Section 26 26 00
Vertiv™ Liebert® TFX
50 kVA to 300 kVA
Power Distribution Unit (PDU)

1.0 GENERAL

1.1 Summary

This guide specification describes requirements for a complete power distribution system, supplying computer grade power to sensitive loads. The specified system shall provide isolation, distribution, control, and monitoring of AC power. It shall include all equipment to properly interface the AC power source to the intended load.

1.2 Definitions

1. **PDU:** Power Distribution Unit
2. **RFI:** Radio-Frequency interference
3. **EMI:** Electromagnetic Interference
4. **SPD:** Surge Protection Device

1.3 Standards

1. The system should dual-UL Bi-National listed as a complete system under UL 60950-1 and UL 62368-1 Standard for Information Technology, Communication Technology and Audio/Video Equipment.
2. The specified system should comply with latest FCC Part 15 emission limits for Class A and for use in Business/Industrial/Commercial Environments.
3. The system shall safely withstand without maloperation or damage:
    - System Surge Rating: Transient voltage surges on the AC power input as defined by ANSI/IEEE C62.41 for Category B1 2 kV/1 kA locations.
    - Electrostatic discharges (ESD) up to 10 kV at any point on the exterior of the unit.
    - Electromagnetic fields from portable transmitters greater than 3 ft. (1 m) from the unit.

1.4 Submittal Documentation Requirements

1. Furnish documentation associated with this bid proposal and Contract including submittals, shop drawings, user manual, and test reports as follows:
    - Submit documents in portable document format (PDF).
2. Provide a Compliance Review of the Specifications, Drawings, and Addenda. The Compliance Review is a paragraph-by-paragraph review of the specifications with the following information: C, D or E marked in the margin of the original specifications and any subsequent Addenda. C, D, E to be completed for all specification, including reference specifications.
    - **C**: Comply with no exceptions.
    - **D**: Comply with deviations. For every deviation, provide a numbered footnote with reasons for the proposed deviation and how the intent of the specification can be satisfied.

- **E**: Exception, do not comply. For every exception, provide a numbered footnote with reasons and possible alternatives.

3. **Submittals**

- **Product Data**: For each type of power distribution unit, overcurrent protective device, TVSS device, accessory, and component indicated. This includes dimensions and technical data of manufacturers on features, performance, electrical characteristics, ratings, and finishes.
- **Shop Drawings**: For each power distribution unit and related equipment.
  - Dimensioned drawings with elevations, sections, and details.
  - Wiring Diagrams, Diagram power, signal, and control wiring and differentiate between manufacturer-installed and field-installed wiring.
- **User Manual**: The manufacturer should furnish an installation/user manual (soft copy) with installation, start-up, operation, and maintenance instructions for the specified system.

1.5 Floor Stand/Bracket Requirements (Optional)

1. Floor Stand (Optional)

- Floor Stand should furnish to support, level the unit, and to provide bottom cabling access without relying upon a raised floor for support. The height of the floor shall accommodate a range of: 9.75 in. to 14.25 in., 13.75 in. to 18.25 in., 17.5 in. to 24.5 in., 23.5 in. to 30.5 in., 29.5 in. to 36.5 in., or 35.5 in. to 42.5 in.
- The floor stand offers micro-adjustments to maximize height variances within the range specified above.
- The floor stand is (have) (not have) a solid top.

2. Floor Bracket (Anchor Kit) (Optional)

- The anchoring kit should include brackets to provide restraint for the PDU to a non-combustible floor.

1.6 Quality Assurance

Manufacturer's Qualifications

- The manufacturer should have a minimum of 40 years' experience in the design, manufacture, and testing of PDU.
- The quality system for the engineering and manufacturing facility should certified to conform to Quality System Standard ISO 9001 for the design and manufacture of power protection systems for computers and other sensitive electronics.
- The specified system should factory-tested before shipment. Testing shall include but shall not be limited to: Quality Control Checks, Hi-Pot Test (per UL requirements), and Metering Calibration Tests.

1.7 Delivery, Storage, And Handling

1. Storage Temperatures: -4 °F to +131 °F (-20 °C to +55 °C).
2. Store indoors in clean dry space (30% to 55% relative humidity) with uniform temperature to prevent condensation. Protect from exposure to dirt, fumes, water, corrosive substances, and physical damage.
3. Handle PDUs per NEMA PB 2.1, NECA 400 and written instructions of manufacturer. Handle carefully to avoid damage to PDU internal components, enclosure, and finish.

1.8 Environmental Conditions

Equipment must be rated for continuous operation under the following conditions, unless otherwise indicated:

1. **Operating Ambient Temperature**:
   - Under normal operation: not to exceed 104 °F (40 °C).
   - At low-line voltage tap setting (432 VAC): ambient temperature not to exceed 95 °F (35 °C).
2. **Operating Altitude above mean sea level:**
   - <3,300 ft. (1,000 m) at full capacity rating and at 104 °F (40 °C) operating temperature.
   - 3,301 ft. to 4,000 ft. (1006 m to 1,219 m) at 99.5% capacity rating or reduce operating temperature to 102 °F (39 °C).
   - 4,001 ft. to 5,000 ft. (1219 m to 1,524 m) at 99.0% capacity or reduce operating temperature to 99.5 °F (37.5 °C).
   - 5,001 – 6,000 feet (1524 m to 1,829 m) at 98.5% capacity or reduce operating temperature to 96.8 °F (36 °C).
   - 6,001 – 6,600 feet (1829 m to 2,011 m) at 98.1% capacity or reduce operating temperature to 94 °F (34.6 °C).
3. **Operating Relative Humidity:** 0% to 90%, non-condensing.
4. **Operating Audible Noise level:** Under normal operation noise level shall not exceed the NEMA ST- 20 standard for transformers.

