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GUIDELINES FOR ENVIRONMENTAL QUALIFICATION OF SAFETY-RELATED COMPUTER-BASED INSTRUMENTATION AND CONTROL SYSTEMS IN NUCLEAR POWER PLANTS

A. INTRODUCTION

Title 10, Part 50, of the *Code of Federal Regulations* (10 CFR Part 50), "Domestic Licensing of Production and Utilization Facilities" (Ref. 1), delineates the design- and qualification-related regulations that the U.S. Nuclear Regulatory Commission (NRC) has established for commercial nuclear power plants. In particular, General Design Criterion 4 in Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50 requires that structures, systems, and components (SSCs) important to safety shall be designed to accommodate the effects of, and to be compatible with, the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including loss-of-coolant accidents (i.e., the equipment shall remain functional under postulated accident conditions). The following sections of 10 CFR Part 50 specify general requirements:

- 10 CFR 50.55a, "Codes and Standards"
- Appendix A, General Design Criteria 1, 2, 4, 13, 21, 22, and 23
- Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," specifically Criterion III, "Design Control," Criterion XI, "Test Control," and Criterion XVII, "Quality Assurance Records"

According to 10 CFR 50.55a(h)(2), protection systems shall meet the requirements set forth in the Institute of Electrical and Electronics Engineers (IEEE) Standard (Std.) 603-1991, "Criteria for Safety Systems for Nuclear Power Generating Stations" (Ref. 2), and the correction sheet dated January 30, 1995, or IEEE Std. 279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations" (Ref. 3), contingent on the date that the NRC issued the related construction permit. The design-basis criteria identified by those standards or by similar provisions in the licensing basis for such facilities include the range of transient and steady-state environmental conditions throughout which the equipment shall perform during normal, abnormal, and accident operational events.

As reported in NUREG/CR-5904, "Functional Issues and Environmental Qualification of Digital Protection Systems of Advanced Light-Water Reactors," issued April 1994 (Ref. 4), safety-related microprocessor-based electric equipment can pose unique functional and qualification issues. Traditional testing and evaluation approaches developed primarily for analog equipment may not fully address these digital issues. The primary focus of IEEE Std. 323, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations" (Refs. 5, 6, and 7), is the reliable operation of safety-related equipment under normal, abnormal, design-basis accident, post-design-basis accident, and containment test conditions. At present, computer-based instrumentation and control (I&C) systems are primarily implemented in nuclear power plant locations that are characterized as mild environments that are not affected by design-basis accident conditions. Thus, the design-basis accident element of type testing for qualification does not apply to computer-based I&C systems in mild environments. In addition, because of ready accessibility for monitoring and maintenance in mild environments, the need to establish a qualified life does not apply. Nonetheless, the qualification criterion of 10 CFR 50.55a(h)(2) will be addressed for safety-related computer-based I&C systems.

This regulatory guide describes a method that the NRC staff considers acceptable for determining the environmental qualification procedures for safety-related computer-based I&C systems for service within nuclear power plants. In so doing, this guide endorses certain practices in the current national standard, and it incorporates guidance to address specific issues posed by the application of microprocessor-based technology. Adherence to these qualification practices contributes to ensuring that a computer-based I&C system can perform its safety-related function under all anticipated service conditions. This guide complements Revision 1 of Regulatory Guide 1.89, "Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants," issued June 1984 (Ref. 8), which addresses compliance with 10 CFR 50.49, "Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants," for harsh environments that are subject to design-basis accidents.

The NRC staff accepted the Electric Power Research Institute (EPRI) Topical Report (TR) 107330, "Generic Requirements Specification for Qualifying Commercially Available PLC for Safety-Related Applications in Nuclear Power Plants" (Ref. 9) in a safety evaluation report (SER) by letter dated July 30, 1998 (Ref. 10). The EPRI report includes guidance on an acceptable method for addressing mild-environment qualification of programmable logic controllers (PLCs). The mild-environment qualification practices endorsed in this regulatory guide are equivalent to, and consistent with, those described in the EPRI TR. The primary distinctions between the two methods are that the scope of this regulatory guide focuses exclusively on environmental qualification, while the EPRI report covers a more extensive scope (e.g., platform evaluation, selection, procurement, qualification, and quality assurance); this regulatory guide addresses all safety-related computer-based I&C systems, while the EPRI report focuses on PLC platforms; and this regulatory guide endorses the current national qualification standard [i.e., IEEE Std. 323-2003 (Ref. 7)], while the EPRI report provides guidance based on a previous version of the national qualification standard [i.e., IEEE Std. 323-1983, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations" (Ref. 6)].

