



U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

Branch Technical Position 7-11

Guidance on Application and Qualification of Isolation Devices

REVIEW RESPONSIBILITIES

Primary - Organization responsible for the review of instrumentation and controls

Secondary - None

A. BACKGROUND

This branch technical position (BTP) provides guidelines for reviewing the use of electrical isolation devices to allow connections between redundant portions of safety systems or between safety and non-safety systems. This BTP deals with the criteria and methods used to confirm that the design of isolation devices assures that credible failures in the connected non-safety or redundant channels will not prevent the safety systems from meeting their required functions.

Guidance for other aspects of isolation device qualification (e.g., electromagnetic compatibility, environmental and seismic qualification) may be found in Standard Review Plan (SRP) Appendix 7.1-B subsection 4.4, SRP Appendix 7.1-C subsection 5.4, and SRP Appendix 7.1-D subsection 5.4. The devices that provide isolation between safety and non-safety portions of power distribution systems are addressed in SRP Chapter 8.

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USNRC STANDARD REVIEW PLAN

This Standard Review Plan, NUREG-0800, has been prepared to establish criteria that the U.S. Nuclear Regulatory Commission staff responsible for the review of applications to construct and operate nuclear power plants intends to use in evaluating whether an applicant/licensee meets the NRC's regulations. The Standard Review Plan is not a substitute for the NRC's regulations, and compliance with it is not required. However, an applicant is required to identify differences between the design features, analytical techniques, and procedural measures proposed for its facility and the SRP acceptance criteria and evaluate how the proposed alternatives to the SRP acceptance criteria provide an acceptable method of complying with the NRC regulations.

The standard review plan sections are numbered in accordance with corresponding sections in Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants (LWR Edition)." Not all sections of Regulatory Guide 1.70 have a corresponding review plan section. The SRP sections applicable to a combined license application for a new light-water reactor (LWR) are based on Regulatory Guide 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)."

These documents are made available to the public as part of the NRC's policy to inform the nuclear industry and the general public of regulatory procedures and policies. Individual sections of NUREG-0800 will be revised periodically, as appropriate, to accommodate comments and to reflect new information and experience. Comments may be submitted electronically by email to NRR_SRP@nrc.gov.

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Communication independence between safety systems and non-safety systems is not discussed in this BTP. Refer to SRP Appendix 7.1-C subsection 5.6 and SRP Appendix 7.1-D subsection 5.6.

1. Regulatory Basis

10 CFR 50.55a(h), "Protection and Safety Systems," requires compliance with IEEE Std 603-1991, "IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations," and the correction sheet dated January 30, 1995. For nuclear power plants with construction permits issued before January 1, 1971, the applicant/licensee may elect to comply instead with the plant-specific licensing basis. For nuclear power plants with construction permits issued between January 1, 1971, and May 13, 1999, the applicant/licensee may elect to comply instead with the requirements stated in IEEE Std 279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations." IEEE Std 603-1991, Clause 5.6, "Independence," states in part, "No credible failure on the non-safety side of an isolation device shall prevent any portion of a safety system from meeting its minimum performance requirements during and following any design basis event requiring that safety function." IEEE Std 279-1971, Clause 4.7.2, "Isolation Devices," states in part, "No credible failure at the output of an isolation device shall prevent the associated protection system channel from meeting the minimum performance requirements specified in the design basis."

10 CFR Part 50 Appendix A, General Design Criterion (GDC) 1, "Quality Standards and Records," requires in part that "structures, systems, and components important to safety shall be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed." GDC 1 also requires that "where generally recognized codes and standards are used, they shall be identified and evaluated to determine their applicability, adequacy, and sufficiency and shall be supplemented or modified as necessary to assure a quality product in keeping with the required safety function."

GDC 21, "Protection System Reliability and Testability," requires in part that "redundancy and independence designed into the protection system shall be sufficient to assure that no single failure results in a loss of the protection function."

GDC 22, "Protection System Independence," requires that "the effects of natural phenomena, and of normal operating, maintenance, testing, and postulated accident conditions on redundant channels do not result in loss of the protection function."

