ANSI/IEEE Std 338-1987
(Revision of ANSI/IEEE Std 338-1977)

An American National Standard

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

Sponsor
Nuclear Power Engineering Committee of the IEEE Power Engineering Society

Approved September 10, 1987
IEEE Standards Board

Approved March 3, 1988
American National Standards Institute

IEEE Standards documents are developed within the Technical Committees of the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Board. Members of the committees serve voluntarily and without compensation. They are not necessarily members of the Institute. The standards developed within IEEE represent a consensus of the broad expertise on the subject within the Institute as well as those activities outside of IEEE which have expressed an interest in participating in the development of the standard.

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. Every IEEE Standard is subjected to review at least once every five years for revision or reaffirmation. When a document is more than five years old, and has not been reaffirmed, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE Standard.

Comments for revision of IEEE Standards are welcome from any interested party, regardless of membership affiliation with IEEE. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments.

Interpretations: Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretations is brought to the attention of IEEE, the Institute will initiate action to prepare appropriate responses. Since IEEE Standards represent a consensus of all concerned interests, it is important to ensure that any interpretation has also received the concurrence of a balance of interests. For this reason IEEE and the members of its technical committees are not able to provide an instant response to interpretation requests except in those cases where the matter has previously received formal consideration.

Comments on standards and requests for interpretations should be addressed to:

Secretary, IEEE Standards Board
345 East 47th Street
New York, NY 10017
USA

IEEE Standards documents are adopted by the Institute of Electrical and Electronics Engineers without regard to whether their adoption may involve patents on articles, materials, or processes. Such adoption does not assume any liability to any patent owner, nor does it assume any obligation whatever to parties adopting the standards documents.

Foreword

(This Foreword is not a part of ANSI/IEEE Std 338-1987, 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 ANSI/IEEE Std 603-1980, IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations and ANSI/ IEEE Std 308-1980, IEEE Standard Criteria for Class lE Power Systems for Nuclear Power Generating Stations, for the performance of periodic surveillance testing programs for safety systems in nuclear power generating stations. It also recognizes the applicability of (since withdrawn) IEEE Std 279-1971, IEEE Standard Criteria for Protection Systems for Nuclear Power Generating Stations, as referred to in Title 10, Part 50, Section 50.5550a(h) of the Code of Federal Regulations. Development of these criteria and requirements is consistent with safety systems designed in accordance with both ANSI/IEEE Std 603-1980 and ANSI/IEEE Std 308-1980, and the following:

1) Station safety systems must, during the life of the station, be appropriately tested to assess the operational availability of the systems.
2) Development and application of testing procedures and equipment shall be consistent with safety system criteria (ANSI/IEEE Std 603-1980) and Class lE power system criteria ANSI/IEEE Std 308-1980).
3) Procedures for testing and documentation of failures should be such that reliability confidence levels are enhanced.

This standard does not contain within its scope, and subsequently does not address, areas concerning plant maintenance. Requirements, guidelines, or recommended practices for these maintenance issues are currently under development and formulation, and as such, shall be identified through future IEEE standards, as applicable.

The Institute of Electrical and Electronics Engineers has developed these criteria to provide guidance in the development of the procedures for, and documentation of, periodic surveillance testing of nuclear power generating station safety systems. Each applicant for a construction permit or an operating license for a nuclear facility is required to develop these items to comply with the Nuclear Regulatory Commission's Code of Federal Regulations, Part 50.

Adherence to these criteria may not suffice for assuring 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 the consequences of accidents. On the other hand, failure to meet these requirements may be an indication of system inadequacy. Each applicant has the responsibility to assure himself and others that this integrated performance is adequate.

During the development of this standard, the Working Group recognized that certain areas relative to its subject material are currently undergoing rapid expansion. Present development and research in automated programmable digital systems, automated testing, and availability of failure rate data at both the component and system levels may require more extensive treatment through future revisions of this document. Based on these considerations, review and subsequent revision of this standard was performed with the purposes of maintaining consistency with current state-of-the-art technology and also to arrive at a standard that is practical and applicable in scope and format for actual implementation in nuclear power generating plants.