The qualification practices endorsed in this regulatory guide are based on the current consensus national standard and employ sound engineering practices for ensuring environmental compatibility of a computer-based I&C system with the environment in which it operates. These practices apply to safety-related computer-based I&C systems intended for implementation in mild environments within a nuclear power plant. The NRC gives the technical basis for the selection of these particular practices in NUREG/CR-6479, "Technical Basis for Environmental Qualification of Microprocessor-Based Safety-Related Equipment in Nuclear Power Plants," issued January 1998 (Ref. 11).

The following related publications include supporting technical findings that were considered in determining the qualification needs for safety-related computer-based I&C systems:

- NUREG/CR-5904, "Functional Issues and Environmental Qualification of Digital Protection Systems of Advanced Light-Water Reactors," issued April 1994 (Ref. 4)
- NUREG/CR-6406, "Environmental Testing of an Experimental Digital Safety Channel," issued September 1996 (Ref. 12)
- NUREG/CR-6476, "Circuit Bridging of Components by Smoke," issued October 1996 (Ref. 13)
- NUREG/CR-6543, "Effects of Smoke on Functional Circuits," issued October 1997 (Ref. 14)
- NUREG/CR-6579, "Digital I&C Systems in Nuclear Power Plants: Risk-Screening of Environmental Stressors and a Comparison of Hardware Availability with an Existing Analog System," issued January 1998 (Ref. 15)
- NUREG/CR-6597, "Results and Insights on the Impact of Smoke on Digital Instrumentation and Controls," issued January 2001 (Ref. 16)
- NUREG/CR-6741, "Application of Microprocessor-Based Equipment in Nuclear Power Plants — Technical Basis for Qualification Methodology," issued January 2003 (Ref. 17)

In general, the NRC's NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," issued 2003 (Ref. 18), reflects the information provided in regulatory guides. The NRC's Office of Nuclear Reactor Regulation uses the Standard Review Plan as guidance in reviewing applications to construct and operate nuclear power plants. This regulatory guide will apply to the 1997 Revision 4 of Chapter 7, "Instrumentation and Controls," of the Standard Review Plan (Ref. 19).

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

Both Regulatory Guide 1.89, "Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants," issued November 1974 (Ref. 20), and Revision 1 of Regulatory Guide 1.89, issued June 1984 (Ref. 8) endorse IEEE Std. 323-1974, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations" (Ref. 5). Regulatory Guide 1.89 specifically limits its scope to compliance with 10 CFR 50.49 "with regard to qualification of electric equipment important to safety for service in nuclear power plants to ensure that the equipment can perform its safety function during and after a design-basis accident." Thus, Regulatory Guide 1.89 focuses on the environmental qualification of equipment intended for use in harsh environments that are subject to design-basis accidents.

The IEEE Std. 323 definition of qualification is "generation and maintenance of evidence to ensure that the equipment will operate on demand to meet system performance requirements." In effect, environmental qualification is verification and validation that a design adequately accommodates the effects of, and is compatible with, the environmental conditions associated with the normal, abnormal, and accident conditions that the equipment or system might encounter. Section 50.49(c) of 10 CFR Part 50 defines a mild environment as one "that would at no time be significantly more severe than the environment that would occur during normal plant operation, including anticipated operational occurrences." However, as a mild environment in a nuclear power plant can encompass environmental conditions that can affect the performance of sensitive equipment, qualification to demonstrate compatibility with those environmental conditions is necessary in those cases. Because Regulatory Guide 1.89 limits its scope to equipment intended for application in harsh environments, additional guidance is warranted to address qualification for mild environmental conditions, as needed for computer-based technologies.

IEEE revised the industry guidance for qualification, IEEE Std. 323, in 2003. A particular distinction between IEEE Std. 323-2003, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations" (Ref. 7), and IEEE Std. 323-1974 (Ref. 5), is that the current version does not require age conditioning to an end-of-installed-life condition for equipment in mild environments where significant aging mechanisms are not present. The practices in IEEE Std. 323-2003 are sufficiently comprehensive to address qualification for the less severe environmental conditions of typical plant locations where safety-related computer-based I&C systems are generally located. These plant areas are unaffected by design-basis accidents and the most severe conditions to which the equipment is subjected, which arise from the environmental extremes resulting from normal and abnormal operational occurrences.

