



IEEE Standard for Criteria for the Periodic Surveillance Testing of Nuclear Power Generating Station Safety Systems

IEEE Power and Energy Society

Developed by the
Nuclear Power Engineering Committee

IEEE Std 338™-2022
(Revision of IEEE Std 338-2012)



STANDARDS

IEEE Standard for Criteria for the Periodic Surveillance Testing of Nuclear Power Generating Station Safety Systems

Developed by the

Nuclear Power Engineering Committee
of the
IEEE Power and Energy Society

Approved 3 December 2022

IEEE SA Standards Board

THIS IS A REDLINE DOCUMENT PRODUCED BY TECHSTREET, AN ASME COMPANY.

This document is intended to provide users with an indication of changes from one edition to the next. It includes a full-text version of the new document, plus an indication of changes from the previous version.

Redlines are designed to save time and improve efficiencies by using the latest software technology to find and highlight document changes. More professionals are using valuable new technologies like redlines, to help improve outcomes in a fast paced global business world.

Because it may not be technically possible to capture all changes accurately, it is recommended that users consult previous editions as appropriate. In all cases, only the current base version of this publication is to be considered the official document.

This Redline is produced solely by Techstreet. IEEE has not prepared this Redline and is not responsible for its accuracy.

Redline Processing Notes:

1. ~~Red Text~~ - Red strikethrough text denotes deletions.
2. Blue Text - Blue underlined text denotes modifications and additions.

Abstract: Criteria for the performance of periodic surveillance testing of nuclear power generating station safety systems are provided in this standard. The scope of periodic surveillance testing consists of functional tests and checks, calibration verification, and time response measurements, as required, to verify that the safety system performs its defined safety function. Post-maintenance and post-modification testing are not covered by this document. The periodic surveillance testing requirements of IEEE NPEC nuclear standards are amplified in this standard. Some design requirements are also identified in this standard.

Keywords: functional tests, IEEE 338™, periodic testing, risk-informed, surveillance testing

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

Copyright © 2023 by The Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 7 April 2023. 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 978-1-5044-9402-1 STD25932
Print: ISBN 978-1-5044-9403-8 STDPD25932

IEEE prohibits discrimination, harassment, and bullying.

For more information, visit <https://www.ieee.org/about/corporate/governance/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 Standards documents are made available for use subject to important notices and legal disclaimers. These notices and disclaimers, or a reference to this page (<https://standards.ieee.org/ipr/disclaimers.html>), appear in all standards and may be found under the heading “Important Notices and Disclaimers Concerning IEEE Standards Documents.”

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

IEEE Standards documents are developed within IEEE Societies and subcommittees of IEEE Standards Association (IEEE SA) Board of Governors. IEEE develops its standards through an accredited consensus development process, which brings together volunteers representing varied viewpoints and interests to achieve the final product. IEEE Standards are documents developed by volunteers with scientific, academic, and industry-based expertise in technical working groups. Volunteers are not necessarily members of IEEE or IEEE SA 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 makes no warranties or representations concerning its standards, and expressly disclaims all warranties, express or implied, concerning this standard, including but not limited to the warranties of merchantability, fitness for a particular purpose and non-infringement. In addition, IEEE does not warrant or represent that the use of the material contained in its standards is free from patent infringement. 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 brought 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: THE NEED TO PROCURE 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 is 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, nor 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 the presenter's views should be considered the personal views of that individual rather than the formal position of IEEE, IEEE SA, the Standards Committee, or the Working Group. Statements made by volunteers may not represent the formal position of their employer(s) or affiliation(s).

Comments on standards

Comments for revision of IEEE Standards documents are welcome from any interested party, regardless of membership affiliation with IEEE or IEEE SA. However, **IEEE does not provide interpretations, 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 subcommittees of the IEEE SA Board of Governors 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 evaluating comments or in revisions to an IEEE standard is welcome to join the relevant IEEE working group. You can indicate interest in a working group using the Interests tab in the Manage Profile and Interests area of the [IEEE SA myProject system](#).¹ An IEEE Account is needed to access the application.

Comments on standards should be submitted using the [Contact Us](#) form.²

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 constitute 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.

Data privacy

Users of IEEE Standards documents should evaluate the standards for considerations of data privacy and data ownership in the context of assessing and using the standards in compliance with applicable laws and regulations.

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

¹Available at: <https://development.standards.ieee.org/myproject-web/public/view.html#landing>.

²Available at: <https://standards.ieee.org/content/ieee-standards/en/about/contact/index.html>.

by public authorities and private users, neither IEEE nor its licensors waive any rights in copyright to the documents.

Photocopies

Subject to payment of the appropriate licensing fees, 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; <https://www.copyright.com/>. 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 [IEEE Xplore](#) or [contact IEEE](#).³ For more information about the IEEE SA or IEEE's standards development process, visit the IEEE SA Website.

Errata

Errata, if any, for all IEEE standards can be accessed on the [IEEE SA Website](#).⁴ Search for standard number and year of approval to access the web page of the published standard. Errata links are located under the Additional Resources Details section. Errata are also available in [IEEE Xplore](#). Users are encouraged to periodically check for errata.

Patents

IEEE Standards are developed in compliance with the [IEEE SA Patent Policy](#).⁵

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 <https://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.

³Available at: <https://ieeexplore.ieee.org/browse/standards/collection/ieee>.

⁴Available at: <https://standards.ieee.org/standard/index.html>.

⁵Available at: <https://standards.ieee.org/about/sasb/patcom/materials.html>.

