RS01476
Section 12-800
May 2025

Standby Battery

Vented Cell Installation and Operating Instructions

SAFETY PRECAUTIONS

ONLY AUTHORIZED AND QUALIFIED PERSONNEL FAMILIAR WITH STANDBY BATTERY INSTALLATION, PREPARATION, CHARGING AND MAINTENANCE SHOULD BE PERMITTED ACCESS TO THE BATTERY.

WARNING

SHOCK HAZARD - DO NOT TOUCH UNINSULATED BATTERY, CONNECTORS OR TERMINALS. BEFORE TOUCHING THE BATTERY, BE SURE TO DISCHARGE STATIC ELECTRICITY FROM TOOLS AND TECHNICIAN BY TOUCHING A GROUNDED SURFACE IN THE VICINITY OF THE BATTERIES BUT AWAY FROM THE CELLS AND FLAME ARRESTORS.

GASES PRODUCED BY THIS BATTERY ARE EXPLOSIVE. PROTECT EYES WHEN AROUND BATTERY. PROVIDE ADEQUATE VENTILATION SO HYDROGEN GAS ACCUMULATION IN THE BATTERY AREA DOES NOT EXCEED TWO PERCENT BY VOLUME (CONSULT LOCAL CODES). DO NOT SMOKE, USE OPEN FLAME, OR CREATE SPARKS IN THE VICINITY OF A BATTERY.

LEAD-ACID CELLS CONTAIN DILUTE SULFURIC ACID. AVOID CONTACT WITH EYES, SKIN AND CLOTHING. SHOULD CONTACT OCCUR, REMOVE CONTAMINATED CLOTHING IMMEDIATELY AND FLUSH AFFECTED BODY AREAS IMMEDIATELY AND THOROUGHLY WITH WATER. WASH CLOTHING THOROUGHLY BEFORE REUSE. DO NOT ATTEMPT TO CLEAN AND REUSE CONTAMINATED SHOES. IF ACID SHOULD CONTACT THE EYE, FLUSH IMMEDIATELY WITH LARGE AMOUNTS OF WATER FOR AT LEAST 15 MINUTES. ALWAYS CONSULT A PHYSICIAN IN CASES OF ACID CONTACT WITH THE EYES.

INSTALLER MUST CONSULT WITH SITE OWNER/MANAGEMENT TO DETERMINE ANY ADDITIONAL PPE REQUIREMENTS AS WELL AS WORK PROCEDURES AND APPROVAL REQUIREMENTS PRIOR TO START OF WORK.

DANGER Contains: Lead, Sulfuric Acid (Electrolyte), Lead Components, Arsenic

Harmful if swallowed, inhaled or in contact with skin. Wear protective gloves/protective clothing, eye/face protection. Acid causes severe skin burns and eye damage. Use only outdoors or in a well-ventilated area. May damage fertility or unborn child if ingested or inhaled. Avoid contact with internal acid.

May cause harm to breast-fed children.

May cause cancer if ingested or inhaled. Causes skin irritation, serious eye damage.

Contact with internal components may cause irritation or severe burns.

Causes damage to central nervous system, blood and kidneys through prolonged or repeated exposure if ingested or inhaled.

Irritating to eyes, respiratory system, and skin.

May form explosive air/gas mixture during charging. Extremely flammable gas (hydrogen).

Explosive, fire, blast or projection hazard. Obtain special instructions before use.

Do not handle until all safety precautions have been read and understood.

Wash thoroughly after handling.

Do not eat, drink or smoke when using this product. Avoid contact during pregnancy/while nursing.

Do not breathe dust, fume, gas, mist, vapors, or spray.

Keep away from heat/sparks/open flames/hot surfaces. No Smoking. IF SWALLOWED OR CONSUMED: rinse mouth. Do NOT induce vomiting. Call a poison center/doctor if you feel unwell.

IF ON CLOTHING OR SKIN (or hair): Remove/take off immediately all contaminated clothing and wash it before reuse. Rinse skin with water/shower.

IF INHALED: Remove person to fresh air and keep comfortable for breathing. Immediately call a POISON CENTER or doctor/physician. IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.

If exposed/concerned, or if you feel unwell, seek medical attention/advice.

Store locked up, in a well-ventilated area, in accordance with local and national regulations.

Dispose of contents/container in accordance with local and national regulation.

Keep out of reach of children.

IMPORTANT: FOLLOW MANUFACTURER'S PUBLISHED INSTRUCTIONS WHEN INSTALLING, CHARGING AND SERVICING BATTERIES.

C&D TECHNOLOGIES, INC.

200 Precision Road | Horsham, PA | 19044 (800) 543-8630 | (215) 619-2700

customersvc@cdtrojan.com | www.cdtechno.com/contact-us

For technical assistance contact the Technical Services Department:
cdtechnical@cdtrojan.com (562) 236-3045

cdwarranty@cdtrojan.com | Warranty Claims

https://www.cdtechno.com/resources/technical-support-and-faqs

WARRANTY NOTICE

THIS INSTRUCTION MANUAL IS NOT A WARRANTY. EACH STANDBY BATTERY IS SOLD SUBJECT TO A LIMITED WARRANTY, WHICH IS IN PLACE OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED (INCLUDING THE WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE) AND WHICH LIMITS A PURCHASER'S (USER'S) REMEDY TO THE REPAIR OR REPLACEMENT OF A DEFECTIVE BATTERY OR PARTS THEREOF. THE TERMS OF THE LIMITED WARRANTY ARE INCORPORATED HEREIN AND ARE AVAILABLE UPON WRITTEN REQUEST FROM:

C&D TECHNOLOGIES, INC.

200 Precision Road| Horsham, PA | 19044

C&D TECHNOLOGIES, CANADA, INC.

6665 Millcreek Dr. | Unit 3 | Mississauga, ON | L5N 5M4

Introduction

Specifications listed herein are subject to change without notice. Contact your nearest C&D sales office for the latest specifications. All statements, information, and data provided herein are believed to be accurate and reliable but are presented without guarantee, warranty, or responsibility of any kind, express or implied. Statements or suggestions concerning possible use of our products are made without representation or warranty that any such use is free of patent infringement and are not recommendations to infringe any patent. The user should not assume that all safety measures are indicated, or that other measures may not be required.

The batteries referenced in this document are C&D Technologies, Inc. (C&D) stationary vented lead-acid (VLA), with sulfuric acid electrolyte, and pasted plate lead alloy electrodes. These batteries are designed for standby applications requiring a **dc** (direct current) power source.

Note: Please refer to *RS02208* for inert gas/dry charge battery Installation and Operating Instructions.

C&D offers three major battery design options - long duration, short duration, and general purpose.

- Long duration batteries are designed for applications where load currents are relatively small but must be supplied for many hours, typically eight hours or longer, often seen in Telecom applications.
- Short duration batteries are specifically designed to supply very high currents for a relatively short period of time, typically 15 minutes or less, and are primarily used for UPS applications.
- General purpose batteries employ design features that optimize their use in applications requiring both short duration, high current loads and longer duration, low current loads, typically 30 minutes to 8 hours, and are generally used in Utility applications.

These instructions assume a certain level of competence by the installer/user. The following recommended practices and codes contain relevant information, and should be consulted for safe handling, installation, testing, and maintenance of standby batteries. Applicable state and local codes must be followed.

Recommended Codes and Practices

- IEEE Std 450 (latest revision) “Recommended Practice for Maintenance, Testing and Replacement of Vented Lead-acid Batteries for Stationary Application”
- IEEE Std 484 (latest revision) “Recommended Practice for Installation Design and Installation of Vented Lead-acid Batteries for Stationary Applications”
- IEEE Std 485 (latest revision) “Recommended Practice for Sizing Lead-acid Batteries for Stationary Applications”
- IEEE Std 1184 (latest revision) “Guide for Batteries for Uninterruptible Power Supply Systems”
- IEEE Std 1375 (latest revision) “Guide for Protection of Stationary Battery Systems”
- IEEE/ASHRAE Std 1635 (latest version) “Guide for the Ventilation and Thermal Management of Batteries for Stationary Applications”
- **Note:** Copies may be purchased at www.ieee.org.
- NESC, National Electric Safety Code, (latest revision)
- NEC National Electrical Code NFPA-70, Articles 480 & 706 (latest version) available from www.nfpa.org.
- CSA C22.1 Canadian Electric Code, Section 64 (latest version)

Federal Codes

- 29CFR1926.441 “Batteries and Battery Charging”
- 29CFR1910.151(c) “Medical Services and First Aid”
- 29CFR1910.268(b) “Telecommunications”
- 29CFR1910.305(j) “Wiring Methods, Components and Equipment”
- STD 1-8.2(e) “OSHA Standing Directive”
- IBC International Building Code

Before handling cells or storing cells for future installation, take time to read this manual. It contains information that could avoid irreparable damage to the battery, the customer site, and/or personal injury.

Please refer to our website for the latest version of the Standby Battery Vented Cell Installation & Operating Instructions manual: www.cdtechno.com

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1 Receiving

1.1 General

Every precaution has been taken to pack the battery for shipment to ensure its safe arrival. As soon as the battery is received, check the packing material for evidence of damage in transit. If the packing material is physically damaged or any wet or dry acid stains are present, make a notation on the delivery receipt before accepting the shipment/delivery.

NOTE: Freight carriers generally require that concealed damage be inspected by the carrier's representative within ten days from the date of delivery to determine responsibility. The resolution of such claims may extend up to nine months. It is the receiving facility's responsibility to notify the freight carrier of concealed damage.

Verify the number of cartons and skids against the bill of lading and verify their components against the packing lists. Keep a copy of the verified lists for installation records. It is important to verify that the accessory package is present, and the component quantities are correct.

Accessory kits for complete battery systems typically consist of:

- Inter-cell and/or inter-unit connectors
- Inter-tier (or step or row) cable connectors
- Terminal plates
- Connection bolts, nuts, and washers
- NO-OX-ID grease
- Brass bristle brush(es)
- Labels, flame arrestor vents, and cell numbers
- Optional hydrometer, hydrometer holder, and thermometer
- Lifting sling and wood spreader board (when applicable for larger cell types)
- Replacement identification labels*

*In some cases, where batteries are shipped from stock or per customer request to a changed location, the battery may not ship with the tracking order number on the battery identification label. In these cases, replacement identification labels containing the correct order number will be shipped as part of the accessory kit. Please apply these updated labels over the existing labels on the cover of the cells.

NOTE: C&D does not furnish cross-aisle connections. If the final system arrangement is different from a specific ordered design, the quantities of the interconnection components will likely change and must be ordered as additional, optional components.

Battery racks are manufactured at a different location than batteries and are shipped separately. Racks are shipped unassembled and consist of:

- Frames
- Support rail assemblies and insulating covers
- Cross braces
- Restraint rails, brackets, and cell spacers (seismic only)
- Nuts, bolts, and washers
- Rack outline drawings/installation instructions

Spill containment systems are available upon request. These electrolyte containment systems may be required by local building or fire codes. Reference Appendix C for additional information.

1.2 Damage and Shortage Situations

C&D ships FOB plant (ownership passes at C&D's dock). If shipments are damaged or if cartons or skids are damaged or missing, a claim must be filed with the carrier. Place an immediate order for a replacement with C&D. Pay both the original invoice and the replacement invoice using the replacement cost as the amount of freight damage or shortages involved as part of the claim. If individual component items are missing, a shortage report should be filed within 30 days from the date of receiving a shipment with the C&D customer service department. E-mail a copy of the VERIFIED component-packing list to customersvc@cdtrojan.com, or call 1-800-543-8630. This verified list should show both the name of the packer, as well as the quantities of items checked off by the receiver.

1.3 Cell Type Identification

C&D historically produced lead-calcium alloy and lead-antimony alloy products. The product distinction can be made by checking the cell type label (lead-calcium white label, lead-antimony green label), the operating instruction label, or the stamping on top of the post as calcium alloy may have "CA" and antimony alloy may be stamped with "SB." As of 2020, C&D is only manufacturing lead-calcium standby VLA cells.

2 Storage and Shelf Life

2.1 Storing Charged VLA Batteries

Lead-acid batteries cannot be stored indefinitely and must be given a freshening charge if they are stored for an extended period of time before installation.

Store batteries indoors in a cool (60° to 85°F or 16° to 29°C), dry location, preferably at 77°F (25°C) or below, and place in service before the date stamped on the shipping carton. The indicated storage time is based on storage at 77°F (25°C) and is six months for lead-calcium cells. Storage at temperatures above 77°F (25°C) requires monthly cell voltage monitoring. Higher than normal storage temperature 77°F (25°C) will accelerate internal self-discharge of a battery. Self-discharge will double for every 15°F (8°C) over nominal 77°F (25°C) storage temperature. This factor will shorten the allowable time between freshening charges. Reference Table 1 for freshening charge interval.

Table 1 - Storage Period in Days Before Requiring Refresh Charge

Battery Chemistry	Storage Temperature		
	0-77°F	78-90°F	91-120°F
Lead-calcium	180	90	45

Storage in hot and/or moist environments may result in white oxidation of the lead. Refer to Section 4.5 for cleaning instructions.

