IEEE Standards

IEEE Std 484™-2002
(Revision of IEEE Std 484-1996)

484™

IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications

IEEE Power Engineering Society

Sponsored by the
Stationary Battery Committee

IEEE

Published by
The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

12 February 2003

Print: SH95015
PDF: SS95015

IEEE Std 484™-2002
(Revision of IEEE Std 484-1996)

IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications

Sponsor

Stationary Battery Committee
of the
IEEE Power Engineering Society

Approved 12 September 2002

IEEE-SA Standards Board

Abstract: Recommended design practices and procedures for storage, location, mounting, ventilation, instrumentation, preassembly, assembly, and charging of vented lead-acid batteries are provided. Required safety practices are also included. These recommended practices are applicable to all stationary applications. However, specific applications, such as emergency lighting units, semiportable equipment, and alternate energy applications, may have other appropriate practices and are beyond the scope of this recommended practice.
Keywords: alarms, assembly, data collection, float operation, flooded cells, freshening charge, installation design criteria, installation procedures, instrumentation, internal ohmic measurements, mounting, precautions, protective equipment, receiving and storage, resistance readings, seismic, testing, vented lead-acid batteries, ventilation

---

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

Copyright © 2003 by the Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 12 February 2003. Printed in the United States of America.

Print: ISBN 0-7381-3353-1 SH95015
PDF: ISBN 0-7381-3354-x SS95015

No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

IEEE Standards documents are developed within the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE-SA) Standards Board. The IEEE develops its standards through a consensus development process, approved by the American National Standards Institute, which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of the Institute and serve without compensation. While the IEEE administers the process and establishes rules to promote fairness in the consensus development process, the IEEE does not independently evaluate, test, or verify the accuracy of any of the information contained in its standards.

Use of an IEEE Standard is wholly voluntary. The IEEE disclaims liability for any personal injury, property or other damage, of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, or reliance upon this, or any other IEEE Standard document.

The IEEE does not warrant or represent the accuracy or content of the material contained herein, and expressly disclaims any express or implied warranty, including any implied warranty of merchantability or fitness for a specific purpose, or that the use of the material contained herein is free from patent infringement. IEEE Standards documents are supplied "**AS IS**."

The existence of an IEEE Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE Standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard. Every IEEE Standard is subjected to review at least every five years for revision or reaffirmation. When a document is more than five years old and has not been reaffirmed, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE Standard.

In publishing and making this document available, the IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity. Nor is the IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing this, and any other IEEE Standards document, should rely upon the advice of a competent professional in determining the exercise of reasonable care in any given circumstances.

Interpretations: Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretations is brought to the attention of IEEE, the Institute will initiate action to prepare appropriate responses. Since IEEE Standards represent a consensus of concerned interests, it is important to ensure that any interpretation has also received the concurrence of a balance of interests. For this reason, IEEE and the members of its societies and Standards Coordinating Committees are not able to provide an instant response to interpretation requests except in those cases where the matter has previously received formal consideration.

Comments for revision of IEEE Standards are welcome from any interested party, regardless of membership affiliation with IEEE. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Comments on standards and requests for interpretations should be addressed to:

Secretary, IEEE-SA Standards Board
445 Hoes Lane
P.O. Box 1331
Piscataway, NJ 08855-1331
USA

Note: Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken with respect to the existence or validity of any patent rights in connection therewith. The IEEE shall not be responsible for identifying patents for which a license may be required by an IEEE standard or for conducting inquiries into the legal validity or scope of those patents that are brought to its attention.

Authorization to photocopy portions of any individual standard for internal or personal use is granted by the Institute of Electrical and Electronics Engineers, Inc., provided that the appropriate fee is paid to Copyright Clearance Center. To arrange for payment of licensing fee, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; +1 978 750 8400. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

Introduction

[This introduction is not part of IEEE Std 484-2002, IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications.]

Stationary lead-acid batteries play an ever-increasing role in industry today by providing normal response and instrument power and backup energy for emergencies. This recommended practice fulfills the need within the industry to provide common or standard practices for the design of battery installations and the battery installation procedures. The methods described are applicable to installations and battery sizes using vented lead-acid batteries. The installations considered herein are designed for float operation with a battery charger serving to maintain the battery in a charged condition as well as to supply the normal dc load.

This recommended practice may be used separately, and when combined with IEEE Std 450™-1995, IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications, and IEEE Std 485™-1997, IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications, will provide the user with a general guide to sizing, designing, placing in service, maintaining, and testing a vented lead-acid battery installation. As a recommended practice, this document presents procedures and positions preferred by the IEEE.

Participants

At the time this recommended practice was completed, the Working Group on Vented Lead-Acid Battery Installation had the following membership.

John K. Coyle, *Chair*
Jeffrey J. LaMarca, *Vice-Chair*
Joel A. Long, *Secretary*

Gary Balash
Gabriel R. Bartek
Richard T. Bolgeo
William P. Cantor
Thomas Carpenter
Jay L. Chamberlin
Mark S. Clark
Garth P. Corey
Peter J. DeMar
Robert J. Fletcher
Paul C. Houck
Wayne Johnson
Roger D. Johnson
Peter Langan
Daniel S. Levin
Jose A. Marrero
Kim Moseley
Patrick Ng
Zbig Noworolski
Bansi Patel
Manahar Patel
Robert S. Robinson
Thomas E. Ruhlmann
Saba N. Saba
Amiya Samanta
Sam Shah
Kenneth Smith
Witold Sokolski
Ed C. Stallings
Harold F. Taylor
Kurt W. Uhlir
Walter A. Wylie

The following members of the balloting committee voted on this standard. Balloters may have voted for approval, disapproval, or abstention.