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 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 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.

IMPORTANT NOTICE

IEEE Standards do not guarantee or ensure safety, security, health, or environmental protection, or ensure against interference with or from other devices or networks. IEEE Standards development activities consider research and information presented to the standards development group in developing any safety recommendations. Other information about safety practices, changes in technology or technology implementation, or impact by peripheral systems also may be pertinent to safety considerations during implementation of the standard. 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.

Participants

At the time this IEEE standard was completed, the Testing Working Group had the following membership:

Yvonne Williams, Chair

John Beatty, Vice Chair

George Ballassi
Suresh Channarasappa
Tom Crawford

Jacob Kulangara
Edward Mohtashemi
Khoi Nguyen
Clint Pierce

Philip Ward
Khadijah West
Kiang Zee

At the time this IEEE standard was completed, Subcommittee 3 (Operations, Maintenance, Aging, Testing and Reliability (SC-3) of the Nuclear Power Engineering Committee had the following membership:

Rebecca Steinman, Chair

George Ballassi
John Beatty
Suresh Channarasappa
Tom Crawford

Jacob Kulangara
Edward Mohtashemi
Khoi Nguyen
Clint Pierce

Philip Ward
Khadijah West
Yvonne Williams
Kiang Zee

The Nuclear Power Engineering Committee (NPEC) that recommended approval of this standard had the following membership:

John White, Chair

Mark Bowman, Vice Chair

Rufino Ayala
George Ballassi
John Beatty
Jason Bellamy
Keith Bush
Suresh Channarasappa
Jonathan Cornelius
Tom Crawford
David Desaulniers
John Disosway
Stephen Fleger
Kenneth Fleischer
Jason Gasque
Jim Gleason

Dale Goodney
Daryl Harmon
David Herrell
Ayodele Ishola-Salawu
Gary Johnson
Wolfgang Koenig
Robert Konnick
Thomas Koshy
Taisuke Koyamada
Jacob Kulangara
Chris Lamb
J. Scott Malcolm
Singh Matharu
Kenneth Miller

Edward Mohtashemi
Warren Odess-Gillett
Gene Poletto
Iftikhar Rana
Eric Rasmussen
Mitchell Staskiewicz
Rich Stattel
Rebecca Steinman
Marek Tengler
Sudhir Thakur
Masafumi Utsumi
Yvonne Williams
Tabatha Womack
Richard Wood

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

S Aggarwal
Robert Aiello
Jason Bellamy
Keith Bush
Suresh Channarasappa
Ritwik Chowdhury
Tom Crawford
David Desaulniers
John Disosway

Neal Dowling
Matthew Evans
Stephen Fleger
Shubhanker Garg
Dale Goodney
Daryl Harmon
Chris Heron
David Herrell
Werner Hoelzl

Ronald Jarrett
Yuri Khersonsky
Robert Konnik
Thomas Koshy
Benjamin Lanz
Jinsuk Lee
Edward Mohtashemi
Khoi Nguyen
Warren Odess-Gillett

James Parello
Bansi Patel
Howard Penrose
Jan Pirrong

Gene Poletto
Eric Rasmussen
Gregg Reimers

Rebecca Steinman
John Vergis
Yvonne Williams
Shuhui Zhang

When the IEEE SA Standards Board approved this standard on 3 December 2022, it had the following membership:

David J. Law, *Chair*
Ted Burse, *Vice Chair*
Gary Hoffman, *Past Chair*
Konstantinos Karachalios, *Secretary*

Edward A. Addy
Ramy Ahmed Fathy
J. Travis Griffith
Guido R. Hiertz
Yousef Kimiagar
Joseph L. Koepfinger*
Thomas Koshy
John D. Kulick

Johnny Daozhuang Lin
Kevin Lu
Daleep C. Mohla
Andrew Myles
Damir Novosel
Annette D. Reilly
Robby Robson
Jon Walter Rosdahl

Mark Siira
Dorothy V. Stanley
Lei Wang
F.Keith Waters
Karl Weber
Sha Wei
Philip B. Winston
Daidi Zhong

*Member Emeritus

Introduction

This introduction is not part of IEEE Std 338-2022, IEEE Standard for Criteria for the Periodic Surveillance Testing of Nuclear Power Generating Station Safety Systems.

This standard provides criteria and requirements supplementary to those in IEEE Std 603TM ⁶ and IEEE Std 308TM for the performance of periodic surveillance testing programs for safety systems in nuclear power generating stations. It also recognizes the applicability of IEEE Std 279TM [B24]⁷ (now withdrawn), as referred to in Title 10, Part 50, Section 50.55a(h), of the Code of Federal Regulations [B5].

Development of these criteria and requirements is consistent with safety systems designed in accordance with IEEE Std 603, IEEE Std 308, and IEEE Std 7-4.3.2TM, as well as the alternative provided in 5.4.3 and the following:

- a) Station safety systems are appropriately tested, during the life of the station, to assess the availability of the systems.
- b) Development and application of testing procedures, equipment, self-diagnostic features, and other methods are consistent with safety system criteria (IEEE Std 603), Class 1E power system criteria (IEEE Std 308), and for digital systems, the programmable digital device criteria (IEEE Std 7-4.3.2).
- c) Procedures for testing, including the alternative method in 5.4.3, and documentation of failures are such that reliability confidence levels are enhanced.

