

IEEE Standard Criteria for Safety Systems for 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 603™-2018
(Revision of
IEEE Std 603-2009)

IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations

Sponsor

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

Approved 27 September 2018

IEEE-SA Standards Board

Currently in preview, click buy full version

Abstract: Minimum functional and design criteria for the power, instrumentation, and control portions of nuclear power generating station safety systems are established. The criteria are to be applied to those systems required to protect the public health and safety by functioning to mitigate the consequences of design basis events. The intent is to promote appropriate practices for design and evaluation of safety system performance and reliability. Although the standard is limited to safety systems, many of the principles may have applicability to equipment provided for safe shutdown, post-accident monitoring display instrumentation, interlock features, or any other systems, structures, or equipment related to safety.

Keywords: associated circuits, Class 1E, design, IEEE 603™, failure, maintenance bypass, operating bypass, safety function, sense and command features, sensor

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

Copyright © 2018 by The Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 7 December 2018. 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 978-1-5044-5219-9 STD23342
Print: ISBN 978-1-5044-5220-5 STDPD23342

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 are 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, and 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 U.S.A.

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 U.S. 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. A current 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 ten years. When a document is more than ten 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 IEEE Xplore 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 rates, 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 Safety Systems and Single-Failure Criteria Working Group had the following membership:

Francis G. Novak, *Chair*

Neil Archambo
Brian K. Arnholt
Danny Duong

Gary Johnson
Richard M. Paese
Jack Rosentel

Ed Schindhelm
Richard Stattel
Dave Theriault

The Nuclear Power Engineering Committee (NPEC) had the following members when it recommended this standard for approval.

Thomas Koshy, *Chair* **Daryl L. Harmon, *Vice Chair*** **Stephen A. Fleger, *Past Chair*** **John White, *Secretary***

George Ballassi
Mark Bowman
Keith Bush
Robert C. Carruth
Suresh Channarasappa
Jonathan Cornelius
Tom Crawford
Dennis Dellinger
David R. Desaulniers
John Disosway
Kenneth Fleischer
Robert J. Fletcher
Robert Francis
Christopher H.
Georgeson

James F. Gleason
Dale Goodney
Robert Hall
David Herrell
Dirk Hopp
Greg M. Hostetter
Steven Hutchins
Gary Johnson
Wolfgang Koenig
Robert Konnik
Bruce Lord
Scott Malcolm
Kenneth Miller
Michael H. Miller

Farzad K. Mohtashemi
Yasushi Nakagawa
Warren R. Odess-Gillett
Ifti Rana
Ted Riccio
Mitchell L. Staskiewicz
Rebecca Steinman
John A. Stevens
Marek Tengler
Sudhir Thakur
Masafumi Utsumi
Tammy Womack
Yvonne Williams
Richard Wood
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.

William Ackerman
S. Aggarwal
Rufino Ayala
George Ballassi
Royce Beaman
Gustavo Buneo
Demeo Bucaneg Jr.
Missen Burstein
Robert Carruth
Suresh Channarasappa
Ashley Chappell
Tom Crawford
Paul Croll
John Disosway
Neal Dowling
Stephen Fleger
Robert Fuld
Eric W. Gray

Randall Groves
Ajit Gwal
Daryl Harmon
Hamidreza Heidarisaifa
Raymond Herb
David Herrell
Werner Hoelzl
Greg Hostetter
Ronald Jarrett
Gary Johnson
Piotr Karocki
Yuri Khersonsky
Chad Kiger
Robert Konnik
Thomas Koshy
Mikhail Lagoda
G. Lang
Benjamin Lanz

Jang-Soo Lee
John Macdonald
Arturo Maldonado
Omar Mazzoni
Michael Miller
Andrew Nack
Francis G. Novak
Warren Odess-Gillett
James Parello
Jan Pirrong
Ted Riccio
Fredrick Roy
Ryandi Ryandi
Edward Schindhelm
Nikunj Shah
David Smith
Richard Stattel
Rebecca Steinman

John Stevens
Gary Stoedter
Eugene Stoudenmire
Masafumi Utsumi

John Vergis
John Webb
Kenneth White

Hughes Wike
Yvonne Williams
Tamatha Womack
Janusz Zalewski

When the IEEE-SA Standards Board approved this standard on 27 September 2018, it had the following membership:

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

Ted Burse
Guido Hiertz
Christel Hunter
Joseph Koepfinger*
Thomas Koshy
Hung Ling
Dong Liu

Xiaohui Liu
Kevin Lu
Daleep Mohla
Andrew Myles
Paul Nikolich
Ron Petersen
Annette Reilly

Robby Robson
Dorothy Stanley
Mehmet Ulema
Phil Wennblom
Philip Winston
Howard Wolman
Jingyi Zhou

*Member Emeritus

Introduction

This introduction is not part of IEEE Std 603-2018, IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations.