James Anderson
Curtis Ashton
Gary Balash
Farouk Baxter
Robert Beavers
Richard Bolgeo
William Cantor
John Carter
Jay L. Chamberlin
Mark S. Clark
Garth P. Corey
John K. Coyle
Eddie Davis
James Edmonds
Robert J. Fletcher
Jerry C. Gordon
Thomas Gorlitz
Randall Groves
Paul Hellen
Paul Johnson
Roger Johnson
Jeffrey J. LaMarca
Alan Lamb
Peter Langan
Daniel Levin
Jose A. Marrero
James McDowall
Kimberly Mosley
Bansi Patel
Edward Rafter
Thomas E. Ruhlmann
Amiya Samanta
Ed C. Stallings
James Stoner
Shawn Tyler
Lesley Varga
Michael Weeks

Copyright © 2003 IEEE. All rights reserved.

When the IEEE-SA Standards Board approved this standard on 12 September 2002, it had the following membership:

James T. Carlo, *Chair*
James H. Gurney, *Vice Chair*
Judith Gorman, *Secretary*

Sid Bennett
H. Stephen Berger
Clyde R. Camp
Richard DeBlasio
Harold E. Epstein
Julian Forster*
Howard M. Frazier
Toshio Fukuda
Arnold M. Greenspan
Raymond Hapeman
Donald M. Heirman
Richard H. Hulett
Lowell G. Johnson
Joseph L. Koepfinger*
Peter H. Lips
Nader Mehravari
Daleep C. Mohla
William J. Moylan
Malcolm V. Thaden
Geoffrey O. Thompson
Howard L. Wolfman
Don Wright

*Member Emeritus

Also included is the following nonvoting IEEE-SA Standards Board liaison:

Alan Cookson, *NIST Representative*
Satish K. Aggarwal, *NRC Representative*

Don Messina
IEEE Standards Project Editor

Copyright © 2003 IEEE. All rights reserved.

Contents

Copyright © 2003 IEEE. All rights reserved.

IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Application

1. Overview

This recommended practice is divided into seven clauses. Clause 1 provides the scope of this recommended practice. Clause 2 lists references to other standards that are useful in applying this recommended practice. Clause 3 provides definitions that are either not found in other IEEE documents, or have been modified for use with this recommended practice. Clause 4 establishes the safety precautions to be followed during battery installation. Clause 5 contains the recommended design criteria for storage, location, mounting, ventilation, instrumentation, preassembly, assembly, and charging of vented lead-acid batteries. Clause 6 presents the recommended design procedures for storage, location, mounting, ventilation, instrumentation, preassembly, assembly, and charging of vented lead-acid batteries. Clause 7 describes the suggested records to be maintained.

This recommended practice also contains three annexes. Annex A provides methods for measuring connection resistances. Annex B provides information on internal ohmic measurements. Annex C provides bibliographical references.

1.1 Scope

This recommended practice provides recommended design practices and procedures for storage, location, mounting, ventilation, instrumentation, preassembly, assembly, and charging of vented lead-acid batteries. Required safety practices are also included. This recommended practice is applicable to full float stationary applications where a battery charger normally maintains the battery fully charged and provides the direct current (dc) loads. However, specific applications, such as emergency lighting units, semiportable equipment, and alternate energy applications, may have other appropriate practices that are beyond the scope of this recommended practice.

The portions of this recommended practice that specifically relate to personnel safety are mandatory instructions and are designated by the word shall; all other portions are recommended practices and are designated by the word should.

Copyright © 2003 IEEE. All rights reserved.

Sizing, maintenance, capacity testing, charging equipment, dry-charged cells, and consideration of other types of batteries are beyond the scope of this recommended practice.

1.2 Purpose

This recommended practice is meant to provide organizations with criteria to be used for storage, location, mounting, ventilation, instrumentation, preassembly, assembly, and charging of vented lead-acid batteries.

2. References

This recommended practice shall be used in conjunction with the following publications. When the following specifications are superseded by an approved revision, the revision shall apply.[1]

IEEE Std 450™-1995, IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.[2]

IEEE Std 485™-1997, IEEE Recommended Practice for Sizing Lead-Acid Storage Batteries for Stationary Applications.

3. Definitions

For the purposes of this recommended practice, the following terms and definitions apply. *The Authoritative Dictionary of IEEE Standards Terms and Definitions*, Seventh Edition [B2][3] should be referenced for terms not defined in this clause.

3.1 vented battery: A battery in which the products of electrolysis and evaporation are allowed to escape freely to the atmosphere. These batteries are commonly referred to as "flooded." *Syn:* **vented cell**.

4. Safety

The safety precautions listed herein shall be followed during battery installation. Work on batteries shall be performed only by knowledgeable personnel with proper, safe tools and protective equipment.

