PIP ELSAP04
Uninterruptible Power Supply (UPS)
System Specification
PURPOSE AND USE OF PROCESS INDUSTRY PRACTICES

In an effort to minimize the cost of process industry facilities, this Practice has been prepared from the technical requirements in the existing standards of major industrial users, contractors, or standards organizations. By harmonizing these technical requirements into a single set of Practices, administrative, application, and engineering costs to both the purchaser and the manufacturer should be reduced. While this Practice is expected to incorporate the majority of requirements of most users, individual applications may involve requirements that will be appended to and take precedence over this Practice. Determinations concerning fitness for purpose and particular matters or application of the Practice to particular project or engineering situations should not be made solely on information contained in these materials. The use of trade names from time to time should not be viewed as an expression of preference but rather recognized as normal usage in the trade. Other brands having the same specifications are equally correct and may be substituted for those named. All Practices or guidelines are intended to be consistent with applicable laws and regulations including OSHA requirements. To the extent these Practices or guidelines should conflict with OSHA or other applicable laws or regulations, such laws or regulations must be followed. Consult an appropriate professional before applying or acting on any material contained in or suggested by the Practice.

This Practice is subject to revision at any time.

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# PIP ELSAP04
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1. **Introduction**

1.1 **Purpose**

This Practice provides the requirements for a complete on-line, continuous duty, uninterruptible power supply (UPS) system.

1.2 **Scope**

This Practice and the purchaser’s *PIP ELSAP04D* Data Sheet describe the minimum requirements for design, fabrication, inspection, testing, shipment, and documentation for a complete on-line, UPS system of either a pulse width modulated (PWM) or ferroresonant type.

A PWM-type UPS system includes a rectifier/charger, inverter, static bypass switch, manual bypass switches, transformers, and accessories. A ferroresonant-type UPS system includes a rectifier/charger, inverter, constant voltage or ferroresonant transformer, static bypass switch, manual bypass switches, transformers, and accessories.

2. **References**

Applicable parts of the following Practices, and industry codes and standards shall be considered an integral part of this Practice. The edition in effect on the date of contract award shall be used, except as otherwise noted. Short titles are used herein where appropriate.

2.1 **Process Industry Practices (PIP)**

- *PIP ELSAP04D - Data Sheet for Uninterruptible Power Supply (UPS) System*
- *PIP ELSAP11 - Design and Fabrication of Flooded-Cell Lead-Acid Batteries*
- *PIP ELSAP12 - Design and Fabrication of Valve-Regulated Lead-Acid Batteries*

2.2 **Industry Codes and Standards**

- American National Standards Institute (ANSI) and Institute of Electrical and Electronics Engineers (IEEE)
  - ANSI/IEEE C57.110 – IEEE Recommended Practice for Establishing Liquid-Filled and Dry-Type Power and Distribution Transformer Capability When Supplying Nonsinusoidal Load Currents
- InterNational Electrical Testing Association (NETA)
  - Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems (ATS)
- International Electrotechnical Commission (IEC)
  - IEC 62040-3 - Uninterruptible Power System (UPS) – Part 3: Method of Specifying the performance and Test Requirements
- National Electrical Manufacturers Association (NEMA)
  - NEMA PB1 - Panelboards
3. Definitions

- **crest factor**: The ratio of the peak (maximum) value of a periodic function to its root-mean-square (rms) value
- **frequency slew-rate**: The rate of change of frequency expressed in hertz per second
- **owner**: The party who owns the facility wherein the UPS system will be used
- **purchaser**: The party who awards the contract to the supplier. The purchaser may be the owner or the owner’s authorized agent.
- **supplier**: The party responsible for providing the UPS system
- **walk-in**: The initial controlled power increase to the rectifier by the UPS from the AC input source

4. Requirements

4.1 General

4.1.1 UPS configuration shall be an on-line type system of the type specified and rated to supply the full load as specified on the purchaser’s PIP ELSAP04D Data Sheet.

4.1.2 UPS shall be designed, constructed, and tested in accordance with the applicable requirements of NEMA PE 1 and UL 1778.

4.1.3 As specified on the purchaser’s PIP ELSAP04D Data Sheet, UPS shall be UL listed or have an owner approved Nationally Recognized Testing Laboratory (NRTL) label.

4.1.4 All components and material shall be new and of the latest field-proven design and in current production.

4.1.5 A typical UPS configuration is shown in Figure 1. The final configuration shall be in accordance with a system one-line or block diagram as specified on the purchaser’s PIP ELSAP04D Data Sheet.
Figure 1. Typical UPS Configuration
4.1.6 UPS shall be capable of carrying 100% unbalanced loads.

4.1.7 UPS shall be capable of operating with a load step change of 0% to 100%, without transferring to the bypass source.

4.1.8 Overload devices shall not be activated when the system is started under any normal operating conditions.

4.1.9 UPS shall be designed so that the battery source can be isolated and removed for maintenance without transferring to bypass mode of operation or interrupting the load.

4.1.10 Control logic power supply shall be redundant to ensure control power at all times. Power to the power supplies shall originate from any of the following:
   a. Rectifier/charger input
   b. Bypass input
   c. Battery input

4.1.11 System shall be designed to permit front access to modules, circuit breakers, fuses, and assemblies.

4.1.12 Any front-panel-mounted input/output device that can be adjusted shall be either password-protected or adjustable by tool only.

4.1.13 The rectifier/charger and inverter bridge semiconductors shall be protected from cascaded failure with special fast-acting fuses.

4.1.14 All power semiconductors, including the static bypass switch, shall be protected from short-circuit failure.

4.1.15 All operating devices shall be accessible from the front of the cabinet or enclosure with the door closed, and their function shall be clearly labeled.

4.1.16 Parts, test-points, and terminals shall be placed so they are accessible for circuit checking, adjustment, and maintenance without removing any adjacent assembly or component or without posing a shock hazard.