1.9 Spare Parts

Provide a list of factories recommended spare parts with a corresponding price list.

1.10 Warranty

The manufacturer shall warrant the unit against defects in workmanship and materials for 12 months after initial startup or 18 months after the shipping date, whichever comes first.

2.0 PRODUCT

2.1 Manufacturers

Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include the Vertiv Liebert®.

2.2 Ratings / Electrical Requirements

1. **Full load continuous capacity**: 50 kVA, 75 kVA, 100 kVA, 125 kVA, 150 kVA, 200 kVA, 225 kVA, 250 kVA, and 300 kVA.
2. **Input Voltage:** 480 VAC and 600 VAC, 3-phase, 3-wire-plus-ground, delta configuration.
3. **Input / Output Frequency:** 60 Hz ± 5 Hz.
4. **Output Voltage:** 208Y/120V or 415Y/240V dual output taps field-configurable in 208Y/120V or 415Y/240V AC, 3-phase, 4-wire-plus-ground, solidly wye configuration.
5. **Load Power Factor:** 0.5 leading to 0.5 lagging full load with nominal input voltage.
6. **Overload Capability:** With nominal input voltage, the PDU shall be capable of supplying:
    - 125% load for 10 minutes.
    - 150% load for 2 minutes.
    - 300% load for 30 seconds.
    - 500% load for 10 seconds.
7. **Maximum Inrush Current:** not exceed 10X NFLA, Low Inrush required, 5X NFLA maximum.
8. **Transformer K-Factor:** K4, K13, and K20.
9. **Transformer Winding Material Type:** Aluminium and Copper.
10. **Transformer Temperature Rise:** 150 °C or 115 °C.
11. **PDU System Withstand Rating:** Units should carry a 35 kA or 65 kA standard short circuit withstand rating without the use of fuses. Withstand ratings should tested and certified; a label shall be applied to the unit clearly identifying this rating as required by the National Electric Code.
12. **Wiring Access:** Top and Bottom entry and exit within the same cabinet. No external cabinet shall be required for top entry or top exit.

2.3 Components

2.3.1 Enclosure and Frame

1. The frame shall be constructed of galvanized steel and riveted to provide a strong substructure. The enclosure shall be mounted on four heavy-duty swivel casters for portability and ease of installation and shall be provided with two stabilizing jacks for final installation.
2. The unit shall have removable input and output conduit plates on the top and bottom of the PDU.
    - **For single stage distribution:** pre-punched cable/conduit openings shall be provided for each output panelboard.
    - **For two stage distribution:** solid conduit plates shall be provided for field punch-provisions.
3. All service shall be capable of being performed with access to the front and top only.
    - A tool shall be required to remove the panels which access the hazardous voltage area of the unit.

4. The unit shall have lockable, removable, hinged front doors made of sheet metal construction.
    - A one-point latch with key lock is provided for security. Doors shall provide access to the main input circuit breaker and to all output circuit breakers.
    - To ensure grounding integrity and for static protection and EMI/RFI shielding, the removable exterior panel with HMI/Display shall be grounded to the frame by way of stranded copper wire.
    - Doors and side panels shall be manufacturer's standard color, black-gray matte (ZP-7021). Optional custom painting to match or accent the data processing equipment shall be available.
5. The unit shall be naturally convection cooled. No fans for forced-air cooling system shall be used. The convection cooling method shall allow continuous full-load operation without activation of overtemperature circuits. For heat rejection, the PDU shall utilize an inverted conduit plate with solid top and vented sides. The solid top shall prohibit entry of foreign materials.
6. The transformer frame shall be configured to accept future field installation bolt-on distribution sections containing additional panel boards or sub-feed breakers. *Refer to the* **Components** *for additional distribution options*.
7. The dimension (wide x high x deep) of base transformer cabinet shall be a maximum of 42 in. x 81.5 in. x 36 in. (1052 mm x 2071 mm x 915 mm). When the top-hat conduit plate is installed, the height of the unit reaches 85.6 in. (2174 mm).

2.3.2 Main Input Circuit Breaker

1. Input Power Connections

- Copper bus bars for 2-hole lugs shall be provided on the line side terminals of the main input circuit breaker for connection of the input power conductors. A copper ground bus bar shall be provided for connection of a parity-sized insulated ground conductor.

2. Single Main Input Breaker

- The specified unit shall be equipped with a main input circuit breaker to provide overcurrent protection and a means for disconnecting all power to the unit. The main input circuit breaker shall be a three-pole molded case circuit breaker sized for 125% of the specified full load input current and rated for 600 VAC. The minimum UL-listed interrupting rating for the main input circuit breaker shall be 35,000 RMS or 65,000 RMS symmetrical amperes at 480 VAC. The main input circuit breaker shall include a 24 VDC shunt trip mechanism to interface with unit controls, EPO button, and other remote controls as required by the NEC and local codes.