4.1 Protective equipment

The following equipment for safe handling of the battery and protection of personnel shall be available:

a) Goggles and face shields
b) Acid-resistant gloves
c) Protective aprons and overshoes
d) Portable or stationary water facilities for rinsing eyes and skin in case of contact with acid electrolyte
e) Bicarbonate of soda mixed approximately 0.1 kg/L of water to neutralize acid spillage[4]

[1]The IEEE standards or products referred to in Clause 2 are trademarks owned by the Institute of Electrical and Electronics Engineers, Incorporated.
[2]IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (http://standards.ieee.org/).
[3]The numbers in brackets correspond to the Bibliography in Annex C.
[4]0.1kg/L converts to 1 lb to 1 gal, English units.

 Copyright © 2003 IEEE. All rights reserved.

f) Class C fire extinguisher
g) Adequately insulated tools
h) Lifting devices of adequate capacity, when required
i) Spill containment kit when moving cells

NOTES

1—The use of bicarbonate of soda to neutralize acid spills result in production of a hazardous waste. Users should be aware of their responsibilities for handling waste. Compliance with appropriate governmental regulations in this matter is recommended.

2—Some battery manufacturers do not recommend the use of CO_2 Class C fire extinguishers due to the potential of thermal shock.

4.2 Precautions

The following safety precautions shall be followed prior to and during installation:

a) Ensure that metal racks are connected to an electrical ground in accordance with applicable codes and design considerations.
b) Inspect all lifting equipment for functional adequacy.
c) Restrict all unauthorized personnel from the battery area.
d) Prohibit smoking and open flame, and avoid the chances of arcing in the immediate vicinity of the battery.
e) Keep the top of the battery clear of all tools and other foreign objects.
f) Ensure that illumination requirements are met.
g) Ensure unobstructed egress from the battery area.
h) Ensure that the battery area is ventilated during charging.
i) Avoid the wearing of metallic objects such as jewelry while working on the battery.
j) Avoid excessive tilting of the cells so as to prevent spillage.
k) Neutralize static buildup by having personnel contact the nearest effectively grounded surface just before working on the battery.

5. Installation design criteria

Considerations that should be included in the design of the battery installation depend upon the requirements or function of the system of which the battery is part. The general installation design criteria for all vented lead-acid batteries are provided in the following subclauses.

5.1 Location

a) Space and floor supports allocated for the battery and associated equipment should allow for present and future needs. Calculations should be performed to ensure that floor loading capabilities are not exceeded.
b) The location should be as free from vibration as practical.
c) The general battery area should be clean, dry, and well ventilated (see 5.4), and provide adequate space and illumination for inspection, maintenance, testing, and cell/battery replacement. Space should also be provided to allow for operation of lifting equipment, addition of water, and taking measurements (e.g., voltage, temperature, specific gravity).
d) The battery should be protected against natural phenomena, such as earthquakes, winds, and flooding, as well as induced phenomena, such as fire, explosion, missiles, pipe whips, discharging fluids, and CO_2 discharge.

Copyright © 2003 IEEE. All rights reserved.

e) Typically batteries are rated at 25 °C[5], and this temperature is the basis for the published performance. A location where this temperature can be maintained will contribute to optimum battery life, performance, and cost of operation. Extreme ambient temperatures should be avoided because low temperatures decrease battery capacity, while prolonged high temperatures shorten battery life and increase maintenance cost. Installation in a location with an ambient below the optimum temperature will affect sizing. Refer to IEEE Std 485-1997.[6]
f) The location and arrangement of cells should result in no greater than a 3 °C temperature differential between cells at a given time.[7] Avoid conditions that result in localized heating or cooling, as temperature variations may cause the battery to become electrically unbalanced.
g) Portable or stationary water facilities should be provided for rinsing spilled electrolyte. Provisions for neutralizing, containing, and safely disposing of acid electrolyte in accordance with appropriate governmental regulations should be included.
h) The charger and main power distribution center should be as close as practical to the battery, consistent with item j) of this subclause.
i) Illumination in the battery area should equal or exceed the interior lighting recommendations in Figure 11.1 of *IESNA Lighting Handbook* [B1].
j) Nearby equipment with arcing contacts shall be located in such a manner as to avoid those areas where hydrogen pockets could form.

5.2 Mounting

a) The most common practice is to mount cells on a steel rack with acid-resistant insulation between the cells and the steel of the rack. Metal racks shall be grounded in accordance with applicable codes and design considerations. The cells may also be mounted on adequately insulated supports secured to a floor or base.
b) Not more than two tiers or two steps should normally be considered for large batteries; this choice of rack results in a minimum temperature differential between cells and will facilitate maintenance. A three-tier rack is acceptable provided the requirements of item f) of 5.1 are met, and maintenance is not adversely affected.
c) Cells in clear jars should be mounted so that one edge of each plate is plainly visible for inspection and so that the electrolyte withdrawal tubes or vent plugs are easily accessible. Some sites require that the cells be arranged on the rails so that the plates are parallel with the rack support rails. This arrangement may save rack length but eliminates the ability for the cell plates to be inspected.
d) Electrical connections to the battery and between cells on separate levels or racks should be made so as to minimize mechanical strain on battery posts.

5.3 Seismic

Where applicable building codes require seismic protection, the racks, cabinets, anchors, and installation thereof shall be able to withstand the calculated seismic forces. To minimize the effect of seismic forces, the battery should be located at as low an elevation as practical. The following criteria should be observed regarding mounting:

a) All cells should be restrained. Side and end rails with spacers between cells is one method that can be used to prevent loss of function due to a seismic event.
b) Where more than one rack section is used, the rack sections should be rigidly joined, or the adjacent end cells in each rack should be connected with flexible connectors as provided by or recommended by the manufacturer. Connections between cells at different levels of the same rack should also be flexible.

