

## **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 NRC has established nuclear station environmental qualification requirements in 10 CFR 50 Appendix A Criterion 4, and 10 CFR 50.49. 10 CFR 50.49 specifically requires that an environmental qualification 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. For the purpose of license renewal only those components with a qualified life of 40 years or greater would be TLAAs.

##### **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 environmental qualification regulatory guidance for compliance with these different qualification criteria is provided in RG 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 environmental qualification considerations based on TLAAs. Compliance with 10 CFR 50.49 provides reasonable assurance that the component can 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 according to the requirements of Section 5.2.4 of the DOR Guidelines. If a qualified life was not previously established, the qualification will be reviewed to the requirements of section 7 of the DOR Guidelines.

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

The qualification of certain electric equipment important to safety that are subject to the requirements of NUREG-0588, Category II, will be reviewed to those requirements for the period of extended operation to assess the validity of the extended qualification. These requirements include IEEE STD. 382-1972 (Ref. 6) for valve operators, and IEEE STD. 334-1971 (Ref. 7.)

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

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

#### **4.4.1.2 Generic Safety Issue**

The NRC has decided that the adequacy of environmental qualification is a potential safety issue to be addressed by the current regulatory process for operating reactors (Refs. 8 and 9). 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 March 2001.

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 TLAAs is contained in the renewal application. A summary description of the evaluation of TLAAs for the period of extended operation is contained in the applicant's 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 delineate acceptable methods for meeting the requirements of the NRC'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) - (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 environmental qualification of certain electric equipment important to safety analyzed to Section 5.2.4 of the DOR Guidelines; NUREG-0588, 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, or 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, or 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 GALL report (Ref. 14), the staff has evaluated the environmental qualification program (10 CFR 50.49) and determined that it is an acceptable aging management program to address environmental qualification 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, the applicant should indicate that the material referenced is applicable to the specific plant involved and should provide the information necessary to adopt the finding of program acceptability as described and evaluated in the report. The 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 CLB for environmental qualification 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 TLAAs for the period of extended operation in the FSAR supplement is appropriate such that later changes can be controlled by 10 CFR 50.59. The description should contain information associated with the TLAA 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, the following review procedures should be 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 of 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 the previous qualification, which consisted of an appropriate combination of testing, analysis, and operating experience, are reviewed to confirm 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. Such a reanalysis is performed on a routine basis as part of an environmental qualification 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, 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, and corrective actions if acceptance criteria are not met (See Table 4.4-1). The reviewer also verifies that the reanalysis has been completed in a timely manner prior to the end of qualified life.

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

The applicant may reference the GALL report in its license renewal application, as appropriate. The review should verify that the applicant has stated that the report is applicable to its plant with respect to its environmental qualification 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 environmental qualification 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 environmental qualification 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 should 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 that includes a summary description of the TLAA evaluation of the environmental qualification of electric equipment. Table 4.4-2 contains examples of acceptable FSAR supplement information for 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 on any renewed license 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 NRC approval, provided that the applicant evaluates each such change pursuant to the criteria set forth in 10 CFR 50.59. The staff will review any such changes when the next update is submitted.

As noted in Table 4.4-2, an applicant need not incorporate the implementation schedule into its FSAR. However, the review should verify that the applicant has identified and committed in the license renewal application to any future aging management activities to be completed before the period of extended operation.

The staff expects to impose a license condition on any renewed license 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), or (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 environmental qualification of Electric Equipment TLAA, [choose which 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 environmental qualification of electric equipment TLAA evaluation for the period of extended operation as reflected in the license condition.

#### **4.4.5 Implementation**

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specific portions of the NRC's regulations, the method described herein will be used by the staff in its evaluation of conformance with NRC 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-1801, "Generic Aging Lessons Learned (GALL)," U.S. Nuclear Regulatory Commission, April 2001.

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**

<b>Reanalysis Attributes</b>	<b>Description</b>
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	environmental qualification 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 environmental qualification 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 (such that 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 of Electric Equipment TLAA Evaluation**

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

TLAA	Description of Evaluation	Implementation Schedule*
Environmental qualification of electric equipment	The original environmental qualification 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 of electric equipment	The environmental qualification has been projected to the end of the period of extended operation. Reanalysis addresses 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 of electric equipment	The existing environmental qualification process, in accordance with 10 CFR 50.49, will adequately manage aging of environmental qualification equipment for the period of extended operation because equipment will be replaced prior to reaching the end of its qualified life. Reanalysis 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 reanalysis will be completed.	Existing program

\* An applicant need not incorporate the implementation schedule into its FSAR. However, the reviewer should verify that the applicant has identified and committed in the license renewal application to any future aging management activities to be completed before the period of extended operation. The staff expects to impose a license condition on any renewed license to ensure that the applicant will complete these activities no later than the committed date.

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