4.4 Environmental Qualification (EQ) of Electric Equipment

Review Responsibilities

Primary - Branch responsible for electrical engineering
Secondary - None

4.4.1 Areas of Review

The Nuclear Regulatory Commission (NRC) has established nuclear station environmental qualification (EQ) requirements in 10 CFR 50, Appendix A, Criterion 4, and 10 CFR 50.49. 10 CFR 50.49 specifically requires that an EQ program be established to demonstrate that certain electrical components located in “harsh” plant environments (that is, those areas of the plant that could be subject to the harsh environmental effects of a loss of coolant accident (LOCA), high energy line breaks (HELBs) or post-LOCA radiation) are qualified to perform their safety function in those harsh environments after the effects of in-service aging. 10 CFR 50.49 requires that the effects of significant aging mechanisms be addressed as part of environmental qualification.

4.4.1.1 Time-Limited Aging Analysis

All operating plants must meet the requirements of 10 CFR 50.49 for certain important-to-safety electrical components. 10 CFR 50.49 defines the scope of components to be included, requires the preparation and maintenance of a list of in-scope components and requires the preparation and maintenance of a qualification file that includes component performance specifications, electrical characteristics and environmental conditions. 10 CFR 50.49(e)(5) contains provisions for aging that require, in part, consideration of all significant types of aging degradation that can affect component functional capability. 10 CFR 50.49(e) also requires component replacement or refurbishment prior to the end of designated life, unless additional life is established through ongoing qualification. 10 CFR 50.49(f) establishes four methods of demonstrating qualification for aging and accident conditions. 10 CFR 50.49(k) and (l) permit different qualification criteria to apply based on plant and component vintage. Supplemental EQ regulatory guidance for compliance with these different qualification criteria is provided in the Regulatory Guide 1.89, Rev. 1, "Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants" (Ref. 1), the Division of Operating Reactors (DOR) Guidelines (Ref. 2), and NUREG-0588 (Ref. 3). The principal nuclear industry qualification standards for electric equipment are IEEE STD. 323-1971 (Ref. 4) and IEEE STD. 323-1974 (Ref. 5). These standards contain explicit EQ considerations based on time-limited aging analyses. Compliance with 10 CFR 50.49 provides evidence that the component will perform its intended functions during accident conditions after experiencing the effects of in-service aging.

4.4.1.1.1 DOR Guidelines

The qualification of electric equipment that is subject to significant known degradation due to aging where a qualified life was previously established will be reviewed for the period of extended operation to the requirements of Section 5.2.4 of the DOR Guidelines.

4.4.1.1.2 NUREG-0588, CATEGORY II (IEEE STD. 323-1971)

The qualification of programs that are committed to conform to the requirements of IEEE STD. 382-1972 (Ref. 6) (for valve operators) and IEEE STD. 334-1971(Ref. 7) (for motors) will be

reviewed for the period of extended operation against Category II requirements in NUREG-0588.

4.4.1.1.3 NUREG-0588, CATEGORY I (IEEE STD. 323-1974)

The qualification of certain electric equipment important to safety that is subject to the requirements of NUREG-0588, Category I, will be reviewed for the period of extended operation to assess the validity of the extended qualification.

4.4.1.2 Generic Safety Issue

The EQ requirements differ for newer and older plants. The Commission has decided that the adequacy of EQ is a potential safety issue to be addressed by the current regulatory process for operating reactors (Refs. 8 and 9). Generic Safety Issue (GSI) 168, "Environmental Qualification of Electrical Equipment," (Ref. 10) is being addressed separately under a generic task action plan (Refs. 11 and 12). Industry data on cables have been reviewed (Ref. 13). The staff continues to make progress in the cable research program, including the investigation of condition monitoring techniques to predict the condition and accident survivability of cables. GSI-168 is scheduled for resolution in December 2000.

An applicant's consideration of GSI-168 for license renewal is an area of review.

4.4.1.3 FSAR Supplement

The detailed information on the evaluation of time-limited aging analyses is contained in the renewal application. A summary description of the evaluation of time-limited aging analyses for the period of extended operation is contained in the applicant's final safety analysis report (FSAR) supplement. The FSAR supplement is an area of review.

4.4.2 Acceptance Criteria

The acceptance criteria for the areas of review described in Subsection 4.4.1 of this review plan section define acceptable methods for meeting the requirements of the Commission's regulations in 10 CFR 54.21(c)(1).

4.4.2.1 Time-Limited Aging Analysis

Pursuant to 10 CFR 54.21(c)(1)(i) through (iii), an applicant must demonstrate one of the following:

(i) the analyses remain valid for the period of extended operation,

(ii) the analyses have been projected to the end of the extended period of operation, or

(iii) the effects of aging on the intended function(s) will be adequately managed for the period of extended operation.

