PIPELSAP11
Design and Fabrication of
Flooded-Cell Lead-Acid Batteries
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.

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1. Introduction

1.1 Purpose
This Practice provides the requirements for design and fabrication of vented, flooded-cell lead-acid batteries and accessories.

1.2 Scope
This Practice describes the design, inspection, testing, shipment, and documentation for vented, flooded-cell lead-acid batteries for application in electrical stations or uninterruptible power supplies (UPS) in indoor, nonclassified areas.

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 will be used herein where appropriate.

2.1 Process Industry Practices (PIP)
- PIP ELSAP11D - Data Sheet for Flooded-Cell Lead-Acid Batteries

2.2 Industry Codes and Standards
- Institute of Electrical and Electronics Engineers (IEEE)
  - IEEE 450 - Recommended Practice for Maintenance, Testing, and Replacements of Vented Lead-Acid Batteries for Stationary Applications
  - IEEE 485 - Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications
  - IEEE 1184 - Guide for the Selection and Sizing of Batteries for Uninterruptible Power Systems
- International Code Council (ICC)
  - IBC - International Building Code
- National Electrical Manufacturer Association (NEMA)
  - NEMA PE 5-1997 (R2003) - Utility Type Battery Chargers
- National Fire Protection Association (NFPA)
  - NFPA 70 - National Electrical Code
- Underwriters Laboratories (UL)
  - UL 94 - Test for Flammability of Plastic Materials for Parts in Devices and Appliances
  - UL 1989 - UL Standard for Safety Standby Batteries
3. Definitions

acceptance test: Capacity test made on a new battery to determine whether it meets specifications or manufacturer’s ratings

aging factor: The additional battery capacity used to account for normal degradation over the battery’s service life

battery duty cycle: The loads a battery is expected to supply for specified periods

capacity test: A discharge of a fully charged battery at a constant current or constant power to a specified voltage

cell container: The enclosure that contains the plates and electrolyte of a single or multiple cell(s), commonly referred to as a “jar”

cell size: The rated capacity of a lead storage cell or the number of plates in the cell

design margin: Additional capacity allowance in cell size for unforeseen additions to the DC system and for less than optimum operating conditions of the battery or expected growth rate to the load

equalizing voltage: A voltage higher than float voltage, applied to a battery to correct the inequalities among battery cells (voltage or specific gravity) that may develop in service to help maintain battery capacity

float voltage: The voltage applied to a battery to maintain it in a fully charged condition during normal operation

flooded-cell: A liquid electrolyte-filled vented cell

full float operation: Operation of a DC system with the battery, battery charger, and load connected in parallel and with the battery charger supplying the normal DC load plus any self-discharge or charging current, or both, required by the battery

owner: The party who owns the facility wherein the flooded-cell lead-acid batteries 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.

rated capacity: The ampere-hour capacity assigned to a lead storage cell by its manufacturer for a given discharge time, at a specified electrolyte temperature and specific gravity, to a given end of discharge voltage

supplier: The party responsible for furnishing the flooded-cell lead-acid batteries

vented battery: A battery in which the products of electrolysis and evaporation are permitted to escape freely to the atmosphere. These batteries are also called “flooded-cell” batteries.
4. Requirements

4.1 General

4.1.1 Battery shall be designed for the battery location conditions specified on the purchaser’s PIP ELSAP11D Data Sheet.

4.1.2 Seismic requirements shall be as specified on the purchaser’s PIP ELSAP11D Data Sheet. When specified on the purchaser’s PIP ELSAP11D Data Sheet the manufacturer shall provide a certificate of compliance and anchoring recommendations for all equipment.

4.1.3 Battery shall be used for either station or UPS applications as specified on the purchaser’s PIP ELSAP11D Data Sheet.

4.1.4 Unless otherwise specified on the purchaser’s PIP ELSAP11D Data Sheet, all hardware, connectors, accessories, and racks necessary for a complete battery system shall be provided. These components shall be in accordance with seismic requirements in Section 4.1.2.

4.1.5 Unless otherwise specified on the purchaser’s PIP ELSAP11D Data Sheet, the design life of all batteries shall be a minimum of 20 years in float service at 25°C (77°F).

4.1.6 Battery shall be connected by the purchaser to a battery charger. The battery shall be in float operation at the recommended float voltage in normal operation.