2.3.3 Isolation Transformer

1. The unit shall contain an electrostatically shielded isolation transformer and meet the technical requirements as described in Section 2.2.
2. Transformer neutral shall be sized for at least 200% of full load.
3. The transformer shall be designed to operate with 100% single-phase, switch-mode power supplies and associated harmonic phase and neutral currents without derating.
4. The transformer shall be a dry-type, double-shielded, 3-phase, common-core, convection air-cooled transformer. The transformer shall conform to UL1561.
5. The transformer shall be energy efficient and meet DOE2016 standards.
6. The transformer shall exhibit the following characteristics:
    - Common mode noise attenuation: 80 dB up to 1.5 kHz, 65 dB minimum 1.15 kHz to 50 kHz.

- Harmonic voltage distortion, 0.5% maximum additive.

7. The isolation transformers shall be provided with six full-capacity compensation taps at 1.9% to 3.5% increments to accommodate field adjustment to match the source voltage.
    - Tap changes include:
        - Two above nominal voltage (upper range limit of at least +3.5%) and four below nominal voltage (lower range limit of at least -6%).
    - These compensation taps shall be accessible from the front, side, and rear.
8. The unit shall be provided with additional thermal overload protection for the transformer.
    - The transformer overtemperature circuit shall include a visual alarm if any internal transformer winding reaches 180 °F (356 °C).
    - Units shall automatically (shut down) (alarm) if the transformer temperature reaches 392 °F (200 °C).
    - Temperature sensors shall be located in each coil of the 3-phase windings.
    - The transformer overtemperature circuit shall trip the main input breaker (if equipped) to remove power automatically when any transformer winding temperature reaches 392 °F (200 °C).
    - The alternate transformer overtemperature circuit shut down shall be disabled and the unit shall alarm when any transformer winding temperature reaches 392 °F (200 °C).

2.3.4 Automatic/Manual Restart

- The specified unit shall be equipped with a manual restart feature to allow for an orderly supervised startup after power failure. The control circuit shall automatically energize the shunt trip mechanism of the main input breaker upon sensing output voltage failure.
- A field-selectable auto-restart mode shall be provided to deactivate the manual restart if desired.

2.3.5 Emergency Power Off

- The local emergency power off (EPO) shall include a covered push button.
    - Pressing the EPO switch shall immediately shut down the unit by activating the shunt trip of the main input circuit breaker.
    - As part of the EPO circuit, an interface shall also be provided for connecting one or more normally open or normally closed remote EPO switches to the EPO circuit.
    - For flexibility in meeting shutdown control schemes, the local EPO (unit shutdown) circuit shall be isolated from the remote EPO (room shutdown) circuit.
    - The remote EPO circuit shall be designed to allow direct connection of multiple units with single and multiple shutdown control contacts.
- A local EPO shall not be included.
    - An interface shall be provided to connecting one or more Normally Open or Normally Closed remote EPO switches which can be used to remotely shunt trip the main input breaker.
    - No local EPO button shall be provided.

2.3.6 Computer-Grade Ground

1. The specified system shall include a computer-grade, single-point ground in accordance with computer manufacturer's recommendations, IEEE Std. 1100, and the requirements of the NEC.
2. The transformer output neutral shall be solidly grounded in accordance with NEC article 250-26.
3. Grounding conductors shall be sized in accordance with IEC 364-HD-384 and applicable national and local codes.

2.3.7 Distribution

1. The PDU system shall contain panel boards, sub-feed breakers, panel boards, and sub-feed breakers.
    - The system shall utilize Square D Siemens manufactured distribution panelboards and/or sub-feed breakers.
    - Each sub-feed, panelboard main, sub-feed, and panelboard main breaker must be equipped with 1A1B and 2A2B auxiliary contacts for monitoring breakers change of state from closed to open.
    - Each breaker must be equipped with an alarm switch contacts for indicating breaker tripped status.
    - The breaker accessories shall be monitored by the PDU monitoring system remotely by the local BMS.
    - (Optional) Load bank provisions, for each panelboard, are required.
2. **Panel board Technical Specs:**
    - Each output distribution panelboard shall be individually protected by a main panelboard circuit breaker.
    - Each panelboard shall be protected with a hinged accent panel which requires a tool for accessing.
    - Each panelboard shall have a rating of 400 A, with an interrupting rating of 22 kA RMS at 240 or 120 VAC minimum.
    - Each panelboard shall provide a total of 42 branch circuit breaker positions and 10 kAIC or 22 kAIC rated branch circuit breakers must be used.
    - Each panelboard shall include separate isolated neutral and safety ground busbars for the neutral and safety-ground connections to match the number of output circuits. The neutral busbar and wiring shall be sized for at least 1.73 times the panelboard's full load rating.
    - Each panelboard shall have removable output cable landing plates.
3. **Sub-feed Breaker Technical Specification**
    - Each sub-feed breaker shall be a 600 volts AC rated molded case circuit breaker and shall be rated for 25 kA amperes symmetrical minimum overall short-circuit current rating at 240 VAC.
4. Each distribution section shall be capable of the following distribution options:

    Section 1:

    - None

- Up to one 42P (Square D bolt/plug-in) (Siemens bolt-in) vertically mounted panelboard with a (250AF, 80%) (400AF, 80%) (250AF, 100%) (400AF, 100%) rated Main breaker.
- Up to five 250AF sub-feed breakers shall be provided.
- Up to two 600AF sub-feed breakers shall be provided.