The Appendix of this document is structured so as to provide additional referral material, if required, for the user. The addition of pertinent IEEE standards and other publications to enhance its data base nature may be further expanded, through future revision, in recognition of currently evolving technologies and data analysis studies.

The IEEE will maintain this standard current with the state of technology. Suggestions for improvement of this standard will be welcome. These should be addressed to the Secretary of the IEEE Standards Board.

This standard was prepared by Working Group 3.0 of Subcommittee 3, Operations, Surveillance and Testing, of the IEEE Nuclear Power Engineering Committee. At the time of preparation, contributing members of Working Group 3.0 were:

K. J. Sweet, *Chair*
R. E. Dulski, *Former Chair*
G. C. Sundberg, *Vice Chair*
T. A. Fey, *Secretary*

J. Bendokaitis
C. Corl
M. Entenberg
R. Grams
J. Henley
A. Hintze
B. Hunter
S. Jain
W. Messer
I. Rubin
F. Siler
J. Summa
D. Webb

This standard was reviewed and approved by Subcommittee 3. At the time of approval, the members of the subcommittee were:

D.C. Lamken, *Chair*
R. E. Dulski, *Vice Chair*
S. Kasturi, *Secretary*

N. K. Agnihotri
J. E. Allen
D. L. Allison
L. P. Gradin
A. R. Hall
A. S. Hintze
M. M. Hintze
B. G. Hunter
S. C. Jain
A. Marion
W. H. Messer
D. P. Millard
N. Pillsbury
I. M. Rubin
R. M. Sorensen
K. J. Sweet
P. F. Tomlinson
J. T. Ullo
D. Webb

At the time it approved this standard, the IEEE Nuclear Power Engineering Committee had the following membership:

R. E. Allen, *Chair*
J. T. Bauer, *Vice Chair*
E.P. Fogarty, *Secretary*
W. G. Schwartz, *Standards Coordinator*

F. D. Baxter
D. F. Brosnan
S. P. Carfagno
R. C. Carruth
F. W. Chandler
R. P. Daigle
E. F. Dowling
R. E. Dulski
J. M. Gallagher
W. C. Gangloft
L. W. Gaussa
L. C. Gonzalez
L. P. Gradin
B. Grim
T. L. Gruber
R. E. Hall
L. F. Hanes
G. K. Henry
S. Kasturi
J. T. Keiper
T. S. Killen
A. Laird
D. C. Lamken
B. Nemroff
M. Pai
J. R. Penland
W. K. Peterson
C. A. Petrizzo
G. Pitcher
N. S. Porter
W. S. Rautio
H. V. Redgate
B. M. Rice
A. R. Roby
Z. Sabri
W. F. Sailer
E. F. Sproat
A. J. Spurgin
L. Stanley
D. F. Sullivan
P. Szabados
L. D. Test
J. E. Thomas
T. R. Vardaro
F. J. Volpe

The following persons were on the balloting committee that approved this document for submission to the IEEE Standards Board:

R. E. Allen
J. T. Bauer
F. D. Baxter
D. F. Brosnan
S. P. Carfagno
R. C. Carruth
F. W. Chandler
R. P. Daigle
E. F. Dowling
R. E. Dulski
E. P. Fogarty
J. M. Gallagher
W. C. Gangloft
L. W. Gaussa
L. C. Gonzalez
L. P. Gradin
B. Grim
T. L. Gruber
R. E. Hall
L. F. Hanes
G. K. Henry
J. T. Keiper
T. S. Killen
A. Laird
D. C. Lamken
B. Nemroff
M. Pai
J. R. Penland
W. K. Peterson
C. A. Petrizzo
G. Pitcher
N. S. Porter
W. S. Rautio
H. V. Redgate
B. M. Rice
A. R. Roby
Z. Sabri
W. F. Sailer
W. G. Schwartz
E. F. Sproat
A. J. Spurgin
L. Stanley
D. F. Sullivan
P. Szabados
L. D. Test
J. E. Thomas
T. R. Vardaro
F. J. Volpe

