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POWER ENGINEERING SOCIETY

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NATURE SAVER™ FAX MEMO 01616	Date 12/16/96	# of pages ▸ 4
To Satish Aggarwal	From Gary Toman	
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December 16, 1996

U.S. Nuclear Regulatory Commission
Office of Research
Washington, DC 20555

ATTN: Mr. Satish K. Aggarwal

Subject: Comments on Draft NUREG/CR-6412

Dear Satish:

Comments on the draft NUREG concerning testing of connectors at Sandia National Laboratories follows. The persons that were at the SC-2 96-2 meeting who expressed interest in reviewing the document have provided these comments. If you have any questions concerning the comments, please do not hesitate to contact me at 618-244-6000.

Yours truly,

Gary J. Toman
Vice Chairman, SC-2

Attachment

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NUREG I FP-11 Guides & Manuals.

COMMENTS ON DRAFT NUREG/CR-6412, DATED JULY 1996
AGING AND LOSS-OF-COOLANT ACCIDENT (LOCA) TESTING OF ELECTRICAL CONNECTIONS

Comments Prepared 12/16/96 By:

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1. Abstract, last sentence. A statement that further work is necessary seems gratuitous. This sentence should be reworded to state that "If the aging levels simulated in the program and the submergence performed in the program are required by plant applications, failures would be expected in 5 of 10 connector types." The aging levels were much more severe in the program than used in the related industry programs and most applications do not involve submergence. This report should not presuppose that current qualifications have requirements that are the same as, or more severe than the conditions assumed in the test program.

2. Section 1.1, second bullet. The plan for this program assumes that a device must be aged to 150% of the original aging for the device to be useful for 60 years. This assumption is not the assumption of the industry. For the most part, the industry is verifying that temperatures and doses are low enough that the pre-conditioning of the original 40 year qualification actually envelops the needs of 60 years at the actual service condition. The pre-conditionings of the industry's qualifications were not gentle. Adding 50% more aging to them is significant and very damaging. Failures of connectors and cables would not be unexpected with this type of additional aging.

3. Section 1.1, last paragraph, last 2 sentences. With the exception of the level of aging, for the most part, the tests performed were the equivalent of a qualification test under current standards. This paragraph infers that qualification would only be valid if statistically sound sample sizes were employed. The industry has addressed this issue and this statement (i.e., "to test enough of each type to get a statistical sample") should be removed.

4. Section 2.3.1, first paragraph and Table 2.4. A 6 month aging period at a 98.8°C thermal condition was chosen based on the arbitrary selection of 1.15 eV, when the range of activation energies for the devices was 0.8 to 3.916 eV. The result of the selection of 1.15 eV as the activation energy is that some devices were significantly underaged (0.23 times the desired life goal) but most were severely overaged (from 1.4 to 106,400 times the desired life goal). While the industry generally selects the component with the lowest activation energy for a device as the weak link, this is only done on a device by device basis; not on the basis of a set of different devices produced by different manufacturers. While underaging would not lead to failures, severe overaging could. Given the large amounts of overaging on top of an attempt to attain 150% aging of the original aging, failures would be expected to the seals and cables in the program.

5. Section 2.1, sixth paragraph. A rough description of the mounting of the connectors is provided. However, there is no description of the actual mounting method including slack in

the cables for expansion and support or lack of support of the connectors and cables. Insufficient information has been provided to allow the reader to understand the full nature of the test setup.

6. Page 7, right hand column, first full paragraph. Rockbestos Firewall III XLPE cable is listed as being used for leads. However, no indication of the jacket type used on the cable is indicated. The jacket could be either neoprene or Hypalon.
Also, there is no indication as to whether the XLPE is cured by irradiation or chemicals. There are differences in properties between the cure methods that could bare on insulation resistance results.

7. Figure 2.9. These figures indicate a lack of control of the aging temperature. Industry programs strive for ±3°C or better. The upper figure indicates limits of ±10°C and more over nearly the entire period of the 6 month test. Again a mix of gross underaging and overaging is indicated. A discussion of the effects of these wide swings in temperature is desirable.

8. Table 2.5. This table compares the test profile with that given in IEEE Std. 323-74. First, the profile in the appendix of the standard is not a requirement of the standard (See disclaimer at start of Appendix A). While the BWR table states 200°F for 100 days, this has rarely been used as a licensing basis for power plants. Older plants have used durations of 17 to 30 days. Only later plants use 100 and 180 day durations. However, the nearly all of the plant specific profiles have much lower tails with long-term temperatures of 120 to 150°F, not 200°F.

