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1. ~~Red Text~~ - Red strikethrough text denotes deletions.
2. Blue Text - Blue underlined text denotes modifications and additions.

IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications

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1. Overview

1.1 Scope

This document provides recommended maintenance, test schedules, and testing procedures that can be used to optimize the life and performance of permanently-installed, vented lead-acid storage batteries used in standby ~~power applications~~ service. It also provides guidance to determine when batteries should be replaced. This recommended practice is applicable to ~~full float~~ standby service stationary applications where a battery charger normally maintains the battery fully charged and provides the dc loads. ~~However, specific applications, such as emergency lighting units and semi-portable equipment, may have other appropriate practices that are beyond the scope of this recommended practice.~~

~~Sizing, installation, qualification, other battery types, and application are also beyond the scope of this recommended practice.~~ The maintenance and testing programs described in this recommended practice represent “the best program” based on the information available at the time this document was developed. The user should evaluate these practices against their operating experience, operating conditions, manufacturer’s recommendations, resources, and needs in developing a maintenance program for a given application. These maintenance and testing recommendations were developed without consideration of economics, availability of testing equipment and personnel, or relative importance of the application. Development of a maintenance and testing program for a specific application requires consideration of all issues, not just the technical issues considered in this document.

1.2 Purpose

The purpose of this recommended practice is to provide the user with information and recommendations concerning the maintenance, testing, and replacement of vented lead-acid batteries used in stationary applications.

1.3 Exclusions

Specific applications, such as emergency lighting units, photovoltaic, cycling, and semi-portable equipment, may have other appropriate practices that are beyond the scope of this recommended practice. Sizing, installation, qualification, other battery types, and application are also beyond the scope of this recommended practice.

This recommended practice does not include any other component of the dc system, or inspection and testing of the dc system, even though the battery is part of that system. Pre-operational and periodic dc system tests of chargers and other dc components may require that the battery be connected to the system. Details for these tests depend on the requirements of the dc system and are beyond the scope of this recommended practice.

1.4 Document Organization

This recommended practice is divided into twelve 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 standards, or have been modified for use with this recommended practice. Clause 4 establishes the safety precautions to be followed during battery maintenance and testing. Clause 5 describes the recommended maintenance practices. Clause 6 establishes the recommended testing program. Clause 7 establishes the types and methodology for battery testing. Clause 8 establishes battery replacement criteria. Clause 9 describes the records to be maintained. Clause 10 provides guidance on trending of battery parameters. Clause 11 describes recycling and disposal of vented lead-acid batteries. Clause 12 describes spill containment management.

This recommended practice has thirteen annexes. Annex A discusses state of charge. Annex B discusses specific-gravity measurements. Annex C provides information on float voltage. Annex D provides information on the urgency of corrective actions for discrepancies found during maintenance and testing. Annex E describes the visual inspection requirements. Annex F provides methods for measuring connection resistances. Annex G discusses alternative test and inspection programs. Annex H describes the effects of elevated temperature on lead-acid batteries. Annex I provides methodologies for conducting a modified performance test. Annex J provides information on internal ohmic measurements. Annex K provides methods for calculation of battery capacity. Annex L provides temperature-correction factors in degrees Fahrenheit. Annex M provides bibliographic references.

2. Normative references

~~This recommended practice shall be used in conjunction with the following publications:~~The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEEE Std 484TM-~~1996~~, IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications (ANSI/BCI).¹²

IEEE Std 485TM-~~1997~~, IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications (BCI).

IEEE Std. 1491TM, IEEE Guide for Selection and Use of Battery Monitoring Equipment in Stationary Applications.

IEEE Std. 1578TM, IEEE Recommended Practice for Stationary Battery Electrolyte Spill Containment and Management.