Section 2:

- None
- Up to one 42P (Square D bolt/plug-in) (Siemens bolt-in) vertically mounted panelboard with a (250AF, 80%) (400AF, 80%) (250AF, 100%) (400AF, 100%) rated Main breaker.
- Up to five 250AF sub-feed breakers shall be provided.
- Up to two 600AF sub-feed breakers shall be provided.

Auxiliary Distribution Section

- None
- The PDU shall offer an auxiliary distribution section which allows for up to two 250AF 80% and 250AF 100% or up to one 400AF 80% or 400AF 100% rated breakers to be installed.

5. Attached Ancillary Distribution Cabinets (optional)

- FLX12A is a front-facing sub-feed breaker cabinet which accommodates up to (three 400AF/600AF sub-feed breakers) (four 250AF sub-feed breakers) which are 80% or 100% rated.
- The dimension (W x H x D) of cabinet 12 in. x 81.5 in. x 36 in. (305 mm x 2071 mm x 915 mm).
- The cabinet shall have two removable conduit plates for punching in the field. When the top- hat conduit plate is installed, the height of the unit reaches 85.6 in. (2174 mm).
- The cabinet shall be mounted on the left or right side of the main transformer cabinet.
- FLX12D is a side-facing panelboard cabinet which shall be equipped with one or two 400 A panel boards and 250AF 80% or 400AF 100% rated panelboard main breakers.
- The cabinet shall be 12 in. (305 mm) Wide by 81.5 in. (2071 mm) High by 36 in. (915 mm) Deep.
- The two panelboards shall be isolated from each other and isolated from the panelboard main breakers. No wiring from one panelboard shall pass through the adjacent panelboard section.
- The cabinet shall have four removable conduit plates; two plates shall be pre-punched for standard 100A or below conduits and the remaining two plates shall be solid and punch-able in the field.
- The cabinet shall be mounted on the left or right side of the main transformer cabinet.
- FLX18E is a side-facing panelboard cabinet which shall be equipped with a 800A I-Line panelboard and 800A panelboard main breaker which is rated for continuous current operation.
- The dimension (W x H x D) of cabinet 18 in. x 81.5 in. x 36 in. (457 mm x2071 mm x 915 mm).
- The cabinet shall have two removable conduit plates; the plates shall be solid and punch-able in the field. When the top-hat conduit plate is installed, the height of the unit reaches 85.6 in. (2174 mm).
- The cabinet shall be mounted on the left or right side of the main transformer cabinet.

- The ancillary distribution cabinets shall utilize the same manufacturer for distribution as the main transformer cabinet.

2.4 Power Monitoring (Transformer Only) And Controls

1. Provide interface for solid-state digital power monitoring as shown on the electrical one-line diagrams, communications block diagrams and in compliance with this Electrical Power Monitoring Control section.
2. The specified system shall be equipped with a microprocessor-based power monitoring system. The monitoring system shall gather and process information from electrical and environmental sensors, relays, and switches both internal and external to the unit. The monitored parameters and alarms shall be displayed on the unit control panel/display and shall also be available for communication to a centralized monitoring system.
3. The monitoring system shall monitor and display all the following parameters:
   - Frequency.
   - Input Voltage, Line-to-Line for all three phases.
   - Output Voltages, Line-to-Line for all three phases.
   - Output Voltages, Line-to-Neutral for all three phases.
   - Output Current for all three phases.
   - Output Neutral Current.
   - System Ground Current.
   - Output Current Load for all three phases.
   - Output Real Power.
   - Output Apparent Power.
   - Output Apparent Power Load.
   - Output Power Factor for all three phases and total.
   - Output Energy.
   - Output Peak Current for all three phases.
   - Output Peak Demand.
   - Output Current Crest Factor (Peak/RMS) for all three phases.
   - Output Current Harmonic K-Factor for all three phases.
   - Output Current Total Harmonic Distortion (THD) for all three phases.
   - Output Current 3rd, 5th, 7th, and 9th Order Harmonic Distortion Components for all three phases.
   - Input Voltage Total Harmonic Distortion (THD) for all three phases, which includes 3rd, 5th, 7th, and 9th Harmonics.
4. All three phases of the 3-phase parameters shall be displayed simultaneously. All voltage and current parameters shall be monitored using true RMS measurements for accurate representation of non-sinusoidal waveforms typical of computers and other sensitive loads.
5. The monitoring system shall detect and annunciate by audible alarm and alarm message the following conditions:

- Output Overvoltage.
- Output Undervoltage.
- Phase Overcurrent.
- Neutral Overcurrent.
- Ground Overcurrent.
- Voltage Distortion.
- Frequency Deviation.
- Phase Sequence Error.
- Phase Loss.
- Transformer High Temperature.