When the IEEE Standards Board approved this standard on September 10, 1987, it had the following membership:

Donald C. Fleckenstein, *Chair*
Marco W. Migliaro, *Vice Chair*
Andrew G. Salem, *Secretary*

James H. Beall
Dennis Bodson
Marshall L. Cain
James M. Daly
Stephen R. Dillon
Eugene P. Fogarty
Jay Forster
Kenneth D. Hendrix
Irvin N. Howell
Leslie R. Kerr
Jack Kinn
Irving Kolodny
Joseph L. Koepfinger*
Edward Lohse
John May
Lawrence V. McCall
L. Bruce McClung
Donald T. Michael*
L. John Rankine
John P. Riganati
Gary S. Robinson
Frank L. Rose
Robert E. Rountree
William R. Tackaberry
William B. Wilkens
Helen M. Wood

*Member emeritus

CLAUSE PAGE

An American National Standard

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

1. Scope

This standard provides design and operational criteria for the performance of periodic testing as part of the surveillance program 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 to meet its defined safety function. The system status, associated system documentation, test intervals, and test procedures during operation are also addressed.

Maintenance is not covered by this document.

This standard amplifies the periodic surveillance testing requirements of ANSI/IEEE Std 603-1980 [4][1] and ANSI/IEEE Std 308-1980 [3].

2. Definitions

2.1

The following definitions apply to key words as used in this standard and are included in ANSI/IEEE Std 100-1984 [2].

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.

failure: The termination of the ability of an item to perform a required 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: (1) go, functioning properly, or (2) no-go, not functioning properly.

operational availability: The measured or observed characteristic of an item expressed by the probability that it will be operable when needed as determined by periodic test and resultant analysis.

overlap testing[2]: 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

[1]The numbers in brackets correspond to those of the references listed in Section 3.
[2]Definition is updated from ANSI/IEEE Std 100-1984 [2].

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.

periodic test: A test performed at scheduled intervals to detect failures and verify operability.

safety function: One of the processes or conditions (for example, emergency negative reactivity insertion, post-accident heat removal, emergency core cooling, post-accident radioactivity removal, and containment isolation) essential to maintain 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 a safety function.

safety system: Those systems (the reactor trip system, an engineered safety feature, or both, including all their auxiliary supporting features and other auxiliary features) that provide a safety function. A safety system is comprised of more than one safety group of which any one safety group can provide the safety function.

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

test duration: The elapsed time between the test initiation and the test 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 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).

2.2

The following definitions apply to key words as used in this standard only and are not included in ANSI/IEEE Std 100-1984 [2].

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, and the performance of a functional test.

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

channel check: A qualitative assessment of performance carried out at designated intervals to determine if all elements of the channel are operating within their designated limits.

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

surveillance testing: Periodic testing to verify that safety systems continue to function or are in a state of readiness to perform their safety function.

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.

test interval: The elapsed time between the initiation (or successful completion) of tests on the same sensor, channel, load group, safety group, safety system, or other specified system or device.

3. References

The following publications shall be used in conjunction with this standard:

[1] ANSI/ANS 3.2-1982, Administrative Controls and Quality Assurance for the Operational Phase of Nuclear Power Plants.[3]

[2] ANSI/IEEE Std 100-1984, IEEE Standard Dictionary of Electrical and Electronics Terms.[4]

[3] ANSI/IEEE Std 308-1980, IEEE Standard Criteria for Class lE Power Systems for Nuclear Power Generating Stations.

[4] ANSI/IEEE Std 603-1980, IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations.

[5] ANSI/IEEE/ANS 7-4.3.2-1982, Application Criteria for Programmable Digital Computer Systems in Safety Systems of Nuclear Power Generating Stations.