4.1.17 Audible noise generated by the UPS under normal full-load operating conditions shall not exceed 75 dBA at a distance of three (3) feet (1 meter) from the front of the cabinet.

4.1.18 The UPS electromagnetic interference suppression shall be in accordance with FCC 47CFR15 for Class A devices.

4.1.19 Cable entry shall be as specified on the purchaser’s PIP ELSAP04D Data Sheet.

4.1.20 Unless otherwise specified on the purchaser’s PIP ELSAP04D Data Sheet, tin-plated copper ground bus shall be provided inside each cabinet and inside the remote maintenance bypass switch (RMBS) enclosure.

4.1.21 Ground buses shall be a minimum of 1/4 inch thick and 1 inch wide, and pre-drilled for the installation of 1-hole compression-type connector(s) for connection to the copper grounding cable.

4.1.22 If individual indicator lights are provided, the lights shall be replaceable LEDs.
4.1.23 Unless otherwise specified on the purchaser’s PIP ELSAP04D Data Sheet, printed circuit boards shall be conformal coated.

4.2 Site Conditions

4.2.1 UPS system shall be designed for indoor continuous operation.

4.2.2 Unless otherwise specified on the purchaser’s PIP ELSAP04D Data Sheet, the UPS shall be capable of operating continuously at rated output in an ambient temperature range of 32°F (0°C) to 104°F (40°C).

4.2.3 Unless otherwise specified on the purchaser’s PIP ELSAP04D Data Sheet, UPS shall operate at full rated output over the entire temperature range at a relative humidity range of 5% to 95% non-condensing.

4.2.4 UPS shall operate at full rated output at an altitude of 3300 feet (1000 meters) or less unless otherwise specified on the purchaser’s PIP ELSAP04D Data Sheet.

4.2.5 Unless otherwise specified on the purchaser’s PIP ELSAP04D Data Sheet, UPS is located in an electrically unclassified area.

4.3 Electrical Characteristics

The electrical performance characteristics for the UPS shall be in accordance with Table 1 for the electrical system specified on purchaser’s PIP ELSAP04D Data Sheet.

<table>
<thead>
<tr>
<th>Table 1. Electrical Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Input</strong></td>
</tr>
<tr>
<td>1. Power rating</td>
</tr>
<tr>
<td>2. Normal input voltage and frequency</td>
</tr>
<tr>
<td>3. Supply system type</td>
</tr>
<tr>
<td>4. Bypass source voltage</td>
</tr>
<tr>
<td>5. Input power factor</td>
</tr>
<tr>
<td><strong>Ferroresonant</strong></td>
</tr>
<tr>
<td>See purchaser’s data sheet</td>
</tr>
<tr>
<td>See purchaser’s data sheet</td>
</tr>
<tr>
<td>Delta, wye, resistance grounded wye; see purchaser’s data sheet</td>
</tr>
<tr>
<td>Same as output voltage, unless otherwise specified on the purchaser’s data sheet</td>
</tr>
<tr>
<td>≥ 0.8 lagging</td>
</tr>
<tr>
<td><strong>Pulse-width Modulated</strong></td>
</tr>
<tr>
<td>See purchaser’s data sheet</td>
</tr>
<tr>
<td>See purchaser’s data sheet</td>
</tr>
<tr>
<td>Delta, wye, resistance grounded wye; see purchaser’s data sheet</td>
</tr>
<tr>
<td>Same as output voltage, unless otherwise specified on the purchaser’s data sheet</td>
</tr>
<tr>
<td>≥ 0.8 lagging</td>
</tr>
<tr>
<td><strong>B. Rectifier/Charger</strong></td>
</tr>
<tr>
<td>1. Normal voltage tolerance</td>
</tr>
<tr>
<td>2. Frequency tolerance</td>
</tr>
<tr>
<td>3. Input current total harmonic distortion at full load and nominal input voltage</td>
</tr>
<tr>
<td>+10% to -10% nominal without discharging batteries or switching to the bypass source ±5%</td>
</tr>
<tr>
<td>≤ 35% THD unless otherwise specified on the purchaser’s data sheet</td>
</tr>
<tr>
<td>+10% to -15% nominal without discharging batteries or switching to the bypass source ±5%</td>
</tr>
<tr>
<td>≤ 35% THD unless otherwise specified on the purchaser’s data sheet</td>
</tr>
<tr>
<td><strong>C. DC Circuit</strong></td>
</tr>
<tr>
<td>1. Voltage regulation</td>
</tr>
<tr>
<td>2. Ripple voltage</td>
</tr>
<tr>
<td>3. Battery recharge time</td>
</tr>
<tr>
<td>±1%</td>
</tr>
<tr>
<td>Shall not exceed the limits specified in NEMA PE 5-1997 (R2003), Table 6</td>
</tr>
<tr>
<td>8 hours maximum</td>
</tr>
<tr>
<td>±1%</td>
</tr>
<tr>
<td>Shall not exceed the limits specified in NEMA PE 5-1997 (R2003), Table 6</td>
</tr>
<tr>
<td>8 hours maximum</td>
</tr>
<tr>
<td>Table 1. Electrical Characteristics (continued)</td>
</tr>
<tr>
<td>---------------------------------------------</td>
</tr>
<tr>
<td><strong>D. Output</strong></td>
</tr>
<tr>
<td>1. Voltage regulation</td>
</tr>
<tr>
<td>±2% for balanced loads, ±5% of nominal for 100% unbalanced 3-phase loads</td>
</tr>
<tr>
<td>2. Inverter steady-state, output voltage regulation</td>
</tr>
<tr>
<td>Shall not change more than ±2% within any of the following conditions:</td>
</tr>
<tr>
<td>a. 0% to 100% load change</td>
</tr>
<tr>
<td>b. 100% to 0% load change</td>
</tr>
<tr>
<td>c. Minimum to maximum DC bus voltage</td>
</tr>
<tr>
<td>d. Minimum to maximum ambient temperature range</td>
</tr>
<tr>
<td>e. Linear loads 0.8 to 1.0 power factor</td>
</tr>
<tr>
<td>f. Non-linear load 0.7 to 1.0 power factor</td>
</tr>
<tr>
<td>3. Transient response</td>
</tr>
<tr>
<td>+8% to -10% due to step load changes of 100% to 50% and 50% to 100% from nominal with recovery to ±2% within three cycles</td>
</tr>
<tr>
<td>±5% from nominal for 100% step load changes with full recovery within three cycles maximum</td>
</tr>
<tr>
<td>4. Phase separation (three phase)</td>
</tr>
<tr>
<td>a. 120° ±1° of nominal with balanced loads</td>
</tr>
<tr>
<td>b. 120° ±3° of nominal for 100% unbalanced loads</td>
</tr>
<tr>
<td>5. Linear load voltage distortion</td>
</tr>
<tr>
<td>5% Total Harmonic Distortion (THD) and 3% single harmonic if connected to 100% linear load</td>
</tr>
<tr>
<td>6. Non-linear load voltage distortion</td>
</tr>
<tr>
<td>7.5% maximum, if connected to 100% non-linear load</td>
</tr>
<tr>
<td>7. Inverter steady-state output frequency</td>
</tr>
<tr>
<td>Inverter shall not deviate more than 0.1% within the following conditions:</td>
</tr>
<tr>
<td>a. 0% to 100% load</td>
</tr>
<tr>
<td>b. Minimum to maximum ambient temperature</td>
</tr>
<tr>
<td>c. Minimum to maximum DC bus voltage</td>
</tr>
<tr>
<td>8. Frequency slew rate</td>
</tr>
<tr>
<td>Nominal 1 Hz./second</td>
</tr>
<tr>
<td>Programmable from 0.25 Hz/second to 4 Hz/second maximum</td>
</tr>
</tbody>
</table>
### Table 1. Electrical Characteristics (continued)