[5] 25 °C = 77 °F.
[6] Information on references can be found in Clause 2.
[7] 3 °C = 5 °F.

Copyright © 2003 IEEE. All rights reserved.

c) Racks shall be firmly connected to the building structure as specified by using approved fastening techniques, such as embedded anchor bolts or racks welded to structural steel face plates (sized to accommodate a range of battery rack sizes). Contact the battery manufacturer for guidance regarding the selection and installation of the appropriate battery rack for the intended location and application.

CAUTION—Anchoring a rack to both the floor and the wall may cause stress due to conflicting modes of vibration.

5.4 Ventilation

The battery area shall be ventilated, either by a natural or mechanical ventilation system, to prevent accumulation of hydrogen. The ventilation system shall limit hydrogen accumulation to less than 2% of the total volume of the battery area. The location should be free of areas that might collect pockets of hydrogen. Maximum hydrogen evolution rate is 0.127 mL/s per charging ampere per cell at 25 °C and standard pressure (760 mm Hg).[8] The worst-case condition exists when forcing maximum current into a fully charged battery.

A battery area that meets the above ventilation requirements should not be considered a classified (hazardous) location; thus special electrical equipment enclosures to prevent fire or explosion should not be necessary.

5.5 Instrumentation and alarms

The following general recommendations for instrumentation and alarms apply to the battery installation only. Requirements for the charger, dc system design, etc., are beyond the scope of this recommended practice.

Each battery installation should include the following instrumentation and alarms:

a) Voltmeter
b) High and low battery voltage alarm
c) Ground detector (for ungrounded systems)
d) Instrumentation to measure current through the battery (refer to 4.5 of IEEE Std 450-1995).

The preceding recommendations for instrumentation and alarms could be satisfied by equipment in the dc system.

6. Installation procedures

See Clause 4 for safety precautions to be followed.

6.1 Receiving and storage

6.1.1 Receiving inspection

Upon receipt, and at the time of actual unloading, each package should be visually inspected for apparent damage and electrolyte leakage. If either is evident, a more detailed inspection of the entire shipment should be conducted and results noted on the bill of lading.

[8]Maximum hydrogen evolution rate is 0.000269 ft^3/min per charging ampere per cell at 77 °F and standard pressure (29.92 in Hg).

Copyright © 2003 IEEE. All rights reserved.

Record receipt date and inspection data results, and notify the manufacturer of any damage or follow the manufacturer's enclosed instructions.

6.1.2 Unpacking

a) When lifting cells, a strap and strap spreader should be used, if applicable.
b) Always lift cells by the bottom, never by the cell posts.
c) Check electrolyte levels for evidence of leakage and to ensure that the plates are covered. Any cell should be replaced if the electrolyte level is 13 mm or more below the top of the plates.[9] If the level is less than 13 mm below the top of the plates, add distilled or other approved quality water (or electrolyte approved by the manufacturer). Fill to above the top of the plates.
d) All cells with defects, such as cracked jars, loose and/or lifted terminal posts, or cracked, broken or improperly aligned plates, should be reported to the manufacturer for resolution or replaced as needed.

6.1.3 Storage

a) Cells should be stored indoors in a clean, level, dry, and cool location; extremely low or high ambient temperatures or localized sources of heat should be avoided.
b) Cells should not be stored for more than the time period recommended by the manufacturer, without applying a charge to the battery; in all cases, a period of 3 months storage is allowable between charges if the recommendations of item a) of this subclause are followed.
c) For charging during storage or special conditions, the battery manufacturer should be consulted. Record dates and conditions for all charges during storage.

6.2 Assembly

6.2.1 Rack assembly

The assembly of the rack should be in accordance with the manufacturer's recommended procedure.

6.2.2 Cell mounting and connections

The following sequence should be used:

a) Lift the individual cells onto the rack following the procedures outlined in item a) and item b) of 6.1.2. Mount the cells in accordance with the manufacturer's recommendations. Do not apply lubricant on rack rails unless approved by the manufacturer(s).
b) Remove shipping plugs and install flame arrestor vent plugs. Shipping plugs are designed to ventilate the battery during transit and storage. The shipping plugs will be needed if the batteries are reshipped for reuse or recycling. Consideration should be given to retaining the shipping plugs after neutralizing residual acid deposits.
c) Check cell polarity for positive to negative connections throughout the battery.
d) Unless otherwise instructed by the manufacturer, clean all terminal posts of corrosion-inhibiting compound. Neutralize corroded areas with a bicarbonate of soda solution and dry. Remove any remaining dirt or corrosion with a nonmetallic brush or pad; then promptly coat all areas with a thin film of the manufacturer’s approved corrosion-inhibiting compound.
e) The intercell connector contact surfaces should be cleaned by rubbing gently with a nonmetallic brush or pad; care should be exercised in cleaning to prevent removal of the plating. Promptly apply a thin film of the manufacturer’s approved corrosion-inhibiting compound to all contact surfaces.

[9] 13 mm = 0.5 inches.