4.1.7 Number of cells and the nominal voltage of the battery shall be as specified on the purchaser’s PIP ELSAP11D Data Sheet.

4.1.8 The following sizing factors shall be applied to the calculated battery capacity:
   a. Design margin (for station batteries only): 10%
   b. Aging factor: 25%
   c. If the specified or calculated battery capacity exceeds a manufacturer’s standard rating by more than 5%, the next larger standard rating shall be selected.

4.1.9 Battery shall be UL recognized.

4.1.10 Power connection lugs or terminal block shall accept the quantity and size of incoming cables specified on the purchaser’s PIP ELSAP11D Data Sheet.

4.1.11 Battery shall accommodate a DC output voltage ripple as indicated in NEMA PE 5-1997 (R2003), Section 5.14.1 without reduction in battery life or number of full discharge cycles.

4.1.12 Unless otherwise specified on the purchaser’s PIP ELSAP11D Data Sheet, battery recharge time shall be 8 hours.

4.1.13 The maximum hydrogen evolution shall be provided by the supplier for all operating conditions at the maximum temperature as defined on the purchaser’s PIP ELSAP11D Data Sheet.

4.1.14 The maximum fault current level from the battery assembly, without charger or any external sources, at the battery terminals if operating at the maximum
ambient temperatures defined on the purchaser’s PIP ELSAP11D Data Sheet shall be provided by the supplier.

4.1.15 The battery capacity data for the manufacturer’s standard conditions and the purchaser’s specific conditions shall be as indicated on the purchaser’s PIP ELSAP11D Data Sheet.

4.1.16 **Station Service Application**

4.1.16.1 The battery shall endure a minimum of 300 cycles (full charge and discharge) during its lifetime at the 1-hour discharge rate.

4.1.16.2 The endurance of a cell or battery shall be stated in terms of the number of full charge/discharge cycles that the cell can sustain during its useful life.

4.1.16.3 The cell shall be considered to have reached the end of its useful life when the ampere-hour capacity drops to 80% of the rated capacity at the 8-hour discharge rate.

4.1.16.4 Battery capacity shall be based on one of the three load options for battery sizing shown on the purchaser’s PIP ELSAP11D Data Sheet. If the load profile option is selected, the calculations used in selecting the battery capacity shall be shown on the purchaser’s PIP ELSAP11D Data Sheet.

4.1.16.5 Method of determining battery capacity shall be in accordance with IEEE 485 for lead-acid batteries.

4.1.16.6 Battery selection shall be based on 1.75-V minimum per cell.

4.1.17 **UPS Application**

4.1.17.1 The battery shall endure a minimum of 100 full charge and discharge cycles during its lifetime at the specified discharge time.

4.1.17.2 The endurance of a cell or battery shall be stated in terms of the number of full charge/discharge cycles that the cell can sustain during its useful life.

4.1.17.3 The cell shall be considered to have reached the end of its useful life when the capacity drops to 80% of the rated capacity.

4.1.17.4 The number of full charge and discharge cycles that the battery can provide over its lifetime shall be provided by the supplier on the purchaser’s PIP ELSAP11D Data Sheet.

4.1.17.5 Battery capacity shall be based on the load shown on the purchaser’s PIP ELSAP11D Data Sheet.

4.1.17.6 Unless otherwise specified on the purchaser’s PIP ELSAP11D Data Sheet, the method of determining battery capacity shall be in accordance with IEEE 1184 for lead-acid batteries.

4.1.17.7 Unless otherwise specified on the purchaser’s PIP ELSAP11D Data Sheet, the UPS DC battery system shall be ungrounded.
4.2 Cells

4.2.1 Unless specified otherwise on the purchaser’s PIP ELSAP11D Data Sheet, the plate design shall be tubular or pasted plate lead-calcium alloy.

4.2.2 Lead-antimony alloys shall not be greater than 2% antimony.

4.2.3 All positive plates shall have retention mats to restrain the loss of active material caused by repeated cycling.

4.2.4 Cell design shall accommodate the total positive plate growth during the design life of the cell. The plate growth shall not cause cracking, deformation, or failure during the lifetime of the cell under normal operating conditions.

