

IEEE Standard for Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations

IEEE Power and Energy Society

Sponsored by the
Nuclear Power Engineering Committee

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

IEEE Std 741™-2017
(Revision of IEEE Std 741-2007)

IEEE Standard for Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations

Sponsor

**Nuclear Power Engineering Committee
of the
IEEE Power and Energy Society**

Approved 15 June 2017

IEEE-SA Standards Board

Currently in preview, click buy full version

Abstract: Criteria that establish protection requirements for Class 1E power systems and equipment are prescribed in this standard. The purpose of and the means for obtaining protection from electrical and mechanical damage, or failures that can occur within a time period that is shorter than that required for operator action, are described. Testing and surveillance requirements are included. Plant physical design requirements to protect against events such as pipe whip, fire, dropped load, etc., are not included.

Keywords: Class 1E, electrical equipment, IEEE 741™, nuclear power generating stations, power systems, protection

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

Copyright © 2017 by The Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 31 August 2017. 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 978-1-5044-4098-1 STD22631
Print: ISBN 978-1-5044-4099-8 STDPD22631

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.

Important Notices and Disclaimers Concerning IEEE Standards Documents

IEEE documents are made available for use subject to important notices and legal disclaimers. These notices and disclaimers, or a reference to this page, appear in all standards and may be found under the heading “Important Notices and Disclaimers Concerning IEEE Standards Documents.” They can also be obtained on request from IEEE or viewed at <http://standards.ieee.org/IPR/disclaimers.html>.

Notice and Disclaimer of Liability Concerning the Use of IEEE Standards Documents

IEEE Standards documents (standards, recommended practices, and guides), both full-use and trial-use, are developed within IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (“IEEE-SA”) Standards Board. IEEE (“the Institute”) develops its standards through a consensus development process, approved by the American National Standards Institute (“ANSI”), which brings together volunteers representing varied viewpoints and interests to achieve the final product. IEEE Standards documents developed through scientific, academic, and industry-based technical working groups. Volunteers in IEEE working groups are not necessarily members of the Institute and participate without compensation from IEEE. While IEEE administers the process and establishes rules to promote fairness in the consensus development process, 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.

IEEE Standards do not guarantee or ensure safety, security, health, or environmental protection, or ensure against interference with or from other devices or networks. Implementers and users of IEEE Standards documents are responsible for determining and complying with all appropriate safety, security, environmental, health, and interference protection practices and all applicable laws and regulations.

IEEE does not warrant or represent the accuracy or content of the material contained in its standards, and expressly disclaims all warranties (express, implied and statutory) not included in this or any other document relating to the standard, including, but not limited to, the warranties of: merchantability; fitness for a particular purpose; non-infringement; and quality, accuracy, effectiveness, currency, or completeness of material. In addition, IEEE disclaims any and all conditions relating to: results; and workmanlike effort. IEEE standards documents are supplied “AS IS” and “WITH ALL FAULTS.”

Use of an IEEE standard is wholly voluntary. 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 from time to time about through developments in the state of the art and comments received from users of the standard.

In publishing and making its standards available, IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity nor is IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing any IEEE Standards document, should rely upon his or her own 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.

IN NO EVENT SHALL IEEE BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO: PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE PUBLICATION, USE OF, OR RELIANCE UPON ANY STANDARD, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE AND REGARDLESS OF WHETHER SUCH DAMAGE WAS FORESEEABLE.

Translations

The IEEE consensus development process involves the review of documents in English only. In the event that an IEEE standard is translated, only the English version published by IEEE should be considered the approved IEEE standard.

Official statements

A statement, written or oral, that is not processed in accordance with the IEEE-SA Standards Board Operations Manual shall not be considered or inferred to be the official position of IEEE or any of its committees and shall not be considered to be, or be relied upon as, a formal position of 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 of IEEE.

Comments on standards

Comments for revision of IEEE Standards documents are welcome from any interested party, regardless of membership affiliation with IEEE. However, IEEE does not provide consulting information or advice pertaining to IEEE Standards documents. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Since IEEE standards represent a consensus of concerned interests, it is important that any responses to comments and questions also receive 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 comments or questions except in those cases where the matter has previously been addressed. For the same reason, IEEE does not respond to interpretation requests. Any person who would like to participate in revisions to an IEEE standard is welcome to join the relevant IEEE working group.

Comments on standards should be submitted to the following address:

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

Laws and regulations

Users of IEEE Standards documents should consult all applicable laws and regulations. Compliance with the provisions of any IEEE Standards document 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

IEEE draft and approved standards are copyrighted by IEEE under US and international copyright laws. They are made available by IEEE and are adopted 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 these documents available for use and adoption by public authorities and private users, IEEE does not waive any rights in copyright to the documents.

