

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS  
499<sup>th</sup> MEETING  
GUIDELINES FOR ENVIRONMENTAL QUALIFICATION OF  
MICROPROCESSOR-BASED EQUIPMENT IMPORTANT  
TO SAFETY IN NUCLEAR POWER PLANTS (DG-1077)  
February 6, 2003

**-STATUS REPORT-**

PURPOSE

The purpose of this session is to discuss the findings and recommendations of the Office of Nuclear Regulatory Research regarding the implementation of DG-1077, "Guidelines for Environmental Qualification of Microprocessor-based Equipment Important to Safety in Nuclear Power Plants," Revision 1, December 2001.

BACKGROUND

On June 8, 2001, the staff provided the Committee with a draft NUREG, prepared by Oak Ridge National Laboratory, on the proposed qualification methodology of microprocessor-based equipment important to safety in nuclear power plants. A Larkinsgram, dated July 25, 2001, was issued stating that the Committee plans to review the proposed final version of this guide after reconciliation of public comments. The staff completed its reconciliation of public comments and on January 6, 2003, submitted the revised DG-1077 to the Committee. In addition, the staff submitted NUREG/CR-6741, "Application of Microprocessor-based Equipment in Nuclear Power Plants - Technical Basis for Qualification Methodology," January 2003, which supports the staff's position in DG-1077.

DISCUSSION

Microprocessor-based equipment present unique characteristics that need to be considered in the qualification process. These characteristics include functional as well as hardware considerations. One significant difference between analog and digital equipment arises from the higher functional density possible with microprocessor-based equipment. Because of the expanding single-chip capabilities, many safety-related implementations involve replacement of multiple functional modules by a multi-function microprocessor-based module. Another difference involves the sequential execution of function that typifies microprocessor-based equipment as opposed to the essentially parallel functional execution of analog modules. This behavior can have a compound effect for distributed implementations that rely upon either successful completion of digital data communication or error detection before continuation of discrete functional steps.

From a hardware standpoint, one significant difference between analog and advanced digital systems is the radiation tolerance of different integrated circuit technologies. Threshold radiation levels for metal oxide semiconductor devices are generally lower than bipolar technologies.

One stressor not previously considered for analog safety system qualification is smoke exposure from an electrical fire. It is clear that smoke has the potential to be a significant environmental stressor that can result in adverse consequences. However, there is no practical, repeatable testing methodology so it is not feasible to assess smoke susceptibility as part of environmental qualification. As a result, the most reasonable approach to minimizing smoke susceptibility is to employ design, implementation, and procedural practices that can reduce the possibility of smoke exposure and enhance smoke tolerance.

Safety-related instrument and control (I&C) system upgrades of present-day nuclear power plants, as well as I&C systems of Advanced Light-Water Reactors, are expected to make increasing use of microprocessor-based technology. The NRC recognized that the use of such technology may pose environmental qualification challenges different from current, analog-based I&C systems. Hence, the staff initiated the "Qualification of Advanced Instrumentation and Control System" program. The objectives of the this confirmatory research project are to (1) identify any unique environmental-stress-related failure modes posed by digital technologies and their potential impact on the safety systems and (2) develop the technical basis for regulatory guidance using these findings.

NUREG/CR-6741 documents a comparative analysis of two environmental qualification standards;

- Institute of Electrical and Electronics Engineers (IEEE) Standard 323-1983, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Plant Generating Stations." September 30, 1983
- International Electrotechnical Commission (IEC) 60780 (1998), "Nuclear Power Plants- Electrical Equipment of the Safety System-Qualifications,"

and provides recommendations for environmental qualification of microprocessor-based systems. The two standards were chosen for this analysis because IEEE 323 is the U.S. standard for the qualification of safety-related equipment in nuclear power plants, and IEC 60780 is its more recent European counterpart.

NUREG/CR-6741 concluded that procedures described by either IEEE 323-1983 or IEC 60780 are appropriate for satisfying the qualification of safety-related microprocessor-based equipment for service in nuclear power plants. The procedures in either standard may be applied in their entirety, without mixing and matching among standards, subject to certain enhancements and exceptions that are described in Chapter 3 of the NUREG (pages 30-33).

DG-1077, "Guidelines for Environmental Qualification of Microprocessor-based Equipment Important to Safety in Nuclear Power Plants," Revision 1, December 2001, describes a method acceptable to the staff for determining the environmental qualification procedures for microprocessor-based electric equipment important safety for service in nuclear power plants and is based on the findings of NUREG/CR-6741. DG-1077 also concluded that procedures described by either IEEE 323-1983 or IEC 60780 may be applied in their entirety, without mixing and matching among standards, subject to certain enhancements and exceptions that are a modified version to those in NUREG/CR-6741.

## HIGHLIGHTS OF INDUSTRY COMMENTS ON THE DRAFT REGULATORY GUIDE

The following is a summary of several (but not all) comments received during the public comment period for the draft regulatory guide. DG-1077 has been updated based on public comment, however, **the Committee should consider the following in developing questions for the meeting:**

NEI: DG-1077 is redundant to guidance already provided to the industry on EQ of nuclear plant equipment. NEI disagrees with the staff's conclusion that the differences between analog and microprocessor-based I&C systems require different qualification approaches. NEI states that DG-1077 should be withdrawn.

Duke Energy: Duke is of the opinion that current Regulatory Guides (RG-1.89 and RG-1.180) offer sufficient guidance for the environmental qualification of electrical equipment important to safety and that with the fire protection requirements of 10 CFR Part 50, Appendix R, provide adequate guidance for the evaluation of potential stressors resulting from electromagnetic interference/radio-frequency interference and smoke. Duke believes that it may be more appropriate for the staff to update existing guidance (e.g., RG 1.89) in lieu of issuing new guidance. In addition, Duke believes that the staff should solicit active participation from the manufactures and industry representatives in the qualifying the equipment.

Dominion: Dominion is concerned that DG-1077 could evolve into a "Mild Environment EQ Program" which would be as extensive as its existing harsh environment EQ program. Dominion is also concerned that the population of vendors supplying safety related microprocessors may be reduced should the requirements of DG-1077 be too stringent. Dominion would not consider using a vendor who has not qualified its equipment through the safety evaluation process and recommends that the staff solicit input from vendors on DG-1077. Lastly, Dominion does not believe there is sufficient guidance in DG-1077 for EMI/RFI testing of digital equipment.

PSEG Nuclear: PSEG believes that EPRI TR-102323 should be included as an additional acceptable method for addressing the EMI/RFI issues.

Nuclear Utility Group on Equipment Qualification: DG-1077 is unnecessary and unwarranted because NRC regulations and regulatory guidance already adequately address EQ of digital equipment.

### EXPECTED COMMITTEE ACTION

The Committee plans to issue a letter on this matter.