



UNITED STATES
NUCLEAR REGULATORY COMMISSION
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March 22, 1994

MEMORANDUM FOR: Ashok C. Thadani, Associate Director
for Inspection and Technical Assessment

FROM: Martin J. Virgilio, Acting Director
Division of Systems Safety and Analysis

SUBJECT: REVIEW OF EQ INFORMATION RELATED TO PLANT LICENSE RENEWAL
(EQ-TAP ACTION ITEM 3.a) (TAC M85648)

As discussed in the staff's Environmental Qualification Task Action Plan (EQ-TAP) of June 16, 1993, we are performing a programmatic review of environmental qualification (EQ) for electrical equipment. Our efforts in this regard are specifically defined under Action Item 3 of the EQ-TAP, which includes the following elements:

- 3.a Review License Renewal Background Information
- 3.b Review Fire Protection Reassessment Report
- 3.c Elicit Opinions from Others (Regions, EQ Experts)
- 3.d Review Existing EQ Program Requirements
- 3.e Review NRC Audit/Inspection Practices
- 3.f Review Licensee Implementation Practices
- 3.g Finalize Review Results

Our objective in completing items 3.a through 3.f (above) is to identify potential EQ issues and concerns that may deserve further staff consideration. It is important to recognize that this part of our programmatic review is not intended to resolve or to otherwise address any of the EQ issues that are identified. After items 3.a through 3.f of the EQ-TAP have been completed, all of the EQ issues will be consolidated and specifically addressed in the staff's final report under item 3.g, "Finalize Review Results," which will include recommendations as appropriate. Our final report is scheduled to be completed by August 30, 1994.

Currently, we have completed the review associated with item 3.a of the EQ-TAP, "Review License Renewal Background Information," and our evaluation is enclosed for your information. The potential issues that were identified during this review will be assembled and addressed in our final report along

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with any other potential issues that are identified as we complete items 3.b through 3.f of the EQ-TAP. Please contact me if you should have any questions regarding the enclosed evaluation.

Original Signed By

Martin J. Virgilio, Acting Director
Division of Systems Safety and Analysis

Enclosure:

Review of EQ Information
Related to Plant License
Renewal (EQ-TAP Action Item 3.a)

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PEVIEW OF EQ INFORMATION RELATED TO PLANT LICENSE RENEWAL
(TAC NO. M85648)

1.0 INTRODUCTION

As discussed in the Environmental Qualification Task Action Plan (EQ-TAP) of June 16, 1993, the staff is performing a reassessment of the NRC environmental qualification requirements for electrical equipment. Action Item 3 of the EQ-TAP lists those actions that pertain to the programmatic review of EQ, which include:

- 3.a Review License Renewal Background Information
- 3.b Review Fire Protection Reassessment Report
- 3.c Elicit Opinions from Others (Regions, EQ Experts)
- 3.d Review Existing EQ Program Requirements
- 3.e Review NRC Audit/Inspection Practices
- 3.f Review Licensee Implementation Practices
- 3.g Finalize Review Results

This particular evaluation is intended to address EQ-TAP Action Item 3.a, "Review License Renewal Background Information." The specific objective is to identify potential EQ issues and concerns by reviewing information related to the license renewal initiative. This is not intended to be a comprehensive review of documents related to license renewal, but rather a review of sufficient background information to identify any significant issues and concerns that pertain to EQ. Ultimately, all of the issues and concerns that are identified during the EQ programmatic review will be consolidated and discussed in the final report (EQ-TAP Action Item 3.g). Therefore, this evaluation does not include specific recommendations for further staff actions.

2.0 BACKGROUND INFORMATION ON LICENSE RENEWAL

In support of 10 CFR 54, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants," the staff reviewed the original EQ requirements that were imposed on licensees in order to determine if additional EQ measures should be required during the renewal period. As a result of this review, the staff ultimately questioned the adequacy of the less stringent EQ criteria that were imposed on licensees by the Division of Operating Reactors (DOR) Guidelines and by the Category II criteria of NUREG-0588, "Interim Staff Position on Environmental Qualification of Safety-Related Electrical Equipment," as compared to the more rigorous Category I criteria of NUREG-0588 that were imposed on the newer plants. Ultimately, the staff determined that the adequacy of EQ requirements (DOR guidelines and NUREG-0588 Category II versus NUREG-0588 Category I) should be reassessed as an operating reactor issue and not as a license renewal issue.

3.0 REVIEW OF PLANT LICENSE RENEWAL INFORMATION PERTAINING TO EQ

The staff reviewed information associated with the Draft Branch Technical Position on EQ (EQ-BTP) for license renewal in order to identify EQ-related issues and concerns. Each document is briefly summarized below, and the EQ-related issues and concerns associated with each document are listed.