Copyright © 2003 IEEE. All rights reserved.

f) Make intercell connections using the manufacturer's approved connectors (normally furnished with the battery).
g) When more than one intercell connector per cell post is required, mount the intercell connectors on opposite sides of the post for maximum surface contact.
h) Tighten both ends of connection bolts to the battery manufacturer's recommended torque values. Use a second wrench for counter torque.
i) Clean all cell covers and containers. For dust and dirt, use a water-moistened, clean wiper. For electrolyte spillage, use a bicarbonate of soda solution and water-moistened wiper. Do not use hydrocarbon-type cleaning agents (oil distillates) and/or strong alkaline cleaning agents, which may cause containers and covers to crack or craze.
j) Measure the voltage of the battery to ensure that individual cells are connected correctly (i.e., the total voltage should be approximately equal to the number of cells multiplied by the measured voltage of one cell). If the measurement is less than anticipated, recheck the connections for proper polarity.
k) For future identification, apply individual cell numbers in sequence beginning with number one at the positive end of the battery; also add any required operating identification.
l) Measure and record intercell connection resistance with a Kelvin-type (4-wire) microohmmeter. This verifies the adequacy of initial installation and provides a reference for future maintenance testing (see Clause 7). Review the records of each connection-resistance measurement, separated by connection type (i.e., intercell, intertier, interrack). Compute a separate average for each connection type. Identify connections if the measured resistance is the greater of 1.1 x the average resistance of each connection type, or the average resistance for the connection type plus 5 microohms. Remake and remeasure the identified connection resistances. See Annex A for detailed procedures.
m) After satisfactory completion of the previous items [a) through l)] in this subclause, make connections from the battery to the charger in preparation for the freshening charge.

6.3 Freshening charge, data collection, and testing

6.3.1 Freshening charge sequence

Since a battery loses some of its charge during shipment and storage, a freshening charge should be applied after installation and before connection to the system. Follow the manufacturer's recommendation for application and duration. Typically, this consists of the following:

a) Prior to applying the charge, measure and record the open circuit voltage of each cell, and the electrolyte temperature and specific gravity of every tenth cell. Select the cell with the lowest specific gravity as a pilot cell for the freshening charge.
b) Inspect all cells to ensure that the electrolyte level is above the top of the plates. If required, add distilled or other approved quality water (or electrolyte approved by the manufacturer). Fill to above the top of the plates.
c) Apply the freshening charge per the manufacturer’s recommendations. If the freshening charge voltage exceeds the system voltage limit, perform the freshening charge off-line, isolated from the dc system.
d) Measure and record at least once per day during the freshening charge: battery voltage, individual cell voltage, electrolyte temperature of every tenth cell, and the specific gravity and electrolyte temperature of the pilot cell.
e) Return charger to float voltage.

6.3.2 Data collection

a) At the end of 72 hours on float charge, measure and record each individual cell voltage, electrolyte temperature, specific gravities, and level (see Clause 7). Refer also to the discussion on specific gravity contained in Annex A of IEEE Std 450-1995.

Copyright © 2003 IEEE. All rights reserved.

b) Any cell that shows a specific gravity or voltage outside the manufacturer's specified limits requires corrective action in accordance with the manufacturer's instructions.
c) As necessary, use distilled or other approved quality water (or electrolyte approved by the manufacturer) to adjust the electrolyte level of all cells to a level specified by the manufacturer.
d) Record new electrolyte levels.

6.3.3 Optional measurements

Measurement techniques for determining the internal ohmic characteristic of a cell have been developed. While standardized techniques have not been developed, the results can be useful for trending and often provide valuable information to the informed user. Refer to Annex B for additional information.

6.3.4 Acceptance test

When required, an acceptance test shall be conducted in accordance with IEEE Std 450-1995.

6.4 Connection to dc system

After the steps in 6.3.2 have been completed, and if the battery is not already connected to the dc system, connect the battery to the dc system at this time.

7. Records

Data obtained from receiving, storage, assembly, and freshening charge are pertinent to the maintenance and operational life of the battery. The recommended records should be referenced to the cell identification (see item k) of 6.2.2). The data should be dated, recorded, and maintained in a suitable permanent file for record purposes and future reference. This data includes the following:

a) Receiving inspection data and conditions of charge [see item a) of 6.1.1 and 6.3.1]
b) Initial resistance values of the intercell connections [see item 1) of 6.2.2]
c) Individual cell specific gravities (corrected for temperature), voltage measurements, and electrolyte levels [see item a) of 6.3.2]
d) Acceptance test data (see 6.3.4)
e) Cell serial number, manufacture date, and lot number

 Copyright © 2003 IEEE. All rights reserved.

Annex A

(informative)

Example methods for performing connection resistance measurements using a Kelvin-type (4-wire) microohmeter

The following are examples of how to take intercell connection resistance measurements for a variety of available battery designs.[10] Other battery designs and methods of taking resistance readings are also used but are not specified in this annex. It is important to select a method for a particular battery design and use the same method consistently for trending purposes.

A.1 Recommended method for performing connection resistance readings using a microohmmeter

a) When taking microohmmeter measurements, the probes should be held perpendicular to the battery post.
b) Set the microohmmeter scale to the lowest resistance scale.
c) DO NOT TAKE A MEASUREMENT ACROSS THE CELL. This reading could damage the meter.
d) When performing microohmmeter readings, it is recommended that these measurements be taken from battery post to the battery post of connected cells, or from battery post to the terminal lug.

NOTE—It is not acceptable to record the microohm readings in milliohms. All measurements must be converted into microohms.

The proper and improper methods of performing connection resistance readings are shown in parts a and b, respectively, Figure A.1.