4.2.5 Cell containers and covers shall be made of a high-impact, flame-retardant plastic material having a minimum oxygen index of 28% and shall meet the criteria needed to be rated V-0 level where an open flame source is removed in accordance with UL 94.

4.2.6 The cover shall be bonded to the container to form a permanent leak-proof seal.

4.2.7 All cell containers shall be transparent or translucent and shall be permanently marked with minimum and maximum electrolyte levels. If batteries are installed in battery racks, levels shall be visible from the front.

4.2.8 Terminal posts shall be cast in lead or lead alloy and configured to provide a reliable, low-resistance interface with the intercell connectors. Terminal posts shall be provided with a composite seal to prevent acid migration to connectors and container cover.

4.2.9 Connections

4.2.9.1 All cell posts shall have bolted connections.

4.2.9.2 Cell-to-cell connections shall be made by tin/lead-plated copper bus bars using 300 series stainless steel hardware.

4.2.9.3 Bus bar design shall limit stress on battery posts.

4.2.9.4 Where required, step-to-step and tier-to-tier connections shall be made by extra-flexible, insulated copper cables using 300 series stainless steel hardware.

4.2.9.5 Battery interconnecting straps shall be guarded in accordance with NFPA 70-2014 Article 110.27. All terminal connectors and interconnecting straps shall be covered as specified on purchaser’s PIP ELSAP11D Data Sheet for protection against inadvertent contact with energized components.

4.2.10 Flame-arrester-type vent plugs with dust caps shall be provided to minimize the possibility of a spark or battery room fire causing an internal battery explosion. The vent plug shall prevent any visible wetting of the cell lid if the cell is being equalized at the maximum temperature specified on the purchaser’s PIP ELSAP11D Data Sheet.

4.2.11 Unless otherwise specified on the purchaser’s PIP ELSAP11D Data Sheet, individual cells shall not weigh more than 200 pounds (90 kilograms). Paralleling of cells shall be subject to the purchaser’s approval.
4.2.12 The recommended specific gravity of the electrolyte shall be provided by supplier on the purchaser’s PIP ELSAP11D Data Sheet. Sufficient electrolyte shall be supplied to provide full capacity at all ratings.

4.3 Battery Racks

4.3.1 Racks shall be constructed of welded structural steel frames with bolted or welded steel runners and braces and with provision for anchoring to the floor and the wall.

4.3.2 Side rails and end rails shall be removable.

4.3.3 Racks shall be suitable for the battery location seismic zone as specified on the purchaser’s PIP ELSAP11D Data Sheet.

4.3.4 Racks shall be painted with acid-resistant epoxy paint or equivalent. One pint of touch-up paint shall be provided.

4.3.5 Rack design shall be a single-tier, two-tier, or two-step arrangement as specified on the purchaser’s PIP ELSAP11D Data Sheet. The width of the racks shall be at least equal to the width of the battery cells. The maximum installed height of the battery tops above the floor shall be 60 inches (1.52 m) or as specified on the purchaser’s PIP ELSAP11D Data Sheet.

4.3.6 All metallic rack components that are in contact with the battery shall be insulated by removable covers.

4.3.7 Each end of each battery rack shall be drilled near the bottom with two 9/16-inch (14.3-mm) diameter holes 1 3/4 inches (44.5 mm) apart to accommodate the purchaser’s grounding lugs.

4.3.8 Unless otherwise specified on the purchaser’s PIP ELSAP11D Data Sheet, an acid-resistant containment pan shall be provided under the battery and rack to collect acid leaks or spills. The pan shall be sized to contain a minimum of the total quantity of electrolyte contained in a one-cell container.

4.3.9 Battery rack assembly instructions shall be provided.

4.4 Accessories

4.4.1 If specified on the purchaser’s PIP ELSAP11D Data Sheet, the following accessories shall be provided:

a. Vent-plug-mounted thermometer

b. Hydrometer

c. Bottle or filling jar with pour spout for adding distilled water

d. Spare hardware for battery racks and cell terminal connections, including at least three of each type bolt, nut, and washer required for rack assembly and three sets of hardware for terminal connections

e. Cell and battery module lifting device or sling for installation and removal of cells and modules weighing more than 50 pounds (22.7 kilograms). Lifting device shall be designed to accommodate cells as installed in battery racks without disturbing adjacent cells. Dimensions and operating clearances for lifting device shall be provided in the supplier’s documentation.
4.4.2 On-line battery-monitoring equipment shall be provided if specified on the purchaser’s PIP ELSAP11D Data Sheet. All material required for the installation of the battery monitoring equipment shall be provided.