Adherence to these criteria may not suffice for ensuring the protection of the public health and safety because it is the integrated performance of the structures, the fluid systems, the instrumentation, and the electric systems of the station that establishes protection against the consequences of accidents.

The 2006 revision of IEEE Std 338 incorporated risk-informed guidance for the determination or modification of test intervals. The guidance is provided primarily through techniques and examples in Annex B, Annex C, and Annex D.

The 2012 revision updated the standard with the following:

- A requirement for testing redundant portions of the same safety group
- Clarification of response time test requirements
- Design requirements for test features of digital systems
- Testing of digital systems
- Acceptability of on-line monitoring
- On-line monitoring as input for risk-informed test intervals
- Integrated decisionmaking to Annex D (for risk-informed test intervals)

This revision updates the standard with the following:

- Added guidance for use of IEEE Std 1819TM by facilities adopting a risk-informed program for equipment categorization and treatment

⁶Information on references can be found in Clause 2.

⁷The numbers in brackets correspond to those in the bibliography in Annex A.

- Added ANSI/ASME NQA-1 as normative reference and in clauses referencing ANS 3.2, since ANS 3.2 now supplements ANSI/ASME NQA-1 for operating plants
- Added considerations for manual indication of bypassed/inoperable status and for multi-unit indication of bypassed/inoperable status
- Enhanced 5.4.3 discussion for digital equipment systems to clarify crediting of system diagnostics (rather than periodic surveillance testing)
- Coordinated terminology for consistency with IEEE Std 7-4.3.2
- Updated per revised template, revised wording consistent with 1.4 (Word usage)
- Updated bibliography ([Annex A](#)), including deleting dates on standards as appropriate
- Miscellaneous editorial and clarification changes

This standard may also be used for other nuclear facilities related to the nuclear fuel cycle from fuel processing, to reprocessing and waste facilities.

Contents

1. Overview	12
1.1 General	12
1.2 Scope	12
1.3 Purpose	13
1.4 Word usage	13
2. Normative references	13
3. Definitions, acronyms, and abbreviations	14
3.1 Definitions	14
3.2 Acronyms and abbreviations	15
4. System design requirements for testing	15
5. Testing program requirements	17
5.1 General considerations	17
5.2 Program objectives	18
5.3 Types of tests	19
5.4 Test methods	22
5.5 Test intervals	24
5.6 Procedure format and documentation	25
Annex A (informative) Bibliography	26
Annex B (informative) General overview of risk-informed surveillance testing	30
Annex C (informative) Evaluation process for surveillance test changes	34
Annex D (informative) Programmatic approach to risk-informed surveillance test interval management	59

IEEE Standard for Criteria for the Periodic Surveillance Testing of Nuclear Power Generating Station Safety Systems

~~IMPORTANT NOTICE: This standard is not intended to ensure safety, security, health, or environmental protection in all circumstances. 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 General

The IEEE has developed these criteria to provide guidance in the development of the procedures for, and documentation of, periodic ~~electrical power~~, instrumentation, and control and electrical power surveillance testing of nuclear power generating station safety systems and other systems that may affect reactor safety.

Periodic surveillance testing of safety systems maximizes desired system availability and calls attention to performance that is not within prescribed limits by observation of equipment parameters. Prescribed limits are minimum performance requirements, such as response time, setpoint accuracy, and other specified performance requirements as stated in the design bases. This standard amplifies the periodic surveillance testing requirements of IEEE Std 603™ and IEEE Std 308™.^{8 1}

^{8 1}Information on references can be found in Clause 2.

This standard includes [four annexes](#) ~~Annex A, Annex B, Annex C, and Annex D~~. Annex A is a bibliography. Annex B, Annex C, and Annex D provide guidance and supporting information to use risk-informed techniques in the development of test intervals. Annex B is informational and provides a general conceptual overview of risk-informed surveillance testing. Annex C is informational and describes, in greater detail, the methodology for determining risk-informed surveillance test intervals and provides some examples. Annex D is informational and provides the method of developing and implementing risk-informed surveillance testing programs.

[Facilities adopting a risk-informed program for equipment categorization and treatment \(in accordance with regulatory approval\) shall implement this standard in conjunction with IEEE Std 1819™ \[B39\]. \(IEEE 1819 identifies and discusses criteria for risk-informed categorization and treatment of electrical and electronic components that are designated by the user to be placed into safety significant categories at nuclear power generating stations and other nuclear facilities.\)](#)

1.2 Scope

The standard provides criteria for the performance of periodic [surveillance](#) testing of nuclear power generating station safety systems. The scope of periodic testing consists of functional tests and checks, calibration verification, and time response measurements, as required, to verify that the safety system performs its defined safety function. Post-maintenance and post-modification testing are not covered by this document. This standard amplifies the periodic [surveillance](#) testing requirements of other [IEEE](#) nuclear ~~safety-related-IEEE~~ standards.

1.3 Purpose

This standard is intended to aid the user not only in designing a periodic test capability, but also in defining and optimizing the primary elements of an effective periodic test program (including planning, performance/_acceptance criteria, procedures, test intervals, and documentation).

1.4 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall equals is required to*).^{9,10}

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should equals is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may equals is permitted to*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can equals is able to*).

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.

ANS 3.2, [Managerial](#), administrative, ~~Controls~~ and quality assurance [controls](#) for the operational phase of nuclear power plants. ¹¹ ²

⁹The use of the word *must* is deprecated and cannot be used when stating mandatory requirements, *must* is used only to describe unavoidable situations.