4. Basis

Periodic surveillance testing of safety systems contributes to the realization of desired system operational availability and calls attention to performance that is not within prescribed limits by detection of equipment operational status. Prescribed limits are minimum performance requirements, such as response time, set point accuracy, and other specified performance requirements as stated in the design bases.

5. Design Requirements

The safety systems shall be designed to be testable during operation of the nuclear power generating station as well as 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, or (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.

The following further amplify these design requirements:

1) Design shall provide the capability for periodic surveillance testing that simulates, as closely as practicable, the required safety function performance. In general, abnormal environmental conditions such as seismic events, radiation fields, extreme pressures, temperatures, and moisture conditions 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 testings; therefore, the environments need not be simulated. Testing provision shall be designed to demonstrate the functional capability of the items under test during normal enviornmental conditions.
2) 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.
3) Safety systems should 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 fullfill this provision.
4) 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 place. When selecting actuation devices, their status indication capability shall be considered.
5) 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

[3]ANSI/ANS publications are available from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018.
[4]ANSI/IEEE publications can be obtained from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018, or from the Institute of Electrical and Electronics Engineers, Service Center, Piscataway, NJ 08854-4150.

system design shall provide overlap testing capability. For example, testing an instrument channel and logic circuits separate from their actuator devices is acceptable.

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:

a) 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, or
b) The operation of certain actuated equipment is prevented during a test of their actuation devices, such as when moving the circuit breaker for an emergency coolant pump motor to a test position that prevents power from being supplied to the pump motor during a test closure of its circuit breaker, or
c) 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.

Design configurations in accordance with preceding paragraphs (b) or (c) 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.

6) Interrelationship among the systems, components, and human factors in each phase of the test activity should 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.
7) A means of communication shall be provided between personnel associated with the test and the main control room 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 communciation shall be provided so that personnel associated with the test can adequately communicate.
8) Automatic testing features should be considered when selecting the type of testing system. However, where a programmable digital computer is included in the design, whether integrated or portable, automatic testing features are subject to the provisions of this standard and ANSI/IEEE/ANS 7-4.3.2-1982 [5].
9) Design considerations for testing the electrical power, instrumentation, and controls portion of the safety system shall be coordinated with the testing provisions of associated mechanical and fluid systems.
10) Provisions used for perturbing the same or a substitute process 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.
11) Means should be included in the design to facilitate response time testing from sensor input to, and including, the actuated equipment if required by 6.3.4.
12) Where practical, test devices, such as test blocks, should be incorporated into the design to eliminate the 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.
13) Where practical, means shall be included in the design to prevent the simultaneous application of any bypass condition to redundant channels or load groups during testing.
14) Where redundant components are used within a single channel or load group, the design should permit each component to be tested independently.
15) 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.
16) Indication should 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 should have automatic indication.

6. Testing Program Requirements

6.1 General Considerations

The periodic surveillance testing program for the safety system shall include, as applicable, functional tests (including channel functional tests), instrument channel checks, verification of proper 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 the following requirements:

1) 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.
2) 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 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 should include a complete test of the safety system.
3) 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.
4) Wherever possible, tests shall be accomplished under actual or simulated operating conditions, including sequence of operations, for example, diesel load sequencing.
5) Testing shall be conducted in accordance with approved written test procedures.
6) The test program shall be periodically reviewed to determine its overall effectiveness.
7) 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. Where possible, the root cause of failure should be determined.
8) 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.
9) The test program of each safety system shall be designed to provide for minimum interference with related operational channels, systems, or equipment.
10) The test program for each system shall be designed to produce data necessary for objective assessment of its performance and availability. The testing program should provide trend data, determine degradation, and provide an indication of incipient failures, where objectively assessable.
11) The administrative controls and quality assurance requirements shall conform to the requirements of ANSI/ANS 3.2-1982 [1], or the equivalent.
12) Functional tests may be supplemented by, but not replaced with, continuity checks.

6.2 Program Objectives

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

1) Facilitate administration and auditing.
2) Identify high failure rates.
3) Minimize interference with overall plant operation and any compromise of safety through proper coordination of the testing activities.
4) Ensure nonconcurrent testing of redundant protection channels and load groups.
5) Provide a master schedule that includes a complete basic testing cycle and status of testing.
6) Identify systems, channels, and load groups to be tested.