4.4.3 If specified on the purchaser’s PIP ELSAP11D Data Sheet, a portable eye wash station shall be provided.

4.4.4 Other accessories shall be supplied as specified on the purchaser’s PIP ELSAP11D Data Sheet.

4.5 Markings

4.5.1 The following information shall be permanently marked on each cell container:
   a. Supplier’s name
   b. Catalog number or type reference
   c. Voltage
   d. Capacity in amp-hrs or kW for 8-hour nominal period
   e. Electrolyte density where fully charged at 25°C (77°F)
   f. Date of manufacture
   g. Interconnection torque value(s)

4.5.2 Adhesive number labels shall be provided for the purchaser to use in labeling the cells.

4.6 Inspection and Testing

If specified on the purchaser’s PIP ELSAP11D Data Sheet, an acceptance test of the battery capacity shall be performed in accordance with IEEE 450 to determine that the battery meets the design specifications. The test shall be done at the factory or on site, as specified on the purchaser’s PIP ELSAP11D Data Sheet.

4.7 Shipping

4.7.1 The supplier shall identify the following on each shipping group:
   a. Purchase order number
   b. Requisition number
   c. Equipment number
   d. Project number

4.7.2 Vented lead-acid cells shall be shipped in charged condition. Cells shall be shipped filled with electrolyte.

4.7.3 Individual cells shall be wrapped and sealed against moisture.

4.7.4 Terminal posts shall be insulated.

4.7.5 Individual cell boxes shall be printed with handling instructions including a warning against lifting the cells by the terminal posts.
4.7.6 Shipping crates and individual cell wrappings shall be marked with instructions for storage in cool, dry locations.

4.7.7 Labels on the shipping crate or the outer wrapping shall state the storage conditions, date of shipment, and the date beyond which the product is not permitted to be stored.

4.8 Documentation

4.8.1 All engineering data provided for this equipment shall represent the actual equipment specified and ordered.

4.8.2 Typical drawings are acceptable only if they are revised to specifically identify the equipment, dimensions, wiring, and accessories being provided.

4.8.3 All documentation shall be identified with the purchaser’s name, project number, purchase order number, and item number along with the shop order number.

4.8.4 Drawings shall have a space on the right-hand bottom corner for the purchaser’s title block.

4.8.5 Documentation of the type and quantity shown in Table 1 and the purchaser’s PIP ELSAP11D Data Sheet shall be provided.

4.8.6 One reproducible set of drawings and the number of copies of all documentation and operating manuals as indicated on the purchaser’s PIP ELSAP11D Data Sheet shall be provided.

4.8.7 Unless otherwise specified on the purchaser’s PIP ELSAP11D Data Sheet, the reproducible drawings shall be in CAD convertible .dxf electronic format.
Table 1. Documentation Requirements

<table>
<thead>
<tr>
<th>A With Bid</th>
<th>B For Review</th>
<th>C Final Certified</th>
<th>D As Built</th>
<th>Description</th>
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<tbody>
<tr>
<td>X</td>
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<td>General layout of equipment, showing all dimensions, weights, locations, and outline drawings of the final assembled configuration</td>
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<td>Hydrogen evolution</td>
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<td>Full charge and discharge cycles</td>
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<td>Copies of certified test reports as required</td>
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<td>X(1)</td>
<td>Installation, operation, and maintenance manuals and required maintenance schedules</td>
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<td>Required purity of the topping-off water and the electrolyte</td>
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<td>X</td>
<td></td>
<td>Safety instructions clearly identifying proper and improper operation that might injure personnel and cause damage to operating equipment</td>
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<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>Dimensions and operating clearances for cell lifting device</td>
</tr>
</tbody>
</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 furnished within 2 weeks following shipment.

4.9 Conflict Resolution
Any conflicts between the referenced documents shall be identified to the purchaser in writing for resolution. If resolving conflicts, the following order of precedence shall apply:
a. Purchase order
b. *PIP ELSAP11D* Data Sheet
c. This Practice, *PIP ELSAP11*
d. Referenced standards