Use of computers in safety systems poses challenges that differ from those associated with analog systems, prompting the development of IEEE Std. 7-4.3.2, "IEEE Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations," issued in 1993 (Ref. 21) and revised in 2003 (Ref. 22). This standard emphasizes that the application of computers in safety systems needs to address reliability and environmental compatibility. In particular, Annex F.2.3 to IEEE Std. 7-4.3.2 states that analyses must be performed to ensure both that the system has a high "correct response probability" and that the probability of common-cause failure is reduced to an acceptable level. Addressing qualification requirements for safety-related computer-based I&C systems is one method of ensuring that the probability of common-cause failure attributable to environmental stressors is reduced to an acceptable level. Specifically, Section 5.4.1 of IEEE Std. 7-4.3.2 provides criteria for the equipment qualification of computer-based safety systems, including performing testing under environment stress with the full range of safety-related software functioning.

Computer-based I&C systems present unique characteristics that must be considered in the qualification process. These characteristics include both functional and hardware considerations. One significant difference between analog and digital equipment is the higher functional density that is possible with computer-based I&C systems. Because of the expanding single-chip capabilities, many safety-related installations involve replacement of multiple functional modules with a multifunction microprocessor-based module. Another difference involves the sequential function execution that typifies computer-based I&C systems compared to the essentially parallel execution of analog modules. The effect of this behavior can be compounded for multiple systems that rely on either successful completion of digital data communication or error detection before continuation of discrete functional steps. The capability of digital system design accommodates the potentially cumulative effects of environmental stress and is an important consideration for qualification of computer-based I&C systems.

From a hardware standpoint, one significant difference between analog and advanced digital systems is the radiation tolerance of different integrated circuit (IC) technologies. The analog technology historically used in nuclear power plants includes discrete bipolar devices. Advanced digital systems tend to use metal oxide semiconductor (MOS) technology, particularly complementary MOS (CMOS) technology. The radiation threshold for MOS devices is generally lower than those for bipolar (analog) devices. However, MOS technology is preferred for ICs because of its technical superiority in other areas (such as higher input impedance, fewer manufacturing processing steps, better temperature stability, and lower noise). Commercial MOS devices are very sensitive to ionizing doses, in contrast to their relative insensitivity to neutron fluence. Ionizing dose radiation hardness levels for MOS IC families range from about 10 gray (Gy) or 1 kilorad (krad) for commercial off-the-shelf (COTS) circuits to about 10^5 Gy (10^4 krad) for radiation-hardened circuits. The threshold fluence hardness level for MOS devices is about 10^{14} neutrons per square centimeter (n/cm^2), 1 million electron volts (MeV) equivalent. In contrast, the ionizing radiation hardness level range for bipolar devices begins around 10^4 Gy (1,000 krad). The threshold fluence hardness level for bipolar devices ranges on the order of 10^{14} to 10^{15} n/cm^2 (1 MeV equivalent).

Another significant difference between analog and advanced digital systems arises from the potential effect of the more rapid evolution of digital technology; in particular, the ever-increasing density and complexity of ICs at the wafer level make previously improbable failure mechanisms more significant. For example, at the level of complexity of current very-large-scale integrated (VLSI) circuits, electron migration can become a significant issue where metal interconnects and/or interlevel contacts are commonly designed to carry a current density exceeding 10^5 amps per cm^2 (A/cm^2), equivalent to an ordinary household electric wire carrying a current above 4,000 A. Reliability tests by VLSI manufacturers typically address this problem by stressing devices at both high temperature and high current density. Synergistic effects of other parameters can precipitate other failure mechanisms, such as dielectric breakdown in semiconductor components.

One stressor not previously considered for analog safety system qualification is smoke exposure from an electrical fire. Based on the investigation of smoke susceptibility and the resulting understanding of key failure mechanisms [as discussed in NUREG/CR-6406 (Ref. 12), NUREG/CR-6476 (Ref. 13), NUREG/CR-6543 (Ref. 14), NUREG/CR-6579 (Ref. 15), and NUREG/CR-6597 (Ref. 16)], smoke clearly has the potential to be a significant environmental stressor that can result in adverse consequences.