¹⁰The use of *will* is deprecated and cannot be used when stating mandatory requirements, *will* is only used in statements of fact.

¹¹ ²ANS publications are available from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (<http://www.ansi.org/>).

[ANSI/ASME NOA-1, Quality Assurance Requirements for Nuclear Facility Applications.](#)¹²

IEEE Std 308™, IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations. [13,14](#) ~~3,4~~

IEEE Std 603™, IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations.

IEEE Std 7-4.3.2™, IEEE Standard Criteria for [Programmable](#) Digital [Devices](#) ~~Computers~~ in Safety Systems of Nuclear Power Generating Stations.

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary* [Online](#) ~~Glossary of Terms and Definitions~~ should be consulted for terms not defined in this clause. [15](#) ~~5~~

channel: An arrangement of components and modules as required to generate a single protective action signal when required by a generating station condition. A channel loses its identity where single protective action signals are combined.

¹²[ASME publications are available from the American Society of Mechanical Engineers, 3 Park Avenue, New York, NY 10016-5990, USA \(<http://www.asme.org/>\).](#)

¹³ ~~3~~ IEEE publications are available from The Institute of Electrical and Electronics Engineers, Inc., 445 Hoes Lane, Piscataway, NJ 08854, USA (~~[https](https://standards.ieee.org/)~~<http://standards.ieee.org/>).

¹⁴ ~~4~~ The IEEE standards or products referred to in this clause are trademarks of The Institute of Electrical and Electronics Engineers, Inc.

¹⁵[IEEE Standards Dictionary Online is available at: <http://dictionary.ieee.org>. An IEEE Account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.](#)

~~⁵IEEE Standards Dictionary: Glossary of Terms and Definitions is available at <http://shop.ieee.org>.~~

channel calibration: The adjustment of channel output such that it responds, with acceptable range and accuracy, to known values of the parameter that the channel measures. [The channel calibration includes](#) ~~and~~ the performance of a functional test.

channel check: The qualitative assessment, by observation, of channel behavior during operation. This determination includes, where possible, comparison of the channel indication and status to other indications or status derived from independent instrument channels measuring the same parameter.

failure: The termination of the ability of an item to perform a required function.

functional test: A test to determine the ability of a component or system to perform an intended purpose or safety function.

go/no-go: A set of terms (in colloquial usage) referring to the condition or state of operability of a unit that can only have two parameters: **(A)** go, functioning properly; or **(B)** no-go, not functioning properly.

limiting condition for operation (LCO): The lowest functional capability or performance level of equipment required for safe operation of the facility.

[on-line monitoring: An automated method of monitoring instrument performance and assessing instrument calibration while the plant is operating, without disturbing the monitored channels.](#)
[\[B13\]](#)

overlap testing: Overlap testing consists of channel, train, or load group verification by performing individual tests on the various components and subsystems of the channel, train, or load group. The individual component and subsystem tests check common parts of adjacent subsystems, such that the entire channel, train, or load group is verified by testing of individual components or subsystems and by repetitive testing of common parts of adjacent subsystems.

safety function: [One of the processes](#) ~~A process~~ or [conditions](#) ~~condition~~ (for example, emergency negative reactivity insertion, post-~~accident~~ heat removal, emergency core cooling, post-accident radioactivity removal, and containment isolation) essential to maintaining plant parameters within acceptable limits established for a design basis event.

safety group: A given minimal set of interconnected components, modules, and equipment that can accomplish ~~accomplishes~~ a safety function.

safety system: A system that is relied upon ~~on~~ to remain functional during and following design basis events to assure ~~(1 ensure (A))~~ the integrity of the reactor coolant pressure boundary; ~~(2 B)~~ the capability to shut down the reactor and maintain it in a safe shutdown condition; or ~~(3 C)~~ the capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposures comparable with regulatory limits.

surveillance: The determination of the state or condition of a system or subsystem.

surveillance test: Periodic test to determine the state or condition of a system or subsystem.

test bypass: A mode of testing whereby the safety group under test is designed to permit any one channel or load group to be maintained, tested, or calibrated during power operation, without initiating a protective action of the safety group. Bypass testing is usually authorized by the regulatory agency with jurisdiction.

test completion: The completion of active testing of the item and the return of the item to service.

test duration: The elapsed time between the test initiation and the test completion ~~termination~~.

test initiation: The application of a test input or removal of equipment train from service to perform a test.

test input: A real or simulated, but deliberate, action that is imposed upon a sensor, channel, train, load group, or other system or device for the purpose of testing.

unavailability: The probability that an item or system will not be operational at a future instant in time. Unavailability may be a result of the item being repaired, maintained, or tested or it may occur as a result of malfunctions. Unavailability is the complement of availability.

~~**unavailability:** The numerical complement of availability. Unavailability may occur as a result of the item being repaired or a detected malfunction (repair unavailability), tested (testing unavailability), or it may occur as a result of undetected malfunctions (unannounced unavailability).~~

3.2 Acronyms and abbreviations

BWR boiling water reactor

CCF common cause failure

CDF core damage frequency

CRMP configuration risk management program

EDG emergency diesel generator

LERs licensee event reports

LERF large early release frequency

MSIV main steam-isolation valve

PRA probabilistic risk assessment

RI risk-informed

RPS reactor protection system

STI surveillance test interval

4. System design requirements for testing

The safety systems shall be designed to be testable during operation of the nuclear power generating station and/or during those intervals when the station is shut down. This testability shall permit the independent testing of redundant channels and load groups while (1) maintaining the capability of these systems to respond to bona fide signals; (2) tripping the output of the channel being tested, if required; or (3) bypassing the equipment consistent with safety requirements and limiting conditions for operation.