Exercise caution when operating or storing batteries at low temperatures because of the possibility of electrolyte freezing. Although the specific gravity of a fully charged battery may present no freezing problem, discharged batteries with depleted electrolyte specific gravities may freeze. Table 1A provides information on freezing temperatures versus specific gravity.

Table 1A - Freezing Temperature Vs. Specific Gravity

Specific Gravity at 60°F (15°C)	Freezing Temperature	
	Celsius	Fahrenheit
1.000	0	+32
1.050	-3.3	+26
1.100	-7.7	+18
1.150	-15	+5
1.200	-27	-17
1.250	-52	-61
1.300	-70	-95
1.350	-49	-56
1.400	-36	-33

A convenient measurement technique is to read the open circuit voltage and compare it with Table 2. If the open circuit voltage drops 0.02 volts from the nominal value shown in Table 2, the cell(s) must be given a freshening charge, at equalize voltage as specified in Section 8.2.

Product must be installed and on float charge within one year of ship date. Contact C&D if this cannot be met.

Failure to charge as noted voids the battery warranty. The freshening charge is conducted at equalize voltage as specified in Section 8.2 Table 6, Equalize Charge Voltages. The freshening charge may be given to individual cells, groups of cells, or the entire battery. If constant-current charging equipment is used, charge at 5 amperes per 100 ampere-hour rated 8-hour capacity for a period not exceeding 24 hours.

Please contact C&D with any questions about storage requirements and/or limitations.

DANGER

DO NOT handle cells during or after freshening charge for 48 hours due to potential hydrogen build-up.

Table 2 - Open Circuit Cell Voltages

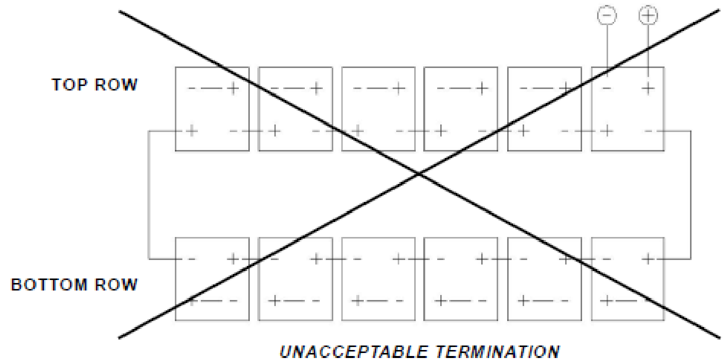
Nominal Specific Gravity of Cell	Individual Cell Voltage
1.215	**2.063**
1.250	**2.098**
1.300	2.145

3 Pre-Installation Planning

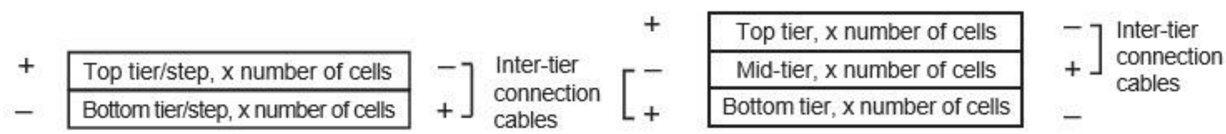
The cell arrangement, rack(s) and connections are typically installed using generic information provided by C&D. However, a customized and detailed installation drawing may be obtained from C&D when placing the original order at an additional charge.

The installer should plan the battery arrangement, starting with the positive terminal of the battery and ending with the negative terminal. Planning should be completed before receipt of the battery. First, sketch a footprint of the rack location. Check the applicable codes for clearance requirements. Allow sufficient aisle width to permit loading cells directly to their ultimate location on the rack and clearance for maintenance including overhead clearance. Determine the battery terminations and locations on the rack layout. The floor loading capacity of the room should be checked, as well as its capability to hold anchor bolts. Floor contact area information for floor loading calculations can be found on rack drawings.

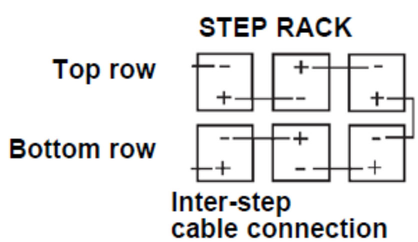
WARNING: The positive and negative terminal connections of a battery should never be terminated within a multi-cell unit. The positive and negative terminal connections of a battery must be from different cell containers properly spaced to provide isolation between the highest potential differences of the battery.

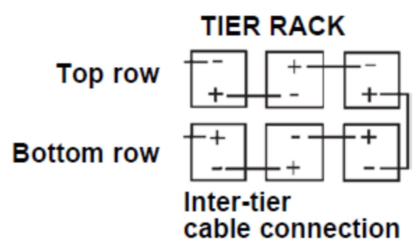


If there are an even number of tiers or steps, the battery will terminate on a common end. If there are an odd number of tiers or steps, the battery will terminate at opposite ends. Polarities below are shown for reference only.



Cells at the end of each row in stepped or tiered racks must be arranged for the shortest cable run between steps and tiers. See the following illustration. Failure to do so will result in some cables being too short due to terminal (post) locations especially on multi-cell units.





3.1 Installation of Battery Rack(s) Overview

NOTE: Standby battery rack assembly instructions and/or rack assembly drawings are supplied with C&D-supplied racks and should be consulted for detailed instructions specific to the rack assembly prior to assembly.

Remember that standby battery and rack systems will be in place for many years. Rack frames, rear cross bracing, bottom support, and rear restraint rails must be assembled before any batteries are installed.

CAUTION

Racks must be installed in a safe location for maintenance and away from radiant heat sources. Before batteries are installed, racks must be level and have cross braces in place. All bolts must be tightened to specified torque values. Floor loading must be considered in the planning phase.

1. For C&D supplied racks, follow the instructions in the rack assembly instruction guides and/or the C&D rack assembly drawing, supplied with the rack, to mark the rack footprint, rack frame locations with spacing, and anchor bolt locations. Then drill holes for the anchor bolts.

   NOTE: Anchor bolts are not selected nor supplied by C&D and are the responsibility of the installer. Installation must be in accordance with local building code and anchor manufacturer requirements.

2. Follow the instructions as noted for initial assembly steps, including mounting the frames to a flat and even floor with anchor bolts and attaching the rear cross-bracing. Hand-tighten all the bolts and nuts.
3. After ensuring that all the frames are plumb, vertical, and level, tighten all bolts and nuts to the specified torque value starting with the rear cross braces and then the support rail clamp nuts. All hardware is to be tightened to the manufacturer's recommended torque value(s).
4. For seismic racks, position rear restraining rails and tighten bolts and nuts to the proper torque. Temporarily position the front restraint rail and cover next to the front support rail prior to installing the cells.
5. Install plastic rail covers prior to installing batteries.
6. Front and end restraining rails are usually installed after the cells have been placed on the rack. Installation of the front restraint rails after the cells are in place can be completed by simply raising the restraint rail into position. A gap between the battery jar walls and the rails of the approximate thickness of a business card is typical.
7. The end restraint rails and corner brackets are to be installed and moved up to the end batteries of the tier.
8. Secure rack assembly checking that all bolts and nuts, including anchor bolts, are tightened to the proper torque.

CAUTION

- Top rows of batteries in multiple-tier installations tend to operate at slightly higher temperatures than those on lower rows.
- Ensure adequate ventilation is in place to avoid extreme temperature conditions.
- Always provide adequate overhead clearance (minimum of 8” to 12” recommended) for ventilation and maintenance.
- When assembled, battery racks must be anchored to the floor.
- Do not place battery cells on the rack until the rack has been completely assembled with the braces installed, secured to the floor, and all bolts tightened to specified torque (refer to sequential steps of rack assembly.) Otherwise, the weight of the cells may cause the rack to shift and collapse.
- Never loosen or remove braces from a standard, loaded battery rack. Removal of bracing can allow the rack to shift and collapse. Front restraining rails on seismic (EP) racks may be removed to accommodate loading/unloading of cells.

NOTE: It is helpful to clean the rack(s) and the area surrounding the installation to remove abrasive materials and residual building materials before installing cells. This will not only reduce the chance of damaging cell containers but will ease installation and simplify final cleaning of the assembled battery.

3.2 Electrolyte Containment

Although it is unlikely that a properly maintained battery will exhibit electrolyte leakage, electrolyte containment systems are required by multiple regulatory codes. These systems are available through C&D. Consult the C&D representative or C&D directly for assistance in specifying and ordering spill containment systems. Reference Appendix C for additional information.

4 Installing Cells

These instructions apply to lead-acid batteries configured as single-cell containers or multi-cell containers. The term containers can apply to both configurations. Ensure batteries are installed in the upright position so the terminals can be accessed from the top of the battery.

NOTE: **Read and follow the "Battery Handling and Installation Guidelines" packed on top of the cells, form *RS-999*.**

Figure 4.1.1 - Removing the Cartons

CAUTION

Before working on the battery, be sure to discharge static electricity that can build up on tools, cell containers, or the technician by touching a grounded surface in the vicinity of the battery but far enough from the cells to avoid creating sparks.

4.1 Unpacking and Handling Cells

If cells were shipped with orange shipping vent caps in place, do not remove them until the cells are in their final installed position. Before installing the battery, gather the following tools and equipment:

- Safety equipment: Eye protection and portable or stationary water facilities for rinsing eyes and skin in the event of contact with electrolyte, safety shoes, rubber apron, and acid-resistant gloves. Shock and arc-flash protection may be required depending on the system size, voltage, and configuration.
- Inch-pound torque wrench and box/open end wrench, both calibrated and insulated.
- Multi-meter with accuracy of 0.001 volts DC.
- Sodium bicarbonate, water, a bucket, and clean rags. **DO NOT USE SOLVENTS** of any kind, other than water.
- Brass bristle brush(es), packed with battery accessories. Optional: fiber bristle brush, or medium grade Scotch Brite™ pad
- Cell lifting sling and wood spreader board (when provided)
- Battery hoist of appropriate lifting capacity
- One inch paint brush or rag for applying NO-OX-ID grease
- Platform lift, when applicable
- Thermostatically controlled hot plate with no open flames (optional)
- Hot air gun or blower (optional)

Figure 4.1.2 – Use of lifting sling and spreader board

Large single-cell and multi-cell containers are packed in individual cartons banded to a wooden pallet. Remove the banding and carefully lift off cartons for access to lifting slots in the bottom support foam. (Figure 4.1.1)

Always lift units from the bottom, **never by the posts**. A lifting sling and spreader board are packed in the accessory's carton. Slip the lifting sling under the cell, then install the spreader board on top of the cell. Ensure the sling fits into notches in the spreader board. Use the loops in the sling to hoist the unit. (Figure 4.1.2)

Smaller units, such as the D series, are supplied in cartons from which they can be lifted by hand.

4.2 Pre-installation procedures

At the first opportunity, check the electrolyte level in each cell. It should be between the high- and low-level lines (see Figure 4.2.1) on the container. If the level is below the top of the plates, order a new cell and file a claim for concealed damage against the carrier.

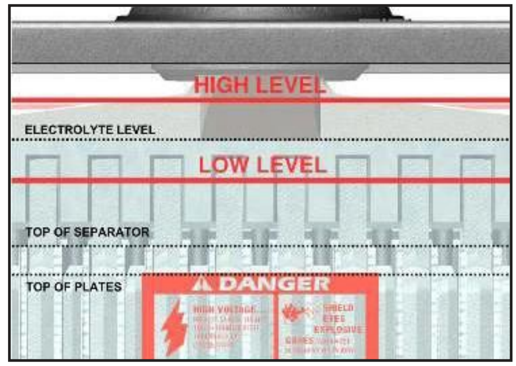


Figure 4.2.1 – Electrolytes should be between the high- and low-level lines

If the cell plates are covered but the level is lower than the low-level mark, **make no** additions (i.e., water, acid) until the cells have been on float charge for one week, and contact your local C&D representative. If electrolyte is found on the top of the cell or terminal posts, clean immediately with a solution consisting of one pound sodium bicarbonate to one gallon of water. Do not allow the cleaning solution to enter cell. Rinse with clean water after neutralization step.

Use of unauthorized cleaning products will void warranty on the battery.

Consult the **optional** battery arrangement plan, **if one was ordered from C&D.** Cells may now be loaded onto the rack(s). Always lift cells by the bottom only.

WARNING

Batteries present both electrical and chemical hazards to those who install or service them. It is essential you always exercise extreme care to ensure a safe working environment.

- Gases produced by vented cell lead-acid batteries are explosive. Do not smoke, use an open flame, or create an arc or sparks in the vicinity of a battery.
- Always use protective insulating equipment, such as gloves, shoes, and eye protectors. Wrenches and other tools must be insulated to comply with applicable codes and safety standards.
- Observe local, state, and national electrical codes at all times.
- Work with the battery ungrounded whenever possible.
- Battery ground connections, if required, should be made last.
- To avoid working with high voltages, break the battery down into convenient, lower-voltage modules, i.e., do not interconnect rows or tiers of cells until the final step in connection.
- Lead-acid cells contain dilute sulfuric acid. Avoid contact with eyes, skin, and clothing. Should contact occur, remove contaminated clothing immediately and flush affected body areas immediately and thoroughly with water. Wash clothing thoroughly before reuse. Do not attempt to clean and reuse contaminated shoes. If acid should contact the eye, flush immediately with large amounts of water for at least 15 minutes. **ALWAYS CONSULT A PHYSICIAN IN CASES OF ACID CONTACT WITH THE EYES.**
- Before working on the battery, be sure to discharge static electricity that can build up on tools or the technician by touching a grounded surface in the vicinity of the battery but far enough from the cells and flame arrestors to avoid ignition of any hydrogen gas present. Avoid creating sparks or exposing cells to open flames that could ignite the gases produced by a charging battery.