<table>
<thead>
<tr>
<th>9. Overload (inverter only, without transfer to bypass)</th>
<th>a. 120% continuous b. 175% to 200% current limited c. 500% for 1 cycle</th>
<th>a. 125% for 10 minutes b. 150% for 1 minute c. 300% for 3 cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>10. Overload/fault-clearing current capability on bypass source, including static transfer switch</td>
<td>a. 125% of UPS rating: continuous b. 150% of UPS rating: 10 minutes c. 200% of UPS rating: 1 minute d. 1000% of UPS rating: 3 cycles</td>
<td>a. 125% of UPS rating: continuous b. 150% of UPS rating: 10 minutes c. 200% of UPS rating: 1 minute d. 1000% of UPS rating: 3 cycles</td>
</tr>
<tr>
<td>11. Crest factor</td>
<td>3.0 maximum at full load without additional filtering or without increasing the size of the system.</td>
<td>3.0 maximum at full load without additional filtering or without increasing the size of the system.</td>
</tr>
<tr>
<td>12. Load power factor at nameplate KVA</td>
<td>0.8 lagging – 1.0 power factor</td>
<td>0.8 lagging – 1.0 power factor</td>
</tr>
</tbody>
</table>

### 4.4 Operating Modes

#### 4.4.1 Normal Mode

1. AC load shall be continuously supplied by the UPS inverter.
2. Rectifier/charger shall derive power from a primary AC source and supply DC power to the inverter while simultaneously float-charging the battery.
3. Alternate power source will be energized.

#### 4.4.2 Backup Mode

1. If failure of the primary AC power source occurs, the AC load shall continue to be supplied by the inverter, which shall obtain power from the battery source without any switching.
2. Power to the load shall not be interrupted upon failure or restoration of the primary AC power source.
3. After battery has discharged to minimum allowable voltage, the UPS shall transfer to the alternate AC power source if alternate source is available.

#### 4.4.3 Recharge Mode

1. Upon restoration of primary AC power source, the rectifier/charger shall recharge the batteries and shall simultaneously supply DC power to the inverter.
2. Recharge shall be an automatic function and shall not cause interruption to the load.

#### 4.4.4 Bypass Mode

1. During an inverter malfunction, overcurrent condition, undervoltage or overvoltage condition, or load fault at the inverter output, the static switch
shall automatically transfer the load to alternate AC power source with less than a 1/4-cycle break.

2. Upon clearing an inverter malfunction or fault condition, the static transfer switch shall automatically transfer the load from the alternate AC power source back to the inverter output, unless manual re-transfer mode has been selected. The re-transfer shall be without interruption (zero-break).

4.4.5 Without Battery Mode

UPS shall continue to meet the normal mode requirement without the battery.

4.4.6 Maintenance Bypass Mode

Maintenance bypass switch shall perform a make before break transfer of the entire load from the UPS to the alternate source, and from the alternate source back to the UPS.

4.5 Isolation and Bypass Transformers

4.5.1 If specified on the purchaser’s PIP ELSAP04D Data Sheet, an input isolation transformer shall be provided for the rectifier/charger.

4.5.2 If specified on the purchaser’s PIP ELSAP04D Data Sheet, a bypass transformer shall be provided.

4.5.3 Transformer rating or capability shall be adjusted based on the amount of non-sinusoidal load on the system in accordance with ANSI/IEEE C57.110.

4.5.4 Input isolation transformer shall be wound with copper wire and shall use a UL-recognized 392°F (200°C) insulation system. The temperature rise at 100% full load shall not be greater than 302°F (150°C).

4.5.5 Bypass transformer shall be wound with copper wire and shall use a UL-recognized 392°F (200°C) insulation system. The temperature rise at 100% full load shall not be greater than 302°F (150°C).