6. All alarm thresholds for monitored parameters shall be adjustable by graphical user interface (GUI) or USB Port to match site requirements. The factory set points for the alarms shall be as follows:
    - **Output Overvoltage:** Output voltage exceeds +6% of nominal.
    - **Output Undervoltage:** Voltage falls below -13% of nominal.
    - **Output Overcurrent:** Current exceeds 80% of full load amps.
    - **Neutral Overcurrent:** Current exceeds 95% of full load amps.
    - **Ground Overcurrent:** Current exceeds 10 A for 150 kVA to 225 kVA and 15 A for 250 kVA to 300 kVA.
    - **Output Voltage Distortion:** Output voltage THD exceeds 10%.
    - **Frequency Deviation:** output frequency exceeds ±0.5 Hz of nominal.
7. To facilitate troubleshooting, all alarms shall be stored in (non-volatile) memory until reset to protect against erasure by a power outage. Alarms shall be able to be manually reset after the alarm condition has been corrected either at the unit or by way of the central monitoring system.
8. Custom Alarm Annunciation
    - The monitoring system shall be capable of providing alarm annunciation for up to two contact closures (two N.O. and N.C.).
    - A custom alarm message up to 29 characters shall be provided for each contact.
    - Alarm messages shall be programmable by the GUI or USB port to match site requirements.
9. Summary Alarm Contact
    - A Form C (one N.O. and N.C.) Summary Alarm Contact shall be provided for remote alarm status. The contacts shall change state upon occurrence of any alarm and shall rest upon alarm silence.
10. Control Panel/Display
    - The PDU shall be provided with a microprocessor-based control panel for operator interface (may also be referred to as graphical user interface or GUI) to configure and monitor the PDU. The control panel shall be located on the front of the unit where it can be operated without opening the hinged front door.
    - A 9.0 in., backlit, menu-driven, full-graphics, color touchscreen liquid crystal display shall be used to display system information, metering information, a one-line diagram of the PDU, active events and event history.
    - No mechanical push buttons shall be used to control the interface. Mechanical EPO push buttons are acceptable.
    - Control Panel Logic

- PDU system logic and control programming shall reside in a microprocessor-based control system with nonvolatile flash memory.
- System control logic shall utilize high-speed digital signal processors (DSPs). CANbus shall be used to communicate between the logic and the User Interface as well as the options.
- Switches, contacts, and relays shall be used only to signal the logic system as to the status of mechanical devices or to signal user control inputs. Customer external signals shall be isolated from the PDU logic by relays or optical isolation.

- The control panel/display shall monitor the base transformer cabinet and any attached ancillary cabinets.

11. Remote Monitoring Communication

- Two Vertiv™ Liebert® IntelliSlot™ ports shall be provided to allow communication to remote monitoring systems using Liebert® IntelliSlot™ cards.
  - Equipped RDU101 Cards, for remote communication, can use up to two of the following protocols: HTTP/HTTPS, Vertiv Protocol, Email, SMS, SNMP v1/v2c/v3, BACnet IP and Modbus TCP output. BACnet/MSTP and Modbus/RTU support will require a USB to RS-485 adapter. The adapter is available as an accessory.

Note: Two of the 3rd party protocols (SNMP, Modbus, or BACnet) may be configured and used simultaneously.

- Modbus RTU and BACnet MSTP cannot both be enabled simultaneously.

3.0 PRODUCT

3.1 Packaging and Shipping

1. The manufacturer shall have tested the packaging to ISTA 3B testing, which will provide adequate packaging to ensure there is no damage to the units while in transport.
2. The manufacturer shall provide adequate notice to the contractor of shipping and arrival times.
3. The contractor shall arrange for receiving and provide storage for any units prior to installation. Unit storage should be provided in accordance with the environmental conditions outlined in this specification.

3.2 Factory Services

1. The manufacturer shall provide a certified copy of the factory test report in electronic format.
2. The owner and/or the owner's representative shall be permitted to witness the factory test of each unit. The factory shall perform an enhanced certified test report to demonstrate the unit meets the required specifications. A copy of the report will be provided with each unit and in electronic format. Optional pricing shall be provided as part of the bid process.
3. (optional) The manufacturer will offer a 2-, 4-, 6-, or 8-hour burn-in system test with data logging every 30 minutes. A copy of the burn-in report will be provided with each unit and in electronic format. Optional pricing shall be provided as part of the bid process.

3.3 Installation (By Others)

1. Install PDUs and accessories per NEMA/ANSI standards.
2. Install the PDUs level on floor as required by manufacturer.
3. Adjustments:
   - Set field-adjustable switches and circuit-breaker trip ranges.
   - Install overcurrent protective devices, transient voltage suppression devices, and instrumentation as required.
4. The contractor shall provide labour for the installation of the new equipment in accordance with the manufacturer. All rigging for unloading and installation shall be the responsibility of the contractor.
5. The contractor shall install the equipment as shown on the drawings and ensure all required working clearances are maintained.

