

1568™

IEEE Recommended Practice for Electrical Sizing of Nickel-Cadmium Batteries for Rail Passenger Vehicles

IEEE Vehicular Technology Society

Sponsored by the
Rail Transit Vehicle Interface Standards Committee



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

12 December 2003

Print: SH95145
PDF: SS95145

IEEE Recommended Practice for Electrical Sizing of Nickel-Cadmium Batteries for Rail Passenger Vehicles

Sponsor

Rail Transit Vehicle Interface Standards Committee
of the
IEEE Vehicular Technology Society

Reaffirmed 25 March 2010

Approved 12 June 2003

IEEE-SA Standards Board

Abstract: A method for defining the electrical load supplied by a nickel-cadmium battery and for sizing the battery to supply that load is described in this recommended practice.

Keywords: ampere hours, available capacity, constant current load, constant power load, fully-charged capacity, nickel-cadmium battery, period, rated capacity, resistive load, state of charge

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 December 2003. Printed in the United States of America.

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

Print: ISBN 0-7381-3722-7 SH95145

PDF: ISBN 0-7381-3723-5 SS95145

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
Piscataway, NJ 08854
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; (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 1568-2003, IEEE Recommended Practice for Electrical Sizing of Nickel-Cadmium Batteries for Rail Passenger Vehicles.]

The storage battery is of primary importance in ensuring the satisfactory operation of rail passenger vehicles. This recommended practice provides methods for electrical sizing of nickel-cadmium batteries for use aboard rail passenger vehicles. It is based on commonly accepted methods used to define the load and to ensure adequate battery capacity. The method described is applicable to all battery sizes.

This recommended practice was prepared by the Electrical Sizing of Nickel-Cadmium Batteries Working Group of Rail Transit Vehicle Interface Standards Committee of the IEEE Vehicular Technology Society. When combined with IEEE Std 1476™ -2000, it will provide the user with a general guide to defining the loads and electrical sizing of nickel-cadmium batteries for rail passenger vehicles.

Participants

At the time this recommended practice was completed, the Working Group on the Electrical Sizing of Nickel-Cadmium Batteries for Rail Passenger Vehicles had the following membership:

Alexander Sinyak, *Chair*

Jacques Boscher
Dick Bruss
Dhiren Chakraborty
Claude Gabriel
Seyed Hosseini

Sachit Kakkar
Tammy Krause
Stanley Kwa
Ted Mavronicolas
James McDowall
Larry Meisner

Lawrence Mirecki
Rich Niederberger
John Pesuit
Norman Vutz
Vince Young

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

Marcos C. Albuquerque
Robert Anderson
Karl Berger
Robert J. DiSilvestro
Jim Dietz
John Ewing
Claude Gabriel
Harold C. Gillen
Harvey Glickenstein
Jerry L. Graham
Robert Heggstad

James R. Hoelscher
Paul E. Jamieson
Kevin D. Johnson
Don Kane
Ronald Kangas
Abe Kanner
Walter R. Keevil
James W. Kemp
Stanley Kwa
John LaForce
David A. Male
Thomas J. McGean

Kamel Mokhtech
Edwin A. Mortlock
William Petit
David R. Phelps
Venkat Rao Pindiprolu
Alan F. Rumsey
Louis Sanders
Gene Sansone
Alexander Sinyak
Thomas J. Sullivan
Arun Virginkar

When the IEEE-SA Standards Board approved this recommended practice on 12 June 2003, it had the following membership:

Don Wright, *Chair*
Howard M. Frazier, *Vice Chair*
Judith Gorman, *Secretary*

H. Stephen Berger
Joe Bruder
Bob Davis
Richard DeBlasio
Julian Forster*
Toshio Fukuda
Arnold M. Greenspan
Raymond Hapeman

Donald M. Heirman
Laura Hitchcock
Richard H. Hulett
Anant Jain
Lowell G. Johnson
Joseph L. Koepfinger*
Tom McGean
Steve Mills

Daleep C. Mohla
William J. Moylan
Paul Nikolic
Gary Robinson
Malcolm V. Thaden
Geoffrey O. Thompson
Doug Topping
Howard L. Wolfman