The most reasonable approach to minimizing smoke susceptibility is to employ design, construction, installation, and procedural practices that can reduce the possibility of smoke exposure and enhance smoke tolerance. In particular, current fire protection methods focus on a preventive approach, employing isolation and detection practices. In addition, postevent recovery procedures can mitigate the extent of smoke damage. Moreover, certain design choices and construction practices, such as chip packaging and conformal coatings, can reduce equipment susceptibility to smoke exposure. The most effective approach for addressing smoke susceptibility is to minimize the likelihood of smoke exposure by rigorously adhering to the fire protection requirements in 10 CFR Part 50.48, "Fire Protection," or other individual plant license commitments.

The safety goal of qualification is to avoid a common-cause failure of the safety-related system when it is needed to perform its safety function. The unique functional and hardware characteristics of computer-based I&C systems suggest that qualification guidance should explicitly state special considerations. These special considerations constitute good engineering practices that the industry generally follows. Nonetheless, the NRC staff developed this regulatory guide to promote clarity and avoid uncertainty, encourage the retention of the qualification records, and endorse the most appropriate standard. This guide does not intend to imply that a qualified life should be established for I&C systems in mild environments. Therefore, for the purposes of this guide, qualification is a validation of design to demonstrate that a safety-related computer-based I&C system is capable of performing its safety function under the specified environmental and operational stresses.

C. REGULATORY POSITION

The guidance described in IEEE Std. 323-2003 (Ref. 7) is appropriate for satisfying the environmental qualification of safety-related computer-based I&C systems for service in mild environments at nuclear power plants. The standard can be applied subject to the following five enhancements and exceptions:

(1) For environmental qualification of safety-related computer-based I&C systems, type testing is the preferred method. Selective use of the service conditions mentioned in Section 6.1.5.1 of IEEE Std. 323-2003 should be based on the actual environmental conditions. The type tests may be manufacturer's tests that document performance to the applicable service conditions with due consideration for synergistic effects, if applicable. The NRC does not consider the age conditioning in Section 6.2.1.2 to be applicable because of the absence of significant aging mechanisms on microprocessor-based modules.

(2) With appropriate justification, IEEE Std. 323-2003 allows the omission of elements of the test plan in Section 6.3.1.1 and the test sequence in Section 6.3.1.7 for mild environment qualification. The qualification testing should be performed with the I&C system functioning, with software and diagnostics that are representative of those used in actual operation, while the system is subjected to the specified environmental service conditions, including abnormal operational occurrences. Testing should exercise all portions of the safety-related computer-based I&C systems necessary to accomplish the safety-related function or those portions whose operation or failure could impair the safety-related function. Qualification testing should confirm the response of digital interfaces and verify that the design accommodates the potential impact of environmental effects on the overall response of the system. Although testing of a safety-related computer-based I&C system as a whole is preferred, type testing an entire system as a unit is not always practical. In those cases, confirmation of the dynamic response to the most limiting environmental and operational conditions for a computer-based I&C system is based on type testing of the individual modules and analysis of the cumulative effects of environmental and operational stress on the entire system.

(3) Section 6.3.1.7(C) of IEEE Std. 323-2003 provides a note to the standards applicable to testing for electromagnetic interference/radio frequency interference (EMI/RFI) and surge as environmental conditions. Guidelines for conducting electromagnetic susceptibility testing of safety-related I&C systems appear in Revision 1 of Regulatory Guide 1.180, "Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems," issued October 2003 (Ref. 23), and in Revision 1 of EPRI TR 102323, "Guidelines for Electromagnetic Interference Testing in Power Plants" (Ref. 24), as endorsed in a related SER dated April 17, 1996 (Ref. 25).

(4) For safety-related computer-based I&C systems intended for implementation in a mild environment, the NRC staff takes exception to Section 7.1 of IEEE Std. 323-2003. The evidence of qualification in a mild environment should be consistent with the guidance given in Section 7.2 selectively based on actual environmental conditions, and the records should be retained at a facility in an auditable and readily accessible form for review and use as necessary.

(5) Regulatory Guide 1.89 (Ref. 8) offers guidance for the environmental qualification of electrical equipment located in a harsh environment, as required by 10 CFR 50.49. For safety-related computer-based I&C systems installed in a harsh environment, the regulatory positions of this guide supplement the harsh environment qualification practices endorsed in Regulatory Guide 1.89.

D. IMPLEMENTATION

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

Except in those 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 NRC staff will use the methods described in this guide to evaluate (1) submittals in connection with applications for construction permits, standard plant design certifications, operating licenses, early site permits, and combined licenses; 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 the subject for which guidance is provided herein.

