CHAPTER X

(August 2000)

TIME-LIMITED AGING ANALYSES

EVALUATION OF AGING MANAGEMENT PROGRAMS UNDER 10 CFR 54.21(c)(1)(iii)

Time-Limited Aging Analyses: Evaluation of Aging Management Programs Under 10 CFR 54.21(c)(1)(iii)

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X.M1

Metal Fatigue of Reactor Coolant Pressure Boundary

PROGRAM DESCRIPTION

In order not to exceed the design limit on fatigue usage, the aging management program monitors and tracks the number of critical thermal and pressure transients for the selected reactor coolant system components.

The aging management program will address the effects of the coolant environment on component fatigue life by assessing the impact of the reactor coolant environment on a sample of critical components that include, as a minimum, those components selected in NUREG/CR-6260 (Ref. 1). The sample of critical components can be evaluated by applying environmental correction factors to the existing ASME Code fatigue analyses. Formulas for calculating the environmental life correction factors are contained in NUREG/CR-6583 for carbon and low-alloy steels and in NUREG/CR-5704 for austenitic stainless steels.

As evaluated below, this is an acceptable option to manage metal fatigue for the reactor coolant pressure boundary, considering environmental effects. Thus, no further evaluation is recommended for license renewal if an applicant selects this option under 10 CFR 54.21(c)(1)(iii) to evaluate metal fatigue for the reactor coolant pressure boundary.

EVALUATION AND TECHNICAL BASIS

(1) ***Scope of Program:*** The program includes preventive measures to mitigate fatigue cracking of metal components of the reactor coolant pressure boundary caused by anticipated cyclic strains in the material.

(2) ***Preventive Actions:*** Maintaining the fatigue usage factor below the design code limit and considering the effect of the reactor water environment, as described under program description above, will provide adequate margin against fatigue cracking of reactor coolant system components due to anticipated cyclic strains.

(3) ***Parameters Monitored/Inspected:*** The program monitors all plant transients that cause cyclic strains that are significant contributions to the fatigue usage factor. The number of plant transients that cause significant fatigue usage for each reactor coolant pressure boundary component may be monitored. Alternatively, more detailed local monitoring of the plant transient may be used to compute the actual fatigue usage for each transient.

(4) ***Detection of Aging Effects:*** The program should provide for periodic update of the fatigue usage calculations.

(5) ***Monitoring and Trending:*** The program may monitor a sample of high fatigue usage locations. As a minimum, this sample should include the locations identified in NUREG/CR-6260.

(6) ***Acceptance Criteria:*** The acceptance criteria involves maintaining the fatigue usage below the design code limit considering environmental fatigue effects as described under program description above.

(7) ***Corrective Actions:*** The program should provide for corrective actions to prevent the usage factor from exceeding the design code limit during the period of extended operation. Acceptable corrective actions may include a more rigorous analysis of the component to

demonstrate that the design code limit will not be exceeded, repair, or replacement of the component. For programs that monitor a sample of high fatigue usage locations, corrective actions include a review of additional affected reactor coolant pressure boundary locations.

(8&9) Conformation Process and Administrative Controls: Site QA procedures, review and approval processes and administrative controls are implemented in accordance with the requirements of Appendix B to 10 CFR Part 50.

(10) Operating Experience: The program should review industry experience regarding fatigue cracking. Applicable experience with fatigue cracking should be considered in selecting the monitored locations.

REFERENCES

NUREG/CR-6260, *Application of NUREG/CR-5999 Interim Fatigue Curves to Selected Nuclear Power Plant Components*, March 1995.

NUREG/CR-6583, *Effects of LWR Coolant Environments on Fatigue Design Curves of Carbon and Low-Alloy Steels*, March 1998.

NUREG/CR-5704, *Effects of LWR Coolant Environments on Fatigue Design Curves of Austenitic Stainless Steels*, April 1999.

X.S1

Concrete Containment Tendon Prestress

PROGRAM DESCRIPTION

In order to ensure the adequacy of prestressing forces in prestressed concrete containments during the extended period of operation, an applicant could develop an aging management program under 10 CFR 54.21(c)(1)(iii).