4.5.6 K factor of the input isolation and bypass transformers shall be a minimum K-4. A higher K factor transformer shall be provided if specified on purchaser’s PIP ELSAP04D Data Sheet, to withstand heating effects of loads with a higher degree of non-linearity.

4.5.7 Grounded shield shall be provided between the input and the output windings of the transformers.

4.6 Rectifier/Charger

4.6.1 General

1. Incoming AC power shall be converted to regulated DC output by the rectifier/charger.

2. Control circuitry shall be included to provide constant voltage/current regulation and current walk-in on start-up of the rectifier/charger.

3. UPS rectifier/charger shall contain a walk-in ramp circuit, which shall be 5 seconds minimum to full-load rating.
4. Rectifier/chargers shall be capable of operating into an absolute short circuit continuously without operating any of its protective devices. The current limit shall be:
   a. Achieved by electronic control
   b. Adjustable from 100% to 125% of the nominal charger current rating
   c. Factory-set at 110%

5. DC output voltage shall be regulated to ±0.5% in the “float” mode and shall be regulated to ±1% in the “equalize” mode for any combination of the following:
   a. AC line voltage variation of ±10% of nominal
   b. AC line frequency variation of ±5% of normal
   c. Load variations of 0% to 100%
   d. Ambient temperature variations of 0° to 50°C (122°F)

6. The root mean square (RMS) DC output ripple voltage measured at the terminals of a connected battery, shall not be greater than the limits specified in NEMA PE 5-1997 (R2003), Table 6.

7. Filtered chargers shall be used for valve regulated lead acid batteries.

8. Common-mode, noise-suppression filter shall be provided at the output of the rectifier/charger.

9. Rectifier/charger shall have the capacity to supply rated load to the inverter while recharging a fully discharged battery. Unless otherwise specified on the purchaser’s PIP ELSAP04D Data Sheet, recharge time to 90% of full battery capacity shall be within 10 times the discharge time of the battery and not greater than 8 hours.

10. If duplicate rectifier/chargers are specified on the purchaser’s PIP ELSAP04D Data Sheet, the following shall apply:
    a. Each rectifier/charger shall be capable of having its DC output terminals paralleled with one or more duplicate chargers such that any one charger is capable of running the inverter at full load while simultaneously charging the batteries in the required time.
    b. Load-sharing circuitry between the two chargers shall be provided.
    c. A method to prevent unnecessary charger failure alarms under low load conditions shall be provided on each charger.

11. If specified on the purchaser’s PIP ELSAP04D Data Sheet, temperature-compensated battery charging shall be provided.

12. Input transient protection shall be in accordance with IEEE C62.41.1, Categories A and B.

4.6.2 Float/Equalizing Voltage Control

The output voltage of the battery charger shall have adjustable float and equalizing ranges as follows:
1. Float/Equalizing Mode Selection
   a. A means shall be provided to manually select the float or equalize mode on the charger.
   b. Indicators shall be supplied to indicate the float and equalizing modes of the battery charger.

2. Float Voltage Adjustment
   The float voltage setting shall have a minimum adjustable range as follows:
   a. Lead-acid battery - 2.15 to 2.35 volts per cell
   b. Nickel-cadmium battery - 1.41 to 1.47 volts per cell
   c. The adjustment device shall be mounted on the front panel.
   d. Recommended float voltage shall be shown on the front panel.

3. Equalizing Voltage Adjustment
   The equalize voltage setting shall have a minimum adjustable range as follows:
   a. Lead-acid battery - 2.20 to 2.45 volts per cell
   b. Nickel-cadmium battery - 1.47 to 1.57 volts per cell
   c. The adjustment device shall be mounted on the front panel.
   d. Recommended equalizing voltage shall be shown on front panel.

4. Equalizing Mode Timer
   a. A timer with a range of 0 to 72 hours shall be provided for the equalizing mode.
   b. The timer range shall be adjustable from the front panel.
   c. The time remaining shall be displayed on the front panel.

4.7 Inverter

4.7.1 Inverter shall supply AC power continuously to the loads.

4.7.2 Inverter shall be equipped with circuitry to provide constant AC voltage regulation and transient response.

4.7.3 Inverter shall automatically synchronize and phase-lock the inverter output to the alternate AC power source if the source is within an adjustable range of 0.5% to 8%. If the bypass source is not within this range, the inverter will break synchronization and lock onto an internal oscillator.

4.7.4 Unless otherwise specified on the purchaser’s PIP ELSAP04D Data Sheet, the control circuit shall turn off the inverter to prevent damage to the battery, as follows:
   a. For lead-acid batteries, 1.75 VDC per cell
   b. For nickel cadmium batteries, 1.00 VDC per cell
4.8 Static Bypass Switch (SBS)

4.8.1 Static bypass switch shall automatically transfer the load, without interruption, from the inverter output to the alternate AC power source for the following conditions:

a. Inverter failure
b. UPS over-temperature
c. Inverter overload (i.e., exceeding the overload limits specified in Table 1)
d. DC overvoltage/undervoltage
e. Inverter output overvoltage/undervoltage
f. Manual transfer from front panel push button

4.8.2 If ferroresonant type UPS is specified on the purchaser’s PIP ELSAP04D Data Sheet, the static-switch current-sense transfer point shall be adjustable from 100% to 125%, factory set at 120%. The current sense shall be designed to prevent premature switching of the static switch with high crest factor loads.

4.8.3 SBS shall have the provisions for selecting either a manual or automatic transfer of the load back to the inverter after the inverter has returned to normal conditions and stabilized. Retransfer shall occur only if the two sources are synchronized.

