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OFFICE OF NUCLEAR REGULATORY RESEARCH

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CRITERIA FOR INDEPENDENCE OF ELECTRICAL SAFETY SYSTEMS

A. INTRODUCTION

Section 50.55a, "Codes and Standards," of 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," requires in 10 CFR 50.55a(h) that protection systems for plants with construction permits issued after January 1, 1971, but before May 13, 1999, must meet the requirements stated in either IEEE Std. 279, "Criteria for Protection Systems for Nuclear Power Generating Stations,"[1] or IEEE Std. 603-1991, "Criteria for Safety Systems for Nuclear Power Generating Stations."[1] For nuclear power plants with construction permits issued before January 1, 1971, protection systems must be consistent with their licensing basis or may meet the requirements of IEEE Std. 603-1991. The safety systems for plants with construction permits issued after May 13, 1999, must meet the requirements of IEEE Std. 603-1991.

Section 4.6 of IEEE Std. 279-1971 requires, in part, that channels that provide signals for the same protective function must be independent and physically separated. Section 5.6.1 of IEEE Std. 603-1991 states, "Redundant portions of a safety system provided for a safety function shall be independent of, and physically separated from, each other to the degree necessary to retain the capability of accomplishing the safety function during and following any design basis event requiring that safety function." General Design Criterion (GDC) 17, "Electric Power Systems," in Appendix A to 10 CFR Part 50 requires, in part, that electric power

[1] Standards promulgated by the Institute of Electrical and Electronics Engineers (IEEE) may be purchased from the IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854 (800-678-4333).

from the transmission network to the onsite electric distribution system shall be supplied by two physically independent circuits that are designed and located so as to minimize to the extent practical the likelihood of their simultaneous failure under operating and postulated accident and environmental conditions. 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.

This regulatory guide describes a method acceptable to the NRC staff for complying with the NRC's regulations with respect to the physical independence requirements of the circuits and electric equipment that comprise or are associated with safety systems.

This regulatory guide contains information collections that are covered by the requirements of 10 CFR Part 50, which the Office of Management and Budget (OMB) approved under OMB control number 3150-0011. The NRC may neither conduct nor sponsor, and a person is not required to respond to, an information collection request or requirement unless the requesting document displays a currently valid OMB control number.

B. DISCUSSION

IEEE Std. 384-1992, "Standard Criteria for Independence of Class 1E Equipment and Circuits,"[2] was prepared by Working Group SC 6.5 of IEEE Nuclear Power Engineering Committee and was approved by the Standards Board on June 18, 1992. This standard provides criteria and requirements for establishing and maintaining the independence of safety-related equipment and circuits, and auxiliary supporting features by physical separation and electrical isolation. Based on the results of separation testing completed by the nuclear industry on internally generated electrical faults, the following significant changes were incorporated in IEEE Std. 384-1992: (1) separation distance criteria were reduced for certain configurations identified in IEEE Std. 384-1981, and (2) separation distance criteria were added for configurations that were not previously addressed. These configurations include cable trays and conduits, cable trays and cable in free air, and conduits and cable in free air. The underlying separation criteria are that (1) physical separation and (2) electrical isolation must be provided to maintain the independence of safety-related circuits and equipment so that the safety functions required during and following any design-basis event can be accomplished .

Section 5.6(3) of IEEE Std. 384-1992 provides general criteria for independence between safety-related and non-safety-related circuits. When minimum separation cannot be met, it allows an analysis of non-safety-related circuits to demonstrate that the safety-related circuits are not degraded below an acceptable level. If the analysis is successful, the non-safety-related circuits can remain as non-safety-related circuits. However, Section 5.5.2(3) contradicts Section 5.6(3) by stating that the analyzed circuits are still called "associated circuits" following an analysis or test demonstrating that the safety-related cables are not degraded below an acceptable level. The staff position is that (1) non-safety-related circuits that are not separated from safety-related circuits through the minimum separation or barriers, must be treated as "associated circuits," and (2) the cables that are associated because they are powered from a safety-related source serving non-safety-related loads or share the safety signal must also be treated as associated circuits. Both of these groups of associated circuits should not ever become associated with a redundant division through its proximity or shared signal to preserve the independence.

The term "associated circuits" has a different connotation in this regulatory guide than it does for fire protection (Appendix R to 10 CFR Part 50). This regulatory guide defines "associated circuits" as "non-safety-related circuits that are not physically separated or not electrically isolated from safety-related circuits by acceptable separation distance, safety class structures, barriers, or isolation devices." The "associated circuits" in Appendix R include both safety-related and non-safety-related circuits because they involve alternative and redundant safe shutdown equipment. Post-fire safe-shutdown capability is distinctly different from, and credits operability of different equipment than the safety-related equipment required for emergency shutdown of a nuclear power plant. Regulatory Guide 1.189, "Fire Protection for Operating Nuclear Power Plants," provides additional guidance concerning the fire protection area.