This standard establishes minimum functional design criteria for the power, instrumentation, and control portions of nuclear power generating station safety systems. These criteria are established to provide a means for promoting appropriate practices for design and evaluation of safety system performance and reliability. However, adhering to these criteria will not necessarily fully establish the adequacy of any safety system's functional performance and reliability; nonetheless, omission of any of these criteria will, in most instances, be an indication of safety system inadequacy.

Application

The criteria established by this standard apply to those systems defined as safety systems and do not necessarily apply to all the structures, systems, and components required for comprehensive plant safety. Although the scope is limited to safety systems, many of the principles may have applicability to equipment provided for safe shutdown, accident monitoring display instrumentation, interlock features, or any other structures, systems, and components related to safety.

To determine those systems subject to these criteria, an analysis of the overall plant response to postulated design basis events will be performed. Good engineering judgment should be exercised in this analysis so that the adequate margins exist in the design to protect the health and safety of the public without imposing unduly restrictive criteria on the design.

Interdisciplinary approach

The safety system criteria herein are established using a systems approach to the design of the power, instrumentation, and control portion of the safety system, as opposed to a specific engineering discipline approach (that is, electrical, mechanical, or civil). It is recognized that the safety functions cannot be accomplished without mechanical as well as electrical equipment and circuitry. Users of this standard should also recognize that some safety functions may be implemented using digital computers and computer programs. When this is the case, the design should meet the criteria in IEEE Std 7-4.3.2.¹ In order for the safety system to meet the requirements of this standard and the supportive standards, the aggregate design of the safety system (without regard to discipline) may be constrained. For example, the consideration of common-cause failure (CCF) is an item that requires interdisciplinary review and design solutions to protect the plant from conditions outside established limits. The criteria for such an interdisciplinary review are outside the scope of this standard. The areas where this standard interfaces with other standards are shown in [Figure 1](#).

While this standard takes a systems approach to the design of the power, instrumentation, and control portion of the safety system, this standard does not attempt to establish new or different criteria for mechanical equipment or components. Such an attempt by a user is a misapplication of this standard. Nor does this standard attempt to establish the system-level requirements that may be required by mechanical or civil equipment; for example, in-service inspection of piping is intentionally excluded. This standard provides criteria for the safety system without conflicting with existing standards. This standard is not intended to duplicate or conflict with component design requirements such as the ASME Boiler and Pressure Vessel Code [B3].² Rather this standard is to complement and interface with such documents. This standard and others establish systems criteria while additional codes and standards establish detailed requirements for the functional adequacy constituent parts of the safety system.

¹Information on references can be found in [Clause 2](#).

²The numbers in brackets correspond to those of the bibliography in [Annex B](#).

Evolution

This standard was evolved from IEEE Std 603-2009. It represents the latest Subcommittee 6 (SC-6), Safety Related Systems, publication of a systems criteria document. The series began with IEEE Std 279™-1968, a trial-use standard for protection systems. This was followed by IEEE Std 279-1971 [B5], a standard for protection systems; IEEE Std 279-1971 has since been withdrawn. IEEE Std 603-1977, a trial use standard for safety systems was issued in 1977. IEEE Std 603 was revised and issued in 1980, 1991, 1998, and 2009. This latest issue represents the current revision to the IEEE standard for safety systems.

Relationship to other standards

This standard establishes functional and design criteria that are general in nature. It requires supportive standards containing both general and detailed criteria to comprise a minimal set of requirements for the safety system.

Other IEEE standards prepared in support of the criteria of this standard are referenced throughout this standard. Various other standards by organizations such as American Nuclear Society (ANS), International Society of Automation (ISA), the International Atomic Energy Agency (IAEA), International Electrotechnical Commission (IEC), and American Society of Mechanical Engineers (ASME) provide additional information on aspects covered in this standard.

Purpose of revision

The purpose of this revision is to include these major changes and activities in the existing standard document:

- a) Delete [Annex B](#)—electromagnetic compatibility. The deletion of this informative annex is part of the original proposed scope of revision. It is acknowledged that other standards, such as IEC/IEEE 60780-323, refer to the annex. However, its deletion does not create a problem because the annex is found in the version of IEEE Std 603 that was current when those standards made the reference.
- b) Enhance existing criteria on CCF, in [5.2.5](#) so it includes a requirement that is consistent with the IEEE Standards Style Manual, and is not limited to software CCF.
- c) Ensure structure and content is consistent with the 2014 IEEE-SA Standards Style Manual and template as well as providing the latest references, definitions, and bibliography content.
- d) Incorporate user-provided feedback.
- e) The U.S. Nuclear Regulatory Commission (NRC) provided feedback following rulemaking activity intended to update the reference to IEEE Std 603 in the federal regulations. Based on the feedback from the NRC staff, the working group revised two requirements. In their direction to the NRC Staff, the Commission recommended the following high-level principles be considered for this standard:
 - 1) New requirements should be performance-based rather than prescriptive.
 - 2) New requirements should be technology neutral.
 - 3) Same requirements should apply to operating and new reactors.
 - 4) Any new requirements should not pose an unnecessary impediment to advancement in nuclear applications of digital technology.