*Member Emeritus

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

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

Andrew Ickowicz
IEEE Standards Project Editor

Contents

1. Overview	1
1.1 Scope	1
1.2 Purpose	1
2. References	1
3. Definitions, abbreviations, and acronyms	2
3.1 Definitions	2
3.2 Abbreviations and acronyms	3
4. Defining loads	3
5. Cell type selection	4
5.1 Cell performance	4
5.2 Selection consideration	4
6. Determining battery size	5
6.1 Calculation of number of cells	5
6.2 Additional considerations	6
6.3 Cell capacity calculation	8
6.4 Cell capacity calculation worksheet	10
Annex A (informative) Sample calculations	12
Annex B (informative) State-of-charge factor	17
Annex C (informative) Calculating capacity rating factors	19
Annex D (informative) Bibliography	20

IEEE Recommended Practice for Electrical Sizing of Nickel-Cadmium Batteries for Rail Passenger Vehicles

1. Overview

This recommended practice describes a method for defining the electrical load supplied by a nickel-cadmium battery and for sizing the battery to supply that load. Necessary factors relating to cell selection are provided for consideration. In order to utilize the methodology embodied in this recommended practice, it is necessary it be used in conjunction with IEEE Std 1476™-2000¹.

1.1 Scope

This recommended practice prescribes a method for electrical sizing of nickel-cadmium batteries for use on passenger rail cars used for battery back up of low voltage dc auxiliary power systems. It encompasses all factors that influence the electrical battery capacity requirements including loads, temperature, cycling, charging and discharging profiles. It does not address physical sizing, qualification or testing of the batteries, and it does not apply to batteries used for motive power or engine starting.

1.2 Purpose

This recommended practice provides a standardized method for electrical sizing of nickel-cadmium batteries for application and use aboard rail passenger vehicles.

2. References

This recommended practice should be used in conjunction with the following publications.

IEC 60623 (2001-09), Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes—Vented Nickel-Cadmium Prismatic Rechargeable Single Cells.²

¹Information on references can be found in Clause 2.

²IEC publications are available from the Sales Department of the International Electrotechnical Commission, Case Postale 131, 3, rue de Varembe, CH-1211, Genève 20, Switzerland/Suisse (<http://www.iec.ch/>). IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

IEEE Std 1476-2000, IEEE Standard for Passenger Train Auxiliary Power Systems Interfaces.^{3,4}

IEEE Std 1536TM-2002, IEEE Standard for Rail Transit Vehicle Battery Physical Interface.

3. Definitions, abbreviations, and acronyms

3.1 Definitions

For the purposes of this recommended practice, the following terms and definitions apply. IEEE 100TM, *The Authoritative Dictionary of IEEE Standards Terms* [B3], should be referenced for terms not defined in this subclause.

3.1.1 aging factor: A quantitative factor expressing the degradation in the ability of the battery, due to usage, to deliver electrical energy under specified operating conditions such as, but not limited to, operating ambient temperature, cycling, depth of discharge, and maintenance practices.

NOTE—This is based on experience, application (cycling/float service), and charging parameters.

3.1.2 available capacity: The capacity for a given discharge time and end-of-discharge voltage that can be withdrawn from a cell under the specific conditions of operation.

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

3.1.4 constant current loads: A load that demands constant current even when the input voltage varies.

NOTE—Typical of such loads is lighting when driven from an inverter ballast configuration.

3.1.5 constant power load: A load that demands constant power from the source even when the voltage value drops such as when switching from the low-voltage power supply to the battery.

NOTE—Typical of such loads are those that have their own built-in regulator such as propulsion control power supplies.

3.1.6 fully charged capacity: state of the battery charge following a constant current charge. Considered to be 100% state of charge of the new battery.

NOTE—Constant current charge in accordance with IEC 60623.

3.1.7 period: An interval of time in the battery duty cycle during which the load is assumed to be constant for purposes of cell sizing calculations.

3.1.8 rated capacity (nickel-cadmium cell): The capacity assigned to a nickel-cadmium cell by its manufacturer for a specific constant current discharge, with a given discharge time, at a specified electrolyte temperature, to a given end-of-discharge voltage. The conditions used to establish rated capacity are based on a constant current charge.

NOTE—Constant current charge in accordance with IEC 60623.

³The IEEE standards or products referred to in Clause 2 are trademarks owned by the Institute of Electrical and Electronics Engineers, Incorporated.

⁴IEEE 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/>).