURE ALL MATERIALS PROVIDED ARE NEW, FREE OF DEFECTS, AND ARE UL LISTED FOR THE INTENDED APPLICATION. ALL ELECTRICAL MATERIALS, INSTALLATION AND SYSTEMS SHALL MEET THE REQUIREMENTS OF THE FOLLOWING STANDARDS, INCLUDING THE LATEST ADDENDA AND AMENDMENTS:
   - AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)
   - ELECTRONIC INDUSTRY ASSOCIATION (EIA)
   - INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)
   - NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION, (NECA)
   - NATIONAL ELECTRICAL MANUFACTURER'S ASSOCIATIONS (NEMA)
   - NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)
   - OCCUPATIONAL SAFETY AND HEALTH ACT (OSHA)
   - TELECOMMUNICATION INDUSTRY ASSOCIATION (TIA)
   - UNDERWRITER'S LABORATORIES, INC. (UL)
7. ENSURE THE ELECTRICAL DRAWINGS ARE NOT TO BE SCALED. CONTRACTOR SHALL TAKE MEASUREMENTS AND MAKE LAYOUTS AS REQUIRED FOR THE PROPER INSTALLATION AND COMPLETION OF THE WORK. WHERE SPECIFIC DETAILS AND DIMENSIONS ARE NOT SHOWN ON THE DRAWINGS,
8. OBTAIN ALL NECESSARY PERMITS, ARRANGE ALL REQUIRED INSPECTIONS, AND PAY ALL FEES AND CHARGES INCIDENTAL THERETO.
9. INSPECT SITE FOR FIELD VERIFICATION OF ALL ASPECTS OF THE PROJECT PRIOR TO BIDDING. SUBMISSION OF A BID CONSTITUTES ACCEPTANCE OF FIELD CONDITIONS.
10. INSTALL WORK AS REQUIRED TO FIT STRUCTURE, AVOID OBSTRUCTIONS, AVOID OR PROVIDE PROTECTION IN AREAS SUBJECT TO DAMAGE, RETAIN CLEARANCE, HEADROOM, OPENINGS AND PASSAGEWAYS.
11. INSTALL ALL MATERIALS AND EQUIPMENT AND COMPLETE ALL WORK IN A NEAT AND WORKMANLIKE MANNER, AND IN ACCORDANCE WITH BEST-IN-CLASS MODERN METHODS AND PRACTICES. ANY MATERIALS INSTALLED WHICH DO NOT PRESENT AN ORDERLY AND REASONABLY NEAT AND/OR WORKMANLIKE APPEARANCE, OR DO NOT ALLOW ADEQUATE SPACE FOR MAINTENANCE, SHALL BE REMOVED AND REPLACED WHEN SO DIRECTED BY THE ENGINEER.
12. COMMISSION EACH ITEM OF EQUIPMENT IN STRICT ACCORDANCE WITH THE MANUFACTURER'S INSTRUCTIONS; OR WHERE NOTED UNDER EQUIPMENT SPECIFICATION. COMMISSIONING SHALL BE PERFORMED BY QUALIFIED MANUFACTURER'S REPRESENTATIVE.
13. THE CONTRACT DRAWINGS ARE DIAGRAMMATIC IN NATURE AND INDICATE THE GENERAL ARRANGEMENT OF CIRCUITS AND OUTLETS, LOCATION OF SWITCHES, PANELBOARDS, CONDUITS, AND OTHER WORK. CONTRACTOR SHALL FIELD VERIFY ALL DIMENSIONS AND LOCATIONS PRIOR TO INSTALLATION OF WORK.
14. THE ELECTRICAL CIRCUITS, COMPONENTS, AND CONTROLS ARE SELECTED AND SIZED FOR THE EQUIPMENT SPECIFIED AND OR SHOWN. IF SUBSTITUTIONS AND/OR EQUIVALENT EQUIPMENT ARE FURNISHED, IT SHALL BE THE RESPONSIBILITIES OF ALL PARTIES CONCERNED, INVOLVED IN AND FURNISHING THE SUBSTITUTE AND/OR EQUIVALENT EQUIPMENT TO VERIFY AND COMPARE THE ELECTRICAL CHARACTERISTICS OF THAT FURNISHED TO THAT SHOWN.
15. FIELD COORDINATE EXACT ELECTRICAL CONNECTION POINTS TO EQUIPMENT PRIOR TO ROUGH IN OF ELECTRICAL COMPONENTS.
16. FIELD COORDINATE EXACT ROUTING OF CONDUIT. SPECIFIED CONDUIT RUNS ARE SHOWN DIAGRAMMATICALLY ONLY.
17. FURNISH AND INSTALL ALL RACEWAYS, BOXES, ENCLOSURES, AND CABINETS IN ACCORDANCE WITH MANUFACTURER'S WRITTEN INSTRUCTIONS.

16\. FURNISH AND INSTALL ALL CHANNEL AND ANGLE SUPPORTING SYSTEMS, HANGERS, ANCHORS, SLEEVES, BRACKETS, FABRICATED ITEMS, AND HARDWARE AS REQUIRED TO PROVIDE SECURE SUPPORT, PER NATIONAL ELECTRICAL CODE.

17\. MAINTAIN, ON THE JOBSITE, ONE SET OF UP TO DATE AS-BUILT ELECTRICAL DRAWINGS. AS-BUILTS SHALL BE KEPT IN GOOD CONDITION. CONTRACTOR SHALL PROGRESSIVELY, NEATLY, LEGIBLY AND EXACTLY RECORD ON THESE DRAWINGS ALL DEVIATIONS FROM THE ORIGINAL DRAWINGS, INCLUDING THE ROUTING OF ALL CONCEALED CONDUIT RUNS, AND ALL WORK WHICH IS INSTALLED IN A DIFFERENT LOCATION OR MANNER THAN INDICATED ON THE DRAWINGS. RECORD COPIES OF THESE PLANS SHALL BE SUBMITTED TO THE ENGINEER AND THE OWNER UPON PROJECT CLOSE-OUT.

18\. PROVIDE A FULL ONE YEAR WARRANTY ON ALL ELECTRICAL LABOR, EQUIPMENT AND MATERIALS INSTALLED ON THIS PROJECT, STARTING FROM THE ISSUANCE OF THE OWNER'S CERTIFICATE OF COMPLETION, EXCEPT AS FOLLOWS:

18.1. SOLAR MODULES
18.1.1. 15 YEARS MATERIALS AND WORKMANSHIP
18.1.2. 25 YEARS LINEAR POWER PRODUCTION
18.2. INVERTERS
18.2.1. 12 YEARS MATERIALS AND WORKMANSHIP
18.3. DC DISCONNECT SWITCHES
18.3.1. 5 YEARS MATERIALS AND WORKMANSHIP

19\. ALL CONNECTIONS OF DISSIMILAR METALS SHALL BE MADE TO MINIMIZE GALVANIC ACTION, CORROSION OR ELECTROLYSIS. ALL CONNECTORS, CONNECTION HARDWARE, CONDUCTORS, AND CONNECTION METHODS SHALL ENSURE THAT METALS IN DIRECT CONTACT ARE GALVANICALLY COMPATIBLE.