3.4 Field Identification (By Others)

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Section 26 xx xx.
2. PDU Nameplates: Label each PDU compartment with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.
3. Provide arc flash potential labelling per NEC, NFPA 70E, and in accordance with Section 26 xx xx, Identification for Electrical Systems.

3.5 Field Testing (by Others)

(optional)

3.6 Factory Onsite Services and Offerings

1. Factory-authorized service representative shall perform startup service.
2. The manufacturer shall directly employ a nationwide service organization of factory-trained field service personnel dedicated to the startup, maintenance, and repair of the manufacturer's power equipment.
3. The manufacturer shall maintain a national dispatch center 24 hours per day, 365 days per year, to minimize service response time and to maximize availability of qualified service personnel.

3.7 Field Quality Control

1. The PDU manufacturer shall provide qualified field service technicians for assistance in the installation, startup, and site acceptance testing. This work shall include but not be limited to the following:
    - Instruct and train the contractor on the installation and wiring of the equipment.
    - Perform a detailed installation inspection of the equipment prior to energizing.
    - Verify all power wiring connections are proper and tight.
    - Verify all control, instrumentation, and communications wiring connections are correct and tight.
2. Manufacturer's technician shall be present and participate in energizing the equipment.
    - Assist in startup of monitoring system.
    - Perform a comprehensive test on the energized unit including:
        - Checkout of all metering, monitoring, and alarm functions and set points including communications to remote monitoring system.

3.8 Cleaning (by Others)

Upon completion of installation, inspect interior and exterior of PDUs. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

4.0 SUPPLEMENTAL ACCESSORIES / OPTIONS

4.1 Additional Options

1. **Skirt Kits**

   Skirt kits are provided in forced air/raised floor applications: the PDU must have an open floor stand to allow forced air cooling to proliferate through the PDU. Refer to submittal TFX-24-S05x for required static pressure (SP).

2. **IR Scan Ports**

IR scan ports are required for monitoring the following internal components:

- Transformer taps
- Ground and neutral installer connections
- Main input circuit breaker connections

4.1.1 Alternate 1 - System Surge Rating

The specified system shall comply with ANSI/IEEE C62.41 Category B2 (4 kV maximum surge rating).

1. **AC Input surge protection to include:**
   - The system shall be equipped with a surge arrester to divert high-voltage input power surges quickly and safely to ground.
   - The surge arrester shall be mounted ahead of all electrical components to provide maximum protection of the unit insulation and wiring.
   - The surge arrester shall be capable of repeated operations and have a surge current rating of 40 kA/phase and short-circuit current rating of 200 kA and discharge current rating of 10 kA. It has UL 1449 4th edition certification and UL96A Lightning protection.
2. **AC Output Surge protection to include:**
   - The unit shall be equipped with a surge suppression module to eliminate high-speed, high-energy transients and to filter high-frequency noise. The surge suppression module shall be mounted on the output of the unit. The surge suppressor components shall be UL recognized.
   - The surge suppressor shall utilize high-energy metal oxide varistors (MOV). Peak current handling capability shall be at least 6,500 amperes based on an 8 x 20 microsecond waveform. Energy absorption capability shall be at least 80 joules for L-N and 130J for L-L.

4.1.2 Alternate 2 - System Surge Rating

The specified system shall comply with ANSI/IEEE C62.41 Category B3 (6 kV maximum surge rating).

3. **AC Input surge protection to include:**
   - The system shall be equipped with a surge arrester to divert high-voltage input power surges quickly and safely to ground.
   - The surge arrester shall be mounted ahead of all electrical components to provide maximum protection of the unit insulation and wiring.
   - The surge arrester shall be capable of repeated operations and have a surge current rating of 40 kA/phase and short-circuit current rating of 200 kA and discharge current rating of 10 kA. It has UL 1449 4th edition certification and UL96A Lightning protection.

4. **Output Surge Suppression (TVSS)**

   - The unit shall be equipped with a high-energy, UL1449 listed Transient Voltage Surge Suppression (TVSS) module connected to the unit output with minimal interconnecting wiring for maximum surge suppression.
   - The TVSS shall be UL 1449 Fourth Edition Listed. Designed, Manufactured and Tested consistent with:
     - ANSI/IEEE C62.41.1-2002, C62.41.2-2002, C62.45-2002, C62.62-2010, C62.72-2016, and IEEE SA.
     - 1100-2005 (Emerald Book).
     - NEC Article 285.
     - NEC Articles 620.51(E), 645.18, 670.6, 695.15, 700.8, and 708 requiring SPDs.
     - UL 96A and NFPA 780 Lightning Protection.
     - IEC 61643, CE.
   - The surge arrester shall be capable of repeated operations and have a surge current rating of 100 kA/phase and Short-Circuit Current Rating of 200 kA and discharge current rating of 20 kA.
   - The maximum continuous operating voltage shall be at least 150 VAC for a 120/208 volt system
   - An alarm contact of the TVSS module shall be connected to the unit monitoring system to annunciate any TVSS failure.