7) 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, abnormal environmental conditions such as seismic events, radiation fields, extreme pressures, temperatures, and moisture conditions are covered by design qualification tests provided unexpected degradation has not occurred. Testing of equipment for extreme environments is not within the scope of periodic surveillance testing, and therefore, need not be simulated.
8) Provide for alteration of the test interval in accordance with the criteria given in 6.5 of this standard.
9) Derive the periodic surveillance testing program from considerations such as:
   a) Systems failure modes and effects
   b) Component failure modes
   c) Applicable reliability and availability analysis
   d) Failure report analyses and other historical data
   e) Logic configuration
   f) Plant operating schedules
   g) Equipment qualification documentation, such as qualified life.

6.3 Types of Tests

6.3.1 Channel Checks

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

1) Comparing readings on channels that monitor the same variable recognizing any differences in the actual process variable between sensor loctions (for example, compare power channel 1 with redundant power channels 2 and 3).
2) Comparing readings between channels that monitor the same variable and bear a known relationship to one another (for example, comparing intermediate range and source range neutron monitoring channels during a startup or shutdown when both channels indicate on scale).
3) Comparing readings between channels that monitor different variables and bear a known relationship to one another (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 mode failures when selecting channels for comparison (for example, comparing level to an instrument sharing a common reference leg).

6.3.2 Functional Tests

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

1) A functional test for equipment (system components) shall consist, as appropriate, of one or more of the following:
   a) Manually starting equipment (for example, motor, pump, compressor, turbine, or engine) and observing proper operation (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 Section 5., paragraphs (5) and (15) are satisfied.
   b) Manually controlling electric operation of valves and timing their stroke, if appropriate. In cases where fully stroking the valve is not practical, a partial stroke test (for example, main steam stop valves, turbine stop, or control valves) or a valve control system test (for example, the control circuit for explosive poison injection valves) may be acceptable. Full stroke testing should be routinely accomplished during plant shutdown periods where practicable.

c) Injecting test signals of an appropriate magnitude to give an approximate indication (for example a numerical output "equivalent" to tripping the output) or tripping the output, or doing both. Alarm and trip functions, as applicable, shall be tested.

2) Testing to verify system or subsystems function shall include, as appropriate:
   a) Individually tripping actuating devices and observing proper load group operation (for example, trip bus under-voltage relays and observe bus transfer, load shedding, diesel generator start, and load sequencing).
   b) 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 (for example, manual reactor trip).
   c) Testing the status and operability of bypasses, bypass and test indications, and bypass and test annunciation circuits.
   d) 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.

6.3.3 Channel Calibration Verification Tests

A channel calibration verification test should prove that with a known precise input, the channel gives the required output, analog, or bistable. 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 (for example, the bistable trip did not occur at the required set point 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 ANSI/ANS 3.2-1982 [1], or the equivalent. Following maintenance or other appropriate disposition of the unacceptable results, a successful rerun of the channel calibration verification test shall be performed.

6.3.4 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 Report including Technical Specifications. The following shall be considered.

1) During a specific test period, it is not required to test discrete portions of safety systems that have been tested and whose response times have been verified to be within acceptable limits. On the other hand, the determination of the overall response time of a system may not adequately evaluate those components that have response times one or more orders of magnitude shorter than the system response time, even as they approach failure.
2) Sufficient overlap shall be provided to verify overall system response. Where it is not practicable to include sensors in individual or system response time tests, the sensors may be periodically removed from their normal installations and tested. When this is done, the test installation shall simulate the relevant environment and configuration of the actual installation.
3) 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 or other tests, or both. 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.
4) 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 set point sufficiently to reset the channel for the untripped condition and ensure complete tripping for the tripped condition.

5) For protective tripping functions where two or more variables enter into the tripping action (for example, the trip point is computed for temperature, pressure, and nuclear flux signals) the channel response time shall be verified using each of the variables 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 will produce conservative test results.
6) 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 the 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.