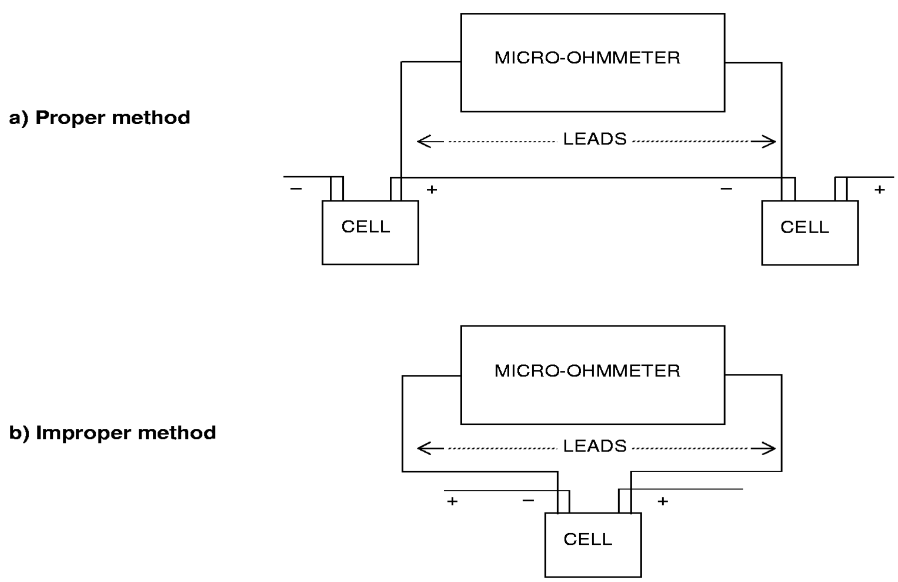

Figure A.1—Connection resistance measurement

[10]See Annex F of IEEE Std 450-1995. Current revisions of IEEE Std 450 may contain improved methods of measuring connection resistance.

Copyright © 2003 IEEE. All rights reserved.

A.2 Recommended method for single intercell connections and parallel-post intercell connections

a) Measure the intercell connection resistance of each intercell connection by measuring from the positive terminal post to the negative terminal post of the adjacent cell.
b) Record the measurements.

NOTE—Connection resistance measurements for single intercell connections and parallel-post intercell connections are treated in the same manner.

Figure A.2 shows a typical single intercell connection. Figure A.3 shows a typical parallel-post intercell connection.

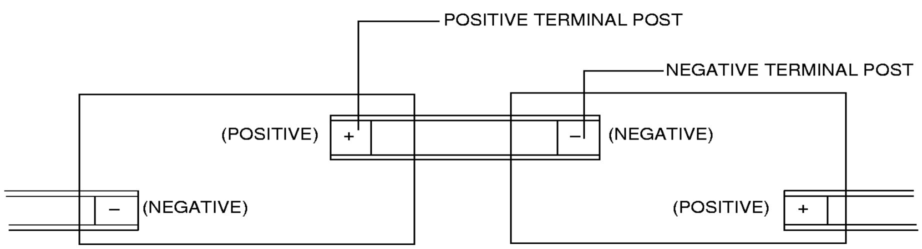

Figure A.2—Single intercell connection (typical)

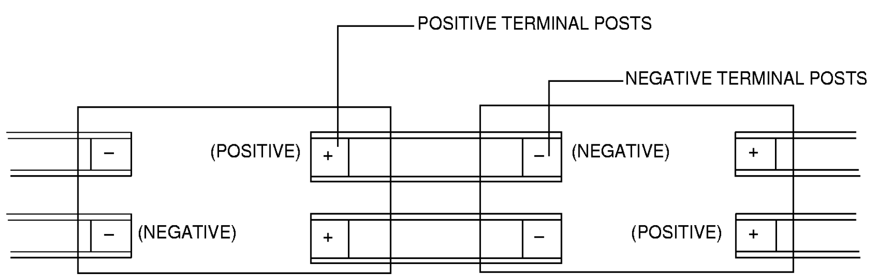

Figure A.3—Parallel-post intercell connection (typical)

A.3 Recommended method for double-post intercell connections

a) Measure the intercell connection resistance of each intercell connection by measuring from

Terminal post A to terminal post C

Terminal post B to terminal post D

b) Record the measurements.

NOTE—The resistance of intertier and interrack connections, with or without connection plates, can be performed using steps a) and b) above.

Figure A.4 shows a typical double-post intercell connection.

 Copyright © 2003 IEEE. All rights reserved.

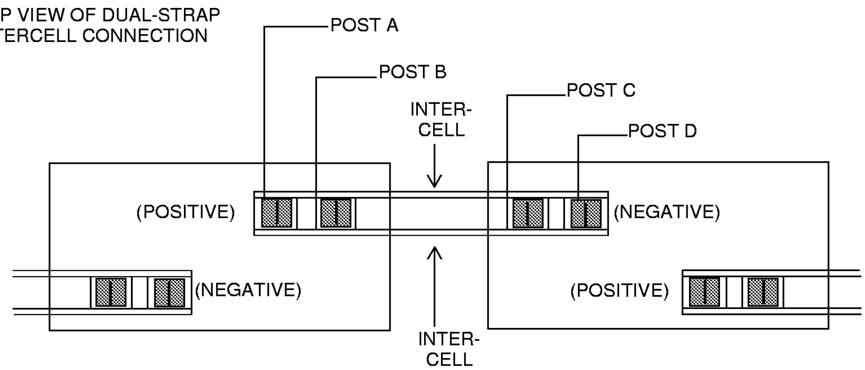

Figure A.4—Double-post intercell connection (typical)

A.4 Recommended method for triple-post intercell connections

a) Measure the intercell connection resistance of each intercell connection by measuring from

Terminal post A to terminal post D

Terminal post B to terminal post E

Terminal post C to terminal post F

b) Record the measurements.