10 CFR Part 50, Appendix B, Criterion III, "Design Control," requires in part that "where a test program is used to verify the adequacy of a specific feature in lieu of other verifying or checking processes, it shall include suitable qualification testing of a prototype unit under the most adverse design conditions."

2. Relevant Guidance

If a referenced industry code or standard has been separately incorporated into NRC's regulations, licensees and applicants must comply with that code or standard as set forth in the regulations. If the referenced code or standard has been endorsed by NRC staff in a regulatory guide, that code or standard constitutes an acceptable method of meeting the related regulatory requirement as described in the regulatory guide. By contrast, if a referenced code or standard

has neither been incorporated into the NRC's regulations nor endorsed by a regulatory guide, licensees and applicants may consider and use the information in the referenced code or standard, if appropriately justified, consistent with current regulatory practice.

Regulatory Guide 1.75, "Criteria for Independence of Electrical Safety Systems," endorses IEEE Std 384-1992, "IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits," which identifies specific electrical isolation criteria for isolation devices used in instrumentation and control circuits. These isolation criteria form part of the basis for this BTP.

Additional guidance on applying the safety system criteria of IEEE Std 603-1991 to computer-based safety systems is provided by IEEE Std 7-4.3.2-2003, "IEEE Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations," as endorsed by Regulatory Guide 1.152, Revision 2, "Criteria for Digital Computers in Safety Systems of Nuclear Power Plants." SRP Appendix 7.1-D provides additional guidance.

IEEE Std C37.90.1-2002, "IEEE Standard for Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems Associated with Electric Power Apparatus," specifies design tests for relays and relay systems that relate to their immunity to electrical transients induced by fault conditions.

IEEE Std C62.41.1-2002, "IEEE Guide on the Surge Environment in Low-Voltage (1000 V and Less) AC Power Circuits," describes the temporary overvoltages induced by fault conditions in low-voltage AC power circuits.

IEEE Std C62.41.2-2002, "IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits," characterizes the overvoltage environment at locations on AC power circuits described in IEEE Std C62.41.1-2002 by means of standardized waveforms and other stress parameters.

IEEE Std C62.45-2002, "IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits," provides acceptable guidance for overvoltage testing of equipment connected to low-voltage AC power circuits.

IEEE Std C62.23-1995 (R2001), "IEEE Application Guide for Surge Protection of Electric Generating Plants," describes electric utility industry practices, accepted theories, existing standards/guides, definitions, and technical references as they pertain specifically to surge protection of electric power generating plants.

IEEE Std C62.36-2000, "IEEE Standard Test Methods for Surge Protectors Used in Low Voltage Data, Communications, and Signaling Circuits," provides guidance for test methods for surge protectors used in low voltage data, communications, and signaling circuits. This guidance is acceptable when credit is taken for surge protection in these types of circuits.

ANSI Std C84.1-1989, "American National Standard for Electric Power Systems and Equipment — Voltage Ratings (60 Hz)." discusses nominal voltages and guidelines for steady-state tolerances.

Regulatory Guide 1.204, "Guidelines for Lightning Protection of Nuclear Power Plants," provides guidance for design and installation of lightning protection systems to ensure that electrical transients resulting from lightning phenomena do not render safety-related systems inoperable or cause spurious operation of such systems.

3. Purpose

The purpose of this BTP is to provide guidance to address the application and qualification of isolation devices through the application of maximum credible fault¹ (MCF) voltages and currents. This BTP has three objectives:

- Confirm that the design and implementation of isolation devices conforms to the guidance of Regulatory Guide 1.75.
- Confirm that the qualification basis for isolation devices is consistent with accepted industry standards and use in the plant.
- Confirm that qualification testing demonstrates that the isolation devices meet the acceptance criteria of IEEE Std 603-1991 or IEEE Std 279-1971.

B. BRANCH TECHNICAL POSITION

1. Introduction

This BTP addresses the electrical qualification and application of isolation devices. Other qualification requirements (such as those that pertain to environmental conditions, EMI/RFI, and seismic events) are addressed in SRP Section 7.1.