6.3.5 Logic System Functional Test

A logic system functional test shall test all logic components from sensor through to the actuated device. Logic components consist of relays, contacts, and solid-state logic elements of a logic circuit. The test may be performed by a series of sequential, overlapping, or total system tests so that an entire logic system is tested.

6.4 Test Methods

A specific test procedure meeting the requirements of this standard and utilizing the applicable methods set forth in this section shall be developed for each system.

1) The test, or a combination of tests, shall check each protection channel or load group in its entirety (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.
2) The indication of a successful test shall be:
   a) A positive and direct indication of a change of state, such as a solid-state or electromechanical device operation, with a corresponding signal transmission/conversion (for example, sounding an alarm, turning a light on or off, change of state of a contact, meter indication, starting of a motor, movement of a valve, or other actuator); and,
   b) Absence of any observed abnormal results in the redundant channels.
3) 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:
   a) By perturbing the monitored variable. This refers to variations introduced in the variable, such as changing the pressures, temperatures, or power levels.
   b) 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.
4) When complete checks, including those of the sensor, are not practicable, an analog or digital input for partial testing of a channel should be introduced and varied as appropriate. The test signal amplitude shall be varied to determine that the protective actions will ensue when the monitored variable reaches the set point value. This usually will be a "go/no-go" type of test.

   Acceptable tolerances from the nominal set point values for the onset of each channel protective action shall have been 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.

   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:

   a) 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.
   b) 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.
   c) 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 (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.
5) 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 that temporary connections are restored to normal after testing.

6.5 Test Intervals

6.5.1 Initial Test Intervals

Initial test intervals shall be determined from consideration of the following factors as appropriate:

1) For equipment and systems:
   a) Regulatory requirements
   b) Scheduled plant operating cycle
   c) Impact on plant safety
   d) Effective manpower utilization
   e) Impact on radiation exposure to plant personnel
   f) Degradation of equipment caused by testing.
2) For equipment:
   a) The manufacturer's specification or recommendation
   b) Historical experience with usage of similar equipment such as:
      1) Failure rate data, including information from reliability data banks
      2) Preoperational testing
      3) Quality information
   c) Equipment qualification reports and analysis
   d) Failure Data. Critical failure modes, their mechanisms of failure, and the respective failure and repair distributions will be a major consideration in determining the test intervals. These distributions are characterized by parameters such as: failure rate; mean time to failure (MTTF); mean time to repair (MTTR); failure probability and variability (which can be obtained from test results); historical data and engineering judgement.
3) Systems/subsystems test intervals shall also incorporate any design basis test intervals, that is, those associated with availability objectives.

6.5.2 Changes to Test Interval

The effect of the testing interval on performance of the involved equipment shall be reevaluated periodically to determine if the interval used is an effective factor in maintaining equipment in an operational status. The following shall be considered:

1) History of equipment performance, particularly experienced failure rates and potential significant increases in failure rates.
2) Corrective action associated with failures.
3) Performance of equipment in similar plants or environment, or both.
4) Plant design changes associated with equipment.
5) Detection of significant changes of failure rates.

Test intervals may be changed to agree with plant operational modes provided it can be shown that such changes do not adversely affect desired performance of the equipment being tested. Tests need not be performed on systems or equipment when they are not required to be operable or are tripped. If tests are not conducted on such systems, they shall be performed prior to returning the system to operation. If test intervals are to be changed, they shall conform to the requirements of 6.5.1.

6.6 Procedure Format and Documentation

Testing shall be performed to written approved test procedures. The test procedures shall be developed in accordance with Section 5.3 of ANSI/ANS 3.2-1982 [1], or the equivalent.

Annex A Informational Reference Documents (Informative)

(This Appendix is not part of ANSI/IEEE Std 338-1987, IEEE Standard Criteria for the Periodic Surveillance Testing of Nuclear Power Generating Station Safety Systems, but is included for information only.)