3.1 Memorandum for J. Craig from P. Shemanski, "Summary of Meeting with NUMARC on Equipment Qualification Issues Related to License Renewal," January 7, 1991

On December 14, 1990, the NRC staff met with representatives from the Nuclear Management and Resources Council (NUMARC) to discuss equipment qualification issues related to license renewal. The following views and information were expressed in the meeting minutes:

The staff indicated that none of the EQ programs currently being implemented by licensees fully satisfied the requirements of an established effective program as defined in draft 10 CFR 50.54, and that some existing programs would have to be modified to adequately determine the qualification of equipment during the renewal term (after 40 years). For example, some components may require additional extensive testing or reanalysis to establish qualification for the renewal period.

NUMARC discussed the use of IEEE 323-1983 as the basis of component qualification for life extension. IEEE 323-83 introduced a new section on extension of qualified life which credits the use of reanalysis for increasing qualified life by using conservatism between the initially assumed environmental conditions and those that actually exist in the plant. The staff agreed to assess the suitability of IEEE 323-83 as an equipment qualification standard (IEEE 323-74 was the version of the standard currently endorsed by the staff).

Components that were qualified to the DOR Guidelines and NUREG-0588 Category II requirements were not required to be aged before type testing. Synergistic and dose rate effects were also not required to be addressed by these criteria.

The staff noted that there was insufficient data to conclusively predict the threshold of aging degradation that a component could sustain and still be able to pass a LOCA qualification test.

The staff indicated that the exemption allowed by Regulatory Guide 1.89 for replacement equipment may not be appropriate for the license renewal term.

The staff indicated that there may be a need to conduct walkdowns and inspections to support the renewal term. Testing may be warranted in conjunction with the inspections for some equipment to determine the state of degradation.

The staff indicated that any justifications for continued operation that are currently in place for inoperable equipment (as allowed by Generic

Letter 88-07) may not be appropriate for continuation into the renewal term.

Potential Issues

Based on the information contained in this memorandum, the following issues and concerns were identified for further consideration by the staff:

- a. adequacy of qualification methodology for establishing initial qualification, including differences between the less rigorous criteria stated by the DOR Guidelines and NUREG-0588 Cat. II versus the criteria stated by NUREG-0588 Cat. I (e.g., aging, synergistic and dose rate effects)
- b. adequacy of existing programs to assure continued equipment qualification, including qualification beyond the established qualified life given the different qualification standards
 - acceptability of the Regulatory Guide 1.89 exemptions to equipment upgrade requirements
 - criteria for acceptable versus unacceptable aging degradation
 - need for walkdown, inspection and additional testing
 - adequacy of existing justifications for continued operation allowed under Generic Letter 88-07

3.2 Memorandum for J. Richardson, A. Thadani, L. Shao, and W. Minners from D. Crutchfield, "Draft Discussion Paper on Equipment Qualification for License Renewal (IAC No. 81534)," October 24, 1991

A draft discussion paper was prepared by the License Renewal Project Directorate (PDLR) staff for extending the qualified life of electrical equipment. Comments from other organizations within the NRC were being solicited on the paper prior to proceeding with further discussions with the Nuclear Management and Resources Council (NUMARC). The discussion paper contained the following information and staff views:

Changes to the qualification criteria for the renewal term are intended to take advantage of current EQ knowledge and in particular, focus on EQ or age-related degradation unique to license renewal. While EQ age-related degradation occurs during the term of the current operating license, the effects are expected to be different in character or magnitude during the period of extended operation.

EQ programs cannot be considered to be effective programs without a determination that age-related degradation will be adequately managed after the current term.

The DOR Guidelines and NUREG-0588 did not address in detail all areas of qualification, since certain areas were not well understood at the time. For example, the effects of aging, sequential versus simultaneous testing, synergistic effects, dose rate, and the potential for combustible gas and chloride formation in equipment containing organic materials have subsequently been evaluated in more detail.

Components qualified to the DOR Guidelines or to NUREG-0588 Cat. II were not required to be pre-aged before type testing, and synergistic and dose rate effects were not required to be addressed.

Since many components were qualified by pre-aging using irradiation at high dose rates of 0.1 to 1 Mrad/hr, the possibility of oxygen diffusion effects having minimized polymer degradation should be addressed to ensure adequate margin.

Augmented inspection may be warranted to address and detect the presence of component age-related degradation.