Specific acceptance criteria for EQ of certain electric equipment important to safety analyzed to Section 5.2.4 of the DOR Guidelines; NUREG-5088, Category II (Section 4); or NUREG-0588, Category I, depend on the applicant's choice, that is, 10 CFR 54.21(c)(1)(i), (ii), or (iii), are:

4.4.2.1.1 10 CFR 54.21(c)(1)(i)

The existing qualification is based on previous testing, analysis, and operating experience or combinations thereof that demonstrate that the equipment is qualified for the period of extended operation. For option (i), the aging evaluation existing at the time of the renewal application for the component remains valid for the period of extended operation and no further evaluation is necessary.

4.4.2.1.2 10 CFR 54.21(c)(1)(ii)

Qualification of the equipment is extended for the period of extended operation by testing, analysis, and operating experience or combinations thereof in accordance with the CLB requirements. For option (ii), a reanalysis of the aging evaluation is performed in order to project the qualification of the component through the period of extended operation. Important reanalysis attributes of an aging evaluation include analytical methods, data collection and reduction methods, underlying assumptions, acceptance criteria, and corrective actions if acceptance criteria are not met. These reanalysis attributes are discussed in Table 4.4-1.

4.4.2.1.3 10 CFR 54.21(c)(1)(iii)

In Chapter X of the Generic Aging Lessons Learned (GALL) report (Ref. 14), the staff has evaluated the EQ program (10 CFR 50.49) and determined that it is an acceptable aging management program to address EQ according to 10 CFR 54.21(c)(1)(iii). The GALL report may be referenced in a license renewal application and should be treated in the same manner as an approved topical report. In referencing the GALL report, an applicant should indicate that the material presented in the GALL report is applicable to the specific plant involved and provide the information necessary to adopt the finding of program acceptability as described and evaluated in the GALL report. An applicant should also verify that the approvals set forth in the GALL report for the generic program apply to the applicant's program.

4.4.2.2 Generic Safety Issue

One acceptable approach is to provide a technical rationale demonstrating that the current licensing basis for EQ will be maintained in the period of extended operation. (Ref. 15)

4.4.2.3 FSAR Supplement

The specific criterion for meeting 10 CFR 54.21(d) is:

The summary description of the evaluation of time-limited aging analyses for the period of extended operation in the FSAR supplement provides appropriate description such that later changes can be controlled by 10 CFR 50.59. The description should contain information associated with the time-limited aging analysis regarding the basis for determining that the applicant has made the demonstration required by 10 CFR 54.21(c)(1).

4.4.3 Review Procedures

For each area of review described in Subsection 4.4.1 of this review plan section, the following review procedures are followed:

4.4.3.1 Time-Limited Aging Analysis

For electric equipment qualified to the requirements of 10 CFR 50.49, the review procedures, depending on the applicant's choice, that is, 10 CFR 54.21(c)(1)(i), (ii), or (iii), are:

4.4.3.1.1 10 CFR 54.21(c)(1)(i)

The documented results, test data, analyses, etc., of previous qualification by an appropriate combination of testing, analysis, and operating experience are reviewed such that it is determined that the original qualified life remains valid for the period of extended operation.

4.4.3.1.2 10 CFR 54.21(c)(1)(ii)

The results of projecting the qualification to the end of the period of extended operation will be reviewed. The qualification methods include testing, analysis, operating experience or combinations thereof.

The reanalysis of an aging evaluation is normally performed to extend the qualification by reducing excess conservatisms incorporated in the prior evaluation. Reanalysis of an aging evaluation to extend the qualifications of a component is performed on a routine basis as part of an EQ program. A component life limiting condition may be due to thermal, radiation, or cyclical aging; the vast majority of component aging limits are based on thermal conditions. Conservatisms may exist in aging evaluation parameters, such as the assumed ambient temperature of the component, an unrealistically low activation energy or in the application of a component (de-energized versus energized). The reanalysis of an aging evaluation is documented according to the plant's quality assurance program requirements, which requires the verification of assumptions and conclusions. For reanalysis, the reviewer verifies that an applicant has completed its reanalysis addressing attributes of analytical methods, data collection and reduction methods, underlying assumptions, acceptance criteria, corrective actions if acceptance criteria are not met, and the period of time prior to the end of qualified life. (See Table 4.4-1).

4.4.3.1.3 10 CFR 54.21 (c)(1)(iii)

An applicant may reference the GALL report in its license renewal application, as appropriate. The applicant should state that the GALL report is applicable to its plant with respect to its EQ program. The reviewer verifies that the applicant has identified the appropriate program as described and evaluated in the GALL report. The reviewer also ensures that the applicant has stated that its EQ program contains the same program elements that the staff evaluated and relied upon in approving the corresponding generic program in the GALL report. No further staff evaluation is necessary.