The purpose of this Appendix is to provide additional information, possible guidance, and reference material to the user of this standard. A thorough review of presently available documents, which in whole or in part may lend themselves to assist the user in satisfying the requirements of this standard, yielded the following listing. It is the opinion of the Working Group that this listing represented a useful, but not necessarily all-inclusive summary, and should be considered as such by the reader.

Documents	Title
IEEE Std 279-1971 (withdrawn)	IEEE Standard Criteria for Protection Systems for Nuclear Power Generating Stations (ANSI N42.7-1972).
IEEE Std 300-1980 (1982)	IEEE Test Procedure for Semiconductor Radiation Devices (ANSI N42.1-1969).
IEEE Std 317-1976 (1983)	IEEE Standard for Electrical Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations.
IEEE Std 323-1974 (1983)	IEEE Standard Qualifying Class lE Equipment for Nuclear Power Generating Stations.
IEEE Std 336-1977 (1985)	IEEE Standard Procedure for Installation, Inspection, and Testing Requirements for Instrumentation and Electric Equipment During the Construction of Nuclear Power Generating Stations.
IEEE Std 352-1975 (1987)	IEEE Guide for General Principles of Reliability Analysis of Nuclear Power Generating Station Protection Systems.
IEEE Std 379-1977 (1988)	IEEE Standard Application of the Single-Failure Criterion to Nuclear Power Generating Station Class lE Systems.
IEEE Std 380-1975 (withdrawn)	Definitions of Terms Used in IEEE Standards on Nuclear Power Generating Stations.
IEEE Std 387-1977 (1984)	IEEE Standard Criteria for Diesel-Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations.
IEEE Std 415-1976 (1986)	IEEE Guide for Planning of Pre-Operational Testing Programs for Class lE Power Systems for Nuclear Power Generating Stations.
IEEE Std 420-1982	IEEE Standard Design and Qualification of Class lE Control Boards, Panels, and Racks Used in Nuclear Power Generating Stations (ANSI N41.17).
IEEE Std 450-1975 (1987)	IEEE Recommended Practice for Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Generating Stations and Substations.
IEEE Std 494-1974	IEEE Standard Method for Identification of Documents Related to Class 1E Equipment and Systems for Nuclear Power Generating Stations.
IEEE Std 498-1980 (1985)	IEEE Supplementary Requirements for the Calibration and Control of Measuring and Test Equipment Used in the Construction and Maintenance of Nuclear Power. Generating Stations.
IEEE Std 500-1984	IEEE Guide to the Collection and Presentation of Electrical, Electronic, Sensing Component and Mechanical Equipment Reliability Data for Nuclear Power Generating Stations.

Documents	**Title**
IEEE Std 566-1977 (withdrawn)	IEEE Recommended Practice for the Design of Display and Control Facilities for Central Control Rooms of Nuclear Power Generating Stations.
IEEE Std 577-1976 (R1986)	IEEE Standard Requirements for Reliability Analysis in the Design and Operation of Safety Systems for Nuclear Power Generating Systems.
IEEE Std 650-1979	IEEE Standard for Qualifying Class lE Battery Chargers and Inverters for Nuclear Power Generating Stations.
EPRI NP-267	Sensor Response Time Verification.
EPRI NP-834	In Situ Response Time Testing of Platinum Resistance Thermometers.
EPRI NP-1486	Temperature Sensor Response Characterization.
NUREG-1024	November 1983, Technical Specifications—Enhancing the Safety Impact.
NUREG/CR-1369	Procedure Evaluation Checklist for Maintenance, Test and Calibration Procedures.
ISA Standard S67.04	Setpoints for Safety Related Instrumentation Used in Nuclear Power Plants.
ISA Standard S67.06	Response Time Testing of Nuclear-Safety-Related Instrument Channels in Nuclear Power Plants.

NOTE — (Year) indicates the status of the referenced document at the time of revision of this standard. Prior revisions are presented since users of this standard may still have commitments to their recommendations, guidelines, or requirements.