



# IEEE Recommended Practice for the Characterization and Evaluation of Emerging Energy Storage Technologies in Stationary Applications

---

**IEEE Power & Energy Society**

Sponsored by the  
Stationary Batteries Committee

IEEE  
3 Park Avenue  
New York, NY 10016-5997, USA

29 October 2010

**IEEE Std 1679™-2010**

Currently in preview, click buy full version

# IEEE Recommended Practice for the Characterization and Evaluation of Emerging Energy Storage Technologies in Stationary Applications

Sponsor

**Stationary Batteries Committee**  
of the  
**IEEE Power & Energy Society**

Approved 17 June 2010

**IEEE-SA Standards Board**

**Abstract:** Recommended information for an objective evaluation of an emerging energy storage device or system by a potential user for any stationary application is covered in this document. Energy storage technologies are those that provide a means for the reversible storage of electrical energy, i.e., the device receives electrical energy and is able to discharge electrical energy at a later time. The storage medium may be electrochemical (e.g., batteries), kinetic (e.g., flywheels), electrostatic (e.g., electric double-layer capacitors), thermal, or some other medium. Devices recharged by non-electrical means, such as fuel cells, are beyond the scope of this document. The document provides a common basis for the expression of performance characteristics and the treatment of life-testing data. A standard approach for analysis of failure modes is also provided, including assessment of safety attributes. The intent of this document is to ensure that characterization information, including test conditions and limits of applicability is sufficiently complete to allow valid comparisons to be made.

**Keywords:** battery, cycling service, electric double-layer capacitor, energy storage, flywheel, standby service, stationary application

---

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

Copyright © 2010 by the Institute of Electrical and Electronics Engineers, Inc.  
All rights reserved. Published 29 October 2010. Printed in the United States of America.

IEEE is a registered trademark in the U.S. Patent & Trademark Office, owned by the Institute of Electrical and Electronics Engineers, Incorporated.

**PDF:** ISBN 978-0-7381-6363-5     **STD96088**  
**Print:** ISBN 978-0-7381-6364-2     **STDPD96088**

IEEE prohibits discrimination, harassment and bullying. For more information, visit <http://www.ieee.org/web/aboutus/whatis/policies/p9-26.html>.  
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 or the soundness of any judgments 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, or every ten years for stabilization. When a document is more than five years old and has not been reaffirmed, or more than ten years old and has not been stabilized, 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 his or her independent judgment in the exercise of reasonable care in any given circumstances or, as appropriate, seek the advice of a competent professional in determining the appropriateness of a given IEEE standard.

**Interpretations:** Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretation 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. A statement, written or oral, that is not processed in accordance with the IEEE-SA Standards Board Operations Manual shall not be considered the official position of IEEE or any of its committees and shall not be considered to be, nor be relied upon as, a formal interpretation of the IEEE. At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position, explanation, or interpretation of the IEEE.

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. Recommendations to change the status of a stabilized standard should include a rationale as to why revision or withdrawal is required. Comments and recommendations on standards, and requests for interpretation, should be addressed to:

Secretary, IEEE-SA Standards Board  
445 Hoes Lane  
Piscataway, NJ 08854  
USA

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 1679-2010, IEEE Recommended Practice for the Characterization and Evaluation of Emerging Energy Storage Technologies in Stationary Applications.

Recent years have seen a significant increase in the number of energy storage devices being proposed for use in traditional battery applications. In addition, the characteristics of an emerging technology may be an enabling factor for new energy storage applications. A problem may arise, however, in the provision and analysis of information regarding the new technology. For existing applications, the technology developer may not be aware of the conventions already in use for submittal of technical data. Furthermore, the prospective user may not request or receive sufficient information to enable a full comparison to be made between technologies.

This recommended practice describes a format for the characterization of emerging energy storage technologies in terms of performance, service life, and safety attributes. This format provides a framework for developers to describe their products. The resulting information assists users in evaluating the possible application of emerging energy storage technologies.

## Notice to users

### Laws and regulations

Users of these documents should consult all applicable laws and regulations. Compliance with the provisions of this standard does not imply compliance with any applicable regulatory requirements. Implementers of the standard are responsible for observing or referring to the applicable regulatory requirements. IEEE does not, by the publication of its standards, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.