The following types of isolation devices are examples of devices that have been found to be acceptable, provided the guidelines of this BTP are satisfied:

- Isolation amplifiers.
- Isolation transformers.
- Fiber optic couplers.
- Fiber optic cable.²
- Photo-optic couplers.
- Relays (coil to contact isolation).

Qualification of isolation devices should be based on a combination of design analysis and qualification testing. The analysis should demonstrate the adequacy of the design, considering the range of possible fault conditions and variability between individual units. The qualification testing should validate the results of the analysis at the extremes of fault conditions.

¹IEEE Std 384-1992 defines a maximum credible voltage or current transient as voltage or current transient that may exist in circuits, as determined by test or analysis, taking into consideration the circuit location, routing, and interconnections combined with failures that the circuit may credibly experience.

² While fiber optic cables are not specifically isolation devices, they do provide an inherent electrical isolation capability. Since the fiber does not provide a conductive path and the separation distance associated with the cable run mitigates the potential for arcing, the isolation provided by fiber optic cable should be credited.

2. Information to be Reviewed

Information to be reviewed includes the applicant/licensee's description of the (1) device application, (2) device design, (3) test method, and (4) test results.

3. Acceptance Criteria

General acceptance guidelines for application and qualification are provided in IEEE Std 603-1991, or IEEE Std 279-1971, and Regulatory Guide 1.75. Acceptance criteria for the descriptions of the device application, device design, test methods, and test results are as follows:

Description of Device Application

Isolation devices should be classified as part of the safety system and powered in accordance with criteria of IEEE Std 603-1991 or IEEE Std 279-1971 and the guidelines of Regulatory Guide 1.75. If non-safety power sources interface to the isolation device, the applicant/licensee should verify that the non-safety power is not required for the device to perform its isolation function.

MCF requirements should be established by analysis of proximate circuits that are credible sources of the fault, either through inadvertent application from human error or through a fault or failure postulated to occur that involves proximate circuits, cabling, or terminations (e.g., a "hot short" from an adjacent conductor). The determination of specific MCF characteristics is plant-specific.

Surge waveforms and characteristics should be defined for the worst-case conditions expected at the installation.

The acceptable leakage current into the safety system should be identified for specified MCFs.

Description of Device Design

The design of isolation devices should conform to IEEE Std 603-1991, or IEEE Std 279-1971, and Regulatory Guide 1.75 guidelines for (1) independence of redundant safety divisions, and (2) independence between protection (safety) and control (non-safety) systems.

The isolation device should include design features for which credit is taken (e.g., surge protectors or barriers) and identification of the application limits of the device.

The device should be designed for postulated electrical faults or failures, including open circuits, short circuits, ground, and application of an MCF. The specified MCF should equal or exceed the application requirements. Regulatory Guide 1.75 suggests that the MCF include the levels and duration of the fault current on the non-safety side of the device. ANSI Std C84.1-1989, Table 1, "Standard Nominal System Voltages and Voltage Ranges," provides an acceptable basis for identifying nominal voltages and guidelines for steady-state tolerances.

The device design should accommodate the fault voltage and current waveforms and characteristics defined for the application. Appropriate industry standards should be used as a basis for establishing the fault-transient exposure level (e.g., IEEE Std C62.41.1-2002, IEEE Std C62.41.2-2002).

The physical arrangement of components in the isolation device should be configured to prevent, in the event of failure, the effects of shattered parts or material (e.g., solder spatter), fire, and smoke from breaching the isolation barrier.

Description of Test Method

A description of the specific testing performed for each type of isolation device should be provided. This should include elementary or schematic diagrams as necessary to describe the test configuration and how the MCF and surges will be applied to the devices during the test.

The basis for the set of postulated electrical faults and failures should be included in the test program.

A specific definition of pass/fail acceptance criteria for each type of device should be provided. This should include justification that the pass/fail acceptance criterion is sufficient to demonstrate that the tested device meets the requirements of IEEE Std 603-1991, Clause 5.6, or IEEE Std 279-1971, Clause 4.7.2.