Potential Issues

Based on the information contained in this memorandum, the following issues and concerns were identified for further consideration by the staff:

- a. adequacy of qualification methodology for establishing initial qualification, including differences between the less rigorous criteria stated by the DOR Guidelines and NUREG-0588 Cat. II versus the criteria stated by NUREG-0588 Cat. I
 - aging
 - sequential versus simultaneous testing
 - synergistic effects
 - dose rate effects
 - combustible gas and chlorine formation effects
 - oxygen diffusion effects
- b. adequacy of existing programs to manage aging
 - age-related degradation unique to license renewal
 - augmented inspection may be warranted to address and detect the presence of component age-related degradation.

1.3 Memorandum for D. Crutchfield from A. Ihedani, "Draft Discussion Paper on Equipment Qualification for License Renewal (IAC No. B1534)." December 10, 1991

The Division of Systems Technology (DST) provided its comments on the subject draft discussion paper. While DST was generally in agreement with the position that was presented, it was pointed out that recent experience at Watts Bar and Browns Ferry indicated that electric cables may become damaged during installation. It was also pointed out that cables that are damaged during installation may not be detected during normal operation.

Potential Issues

Based on the information contained in this memorandum, the following issue was identified for further consideration by the staff:

- effects of installation, maintenance and surveillance practices on equipment qualification

3.4 Memorandum for P. Shemanski from J. Vora, "EQ for License Renewal," February 5, 1992

The Office of Research (RES) provided its comments on the Draft Discussion Paper on Equipment Qualification for License Renewal. RES was supportive of the paper, but indicated that some improvement was needed. Aside from clerical and administrative improvements, RES indicated that more definitive explanations were needed on what constituted an adequate "supporting analysis" and what an acceptable "conservatism" was. Also, additional discussion on "hot spots" and treatment of localized anomalies attributable to installation errors or improper maintenance or age-related degradation was needed.

Potential Issues

Based on the information contained in this memorandum, the following issue was identified for further consideration by the staff:

adequacy of existing programs for addressing "hot spots,"
localized anomalies attributable to installation errors, improper
maintenance and age-related degradation.

3.5 Meeting Minutes Prepared by S. Carfagno (NRC Consultant), "Equipment Qualification for License Renewal," March 19, 1992

A meeting involving NRC staff (including its consultant, S. Carfagno) was held on March 18, 1992, to discuss the above stated subject. The following information was included in the meeting minutes:

Safety-related equipment for older plants was qualified in accordance with the DOR Guidelines or NUREG-0588, Cat. II, which did not require the age conditioning of specimens prior to testing for seismic and LOCA endurance. This was cited as a major concern.

The cable qualification process does not address "weak links" such as hot spots, long overhangs, and damage due to installation or maintenance. It may be appropriate for licensees to institute surveillance procedures to address "weak links" for the license renewal period.

The license renewal process may provide an opportunity to review the adequacy of current LOCA testing in which test durations of 10 to 30 days are sometimes used to demonstrate satisfactory performance of equipment for periods of up to one year.

While the current "accelerated aging" methodology using Arrhenius techniques may possibly account for thermal effects, it does not address the effects of long-term exposure to moisture.

A point to consider is that some PRAs show that safety can be maintained even if certain components fail after several days of accident exposure, even though the design basis may be that they remain available for periods of up to one year of accident exposure.

Potential research needs that were discussed included:

(a) investigation of the acceptability of butyl rubber insulation inside containment in view of its reversion under irradiation; (b) comparison of the properties of cables removed from older plants with the properties of new cables subjected to age conditioning equivalent to the age of the naturally aged cables; (c) conducting LOCA tests in accordance with current qualification practice on cables that were qualified on the basis of DOR or NUREG-0588, Cat. II; (d) identification of weak links; and (e) establishing weak link surveillance procedures.

Potential Issues

Based on the information contained in these meeting minutes, the following issues were identified for further consideration by the staff:

- a. PRA implications/need for screening criteria
- b. adequacy of qualification methodology for establishing initial qualification, including differences between the less rigorous criteria stated by the DOR Guidelines and NUREG-0588 Cat. II versus the criteria stated by NUREG-0588 Cat. I
 - age conditioning (especially for older plants)
 - test duration used to establish long-term qualification
 - long-term exposure to moisture
- b. adequacy of existing programs to manage aging
 - augmented inspection may be warranted to address weak links such as hot spots, long overhangs, and damage due to installation or maintenance activities
- c. aging of Butyl rubber
- d. potential research topics
 - LOCA testing of naturally aged DOR/NUREG-0588 Cat. II cables
 - identification of "weak links"/condition monitoring needs