These high-level principles were used by the working group in the preparation and revision to this standard to the extent possible.

Acknowledgements

Grateful acknowledgment is made to the International Atomic Energy Agency for permission to reprint three definitions from Design of Instrumentation and Control Systems for Nuclear Power Plants, IAEA, Vienna (2016) [B4].

Contents

1. Overview.....	12
1.1 Scope.....	12
1.2 Illustration.....	12
1.3 Application.....	15
1.4 Word Usage.....	15
1.5 Conformance.....	15
2. Normative references.....	16
3. Definitions.....	16
4. Safety system design basis.....	19
5. Safety system criteria.....	20
5.1 Single-failure criterion.....	20
5.2 Completion of protective action.....	21
5.3 Quality.....	21
5.4 Equipment qualification.....	21
5.5 System integrity.....	21
5.6 Independence.....	21
5.7 Capability for testing and calibration.....	23
5.8 Information displays.....	23
5.9 Control of access.....	24
5.10 Repair.....	24
5.11 Identification.....	24
5.12 Auxiliary features.....	24
5.13 Multi-unit stations.....	24
5.14 Human factors considerations.....	25
5.15 Reliability.....	25
5.16 Common-cause failure.....	25
6. Sense and command features—Functional and design requirements.....	25
6.1 Automatic control.....	26
6.2 Manual Control.....	26
6.3 Interaction between the sense and command features and other systems.....	26
6.4 Derivation of system inputs.....	27
6.5 Capability for testing and calibration.....	28
6.6 Operating bypasses.....	28
6.7 Maintenance bypass.....	28
6.8 Setpoints.....	29
7. Execute features—Functional and design requirements.....	29
7.1 Automatic control.....	29
7.2 Manual control.....	29
7.3 Completion of protective action.....	29
7.4 Operating Bypass.....	29
7.5 Maintenance Bypass.....	30
8. Power source requirements.....	30
8.1 Electrical power sources.....	30
8.2 Non-electrical power sources.....	30
8.3 Maintenance bypass.....	30
Annex A (informative) Illustration of some basic concepts for developing the scope of a safety system.....	31
Annex B (informative) Bibliography.....	42

IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations

1. Overview

1.1 Scope

The criteria contained in this standard establish minimum functional and design requirements for the power, instrumentation, and control portions of safety systems for nuclear power generating stations. To satisfy the criteria in this standard, interface requirements may be imposed on the other portions of the safety system as shown in [Figure 1](#). Safety system functional and design criteria are also contained in other standards.

1.2 Illustration

[Figure 1](#) depicts the potential for interface requirements to be imposed on the other portions of the safety system.

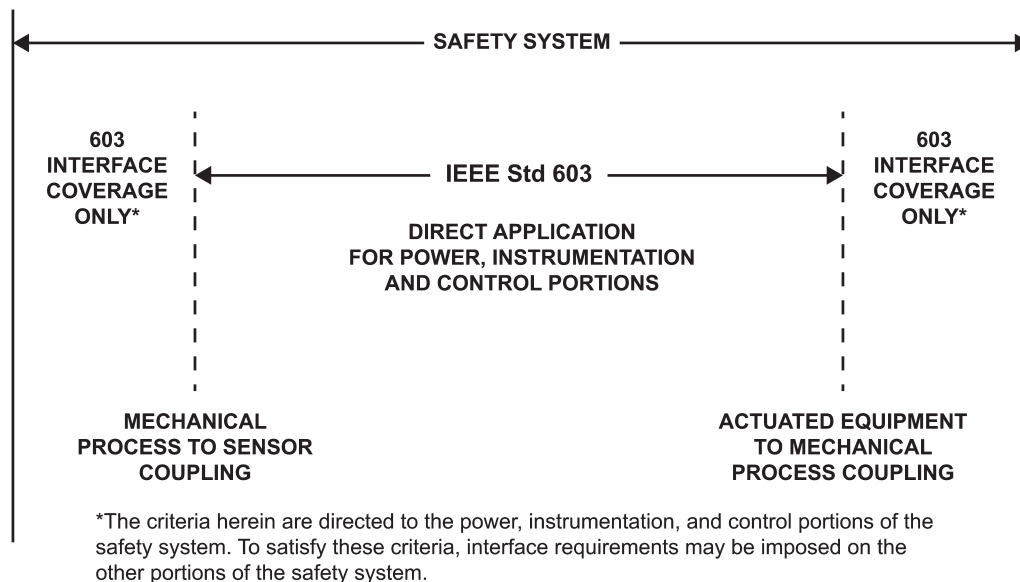


Figure 1—Non-electrical interface scope diagram