### Copyrights

This document is copyrighted by the IEEE. It is made available for a wide variety of both public and private uses. These include use, by reference, in laws and regulations, and use in private self-regulation, standardization, and the promotion of engineering practices and methods. By making this document available for use and adoption by public authorities and private users, the IEEE does not waive any rights in copyright in this document.

### Updating of IEEE documents

Users of IEEE standards should be aware that these documents may be superseded at any time by the issuance of new editions or may be amended from time to time through the issuance of amendments, corrigenda, or errata. An official IEEE document at any point in time consists of the current edition of the document together with any amendments, corrigenda, or errata then in effect. In order to determine whether a given document is the current edition and whether it has been amended through the issuance of amendments, corrigenda, or errata, visit the IEEE Standards Association web site at <http://ieeexplore.ieee.org/xpl/standards.jsp>, or contact the IEEE at the address listed previously.

For more information about the IEEE Standards Association or the IEEE standards development process, visit the IEEE-SA web site at <http://standards.ieee.org>.

## Errata

Errata, if any, for this and all other standards can be accessed at the following URL: <http://standards.ieee.org/reading/ieee/updates/errata/index.html>. Users are encouraged to check this URL for errata periodically.

## Interpretations

Current interpretations can be accessed at the following URL: <http://standards.ieee.org/reading/ieee/interp/index.html>.

## Patents

Attention is called to the possibility that implementation of this recommended practice may require use of subject matter covered by patent rights. By publication of this recommended practice, no position is taken with respect to the existence or validity of any patent rights in connection therewith. The IEEE is not responsible for identifying Essential Patent Claims for which a license may be required, for conducting inquiries into the legal validity or scope of Patents Claims or determining whether any licensing terms or conditions provided in connection with submission of a Letter of Assurance, if any, or in any licensing agreements are reasonable or non-discriminatory. Users of this recommended practice are expressly advised that determination of the validity of any patent rights and the risk of infringement of such rights, is entirely their own responsibility. Further information may be obtained from the IEEE Standards Association.

## Participants

At the time this recommended practice was submitted to the IEEE-SA Standards Board for approval, the Emerging Technologies Working Group had the following membership:

**James McDowall**, *Chair*

**Mike Nispel**, *Vice Chair*

Curtis Ashton  
Gary Balash  
Tom Croda  
Ramesh Desai  
John George  
Roger Johnson

John J. Kopera  
Steve McCluer  
William McCoy  
Dan McMenamin  
Jerry Meyers  
MuMu Moorthi

Adam Moyer  
Samuel Norman  
Zbig Noworolski  
Jan Reber  
Sam Shah  
Stephen Vechy

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

William J. Ackerman  
S. Aggarwal  
Edward Amato  
James Anderson  
Stan Arnot  
Curtis Ashton  
Gary Balash  
Thomas Basso  
Robert Beavers  
Steven Bezner  
William Bloethe  
William Cantor  
Jay Chamberlin  
Randy Clelland  
Garth Corey  
Luis Coronado  
Charles Cotton  
Peter Demar

Neal Dowling  
Gary Engmann  
John Gagge  
James Graham  
Randall Groves  
Werner Hoelzl  
David Horvath  
Alan Jensen  
Wayne Johnson  
Piotr Karocki  
Tanuj Khandelwal  
Yuri Khersonsky  
John J. Kopera  
Jim Kulchisky  
Chung-Yiu Lam  
Jeffrey LaMarca  
Daniel Levin  
James McDowall

Kimberly Mosley  
Michael S. Newman  
Charles Ngethe  
Bansi Patel  
Percy Pool  
Edward Rafter  
Michael Roberts  
Charles Rogers  
Steven Sano  
Bartien Sayogo  
Gil Shultz  
David Smith  
James Smith  
James Timperley  
Charlie Vartanian  
Stephen Vechy  
John Vergie  
Kenneth White

When the IEEE-SA Standards Board approved this recommended practice on 17 June 2010, it had the following membership:

**Robert M. Grow, Chair**  
**Richard H. Hulett, Vice Chair**  
**Steve M. Mills, Past Chair**  
**Judith Gorman, Secretary**

Karen Bartleson  
Victor Berman  
Ted Burse  
Clint Chaplin  
Andy Drozd  
Alexander Gelman  
Jim Hughes