3.6 NUREG-1299, Section F-2.0, "Environmental Qualification of Electric Equipment Important to License Renewal," September 1992 (Draft 2)

The staff's Branch Technical Position (BTP) discussed background information related to EQ and established specific criteria to be imposed for license renewal. The BTP was essentially the draft discussion paper that was prepared by the staff in its (b)(6) (b)(7)(C) position that the (b)(6) requirements stated in the (DOR Guidelines and in NUREG-0588 for Category II equipment were insufficient for license renewal purposes due to shortcomings in methodology related to: (1) preaging of components, (2) maintaining margins, and (3) consideration of synergistic effects. It was the staff's view that licensees should demonstrate that NUREG-0588 Category I criteria have been satisfied for the renewal term. The following additional views were also expressed:

"Sound reasons to the contrary" that may have been established

previously for not using replacement equipment that satisfies the criteria in Regulatory Guide 1.89, Revision 1, will not automatically be accepted.

Specific guidance for demonstrating equipment qualification by reanalysis, similarity, type testing, and by ongoing experience for the renewal term was provided.

Equipment in the environmental qualification program should be subjected to a one-time only inspection or a series of inspections designed to identify and assess areas that can potentially shorten the demonstrated qualified life.

Following the staff's presentation of the BTP to the Advisory Committee on Reactor Safeguards (ACRS) on September 16 and on October 8, 1992, Dr. Carfagno (NRC consultant) provided comments pertaining to the ACRS discussions in letters dated September 17 and October 9, 1992 (respectively). These letters provided additional background information and indicated that in the early days of EQ (before IEEE 323-74), thermal aging was somewhat arbitrary and not based on the Arrhenius methodology. Nonetheless, it was Dr. Carfagno's recollection that age conditioning was conducted and that the early cable qualification programs included substantial radiation exposure (typically 50 Mrad as the 40-year dose and 150 Mrad as the accident dose). Dr. Carfagno also indicated that questions may remain as to the adequacy of the DOR LOCA tests that were conducted and that even today there remain technical questions concerning the justification for LOCA acceleration (i.e., the use of excess margin in the LOCA tests to simulate post-accident service periods longer than the test duration). While it was Dr. Carfagno's recollection that the adequacy of DOR LOCA tests was checked during the NRC's EQ review, he was not certain whether the evaluation criteria were consistent with the present technical knowledge. Dr. Carfagno pointed out that cables are only one component in the long list of equipment important to safety and that data demonstrating the insignificance of aging on other components are most likely not available.

The ACRS provided its view of the staff's proposed BTP in a letter to James Taylor on October 22, 1992. The ACRS indicated that the BTP should not be issued for public comment until the following matters were addressed: (a) an analysis of the risk importance of EQ during the renewal period should be completed, and (b) the effects of fire-retardant coatings on the aging of electric cables should be evaluated.

Potential Issues

Based on the information contained in the staff's draft BTP and the related correspondence discussed above, the following issues were identified for further consideration by the staff:

- a. adequacy of DOR Guidelines and NUREG-0588 Cat. II criteria
 - preaging
 - margins
 - synergistic effects

- b. adequacy of DOR LOCA testing
 - use of excess margin to justify shortened post-accident test duration
- c. adequacy of EQ for components other than cables
- d. effects of fire-retardant coatings
- e. risk importance of EQ
- f. adequacy of existing programs to assure continued equipment qualification
 - acceptability of the Regulatory Guide 1.89 exemptions to equipment upgrade requirements
 - need for walkdown, inspection and additional testing

3.7 "Low-Voltage Environmentally-Qualified Cable License Renewal Industry Report," March 1993 (Revision 1)

This industry report (IR) was prepared under the direction of the Nuclear Management and Resources Council (NUMARC) Nuclear Plant Life Extension (NUPLEX) working group. Funding and development of this project was supplied by the United States Department of Energy and managed through Sandia National Laboratories.

The NUPLEX study was limited to low-voltage cables (i.e., less than 1000 volts) that are environmentally qualified per the provisions of 10 CFR 50.49 and related regulatory guidance documents and industry standards. The scope of the study included factory splices and factory insulation rework, component and panel internal wiring, and ancillary cable-related hardware such as electrical or pressure connectors, terminal blocks, and splices between field cable and equipment extension leads. Cable using polyimide (e.g., Kapton) and Butyl rubber insulations were excluded from the study since Kapton has unique characteristics and Butyl rubber exhibits a unique response to aging (i.e., it softens rather than embrittles). Mineral insulated cables were also excluded from the study since the insulation and jacket materials are not organic and their construction is unique. Finally, cables used in pulse-type applications (e.g., digital transmission circuits and some neutron monitoring circuits) were excluded from the study since cable impedance could be an important design characteristic for these cables. Aside from the cable types, cable degradation due to the following shortcomings were also excluded from this study:

- design non-conformance (e.g., mechanical damage caused by misapplication or improper installation);
- unintended long-term submergence during normal plant operation;
- unintended exposure to chemical attack (e.g., boric acid leakage or decontamination activities); and
- improper maintenance.