REGULATORY ANALYSIS / BACKFIT ANALYSIS

The regulatory analysis and backfit analysis for this regulatory guide are available in Draft Regulatory Guide DG-1142, "Guidelines for Environmental Qualification of Safety-Related Computer-Based Instrumentation and Control Systems in Nuclear Power Plants" (Ref. 26). The NRC issued DG-1142 in October 2006 to solicit public comments on the draft of this Regulatory Guide 1.209.

REFERENCES

1. *U.S. Code of Federal Regulations*, Title 10, Part 50, "Domestic Licensing of Production and Utilization Facilities," U.S. Nuclear Regulatory Commission, Washington, DC.[1]

2. IEEE Std. 603-1991, "Criteria for Safety Systems for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, Piscataway, NJ, 1991 , and the correction sheet dated January 30, 1995.[2]

3. IEEE Std. 279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, Piscataway, NJ, 1971.[2]

4. NUREG/CR-5904, K. Korsah, R.L. Clark, and R.T. Wood, "Functional Issues and Environmental Qualification of Digital Protection Systems of Advanced Light-Water Reactors," U.S. Nuclear Regulatory Commission, Washington, DC, April 1994.[3]

5. IEEE Std. 323-1974, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, Piscataway, NJ, 1974.[2]

6. IEEE Std. 323-1983, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, Piscataway, NJ, 1983.[2]

7. IEEE Std. 323-2003, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, Piscataway, NJ, 2003.[2]

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[1] All NRC regulations listed herein are available electronically through the Electronic Reading Room on the NRC's public Web site, at http://www.nrc.gov/reading-rm/doc-collections/cfr/part050. Copies are also available for inspection or copying for a fee from the NRC's Public Document Room (PDR) at 11555 Rockville Pike, Rockville, MD; the PDR's mailing address is USNRC PDR, Washington, DC 20555; telephone (301) 415-4737 or (800) 397-4209; fax (301) 415-3548; email PDR@nrc.gov.

[2] IEEE publications may be purchased from the IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08855; online at http://www.ieee.org; telephone (800) 678-4333.

[3] All NUREG-series reports listed herein were published by the U.S. Nuclear Regulatory Commission. Copies are available for inspection or copying for a fee from the NRC's Public Document Room at 11555 Rockville Pike, Rockville, MD; the PDR's mailing address is USNRC PDR, Washington, DC 20555; telephone (301) 415-4737 or (800) 397-4209; fax (301) 415-3548; email PDR@nrc.gov. Copies are also available at current rates from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20402-9328, telephone (202) 512-1800; or from the National Technical Information Service (NTIS) at 5285 Port Royal Road, Springfield, Virginia 22161, online at http://www.ntis.gov, by telephone at (800) 553-NTIS (6847) or (703) 605-6000, or by fax to (703) 605-6900. NUREG-0800 is also available electronically through the Electronic Reading Room on the NRC's public Web site, at http://www.nrc.gov/ reading-rm/doc-collections/nuregs/.

8. Regulatory Guide 1.89, "Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants," Revision 1, U.S. Nuclear Regulatory Commission, Washington, DC, June 1984.[4]

9. EPRI TR-107330, "Generic Requirements Specification for Qualifying Commercially Available PLC for Safety-Related Applications in Nuclear Power Plants," Electric Power Research Institute, Pleasant Hill, CA, December 1996.[5]

10. Safety Evaluation Report, issued by letter dated July 30, 1998, from Frank Miraglia, U.S. Nuclear Regulatory Commission, to Joseph Naser, Electric Power Research Institute, "Review of EPRI Utility Working Group Topical Report TR-107330, 'Generic Requirements Specification for Qualifying Commercially Available PLC for Safety-Related Applications in Nuclear Power Plants'."[6]

11. NUREG/CR-6479, K. Korsah, et al., "Technical Basis for Environmental Qualification of Microprocessor-Based Safety-Related Equipment in Nuclear Power Plants," U.S. Nuclear Regulatory Commission, Washington, DC, January 1998.[3]

12. NUREG/CR-6406, K. Korsah et al., "Environmental Testing of an Experimental Digital Safety Channel," U.S. Nuclear Regulatory Commission, Washington, DC, September 1996.[3]

13. NUREG/CR-6476, T.J. Tanaka, S.P. Nowlen, and D.J. Anderson, "Circuit Bridging of Components by Smoke," U.S. Nuclear Regulatory Commission, Washington, DC, October 1996.[3]