4.8.4 SBS shall inhibit transfer to the alternate AC source if any of the following conditions exist:

a. Alternate AC source voltage is less than 90% of nominal.
b. Alternate AC source voltage is greater than 110% of nominal.
c. Inverter output and alternate source are not synchronized.

4.8.5 If selected, the SBS shall automatically retransfer to the inverter only when all of the following conditions are met:

a. Inverter output and alternate AC power sources are synchronized.
b. UPS conditions are normal.
c. UPS load is within normal range for inverter.

4.8.6 Sensing and transfer times of the SBS in either direction shall not exceed 1/4 cycle.

4.8.7 Manual transfers shall be make before break.

4.8.8 Overcurrent protection shall be provided to prevent damage to the SBS.

4.8.9 The SBS shall be designed to fail to the alternate AC power source.

4.8.10 An independent watchdog circuit shall be provided to ensure SBS transfer to alternate AC power source upon microprocessor failure.
4.9 **Internal Manual Bypass Switch (MBS)**

4.9.1 If specified on the purchaser’s *PIP ELSAP04D* Data Sheet, a manual bypass switch shall be provided on the front of the UPS inverter cabinet to permit the load to be directly connected to the alternate AC power source.

4.9.2 Switch shall be a mechanical cam type with a grip handle for manual snap-action rotation.

4.9.3 Contacts shall be make before break in both directions to ensure continuity of power to the load.

4.9.4 If specified on the purchaser’s *PIP ELSAP04D* Data Sheet, MBS position LEDs shall be provided on the inverter cabinet.

4.10 **Remote Maintenance Bypass Switch (RMBS)**

4.10.1 If specified on the purchaser’s *PIP ELSAP04D* Data Sheet, a remote maintenance bypass switch shall be provided in a separate enclosure to be mounted remotely from the UPS cabinet. This switch shall permit the load to be connected to the alternate AC power source and shall isolate the entire UPS system.

4.10.2 The switch shall be a make before break type and shall have the same minimum overload and short-circuit ratings as those of the SBS.

4.10.3 Position LEDs shall be provided on the switch enclosure.

4.10.4 The RMBS shall have circuit breaker(s) as specified on the purchaser’s *PIP ELSAP04D* Data Sheet.

4.11 **Inverter Test Load Connection**

4.11.1 If specified on the purchaser’s *PIP ELSAP04D* Data Sheet, a test load connection shall be provided at the inverter output.

4.11.2 If specified on the purchaser’s *PIP ELSAP04D* Data Sheet, a circuit breaker or disconnect device shall be provided and shall be sized as specified on the Data Sheet.

4.11.3 Circuit breakers shall be in accordance with Section 4.15.

4.11.4 Device used for the test load connection shall be clearly identified as specified on the one-line diagram.

4.12 **Battery Disconnect**

4.12.1 If specified on the purchaser’s *PIP ELSAP04D* Data Sheet, a disconnecting device shall be provided for battery isolation and/or over-current protection.

4.12.2 Disconnecting device shall be provided with auxiliary contacts for open/close position indication.

4.12.3 Disconnecting device shall be lockable in the “off” position only.

4.13 **Batteries**

4.13.1 If specified, the batteries provided with the UPS shall be in accordance with *PIP ELSAP11* or *PIP ELSAP12* and the purchaser’s *PIP ELSAP11D* or *PIP ELSAP12D* Data Sheet.
4.13.2 Unless otherwise specified on the purchaser’s PIP ELSAP04D Data Sheet, batteries shall be sized to provide 30 minutes backup time at the specified load and a 1.0 power factor, in an ambient temperature of 77°F (25°C).

4.14 Enclosures

4.14.1 Unless otherwise specified on the purchaser’s PIP ELSAP04D Data Sheet, enclosures shall be constructed to manufacturer’s standard.

4.14.2 Hinged panels, 36 inches and greater, shall be provided with at least a two-point latching system for holding the panels securely.

4.14.3 Unless otherwise specified on the purchaser’s PIP ELSAP04D Data Sheet, enclosure shall be mounted on channels with a 3-inch lifting base.

4.14.4 Unless rear access is specified on the purchaser’s PIP ELSAP04D Data Sheet, enclosures shall be designed for installation against a wall and for front access only to all components.

4.14.5 Equipment within an enclosure shall be designed to allow replacement or maintenance of all components from the front.

4.14.6 High-voltage warning labels shall be visible if any of the cabinet doors are opened.

4.14.7 If forced ventilation is used, redundant cooling fans shall be provided. In the event of one fan failure, the UPS shall continue to operate in normal mode without load de-rating. An alarm shall be provided for notification of any fan failure.

4.14.8 Vermin screens shall be provided to prevent the entry of small animals into enclosures.

4.14.9 Removable covers shall be attached with machine screws.

4.14.10 If specified on the purchaser’s PIP ELSAP04D Data Sheet, air inlets shall be equipped with dust particle filters.

4.14.11 Unless otherwise specified on the purchaser’s PIP ELSAP04D Data Sheet finish shall be manufacturer’s standard.

4.14.12 If specified on the purchaser’s PIP ELSAP04D Data Sheet, a battery cabinet shall be provided with necessary hardware to mount cabinet adjacent to the UPS cabinet.

4.14.13 If specified on the purchaser’s PIP ELSAP04D Data Sheet, a strategically positioned sensor shall monitor the ambient temperature inside the UPS cabinet.

4.15 Circuit Breakers and Switches

4.15.1 Circuit breakers and switches for the UPS shall be provided in accordance with the one-line diagram. As a minimum, the following circuit breakers shall be provided:

a. Charger/rectifier input circuit breaker open/close
b. Inverter/UPS output circuit breaker open/close

4.15.2 Circuit breakers shall be molded-case, thermal-magnetic devices.
4.15.3 All AC circuit breakers shall be capable of interrupting the fault current specified on the purchaser’s PIP ELSAP04D Data Sheet.