The study expressed the view that these degradation mechanisms are plant-specific and would be evaluated by a utility at the time of discovery. Based on a review of nuclear power plant operating experience, relevant laboratory data and related experience in other industries, the following age-related degradation mechanisms were selected for consideration in this IR:

- changes in low-voltage electrical properties of insulation materials;
- embrittlement of cable insulation materials;
- conductor/shield corrosion;
- loss of fire-retardants from insulation and jacket materials;
- embrittlement of cable jacket materials;
- corona degradation and breakdown phenomena; and
- water and electrical trees in insulation materials.

Of the cable degradation mechanisms that were considered, the IR concluded that the only "potentially significant" degradation mechanisms included: (a) embrittlement of cable insulation materials and (b) embrittlement of cable jacket materials if the jacket is credited for beta radiation shielding, if electrical shield isolation is important, if the jacket is bonded to the insulation, or if the physical integrity of the jacket is necessary for qualification of cable connectors and splices. The study concluded that: (a) current and acceptable programs for managing insulation and jacket embrittlement include reevaluation, requalification, and replacement strategies; and (b) no further evaluation of cable insulation and jacket embrittlement for the purposes of license renewal is required when reevaluation or requalification establishes qualification for the renewal term.

Potential Issues

Based on the information contained in the industry report on cable degradation, the following issues were identified for further consideration by the staff:

- a. adequacy of existing programs to assure continued equipment qualification
 - insulation and jacket embrittlement
 - design non-conformances
 - unintended long-term submergence
 - exposure to chemical attack (e.g., boric acid leakage, decontamination activities)
- b. adequacy of EQ for certain specific applications
 - polyimide insulation (Kapton)
 - Butyl rubber insulation

- mineral wool insulation
- coaxial cable
- bonded jackets

4.0 CONCLUSIONS

Extensive work has been completed by both the NRC staff and by the nuclear industry in attempting to establish a technical position on EQ for the license renewal term. The previous efforts in this regard proved to be very helpful in identifying potential EQ issues, and it is difficult to argue that these issues are not applicable to the current license term for operating reactors. The specific issues identified during this review are listed below and will be addressed in the staff's final report (EQ-TAP Action Item 3.g):

- a. adequacy of the qualification methodology for establishing initial qualification, including consideration of the differences between the criteria stated by the DOR Guidelines and NUREG-0588 Cat. II versus the more rigorous criteria stated by NUREG-0588 Cat. I

- age conditioning (especially for older plants)
- margins
- synergistic effects
- sequential versus simultaneous testing
- dose rate effects
- combustible gas and chlorine formation effects
- oxygen diffusion effects
- long-term exposure to moisture
- test duration used to establish long-term qualification
- use of excess margin to justify shortened post-accident test duration during DOR LOCA testing

- b. adequacy of existing programs to assure continued equipment qualification, including qualification beyond the established qualified life given the different qualification standards

- criteria for acceptable versus unacceptable aging degradation
- effects of installation, maintenance and surveillance practices on equipment qualification
- identification and treatment of "hot spots," long overhangs, insulation and jacket embrittlement, unintended long-term submergence, exposure to chemical attack (e.g., boric acid leakage, decontamination activities), and localized anomalies attributable to installation errors, improper maintenance and age-related degradation
- need for walkdown, inspection and additional testing to address and detect the presence of component degradation (age-related and other)
- adequacy of existing justifications for continued operation allowed under Generic Letter 88-07
- acceptability of the Regulatory Guide 1.89 exemptions to equipment upgrade requirements
- age-related degradation unique to license renewal

- c. effect of fire-retardant coatings on EQ

- d. adequacy of EQ for certain specific applications
 - polyimide insulation (Kapton)
 - Butyl rubber insulation
 - mineral wool insulation
 - bonded jackets
 - coaxial cable
- e. adequacy of EQ for components other than cables
- f. PRA implications/need for EQ screening criteria
- g. risk importance of EQ
- h. potential research topics
 - LOCA testing of naturally aged DOR/NUREG-0588 Cat. II cables
 - identification of "weak links"/condition monitoring needs

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