4.4.3.2 Generic Safety Issue

For license renewal, the Statements of Consideration (SOC) for the amended license renewal rule (60 FR 22484) provide four approaches that could be used to satisfy the finding required by 10 CFR 54.29. With respect to addressing GSI-168 for license renewal, until completion of an ongoing research program and staff evaluations, the potential issues associated with GSI-168 and their scope have not been defined to the point that a license renewal applicant can reasonably be expected to address them at this time. Therefore, an acceptable approach described in the SOC is to provide a technical rationale demonstrating that the current licensing

basis for EQ pursuant to 10 CFR 50.49 will be maintained in the period of extended operation. Although the SOC also indicates that an applicant should provide a brief description of one or more reasonable options that would be available to adequately manage the effects of aging, the reviewer should not expect an applicant to provide the options at this time. A renewal applicant should monitor updates to NUREG-0933, "A Prioritization of Generic Safety Issues," for revisions to GSI-168 during the review of its application and supplement its license renewal application if the issues associated with GSI-168 become defined such that providing the options or pursuing one of the other approaches described in the SOC becomes feasible (Ref. 15).

4.4.3.3 FSAR Supplement

The reviewer verifies that the applicant has provided information to be included in the FSAR supplement including a summary description of the evaluation of EQ Electric Equipment TLAA. Table 4.4-2 of this review plan section contains examples of acceptable FSAR supplement information of this TLAA. The reviewer verifies that the applicant has provided a FSAR supplement with information equivalent to that in Table 4.4-2. The staff expects to impose a license condition in the renewed license, if granted, to require the applicant to update its FSAR to include this FSAR supplement, at the next update required pursuant to 10 CFR 50.71(e)(4). As part of the license condition, until the FSAR update is complete, the applicant may make changes to the programs described in its FSAR supplement without prior Commission approval, provided that the applicant evaluates each such change pursuant to the criteria set forth in 10 CFR 50.59.

As noted in Table 4.4-2, an applicant need not incorporate the implementation schedule into its FSAR. However, an applicant should identify and commit to any future aging management activities to be completed before the period of extended operation. The staff expects to impose a license condition in the renewed license, if granted, to ensure that the applicant will complete these activities no later than the committed date.

4.4.4 Evaluation of Findings

The reviewer verifies that the applicant has provided information sufficient to satisfy the provisions of this review plan section and that the staff's evaluation supports conclusions of the following type depending on the applicant's choice of 10 CFR 54.21(c)(1)(i), (ii), (iii), to be included in the staff's safety evaluation report:

> The staff concludes that the applicant has provided an acceptable demonstration, pursuant to 10 CFR 54.2 (c)(1), that, for the EQ of Electric Equipment TLAA [choose what is appropriate], (i) the analyses remain valid for the period of extended operation. (ii) the analyses have been projected to the end of the period of extended operation, or (iii) the effects of aging on the intended function(s) will be adequately managed for the period of extended operation. The staff also concludes that the FSAR supplement contains an appropriate summary description of the EQ of Electric Equipment TLAA evaluation for the period of extended operation.

4.4.5 Implementation

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specific portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

4.4.6 References

1. Regulatory Guide 1.89, Rev. 1, "Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants," June 1984.

2. "Guidelines for Evaluating Environmental Qualification of Class 1E Electrical Equipment in Operating Reactors," (DOR Guidelines), November 1979.

3. NUREG-0588, "Interim Staff Position on Environmental Qualification of Safety-Related Equipment," July 1981.

4. IEEE STD. 323-1971, "IEEE Trial Use Standard; General Guide for Qualifying Class 1E Equipment for Nuclear Power Generating Stations."

5. IEEE STD. 323-1974, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations."

6. IEEE STD. 382-1972, "Standard for Qualification of Actuators for Power Operated Valve Assemblies with Safety Related Functions for Nuclear Power Plants."

7. IEEE STD. 334-1971, "IEEE Standard for Type Tests of Continuous Duty Class 1E Motors for Nuclear Power Generating Stations."

8. SECY-93-049, "Implementation of 10 CFR Part 54, 'Requirements for Renewal of Operating Licenses for Nuclear Power Plants,'" March 1, 1993.

9. Staff Requirements Memorandum from Samuel J. Chilk, dated June 28, 1993.

10. NUREG-0933, "A Prioritization of Generic Safety Issues," Supplement 20, July 1996.

11. Letter from William T. Russell of NRC to William Rasin of the Nuclear Management and Resources Council, dated July 30, 1993.