4.15.4 If a disconnect device is required, a molded-case, non-automatic switch shall be used.

4.15.5 Circuit breakers and switches shall be accessible and lockable from the front of the enclosure.

4.15.6 DC circuit breakers shall be listed for DC service with ratings sufficient to interrupt the short-circuit current.

4.16 Fuses

4.16.1 Fuse holders for control circuit fuses shall be finger safe, with an open fuse indication light.

4.16.2 All fuses shall be capable of interrupting the fault current for the intended service.

4.16.3 All power fuse blocks shall be provided with polycarbonate covers (e.g., Lexan or approved equivalent).

4.17 Wiring and Terminals

4.17.1 All power terminal blocks and alarm terminal blocks shall be provided with polycarbonate barriers (e.g., Lexan or approved equivalent).

4.17.2 Permanent wire supports shall be used. Adhesive-backed wire supports shall not be used.

4.17.3 All wiring and bus work shall be copper throughout the system.

4.17.4 All terminals and wiring shall be uniquely identified as shown in manufacturer’s drawings.

4.17.5 Wires shall be identified at both ends with permanent wire markers.

4.18 UPS Controls, Monitoring, and Communications

4.18.1 General

4.18.1.1 UPS shall have a control and monitoring that provides system controls, system status, diagnostic, metering, alarm indications and event logging.

4.18.1.2 All controls shall be operable with the cabinet doors closed.

4.18.1.3 If specified on the purchaser’s PIP ELSAP04D Data Sheet, the UPS shall be capable of automatically testing the battery under load conditions at an adjustable interval.

4.18.2 Indications

4.18.2.1 Indicators may be light-emitting diodes (LEDs) or digitally displayed as specified on the purchaser’s PIP ELSAP04D Data Sheet.

4.18.2.2 LED indicators shall have a test feature for testing functionality.
4.18.2.3 As a minimum the following indications or status messages shall be displayed:
   a. Normal AC power source available/not available
   b. Alternate AC power source available/not available
   c. Alternate AC power source out of tolerance
   d. Inverter output out of tolerance
   e. Load on inverter
   f. Load on bypass
   g. Inverter/bypass synchronized
   h. Status of input, battery and output circuit breakers or switches
   i. Float/equalize
   j. Low DC bus voltage
   k. UPS on battery
   l. System shutdown
   m. Fan failure (where applicable)
   n. Over-temperature

4.18.2.4 Additional indicators shall be provided as shown on the purchaser’s PIP ELSAP04D Data Sheet.

4.18.3 Measurement

4.18.3.1 Unless otherwise specified on the purchaser’s PIP ELSAP04D Data Sheet, a mimic screen that displays a real time graphic representation of the UPS system in one line diagram form indicating the status and real-time power flow through the UPS components shall be provided.

4.18.3.2 Meters may be analog or digital as specified on the purchaser’s PIP ELSAP04D Data Sheet.
   a. If analog meters are provided, the meters shall be 3.5-inch scale and 2% accuracy.
   b. If digital, metering shall be provided either by individual digital meters or through an LCD monitoring panel mounted on the front of the UPS system as specified on purchaser’s PIP ELSAP04D Data Sheet.

4.18.3.3 As a minimum the following measurements shall be displayed:
   a. Input AC voltage line-to-line
   b. Input AC current for each phase
   c. Input frequency
   d. Battery voltage
   e. Battery charge/discharge current
f. Output AC voltage line-to-line and line-to-neutral for each phase
g. Output AC current for each phase
h. Output frequency
i. If an LCD or digital display is provided, the following additional measurements shall be provided:
   1. Output kVA and kW for each phase
   2. Percent of rated load being supplied by the UPS
   3. Battery time remaining during battery operation

4.18.4 Protection and Alarms

4.18.4.1 A dry-contact shall be supplied for common alarm indication for the purchaser’s use.

4.18.4.2 Additional dry-contacts shall be provided for the functions listed on purchaser’s PIP ELSAP04D Data Sheet.

4.18.4.3 Alarm circuits shall be failsafe (de-energize to alarm).

4.18.4.4 Each “voltage free” alarm output shall be one form “C” contact-rated for a minimum of 3 amperes, 120 VAC/28 VDC.

4.18.4.5 Alarms shall require acknowledgement before clearing.

4.18.4.6 As a minimum, the following alarms shall be displayed and shall activate the common alarm:
   a. Not synchronized with alternate source
   b. Fan failure
   c. Load on transfer switch bypass
   d. Load on manual bypass switch
   e. Battery supplying load
   f. Alternate source failure
   g. DC bus overvoltage
   h. Battery disconnected
   i. Loss of input power
   j. If an LCD or digital display is provided, the following additional alarms shall be displayed and shall activate the common alarm:
      1. Loss of input power
      2. Input voltage out of tolerance
      3. Input frequency out of tolerance
      4. Output frequency out of tolerance
      5. Output not synchronized to input
      6. Output not synchronized to alternate source
7. Output overloaded
8. Shutdown due to overload
9. Low battery warning
10. Low battery shutdown
11. Charger/Rectifier failure
12. Inverter failure
13. Charger/Rectifier in current limit
14. DC bus overvoltage
15. DC bus/circuit ground fault
16. Output undervoltage
17. Output overvoltage
18. Control power supply failure
19. Over temperature shutdown
20. Static transfer switch operation inhibited

4.18.4.7 An audible alarm shall be provided if specified on the purchaser’s PIP ELSAP04D Data Sheet.

4.18.5 Control, Set Points, and Calibrations

4.18.5.1 As a minimum, the UPS shall include the following controls:
   a. Battery charger DC float voltage adjustment
   b. Battery charger DC equalize voltage adjustment
   c. DC equalize voltage timer
   d. DC input undervoltage disconnect set point adjustment
   e. Inverter output voltage adjustment
   f. Static transfer switch transfer point adjustments
   g. UPS inverter over voltage
   h. UPS inverter under voltage
   i. Static transfer switch Normal/Bypass mode

4.18.5.2 The operating set points may be manually adjusted, user-programmed by password protected key pad entries, or software programmable.

