IEEE STANDARDS ASSOCIATION

IEEE Recommended Practice for 1 kV to 35 kV Medium-Voltage DC Power Systems on Ships

IEEE Industry Applications Society

Sponsored by the
Petroleum and Chemical Industry Committee

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

2 November 2010

IEEE Std 1709™-2010

IEEE Recommended Practice for 1 kV to 35 kV Medium-Voltage DC Power Systems on Ships

Sponsor

Petroleum and Chemical Industry Committee
of the
IEEE Industry Applications Society

Approved 17 June 2010

IEEE-SA Standards Board

Abstract: Guidelines to specify, procure, design, manufacture and develop manuals, safety procedures, practices and procedures for effective maintenance of medium-voltage direct current (MVDC) electrical power systems is discussed in this recommended practice. Recommendations are made for analytical methods, preferred interconnection interfaces and performance characteristics for reliable integration of MVDC electrical components into the ship MVDC electrical power systems.

Keywords: integrated power systems, marine electrical-power systems, medium-voltage DC, MVDC power electronics, power-electronic building blocks

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

PDF: ISBN 978-0-7381-6365-9 STD96089
Print: ISBN 978-0-7381-6366-6 STDPD96089

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 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. 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 a revision or withdrawal is required. Comments and recommendations on standards, and requests for interpretations should be addressed to:

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

Introduction

This introduction is not part of IEEE Std 1709-2010, IEEE Recommended Practice for 1 kV to 35 kV Medium-Voltage DC Power Systems on Ships.

The purpose of this recommended practice is to provide a set of guidelines that can be used by the of medium-voltage DC (MVDC) Power systems stakeholders to specify, procure, design, manufacture and develop manuals, safety guidelines, practices and procedures for effective maintenance of their MVDC system. It is not intended that these recommended practice form the basis for a mandatory standard. Acceptance or rejection of any or all of the recommendations contained herein is left to the discretion of the individual agency, which should determine their applicability to its proposed or existing operating practices and procedures.

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 to 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 both 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 to 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 Medium-Voltage DC Power Systems on Ships Working Group had the following membership:

Yuri Khersonsky, *Chair*
Terry Ericsen, *Vice Chair*
Paul Bishop, *Secretary*

John Amy
Michael Andrus
Tom Baldwin
Bart Bartolucci
Nicholas Benavides
Dushan Boroyevich
Arvind Chaudhary
David Clayton
Robert Cuzner
Charles Darnell
Norbert Doerry
Roger Dugal
Lyndsay Garrett
Herb Ginn
Narain Hingorani
Boris Jacobson
Hans Krattiger
Stephen Kuznetsov
Steven Ly
Earl MacDonald
Mohamed Maharsi
Timothy J. McCoy
Antonello Monti
Michael Moodie
Dev Paul
Steven Pekarek
Lynn Petersen
Joseph Piff
James Rockot
Mike Roa
George Robinson
John Shegerian
Donald Shmucker
Karl Schoder
Charles Smith
Zareh Soghomonian
Michael (Mischa) Steurer
Giorgio Sulligoi
Fabio Tosato
Albert Tucker
Peter Walsh
Fei (Fred) Wang
Jim Zgliczynski

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

John R. Barker
Keith Chow
Robert Cuzner
Alireza Daneshpooy
Norbert Doerry
Carlo Donati
Garry Donner
Randall Groves
Lee Herron
Narain Hingorani
Werner Hoelzl
Mohammed Islam
Yuri Khersonsky
Robert Konnik
Saumen Kundu
Benjamin Lanz
G. Luri
Earl MacDonald
Homer Alan Mantooth
William McBride
Michael S. Newman
Lorraine Padden
Jiuping Pan
Kevin Peterson
Iulian Profir
George Robinson
Bartien Sayogo
Robert Seitz
Veselin Skendzic
Charles Smith
James Smith
Jerry Smith
Zareh Soghomonian
Michael Steurer
Albert Trucker
Ahmed Zobaa

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
Young Kyun Kim
Joseph L. Koepfinger*
John Kulick
David J. Law
Hung Ling
Oleg Logvinov
Ted 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*

Michelle Turner
IEEE Standards Program Manager, Document Development

Patricia Gerdon
IEEE Standards Program Manager, Technical Program Development

Contents

IEEE Recommended Practice for 1 kV to 35 kV Medium-Voltage DC Power Systems on Ships

1. Overview

This recommended practice addresses specific aspects of shipboard medium-voltage DC (MVDC) power systems and defines recommended practice for applying contemporary technologies to convert and distribute shipboard electrical power with improved reliability, survivability, and power quality. It is not intended in any way to impede development of new or improved techniques.

Target users for this recommended practice are evaluators and designers of electrical power systems for commercial marine and military applications, commercial and military ship end-users, shipbuilders, port operators, classification societies, machinery and equipment manufacturers, research institutes, and universities.

1.1 Scope

This recommended practice is based on current electrical engineering methods and practices for applying 1 kV to 35 kV MVDC power distribution and DC power delivery systems on ships. Recommendations are made for analytical methods, preferred interconnection interfaces and performance characteristics for reliable integration of MVDC electrical components into the ship electrical power systems.

1.2 Purpose

The purpose of this document is to recommend a methodology for analysis and specifications parameters for 1 kV to 35 kV MVDC power systems on ships. It will describe impact of MVDC on all electrical