20\. AFTER INSTALLATION OF ALL CONDUCTORS, CONTRACTOR SHALL COMPLETELY SEAL OFF ALL CONDUIT ENDS TO PREVENT THE POSSIBILITY OF ANY MOISTURE FROM ENTERING ANY ELECTRICAL ENCLOSURE. ALL USED AND UNUSED OPENINGS IN ALL EQUIPMENT, BOXES, AND ENCLOSURES SHALL BE SEALED WEATHERTIGHT WITH A MATERIAL THAT WILL ALSO PREVENT INSECT INCURSION.

SUBMITTALS:

1. CONTRACTOR SHALL SUBMIT MANUFACTURER CUT SHEETS AND CATALOG DATA FOR ALL MATERIALS, CLEARLY INDICATING THE SPECIFIC PART OR PRODUCT CATALOG NUMBER(S) TO BE USED. ITEMS REQUIRING SIGNIFICANT LEAD TIME SHOULD BE SUBMITTED AS SOON AS POSSIBLE. ELECTRONICALLY SUBMIT 1 COPY OF ALL REQUESTED INFORMATION TO THE ENGINEER, NEATLY INDEXED PER CATEGORY, FOR THE FOLLOWING ITEMS:
   A. SWITCHBOARDS, PANELBOARDS, AC DISCONNECT SWITCHES.
   B. CONDUIT, RACEWAYS, WIREWAYS, ENCLOSURES, BOXES, FITTINGS, SUPPORTS AND HARDWARE.
   C. CONDUCTORS, BOTH DC AND AC.
   D. LIGHT FIXTURES, RECEPTACLES, SWITCHES AND ASSOCIATED ACCESSORIES.
   E. EV CHARGING STATION(S) AND ACCESSORIES.
   F. PHOTOVOLTAIC INVERTERS AND ASSOCIATED CONTROL SYSTEMS.
   G. PHOTOVOLTAIC MODULES.
   H. DC PHOTOVOLTAIC COMBINER BOXES, SPLICE BOXES AND DISCONNECT SWITCHES.
   I. METERING AND COMMUNICATIONS EQUIPMENT.
2. FOR ALL OWNER-FURNISHED EQUIPMENT, CONTRACTOR SHALL SUBMIT A COPY OF ALL INSTALLATION, COMMISSIONING AND PROGRAMMING DATA AND/OR SETTINGS, INCLUDING PASSWORD AND LOGIN DATA. CONTRACTOR SHALL ELECTRONICALLY SUBMIT 1 COPY TO THE ENGINEER.

MODULES:

1. CONTRACTOR SHALL RECEIVE, INSPECT, UNLOAD AND INSTALL ALL SOLAR PHOTOVOLTAIC MODULES. ALL MODULES DAMAGED DURING SHIPPING SHALL BE REFUSED AND SHALL NOT BE INSTALLED. COORDINATE SPECIFIC SCOPE REQUIREMENTS DURING BIDDING.
2. MODULES SHALL BE INSTALLED, SECURED, AND MECHANICALLY GROUNDED TO THE RACKING SYSTEM AND EACH OTHER PER THE MANUFACTURER'S WRITTEN INSTALLATION INSTRUCTIONS AND PER UL LISTING TO ENSURE ELECTRICAL CONTINUITY.
3. CONTRACTOR SHALL NOT PLACE ANY TOOLS, EQUIPMENT OR OTHER WEIGHT (INCLUDING BODYWEIGHT) ON THE SURFACE PORTION OF ANY MODULE. CONTRACTOR SHALL PROMPTLY REPORT MODULE DAMAGE, INCLUDING MICRO-FRACTURES, AND SHALL IMMEDIATELY REPLACE THE DAMAGED MODULE WITH A NEW, UNDAMAGED MODULE AT CONTRACTOR'S EXPENSE.

INVERTERS:

1. CONTRACTOR SHALL RECEIVE, UNLOAD AND INSTALL ALL INVERTERS, ASSOCIATED EQUIPMENT AND ACCESSORIES. COORDINATE SPECIFIC SCOPE REQUIREMENTS DURING BIDDING.
2. INVERTERS SHALL BE NEW, UTILITY GRADE, FROM A REPUTABLE MANUFACTURER, AND SHALL BE SPECIFICALLY DESIGNED FOR GRID-TIED PHOTOVOLTAIC INSTALLATIONS.
3. INVERTERS SHALL MEET THE FOLLOWING MINIMUM STANDARDS: UL 1741 SA STANDARD FOR INVERTERS, CONVERTERS, CONTROLLERS AND INTERCONNECTION SYSTEM EQUIPMENT FOR USE WITH DISTRIBUTED ENERGY RESOURCES. IEEE 929-2000 - RECOMMENDED PRACTICE FOR UTILITY INTERFACE OF PHOTOVOLTAIC (PV) SYSTEMS.
4. COORDINATE SPECIFIC SCOPE REQUIREMENTS DURING BIDDING.
5. INVERTERS SHALL BE INSTALLED, SECURED, WIRED, TESTED AND GROUNDED PER THE MANUFACTURER'S WRITTEN INSTALLATION INSTRUCTIONS.
6. CONTRACTOR SHALL CONFIGURE ALL INVERTER PROTECTION AND COMMUNICATIONS SETTINGS IN COMPLIANCE WITH LOCAL UTILITY STANDARDS, AHJ REQUIREMENTS, AND SHALL COORDINATE WITH OWNER'S REPRESENTATIVE TO PROVIDE MONITORING ACCESS.

ENCLOSURES:

1. ALL ELECTRICAL EQUIPMENT ENCLOSURES SHALL BE SPECIFIED AND INSTALLED IN ACCORDANCE WITH NEMA STANDARDS AND TYPE NUMBER AND SHALL BE SUITABLE FOR THE LOCATION CONDITIONS.
2. ALL EXTERIOR ELECTRICAL EQUIPMENT ENCLOSURES SHALL BE MINIMUM TYPE NEMA 4X. THIS SHALL INCLUDE BUT NOT BE LIMITED TO SWITCHBOARDS, DISTRIBUTION PANELS, CONTROL CABINETS, PULL BOXES, JUNCTION BOXES, DISCONNECT SWITCHES, COMBINER BOXES, WIREWAYS, ETC.
3. ALL ENCLOSURES SHALL BE PROVIDED WITH PADLOCKING PROVISIONS OR EQUIVALENT.
4. ALL SOLAR PHOTOVOLTAIC MODULES AND OTHER MATERIALS ENCLOSURES, INCLUDING LARGE CONTRACTOR INSTALLED ELECTRICAL EQUIPMENT (INCLUDING SWITCHBOARDS, DISTRIBUTION PANELS, CONTROL CABINETS, PULL BOXES, JUNCTIONS BOXES, COMBINER BOXES, AND INVERTERS) SHALL BE ENTIRELY LOCATED AT OR ABOVE THE EQUIPMENT ELEVATION SHOWN, UNLESS OTHERWISE APPROVED BY OWNER. CONTRACTOR SHALL PROVIDE SAFE EGRESS IN COMPLIANCE WITH OSHA AND CUSTOMER STANDARDS TO ALLOW FOR ACCESS TO SUCH EQUIPMENT ENCLOSURES FOR OPERATIONS AND MAINTENANCE RESPONSIBILITIES. SUCH EGRESS FEATURES SHALL INCLUDE BUT NOT BE LIMITED TO STAIRS, LADDERS, HANDRAILS, TIE-OFF POINTS, ETC.