4.3 Arrangement of Cells on Racks

- Lifting slings and spreader boards are effective tools for safely moving cells.
- Install cells in the center of the row and work out towards the ends. On properly anchored step type racks, it is permissible to load the middle of the top step first to avoid reaching across cells that could be installed on the bottom step. On multi-tier type racks, always begin installing cells on the bottom tier, completing that row before starting the next higher tier.
- Cell models KT/KCT, LT/LCT & MCT-HP can be installed with the plates perpendicular or parallel to the longitudinal axis of the rack; all other cell models can only be installed with plates perpendicular. Note that racks and accessory kits are designed for a specific plate orientation.
- Retrofit models may need further assistance to connect. Contact C&D for further information.
- Cells should be loaded by placing them directly in front of the designated location on the rack. It is recommended that a platform lift be used for this procedure, however the hoist used to lift a cell from its container may be used to position the cell. Carefully adjust the cell into its final position. When moving cells on rack, **DO NOT push on the center of the jar walls.** Move cells by placing hands on the corners of the jar and pushing. Arrange cells so the positive post (terminal) of one cell can be connected to the negative post (terminal) of the next cell. Cell post polarity is marked with symbols molded in the cover. A plus sign (+) denotes the positive post and a minus sign (-) denotes the negative post.
- Space cell containers approximately one-half inch apart at the top of the jar. If batteries are being installed on a seismic rack, use provided cell spacers to position cells.
- If the aisle is too narrow to allow access to the rack from the front, it may be necessary to load the rack from the end.
- **Lubrication is typically not required since the plastic rail covering provides a low friction surface for sliding the cells. If a lubricant is deemed necessary, only use unscented talcum powder, Dow Corning 111® silicon compound, or a small amount of clean water, applied sparingly to the rail cover.** The talcum powder may be removed with a cloth dampened in water. **Do not use any solvents**.

WARNING

Do not use wire pulling compounds, oils, grease, or any other material not specifically authorized by C&D in writing, as these may contain additives that could damage the plastic containers. Use of any unauthorized solvents voids warranty.

For seismic (EP) racks, spacers between cells are required as noted in rack or layout drawings.

Add front and end restraining rails and install front-to-back restraining rail tie rods if supplied, for EP racks. End rails should be placed within one-eighth of an inch from end cells. Reference provided rack instructions or drawings for more information.

NOTE: Depending on the EP rack type, spacers provided may be foam or molded PVC.

Do not tighten end rails against cells as it can result in jar damage. Tighten tie rods/cell restraining rails to allow a business card to fit between the cell jar and the restraining rail.

CAUTION

Where multiple standard type racks are installed end-to-end, no more than one-eighth inch of cell length should rest over a support rail that is not rigidly spliced.

Never move or adjust a rack with batteries loaded on it.

4.4 Numbering Cells, Labels and Warnings for Battery

C&D provides labels and warnings to help maintain the battery and to apprise of certain hazards. **Be certain to attach maintenance and operating labels to cells so they may be read by anyone working on or in the vicinity of the battery. Reference Section 11.7 for examples.**

Every cell has an identification label on the cover. This label is very important since it lists cell type, date code, and order number. This information is needed for warranty purposes.

The cell ID label is usually placed prior to shipment at the factory. However, some cells are prepacked to expedite delivery. In this case, the ID labels will be shipped separately and must be placed onto the cover by the installer during installation.

Figure 4.4.1 – Example of label application

For ease of identification, all cells of a battery should be numbered. Plastic peel-and-stick numbers are furnished in the accessories package. Common practice is to start with "1" at the positive terminal of the battery and follow the electrical circuit with succeeding numbers. Remove the plastic backing and firmly press the number into position on the appropriate cell. (Figure 4.4.1)

> **NOTE:** This is a good time to confirm proper cell orientation, ensuring correct polarity and terminal location (i.e., positive to negative to positive, etc.)

4.5 Preparing Electrical Contacting Surfaces

All electrical contacting surfaces must have a clean, electrolyte-free finish. Any tarnish or discoloration should be removed with the brass bristle brush, optional fiber bristle brush, or medium grade Scotch Brite™ pad.

For the connectors (inter-cell & terminal plates), lead plating effectively protects the copper from corrosion in the presence of sulfuric acid while tin plating is an alternate material that can also resist corrosion from moisture and oxidation but is not as resistant against exposure to sulfuric acid. C&D recommends and provides lead-plated connectors for VLA (Flooded) battery systems where contact with sulfuric acid is common. Tin plating is available as a special order, however the protective plating is not warrantied or guaranteed in these applications due to the risk of exposure to battery electrolyte.

Battery cables (inter-tier, inter-step, when supplied, are assembled with tin-plated crimped lugs for attaching to terminal plates (not directly to battery posts).

> **NOTE: DO NOT REMOVE ALL PLATING FROM THE CONNECTORS**

Cell posts are typically factory coated with oil and may be covered with a plastic cap to prevent oxidation of the lead during transportation and storage.

To maintain electrical contact integrity, C&D supplies NO-OX-ID grease (in the accessories package) as a corrosion-resistant coating for all bolted, electrical contacting surfaces. For optimum connection integrity, C&D recommends the following procedure:

1. Remove any factory-applied coating from the posts and post seals with a dry cloth as they may be contaminated with dirt or residual acid. **NOTE:** Post seals, and the surrounding areas, may appear wet due to the factory-applied coating.
2. With a neutralizing solution, consisting of one pound sodium bicarbonate mixed with one gallon water, wipe the cover, post and post seal with a cloth or fiber bristle brush moistened with the neutralizing solution.

3. Rinse with clean water and dry thoroughly. Do not use any industrial battery cleaners as this will void warranty.

CLEANING OF BATTERIES WITH WATER OR ISOPROPYL ALCOHOL ALONE WILL NOT NEUTRALIZE ACID.

4. Lightly brush the post and adjacent lead of the post seal with the brass bristle brush (provided in the accessories,) or medium grade Scotch Brite™ pad, to provide a clean bright finish. **NEVER USE STEEL BRUSHES OR OTHER ABRASIVE TOOLS OR MATERIALS.** Cells designed for high discharge currents are constructed with plated copper inserts cast within the lead posts to optimize conductivity. The copper faces should be lightly brushed to minimize scratching or removal of this protective plating.

NOTE: Minor copper exposure on post terminal faces and within bolt holes due to handling and installation (see examples to the right) will neither degrade the battery's performance nor reduce the battery's expected operating life when installed using NO-OX-ID grease as recommended and properly maintained.

5. Carefully remove any oxidation or white powder from the inter-cell connectors' mating surfaces with either the brass bristle brush, fiber bristle brush, or medium grade Scotch Brite™ pad and buff to a clean and uniform finish. Inter-cell connectors are plated copper and require that care be taken not to remove the plating.
6. NO-OX-ID grease must be applied to the terminal post and to the horizontal lead surface of the post seal to ensure all exposed lead is properly coated to protect against surface discoloration. It is optional to heat the NO-OX- ID grease to a cream-like consistency using a thermostatically controlled hot plate (with no open flames.) Set the temperature between 160°F (71°C) to 185°F (85°C) to maintain the desired consistency.

CAUTION

C&D recommends consulting with site owner/management prior to using hot plates for NO-OX-ID applications. If the hot plate does not have a thermostatic control, exercise extreme care to avoid overheating the grease and causing a fire. Do not use open flames. NO-OX-ID grease has a minimum flash point of 450°F (232°C.)

7. Apply a <u>**thin coat**</u> of grease to each end of the inter-cell connectors and terminal plates where they will contact the posts. On larger and longer connectors, use a one-inch paint brush to apply NO-OX-ID grease to both sides of the middle holes and to cell posts. Wipe any excess NO-OX-ID grease from battery jars, covers, and terminal covers. Reference Figures 4.6.3A and 4.6.3B.

4.6 Making the Connections

C&D batteries are supplied with stainless steel connecting hardware; optional lead-brass hardware is available (see Figure 4.6.1 and Table 3.)

Type	Hardware Description
A	1/4 - 20 brass bolt with cast-on lead head and brass-inserted cast lead nut.
B	5/16 - 18 brass stud and two brass-inserted cast lead nuts.
C	Stainless steel hexagonal bolt, two flat washers, and hexagonal nut.
D	Stainless steel hexagonal bolt and one flat washer.

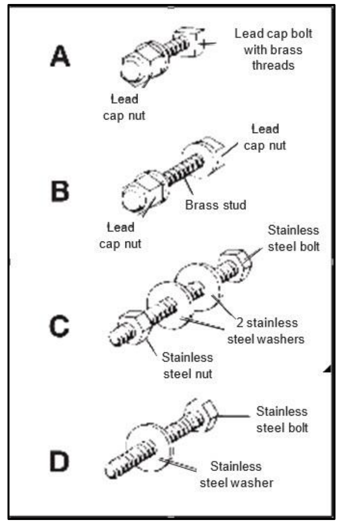


Figure 4.6.1– Connecting bolt assemblies

Cells are supplied with different post configurations suited to their current handling requirements, see Figure 4.6.2.

Place inter-cell connectors against cell posts and insert C&D-supplied brass stud or stainless-steel bolt through the bolt hole in the post and the hole in the connector. For stainless steel bolts, install heavy-duty washers and nuts. Ensure the sharp side of the stamped steel washer is facing away from the inter-cell connector. Hand tighten.

Where one brass stud and two lead cap nuts are supplied, be sure that an equal number of threads is engaged on each nut. Tighten connections to the torque values shown in Table 3, using an insulated torque wrench and an insulated box/open end wrench in counter-torque, as shown in Figure 4.6.3.

Refer to Table 3 to verify the correct hardware is used for the battery type being installed. Align cells so the inter-cell connectors match up with the holes of the terminal posts.

When two inter-cell connectors are supplied for connecting cells, they must be placed on opposite sides of the posts. Make the inter-cell connection (positive to negative) using the bolt assemblies supplied. Refer to Figure 4.6.1.

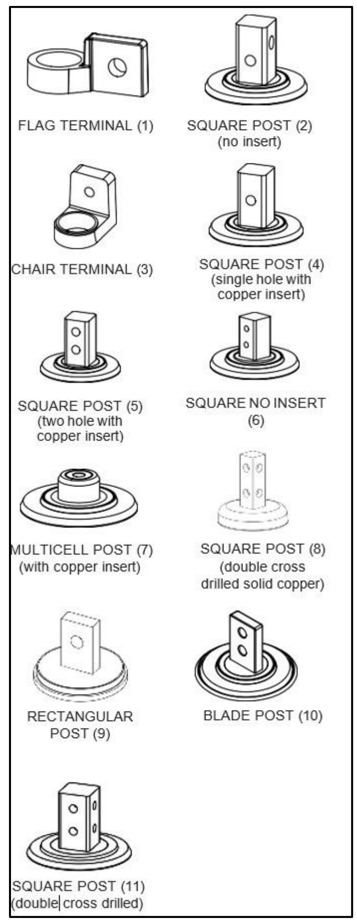


Figure 4.6.3 – Torquing Connections

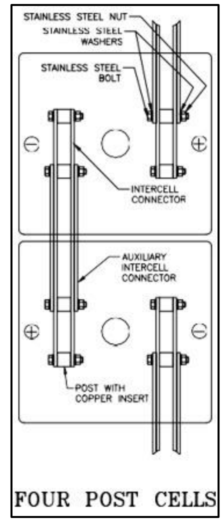
Figure 4.6.3A – Connection with proper no-OX application

Figure 4.6.3B – Lug with proper no-OX application

Figure 4.6.2 – Post and Terminal Design

Table 3 - Torque Requirements for Specific Cell/Unit Types

Bolt Assembly Standard	Optional	Terminal Design	Initial Torque (inch-pounds)	Maintenance Torque (inch-pounds)	Current Cell/ Unit Types	Discontinued Cell/Unit Types
C	A	FLAG (1)	70	60	3DCU 3-11	-
C	B	SQUARE NO INSERT-CROSS DRILLED 1H (2)	110	100	DCU 13-17 KCT LCT/LCT-HP LCR 13-17 4LCY 544 & 660	KCR 5-13 (Pre-2018) LCUN 19-33
C	B	CHAIR (3)	110	100	4LCY290 & 420	4JC, 2JC 3KCT180 CJCSD
C	N/A	CHAIR (3)	160	125	4LCY 5 & 7 4XTH/4XTHP 7 & 9	3KCR 5 XT4J 7-11 XT4L/XT4LP7 & 9
C	N/A	SQUARE WITH INSERT; SINGLE HOLE (4)	160	125	LCR 19-33 LCY 35-39 4LCY 9 & 11	KCR 15-21 (Pre-2018) LCU 19 & 27
C	N/A	SQUARE WITH INSERT; 2 HOLES (5)	160	125	KCR 15-21 2LCR 13 & 15 (2-cell) XT2L/XT2LP 23 & 25 XT1L/XT1LP 35-53	XT4L/XT4LP 11-15 XT2L/XT2LP 17-21 XT1L/XT1LP 27-33
C	B	SQUARE NO INSERT; 2 HOLES (6)	110	100	KCR 5-13	MT/MCT LCM-HP
D	N/A	MULTI-CELL INTER-CELL POST (7)	160	125	4LCY 9 & 11 4LCY 544 & 660	XT4L/XT4LP 11-15
C	N/A	SQUARE (8)	160	125	-	LCT II 1700
C	N/A	RECTANGULAR (9)	110	100	3DJ-HP 4JC-HP	3DJ, 3DJU, 3XDJ
C	N/A	BLADE (10)	160	125	4XTH/4XTHP 11-23 2XTH/2XTHP 25-33	N/A
C	N/A	SQUARE NO INSERT-CROSS DRILLED 2H (11)	110	100	MCT-HP	-