An alternative approach is provided in 5.4.3 for digital systems to detect and alarm failures, replacing surveillance test requirements. Meeting the requirements of 5.4.3 can be credited as meeting the surveillance testing requirements for those portions of the control/protection system that provide equivalent assurance that faults and failures within the control/protection system will be detected. Use of the alternative approach shall be documented, including an evaluation of potential failure mechanisms and effectiveness of the detection and alarming scheme provided by the digital equipment or component.

~~The following issues further amplify~~ These design requirements are further amplified by the following:

- a) Design shall provide the capability for periodic surveillance testing that simulates, as closely as practicable, the required safety function performance with the exception of abnormal environmental conditions, such as seismic events, radiation fields, extreme pressures, temperatures, and moisture conditions that are covered by design qualification provided unexpected degradation has not occurred. Testing of equipment for external environments is not within the scope of periodic surveillance testing; therefore, the environments need not be simulated. Testing provisions shall be designed to demonstrate the functional capability of the items under test during normal environmental conditions.
- b) Test equipment interfaces and installed test equipment shall not cause a loss of independence between redundant channels or load groups. Equipment included in the safety system for test purposes shall be included in the determination of system availability, to the extent that it could impact the safety function.
- c) Safety systems shall be designed with due consideration of the impact of testing on plant availability, maintainability, operation, operational mode, and limiting conditions for operation. Coincidence logic may be provided where necessary to fulfill this provision.
- d) Testability shall be considered in the selection of all components of the safety system. Sensors should be accessible and, where practicable, installed such that their calibration can be verified in situ ~~place~~. When selecting actuation devices, their status indication capability shall be considered.

- e) Design shall provide for the functional testing capability of the safety system. Simultaneous testing of the system from sensor to actuated equipment is the preferred method. However, where this is not practical, the system design shall provide overlap testing capability. For example, testing an instrument channel and logic circuits separate from their actuator devices is acceptable. Design configurations in accordance with item 2) or item 3) below shall have documented justification that the probability of failure of actuated equipment not tested during plant operation is acceptably low, and that the actuated equipment can be routinely tested when the plant is shut down.

Where it is not practicable to initiate the protective action as part of the periodic surveillance testing procedure, the system shall be designed such that:

- 1) All actuation devices and actuated equipment can be tested individually or in judiciously selected groups, such as when testing the actuation device for a containment spray pump separately from the actuation device for the containment spray system valves.
 - 2) The operation of certain actuated equipment is ~~prevented~~ blocked during a test of their actuation devices, such as supplying alternative power to a normally energized solenoid while testing its current interrupting device.
 - 3) Operation of the actuated equipment requires the (coincident) operation of more than one actuation device, such as when individually testing the two solenoid-operated valves that act in coincidence to control compressed air to an isolation valve.
- f) Interrelationship among the systems, components, and human factors in each phase of the test activity shall be considered and reflected in the system design. Test points, test devices, and associated test equipment should be located to facilitate performance of periodic surveillance testing.

- g) A means of communication shall be provided between personnel associated with the test and the main control room so ~~to ensure~~ that control room operators and associated test personnel are cognizant of the status of those systems under test. In addition, a means of communication shall be provided so that personnel associated with the test can adequately communicate.
- h) Automated ~~Automatic~~ testing features should be considered when selecting the type of testing system. However, where a programmable digital device ~~computer~~ is included in the design, whether integrated or portable, self-diagnostic ~~automatic testing~~ features are subject to the provisions of this standard and IEEE Std 7-4.3.2.
- i) Design considerations for testing the ~~electrical power~~, instrumentation, and control and electrical power controls portion of the safety system shall be coordinated with the testing provisions of associated mechanical and fluid systems, if applicable.
- j) Provisions used for perturbing the same or a substitute monitored variable are preferred over using simulated signals to verify overall tripping of each protective channel. Where perturbing the monitored variable or substitute is not practical, the proposed alternative tests shall have documented justification.
- k) Means should be included in the design to facilitate response time testing from sensor input to, and including, the actuated equipment if required by 5.3.4.
- l) Where practical, test devices, such as test blocks and test jacks, should be incorporated into the design to eliminate the need for the installation ~~application~~ and removal of wires in order to perform periodic surveillance testing. These devices shall not interfere with the operability or safety function of the component or system under test.
- m) Test devices incorporated into the design, such as test blocks and test jacks, shall have a means to verify that the portions of the channel or system being tested have been returned to functional connected status prior to returning the system to service.