Photocopies

Subject to payment of the appropriate fee, IEEE will grant users a limited, non-exclusive license to photocopy portions of any individual standard for company or organizational internal use or individual, non-commercial use only. To arrange for payment of licensing fees, 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.

Updating of IEEE Standards documents

Users of IEEE Standards documents 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.

Every IEEE standard is subjected to review at least every 10 years. When a document is more than 10 years old and has not undergone a revision process, 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 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 Explore at <http://ieeexplore.ieee.org/> or contact IEEE at the address listed previously. For more information about the IEEE-SA or IEEE's standards development process, visit the IEEE-SA Website at <http://standards.ieee.org>.

Errata

Errata, if any, for all IEEE standards can be accessed on the IEEE-SA Website at the following URL: <http://standards.ieee.org/findstds/errata/index.html>. Users are encouraged to check this URL for errata periodically.

Patents

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 by the IEEE with respect to the existence or validity of any patent rights in connection therewith. If a patent holder or patent applicant has filed a statement of assurance via an Accepted Letter of Assurance, then the statement is listed on the IEEE-SA Website at <http://standards.ieee.org/about/sasb/patcom/patents.html>. Letters of Assurance may indicate whether the Submitter is willing or unwilling to grant licenses under patent rights without compensation or under reasonable terms, with reasonable terms and conditions that are demonstrably free of any unfair discrimination to applicants desiring to obtain such licenses.

Essential Patent Claims may exist for which a Letter of Assurance has not been received. 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 Patent 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 standard 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 IEEE standard was completed, the WG-4.7 Working Group had the following membership:

Mark Bowman, *Chair*
John Disosway, *Vice Chair*

George Attarian	Yoon Kim	Kenneth Miller
Jason Bellamy	Hari Kodali	David Pokon
Jeri Chadwick	Edvin Kozo	Gene Poletto
Paul Colaianne	Jusuf Krvavac	Jim Reddy
Nader Eldeiry	Harvey Leake	Gregg Reimers
Kenneth Fleischer	Timothy Lensmire	Myat San
Christopher Georgeson	Roy Lyon	Thomas Solinsky
Melvin Hess	Tania Martinez Navedo	Robert Stark
Steven Hutchins	Paul Martini	Hideki Tanaka
Ayodele Ishola-Salawu	Singh Matharu	Sudhir Thakur
Wayne Johnson		Tamatha Womack

The Subcommittee on Auxiliary Power (SC4) of the Nuclear Power Engineering Committee that recommended approval of this IEEE standard had the following membership:

Keith Bush, *Chair*
Mark Bowman, *Vice Chair*

George Attarian	Dale Goodney	John MacDonald
Elnora Basler	Evans Heacock	John Mallanda
Duane Brock	Melvin Hess	Singh Matharu
Robert Carruth	Dirk Hopp	Kenneth Miller
Jack Carter	Ayodele Ishola-Salawu	Gene Poletto
Richard Casalaina	Yoon Kim	Gregg Reimers
Paul Colaianne	Hari Kodali	Bill Roettger
Parthiv Desai	Edvin Kozo	Myat San
John Disosway	Jusuf Krvavac	Shawn Simon
Nader Eldeiry	Justin Lane	William Snider
Kenneth Fleischer	Harvey Leake	Robert Stark
Robert Fletcher	Bruce Lord	Mitchell Staskiewicz
Christopher Georgeson	Roy Lyon	Sudhir Thakur
David Gladey		Tamatha Womack

At the time this IEEE standard was submitted to the IEEE-SA Standards Board for approval, the Nuclear Power Engineering Committee (NPEC) had the following membership:

Stephen Fleger, *Chair*
Thomas Koshy, *Vice Chair*
Daryl Harmon, *Secretary*

Satish Aggarwal
Ijaz Ahmad
George Attarian
George Ballassi
Royce Beacom
Mark Bowman
Keith Bush
Robert Carruth
Jack Carter
Suresh Channarasappa
Paul Colaianne
Tom Crawford
Dennis Dellinger
David Desaulniers
John Disosway
Kenneth Fleisher
Robert Fletcher

Robert Francis
Christopher Georgeson
James Gleason
Dale Goodney
Robert Hall
David Herrell
Dirk Hopp
Greg Hostetter
Gary Johnson
Christopher Kerr
Wolfgang Koenig
Robert Konnik
James Liming
Bruce Lord
John MacDonald
Scott Malcom
Kenneth Miller

Michael H. Miller
Edward Mohtashemi
Yasushi Nakagawa
Warren Odess-Gillett
Ted Riccio
Mitchell Staskiewicz
Rebecca Steinman
John Stevens
Marek Tengler
Sudhir Thakur
James Thomas
Masafumi Tsutsumi
Michael Vaternian
John White
Lyvonne Williams
Tamatha Womack
Paul L. Yanosy Sr.