9. Section 3.2.2, second paragraph, second sentence. The text states that "Each plotted point is the average..." Please state what the average is. Is it the average of each individual conductor to the surrounding grounded conductors? In addition, giving separate plots for the outliers as compared to the well insulated conductors would be highly informative to the engineering mind.

10. Post-LOCA Inspection. There is no discussion of the condition of the specimens from physical and visual inspection following the LOCA test. Statements from NRC Research personnel indicate that the cable jackets had degraded significantly. Given that the cable jacket often forms part of the seal system with the connector backshell, some indication of the physical condition of the interface with the backshell should be given. Before and after photographs of the connectors would be highly desirable.

11. Section 3.3, Bulleted Conditions. The use of 1000 Vac and 2400 Vac high potential tests at the end of the complete test program under full submerged conditions is excessive and outside of the guidance of industry practice. No qualification standard requires such tests. There are no control and instrumentation circuits that operate at such voltage and no manufacturer would recommend such a test on a device that by definition has to be degraded from its original condition. The highest voltage in use on most of these connectors is 480 Vac and that is only for a limited number of them. Most will not be operated above 130 Vac or 142 Vdc and most will be operated at 24 to 50 Vdc. Connectors are not tested as if they were field cables.

12. Section 3.3. With regard to TDR shifts, the cable jackets and insulation would be infused with water from the pressurized steam exposure. The infusion of water would increase the capacitance of the insulation which would greatly affect the transmission properties and would

cause the results to seem as if the cable lengthened.

13. Page 26, first full paragraph. Without information from a careful dissection of the connectors and cables, the data from 13 months after the test is of little value. While one would surmise that the cables had "dried out," many other phenomena may have occurred that have not been accounted for.

14. Page 27, first and second paragraphs. No useful information is imparted by stating that the conductors under tests "tripped the test set." What was the setting for the test set? Was it set on the most sensitive level or did a significant leakage current have to flow before the set tripped?

15. Page 27 second paragraph. Submitting a component to a second dielectric test after it failed the first is adding insult to injury. Electrical failures are rarely self healing. The devices did not fail two tests; they were failed at the end of the first test.

16. Section 4 top of right hand column. The requirement for device qualification is to adequately function under specified conditions. Most connectors are not used in submerged conditions. Those that are would not be operated at the test set voltage levels. Without an indication of the current required to "trip the test set," few inferences can be made with respect to actual applications that do involve submergence.

17. Section 4, last paragraph. As stated above, most utilities only plan to use existing qualifications for use beyond 40 years based on the existence of less severe normal conditions than were assumed in developing a 40 year qualified life. As such the overaging that occurred in this program, especially with respect to a number of the devices that failed, can help explain the failures. Any further work should not use the basis that was used in this program and should be tailored to device specific activation energies rather than an assumed generic activation energy. The last bullet should be deleted, it does not appear to be correct (the inline splices did not fail) and it adds nothing to the technical content of the report.

18. Section A.2 Second paragraph. This paragraph states "The slow test chamber flooding that occurred through day 5 caused even larger reductions in the measured IR values..." This flooding should be explained in detail in the context of the terminal blocks and in the main part of the report. No mention is made in the main report of such a significant event as chamber flooding.

19. Appendix B, last paragraph on page 63. This paragraph is too terse for the average reader to understand what is being said. Breaking the discussion of increases and decreases into two sentences rather than using parenthetical statements would help. TDR testing is not a common test to most engineers. More explanation would be highly beneficial.

This section should also explain why multiple plots are given in each figure. Are these merely the results of multiple tests? If so why are there gross differences between some of the upper and lower plots as has occurred in the left hand plot in Figure B.1.

20. Figure B.1. What is the significance of the left hand and right hand portion of the plots? Does one apply to open circuit conditions and the other apply to closed circuit conditions? Or does one apply to conductor to shield and the other shield to ground? An explanation is necessary.

Also, an explanation of the meaning of the plots is necessary. The reader needs to know that the step change on the right hand plots indicates the connector interface (if it really does). For the left hand plot the reader needs to know what it is and what it means. This concept applies to all of the Figures. Very little information has been imparted.