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. *The IEEE Standards Dictionary: Glossary of Terms & Definitions* should be consulted for terms not defined in this clause.³

acceptance test: A ~~constant-current or constant-power~~ capacity test made on a new battery to determine if it meets specifications or manufacturer's ratings.

capacity test: A controlled constant-current or constant-power discharge of a battery to a specified terminal voltage.

critical period: That portion of the duty cycle that is the most severe, or the specified time period of the battery duty cycle that is most severe.

duty cycle: The sequence of loads a battery is expected to supply for specified time periods ~~while maintaining a minimum specified voltage.~~

equalizing voltage: ~~The voltage, charge:~~ A charge, at a level higher than ~~float~~ the normal float voltage, applied ~~to a battery for a limited period of time,~~ to correct inequalities ~~among battery cells (voltage or specific gravity, or state of charge that may have developed between the cells during normal operation)~~ service.

~~3.7 flooded cell:~~ A cell in which the products of electrolysis and evaporation are allowed to escape to the atmosphere as they are generated. ~~These batteries are also referred to as "vented."~~

equalizing voltage: The voltage at which an equalizing charge is performed.

~~3.8 modified float charge:~~ A constant-potential charge applied to a battery to maintain it in a fully charged condition while minimizing degradation or water consumption.

float current: The current flowing during a float charge.

float voltage: The voltage applied to a battery during a float charge.

modified performance test: A test, in the "as found" condition, of battery capacity and the ability of the battery to satisfy the duty cycle.

¹ 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/>), and ~~<http://standards.ieee.org/sds/index.html>~~.

² IEEE standards or products referred to in this clause are trademarks of the Institute of Electrical and Electronics Engineers, Inc.

³ *The IEEE Standards Dictionary: Glossary of Terms & Definitions* is available at <http://shop.ieee.org/>.

performance test: A constant-current or constant-power capacity test made on a battery after it has been in service, ~~to detect any change in the capacity.~~

polarization: The shift in the potential of an electrode, or the voltage of a cell/battery, from the open-circuit value, brought about by the flow of current.

rated capacity (lead-acid): The capacity assigned to a cell by its manufacturer for a given discharge rate, at a specified electrolyte temperature and specific gravity, to a given end-of-discharge voltage.

service test: A test of a battery's capability, in an "as-found" condition, to satisfy the battery duty cycle.

terminal connection: Connections made between cells or at the positive and negative terminals of the battery, which may include terminal plates, cables with lugs, and connectors.

vented cell: A cell in which the products of electrolysis and evaporation are allowed to escape into the atmosphere as they are generated (sometimes also referred to as “flooded”).

3.2 Abbreviations

S.G. specific gravity

MPT modified performance test

4. Safety

WARNING

BATTERIES ARE POTENTIALLY DANGEROUS AND PROPER PRECAUTIONS MUST BE OBSERVED IN ALL BATTERY HANDLING AND MAINTENANCE. WORK ON BATTERIES SHALL BE PERFORMED ONLY WITH PROPER TOOLS AND SHALL UTILIZE THE PROTECTIVE EQUIPMENT LISTED. BATTERY MAINTENANCE SHALL BE PERFORMED BY PERSONNEL KNOWLEDGEABLE OF BATTERIES AND TRAINED IN THE SAFETY PRECAUTIONS INVOLVED.

4.1 Protective equipment

The following protective equipment shall be worn by personnel who perform battery maintenance work or made available to such personnel:

- a) Goggles and face shields
- b) Acid-resistant gloves
- c) Protective aprons
- d) Portable or stationary water facilities for rinsing eyes and skin in case of contact with electrolyte
- e) Bicarbonate of soda solution, mixed 100 grams bicarbonate of soda to 1 liter of water, to neutralize acid spillage

NOTE—The removal and/or neutralization of an acid spill may result in production of hazardous waste. The user should comply with appropriate governmental regulations concerning disposal of such hazardous waste.

- f) Class C fire extinguisher

NOTE—Some battery manufacturers do not recommend the use of CO₂ Class C fire extinguishers due to the potential of thermal shock.

- g) Adequately insulated tools
- h) Barriers to prevent the spread of acid spills are extremely important when moving cells such as during battery installation or removal activities. See IEEE Std 1578⁴ for information on barriers.