- n) Where practical, means shall be included in the design to ~~prevent~~ [block](#) the simultaneous application of any bypass condition to redundant channels or load groups during testing.
- o) Where redundant components are used within a single channel or load group, the design should permit each component to be tested independently.
- p) The system should be designed such that the removal of fuses or opening of breakers is only required for the purposes of testing if such action causes the actuation of the logic for a channel or load group. For example, the actuation of a loss of channel power supply is simulated by the removal of its fuses.
- q) For analog-to-digital converters and digital-to-analog converters, the system shall have the capability to verify the counts or ratios are still within acceptable values. This is typically done on a module level and can also be accomplished during an auto-~~cal~~ibration test.
- r) Control/protection systems shall have a mechanism to verify functionality of inputs. This can be accomplished during self-test intervals or during a periodic manual test. Inputs should be cycled for testing as long as other functions connected to the input are not adversely impacted.
- s) Digital control/protection systems shall have a mechanism to verify functionality of digital outputs. This can be accomplished during self-test intervals or during a periodic manual test.
~~Digital outputs to the field device should either be blocked or the field device placed in a controlled state before testing.~~
- t) Indication shall be provided in the control room if a portion of the safety system is inoperable or bypassed. Systems that are frequently placed in a bypass or inoperative condition for the purposes of testing shall have automatic indication. [Manual capability should be considered for displaying those inoperable or bypassed conditions, whether deliberately induced or not, that are not automatically indicated. For multi-unit sites, the control room of each affected unit shall receive indication of any bypassed condition that affects those units.](#)

5. Testing program requirements

5.1 General considerations

A surveillance test program shall be developed and implemented, and shall include as a minimum the following three elements: (1) identification of components and equipment within the scope of the program; (2) acceptance criteria for determining satisfactory testing performance; and (3) testing frequency or ~~minimum~~ intervals between testing.

The periodic surveillance testing program for the safety system shall include, as applicable, functional tests (including channel functional tests), instrument channel checks, channel calibration, and response time tests. It shall also establish the extent and frequency of the testing required commensurate with plant safety concerns. The program shall be designed and conducted to meet at least the following requirements:

- a) The operability of each redundant portion of the safety system shall be independently verified. Where such testing is not practical during reactor operation, the operability shall be tested when the station is shut down.
- b) The verification of operability during reactor operation shall include as much of the channel and load group under test as practically possible, including sensors and actuators, without jeopardizing continued normal plant operation. Overlap tests are permitted [as identified in 5.3.5](#) ~~where full functional tests are not practicable~~. Tests that would interfere with normal or safe plant operation should be scheduled during plant shutdown periods ~~and shall include a complete test of the safety system~~.
- c) The test procedure shall have requirements for confirming that when a test is completed the equipment tested has been restored to its normal operational mode.
- d) Wherever possible, tests shall be accomplished under actual or simulated operating conditions, including sequence of operations, ~~e.g. for example~~, diesel load sequencing. This does not include simulating environmental conditions.

- e) Testing shall be conducted in accordance with approved written test procedures.
- f) The test program shall be periodically reviewed to determine its overall effectiveness.
- g) Results of a failed test cannot be negated by a simple successful repetition. A successful repetition of the test shall be preceded by documented evaluation or corrective action such as maintenance, repair, or changes to procedures, as applicable. Failures should be understood where possible.
- h) Testing programs shall be conducted in a logical sequence such that the overall condition of the system under test can immediately be assessed and the need for progressing further into the testing of individual components can be determined.
- i) The test program of each safety system shall be designed to provide for minimum interference with related operational channels, systems, or equipment.
- j) Where redundant components are used within a single channel or load group, each redundant portion shall be tested independently.
- k) The test program for each system shall be designed to produce data necessary for objective assessment of its performance and availability. The testing program shall provide an indication of incipient failures, trend data, and determine degradation, where objectively assessable.
- l) The administrative controls and quality assurance requirements shall conform to the requirements of ANS 3.2 [and ASME NQA-1](#), or the equivalent.
- m) Functional tests may be supplemented by but not replaced with continuity checks. [Failure mechanisms shall be determined and documented for failures seen during the tests.](#)

5.2 Program objectives

The periodic test program shall include procedures and reports that accomplish at least the following objectives:

- a) Facilitate administration and auditing.
- b) Identify unacceptable failure rates.
- c) Reduce ~~Minimize~~ interference with overall plant operation and any compromise of safety through proper coordination of the testing activities.
- d) Provide for ~~Ensure~~ non-concurrent testing of redundant protection channels and load groups.
- e) Provide a master schedule that includes a complete basic testing cycle and status of testing.
- f) Identify systems, channels, and load groups to be tested.
- g) Provide tests that simulate, as much as practicable, the actual operating conditions during which the system under test would be required to operate. In general, testing of equipment for abnormal environmental conditions such as seismic events, radiation fields, extreme pressure ~~pressures~~, temperatures, and moisture conditions is not within the scope of periodic surveillance testing and, therefore, need not be simulated.
- h) Provide for alteration of the test interval in accordance with the criteria given in 5.5.
- i) Derive the periodic surveillance testing program from considerations such as:
 - 1) Systems failure modes and effects
 - 2) Component failure modes
 - 3) Applicable risk, reliability, and availability analyses ~~analysis~~
 - 4) Failure report analyses and other historical data
 - 5) Logic configuration
 - 6) Plant operating schedules
 - 7) Equipment qualification documentation, such as qualified life
 - 8) Regulatory requirements

5.3 Types of tests

5.3.1 Channel checks

The operability of channels that have indication available shall be verified by one or more of the following:

- a) Comparing readings on channels that monitor the same variable, recognizing any differences in the actual monitored variable between sensor locations (e.g. ~~for example~~, compare power channel 1 with redundant power channels 2 and 3).
- b) Comparing readings between channels that monitor the same variable and bear a known relationship to one another (e.g. ~~for example~~, comparing intermediate range and source range neutron monitoring channels during a startup or shutdown when both channels indicate on scale).
- c) Comparing readings between channels that monitor different variables and bear a known relationship to one another (e.g. ~~for example~~, at a given power level the primary coolant outlet temperature is a certain value or steam pressure is in a certain range).