4.18.5.3 The following transfer function controls shall be provided on the front of the UPS enclosure:
   a. “Transfer to Inverter” transfers the load to the inverter if an inhibiting condition does not exist.
   b. “Transfer to Bypass” transfers the load to the alternate AC source if an inhibiting condition does not exist.
4.18.6 Event Logging, Statistics, and History

Alarms and changes in operation mode shall be time stamped and stored in a non volatile memory whose capacity shall keep at least the last 100 entries in a first in – first out (FIFO) manner.

4.18.7 Communications

4.18.7.1 Communications options provided shall be as specified on the purchaser’s PIP ELSAP04D Data Sheet.

4.18.7.2 If specified on the purchaser’s PIP ELSAP04D Data Sheet, the UPS shall be provided with a communications port or link for connection to a distributed control system (DCS) or SCADA system to monitor/adjust system parameter adjustments, status and alarm indicators, monitored parameters, and alarm history for customer support and system users.

4.18.7.3 The event log, indications, alarm history, etc., shall be accessed through the communication type selected on the purchaser’s PIP ELSAP04D Data Sheet.

4.19 Tagging and Nameplates

4.19.1 A graphic representation of the UPS system in one line diagram form shall be displayed on the front of the UPS. All key power components shall be shown including (but not limited to) circuit breakers, fuses, integral bypass, maintenance bypass, remote bypass and static switches. Unless otherwise specified on the purchaser’s PIP ELSAP04D Data Sheet, the graphic representation shall be through an HMI display integral to the UPS.

4.19.2 UPS startup, shutdown, and switching procedures shall be permanently affixed on the front of the UPS cabinet. These procedures must clearly point out the sequence for placing the unit in service, for taking it out of service, and for switching the load to the alternate AC source.

4.19.3 The following minimum information shall be shown on the UPS nameplate:

a. Manufacturer’s name and address
b. Manufacturer, model number, and serial number
c. AC input voltage, current, number of phases, and frequency
d. Rated AC output voltage, amperes, frequency, power factor, kVA, and kW
e. Alternate AC source voltage, phase, and frequency
f. Designed load kVA and battery backup time
g. Month and year of manufacture

4.19.4 A nameplate shall be provided on the outside of the enclosure identifying the owners service, item tag, and unit number as specified on purchaser’s PIP ELSAP04D Data Sheet.

4.19.5 The following minimum information shall be shown on the remote maintenance bypass switch:

a. Manufacturer’s name and address
b. Manufacturer, model number, and serial number

c. Rated AC input voltage, current, number of phases

4.19.6 All operating devices shall be clearly labeled.

4.19.7 All power circuit breakers, indicator lights, meters, controls, semiconductors, and fuses shall be clearly marked with the component designation for ease of serviceability.

4.20 Inspection and Testing

4.20.1 System testing shall be in accordance with NEMA PE 1 and IEC 62040-3.

4.20.2 All test results and certified test data shall be provided to purchaser to verify test results and for record.

4.20.3 Type-test data shall be available to the purchaser to demonstrate system performance and performance with switch-mode type power supplies.

4.20.4 All tests and inspections shall be performed that are necessary to determine that all equipment and wiring are installed in accordance with this Practice and in satisfactory condition to be energized.

4.20.5 All equipment shall be inspected for compliance with all parts of this Practice.

4.20.6 In addition to testing required by individual equipment specifications, the following Factory Acceptance Testing/functional testing shall be performed to ensure proper operation of all devices and components.

1. If specified on the purchaser’s PIP ELSAP04D Data Sheet, a continuous operation at full rated capacity burn-in test shall be completed before the factory acceptance test. The duration of the test shall be as specified on the Data Sheet. If any component fails during this test, the component shall be replaced and the test restarted from time zero.

2. Measurements of inverter output voltage variations, in the form of oscillograms, shall be recorded during all load tests. Individual sections or modules shall be measured in the same way in parallel or redundant UPS systems.

3. Test Rectifier/Charger voltage regulation from no load to full load.

4. Test Rectifier/Charger current limiting ability by applying a minimum 150% load.

5. Test inverter AC output voltage regulation from no load to full load.

6. Three phase inverters shall be subjected to a maximum 100% load phase unbalance condition to verify compliance of the required voltage regulation.

7. Static load tests, at 100% rated load, measure, and record the following:
   a. Input voltage
   b. Input current
   c. DC voltage
   d. DC current
e. DC ripple current (at unity power factor)
f. Output voltage, frequency, and waveform distortion
g. Output phase current(s)
h. Output power
i. Determination of unit overall efficiency (at nominal input voltage)
j. Input harmonics components
k. Output harmonics components

8. Batteries used during factory testing and functional testing do not need to be of the same manufacturer or capacity of that to be used in the field.

9. Measurements shall be carried out to verify the correct functioning of the bypass circuit voltage and frequency monitoring circuit, and the inverter/bypass synchronous operating controls. Tests shall be performed with the UPS delivering full load and with the inverter operating in synchronism with the bypass circuit supply.

10. Load transfer tests
    Observe and measure with an oscillograph all load transfers from inverter to alternate AC source and back.
    a. Load transfer to bypass initiated by manual operation of static load transfer switch.
    b. Load transfer to bypass initiated by simulating inverter malfunction.
    c. Load transfer to battery initiated by simulating loss of input or rectifier/charger malfunction without transfer to bypass.
    d. Load transfer to bypass initiated by low DC voltage independent of DC battery voltage (rectifier failure).
    e. Load transfer to bypass initiated by input AC voltage out of tolerance.
    f. Load transfer to bypass initiated by load fault.
    g. Load retransfer to inverter initiated automatically and manually.
    h. Load transfer by maintenance bypass switch.
    i. Load transfer by remote maintenance bypass.
    j. Operation of system without battery and no transfer to bypass.