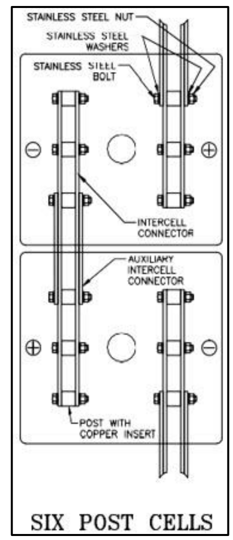


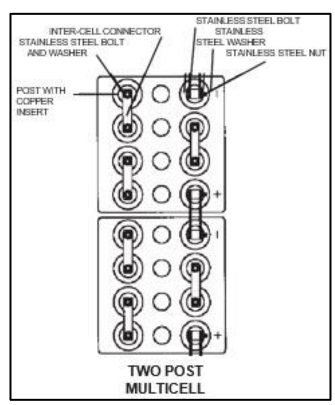
Figure 4.6.3B – Dual Intercell Connections

NOTE: Use the same torque values for connection of terminal plates or cable lugs to battery posts. It is recommended to recheck all connections after assembly, using maintenance torque values.

Refer to Appendix A for the connection torque of load cables to terminal plates.

High current batteries may use shorter piggyback inter-cell connectors applied over the top of the full-length inter-cell connectors connecting all posts. See illustrations for four and six post cells, Figure 4.6.3B.

<u>Tighten the connections to the torque values specified in Table 3, using an insulated torque wrench and a box/open end wrench in counter-torque to avoid damaging posts.</u>



4.7 Checking Connection Integrity and Polarity

After connecting and torquing all cells in the battery, and prior to connecting to the charger or dc system, recheck the torque of all connections in sequence using a digital low resistance micro-ohm meter (DLRO), and immediately check the total voltage of the battery using a calibrated, digital dc voltmeter. The total battery voltage should equal the open circuit voltage (Table 2) of an individual cell multiplied by the number of cells in series connection. The cell nameplate provides information on the specific gravity of the cell(s). Refer to Section 11.7 for the description of nameplate information.

If the battery voltage is less than the calculated total battery voltage, either the voltmeter is problematic or one or more of the cells is installed in reverse polarity. Check and correct any reversed cell polarities. Making this correction will avoid the possibility of charging cells in reverse and destroying them.

Initial cleaning, surface preparation, and proper torquing establishes the lowest possible connection resistance between posts, connectors, and lugs, all of which may have slightly irregular surface finishes. Over-torquing will distort lead posts, permanently damaging the cells and voiding the warranty.

Maintain clean, tight connections. Per Section 11.6 of this manual, check connection resistance. Connection maintenance is the responsibility of the battery end user. Refer to Section 12 for additional maintenance information.

The preferred method of checking connection integrity is by using a digital low resistance ohmmeter (DLRO) and recording the resistance values of each connection. For new installations, remake any connection that is more than ten percent above the average value or five micro-ohms, whichever is greater. Refer to the Reference section of this manual, IEEE-450, and IEEE-484 standards for additional information.

CAUTION

It is the sole responsibility of the battery end user to check connection integrity. Never operate a battery with loose or corroded connections.

4.8 Flame Arrestors

All C&D standby cells use flame arrestors, that are installed on-site, see Figure 4.8.1. Most cells are shipped with orange-colored vent plugs which must be removed before installing the flame arrestors.

After cells have been installed and connected, remove the orange shipping vents, and install the flame arrestors and dust cover vent assemblies provided in the accessory kit.

CAUTION: Be sure flame arrestors are installed before making final battery termination connections. Use caution not to over-rotate (tighten).

Figure 4.8.1 – Flame arrestor vent with dust cover

4.9 Terminal Plates, Cables, and Lugs

C&D offers a variety of cables, terminal lugs, and special terminal plates as optional equipment for specific battery installations. Before beginning installation, check the accessories cartons to determine if the parts ordered have been received. Also check for additional instructions which may be specific to the intended application. This should be done before scheduling installation to permit delivery of any necessary additional hardware.

Standard length inter-step and inter-tier (not inter-aisle or charger) cables are routinely supplied by C&D. They are flexible battery cables with lugs, properly sized for minimal voltage drop.

Terminal plates facilitate the connection of multiple power leads. They are made of lead- or tin-plated copper and formed to permit connection to posts of various configurations. See Appendix A for details of the terminal plates supplied in the standard accessory kits and recommended cable connection torque values.

Figure 4.9.1 – Example of cable

CAUTION

Unsupported cables may cause excessive stress to terminal plates and posts. The maximum unsupported length of an inter-tier, inter-row or inter-rack cable should be 3 feet. Cabling dropping from overhead cable supports may have a maximum unsupported length of 4 feet. Reference Figure 4.9.1 for example of supported cables. Cables should be of sufficient length as to avoid placing tension on battery terminals. Cables should not be installed in such a manner that any force is transmitted to the post due to cable tension or torsion.

CAUTION: ELECTRICAL HAZARD — AUTHORIZED PERSONNEL

Before connecting battery to charger, it is important to note that several hazards are associated with battery systems, particularly those used for large UPS applications where terminal voltages can approach several hundred volts and currents may exceed several thousand amperes. By exercising proper care and allowing only properly trained personnel to work on them, batteries should serve their intended purpose well and perform without incident. Observe precautions and become familiar with local, state, federal, and professional codes, and procedures.

NOTE: It is advisable to determine if the UPS topology includes an isolation input transformer. If it does not, an electrical ground reference will be present at the battery necessitating additional precautions be taken.

CAUTION: If proper polarity is not observed when charging the battery, the battery or groups of reverse-connected cells will be irreparably damaged.

NOTE: Always complete a record of open circuit voltage, initial charge, float charge readings and connection resistances with DLRO. Retain the readings for future reference. Any future warranty discussions will require this information. For convenience, use Form RS-105. A sample is included in this manual. Make a photocopy of the sample so the original will be available for subsequent use. The service life of the battery will depend on freshening charges (if in storage), its operating temperature, frequency of use, depth of discharge, discharge rate, and float charge voltage and regulation.

4.10 Connecting Battery to Charger

Use only direct current (dc) for charging. With the charging source de-energized, connect the positive terminal of the battery to the positive terminal of the charger or system bus, and the negative terminal of the battery to the negative terminal of the charger or system bus. Check connections with a voltmeter to be sure that polarities are correct. Energize the system by following the charger manufacturer's procedures.

NOTE: AC Ripple

Commercial battery chargers convert ac electrical energy to dc. However, the conversion is not perfect, and some variation remains in the output voltage and current. This is known as ac ripple voltage and ac ripple current. The frequency and magnitude of the ripple depends on the design of the charger and the filtering included in the supply. Lead-acid batteries act as a filter for ac ripple, and any variable energy delivered to the batteries is converted to heat. If the magnitude of the ripple is high enough, shallow charge and discharge cycles may take place.

The impact of ac ripple on flooded battery performance and life has been studied; however, there are few conclusions about recommendations for maximum ripple voltage. It is clear that any voltage variation that forces the batteries between gassing and discharge voltages may have an adverse effect on product life. The key parameter is the difference between the float voltage setpoint and the product open circuit voltage. If the charge voltage falls below the unit open circuit voltage, the batteries will discharge. For most C&D flooded products, the difference between float voltage and OCV is 6% of the recommended mid-range float voltage.

Example: KCR-13 (60 Cell String)

Per Cell	Per String
Float Voltage: 2.21 V	Float Voltage: 132.6 V
OCV: 2.055 V	OCV: 123.3 V

132.6 x 0.06 = 7.956
132.6 - 7.956 = 124.64
124.64 > 123.3 **(AC ripple is acceptable)**

CAUTION

Do not adjust electrolyte levels before initial charging. Adjust electrolyte levels only when cells are fully charged and stabilized at float voltage.

5 Charging Battery

Battery charger shall comply with UL 1012, UL 1741, UL 60335-2-29/CSA C22.2 No. 60335-2-29, CAN/CSA C22.2 No.107.2, or UL62368-1/CSA C22.2 No. 62368-1.

5.1 Initial Charge

All batteries shipped wet and fully charged lose some charge in transit or while standing idle before installation and require an initial charge, using either the constant voltage method or the constant current method, prior to placing into service.

Provide an initial charge to the battery at the recommended voltage shown in Table 4. Alternative initial charging methods should be verified with C&D prior to execution.

Table 4 - Initial Charge Voltage and Duration of Charge

LEAD CALCIUM CELLS

Nominal Specific Gravity (Section 11.3)	Maximum Average Volts Per Cell (VPC)*	Time (in Hours) at Maximum Cell Voltage
1.215	2.38	24 - 100
1.250	2.43	24 - 100

***Note**: Applies to average cell voltage. Battery system voltage should be set at average cell voltage multiplied by the number of cells in battery.

CHARGE COMPLETION: The charge is complete when the lowest cell voltage is stable over three consecutive hourly readings, and the voltage of the lowest cell is within 0.05 V of the string average. The string charge current (amps) should remain the same over a 3-hour period by the end of the initial charging period.

NOTE ON THE SPECIFIC GRAVITY OF THE CELLS: The electrolyte of the cells is set at the factory to the nominal specific gravity shown in Figure 11.3.1, at 77°F (25°C), with the electrolyte level between the high- and low-level lines, as specified in Section 11.3 of this manual.

NOTE: As the cell operates and the electrolyte is depleted and replenished, and the state of charge changes due to usage of the battery leading to sulfation and/or stratification, the specific gravity of the electrolyte is impacted accordingly, and specific gravity measurements may not reflect the overall cell specific gravity. In such cases, the use of the string average specific gravity measurements is recommended in troubleshooting possible outlying cells versus their shift from nominal. For a new cell, following proper initial charge methods, the measured specific gravity should reflect the factory requirements for nominal gravity on the initial float charge. Reference Section 11.3.

5.2 Float Charge

Standby batteries are continuously connected to control circuits which must be energized at all times. Connected to a load in parallel with a continuously operating charger, these batteries ensure instantaneous support of the load in the event of a power failure or brownout. In addition to operating the connected load, the power supply maintains the standby battery in a fully charged condition. This parallel interconnection and operation is called float service.

For optimum service, adjust the charger to the float voltages shown in Table 5.

Table 5 - Float Voltage Per Cell (VPC)

LEAD-CALCIUM CELLS

Nominal Specific Gravity	Float Voltage Setpoint Range @ 77ºF (25ºC) (1)	Allowable Individual Cell Voltage	Applications
1.215	2.17 – 2.22	2.12 - 2.27	Telecom including: DCU, KCT, & LCT
1.215	2.20 – 2.25	2.12 - 2.29	UPS (XT Series), SG&C, MCT II, & All -HP models
1.250	2.22 – 2.27	2.15 - 2.32	All
1.300	2.32 – 2.36	2.23 - 2.41	All

1. **Setpoint:** The recommended float voltage setpoint range for the system is based upon voltage reading at battery terminals. Charger settings can be calculated by multiplying the recommended target voltage times the number of series cells in the battery system. Charger setpoints can be made anywhere within the range commensurate with the battery operating temperature, however, the best results for battery life and recharge time will be obtained by setting the charger in the middle of the range.
2. **Individual Cell Voltage:** Allowable cell voltage range; individual cells will vary around the float voltage set point. The individual cell voltage range is provided to identify cells with unusually high or low voltages. These cells should be identified for further action such as charging at a higher voltage (equalizing.)

   For information on constant current charging, consult Section 11.2 of this manual. See Section 11.3 for operation at temperatures other than 77°F (25°C).

6 Watering Cells and Adjusting Electrolyte Level

Before adding water to a battery, its condition and state of charge must be considered. If the plates are covered by electrolyte, the battery should be placed on charge. The gases produced by charging will displace the electrolyte and raise it to an acceptable level between the high- and low-level lines on the container. Had the level been adjusted to the high mark before charging, charging could have caused the electrolyte to rise to a point where it could overflow through the vent or be forced up into the flame arrestor, requiring needless maintenance.

NOTE: Adding water to a battery to bring the initial electrolyte levels up will reduce the specific gravity and introduce a higher level of variation to specific gravity measurements.