Consideration shall be given to common cause ~~mode~~ failures when selecting channels for comparison (for example, comparing level to an instrument sharing a common reference leg).

5.3.2 Functional tests

A functional test shall demonstrate ~~assure~~ that the tested equipment is capable of performing its design function, as follows: ~~The test should neither be lengthy nor require extensive test equipment or personnel.~~

- a) A functional test for equipment (system components) shall consist, as appropriate, of one or more of the following:

- 1) Manually starting equipment (e.g. ~~for example~~, motor, pump, compressor, turbine, or engine) and observing proper operation (e.g. ~~for example~~, pressure, flow, temperature, voltage, or speed). Test duration shall be sufficient to achieve stable operating conditions. Where starting a pump or other equipment is not practical, test operation of the circuit breakers (and other equipment having provision for testing without energizing or deenergizing loads) in “test” position may be acceptable if the requirements of item e) and item t) of Clause 4 are met.
 - 2) Manually controlling electric operation of valves and other components, if appropriate. In cases where fully stroking the valve is not practical, a partial stroke test (e.g. ~~for example~~, main steam stop valves, turbine stop, or control valves) or a valve control system test (e.g. ~~for example~~, the control circuit for explosive poison injection valves) may be acceptable. Full stroke testing shall be routinely accomplished during plant shutdown periods where practicable.
 - 3) Injecting test signals of an appropriate magnitude to give an approximate indication (e.g. ~~for example~~, a numerical output “equivalent” to tripping the output), ~~or~~ tripping the output, or doing both. Alarm and trip functions, and other indications as applicable, shall be tested.
- b) Testing to verify the system or subsystem function shall include, as appropriate:
- 1) Individually tripping actuating devices and observing proper load group operation (e.g. ~~for example~~, trip bus under-voltage relays and observe bus transfer, load shedding, diesel generator start, and load sequencing).
 - 2) Verifying manually initiated safety functions. Where it is not possible to perform a test during plant operation, the tests may be performed during reactor shutdown (e.g. ~~for example~~, manual reactor trip).
 - 3) Testing the status and operability of bypasses, bypass and test indications, and bypass and test annunciation circuits.

- 4) Varying input signal levels for one or more parameters to achieve tripping or change in calculated output, while signals for other variables are maintained at their normal, expected values. The parameters to be varied shall be selected based on expected design basis event conditions and anticipated operational occurrences. It may be necessary to vary more than one parameter from its normal expected value.

5.3.3 Channel calibration tests

5.3.3.1 General

A channel calibration test shall prove that, with a known precise input, the channel gives the required output, analog, or discrete. Additionally, in analog channels, linearity and hysteresis may be checked. If the required output is achieved, the test is acceptable. If the required output is not achieved (~~e.g. for example~~, the bistable trip did not occur at the required setpoint or the analog output was out of tolerance) or saturation or foldover is observed and adjustment or alignment of gain, bias, trip set, etc., is required, the test is unacceptable. Adjustment or alignment procedures are maintenance activities and are outside the scope of this standard. Test results, however, shall be recorded in accordance with ANS 3.2 [and ANSI/ASME NQA-1](#) or the equivalent. After maintenance or other appropriate disposition of the unacceptable results, a successful rerun of the channel calibration verification test shall be performed.

5.3.3.2 On-line monitoring

On-line monitoring (OLM) techniques enable the determination of portions of an instrument channel's status during plant operation. This methodology is ~~an acceptable input~~ for establishing calibration frequency of those monitored portions of instrument channels without adversely affecting reliability. [Automatic on-line monitoring may be employed, e.g., through the plant computer.](#)

~~Continuous monitoring shall be employed, e.g., through the plant computer. Periodic manual testing is either a maintenance or surveillance task and is not on-line monitoring.~~

On-line monitoring shall provide evidence ~~ensure~~ that setpoint calculation assumptions and the safety analysis assumptions remain valid.

NOTE—Periodic manual testing is either a maintenance or surveillance task and is not on-line monitoring.¹⁶

5.3.4 Response time verification tests

Response time testing shall be required only on safety systems or subsystems to verify that the response times are within the limits given in the safety analysis documents, including regulatory requirements. The following issues shall be addressed:

- a) During a specific test period, testing of like-for-like components replaced is not necessary provided:
 - 1) The time response is a small portion of the total system response.
 - 2) The component has few moving parts.
 - 3) The component is not already aged.
 - 4) Few ~~There are not a significant number of~~ components within the system ~~that~~ have not already been tested.

Time response testing shall be performed on components such as final actuated devices that contribute a large portion of the time allocation, breakers that may have many moving parts, and components that ~~which~~ have adjustable time response characteristics. Parts that have been reworked or declared equivalent shall be evaluated. If the rework or equivalency does not affect time response, the reworked part may be considered as a new component or the equivalent part may be considered like for like.

¹⁶Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement the standard.