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

Amber Aboulfaida
Satish Aggarwal
Robert Atkinson
George Ballassi
Robert Beavers
Jason Bellamy
William Bloethe
Mark Bowman
Duane Brock
Daniel Brosnan
Nissen Burstein
Keith Bush
Robert Carruth
Suresh Channarasappa
Arvind Chaudhary
Preston Cooper
John Disosway

Wells Fargo
Stephen Fleger
Kenneth Fleischer
David Gladey
Dale Goodney
Randal Groves
Dimitri Gvozden
Daryl Harmon
Hamidreza Heidarisaifa
Werner Hoelzl
Steven Hutchins
Jim Kulchisky
G. Lang
Benjamin Lanz
Michael Lauxman
Harvey Leake
Timothy Lensmire
Bruce Lord

Robert Lyon
John Macdonald
Michael Maddox
Michael May
Omar Mazzoni
Andrew Nack
Michael Newman
Rajendra Patel
Jan Pirrong
Robert Stark
John Stevens
Eugene Stoudenmire
John Vergis
Kenneth White
James Wilson
Tamatha Womack
Shuhui Zhang

When the IEEE-SA Standards Board approved this standard on 15 June 2017, it had the following membership:

Jean-Philippe Faure, *Chair*
Gary Hoffman, *Vice Chair*
John D. Kulick, *Past Chair*
Konstantinos Karachalios, *Secretary*

Chuck Adams
Masayuki Ariyoshi
Ted Burse
Stephen Dukes
Doug Edwards
J. Travis Griffith
Michael Janezic

Thomas Koshy
Joseph L. Koepfinger*
Kevin Lu
Daleep Mohla
Damir Novosel
Ronald C. Petersen
Annette D. Reilly

Robby Robson
Dorothy Stanley
Adrian Stephens
Mehmet Ulema
Phil Wennblom
Howard Wolfman
Yu Yuan

*Member Emeritus

Currently in preview, click buy full version

Introduction

This introduction is not part of IEEE Std 741-2017, IEEE Standard for Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations.

The IEEE Power Engineering Society has developed this standard to provide the principal design criteria, design features, and testing requirements for the protection of Class 1E power systems and equipment supplied from those systems. It is of particular use in identifying the need for special protection features where the requirements of nuclear power generating stations necessitate supplementing accepted industry practices.

Wherever possible, this standard identifies other standards or documents that provide more explicit guidance for specific protection requirements. By definition, the protection shall be adequate to sense and to determine the presence of an unacceptable condition and to execute the operations required in order to limit degradation effects. In this role, this standard pays special attention to the requirements for design verification documentation to support the protection performance.

This standard also addresses the electrical penetration assemblies installed as part of the containment structure that may require special considerations for protection. Also included are the criteria used to establish the necessity for special considerations and the resulting protection requirements.

The revision of this standard includes the following principal changes:

- Updating normative references revisions, as necessary
- Moving definitions from Annexes to main body
- Updating [Annex A](#) to include one method found acceptable for the determination of the proper settings for loss of voltage and degraded voltage protection systems and their associated time delays.

Contents

1. Scope.....	11
2. Normative references	11
3. Definitions, abbreviations, and acronyms	13
3.1 Definitions	13
Abbreviations and acronyms	14
4. General design criteria.....	14
5. Principal design criteria and requirements	15
5.1 AC power distribution systems	15
5.2 DC power system	17
5.3 Instrumentation and control power system	17
5.4 Primary containment electrical penetration assemblies	18
5.5 Valve actuator motors (direct gear driven).....	18
6. Testing and surveillance	19
6.1 Device testing.....	19
6.2 Preoperational tests.....	19
6.3 Surveillance.....	20
Annex A (normative) Illustration of concepts associated with degraded voltage protection	21
Annex B (informative) Guidelines for selection of overload protection for VAM circuits	32
Annex C (informative) Auxiliary system automatic bus transfer—protection concerns	52
Annex D (informative) Use of high-speed magnetic circuit breakers for special applications	59
Annex E (informative) Bibliography.....	62

IEEE Standard for Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations

1. Scope

This standard provides the principal design criteria, design features, and testing requirements for the protection of Class 1E power systems and equipment supplied from those systems. It identifies special protection features that are needed where the requirements of nuclear power generating stations necessitate supplementing accepted industry practices.

2. Normative references

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 141™-1993, IEEE Recommended Practice for Electric Power Distribution for Industrial Plants (*IEEE Red Book™*).^{1,2}

IEEE Std 142™, IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems (*IEEE Green Book™*).

IEEE Std 242™, IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (*IEEE Buff Book™*).

IEEE Std 308™, IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations.

IEEE Std 317™, IEEE Standard for Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations.

IEEE Std 336™, IEEE Standard Installation, Inspection, and Testing for Power, Instrumentation, and Control Equipment at Nuclear Facilities.

¹IEEE publications are available from the Institute of Electrical and Electronics Engineers (<http://standards.ieee.org>).

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