Branch Technical Position HICB-11

Guidance on Application and Qualification of Isolation Devices

A. Background

This branch technical position (BTP) provides guidelines for reviewing the use of isolation devices in instrumentation and control systems. These acceptance guidelines are based on experience in the review of applicant/licensee submittals for electrical qualification and application of isolation devices in safety systems. The devices that provide isolation between safety and non-safety portions of power distribution systems are addressed in SRP Chapter 8.

1. Regulatory Basis

10 CFR 50.55a(h) requires in part that protection systems satisfy the criteria of ANSI/IEEE Std 279, "Criteria for Protection Systems for Nuclear Power Generating Stations," paragraph 4.7.2, "Isolation Devices." These criteria state that "the transmission of signals from protection system equipment for control system use shall be through isolation devices which shall be classified as part of the protection system...," and that "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 bases."

10 CFR 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 modified as necessary to assure a quality product in keeping with the required safety function."

10 CFR 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

Reg. Guide 1.75, "Physical Independence of Electrical Systems," endorses IEEE Std 384, "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.

Reg. Guide 1.153, "Criteria for Power, Instrumentation, and Control Portions of Safety Systems," endorses IEEE Std 603, "IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations." Section 5.6.3.2 of IEEE Std 603 provides guidance on the requirements for isolation devices.

The following industry standards should be considered, as appropriate to the technology, application, and configuration of the isolation device being qualified:

ANSI Std C37.90.a/IEEE Std 472, "IEEE Guide for Surge Withstand Capability (SWC) Tests," identifies acceptable guidance for testing the surge withstand capability of static relays used as isolation devices, provided that the electrical environment at the device installation is shown to be adequately bounded by the waveform characteristics. This standard has been redesignated as ANSI Std C37.90.1, "IEEE Standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems," and its scope is currently intended for electrical protective relaying applications.

ANSI Std C62.41, "IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits," (Formerly IEEE Std 587) provides acceptable guidance for describing and characterizing the surge environment in low-voltage AC power circuits for low, medium, and high exposure levels.

ANSI Std C62.45, "IEEE Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits," provides acceptable guidance for surge testing of equipment connected to low-voltage AC power circuits.

ANSI Std C62.36, "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 where credit is taken for surge protection in these types of circuits.

The standards above address electrical surges to the device. EMI/RFI considerations are addressed in SRP Section 7.1.

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 fault and surge withstand capability. This BTP has three objectives:

- Confirm that the design of isolation devices conform to the guidance of Reg. Guides 1.75 and 1.153.
- 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 ANSI/IEEE Std 279 and the guidance of Reg. Guide 1.153.

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 Section 7.1.

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

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

Qualification of isolation devices should be based upon 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.

2. Information to be Reviewed

The 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 ANSI/IEEE Std 279 and Reg. Guides 1.75 and 1.153. 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 the guidelines of Reg. Guides 1.75 and 1.153. 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.

Maximum credible fault (MCF)[1] requirements should be established by analysis of proximate circuits that are credible sources of the fault, either through inadvertent application through human error or through a fault or failure postulated to occur that involves proximate circuits, cabling, or terminations (for example, a "hot short" from an adjacent conductor). The determination of specific MCF characteristics is plant-specific.

[1]IEEE Std 384 defines a maximum credible voltage or current transient as that 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 circuits may credibly experience.

The 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 MCF.

Description of Device Design

The design of isolation devices should conform to ANSI/IEEE Std 279 and Reg. Guides 1.75 and 1.153 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. Reg. Guides 1.75 and 1.153 suggest that the MCF include the levels and duration of the fault current on the non-safety side of the device. ANSI Std C84.1, "American National Standard for Electric Power Systems and Equipment — Voltage Ratings (60 Hz)," 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 surge waveforms and characteristics defined for the application. Appropriate industry standards should be used as a basis for establishing the surge exposure level (for example, ANSI Std C62.41).

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 (for example, solder spatter), fire, and smoke on 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 to describe 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 ANSI/IEEE Std 279 Section 4.7.2.

Reg. 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 (for example, 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 (for example, ANSI Std C62.45).

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 will depend upon 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 AC and DC voltages and currents that are applied to the device in common and transverse modes (as defined by IEEE Std 100, "The New IEEE Standard Dictionary of Electrical and Electronic Terms") as installed. 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 to the output (non-safety) in the transverse mode and between any output terminal and ground (common mode).

- Surges should be applied to power terminals. The guidance of ANSI Std C62.45 is acceptable for surge testing at the power input.

- The 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 to the input in the transverse 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 ANSI Std C62.45 is acceptable for surge testing at the power input.

- MCFs should also be applied to the output terminals in the transverse 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 Reg. Guides 1.75 and 1.153.

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 ANSI/IEEE Std 279 and Reg. Guides 1.75 and 1.153 were met during the tests.

C. References

ANSI Std C37.90.1-1989 (R 1991). "IEEE Standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems."

ANSI Std C37.90a-1974/IEEE Std 472-1974. "IEEE Guide for Surge Withstand Capability (SWC) Tests."

ANSI Std C62.45-1987. "IEEE Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits."

ANSI Std C84.1-1989. "American National Standard for Electric Power Systems and Equipment-Voltage Ratings (60 Hz)."

ANSI/IEEE Std 279-1971. "Criteria for Protection Systems for Nuclear Power Generating Stations."

ANSI/IEEE Std C62.36-1991. "IEEE Standard Test Methods for Surge Protectors Used in Low-Voltage Data, Communications, and Signaling Circuits."

ANSI/IEEE Std C62.41-1991. "IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits."

IEEE Std 100-1992. "The New IEEE Standard Dictionary of Electrical and Electronic Terms."

IEEE Std 384-1992. "IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits."

IEEE Std 603-1991. "IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations."

Regulatory Guide 1.153. "Criteria for Power, Instrumentation, and Control Portions of Safety Systems." Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, 1996.

Regulatory Guide 1.75. "Physical Independence of Electrical Systems." Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, 1978.