May 7, 2001

MEMORANDUM TO: Jack R. Strosnider, Jr., Director
Division of Engineering
Office of Nuclear Reactor Regulation

FROM: Michael E. Mayfield, Director /RA/
Division of Engineering Technology
Office of Nuclear Regulatory Research

SUBJECT: TRANSMITTAL OF NUREG/CR-6597, "RESULTS AND INSIGHTS ON THE IMPACT OF SMOKE ON DIGITAL INSTRUMENTATION & CONTROL

This memorandum transmits NUREG/CR-6597, "Results and Insights on the Impact of Smoke on Digital Instrumentation & Control." NUREG/CR-6597 is the final report from Sandia National Laboratories (SNL) on the investigation into the effects of smoke on digital I&C equipment.

In 1994, the Office of Nuclear Regulatory Research initiated a program at SNL to determine the impact of smoke on advanced I&C safety systems in response to a request from the Advisory Committee on Reactor Safeguards (ACRS) to include smoke in the investigation of environmental qualification. The fundamental questions posed by ACRS were: (1) Is smoke a significant environmental stressor and (2) should smoke susceptibility be evaluated as part of environmental qualification for digital safety-related instrumentation and control (I&C) systems.

A subsequent user need from the Office of Nuclear Reactor Regulation, dated March 17, 2000, from S. J. Collins to A. C. Thadani, reinforced the goal that the findings of this research project be integrated into the technical basis for comprehensive guidance and acceptance criteria on environmental qualification of digital safety-related I&C systems.

The subject report presents the insights and conclusions drawn from the project findings. The documentation includes a brief overview of the project, a summary of previously reported smoke tests, and results from the recently completed tests at SNL involving conformal coatings on functional circuit boards, memory chips, digital throughput boards, and hard disks (see NUREG/CR- 6597, Table 1 for tests performed). The details of tests performed before 1997 have been published in NUREG/CR- 6476 “Circuit Bridging of Components by Smoke” and NUREG/CR 6543 “Effects of Smoke on Functional Circuits.”

Significant insights drawn from project findings include:

(1) Smoke exposure can result in failure mechanisms for safety-related digital equipment that can have an immediate adverse effect on safety-related functions. Thus, undetected smoke exposure has the potential to be a significant environmental stressor that can result in adverse consequences.

(2) There is no practical, repeatable smoke testing methodology, therefore it is not feasible to assess smoke susceptibility through environmental qualification.

(3) There are design choices, and implementation practices that can reduce equipment susceptibility to the effects of smoke exposure; however, the lack of consensus approaches precludes definitive guidance beyond the acknowledgment that "levels of protection" can be employed to enhance smoke tolerance as specified in DG-1077 "Guidelines for Environmental Qualification of Microprocessor-Based Equipment Important to Safety in NPPs."

(4) Therefore 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 in particular, preventative approaches included in current fire protection guidance are appropriate.

The findings and insights from this project are being integrated into the technical basis for draft regulatory guide DG-1077 "Guidelines for Environmental Qualification of Microprocessor-Based Equipment Important to Safety in NPPs." In particular, the question of whether smoke susceptibility should be explicitly included as an element of qualification testing has been resolved. There is no practical means available for conducting systematic, repeatable smoke testing so it is not feasible to include smoke as service condition requiring qualification. However, the value of minimizing the risk of exposure to smoke is clear and so the rigorous adherence to fire protection guidance, given in Appendix R of the Code of Federal Regulation, Title 10, Part 50, is emphasized. Finally, the findings relating to the potential for increasing smoke tolerance of equipment and components are incorporated through the recommendation that "levels of protection" be identified as part of the environmental qualification documentation for a microprocessor-based safety-related I&C system, DG-1077.

If you have any questions, please call me (415-5678) or Christina Antonescu (415-6792) of my staff. Christina is the Project Manager for this study in the Engineering Research Applications Branch in the Division of Technology.

Attachment: As stated
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