AC SYSTEM WIRING:

1. ALL CONDUCTORS, LUGS AND CABLE ACCESSORIES SHALL BE NRTL LISTED TO APPLICABLE UL STANDARDS.
2. ALL LOW VOLTAGE AC WIRING SHALL UTILIZE COPPER CONDUCTORS WITH INSULATION AS NOTED ON THE PLANS.
3. AC WIRING FROM INVERTERS TO AC COMBINER SHALL BE XHHW-2 AND AC LOW VOLTAGE WIRING BETWEEN AC MAIN CB AND EQUIPMENT LOW VOLTAGE TERMINALS SHALL BE COPPER TYPE XHHW-2, 600V.
4. ALL CONDUCTORS INSTALLED BELOW THE EQUIPMENT ELEVATION (AND THEREFORE INCLUDES CONDUCTORS BELOW GRADE) MUST BE LISTED FOR USE IN WET LOCATIONS (PER NEC AND UL DEFINITIONS, INCLUDING SUBMERSION), AND BE OF A CORROSION RESISTANT DESIGN.
5. ALL CONDUCTORS SHALL BE SIZED IN ACCORDANCE WITH CURRENT NEC CODE REQUIREMENTS.
6. CONDUCTORS SHALL HAVE INTEGRAL COLORING OR COLORED HEAT SHRINK SLEEVE AT ALL TERMINATIONS TO INDICATE GROUNDED CONDUCTORS, EQUIPMENT GROUNDING CONDUCTORS, AND AC PHASE CONDUCTORS. COLOR CODING SHALL BE AS FOLLOWS:
   - PHASE A: BROWN (480VAC), BLACK (208VAC)
   - PHASE B: ORANGE (480VAC), RED (208VAC)
   - PHASE C: YELLOW (480VAC), BLUE (208VAC)
   - NEUTRAL: GRAY (480VAC), WHITE (120-208VAC)
   - GROUND: GREEN WITH STRIPE OR BARE

6\. ALL LUGS AND CONNECTORS SHALL BE 90C RATED, UL LISTED AND DESIGNATED FOR USE WITH THE CONDUCTOR BEING CONNECTED.

7\. LUGS AND CONNECTORS USED TO TRANSITION FROM COPPER TO ALUMINUM WIRE SHALL BE LISTED AND RATED FOR SUCH USE. APPLY ANTI-OXIDANT COATING MATERIAL TO ALL ALUMINUM TERMINATIONS.

8\. ALL AC POWER CONDUCTOR TERMINATIONS SHALL BE IRREVERSIBLE, DOUBLE CRIMP, LONG BARREL, TWO BOLT COMPRESSION TYPE LUGS RATED AT 90C AND APPROVED BY THE EQUIPMENT MANUFACTURER OR SUPPLIER. WHERE NOT POSSIBLE, SINGLE BOLT COMPRESSION LUGS MAY BE USED. MECHANICAL SET SCREW TERMINATIONS ARE APPROVED FOR EQUIPMENT TERMINATIONS WITH FACTORY INSTALLED MECHANICAL LUGS. ALL CRIMPED CONNECTIONS MUST BE INSTALLED PER MANUFACTURER'S SPECIFICATIONS. COAT CONDUCTOR WITH DIELECTRIC GREASE PRIOR TO CRIMPING.

9\. PROVIDE A MAXIMUM OF TWO STACKABLE COMPRESSION LUGS WHEN MORE THAN ONE COMPRESSION LUG NEEDS TO BE TERMINATED AT A SINGLE SET OF BUS BAR HOLES.

10\. NO SPLICING OF ANY WIRES WITHOUT WRITTEN CONSENT OF OWNER. ALL UNDERGROUND WIRING SHALL BE CONTINUOUS WITHOUT SPLICES.

11\. ALL SINGLE PHASE POWER CIRCUITS SHALL HAVE A DEDICATED NEUTRAL.

12\. CLASS 1 AND CLASS 2 CONTROL CIRCUITS SHALL BE TYPE THHN/THWN, INSTALLED IN RACEWAY.

13\. TERMINAL SCREW TORQUE SPECS PER MANUFACTURER TO BE FOLLOWED AND WITNESSED BY QA.

DC SYSTEM WIRING:

1. ALL CONDUCTORS SHALL BE SIZED IN ACCORDANCE WITH CURRENT NEC CODE REQUIREMENTS, INCLUDING TEMPERATURE RATING, AND OWNER SPECIFIED VOLTAGE DROP.
2. ALL CONDUCTORS INSTALLED BELOW THE EQUIPMENT ELEVATION (AND THEREFORE INCLUDES CONDUCTORS BELOW GRADE) MUST BE LISTED FOR USE IN WET LOCATIONS (PER NEC AND UL DEFINITIONS, INCLUDING SUBMERSION), AND BE OF A CORROSION RESISTANT DESIGN.
3. ALL SOLAR DC STRING AND STRING TO DC COMBINER BOXES, AND BESS DC CONDUCTORS AND CABLES SHALL BE COPPER TYPE "PV-2", 2000VDC, 90'C (WET OR DRY), UV RESISTANT, COPPER WIRE, UL 4703. DC CONDUCTORS FROM DC BOXES TO INVERTERS SHALL BE COPPER.
4. FURNISH STRANDED WIRE FOR SIZES #8 AND LARGER UNLESS OTHERWISE NOTED. MINIMUM CONDUCTOR SIZE SHALL BE AWG #12.
5. ALL WIRES AND CABLE SHALL HAVE UV RESISTANT AND OUTDOOR RATED WRAP-AROUND LAMINATING VINYL MACHINE PRINTED ID LABELS OR OTHER APPROVED LABELING METHOD INDICATING DESIGNATION AND POLARITY. CONDUCTORS SHALL HAVE INTEGRAL COLORING OR A COLORED OUTDOOR RATED HEAT SHRINK SLEEVE AT ALL TERMINATIONS TO INDICATE GROUNDED CONDUCTORS, EQUIPMENT GROUNDING CONDUCTORS AND CURRENT-CARRYING CONDUCTORS, PER NEC REQUIREMENTS AND INDUSTRY STANDARDS. COLOR CODING SHALL BE AS FOLLOWS:
   - PV POSITIVE (+): RED
   - PV NEGATIVE (-): BLACK
   - GROUND: GREEN WITH STRIPE OR BARE
6. SERIES STRING CONNECTIONS BETWEEN SOLAR PHOTOVOLTAIC MODULES SHALL BE VIA FACTORY-SUPPLIED TYPE "MC4" QUICK CONNECT CONNECTORS. FIELD INSTALLED QUICK CONNECT CONNECTORS SHALL BE OF THE SAME MAKE AND MODEL AS THOSE FACTORY SUPPLIED WITH THE MODULES. ALL MODULE CONNECTORS SHALL BE UL LISTED, NEC 690 COMPLIANT, LATCHING TYPE WITH POSITIVE LATCHING INDICATOR. CONNECTORS SHALL BE POLARIZED SUCH THAT POSITIVE AND NEGATIVE TERMINALS ARE NOT INTERCHANGEABLE.
7. STRING WIRING SHALL BE RATED FOR DIRECT SUNLIGHT EXPOSURE. STRING WIRING SHALL BE PROPERLY SUPPORTED TO RACK AND/OR MODULE FRAMES USING STAINLESS STEEL PV CABLE CLIPS, AND/OR OTHER OWNER-APPROVED WIRE MANAGEMENT METHOD. NYLON CABLE TIES SHALL NOT BE ALLOWED. PV CABLE CLIPS AND WIRE MANAGEMENT METHOD MUST BE APPROVED BY OWNER BEFORE INSTALLATION. ALL CABLES SHALL BE SECURED MINIMUM 24" ON CENTER AND 6" AT EACH END WHEN CHANGING DIRECTION. NO CABLE SHALL BE ALLOWED TO TOUCH THE SURFACE OF THE GROUND.
8. RUN WIRING UNDERNEATH MODULE FRAMES.
9. STRING WIRING SHALL ENTER ENCLOSURES THROUGH CONDUIT, CORD GRIPS, OR OTHER APPROVED METHOD THAT WILL PROPERLY SEAL THE PENETRATION AND UPHOLD THE WEATHERPROOF RATING OF THE ENCLOSURE OR BOX.
10. ON PROJECTS WITH COMBINERS, COMBINER OUTPUT FEEDERS SHALL BE COPPER, WITH THERMOSET XLPE INSULATION AND JACKET MATERIALS, NON-THERMOPLASTIC INSULATION. CABLE SHALL BE 2000V RATED, WET LOCATION, 90 C OR BETTER.
11. ALL POWER CONDUCTOR TERMINATIONS SHALL BE IRREVERSIBLE, DOUBLE CRIMP, LONG BARREL, TWO BOLT COMPRESSION TYPE LUGS RATED AT 90C WHERE APPROVED BY THE EQUIPMENT MANUFACTURER OR SUPPLIER. WHERE NOT POSSIBLE, SINGLE BOLT COMPRESSION LUGS MAY BE USED. MECHANICAL SET SCREW TERMINATIONS ARE APPROVED FOR COMBINER BOX TERMINATIONS ONLY. ALL CRIMPED CONNECTIONS MUST BE INSTALLED PER MANUFACTURER'S SPECIFICATIONS.
12. ALL CONTROL AND INSTRUMENTATION CONDUCTORS SHALL BE TERMINATED BY CONTRACTOR.
13. ALL LUGS AND CONNECTORS SHALL BE 90C RATED, UL LISTED AND DESIGNATED FOR USE WITH THE CONDUCTOR BEING CONNECTED.
14. NO SPLICING OF ANY WIRES SHALL BE PERFORMED WITHOUT WRITTEN CONSENT FROM OWNER.
15. TERMINAL SCREW TORQUE SPECS PER MANUFACTURER TO BE FOLLOWED AND WITNESSED BY QA.

GROUNDING:

1. SOLAR MODULE EQUIPMENT GROUNDING CONNECTION SHALL BE INSTALLED IN ACCORDANCE WITH MANUFACTURER'S GUIDELINES AND APPLICABLE LISTINGS. MODULE FRAME GROUNDING HARDWARE SHALL BE LISTED TO UL3703 AND SPECIFIED BY MODULE MANUFACTURER AS ACCEPTABLE FOR USE WITH THE MODULE MODEL. WEEBS WILL BE CONSIDERED AN ACCEPTABLE MEANS OF GROUNDING BUT THEIR USE MUST BE AN APPROVED USE BY THE APPLICABLE MANUFACTURER(S). MANUFACTURER'S APPROVAL LETTER FOR THE SPECIFIC CASE MUST BE PROVIDED TO OWNER AND APPROVED BY OWNER, OTHERWISE A CONTINUOUS GROUND LOOP MUST BE INSTALLED.
2. METHODS THAT GROUND MODULE FRAMES BY UTILIZING THE RACKING AS THE GROUNDING MEANS SHALL BE LISTED TO UL 3703.
3. ALL BRANCH AND FEEDER CIRCUITS SHALL CONTAIN A GROUNDING CONDUCTOR, UNLESS OTHERWISE NOTED, AND BE SIZED AND BONDED IN ACCORDANCE WITH NEC ART. 250.
4. UNLESS OTHERWISE NOTED, GROUNDING CONDUCTORS SHALL BE COPPER. EQUIPMENT GROUNDING CONDUCTORS SHALL BE INSULATED WITH GREEN-COLORED INSULATION. UNDERGROUND CONDUCTORS SHALL BE BARE, TINNED, AND STRANDED. USE ONLY COPPER CONDUCTORS FOR BOTH INSULATED AND BARE GROUNDING CONDUCTORS IN DIRECT CONTACT WITH EARTH, CONCRETE, MASONRY, CRUSHED STONE AND SIMILAR MATERIALS. IN RACEWAYS, USE INSULATED EQUIPMENT GROUNDING CONDUCTORS. EXPOSED BARE EQUIPMENT GROUNDING CONDUCTORS WILL BE MINIMUM 6 AWG COPPER.
5. INSTALL INSULATED EQUIPMENT GROUNDING CONDUCTORS WITH CIRCUIT CONDUCTORS FOR THE FOLLOWING ITEMS, IN ADDITION TO THOSE REQUIRED BY NEC: FEEDERS AND BRANCH CIRCUITS; RECEPTACLE CIRCUITS; SINGLE-PHASE MOTOR AND APPLIANCE BRANCH CIRCUITS; THREE-PHASE MOTOR AND APPLIANCE BRANCH CIRCUITS; FLEXIBLE RACEWAY RUNS.
6. ALL NON-CURRENT CARRYING EXPOSED METAL PARTS OF SYSTEM JUNCTION BOXES, EQUIPMENT, MODULE FRAMES, SUPPORT RACKING, INVERTER CASES AND APPLIANCES IN THE ENTIRE ELECTRICAL SYSTEM THAT MAY BE ACCIDENTALLY ENERGIZED SHALL BE GROUNDED PER NEC 690.43 AND 690.45 AND SIZED PER 250.122.
7. GROUND LUGS SHALL BE MECHANICAL AND ACCEPTABLE FOR COPPER CONDUCTOR TERMINATION. LUGS SHALL BE SELECTED SO AS TO PREVENT GALVANIC CORROSION AND DISSIMILAR THERMAL EXPANSION OF LUGS AND CONDUCTORS.
8. TIN-PLATED COPPER LAY-IN GROUND LUGS OR CONDUIT GROUND CLAMPS SHALL BE PROVIDED FOR ALL METALLIC CONDUIT CARRYING POWER CONDUCTORS. SUCH MEANS OF GROUNDING SHALL NOT BE REQUIRED FOR METALLIC CONDUIT CARRYING COMMUNICATION CONDUCTORS.
9. ALL GROUND LUGS NOT INSTALLED IN AN ENCLOSURE MUST BE UL LISTED FOR DIRECT BURIAL.
10. ALL EQUIPMENT GROUNDING CONDUCTORS (EGC) AND GROUNDING ELECTRODE CONDUCTORS (GEC) SHALL BE SIZED IN ACCORDANCE WITH THE PROPER SECTIONS OF THE NEC.
11. METALLIC CONDUIT CONTAINING A GROUNDING ELECTRODE CONDUCTOR MUST BE BONDED AT BOTH ENDS.
12. ALL SOLAR AND BESS INVERTERS AND INTERCONNECTION SWITCHBOARDS SHALL UTILIZE A GROUNDING ELECTRODE SYSTEM CONSISTING OF A GROUND RING/GRID SIZED AND INSTALLED TO COMPLY WITH NEC AND IEEE STANDARDS. IF THE APPLICABLE GOVERNMENTAL AUTHORITY REQUIRES A GROUNDING CONDUCTOR TO BE EXTENDED FROM THE GROUND GRID TO THE EXISTING BUILDING STRUCTURE, SUCH WORK WILL BE INCLUDED IN SCOPE AT NO EXTRA COST TO OWNER.
13. EQUIPMENT GROUNDING CONDUCTORS SHALL BE ROUTED WITH ALL CIRCUIT AND PHASE CONDUCTORS.
14. ALL BELOW GRADE CONNECTIONS SHALL BE CRIMPED AND UL LISTED FOR DIRECT BURIAL APPLICATIONS.
15. GROUND RODS, IF REQUIRED, SHALL BE SECTIONAL TYPE; COPPER-CLAD STEEL, 3/4" IN DIAMETER BY 10' DRIVEN VERTICALLY.
16. PROVIDE MECHANICAL CONNECTIONS FOR CONNECTIONS TO STRUCTURAL STEEL AND FOR UNDERGROUND CONNECTIONS.
17. ALL EXPOSED GROUND CONNECTIONS TO EQUIPMENT SHALL BE CABLE LUGS WITH BOLTED/MECHANICAL ATTACHMENTS.
18. USE INSULATED COPPER EQUIPMENT GROUNDING CONDUCTORS FOR GROUNDING RACKING SYSTEMS WHEN ALUMINUM RACKING IS USED. BOND TO RACKING WITH CU-AL RATED LUGS PER RACKING MANUFACTURER'S REQUIREMENTS.
19. INSTALL #6 CU INSULATED BONDING JUMPERS BETWEEN ADJACENT RACKS PER MANUFACTURERS GROUNDING AND INSTALLATION DETAILS.
20. GROUNDING SCREWS SHOULD BE THREAD-FORMING OR HOT DIPPED, NOT THREAD CUTTING.

CONDUCTOR PROTECTION:

1. ALL ABOVE GROUND AC CABLES SHALL BE PROTECTED IN CONDUIT OR CABLE TRAYS, AS NOTED ON THE PLANS.
2. PULL AND JUNCTION BOXES SHALL BE PROVIDED WHERE REQUIRED TO FACILITATE THE INSTALLATION OF WIRING. BENDS IN CONDUITS BETWEEN PULL BOXES SHALL NOT EXCEED THE EQUIVALENT OF FOUR 90 DEGREE BENDS.
3. CONDUITS REQUIRING FIELD CUTTING SHALL BE CUT SQUARE AND DE-BURRED. CONDUIT END BELLS OR BUSHINGS SHALL BE PROVIDED TO PREVENT CABLE DAMAGE.
4. BENDS IN CONDUITS SHALL NOT DAMAGE RACEWAYS OR SIGNIFICANTLY CHANGE THE INTERNAL DIAMETER OF RACEWAYS (NO KINKS).
5. COMMUNICATIONS WIRING SHALL BE RUN IN SEPARATE CONDUITS FROM POWER CIRCUIT WIRING.
6. ALL AC BRANCH CIRCUIT WIRE SHALL BE INSTALLED IN RACEWAY, UNLESS OTHERWISE NOTED. MINIMUM SIZE SHALL BE 3/4".
7. ALL EXPOSED CONDUITS INSTALLED IN EXTERIOR LOCATIONS SHALL BE RGSC TYPE. RACEWAYS SHALL BE SUPPORTED BY APPROVED TYPES OF GALVANIZED SUPPORTS. USE STAINLESS STEEL HARDWARE AND CONDUIT STRAPS OUTDOORS. PAINT ALL EXPOSED MATERIALS TO MATCH EXISTING COLORS.
8. JOB CUT THREADS SHALL BE GIVEN A COAT OF RUST RESISTANT PAINT SUCH AS ZINC CHROMATE OR EQUAL.
9. WIRE TERMINATIONS AND SPLICES SHALL BE COMPLETED WITH THE APPROPRIATE UL LISTED HEAVY DUTY RATCHETING TYPE JAWS AND INTERCHANGEABLE DIES FOR PROPER CRIMPING OF TERMINALS. TERMINALS SHALL BE UN-INSULATED TYPE AND CORRECTLY SIZED FOR THE WIRE USED.
10. BLOCKS AND TERMINAL LUGS SHALL BE LISTED FOR THE APPROPRIATE CONDUCTOR MATERIAL.
11. AFTER INSTALLATION OF CONDUCTORS, ALL RACEWAYS SHALL BE SEALED WITH DUCTSEAL.

NOTE:

THESE SPECIFICATIONS ARE PROVIDED FOR GENERAL INSTALLATION AND EQUIPMENT REQUIREMENTS. REFER TO TBPP TECHNICAL SPECIFICATIONS FOR ADDITIONAL REQUIREMENTS. SHOULD THERE BE ANY CONFLICTS BETWEEN THE SPECIFICATIONS HEREIN AND THAT OF THE TBPP, THE TBPP SPECIFICATIONS SHALL TAKE PRECEDENCE.