Richard H. Hulett  
Young Kyun Kim  
Joseph L. Koepfinger\*  
John Kuligowski  
David J. Lawless  
Hughes  
Oleg Logvinov  
Tom Olsen

Ronald C. Petersen  
Thomas Prevost  
Jon Walter Rosdahl  
Sam Sciacca  
Mike Seavey  
Curtis Siller  
Don Wright

\*Member Emeritus

Also included are the following nonvoting IEEE-SA Standards Board liaisons:

Satish Aggarwal, *NRC Representative*  
Richard DeBlasio, *DOE Representative*  
Michael Janezic, *NIST Representative*

Lisa Perry  
*IEEE Standards Program Manager, Document Development*

Soo H. Kim  
*IEEE Standards Program Manager, Technical Program Development*

## Contents

1. Overview .....	1
1.1 Scope .....	1
1.2 Purpose .....	2
2. Definitions, acronyms, and abbreviations .....	2
2.1 Definitions .....	2
2.2 Acronyms and abbreviations .....	2
3. Characterization information .....	3
3.1 Submittal conventions .....	3
3.2 Aging mechanisms and failure modes .....	6
3.3 Safety .....	7
3.4 Independent verification .....	10
4. Qualification testing .....	10
4.1 Functional testing .....	10
4.2 Abuse tolerance .....	10
4.3 Fault tolerance .....	10
4.4 Field testing .....	11
4.5 Standards compliance testing .....	11
5. Technology description .....	11
5.1 General .....	11
5.2 Storage medium .....	11
5.3 Intended applications .....	11
5.4 Components and construction .....	12
5.5 Operating conditions .....	13
5.6 Power and energy characteristics .....	13
5.7 Charging characteristics .....	14
5.8 Active management requirements .....	14
5.9 Application interface .....	15
5.10 Maintenance requirements .....	15
6. Regulatory issues .....	16
6.1 Hazard classes .....	16
6.2 Transportation .....	16
6.3 Material Safety Data Sheet (MSDS) .....	17
6.4 Permitting issues .....	17
6.5 Spill containment .....	17
6.6 Ventilation .....	17
6.7 Disposal/recycling .....	17
6.8 Interconnection .....	17

7. Evaluation techniques.....	18
7.1 General .....	18
7.2 Application considerations .....	18
7.3 Safety .....	18
7.4 Code compliance .....	19
7.5 Life-cycle costing .....	19
Annex A (informative) Bibliography .....	21
Annex B (informative) Sample data for lead-acid batteries .....	22
Annex C (informative) Interpretation of application data involving variable cycling regimes .....	25

# IEEE Recommended Practice for the Characterization and Evaluation of Emerging Energy Storage Technologies in Stationary Applications

*IMPORTANT NOTICE: This standard is not intended to ensure safety, security, health, or environmental protection. Implementers of the standard are responsible for determining appropriate safety, security, environmental, and health practices or regulatory requirements.*

*This IEEE document is made available for use subject to important notices and legal disclaimers. These notices and disclaimers appear in all publications containing this document and may be found under the heading “Important Notice” or “Important Notices and Disclaimers Concerning IEEE Documents.” They can also be obtained on request from IEEE or viewed at <http://standards.ieee.org/IPR/disclaimers.html>.*

## 1. Overview

### 1.1 Scope

This document covers recommended information for an objective evaluation of an emerging energy storage technology by a potential user for any stationary application. Energy storage technologies are those that provide a means for the reversible storage of electrical energy, i.e., the device receives electrical energy and is able to discharge electrical energy at a later time. The storage medium may be electrochemical (e.g., batteries), kinetic (e.g., flywheels), electrostatic (e.g., electric double-layer capacitors [EDLCs]), thermal, or some other medium. Devices recharged by non-electrical means, such as fuel cells, are beyond the scope of this document.

For the purposes of this document, “emerging” technologies are defined as those technologies recently, or soon to be, made available for sale under customary commercial terms (e.g., defined scope-of-supply, warranted performance). Stationary applications include both standby and cycling operation.

The document provides a common basis for the expression of performance characteristics and the treatment of life-testing data. A standard approach for analysis of failure modes is also provided, including assessment of safety attributes. The intent of this document is to ensure that characterization information,