Regulatory Guide 1.75 recommends that:

- The maximum credible voltage or current transient applied to the device output should not degrade below an acceptable level the operation of the circuit connected to the device input.
- Shorts, grounds, or open circuits occurring in the output will not degrade below an acceptable level the circuit connected to the device input.
- Transient voltages that may appear in the output circuit (e.g., surges) must also be considered.
- The qualification should consider the levels and duration of the fault current on the non-safety side of the device.

For safety/non-safety isolation, during and following the application of the MCF or surge test, there should be no degradation or distortion of the isolation device input that would have a detrimental effect on the performance of the safety system. For isolation of redundant safety circuits, there should be no degradation or distortion of the redundant channel that would have a detrimental effect on the performance of the safety system.

Applicable industry standards should be used as the basis for performing the qualification testing (e.g., IEEE Std C62.45-2002).

Devices might be used either for isolation of safety circuits from non-safety circuits or for isolation of redundant safety divisions. For qualification testing, the detailed device configuration depends on the objective of the isolation and the specific type and configuration of the isolation device (e.g., relay, isolation amplifier, optical-electronic device).

The MCF represents the application of the maximum credible alternating current (AC) and direct current (DC) voltages and currents that are applied to the device in common and differential modes (as defined by IEEE Std 100-2000, "The Authoritative Dictionary of IEEE Standards Terms 7th Edition") that exist based on the installation of the device. Common mode

refers to faults between both signal terminals and a common reference plane (ground) and causes the potential of both sides of the transmission path to be changed simultaneously and by the same amount relative to the common reference plane (ground). Differential mode refers to faults between the signal terminals that cause the potential of one side of the signal transmission path to be changed relative to the other side. The mode of application should satisfy the following guidelines for test configurations.

For isolation of safety circuits from non-safety circuits:

- MCFs and surges should be applied between the signal output terminals of the (non-safety) circuits (differential mode) and between any output terminal and ground (common mode).
- Surges should be applied to power terminals. The guidance of IEEE Std C62.45-2002 is acceptable for surge testing at the power input.
- The signal input terminals should be monitored to assure that no unacceptable interactions (degradations or distortions) between the safety and non-safety circuits would occur.

For isolation between redundant safety circuits:

- MCFs should be applied between the signal input terminals (differential mode) and between any input terminal and ground (common mode); the output should be monitored to assure that no unacceptable interactions (degradations or distortions) between redundant safety circuits will occur.
- Surges should be applied to power terminals. The guidance of IEEE Std C62.45-2002 is acceptable for surge testing at the power input.
- MCFs should also be applied to the output terminals in the differential mode and between any output terminal and ground (common mode); the input should be monitored to assure that no unacceptable interactions (degradations or distortions) between redundant safety circuits will occur.

MCFs should be applied to the isolation device for a sufficient duration to allow any measurable effects to occur on the isolation device and to allow monitored values or effects to reach steady-state.

Description of Test Results

Test data and results should verify that the design basis faults, including short circuits, open circuits, grounds, MCF, and surge were applied to the device in all of the applicable connection modes (i.e., applicable input, output, power, and ground connection modes).

Test data and results should verify that the test acceptance criteria are met.

4. Review Procedures

Confirm that the device design conforms to the guidance of Regulatory Guide 1.75.

Confirm that the applicant/licensee has established an acceptable test method and that the specified testing addresses the conditions of the intended applications.

Confirm that the applicant/licensee's testing properly applied the MCF and surges to devices under test.

Confirm that the acceptance criteria of IEEE Std 603-1991, or IEEE Std 279-1991, and Regulatory Guide 1.75 were met during the tests.