11. The correct functioning of all measuring instruments, alarms, indicators, protective devices and controls shall be verified in accordance with NETA ATS.

12. Transfer of data to the purchaser’s DCS or SCADA system shall be demonstrated/simulated.

4.20.7 For parallel or redundant UPS systems, the tests specified in Section 4.21.6 shall be adapted to prove the performance of the individual UPS sections or modules and the overall performance of the UPS. Load sharing among modules shall be monitored and measured throughout the testing.
4.20.8 If specified on the purchaser’s PIP ELSAP04D Data Sheet, the purchaser shall witness all factory and functional tests. Two weeks’ notice of the required inspection and testing date to meet shipment deadlines shall be given to the purchaser.

4.21 Shipping

4.21.1 Preparation for shipment shall be in accordance with the supplier’s standards unless otherwise noted on the request for quotation and/or purchase order.

4.21.2 Supplier shall be solely responsible for the adequacy of the preparation for shipment and for providing materials to their destination in working condition.

4.21.3 Each shipping package shall be identified with the following numbers:
   a. Purchase order number
   b. Requisition number
   c. Equipment number
   d. Project number

4.21.4 If shipped separately, each assembly shall be individually crated and tagged with its location and the compartment to which it belongs.

4.21.5 All items blocked and braced for shipment shall be clearly tagged and identified as such. Any blocking, bracing, or other foreign material that must be removed before energizing the equipment shall be clearly identified by tags, signs, or markings.

4.21.6 If shipment in sections is required, each section shall be identified with a permanent, readily visible identification tag.

4.21.7 All materials and instructions required for reassembly of the sections in the field shall be provided.

4.21.8 Terminal blocks and wire tags shall be provided for all control wiring that must be reconnected.

4.21.9 Each shipping structure shall be provided with removable lifting angles or plates to accommodate the use of crane hooks or slings.

4.21.10 Recommendations for proper storage of the equipment in the field shall be provided.

4.21.11 Packing lists shall clearly identify any components of the purchase order that are being shipped separately.

4.21.12 Each shipping section of stationary structures shall be provided with a permanently attached, readily visible identification tag bearing the equipment number of the assembly of which it is a part.

4.22 Documentation

4.22.1 All drawings and data provided shall be identified with the owner’s name, project number, purchase order number, and equipment number along with the supplier’s shop order number.
4.22.2 Drawings shall have a space on the right-hand bottom corner for the purchaser’s title block.

4.22.3 Documentation of the type and quantity shown in Table 2 and the purchaser’s data sheet, PIP ELSAP04D, shall be provided.

4.22.4 One reproducible set of drawings and the specified number of copies of all documentation and operating manuals as specified on the purchaser’s PIP ELSAP04D Data Sheet, shall be provided.

4.22.5 Unless otherwise specified on the purchaser’s data sheet, PIP ELSAP04D, format for reproducible drawings shall be CAD convertible .dwg and pdf electronic format.

4.22.6 For general layout drawings and schematic/interconnect drawings, the following items shall be included:

a. Location of any removable plates for the owner’s conduit entry
b. Location and size of all terminal blocks for the owner’s connections
c. Location and size of ventilation openings
d. Location of cabinet grounds
e. Block diagram including currents for purchaser cable sizing
f. Circuit breaker locations, sizes, and meter locations
g. Size and weight of equipment
h. Front panel identification chart
i. Nominal heat loss for the specified equipment
j. Relay contact diagrams shown in the deenergized position
k. Wire sizes and numbers displaying the same designations that appear in the equipment
l. Equipment anchoring requirements and locations
m. Lifting points and locations

4.22.7 Equipment shall be shipped with one set of installation, operation, and maintenance manuals.
Table 2. Documentation Requirements

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<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>Description</th>
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<tr>
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<td></td>
<td></td>
<td>X(1)</td>
<td>UPS system overall efficiency</td>
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<td>Equipment full load heat rejection rate</td>
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<td>General layout of equipment, showing all dimensions and weights, and outline drawings, showing the final assembled configuration. Control and monitoring panel description and details of operations. Mean time between failures (MTBF) and other reliability data.</td>
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<td>X</td>
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<td>Copies of certified test reports</td>
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<td>One-line diagram, three-line diagram, control schematics, connection-wiring diagrams, foundation-loading diagram, and soleplate details. Detailed plans and elevation drawings showing location of all components.</td>
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<td>General bill of materials including name of the manufacturer of all components</td>
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<td>Detailed bill of materials including name of the manufacturer and catalog number of all components</td>
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<td>Installation, operation, and maintenance manuals and required maintenance schedules</td>
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<td>Safety instructions clearly identifying proper and improper operation that might injure personnel and cause damage to operating equipment</td>
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<td>Final as-built drawings</td>
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<td>Recommended spare parts list with pricing</td>
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</table>

Notes:
A. These documents shall be provided with the proposal.
B. These documents shall be provided for the purchaser’s review and authorization to proceed before fabrication.
C. These documents shall be provided as part of the final certified document submittal.
(1) Equipment shall be shipped with one set of installation, operation, and maintenance manuals.
D. The final as-built documents shall be provided within 2 weeks following shipment.

4.23 Conflict Resolution

Any conflicts among the referenced documents shall be identified to the purchaser in writing for resolution. When resolving conflicts, the following order of precedence shall apply:

a. Purchase order
b. One-line diagram(s) and associated drawings
c. Purchaser’s PIP ELSAP04D Data Sheet
d. This Practice, PIP ELSAP04
e. Referenced standards