MONITORING:

THE CONTRACTOR SHALL:

1. FURNISH AND INSTALL ALL COMMUNICATIONS DEVICES NECESSARY TO BRING ALL TBPP AS WELL AS ALL PV SYSTEM DATA TO THE OWNER'S IT EQUIPMENT RACK. FINAL SYSTEM CONNECTIVITY TO BE DETERMINED BY OWNER.
2. FURNISH AND INSTALL AN RS485, 2C#16, SHIELDED, TWISTED PAIR CABLE BETWEEN EACH INVERTER AND A SYSTEM COMMUNICATIONS GATEWAY. (GATEWAY TO BE COMPATIBLE WITH SUPPLIED INVERTERS). GROUND SHIELD PER INVERTER MANUFACTURER'S REQUIREMENTS.
3. CONNECT COMMUNICATIONS GATEWAY ETHERNET OUTPUT TO OWNERS LAN SWITCH, IF AVAILABLE. ETHERNET CABLE SHALL HAVE RJ45 CONNECTORS AT EACH END. ETHERNET CABLE SHALL BE CONSISTENT WITH OWNERS LAN (CAT5e OR CAT6).
4. A TBPP CONTROLLER SHALL BE PROVIDED AND SHALL CONTROL THE ENTIRE TBPP PACKAGE IN A COORDINATED MICROGRID FASHION INCLUDING CONTROLLING THE OUTPUT OF GENSET, SOLAR PV ARRAY AND BESS TO MINIMZE FUEL USAGE AT THE GENSET AND MAXIMIZE THE USE OF THE SOLAR AND BESS TO POWER THE CF. THE CONTROLLER SHALL MAINTAIN POWER OUTPUT TO THE CF FOR A PERIOD OF 48 HOURS.

MISCELLANEOUS:

1. ALL EXTERIOR MOUNTING HARDWARE USED SHALL BE STAINLESS STEEL, SIZED PER SYSTEM MANUFACTURER'S RECOMMENDATIONS. USE ANTI-SEIZE FOR EACH CONNECTION.
2. STRUT TYPE SWITCH RACKS AND SUPPORTS MAY BE GALVANIZED STEEL OR ALUMINUM.
3. PANELBOARDS SHALL BE FULLY RATED TO INTERRUPT SYMMETRICAL SHORT-CIRCUIT CURRENT AVAILABLE AT TERMINALS. PANELBOARDS SHALL UTILIZE CIRCUIT-BREAKER TYPE OCPD's AND ALL PHASE AND GROUND BUSSES SHALL BE COPPER.
4. UNLESS OTHERWISE NOTED, ALL ENCLOSURES FOR OUTDOOR EQUIPMENT SHALL BE NEMA 3R RATED. ENCLOSURES. ENCLOSURES FOR INDOOR EQUIPMENT SHALL BE NEMA 1 RATED.
5. CONTRACTOR SHALL REMOVE AND DISPOSE OF ALL SPOILS FROM THE PROJECT SITE. CONTRACTOR SHALL PROVIDE DUMPSTERS OR OTHER CONTAINERS AS REQUIRED, AND SHALL COORDINATE LOCATIONS AND PICKUP SCHEDULES WITH THE OWNER TO MINIMIZE INTERRUPTION.

COMMISSIONING:

1. CONTRACTOR SHALL PERFORM START-UP AND COMMISSIONING UPON COMPLETION OF INSTALLATION OF THE TBPP AT THE CRITICAL FACILITY. TO SUCCESSFULLY COMMISSION THE TBPP, CONTRACTOR MUST ENSURE A COMPLETE INSTALLATION, APPROPRIATE CONFIGURATION, AND MUST DEMONSTRATE THAT THE TBPP PERFORMS IN ITS FULL, PROPER OPERATING CONDITION. CONTRACTOR SHALL RECORD ALL MEASURED DATA AND PROVIDE OWNER AND ENGINEER WITH A DETAILED REPORT REGARDING ANY ISSUES THAT CONTRACTOR DISCOVERS DURING SUCH PERFORMANCE TESTING.
2. PROVIDE FINAL CLEANUP AND CONDUCT FIELD TESTS AFTER INSTALLATION OF ALL ELECTRICAL WORK. ADJUST ITEMS TO THE SATISFACTION OF THE OWNER AND ENGINEER. LEAVE ALL EQUIPMENT INTERIORS CLEAN AND FREE FROM CONSTRUCTION DEBRIS. NEATLY DRESS ALL WIRING, AND RE-TIGHTEN ALL TERMINATIONS PER MANUFACTURERS' RECOMMENDATIONS.
3. AS A CONDITION OF ACHIEVING SUBSTANTIAL COMPLETION, CONTRACTOR SHALL COMPLETE ALL ITEMS IDENTIFIED IN THE PUNCHLIST. PUNCHLIST SHALL BE PREPARED BY OWNER AND OWNER'S ENGINEER.

REQUESTS FOR INFORMATION:

UNLESS SPECIFIED DIFFERENTLY IN THE CONTRACT DOCUMENTS:

FOR THOSE PROJECTS WHERE TBPP VENDOR IS THE PRIME CONSULTANT, ALL QUESTIONS OR REQUESTS FOR INFORMATION (RFI) SHALL BE SUBMITTED IN WRITING DIRECTLY TO THE VENDOR. PLEASE INCLUDE: 1) DATE; 2) THE PROJECT NAME; 3) FIRM NAME; 4) YOUR NAME ; 5) DRAWING NUMBER, DATE AND REVISION NUMBER &/OR SPECIFICATION SECTION REFERENCE; AND 6) ADEQUATE SPACE FOR REPLY.

UNDOCUMENTED PHONE CALLS TO VENDOR SHALL NOT BE USED AS A BASIS FOR ANY FUTURE CLAIMS.

WIRING AND WIRING METHODS:

1. IF APPLICABLE, PV MODULES SHALL FOLLOW SKIP STRINGING WITH TYPICAL WIRE MANAGEMENT PRACTICES. ALL CONNECTORS SHALL BE MANUFACTURER & ENGINEER APPROVED.
2. HOMERUNS FROM THE STRINGS BACK TO THE DC COMBINERS, AND FROM THE COMBINERS BACK TO THE INVERTERS, SHALL BE SIZED AS NOTED ON THE PLANS. ALL HOMERUNS SHALL BE MINIMUM #10 AWG. PROVIDE #10 AWG GREEN GROUNDING CONDUCTOR WITH EACH STRING. NO STRING CABLE LENGTH (ROUND-TRIP) SHALL EXCEED 1000'.

UTILITY COORDINATION

1. IT WILL BE THE RESPONSIBILITY OF THE CONTRACTOR TO COORDINATE ITS WORK WITH THE CF OWNER AND SERVING UTILITY.
2. IT MAY BE NECESSARY FOR THE SERVING UTILITY TO INSTALL REVENUE METERING AND UTILITY RELAYING AND RECLOSER. THE CONTRACTOR SHALL COORDINATE ITS WORK WITH THIS EFFORT WITH THE SEERVING UTILITY AND OWNER.