4.1.3 Alternate 1 - Dual Main Input Breaker

1. The specified unit shall be equipped with two main input circuit breakers to provide overcurrent protection from two independent sources while also supplying a means for disconnecting all power to the unit. The main input circuit breakers shall be a three-pole moulded case circuit breaker sized for 125% of the specified full load input current and rated for 600 VAC. The minimum UL-listed interrupting rating for the main input circuit breakers shall be 35,000 RMS or 65,000 RMS symmetrical amperes at 480 VAC. The main input circuit breakers shall include a 24 VDC shunt trip mechanism to interface with unit controls, EPO button and other remote controls as required by the NEC and local codes.
2. The Dual MICB provides a kirk-key configuration for a break-before-make configuration.

4.1.4 Alternate 2 - No Main Input Breaker

The specified unit shall be equipped without a main input circuit breaker; the customer is responsible for providing overcurrent protection upstream. Refer to the technical details submittal for breaker requirements.

4.1.5 Alternate - IP-2X Touch-safe Distribution

1. The PDU manufacturer shall provide an Enhanced Finger safe IP-2X IEC 60529 certified NQ panel board solution manufactured by Square D. Square D's Enhanced Finger safe panel boards greatly reduces risk when workers attempt to work on an energized panel per OSHA CFR 1910.333(a)(1) guidelines. The panel board must utilize off-the-shelf branch circuit breakers available locally or via distribution to assure uptime and flexibility onsite.
2. Panel board Technical Specification:
   - Each output distribution panelboard shall be individually protected by a main panelboard circuit breaker.

- Each panelboard shall be protected with a hinged accent panel which requires screws for accessing.
- Each panelboard shall have a rating of 400 amperes, with an interrupting rating of 22 kA RMS at 240/120 VAC minimum.
- Each panelboard shall provide a total of 42 branch circuit breaker positions and 10 kAIC or 22 kAIC rated branch circuit breakers must be used.
- Each panelboard shall include separate isolated neutral and safety ground busbars for the neutral and safety-ground connections to match the number of output circuits. The neutral busbar and wiring shall be sized for at least 1.73 times the panelboard's full load rating.
- Each panelboard shall have removable output cable landing plates.

3. Each distribution section shall be capable of the following distribution options:

   Section 1:

   - None
   - Up to one 42P (Square D bolt/plug-in) (Siemens bolt-in) vertically mounted panelboard with a (250AF, 80%) (400AF, 80%) (250AF, 100%) (400AF, 100%) rated Main breaker.

   Section 2:

   - None
   - Up to one 42P (Square D bolt/plug-in) (Siemens bolt-in) vertically mounted panelboard with a (250AF, 80%) (400AF, 80%) (250AF, 100%) (400AF, 100%) rated Main breaker.

   Auxiliary Distribution Section

   - The PDU shall offer an auxiliary distribution section which allows for up to two (250AF, 80%) (250AF, 100%) or one (400AF, 80%) (400AF, 100%) rated breakers to be installed.

4.2 Alternate 1 — Power Monitoring (Transformer and Distribution) and Controls

1. Provide interface for solid-state digital power monitoring as shown on the electrical one-line diagrams, communications block diagrams and in compliance with this Electrical Power Monitoring Control section.
2. The specified system shall be equipped with a microprocessor-based power monitoring system. The monitored parameters and alarms shall be displayed on the unit control panel/display and shall also be available for communication to a centralized monitoring system.
3. The monitoring system shall monitor and display all the following primary side input and secondary side output parameters:
   - Frequency.
   - Input Voltage, Line-to-Line for all three phases.
   - Output Voltages, Line-to-Line for all three phases.
   - Output Voltages, Line-to-Neutral for all three phases.
   - Output Current for all three phases.
   - Output Neutral Current.
   - System Ground Current.
   - Output Current Load for all three phases.

- Output Real Power (kW).
- Output Apparent Power (kVA).
- Output Apparent Power Load.
- Output Power Factor for all three phases and total.
- Output Energy (kWH).
- Output Peak Current for all three phases (kW).
- Output Peak Demand (kW).
- Output Current Crest Factor (Peak/RMS) for all three phases.
- Output Current Harmonic K-Factor for all three phases.
- Output Current Total Harmonic Distortion (THD) for all three phases, which includes monitoring the 3rd, 5th, 7th, and 9th Harmonics.
- Input Voltage Total Harmonic Distortion (THD) for all three phases, which includes monitoring the 3rd, 5th, 7th, and 9th Order Harmonics.
- Output Voltage Total Harmonic Distortion (THD) for all three phases, which includes monitoring the 3rd, 5th, 7th, and 9th Order Harmonics.

4. The monitoring system shall monitor and display all the following panel board main and/or sub-feed breaker parameters.
    - Phase Current.
    - Neutral Current.
    - Ground Current.
    - Current Load percentage.
    - Voltage Line-to-Line.
    - Voltage Line-to-Neutral.
    - Frequency.
    - Real Power (kW).
    - Apparent Power (kVA).
    - Power Factor.
    - Energy (kW-Hours).
    - Peak Current (A).
    - Peak Demand (kW).
    - Current Crest Factor.
    - Current Total Harmonic Distortion (THD) in total THD and includes 3rd, 5th, 7th, and 9th Harmonics.
    - Voltage Total Harmonic Distortion (THD) in total THD and includes 3rd, 5th, 7th, and 9th Harmonics.
    - Circuit identification and status of each breaker shall be displayed.