NOTE—The resistance of intertier and interrack connections, with or without connection plates, can be performed using steps a) and b) above.

Figure A.5 shows a typical triple-post intercell connection.

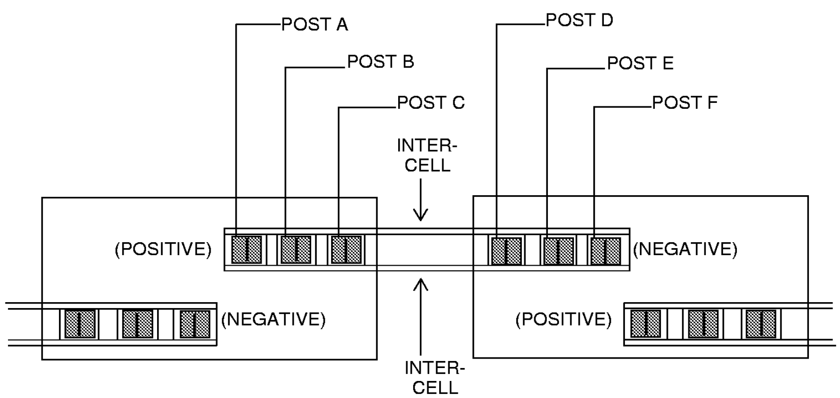

Figure A.5—Triple-post intercell connection (typical)

Copyright © 2003 IEEE. All rights reserved.

A.5 Recommended method for flag-post intercell connections

a) Measure the connection resistance of the intercell connections from terminal post A to terminal post B.
b) Measure the connection resistance of the intertier and interrack connections from terminal post A to terminal post B and/or from terminal post A to terminal lug A and terminal post B to terminal lug B.
c) Measure the connection resistance of the terminal connections from terminal post C to terminal lug D on the connecting cable.
d) Record the measurements.

Figure A.6 shows typical flag-post terminal connections.

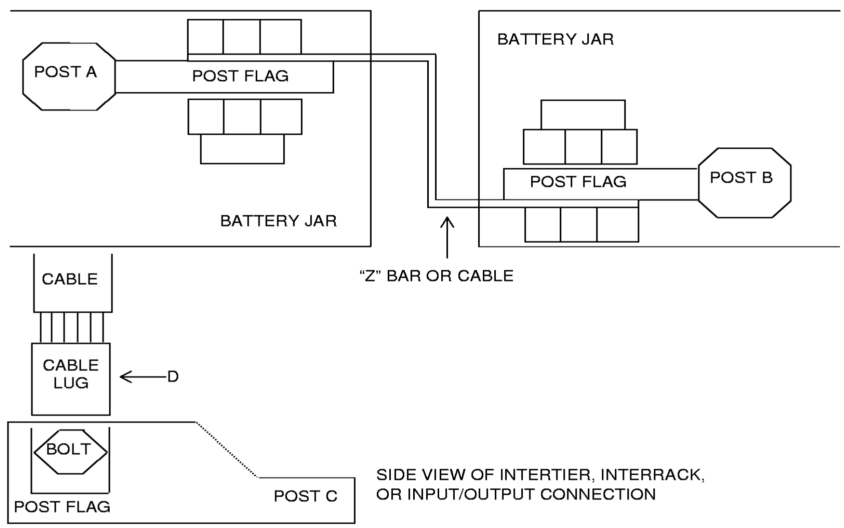

Figure A.6—Flag-post terminal connections (typical)

A.6 Recommended method for single connections

a) Measure the connection resistance of single terminal connections by measuring from terminal lug to terminal post.
b) Record the measurements.

Figure A.7 shows a typical single terminal connection.

A.7 Recommended method for multiple terminal connections

a) Measure the connection resistance of each terminal connection by measuring from

  Terminal lug A to terminal post A

  Terminal lug B to terminal post B

b) Record the measurements.

 Copyright © 2003 IEEE. All rights reserved.

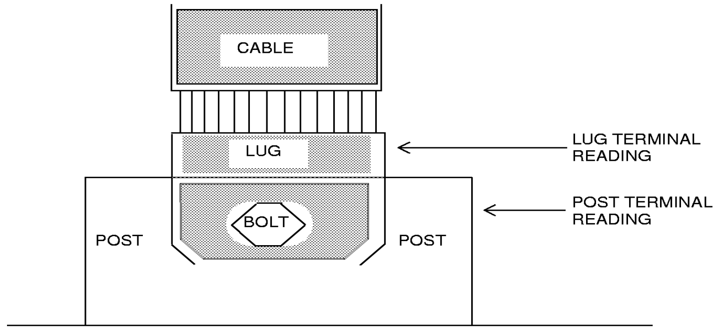

Figure A.7—Single terminal connection (typical)

Figure A.8 shows a typical multiple terminal connection.