MARKING OR LABELING

1. SHALL COMPLY WITH NEC 2023, PART VI OF SECTION 690, FOR SOLAR PV SYSTEMS.
2. FOR LOW VOLTAGE AC AND ALL DC MAIN DISCONNECTS, PROVIDE LABELS:

   WARNING
   ELECTRIC SHOCK HAZARD
   DO NOT TOUCH TERMINALS
   TERMINALS ON BOTH THE LINE AND LOAD SIDES
   MAY BE ENERGIZED IN THE OPEN POSITION

3. FOR MAIN AC DISCONNECT, ALSO PROVIDE THE FOLLOWING LABEL:

   PLACE THIS SWITCH IN THE
   "OFF" POSITION TO SHUTDOWN PV
   SYSTEM AND REDUCE SHOCK HAZARD
   IN THE ARRAY.

4. FOR NEW AC COMBINER AND OCPD PANELS, PROVIDE LABEL:

   WARNING
   MULTIPLE POWER SOURCES

TYPICAL TBPP EQUIPMENT LIST:

1. EQUIPMENT SHALL BE AS INDICATED BELOW UNLESS OTHERWISE APPROVED BY OWNER:
   1.1. TRANSFORMER (IF REQUIRED TO MEET CF OPERATING VOLTAGE
   1.2. INVERTERS
   1.3. DC COMBINERS
   1.4. AC SWITCHBOARDS
   1.5. RELAYS
   1.6. SOLAR PV MODULES
   1.7. FIXED GROUND MOUNT BALLASTED SOLAR RACKING
   1.8. SOLAR ARRAY AND SYSTEM GROUNDING

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PROFESSIONAL DESIGN FIRM
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Owner/Clie

Scale:	
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Approved:	DJS

Rev. No.	Date	Description
A	01/21/2025	ORIGINAL ISSUE

ISSUES & REVISIONS

Project: TEXAS BACKUP POWER PACKAGE PUBLIC UTILITY COMMISSION OF TEXAS

Sheet Title: GENERAL SPECIFICATIONS

Date: 01/21/2025 Proj. No: 22483.005

PROJECT PHASE

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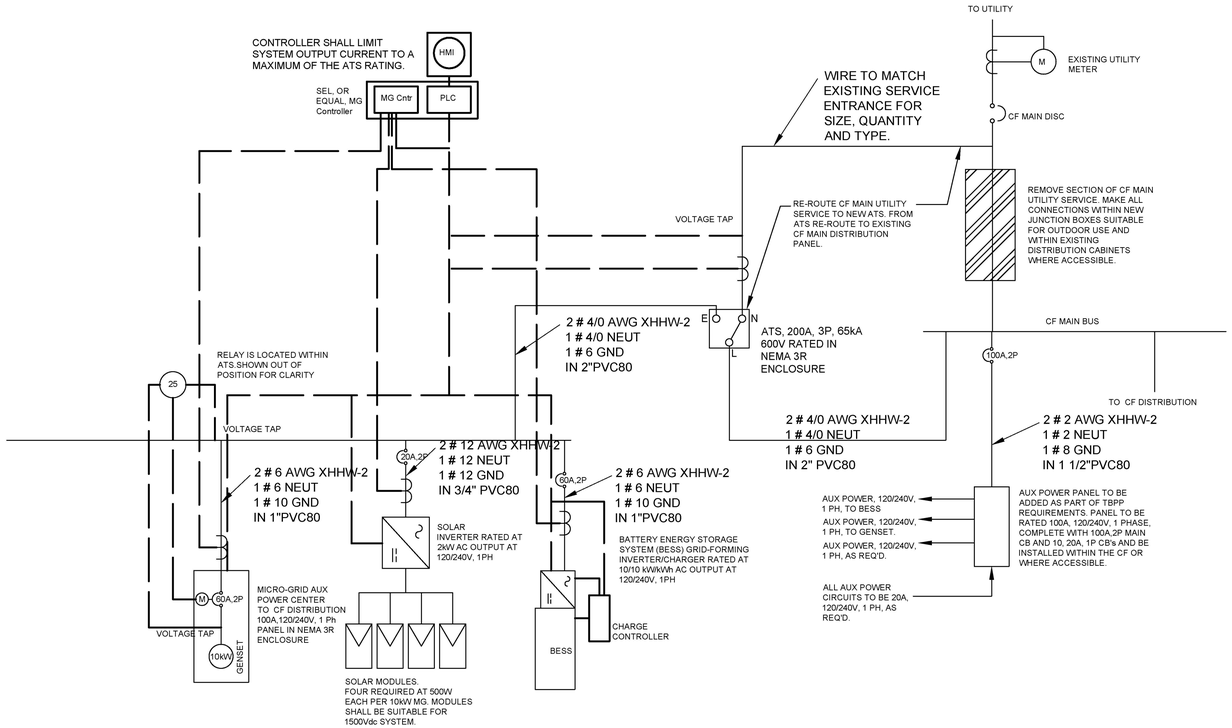
Sheet No: E1.02

Sheet of

Revision No.: 0



General Notes:

1. Equipment sizing is schematic and is representative of actual minimum desired kW, A, watts required for a coordinated system. Actual ratings of equipment are allowed to meet standard offerings from vendor/s that equal or exceed those minimums. All equipment associated with the proposed offering shall be adjusted to meet the actual power generation equipment being offered. For example if a 100kW genset is being offered in lieu of a required 80kW genset the main CB and other associated equipment shall also be upsized to handle the larger power package output.
2. One-line is a schematic representation of the component layout of the microgrid. Component sizing requirements can be found in the sizing charts accompanying the plans for the specific TBPP being installed.
3. Actual component sizing shall meet the TBPP rating required as a minimum but may be in the range of 0 to +10%.
4. Overall basic TBPP sizes shall be 10kW, 25 kW, 100kW, 500 kW, and 1000 kW. Required ratings of installed packages that do not fall into one of these sizes shall be considered as meeting the installed kW rating by aggregating multiple gensets of the base rating together. Other components shall be upsized as listed in the sizing charts. Aggregation limits to no more than three MG's have been set to minimize space requirements.
5. Communication standard shall be RS485. Fiber optic may be used at suppliers option. Communications protocols shall be ethernet, CAN, or other approved vendor standard offering.
6. All equipment including wire is for the existing 10kW Critical Facility and is assumed to be served and operated at 120/240V, 1 phase, 200A. See appropriate one-line for equipment and wire sizing required.
7. Solar array sizing is based on a DC/AC ratio of 1.25 with a design AC output equal to 16% of the TBPP kW rating. This should be able to fully charge a 1 hour BESS in 6 hours from a discharge state of 20% charge left on the BESS.