IEEE Std. 384-1992 includes an informative appendix that provides background information about the cable testing program that various public utilities conducted to support the criteria for reduced separation distance. In particular, the appendix states — and the NRC staff agrees — that the use of cable wrapping is an acceptable method to reduce separation distances, but each wrapping system should be analyzed or tested on a case-by-case basis. This method will be subject to approval by the NRC staff.

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[2] Standards promulgated by the IEEE may be purchased from the IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854.

C. REGULATORY POSITION

Conformance with the requirements of IEEE Std. 384-1992, "Standard Criteria for Independence of Class 1E Equipment and Circuits," provides a method that the NRC staff considers acceptable for satisfying the agency's regulatory requirements concerning physical independence of the circuits and electrical equipment that comprise or are associated with safety systems, subject to the following:

(1) Sections 7.1.2.1, 7.1.2.4, and 7.2.2.3 of IEEE Std. 384-1992 should be supplemented as follows:

The breaker or fuse that is automatically opened by fault current may be used as an isolation device, provided that (a) the fault current under bolted and arcing fault conditions (assuming multiple faults of all non-safety-related loads and load current of all safety-related circuits) will cause the nearest circuit breaker or fuse to interrupt the fault current prior to initiation of a trip of any upstream protection device, and (b) periodic testing of circuit breakers (visual inspection of fuses and fuse holders) during every refueling must demonstrate that the overall coordination scheme under multiple faults of non-safety-related loads remains within the limits specified in the design criteria for the nuclear power plant.

(2) The summary results of the analysis performed to meet the requirements of IEEE Std. 384-1992, for example, to comply with Sections 5.5.2, 5.6, 6.1, etc., should be included in the final safety analysis report for the nuclear power plant.

(3) Section 6.1.1.2 of IEEE Std. 384-1992 should be supplemented as follows:

Cable splices in raceways should generally be avoided to the extent that it is practical to do so.

(4) Section 5.6(3) of IEEE Std. 384-1992 should not be construed as allowing less than minimum separation of non-safety-related circuits from safety-related circuits to be justified by analyses without treatment of the affected non-safety-related circuits as associated circuits.

(5) Section 3 of IEEE Std. 384-1992 references several industry codes and standards. If a referenced standard has been separately incorporated into the NRC's regulations, licensees and applicants must comply with the standard as set forth in the regulation. If a referenced standard has been endorsed by the NRC staff in a regulatory guide, the standard constitutes an acceptable method of meeting a regulatory requirement as described in the regulatory guide. If a referenced standard has been neither incorporated into the NRC's regulations nor endorsed in a regulatory guide, licensees and applicants may consider and use the information in the referenced standard, if appropriately justified, consistent with regulatory practice.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC staff's plans for using this guide. No backfitting is intended or approved in connection with the issuance of this guide.

Except in cases in which an applicant or licensee proposes or has previously established an acceptable alternative method for complying with specified portions of the NRC's regulations, the methods described in this guide will be used in the evaluation of (1) submittals in connection with applications for construction permits, design certifications, operating licenses, and combined licenses for application of independence criteria to safety systems, and (2) submittals from operating reactor licensees who voluntarily propose to initiate system modifications if there is a clear nexus between the proposed modifications and this guidance with respect to the requirements for physical independence of the circuits and electrical equipment that comprise or are associated with safety systems.

REGULATORY ANALYSIS

A separate regulatory analysis was not prepared for this regulatory guide. The regulatory analysis prepared for Draft Regulatory Guide DG-1129, "Criteria for Independence of Electrical Safety Systems," dated December 2003, also provides the regulatory basis for this regulatory guide. The NRC issued DG-1129 to solicit public comment concerning the draft of this third revision of Regulatory Guide 1.75.

A copy of the regulatory analysis for DG-1129 is available for inspection and copying for a fee at the NRC's Public Document Room (PDR), which is located at 11555 Rockville Pike, Rockville, Maryland; the PDR's mailing address is USNRC PDR, Washington, DC 20555-0001. The PDR can also be reached by telephone at (301) 415-4737 or (800) 397-4205, by fax at (301) 415-3548, and by email to PDR@nrc.gov. Copies are also available at current rates from the U.S. Government Printing Office at P.O. Box 37082, Washington, DC 20402-9328 or by telephone at (202) 512-1800. In addition, copies are available at current rates from the National Technical Information Service at 5285 Port Royal Road, Springfield, VA 22161, on the Internet at http://www.ntis.gov, or by telephone at (703) 487-4650. In addition, the regulatory analysis is available electronically as a part of Draft Regulatory Guide DG-1129 through the NRC's Agencywide Documents Access and Management System (ADAMS) at http://www.nrc.gov/reading-rm/adams.html, under Accession No. ML040020126. Note, however, that the NRC has temporarily suspended public access to ADAMS so that the agency can complete security reviews of publicly available documents and remove potentially sensitive information. Please check the NRC's Web site for updates concerning the resumption of public access to ADAMS.