12. Memorandum from James M. Taylor of NRC to the Commission, "Environmental Qualification of Electric Equipment," dated April 8, 1994.

13. NUREG/CR-6384, Volumes 1 and 2, "Literature Review of Environmental Qualification of Safety-Related Electric Cables," April 1996.

14. NUREG-xxxx, “Generic Aging Lessons Learned (GALL),” U.S. Nuclear Regulatory Commission, XXXX.

15. Letter from Christopher I. Grimes (NRC) to Doug Walters (NEI), “Guidance on addressing GSI-168 for license renewal”, dated June 2, 1998.

Table 4.4-1. Environmental Qualification Reanalysis Attributes

Reanalysis Attributes	Description
Analytical Methods	The analytical models used in the reanalysis of an aging evaluation should be the same as those previously applied during the prior evaluation. The Arrhenius methodology is an acceptable thermal model for performing a thermal aging evaluation. The analytical method used for a radiation aging evaluation is to demonstrate qualification for the total integrated dose (that is, normal radiation dose for the projected installed life plus accident radiation dose). For license renewal, one acceptable method of establishing the 60 year normal radiation dose is to multiply the 40 year normal radiation dose by 1.5 (that is, 60 years/40 years). The result is added to the accident radiation dose to obtain the total integrated dose for the component. For cyclical aging, a similar approach may be used. Other models may be justified on a case-by-case basis.
Data Collection and Reduction Methods	Reducing excess conservatisms in the component service conditions (for example, temperature, radiation, cycles) used in the prior aging evaluation is the chief method used for a reanalysis. Temperature data used in an aging evaluation should be conservative and based on plant design temperatures or on actual plant temperature data. When used, plant temperature data can be obtained in several ways including monitors used for technical specification compliance, other installed monitors, measurements made by plant operators during rounds and temperature sensors on large motors (while the motor is not running). A representative number of temperature measurements are conservatively evaluated to establish the temperatures used in an aging evaluation. Plant temperature data may be used in an aging evaluation in different ways, such as (a) directly applying the plant temperature data in the evaluation, or (b) using the plant temperature data to demonstrate conservatism when using plant design temperatures for an evaluation. Any changes to material activation energy values as part of a reanalysis should be justified. Similar methods of reducing excess conservatisms in the component service conditions used in prior aging evaluations can be used for radiation and cyclical aging.
Underlying Assumptions	EQ component aging evaluations contain sufficient conservatisms to account for most environmental changes occurring due to plant modifications and events. When unexpected adverse conditions are identified during operational or maintenance activities that affect the environment of a qualified component, the affected EQ component is evaluated and appropriate corrective actions are taken, which may include changes to the qualification bases and conclusions.
Acceptance Criteria and Corrective Actions	The reanalysis of an aging evaluation should extend the qualification of the component. If the qualification cannot be extended by reanalysis, the component must be refurbished, replaced, or requalified prior to exceeding the current qualification. A reanalysis should be performed in a timely manner (that is, sufficient time is available to refurbish, replace, or requalify the component if the reanalysis is unsuccessful).

Table 4.4-2. Examples of FSAR Supplement for Environmental Qualification (EQ) of Electric Equipment TLAA Evaluation

10 CFR 54.21(c)(1)(i) Example

TLAA	Description of Evaluation	Implementation Schedule*
Environmental qualification (EQ) of electric equipment	The original EQ qualified life has been shown to remain valid for the period of extended operation.	Completed

10 CFR 54.21(c)(1)(ii) Example

TLAA	Description of Evaluation	Implementation Schedule*
Environmental qualification (EQ) of electric equipment	The EQ qualification has been projected to the end of the period of extended operation. Re-analysis addressed attributes of analytical methods, data collection and reduction methods, underlying assumptions, acceptance criteria, and corrective actions.	Completed

10 CFR 54.21(c)(1)(iii) Example

TLAA	Description of Evaluation	Implementation Schedule*
Environmental qualification (EQ) of electric equipment	The existing EQ process, in accordance with 10 CFR 50.49, will adequately manage aging of EQ equipment for the period of extended operation because equipment will be replaced prior to reaching the end of its qualified life. Re-analysis addresses attributes of analytical methods, data collection and reduction methods, underlying assumptions, acceptance criteria, corrective actions if acceptance criteria are not met, and the period of time prior to the end of qualified life when the re-analysis will be completed.	Existing program

*An applicant need not incorporate the implementation schedule into its FSAR. However, an applicant should identify and commit to any future aging management activities to be completed before the period of extended operation. The staff expects to impose a license condition in the renewed license, if granted, to ensure that the applicant will complete these activities no later than the committed date.