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ISSUES & REVISIONS

Project:
TEXAS BACKUP POWER PACKAGE
PUBLIC UTILITY COMMISSION OF TEXAS

Sheet Title:
ONE-LINE DIAGRAM

Date: 01/21/2025

Proj. No: 22483.005

PROJECT PHASE

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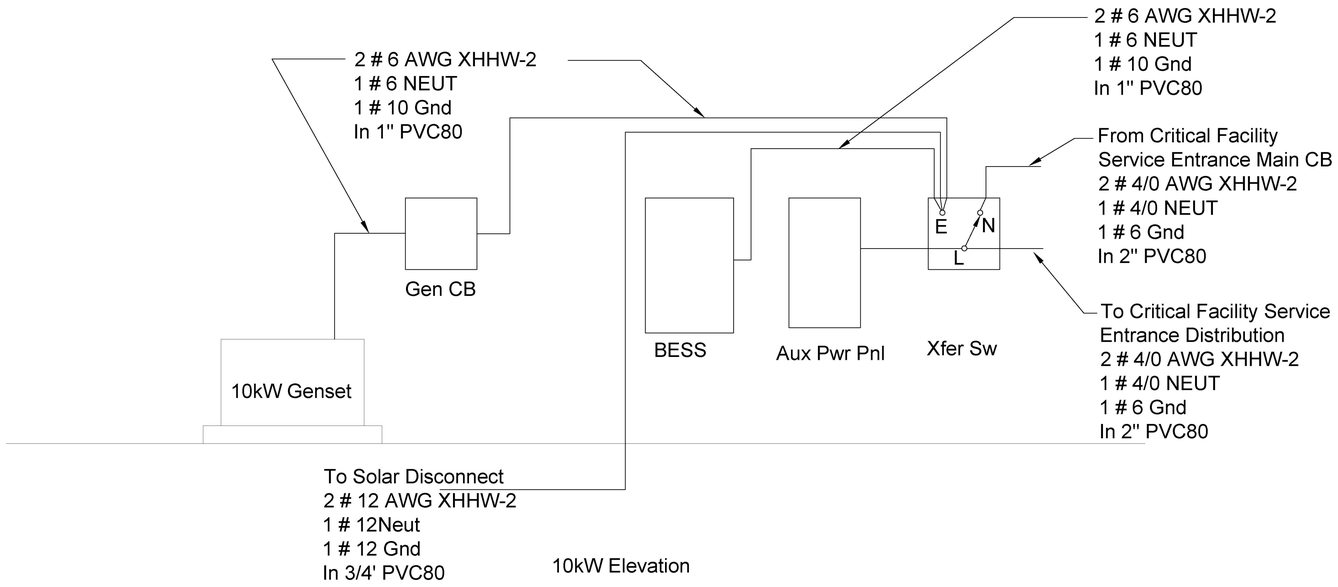
Sheet No:
E2.01

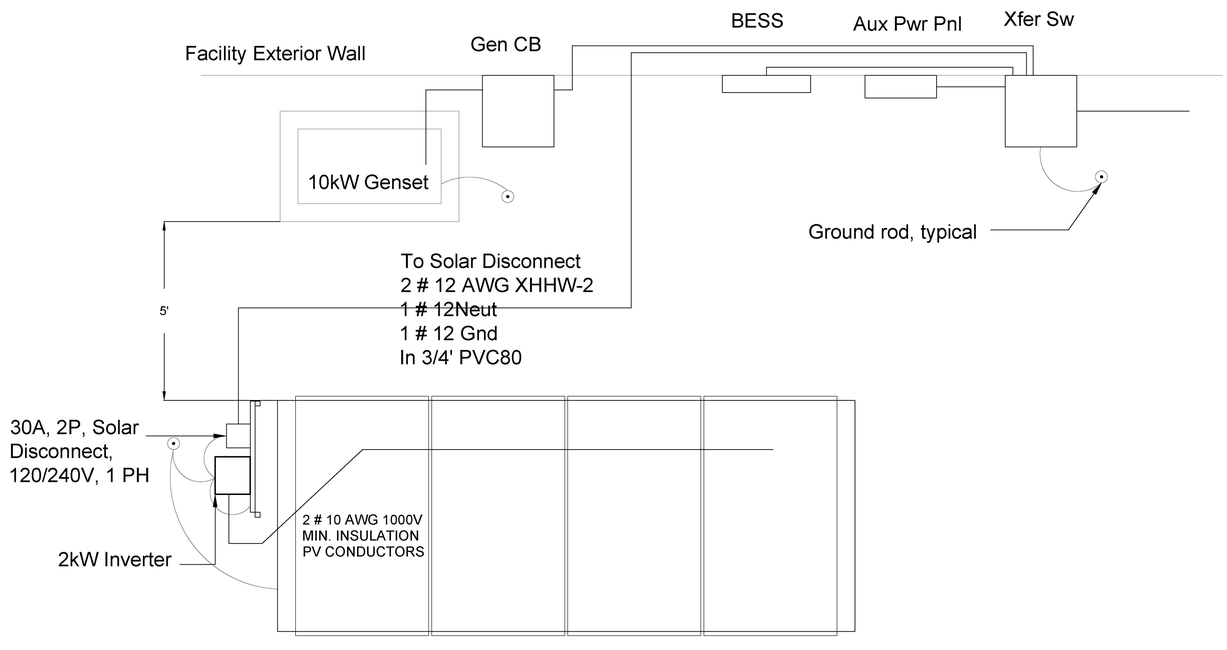
Sheet of

Revision No.:
0

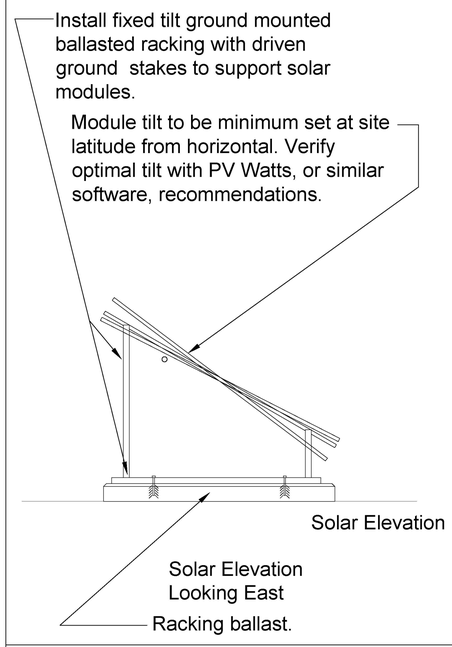
FILE NAME: P:\Jobs\Public Utility Commission of Texas (PUCT)\22483.005 Backup Power Package Design\11_Drawings\11-3_Electrical\10dwg\E2.01 ONE-LINE DIAGRAM ISLAND ALL.dwg LAYOUT NAME: E2.01 PLOTTED: Monday, January 20, 2025 - 5:10pm USER: AHOO4



10kW Elevation



10kW Plan



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ISSUES & REVISIONS

THE INFORMATION CONTAINED ON THESE DRAWINGS IS FOR USE ON THIS PROJECT ONLY

Project:
TEXAS BACKUP POWER PACKAGE
PUBLIC UTILITY COMMISSION OF TEXAS

Sheet Title:
10KW TBPP LAYOUT

Date: 01/21/2025 Proj. No: 22483.005

PROJECT PHASE

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Sheet No:
E3.01

Sheet of

Revision No.: 0