The aging management program should consist of an assessment of the results of inspections performed in accordance with the requirements of Subsection IWL of the ASME Section XI Code, as supplemented by the requirements of 10 CFR 50.55a(b)(2)(ix) or (viii) in the later amendment of the regulation. The assessment related to the adequacy of the prestressing force will consist of the establishment of (1) acceptance criteria, and (2) trend lines. The acceptance criteria will normally consist of predicted lower limit (PLL) and the minimum required prestressing force (also called minimum required value-MRV). See Regulatory Guide 1.35.1 (Ref. 1) for guidance. The trend line represent the trend of prestressing forces based on the actual measured forces. See Information Notice 99-10 for constructing the trend line (Ref. 2). The goal would be to keep the trend line above the PLL, because as a result of any inspection performed in accordance with Subsection IWL (Ref. 3), if the trend line crosses the PLL, the existing prestress in the containment could go below the MRV soon after the inspection, which will not meet the requirement of 10 CFR 50.55a(b)(2)(ix)(B) or 10 CFR 50.55a(b)(2)(viii)(B).

As evaluated below, this is an acceptable option to manage containment tendon prestress force, except for the program element/attribute regarding operating experience. Thus, it is recommended that the staff should further evaluate an applicant's operating experience related to the containment prestress force.

The aging management program related to the adequacy of prestressing force for containments with grouted tendons will be reviewed on a case by case basis.

EVALUATION AND TECHNICAL BASIS

(1) Scope of Program: The program addresses the assessment of containment prestressing force, when an applicant chooses to perform the containment prestress force TLAA using 10 CFR 54.21(c)(1)(iii).

(2) Preventive Actions: Maintaining the prestress above the MRV as described under program description above, will ensure that the structural and functional adequacy of the containment are maintained.

(3) Parameters Monitored: The parameters to be monitored are the containment prestressing forces in accordance with requirements specified in Subsection IWL of Section XI of the ASME Code as incorporated by reference in 10 CFR 50.55a.

(4) Detection of Aging Effects: The loss of containment prestressing forces is detected by the program.

(5) Monitoring and Trending: The estimated and measured prestressing forces should be plotted against time and the PLL, MRV, and trending lines developed for the period of extended operation.

(6) ***Acceptance Criteria***: The prestressing force trend lines should be shown to indicate that existing prestressing forces in the containment would not be below the MRVs prior to the next scheduled inspection as per 10 CFR 50.55a(b)(2)(ix)(B) or 10 CFR 50.55a(b)(2)(viii)(B).

(7) ***Corrective Actions***: If acceptance criteria are not met, then either systematic retensioning of tendons or a reanalysis of the containment is warranted to ensure the design adequacy of the containment..

(8&9) ***Conformation Process and Administrative Controls:*** Site QA procedures, review and approval processes and administrative controls are implemented in accordance with the requirements of Appendix B to 10 CFR Part 50***.***

(10) ***Operating Experience***: The program should incorporate the relevant operating experience that occurred at the applicant's plant as well as at other plants. The applicable portions of the experience with prestressing systems described in NRC Information Notice 99-10 (Ref. 2) could be useful for the purpose. However, tendon operating experience could be different at plants with prestressed concrete containments. The difference could be due the prestressing system design (e.g. button-headed, wedge or swaged anchorages), environment, and type of reactor (that is, PWR and BWR). Thus, the applicant's plant-specific operating experience should be further evaluated for license renewal.

REFERENCES

Regulatory Guide 1.35.1, *Determining Prestressing Forces for Inspection of Prestressed Concrete Containments*, July 1990.

NRC Information Notice 99-10, *Degradation of Prestressing Tendon Systems in Prestressed Concrete Containments*, April 1999.

ASME Boiler and Pressure Vessel Code, Section XI, *Rules for In-Service Inspection of Nuclear Power Plant Components*, American Society of Mechanical Engineers, Subsection IWE, *Requirements for Class MC and Metallic Liners of Class CC Components of Light-Water Cooled Plants*, and Subsection IWL, *Requirements for Class CC Concrete Components of Light-Water Cooled Plants*, 1992 or later edition as approved in 10 CFR 50.55a.