14. NUREG/CR-6543, T.J. Tanaka, "Effects of Smoke on Functional Circuits," U.S. Nuclear Regulatory Commission, Washington, DC, October 1997.[3]

15. NUREG/CR-6579, M. Hassan and W.E. Vesely, "Digital I&C Systems in Nuclear Power Plants: Risk-Screening of Environmental Stressors and a Comparison of Hardware Availability with an Existing Analog System," U.S. Nuclear Regulatory Commission, Washington, DC, January 1998.[3]

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[4] All regulatory guides listed herein were published by the U.S. Nuclear Regulatory Commission. Where an ADAMS accession number is identified, the specified regulatory guide is available electronically through the NRC's Agencywide Documents Access and Management System (ADAMS) at http://www.nrc.gov/reading-rm/adams.html. All other regulatory guides are available electronically through the Electronic Reading Room on the NRC's public Web site, at http://www.nrc.gov/reading-rm/doc-collections/reg-guides/. Single copies of regulatory guides may also be obtained free of charge by writing the Reproduction and Distribution Services Section, ADM, USNRC, Washington, DC 20555-0001, or by fax to (301)415-2289, or by email to DISTRIBUTION@nrc.gov. Active guides may also be purchased from the National Technical Information Service (NTIS) on a standing order basis. Details on this service may be obtained by contacting NTIS at 5285 Port Royal Road, Springfield, Virginia 22161, online at http://www.ntis.gov, by telephone at (800) 553-NTIS (6847) or (703)605-6000, or by fax to (703) 605-6900. Copies are also available for inspection or copying for a fee from 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) 397-4209, by fax at (301) 415-3548, and by email to PDR@nrc.gov.

[5] EPRI publications may be purchased from the EPRI Distribution Center, 207 Coggins Drive, P.O. Box 23205, Pleasant Hill, CA 94523; telephone (510) 934-4212.

[6] Copies are available for inspection or copying for a fee from the NRC's Public Document Room, 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) 397-4209, by fax at (301) 415-3548, and by email to PDR@nrc.gov.

16. NUREG/CR-6597, T.J. Tanaka and S.P. Nowlen, "Results and Insights on the Impact of Smoke on Digital Instrumentation and Controls," U.S. Nuclear Regulatory Commission, Washington, DC, January 2001.[3]

17. NUREG/CR-6741, K. Korsah and R.T. Wood, "Application of Microprocessor-Based Equipment in Nuclear Power Plants—Technical Basis for Qualification Methodology," U.S. Nuclear Regulatory Commission, Washington, DC, January 2003.[3]

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19. NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," Chapter 7, "Instrumentation and Controls," Revision 4, U.S. Nuclear Regulatory Commission, Washington, DC, June 1997.[3]

20. Regulatory Guide 1.89, "Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants," U.S. Nuclear Regulatory Commission, Washington, DC, November 1974.[4]

21. IEEE Std. 7-4.3.2-1993, "IEEE Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, Piscataway, NJ, 1993.[2]

22. IEEE Std. 7-4.3.2-2003, "IEEE Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, Piscataway, NJ, 2003.[2]

23. Regulatory Guide 1.180, "Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems," Revision 1, U.S. Nuclear Regulatory Commission, Washington, DC, October 2003.[4]

24. EPRI TR-102323, "Guidelines for Electromagnetic Interference Testing in Power Plants," Electric Power Research Institute, Pleasant Hill, CA, September 1994.[5]

25. Safety Evaluation Report, issued by letter dated April 17, 1996, from Eric Lee, U.S. Nuclear Regulatory Commission, to Carl Yoder, Electric Power Research Institute, "Review of EPRI Utility Working Group Topical Report TR-102323, 'Guidelines for Electromagnetic Interference Testing in Power Plants'."[6]

26. Draft Regulatory Guide DG-1142, "Guidelines for Environmental Qualification of Safety-Related Computer-Based Instrumentation and Control Systems in Nuclear Power Plants," U.S. Nuclear Regulatory Commission, Washington, DC.[7]

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[7] Draft Regulatory Guide DG-1142 is available electronically under Accession #ML063040591 in the NRC's Agencywide Documents Access and Management System (ADAMS) at http://www.nrc.gov/reading-rm/adams.html. Copies are also available for inspection or copying for a fee from 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) 397-4209 by fax at (301) 415-3548, and by email to PDR@nrc.gov.