5. The sub-feed breakers or panel board mains shall be monitored using 5W (3PH+N+G) 4W (3PH+N) current transformer (CT) kits.
6. The monitoring system shall monitor and display all the following panel board branch breaker parameters.
    - Phase Current.
    - Percent Load.
    - Real Power (kW).
    - Power Factor.
    - Energy (kW-Hours).
    - Peak Current (A).
    - Peak Demand (kW).
    - Circuit identification of each breaker shall be displayed.
7. All three phases of the three-phase parameters shall be displayed simultaneously. All voltage and current parameters shall be monitored using true RMS measurements for accurate representation of non-sinusoidal waveforms typical of computers and other sensitive loads.
8. The monitoring system shall detect and annunciate by audible alarm and alarm message the following conditions:
    - Output Overvoltage.
    - Output Undervoltage.
    - Phase Overcurrent.
    - Neutral Overcurrent.
    - Ground Overcurrent.
    - Voltage Distortion.
    - Frequency Deviation.
    - Phase Sequence Error.
    - Phase Loss.
    - Transformer High Temperature.
    - Sub-feed or Panelboard mains equipped with alarm switches shall indicate tripped status.
    - Sub-feed or Panelboard mains equipped with auxiliary switches shall indicate accessory fail if the aux switch fails.
    - Summary Alarm.
9. All alarm thresholds for monitored parameters shall be adjustable by graphical user interface (GUI) or USB Port to match site requirements. The factory set points for the alarms shall be as follows:
    - **Output Overvoltage**: Voltage exceeds +6% of nominal.
    - **Output Undervoltage**: Voltage falls below -13% of nominal.
    - **Output Overcurrent:** Current exceeds 80% of full load amps.

- **Neutral Overcurrent**: Current exceeds 95% of full load amps.
- **Ground Overcurrent:** Current exceeds 10 A for 150 kVA to 225 kVA or 15 A for 250 kVA to 300 kVA.
- **Output Voltage Distortion:** Output voltage THD exceeds 10%.
- **Frequency Deviation**: Output frequency exceeds ±0.5 Hz of nominal.

10. To facilitate troubleshooting, all alarms shall be stored in (non-volatile) memory until reset to protect against erasure by a power outage.
11. Alarms shall be able to be manually reset after the alarm condition has been corrected either at the unit or by way of the central monitoring system.
12. Custom Alarm Annunciation
    - The monitoring system shall be capable of providing alarm annunciation for up to two contact closures (two N.O. and N.C.).
    - A custom alarm message up to 29 characters shall be provided for each contact.
    - Alarm messages shall be programmable by the GUI or USB port to match site requirements.
13. Summary Alarm Contact
    - A Form C (one N.O. and N.C.) Summary Alarm Contact shall be provided for remote alarm status. The contacts shall change state upon occurrence of any alarm and shall rest upon alarm silence.
14. Control Panel/Display
    - The PDU shall be provided with a microprocessor-based control panel for operator interface (may also be referred to as graphical user interface or GUI) to configure and monitor the PDU. The control panel shall be located on the front of the unit where it can be operated without opening the hinged front door.
    - A 9 in., backlit, menu-driven, full-graphics, color touchscreen liquid crystal display shall be used to display system information, metering information, a one-line diagram of the PDU, active events and event history.
    - In addition to measuring and recording numerical values for voltage and current, the PDU shall be able to also capture sinusoidal waveform data. The captured current and voltage waveform provides additional information for analyzing the system's power quality.
    - No mechanical push buttons shall be used to control the interface. Mechanical EPO push buttons are acceptable.
    - Control panel logic.
      - PDU system logic and control programming shall reside in a microprocessor-based control system with nonvolatile flash memory.
      - System control logic shall utilize high-speed digital signal processors (DSPs). CANbus shall be used to communicate between the logic and the User Interface as well as the options.
      - Switches, contacts, and relays shall be used only to signal the logic system as to the status of mechanical devices or to signal user control inputs. Customer external signals shall be isolated from the PDU logic by relays or optical isolation.

- The control panel/display shall monitor the base transformer cabinet and any attached ancillary cabinets.

15. **Remote Monitoring Communication**

Two Vertiv™ Liebert® IntelliSlot™ Slot ports shall be provided to allow communication to remote monitoring systems using Liebert® IntelliSlot™ cards.

- Equipped RDU101 Cards, for remote communication, can use up to two of the following protocols: HTTP/HTTPS, Vertiv Protocol, Email, SMS, SNMP v1/v2c/v3, BACnet IP, and Modbus TCP output. BACnet/MSTP and Modbus/RTU support will require a USB to RS-485 adapter. The adapter is available as an accessory.

NOTE: Two of the 3rd party protocols (SNMP, Modbus, or BACnet) may be configured and used simultaneously.

- Modbus RTU and BACnet MSTP cannot both be enabled simultaneously.

4.2.1 Alternate 2 - No Power Monitoring and No Controls

16. The no-monitoring option shall have transformer overtemperature and emergency power off (EPO) circuits only.
17. The transformer overtemperature circuit shall include a visual alarm if any internal transformer winding temperature reaches 356 °F (180 °C).