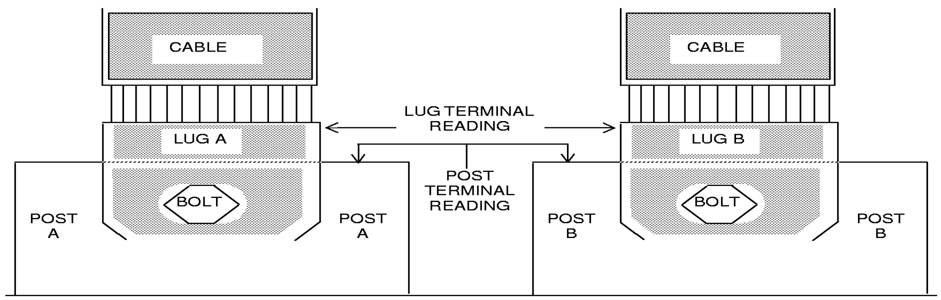

Figure A.8—Multiple terminal connection (typical)

A.8 Recommended method for cable, plate, and post connections

a) Measure the terminal connection resistance of each terminal connection by measuring from

Terminal lug A to terminal post A

Terminal lug B to terminal post A

Terminal lug C to terminal post B

Terminal lug D to terminal post A

Terminal lug E to terminal post B

Terminal lug F to terminal post B

b) Record the measurements.

NOTE—The resistance of interrack connections and terminal connections will be performed using steps a) and b) above.

Figure A.9 shows cable, plate, and post connections.

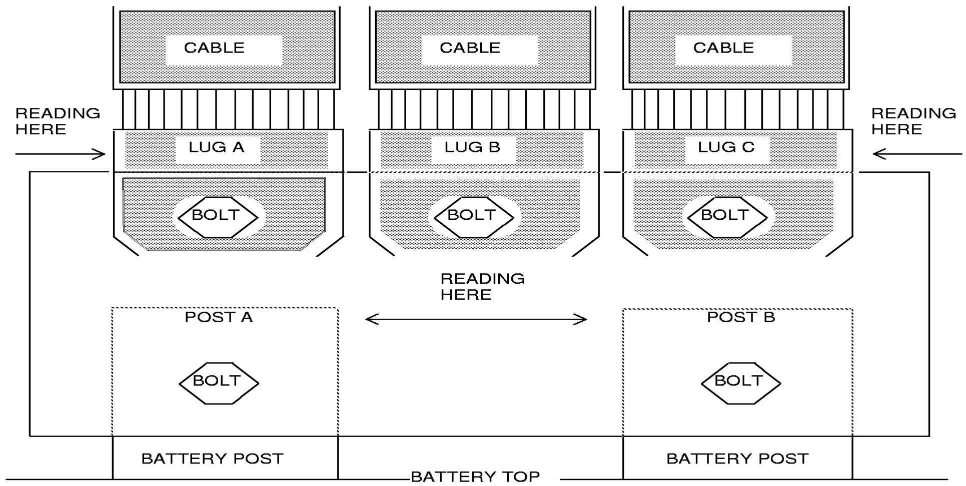

Figure A.9—Cable, plate, and post connections

NOTE—The lug on the other side of the plate from Lug A is marked as Lug D, Lug B as Lug E, and Lug C as Lug F.

 Copyright © 2003 IEEE. All rights reserved.

Annex B

(informative)

Cell/unit internal ohmic measurements

Internal ohmic measurements (conductance, impedance, and resistance measurements) can be used in the field to evaluate the electrochemical characteristics of battery cells. The measurements can provide possible indication of battery cell problems and may identify those cells that have internal degradation.

The results obtained by the different types of technology or slight changes in instrumentation for a particular technology are not the same. The measurement data will differ with each style and model of instrument. The consistent use of the same type and model of instrument will provide the most consistent results. If internal ohmic measurements are taken with different types or model instruments on a given cell, the data must be carefully evaluated because of the above described difference in this measurement technology.

All internal ohmic readings should be taken in a consistent manner (e.g., at full charge and as close as possible to the same temperature. (If readings cannot be taken at close to the same temperature, contact your test set manufacturer for correction factors). Baseline measurements should be taken within 6 months of installation. The results of the internal ohmic measurement should be investigated when a significant change in cell measurements occurs over a period of time. Significant changes (e.g., over 100% for impedance and resistance measurements and 50% for conductance measurements) in the internal ohmic value of a cell are an indication of internal cell degradation. Changes less than these values may indicate possible problems, which could be confirmed by a discharge test.

The internal ohmic characteristics of a cell consist of a number of factors, including the physical connection resistances, the ionic conductivity of the electrolyte, and the activity of electrochemical processes occurring at the plate surfaces. With multicell units, there are additional contributions due to intercell connections.

After making initial measurements using the particular technique, the observed values should be recorded as baseline values. The type of test equipment used, the test points selected, cell/unit voltages, and electrolyte temperatures should be recorded for future reference.

Copyright © 2003 IEEE. All rights reserved.

Annex C

(informative)

Bibliography

[B1] Illuminating Engineering Society of North America, *IESNA Lighting Handbook*, 1993.

[B2] IEEE 100™, *The Authoritative Dictionary of IEEE Standard Terms and Definitions*, Seventh Edition, New York, Institute of Electrical and Electronics Engineers, Inc.[11]

[11]The IEEE standards or products referred to in Annex C are trademarks owned by the Institute of Electrical and Electronics Engineers, Incorporated.

 Copyright © 2003 IEEE. All rights reserved.