If, after charging, the electrolyte levels have not risen to between the high- and low-level lines, sulfuric acid of the same specific gravity may be added to bring levels to the high mark (on charge). Adding acid is a procedure that should be done only after consultation with C&D and performed by a C&D representative.

CAUTION: POTENTIALLY EXPLOSIVE GASES

VLA (flooded) lead-acid cells release hydrogen gas during charge, which is potentially explosive. Flame arrestors reduce the likelihood of ignition within a cell; however, caution must still be exercised not to bring an open flame or sparks near the battery. Hydrogen can be evolved at the rate of 0.000269 cubic feet per minute per charging ampere per cell at 77°F (25°C). The maximum level of hydrogen gas in the battery room should not exceed concentrations specified by local codes, typically one to two percent by volume. Do not install batteries in unventilated areas or enclosures. Under normal float conditions, hydrogen generation is minimal, reference IEEE 1635, "Guide for the Ventilation and Thermal Management of Batteries for Stationary Applications."

7 Cleaning Cells and Battery Rack(s)

CAUTION: CLEANING THERMOPLASTIC CELL CONTAINERS – clean or wash the containers with clean water only. Do not use solvents or glass cleaners.

Neutralize acid spills with a solution of sodium bicarbonate – one pound of sodium bicarbonate mixed with one gallon of clean water. Never use ammonia, soda ash, sodium hydroxide, or any strong alkalis. If alkalis are inadvertently spilled on the containers, they should be immediately washed off with clean water.

8 Battery Operation

8.1 Float Service

In ideal float service, a battery is always maintained in a fully charged condition. However, in the event of a power failure or system test in which the chargers are shut down, the battery must support the load resulting in a battery discharge. Typically, a standby battery will not be subjected to more than one test discharge each year and a transfer test monthly.

Additional deep and/or frequent discharges can shorten service life, even with proper maintenance and operation. This section will consider batteries that are used in full float service. They should not be exposed to service in which the primary power system is not capable of supporting peak loads. In such cases, the battery would be exposed to numerous partial discharges. In float service, the charger voltage is regulated and filtered, and the battery is operated in a temperature-controlled environment.

For optimal service, adjust the chargers to the recommended float voltages shown in Table 5. See Section 11.3 for temperature correction factors. If more frequent discharges are anticipated, use a higher float voltage setting. Operating within these criteria will maximize battery service life.

Equalize charges are used to bring cell voltages into a narrower operating range, or to ensure full state of charge before a discharge performance test. An equalizing charge may be required at a voltage higher than the nominal float voltage to restore proper voltage to a battery which has:

- Been subjected to frequent discharges, resulting in a partial state of charge condition
- Been charged at less than minimum float voltage, resulting in an undercharged condition

An equalizing charge should be given when the lowest cell voltage reaches the minimum allowable cell voltage shown in Table 6. Lead-calcium cells should be equalized when a cell reaches a low voltage limit.

8.2 Equalize Charge

As noted above, equalize charges are used to narrow the overall voltage spread of a battery system. Equalize charges are performed on an as-needed basis. Minimum allowable cell voltage is the point at which an equalizing charge should be performed. It does not imply the battery is malfunctioning or will not provide power if called upon. The ability to perform an equalize charge on a system will depend on the maximum voltage capability for the system and any downstream components. Verify that all equipment fed from the system can withstand a sustained equalize voltage. Contact the C&D Technologies representative if system limitations require equalizing at an alternate voltage to what is recommended.

Table 6 - Equalize Charge Voltages

LEAD-CALCIUM CELLS

Nominal Specific Gravity (See Section 11.3)	Equalize When Lowest Cell in String Reaches	Equalize Voltage per Cell (VPC)	Duration*
1.215	2.12	2.33-2.38	48-24 Hours
1.250	2.15	2.38-2.43	
1.300	2.23	2.45-2.50	

*The longer equalization time is to be used for the lower equalization voltage; the shorter equalization time is to be used for the higher equalization voltage.

Terminating Equalize Charge: The duration of an equalize charge for lead-acid batteries will depend on various factors, including the local battery environment, the conditions causing the need for equalization, the total voltage variability within the system, and the length of time that the low cell voltage condition persisted. Terminating the charge will depend on the voltage rise of the low cell and the stability of the voltage in the lowest cell. Start measuring the voltage of the lowest cell in the system eight hours after initiation of the equalize charge. The equalization can be terminated after 24 hours when the lowest voltage cell is within 0.05 V of the string average (in volts per cell) AND the voltage has not changed for three consecutive hourly readings and the charging current is stable. If these conditions are not reached within two days of charge initiation, please contact the C&D representative.

Single Cell Equalize: Some equipment may not have the required equalizing voltages available, thereby lengthening the charging period. As an alternative, a single-cell charger with ac line isolation may be paralleled across the affected cell while still part of the overall battery to provide an over-voltage to the subject cell. Set points similar to system equalize should be used. Termination of the charge should occur when the cell voltage and charger current (in amperes) stabilizes over three consecutive hourly readings. Again, contact the C&D representative with questions on system issues.

Equalization Frequency: Lead-calcium cells rarely require equalize charge. If an equalization charge is performed to correct low cell voltage or another condition referenced in this manual and the condition returns within 12 months, additional corrective action may be required. It is not recommended to equalize charge lead-calcium cells more than once per 18-month period without consulting C&D.

8.3 Performance Characteristics

Battery performance is rated at 77°F (25°C). Operation at higher temperatures increases capacity but reduces life approximately 50 percent for every 15°F (8°C) rise. Operation at lower temperatures reduces capacity but extends life. It is recommended to size the battery with additional margin for operation at the minimum expected temperature.

Battery performance at a given rate is related to the internal resistance of the cells and the external resistance of the conductors connecting the cells. Aging increases internal resistance that results in greater voltage drop, or losses. The effects of aging have the greatest impact on high-rate performance. A battery whose resistance has increased by 10%, for example, when discharged at its 8-hour rate will experience a loss of approximately 10% of its reserve capacity or provide only 7.2 hours of support. But the same battery discharged at its 15-minute rate will experience a loss of approximately 20% capacity and may not provide adequate support time.

Typically, during the last half of the battery service life, capacity will begin to fall slowly at first, then at an increasing rate. Lead-acid batteries have been historically considered to reach the end of their useful life when they have reached 80% capacity. It is recommended that a battery be sized with an aging margin to compensate for loss of capacity as the battery ages. At short-duration high rates, there may be little, or no time left when the battery reaches 80% capacity. It is strongly recommended that in such applications, an aging factor be applied to ensure that the critical load will be supported for adequate time at end of life. For further information on this topic, refer to Annex K of IEEE Std-450, Recommended Practice for Maintenance, Testing and Replacement of Vented Lead-acid Batteries for Stationary Applications and IEEE Std-1184, Guide for Batteries for Uninterruptible Power Supply Systems.

NOTE: Frequent charge/discharge cycles accelerate battery aging and performance degradation.

8.4 Environmental Requirements

Recommended operating temperature range for standby battery operation is 60°F (15°C) minimum to 90°F (32°C) maximum; 77°F (25°C) yearly average.

Operating temperature limits to prevent mechanical and/or performance degradation (or failure) is 32°F (0°C) minimum to 120°F (49°C) maximum at standard atmospheric pressure.

9 Basic Battery Maintenance

CAUTION: The battery string must be disconnected from the charging bus before working on individual cells or batteries. In multi-cell containers, disconnecting an inter-cell (within the same container) connector does not guarantee the absence of voltage or current at the end terminals. A potential shock hazard may therefore exist. This is very important since there is always the possibility of a small, internal leak path across an inter-cell partition.

Proper maintenance will prolong the life of a battery and will aid in ensuring it can satisfy its performance requirements. A good battery maintenance program will also serve as a valuable aid in determining the need for battery replacement.

NOTE: These recommended procedures are designed to minimize specific gravity measurements and emphasize cell voltage measurement as an indicator of acceptable operation. The reason for this choice of procedure is that voltage measurements, particularly with digital voltmeters, tend to be more accurate in comparison to readings taken with either a digital or an analog hydrometer. Specific gravity measurements are significantly influenced by method of measurement, current cell conditions and recent maintenance (see Section 11.3 for specifics related to specific gravity measurements). In addition, hydrometer measurements are a common source of spillage of electrolyte onto cell covers and connecting hardware and cell posts.

CAUTION: If electrolyte spillage occurs and is not immediately removed and neutralized, it will become a source of corrosion and staining of the accessory parts. This condition is sometimes mistaken as electrolyte leakage from post seals, gravity sampling tubes, and even container to cover seals.

The frequency of battery inspections should be based on the criticality of the loads that must be supplied by the battery and the availability of other power sources. **<u>As a minimum, records of three (3) quarterly reports and one (1) annual inspection per year must be maintained to preserve warranty. Record findings clearly and date originals and copies.</u>**

9.1 Monthly Battery Inspection

The monthly battery inspection should include the following observations/measurements:

- Float voltage measured at battery terminals
- General appearance and cleanliness of battery, battery rack, and the battery area
- Charger output current and voltage. **NOTE:** Gross charger output may be greater than the float current required by the battery as the charger may also be providing the dc system load. Measure battery float current at the battery terminals.
- Electrolyte levels (visual check)
- Cracks in cell containers or leakage of electrolyte
- Any evidence of corrosion at cell terminals, connectors, or racks
- Ambient temperature and operation of ventilation equipment
- Pilot-cell voltage and electrolyte temperature
- Ground faults

- Verification that all battery monitoring systems are operational, if installed
- Record findings clearly and date entries

9.2 Quarterly Battery Inspection

The quarterly battery inspection should include performance of the monthly observations, plus:

- Voltage of every cell
- Temperature of electrolyte in representative cell(s), typically one cell/tier distributed throughout battery

Optional Inspection

Specific gravity of any cell where the individual cell float voltage is outside of the acceptable cell float voltage range indicated in Table 5.

9.3 Annual Battery Inspection

The annual battery inspection should include the quarterly observations, plus:

- Cell condition and visual inspection
- Inter-cell/inter-unit connection integrity, measured with DLRO (see Section 11.6)
- Check for signs of acid leakage

NOTE: If the battery has experienced abnormal operation, such as severe discharge or overcharge, a more extensive inspection should be made to ensure that the battery has not been damaged. More information can be found in the Reference and Maintenance sections, Sections 11 & 12 of this manual.

Periodic inspections, as outlined above, and the subsequent corrective actions are intended to provide a properly maintained battery that will meet its performance requirements. In addition, yearly performance tests can be used to demonstrate the adequacy of the maintenance practices. Each of these inspections and tests should be used as best suited for the needs of the application. It is the user's responsibility to format a maintenance inspection and testing program to optimize the benefits available.

Under specified conditions (see Section 11.3), the battery specific gravity readings are not going to fluctuate much over the life of the cell. Specific gravity readings are best utilized as a troubleshooting tool. Specific gravity will typically increase 10 to 20 points, depending on design, as water is electrolyzed, and the electrolyte levels drop from the high to low lines. The only times that gravity drops are when water is added to bring the levels back up, the battery is in a discharged state, or battery is being self-discharged due to an internal short. Both discharge situations can be determined without the need for regular gravity maintenance readings, e.g., by low cell voltage readings or the presence of sulfate crystals on the surface of the positive plates and/or internal connector straps.

9.4 Watering the Battery

Apart from losses due to evaporation and oxygen diffusion, the quantity of water consumed by a battery is proportional to the amount of overcharge it receives. Batteries manufactured with lead-calcium alloy, because of the purity of their grid components, require only about one-tenth the water used by new lead-antimony batteries of the same size. This low requirement remains constant during their entire life. The tops of the plates and bottom of the flame-arrestor funnel stem should never be exposed, so water should be added before the electrolyte level reaches the low-level-line.

NOTE: Distilled or de-ionized water is recommended for adjusting electrolyte levels

If intending to use public water and the suitability of the local water supply for use in lead-acid batteries is questioned, consult the local C&D representative. If a recent analysis report is not available, it is prudent to conduct an analysis in-house or at a convenient laboratory. Table 7 details acceptable water purity acceptance criteria.

Table 7- Minimum Requirements for Battery Water used to Adjust Electrolyte Levels in Standby Lead-Acid Batteries

Impurities in Water	Maximum Allowable Quantity (ppm)
Total Solids	350.0
Fixed Solids	200.0
Organic and Volatile Matter	150.0
Iron	4.0
Chloride	25.0
Ammonia as NH4	5.0
Nitrates as NO2	10.0
Nitrates as NO3	10.0

9.5 Connection Integrity

Connection integrity is critical to the safe and efficient operation of any battery. This is the sole responsibility of the installer/end user. Connections must be inspected at least once a year for the following:

- CLEANLINESS: Remove all corrosion by-products and restore as described in Section 4.5.
- TIGHTNESS: At least once a year, verify connection integrity using a DRLO meter. Connection resistance measurements that are more than 20% higher than the average for other identical connections require additional maintenance. High-resistance connections should be inspected for correctness and corrosion. If no corrosion is observed, the connection can be re-torqued to the values given in Table 3 (Refer to Sections 4.6 and 4.7). If the connection does not improve, the connection should be disassembled, cleaned, inspected, and re-made.
- HARDWARE: Replace worn or damaged hardware.