C. REFERENCES

1. ANSI Std C84.1-1989, "American National Standard for Electric Power Systems and Equipment — Voltage Ratings (60 Hz)."
2. IEEE Std C37.90.1-2002, "IEEE Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus."
3. IEEE Std C62.23-1995 (R 2001), "IEEE Application Guide for Surge Protection of Electric Generating Plants."
4. IEEE Std C62.36-2000, "IEEE Standard Test Methods for Surge Protectors Used in Low-Voltage Data, Communications, and Signaling Circuits."
5. IEEE Std C62.41.1-2002, "IEEE Guide on the Surge Environment in Low-Voltage (1000 V and Less) AC Power Circuits."
6. IEEE Std C62.41.2-2002, "IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits."
7. IEEE Std C62.45-2002, "IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits."
8. IEEE Std 100-2000, "The Authoritative Dictionary of IEEE Standards Terms 7th Edition."
9. IEEE Std 279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations."
10. IEEE Std 384-1992, "IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits."
11. IEEE Std 603-1991, "IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations."
12. IEEE Std 7-4.3.2-2003, "IEEE Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations."

13. Regulatory Guide 1.75, "Criteria for Independence of Electrical Safety Systems." Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, 2005.
14. Regulatory Guide 1.152, "Criteria for Digital Computers in Safety Systems of Nuclear Power Plants." Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, 2006.
15. Regulatory Guide 1.204, "Guidelines for Lightning Protection of Nuclear Power Plants," Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, 2005.

PAPERWORK REDUCTION ACT STATEMENT

The information collections contained in the Standard Review Plan are covered by the requirements of 10 CFR Part 50 and 10 CFR Part 52, and were approved by the Office of Management and Budget, approval number 3150-0011 and 3150-0151.

PUBLIC PROTECTION NOTIFICATION

The NRC may not conduct or sponsor, and a person is not required to respond to, a request for information or an information collection requirement unless the requesting document displays a currently valid OMB control number.

SRP BTP 7-11
Description of Changes

This SRP section updates the guidance previously provided in Revision 4, dated June 1997, of this SRP. See ADAMS accession number ML05250544.

In addition, this SRP section was administratively updated in accordance with NRR Office Instruction, LIC-200, Revision 1, "Standard Review Plan (SRP) Process." The revision also adds standard paragraphs to extend application of the updated SRP section to prospective submittals by applicants pursuant to 10 CFR Part 52.

The technical changes are incorporated in Revision 5, dated [Month] 2007:

Review Responsibilities — Reflects changes in review branches resulting from reorganization and branch consolidation. Change is reflected throughout the SRP.

A. BACKGROUND

1. Added discussion to clarify that the scope of this BTP is only the qualification of the electrical isolation function, and that guidance on other aspects of qualification (environmental, seismic, electromagnetic interference) is located elsewhere.
2. Updated regulatory requirements discussion to reflect the 1999 revision of 10 CFR 50.55a(h), "Protection and Safety Systems."
3. Added discussion of isolation requirements contained in 10 CFR 50 Appendix A GDC 21 and 22 requirements.
4. Deleted reference to Regulatory Guide 1.153.
5. Updated discussion of ANSI Std C62.41 standards to reflect current state of industry guidance.
6. Identified additional guidance found in IEEE Std. C62.23-1995 and ANSI Std C84.1-1989.
7. Updated discussion of standards to reference the most current version, or in the case of standards endorsed by Regulatory Guide, the endorsed version.
8. Added references to Regulatory Guide 1.152, IEEE Std 7-4.3.2-2003, and new SRP Appendix 7.1-D.
9. Added reference to Regulatory Guide 1.204.

B. BRANCH TECHNICAL POSITION

1. Added IEEE Std 603-1991 criteria.
2. Replaced term "transverse mode" with the IEEE defined term "differential mode."

3. Expanded explanation of the meaning of common and differential modes.
4. Added reference to IEEE Std 603-1991 and IEEE Std 279-1971 to discussion of review procedures.

C. REFERENCES

1. Updated to cite current versions of regulatory guides and endorsed or referenced standards.
2. Deleted reference to ANSI Std C37.90a / IEEE Std 472-1974.
3. Added reference to IEEE Std C62.23-1995.
4. Added reference to IEEE Std 7-4.3.2-2003.
5. Added reference to Regulatory Guide 1.152.
6. Deleted reference to Regulatory Guide 1.153.
7. Added reference to Regulatory Guide 1.204.