- b) Sufficient overlap shall be provided to verify overall system response. ~~When~~ Where it is necessary ~~not practicable~~ to remove a sensor ~~include sensors in individual or system response time tests, the sensors may be periodically removed~~ from ~~its~~ their normal ~~installations and tested. When this is done, the test~~ installation for testing, the test setup shall simulate the relevant environment and configuration of the actual installation.
- c) Response time testing of ~~all~~ safety-related equipment is not required if, in lieu of response time testing, the response time of safety system equipment is verified by functional testing, calibration checks, self-diagnostics, or other tests. This is acceptable if it can be demonstrated that changes in response time beyond acceptable limits are accompanied by changes in performance characteristics that are detectable during routine periodic tests.
- d) For channel response time testing that does not include sensors, the test equipment shall simulate sensor output over its required functional range and simultaneously record input and output conditions for determining the overall response time. The test input shall span the normal trip setpoint sufficiently to reset the channel for the untripped condition and confirm ~~ensure~~ complete tripping for the tripped condition.
- e) For protective tripping functions where two or more variables enter into the tripping action (e.g. ~~for example~~, the trip point is computed for temperature, pressure, and neutron ~~nuclear~~ flux signals), the channel response time shall be verified using each variable to produce the tripping action. During this tripping action, the test signals for the remaining variables shall be adjusted to a value within their expected operating range that produces conservative test results.
- f) The response time test should include as much of each safety system, from sensor input to actuated equipment, as is practicable in a single test. Where it is not practical to simultaneously test the entire set of equipment from sensor to actuated equipment in one test, verification of system response time shall be accomplished by measuring the response times of discrete portions of the system and showing that the sum of all response times is within limits of the overall system requirement. Response time testing of the process to sensor coupling and of the actuated equipment to process coupling is not required by this standard.

5.3.5 Logic system functional test

A logic system functional test shall test from sensor through to the actuated device. The test may be performed by a series of sequential, overlapping, or total system tests so that an entire logic system is tested.

5.4 Test methods

5.4.1 General

A specific test procedure meeting the requirements of this standard and using applicable methods similar to those in this subclause shall be developed for each system, equipment, or function as required. This subclause does not attempt to describe every type of test that may be applicable for every equipment type, system, or function. Test methods differ for analog and digital equipment/systems.

In general, the function shall be verified to within operational limits or capacity, as follows:

- a) The test, or a combination of tests, shall check each protection channel or load group in its entirety (e.g. for example, include the sensor and the final actuation or initiation device to all connected loads). During this testing, observations shall be made to detect interactions with other redundant channels, if applicable.
- b) The indication of a successful test shall be:
 - 1) A positive, predetermined, and direct indication of a change of state, such as a solid-state or electromechanical device operation, with a corresponding signal transmission/conversion (e.g. for example, sounding an alarm; turning a light on or off; change of state of a contact or optical isolator, meter, or computer indication; starting of a motor; or movement of a valve or other actuator).
 - 2) Absence of any observed abnormal results in the redundant channels, if applicable.

- c) The test input to the channel shall be introduced as close to the sensor as is practicable. This may be accomplished in various ways, such as:
- 1) By perturbing the monitored variable. This refers to variations introduced in the variable, such as changing the pressures, temperatures, or power levels.
 - 2) By introducing and appropriately varying a substitute input to the sensor of the same nature as the monitored variable. This refers to such actions as opening the equalizing valve on flow measuring differential pressure cells, isolating and bleeding the inputs to pressure measuring devices, or injecting hot or cold liquids into liquids whose temperature is being monitored.
- d) When complete checks, including those of the sensor (~~are not practicable~~ such as a neutron detector), are not practicable, an analog or digital input for partial testing of a channel shall be introduced and varied as appropriate.
- e) Acceptable tolerances from the nominal setpoint values for the onset of each channel protective action shall be established for the various types of signals expected. For example, from design performance or qualification test data, the allowable deviation of the onset of protective action due to variation in the rate of change at the input signal should be determined.
- f) The capability to vary the test signal amplitude shall be sufficient to permit verification of protective action for expected variable parameter extremes. The nature of the test signal variation is to be developed in recognition of the performance characteristics of the particular channels involved. The response to rise time, amplitude, or other wave shape characteristics may be affected by equipment degradation or malfunction. Examples of the nature of the test signals that may be used are:
- 1) A slowly changing signal. This type shall be selected if protective action is required for this kind of signal and if the equipment condition (as indicated by observation or by the change in response toward the limits of the tolerance band) indicates that a slow rate of change of the signal might not produce the protective action.

- 2) A rapidly changing signal. This type shall be selected if protective action is required for this kind of signal and if the equipment condition (as indicated by observation or by the change in response toward the limits of the tolerance band) indicates that a high rate of change of the signal might not produce the protective action.
- 3) A large change in signal. This type shall be selected if protective action is required for this kind of signal and if the equipment condition (as indicated by observation or by the change in response toward the limits of the tolerance band) indicates that large deviations of the signal from normal might not produce the protective action (e.g. for ~~example~~, by saturation or foldover).

The test to be performed on given channels or equipment may be either single type or a combination of types, as practically required to verify acceptable channel performance under various expected conditions.

- g) Procedures for periodic tests within the scope of this standard should not require makeshift test connections. Where temporary test connections, removal of fuses, opening of breakers, or the opening of circuits by other methods are required for test purposes, such activities shall be subject to appropriate administrative controls. The test procedures or administrative controls shall provide for verifying the open circuit or verifying that temporary connections are removed and the system has been restored to the correct operating configuration ~~normal~~ after testing.

5.4.2 Analog equipment/systems

The test signal amplitude shall be varied to determine that the protective actions ensue when the monitored variable reaches the setpoint value. This type of test usually is a “go/no-go” type.

Analog inputs should be tested to verify the status of input channels for out of range parameters. The analog inputs can be tested during self-test intervals or during outages to verify that the over-range and under-range alarm setpoints are still valid settings from previous records. Auto-calibration is also a method used to check analog input channels. This method is usually done on a module basis and provides an alarm to the operator when any channel is out of calibration.