The importance of connection integrity cannot be overemphasized. Take time to check all connections periodically. Batteries with voltages of 250 volts or greater and/or batteries used in high-rate applications should have their connections inspected at least twice each year.

CAUTION

An improper or loose connection can cause arcing and possibly a fire.

9.6 Ohmic Measurements

Internal Ohmic Measurements (resistance, conductance, impedance, admittance) are often taken as part of a maintenance program on VRLA and other battery types. These measurements can be used as a trending tool for C&D VLA batteries; however, it is important to note that the measurements can be highly variable. Temperature, state of charge, electrolyte level and several other factors can affect internal Ohmic measurements. If internal Ohmic measurements will be taken, baseline values should be established approximately three months after the battery has been placed into service and trended over time. C&D does not publish internal Ohmic reference values for VLA cells. See section 12.11 for additional information.

9.7 Float Current

Float current measurements and trending are an important tool in monitoring the state of health of any standby battery system. Float current is best measured using clamp-on style ammeter that has been zeroed just before clamping over the cable or connector. The measurement can be taken anywhere within the battery string where the clamp will fit over the cable or connector. If the clamp is not large enough to clamp around multiple cables, measurements can be taken from each cable in a single connection and then added together.

Float current for lead-calcium cells should measure between 10 and 50 milliamps of float current per 100 Ampere-hours of battery capacity and remain relatively stable over the life of the battery. Increasing float current can be a result of increased temperatures, a recent discharge or battery aging. If the float current exceeds 1A per 100Ah of battery capacity, verify float voltage and operating temperature are within C&D recommendations. If float current continues to rise, contact C&D Technical Services.

10 Measuring Specific Gravity of a Cell

10.1 Use of the Float Hydrometer

A hydrometer float inserted in a glass-barreled, rubber bulb syringe is used to measure the specific gravity of electrolyte. The float is graduated in points of specific gravity, wherein 0.001 equals one point of specific gravity. The specific gravity is read on the hydrometer scale at the level at which it floats in the electrolyte.

Figure 10.1.1 – Taking a specific gravity reading

NOTE: Digital electronic hydrometers are available and may provide a more convenient method of measurement. They still require immersion into the electrolyte and the same care should be taken to avoid spillage of electrolyte onto the cell and connections.

When taking hydrometer readings, always hold the hydrometer syringe vertically and make sure the float is able to move freely with no pressure applied to the bulb (see Figure 10.1.1).

The glass parts of the hydrometer syringe should be washed with soap and warm water as needed and rinsed with clean water to keep them clean and accurate.

Information regarding the specific gravity of a fully charged cell appears on the cell name plate as part of the model number. As the cell discharges, the specific gravity will decrease. The specific gravity is an indication of the state of charge or discharge of the cell. <u>However, note that readings on recharge lag behind the ampere-hours returned on charge. The specific gravity does not immediately indicate the true state of recharge</u>. Mixing the electrolyte is dependent upon the amount of gas generated and acid diffusion. Usually, specific gravity measured at the top of the cell is most accurate **following an equalizing charge** during which the cell has gassed enough to thoroughly mix the electrolyte.

On cell models that have specific gravity sampling tubes (typically located in corner of cell covers,) it is recommended to sample electrolyte through these tubes. First, remove either the small white cap or translucent plug by gently twisting one quarter-turn back and forth as it is being lifted. Otherwise, sample electrolyte through the flame arrestor tube (remove flame arrestor dust cap, see Figure 4.8.1). To obtain a good reading of specific gravity, sample the electrolyte from the hydrometer tubes, discharging the first sample into the filler vent of the flame arrestor and withdraw a second sample for the actual reading. Carefully discharge the second sample into the filler vent and avoid spilling or splashing acid. Any spills should be blotted, and the area rinsed with clean water.

NOTE: For cells without electrolyte sampling tubes on the cover, take gravity readings through the filler funnel of the flame arrestor.

10.2 Pilot Cells

One or more cells in a battery may be selected as a pilot cell for readings. Since all cells in the battery receive the same amount of charge or discharge current, their specific gravities will fall or rise proportionately to that of the pilot cell. It is advisable to change pilot cells after about 10 readings, because a slight amount of electrolyte is lost each time a hydrometer reading is taken. This rotation of pilot cells distributes the electrolyte loss among all the cells in the battery. Always return the electrolyte in the hydrometer syringe to the cell from which it came.

In battery strings with multiple tiers or multiple racks it is recommended to select multiple cells from different locations on the racks to be pilot cells.

NOTE: Typical maintenance procedures are discussed in detail in Section 12 of this manual.

11 Reference Information

A battery used in full float service that has been properly installed, not subjected to frequent discharges and recharges, floated at the recommended charging voltages, and maintained in accordance with recommended practices will require minimal attention.

11.1 Battery Voltage Measurements and Equipment Voltmeter Calibration

Battery voltage measurements must be taken at the battery terminals, not at the attached equipment. The voltmeter should be a digital type with 0.001V resolution to 1000V and 0.25% accuracy.

When the battery is not subject to any discharge, but merely in full float operation, the battery terminal voltage should be close to the meter reading on the attached equipment. If this is not the case, check the voltmeter(s) for errors and have them calibrated by a certified testing laboratory.

11.2 Constant Current Charging

Although constant voltage charging is more common, another method of charging a battery which may be used in some applications is one in which the battery receives its charge from a charger having a constant current control. Under this method, the voltage will rise to any value consistent with the current (a pre-adjusted value). Usually, the current is adjusted to 5 amperes per 100 ampere-hours of battery eight-hour rating. In no event should cell temperature be allowed to exceed 104°F (40°C). If cell temperatures approach this level, reduce the charging current or immediately remove charger.

Note: This type of charging is only to be employed for the initial charge or recharge after a performance test.

For example, a 1200 ampere-hour cell may be charged at 24 to 30 amperes for a prescribed time, which typically does not exceed 48 hours. One method for determining if a battery is fully charged is to monitor the voltage of selected cells three times for three successive hours. It is optional to also check the specific gravity as a secondary confirmation the battery is fully charged. When these values cease to increase between readings, the battery is fully charged. A slight increase in cell temperature may cause readings to vary slightly.

11.3 Specific Gravity, Effects of Temperature, Electrolyte Level and Recharge

The nominal specific gravity of a cell is specified at 77°F (25°C) when fully charged, with the electrolyte fully mixed, and between the high and low lines marked on the battery container. Under these conditions, the variation from nominal should be in accordance with Figure 11.3.1. Variation in readings may have many causes unrelated to battery condition, including stratification, need for watering, recent water addition, or less than full state of charge.

Acceptable Specific Gravity			
Nominal	1.215	1.250	1.300
Minimum	1.200	1.235	1.285
Maximum	1.240	1.275	1.325

Figure 11.3.1

NOTE: Maximum specific gravities will occur near the low-level line.

Effect of Temperature

Electrolyte temperature above 77°F (25°C) will result in a lower specific gravity reading approximately equal to a loss of one point (0.001) for every 3°F (1.67°C). In contrast, electrolyte below 77°F (25°C) will read approximately one point (0.001) higher for every 3°F (1.67°C). Higher temperatures expand the volume of electrolyte which reduces the observed specific gravity, while lower temperatures contract the electrolyte and thereby concentrate the electrolyte.

Note: When measuring specific gravity using a float-style hydrometer, manual temperature adjustment is required. When using a digital hydrometer, temperature adjustment is often a setting that needs to be activated.

The lead-acid battery is an electrochemical device. Heat accelerates chemical activity; cold slows it down. Normal battery operating temperature is considered to be 77°F (25°C). Higher-than-normal temperature has the following effects on a lead-acid battery:

- Shortens life
- Increases performance
- Increases self-discharge
- Lowers cell voltage for a given charge current
- Raises charging current for a given charge voltage
- Increases water usage
- Increases maintenance requirements

Lower-than-normal temperatures do not have the same effects (see Appendix D, Table D1) In general, at recommended float voltage, a battery in a cool location requires less maintenance than one in a warm location. If the operating temperature is something other than 77°F (25°C), it is desirable to modify the float voltage (temperature compensate) as follows:

For electrolyte temperatures other than 77°F (25°C), correct individual cell float voltage by 2.8 mV/°F (5.0 mV/°C):

- Add 2.8 mV (0.0028 Volt) per °F (5.0 mV/°C) below 77°F (25°C) per cell
- Subtract 2.8 mV (0.0028 Volts) per °F (5.0 mV/°C) above 77°F (25°C) per cell

Example:

LCT 1680

Nominal float @ 77°F is 2.20 VPC

Corrected float @ 67°F is 2.228 VPC

Corrected float @ 87°F is 2.172 VPC

At lower-than-normal operating temperatures, battery performance will be reduced (see Appendix D, Table D1)

At higher-than-normal operating temperatures, for every additional 15°F (8°C) battery life is decreased by 50 percent. Therefore, continued operation at an average cell temperature of 92°F (33°C) will reduce battery life to 50 percent of that typical at 77°F (25°C). See Figure D1 in Appendix D.

Electrolyte Level

When water is lost from the electrolyte, the result will be a more concentrated solution and thereby a higher specific gravity reading. The reverse condition applies when water has been added to adjust electrolyte level. The apparent level can be significantly affected by charging voltage. If the voltage is higher than specified in the float tables or if the battery is being charged at equalize voltage, gases will be generated displacing the electrolyte causing the level to rise.

CAUTION: Never allow the electrolyte level to drop below the bottom of the flame arrestor vent tube. Should this occur, hydrogen generated within the cell will not be contained by the flame arrestor and ignition is possible from an outside spark or flame.

Recharge and Electrolyte Stratification

When the battery is discharged, the specific gravity of its electrolyte is reduced. This is a result of the utilization of sulfate ions in the chemical reaction with the active materials in the positive and negative plates. The sponge lead in the negative plate and the lead dioxide in the positive plate both convert to lead sulfate, trapping the sulfate ions in a chemical bond with the plates.

On recharge, lead sulfate in the plates is converted back to the original compounds and the sulfate ions are released from the plates. The sulfate ions recombine to produce sulfuric acid with a density greater than that of the electrolyte. As a result, the newly generated, concentrated (heavy) acid falls to the bottom of the cell container. Specific gravity measurements taken at the top of the cell will be lower than those taken at the bottom. This physical condition is called **electrolyte stratification.**

Stratification does not materially inhibit the ability of a lead-acid battery to deliver power. However, battery performance will be less than optimal, and specific gravity measurements must take into consideration the stratification of the electrolyte. Specific gravity measurements may not reflect the average cell gravity.

There are two ways to eliminate stratification. The first is to provide sufficient time for chemical diffusion. This can take several weeks or longer at float voltage, depending upon the degree of stratification.

A more efficient method is to provide an equalize charge to mix the electrolyte. Gases produced by an equalizing charge agitate the electrolyte, causing the electrolyte to become mixed and more homogenous throughout the cell. The degree of gassing and therefore the equalize voltage are directly associated with the time required for mixing.

11.4 Battery Performance Tests

Batteries are rated on their ability to deliver a certain number of amperes or watts to the load for a specified amount of time before the battery voltage drops to a final cutoff voltage. It is important to recognize that the performance of a cell or battery depends on several factors:

- The discharge rate
- Electrolyte temperature at the start of the discharge
- State of charge
- Integrity of the connections
- Operating history and age of battery

Consult C&D specification sheets for ratings of various cell types.

To be valid, a performance test requires that the following conditions exist:

- A fully charged battery, balanced cell voltages, and specific gravity. In some cases, this may require an equalize charge or, in cases of sulfation, other action. Consult with the C&D Technical Services Department.
- Battery must remain at float voltage for at least 72 hours prior to capacity testing. This is especially important following an equalize charge to clear the gases developed at the surface of the plates.
- All connections (inter-cell, inter-row/tier, and/or inter-aisle) must be optimized to their minimum resistance and be within specification limits established in Sections 4.6 and 4.7.

The discharge rate depends upon the type of test. For an acceptance or performance test, the discharge rate should be a constant current or constant power load equal to the rating of the battery for a selected test duration and to a final predetermined voltage. To facilitate meaningful analysis, any test data submitted to C&D for review must be collected in accordance with the latest revision of IEEE-450 procedures. If the test is run to determine battery capacity, the documentation must demonstrate that the battery was fully charged prior to test. Initial readings as well as discharge readings must be included in the data submitted. All voltage and current measurements must be taken at the battery/cell terminals.

REFERENCE INFORMATION

A complete description for testing vented lead-acid batteries is beyond the scope of this manual but is discussed in detail in IEEE-450 or supplements and other professional standards.

It is important to recognize that standby batteries are designed for a finite number of discharges. Excessive testing or cycling of the battery can shorten battery life. For more information, refer to Section 8.1.

11.5 Connection Voltage Drop

The importance of the integrity of inter-cell, inter-aisle and inter-row connections has been stated. Loose, dirty, or oxidized connections have higher-than-normal resistance and increased voltage drop resulting in less reserve time.

Typically, the designed voltage drop between cells should be 30 millivolts or less. Voltage drop between rows for standard (inter-tier/inter-step) cables is typically less than 100 millivolts.

11.6 Measuring Connection Resistance

Reference Information

IEEE-450 provides a comprehensive description of how to measure connection resistance. Details may be found in Annex F of IEEE-450.

The preferred method of measuring connection resistance uses a calibrated, digital, low resistance meter (DLRO). See Figure 11.6.1.

Figure 11.6.1 - Measuring connection resistance with

To measure connection resistance with a DLRO, proceed as follows:

- With the battery on float charge or open circuit (make sure the battery is not on charge or discharging,) take measurements post to post; positive post of one cell to the negative post of the next cell. The probes used should always be in the same location relative to each other and the flow of float current through the battery.
- Starting at one end of the string, work toward the other end, recording micro-ohm resistances and noting connections with unacceptable resistances or resistance values that exceed the average by 20 percent. **NEVER USE THE DLRO TO TAKE A READING ACROSS A CELL OR THE TERMINALS OF THE BATTERY. THIS COULD RESULT IN PERSONAL INJURY AND COULD SERIOUSLY DAMAGE THE INSTRUMENT.**
- Recheck connections that exhibit unacceptable resistance. Clean and re-torque to the original (initial) torque value, when required.

NOTE: Whenever a connection must be disassembled and reworked, be certain to re-torque the connection to the original (initial) installation torque value.

Compare resistance readings with the original installation readings and records taken when the battery was first installed. Connections that still exhibit unacceptable resistance after cleaning and re-torquing may indicate the presence of improperly sized or damaged cables or inter-cell connectors. Contact a C&D representative for assistance.

11.7 Cell Type Identification

C&D cells may be identified by looking at the label placed on the cover of each cell. The label contains valuable information such as:

- Cell type
- Nominal specific gravity
- Rated discharge time, capacity and final cell voltage (an average of all cells in the battery)
- Date of manufacture
- C&D battery order number

Examples of Labels:

4 JC- 05HP SAN
1 Hr. 56.6 AMP to 1.75 VPC
4 /19 A # 2502378

12 Troubleshooting and Extended Maintenance

12.1 General

When properly maintained and charged, lead-acid storage batteries should provide many years of trouble-free service. However, despite their inherent dependability, failure to operate or maintain them correctly may lead to damage, shortened life, and possible loss of service. The following addresses some of the typical errors in operation and maintenance:

12.2 Float Versus Cycle Life

Standby batteries are designed and constructed to provide long life in continuous float service. They differ in design significantly from other batteries, such as starting or traction types. Traction batteries are designed to be discharged and recharged daily. In contrast, standby batteries are float charged continuously ready to supply instantaneous power either directly to the load or by way of interfacing electronics.

To ensure a battery will perform its intended function, it is strongly recommended that unnecessary testing be kept to a minimum, not to exceed the following:

- an initial acceptance test not to exceed user's originally specified reserve time.
- a load test not more than once every 12 months to verify battery capacity at user's originally specified discharge rate.
- a monthly transfer test to verify system load transfer and electrical system performance.

The end user is expected to maintain records of all battery testing and unplanned equipment discharges to comply with the requirements of the warranty.

CAUTION: Checking voltage drop with conventional voltmeters requires that measurements be taken while the battery is discharging at its rated discharge current. The resistance may be calculated using Ohm's law. Note that cycling will shorten the life of the battery. For this reason, the use of digital, low-resistance ohmmeters is recommended. This type of equipment allows the measurement of connection resistance without discharging or cycling the battery.

12.3 Low Float Voltage and Sulfation

A battery that is below the specified float voltage at the main battery terminals will develop sulfated plates. The result of such a condition is a battery left in a partially charged state. The first noticeable signs may be erratic cell voltage. Finally, the plates may become sulfated. This condition can be visually recognized by an experienced battery technician. If recognized in its early stages, sulfate may be removed by providing equalize charge to the battery. In advanced cases, sulfate may be extremely difficult to remove. In cases of advanced sulfation, contact C&D. Sulfated batteries are not fully charged and therefore have not completed the electrochemical reaction of recharge. Accordingly, they will have reduced capability or performance. If allowed to remain in a partially recharged condition for an extended period, sulfated batteries may suffer irreversible damage, possibly requiring replacement.

For additional information on recovery of sulfated batteries, contact C&D.

CAUTION: RECHARGE BATTERIES AS SOON AS POSSIBLE AFTER A DISCHARGE. Failure to recharge batteries promptly after a discharge may lead to sulfation or, in the case of deep discharge, to a complete battery failure due to hydration. If charging at equalize voltage is not practical, recharge battery at float voltage.

12.4 Batteries on Open Circuit

As soon as a battery is removed from a charger, self-discharge begins. This is caused by internal losses in the cell. Lead-calcium cells will self-discharge at a rate of one to two percent a month.

Therefore, if cells remain on open circuit (with no charging voltage supplied) for prolonged periods, the affected cells may become sulfated and require corrective action. In most cases, an equalize charge is adequate to restore the cells/battery to a satisfactory operating condition. However, in extreme conditions, when the battery is left on open circuit for a very long time, the cells may develop hard sulfate and never fully recharge as mentioned in Section 12.3.

12.5 Hydrated Batteries

When a battery has been discharged beyond its design limits, and left in a discharged state, it is subject to irreversible damage known as hydration. This is a phenomenon in which the specific gravity of the electrolyte has been depleted to a value so low that it permits the lead components to go into solution, destroying the cells. The reaction of dissolution forms many compounds and salts generically referred to as hydrate. These compounds clog the separator pores and upon recharge, react to form metallic lead. As the process continues, thousands of short circuit paths are created. Very often, the effect of the short circuits goes unnoticed except for an observed increase in charging current. As the reaction proceeds, over an extended period, the short circuits become so extensive that it is difficult to keep the cells charged. Finally, the cells may experience terminal short circuit failure.

The cells and cell components shown in Figures 12.5.1 and 12.5.2 exhibit the damaging effects of hydration. The battery must be recharged as soon as possible. Battery hydration usually occurs when the load on the battery is much more than the design load current which causes the battery to discharge for extended periods of time at low voltages. This condition allows the battery to discharge to a very low depth of discharge depleting the available acid ions in the electrolyte. The specific gravity of the electrolyte finally approaches that of water.

Typically, if one or more cells in a battery become visibly hydrated, it is only a matter of time before the remaining cells exhibit the same condition.

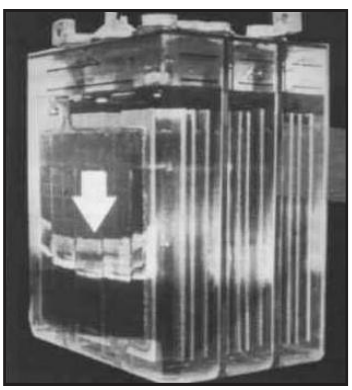


Figure 12.5.1 – Arrow points to white, crystalline hydrate

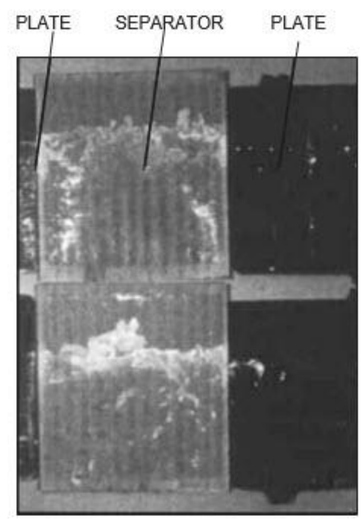


Figure 12.5.2 – Cutaway shows clogged separator with the by-products of hydration

12.6 Cleaning Cell Containers

Wipe the outside of the cells as necessary with a cloth moistened with water to remove dust and ordinary dirt. If electrolyte is spilled on the covers, neutralize it with a cloth moistened with a solution of sodium bicarbonate and water mixed in the proportion of one pound of sodium bicarbonate to one gallon of water. When fizzing stops as fresh sodium bicarbonate solution is applied, wipe with a water-moistened cloth to remove all traces of sodium bicarbonate. Covers and containers should always be clean and dry.

Never use solvents, detergents, glass cleaners, special battery cleaning materials, oils, waxes, or polishes on the plastic containers or covers since these materials may attack the plastic and cause it to craze or crack. Use of any of these materials will void the warranty. Cracks and crazing of the plastic components may not be observed for months, but eventually the condition will occur and, in many cases, result in large cracks in the containers or covers causing failure and leakage of electrolyte.

12.7 Cell Reversal

Excessive deep discharging of a string can result in individual cells driven to negative voltages. On recharge, these cells may read as high as 4 volts indicating a high internal resistance. Reversed cell temperatures may rise significantly on recharge and immediate action is necessary to avoid permanent damage to the cell(s). Recharge voltage must be decreased to ensure that the reversed cell(s) do not exceed 3.0 volts or 110ºF (43ºC). If the cell(s) do not respond to this special charging, it may be advisable to charge the cell individually. An ac-isolated single cell charger is required for this procedure. Contact a C&D representative for additional assistance.

12.8 Flame Arrestors, Contamination

If electrolyte levels are permitted to exceed the high-level mark at full charge, it is possible for electrolyte to be pumped up into the vent and contaminate the porous stone. In such cases, it will be necessary to remove the flame arrestor for cleaning or replacing it with another flame arrestor. Adjust the electrolyte level to between the high- and low-level lines while the battery is on float charge.

Clean the contaminated flame arrestor stone in a mild solution of sodium bicarbonate and water. Provide a final rinse in water and allow the stone to dry. All white deposits should be removed from the stone if the procedure was performed successfully.

12.9 Battery Recycling

When a battery reaches 80% of its rated capacity it is typically considered for replacement. Government regulations require that lead-acid batteries be recycled at the end of their useful life. It is illegal to dispose of industrial lead-acid batteries in the trash. Details of C&D's recycling program can be found by at www.cdtechno.com\about-us\sustainability-and-csr\recycling. Contact C&D for assistance in the recycling of your battery.

12.10 Battery Records

As noted throughout this manual, battery records are extremely useful for evaluating the installation, operation, and maintenance of the battery over its service life. Adequate battery records are required for all warranty claims. A form is attached (RS-105) to assist you in maintaining a record of service and to be used for warranty records. It is recommended that you make a photocopy of the original RS-105 in the back of this manual so that additional copies may be made for future records.

12.11 Measurements of Internal Cell Ohmic Values (Impedance, Resistance, and Conductance)

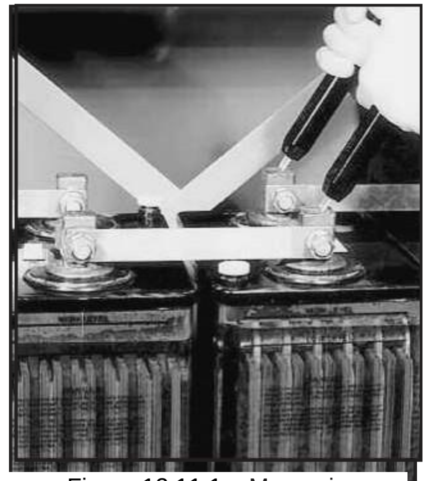


Figure 12.11.1 – Measuring internal cells ohmic values

Internal Ohmic measurements (Resistance, Conductance, Impedance, Admittance) typically do not provide consistent trending for VLA cells due to variability of electrolyte levels, specific gravity and gassing. These measurements can still be collected and used but should not take the place of visual inspections or voltage, current and temperature measurements and trending.

To establish a baseline internal Ohmic measurement, collect measurements after the string has been installed, given an initial charge and has been on float charge for at least 72 hours. The electrolyte level and cell temperature should be consistent from cell to cell and be recorded at the time of the measurement. Subsequent measurements (typically quarterly or annually) should be collected while the electrolyte level and cell temperature closely match the original levels when the baseline was established. Collected data should be trended and compared on a cell-by-cell basis and not based on the string average.

Note that baseline measurements may vary up to 25% from cell to cell on a new VLA battery.

The measurement of internal ohmic values utilizes either ac at various frequencies (impedance or conductance) or dc (resistance) measured across the cell terminals to determine the degree of deterioration of the element from a baseline value. C&D considers these techniques most useful for identifying cells with gross defects. See IEEE-450, Annex J for further information.

12.12 Plate polarization measurements

The life of a lead-acid battery is optimized when it is properly floated at the middle of the recommended string float voltage, operated in a temperature-controlled environment, and is rarely cycled. Application requirements can make the ideal operating parameters impossible to achieve. To better understand and monitor the health of a flooded lead-acid battery, it is possible to measure the plate potentials independent of the float voltage of a given cell.

This technique makes use of an instrument known as a third electrode or reference electrode. The third electrode is inserted into the electrolyte of the cell under examination and voltage measurements are made that may be either direct measurements or converted measurements, depending on the type of third electrode used to record the polarization potentials of the positive and negative plates. It is interesting to note that, although a given cell float voltage may be above or below the recommended average value of cells in a battery, the cell may be operating properly. This is because the polarization potentials of the positive and negative plates are within an acceptable range. Third electrode measurement instruments are available in both miniature lead-acid cells and mercury-mercurous sulfate cells.

Although the technique has been used almost exclusively by battery manufacturers and research and development laboratories for years or under highly controlled field test conditions, some battery testing organizations have added this test parameter for in-depth customer site evaluations.

Third electrode measurements can inform the experienced battery technician of the following:

- If the positive plates are properly polarized, excessive plate corrosion will be minimized while still maintaining the plates at a sufficient potential and state of charge to avoid sulfation.
- It is essential that the negative plates remain fully charged while at the same time not depressing the potential of the positive plates. The correct negative plate potential is dependent on individual

manufacturers' design parameters and vary widely due to the addition of organic material (expanders) in the negative plates and depolarizers added to the electrolyte.

12.13 Sedimentation

As the lead-acid battery ages, a phenomenon occurs that result in an accumulation of positive active material in the sediment chamber of the cell. This is called sedimentation. This occurrence is a natural result of the charging process while the battery is on float charge. During the charging process, the mechanical agitation from the generation of oxygen at the positive plate loosens contact at the surface of the plate, resulting in shedding. The shed active material settles to the bottom of the jar where design space has been provided for the containment of the sediment. As previously mentioned, buildup of sedimentation is a normal part of battery operation. Abnormal sedimentation occurs when the accumulation becomes excessive - the sediment reaches the bottom of the separator material, especially in products at half of their expected life or less. Typically, this is the result of discharging the battery too frequently, overcharging the battery for a prolonged time at higher voltages, or failure to temperature compensate the charging voltage in warm environments. An example of excessive sedimentation is shown in Figure 12.13.1.

Figure 12.13.1

12.14 Shifted Separators

Misaligned separators are the result of an element pack that has allowed separator movement. Figure 12.14.1 shows that a shifted separator will be close to the jar wall on one side. This causes the edge of the plate to be close to the edge of the separator on the opposite side. This is a cosmetic flaw; the operability of the cell is not compromised, and the cell remains functional provided plate edges are at least flush with the edges of the separator. As can be seen in Figure 12.14.2, there is no danger of short circuiting between the plates even though the positive plates are nearer to the separators edge than normal.

Figure 12.14.1

Figure 12.14.2

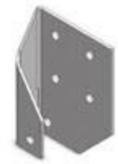
Appendix A Terminal Plate Examples

PT00448A
TYPE "L" CELLS WITH
(4) 1" SQUARE SINGLE
HOLE POSTS

PT00449A
TYPE "L" CELLS WITH
(6) 1" SQUARE SINGLE
HOLE POSTS

PT00450
TYPE "K" SINGLE &
"L" MULTI-CELLS WITH
1" SQUARE POST

PT00494
TYPE "K" CELLS
WITH 1" SQUARE
POST



PT00496
TYPE "XTJ", "K" &
"L" MULTI-CELLS
WITH FLAG
TERMINALS

PT00515A
TYPE "L" and "LCM-HP" CELLS
WITH (4) 1" SQUARE DOUBLE
HOLE POSTS

PT00516A
TYPE "L" CELLS WITH
(6) 1" SQUARE DOUBLE
HOLE POSTS

PT00539A
TYPE "L" 2-CELL & LARGE
4-CELL WITH 1" SQUARE
DOUBLE HOLE POST FOR
MORE THAN (4) CABLES
BETWEEN TIERS OF RACKS

PT00559
TYPE "L" 2-CELL & LARGE
4-CELL WITH 1" SQUARE
DOUBLE HOLE POST

PT00681
TYPE "L" CELLS
WITH (4) 1"
SQUARE POSTS

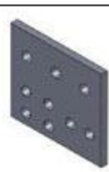
PT01088
TYPE "KCR" & "LCM-HP" WITH
(2) 1" SQUARE DOUBLE HOLE
POSTS

PT00821
TYPE "DJ","DJ-HP", "DJU",
"JC-HP" & "XDJ" WITH
RECTANGULAR POST

PT00934
XTH (P) - 29
THRU 33

PT00938A
XTH (P) 11 THROUGH 27
(7-8 CABLES ONLY)
FOR INTER-TIER/
INTER-RACK
CABLE CONNECTIONS

PT00976A
XTH (P) - 11
THRU 27
INTER-TIER/INTER-RACK
CABLE CONNECTIONS
6 CABLES OR LESS



PT00973A
XTH TERMINAL
PLATE ASSEMBLY
FOR INTER-TIER/
INTER-RACK
CABLE CONNECTIONS

Recommended torque for customer connections to the terminal plate is 160 +10/-0 in-lb regardless of the size of the hardware used. Higher torque values are acceptable for larger hardware as follows:

⅜"-16: 195 inch-lbs ± 5 in-lbs
½"-13: 225 inch-lbs ± 25 in-lbs

Appendix B Safety Data Sheet

Please refer to C&D's website at www.cdtechno.com/resources/datasheets/ for the latest safety data sheet information; 14-324 Flooded Lead-Calcium Batteries and 14-326 Sulfuric Acid, Battery Electrolyte.

Appendix C Spill Containment

Introduction

Spill containment systems are used to contain and absorb/ neutralize the release of battery electrolyte from damaged lead-acid batteries used in stationary applications. Spill containment systems are designed with a minimal number of components for ease of installation. Components may vary from supplier to supplier, yet all systems produce the same results. Components include a 4” high barrier that is typically bolted to the floor with sealed seams and joints. The floor can either be coated with an epoxy paint or have a protective liner. The barriers and the floor must create a watertight area and must be impervious to the battery electrolyte. Flame retardant, neutralizing and absorbent pillows are the final component of the system. Contact the local C&D representative for additional information.

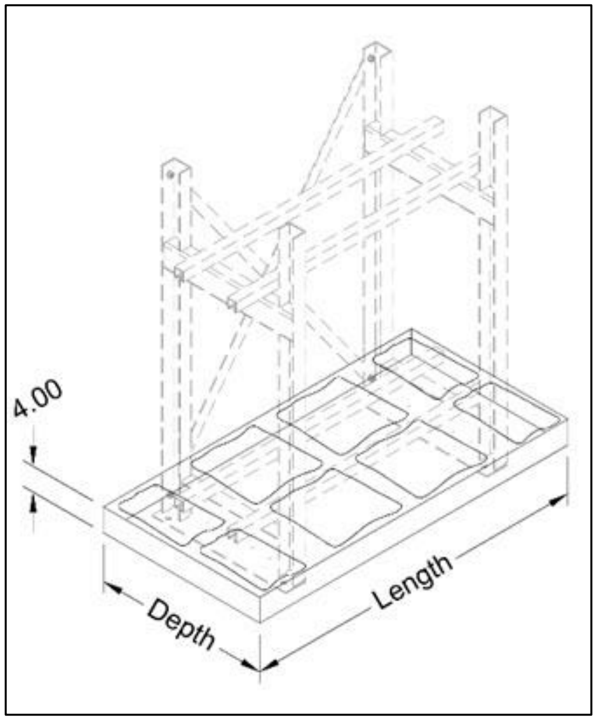


Figure C.1 – Spill containment barriers with pillows

Compliance

Spill containment systems are required to comply with various codes used for building safety when stationary lead-acid batteries systems have been installed. The decision to use a spill containment system is based on local, regional, state, or national codes as directed by the authority having jurisdiction (AHJ). C&D recommends the use of any methods and products that ensure building and battery room safety for our customers.

Spill Containment Systems Suppliers

Spill containment systems offered by C&D, with or without stationary batteries, are designed to meet or exceed all requirements and specifications set forth by applicable codes pertaining to stationary lead-acid batteries and battery room safety. C&D’s suppliers warrant these products and warranty copies are available upon request. C&D will provide information on the available spill containment systems including any specifications or third-party testing and verification, if requested.

Selection

Consult with the local C&D representative for assistance in properly sizing spill containment systems. For code compliance, the inside barrier area must have a 1” perimeter (2” recommended) around the shadow area of the battery rack. Custom sizes to fit specific room layouts are available by request.

Installation

Provided with the spill containment system are instructions for proper installation with diagrams and a bill of materials or packing list. In most cases, the installation of spill containment systems should be made prior to the installation of the battery rack. If a spill containment system is to be installed after the installation of the battery rack, please consult with a C&D representative to determine which spill containment system will be best for this situation.

Appendix D Temperature Impact on VLA Batteries

Battery Capacity v. Operating Temperature

Initial temperature (°C)	Initial temperature (°F)	Temperature-correction factor K_C	Initial temperature (°C)	Initial temperature (°F)	Temperature-correction factor K_C
4.4	40	1.300	26.1	79	0.987
7.2	45	1.250	26.7	80	0.980
10.0	50	1.190	27.2	81	0.976
12.8	55	1.150	27.8	82	0.972
15.6	60	1.110	28.3	83	0.968
18.3	65	1.080	28.9	84	0.964
18.9	66	1.072	29.4	85	0.960
19.4	67	1.064	30.0	86	0.956
20.0	68	1.056	30.6	87	0.952
20.6	69	1.048	31.1	88	0.948
21.1	70	1.040	31.6	89	0.944
21.7	71	1.034	32.2	90	0.940
22.2	72	1.029	35.0	95	0.930
22.8	73	1.023	37.8	100	0.910
23.4	74	1.017	40.6	105	0.890
23.9	75	1.011	43.3	110	0.880
24.5	76	1.006	46.1	115	0.870
25.0	77	1.000	48.9	120	0.860
25.6	78	0.994			

Table D1[1]: Current Rate Correction Factors.

[1]Table L.2 Recommended current rate correction factors (K_C) from IEEE 450-2020 *IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications*

Battery Life v. Ambient Temperature

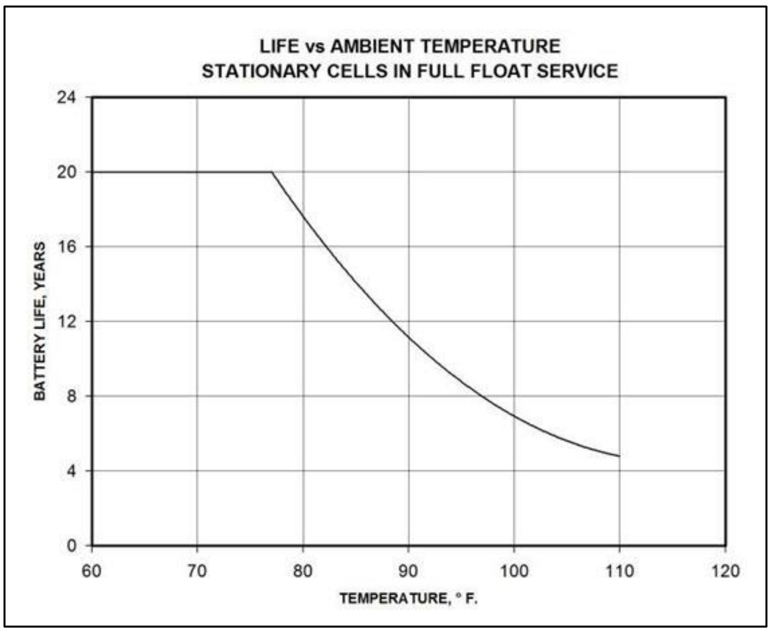


Figure D1: Life versus Temperature, Float Service

Appendix E Stationary Batteries and Chargers Inspection Report

TECHNOLOGIES, INC.
Power Solutions

1400 UNION MEETING ROAD
P.O. Box 3053 • Blue Bell, PA 19422-0858

Inspected By:

Inspected Date:

STATIONARY BATTERIES AND CHARGERS
INSPECTION REPORT

User:	Contact:
Battery Location:	Phone No:
	Other:
OEM:	Installed By:

BATTERY INFORMATION	
USER INSPECTION	C&D INSPECTION
C&D Order No.*	Appearance of Following:
Date Mfg.	Pos. Post
Date Installed	Pos. Strap
Model	Pos. Plate
Cells x Strings	Neg. Post
Application	Neg. Strap
Electrolyte Level	Neg. Plate
Bus Volts, Portable Meter	Cover rise, (eighths of an inch)
Bus Volts, Panel, Final	Jar Bulge, (eighths of an inch)
Top Tier, Cells	Jar Cracks
Mid Tier, Cells	Sediment Amount
Bottom Tier, Cells	Sediment Appearance
Charger Cap & Type	Lubricant observed on rack rails or bottom of cell containers:
Serial No. Or WO	☐ yes ☐ no
Room Ambient Temp.	
Watering Interval	
Last Discharge	
Peak Load	
Typical Load	

*See Part 4, Section 1.7 for C&D Order No. location

COMMENTS AND RECOMMENDATIONS

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Appendix F Required Maintenance Documents for Warranty

BATTERY STATUS ☐ OPEN CIRCUIT ☐ FLOAT ☐ EQUALIZE

Office: Model: Date:

Cell	Volts	Temp.	Sp.Gr.	R*	Serial or	Cell	Volts	Temp.	Sp.Gr.	R*	Serial or
No.	+2.000	Deg. F	+1.000	Ω	Work Order No.	No.	+2.000	Deg. F	+1.000	Ω	Work Order No.

*Record the intercell connection resistance
Note: Measure and record string charge current (amps) after 96 and 100 hours equalization or 68 and 72 hours float.

Form RS 105-Rev. 6 2003

REVISION INDEX

Rev	ECN	Date	Description
A			Initial release.
B	18788	4/15/25	Minor grammatical fixes. Updated template – reformat. Removed antimony product references, added tin-plated cable lugs 4.5