X.E1

Environmental Qualification (EQ) of Electric Components

PROGRAM DESCRIPTION

The Nuclear Regulatory Commission (NRC) has established nuclear station environmental qualification (EQ) requirements in 10 CFR 50 Appendix A, Criterion 4 and in 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.

All operating plants must meet the requirements of 10 CFR 50.49 for certain electrical components important to safety. 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 DOR Guidelines, *Guidelines for Evaluating Environmental Qualification of Class 1E Electrical Equipment in Operating Reactors*; NUREG-0588, *Interim Staff Position on Environmental Qualification of Safety-Related Electrical Equipment;* and Regulatory Guide 1.89, Rev. 1, *Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants*. 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.

EQ programs manage component thermal, radiation and cyclical aging through the use of aging evaluations based on 10 CFR 50.49(f) qualification methods. As required by 10 CFR 50.49, EQ components must be refurbished, replaced or its qualification extended prior to reaching the aging limits established in the evaluation. Aging evaluations for EQ components that specify a qualification of at least 40 years are considered time-limited aging analyses (TLAA) for license renewal.

Under 10 CFR 54.21(c)(1)(iii), EQ programs, which implement the requirements of 10 CFR 50.49 (as further defined and clarified by the DOR Guidelines, NUREG-0588 and Regulatory Guide 1.89, Rev. 1.), at plants are viewed as aging management programs for license renewal. Reanalysis of an aging evaluation to extend the qualifications of components is performed on a routine basis as part of an EQ program. Important attributes for the reanalysis 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 attributes are discussed in the "EQ Component Reanalysis Attributes" section.

As evaluated below, this is an acceptable aging management program. Thus, no further evaluation is recommended for license renewal if an applicant selects this option under 10 CFR 54.21(c)(1)(iii) to evaluate EQ of electric equipment.

However, Generic safety issue (GSI) 168 is related to low-voltage EQ instrumentation and control cables and is currently an open generic issue. NRC research is ongoing to provide information to resolve it. An applicant should address GSI-168 in its application. The staff should review the information in accordance with the guidance in the Standard Review Plan for License Renewal.

EQ COMPONENT REANALYSIS ATTRIBUTES

The reanalysis of an aging evaluation is normally performed to extend the qualification by reducing excess conservatism 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. Conservatism 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 station's quality assurance program requirements, which requires the verification of assumptions and conclusions. Important attributes of a reanalysis include analytical methods, data collection and reduction methods, underlying assumptions, acceptance criteria and corrective actions (if acceptance criteria are not met). These attributes are discussed below.

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 & Reduction Methods: Reducing excess conservatism 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 conservatism 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 conservatism 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 & Corrective Actions: The reanalysis of an aging evaluation could 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).

EVALUATION AND TECHNICAL BASIS

(1) Scope of Program: EQ programs include certain electrical components that are important to safety and could be exposed to harsh environment accident conditions, as defined in 10 CFR 50.49.

(2) Preventive Actions: 10 CFR 50.49 does not require actions that prevent aging effects. EQ program actions that could be viewed as preventive actions include (a) establishing the component service condition tolerance and aging limits (for example, qualified life or condition limit), (b) refurbishment, replacement or requalification of an installed component prior to reaching these aging limits and (c) where applicable, requiring specific installation, inspection, monitoring or periodic maintenance actions to maintain component aging effects within the qualification.

(3) Parameters Monitored/Inspected: EQ component aging limits are not typically based on condition or performance monitoring. However, per Regulatory Guide 1.89 Rev. 1, such monitoring programs are an acceptable basis to modify aging limits. Monitoring or inspection of certain environmental, condition or component parameters may be used to ensure that the component is within its qualification or as a means to modify the qualification.

(4) Detection of Aging Effects: 10 CFR 50.49 does not require the detection of aging effects for in-service components. Monitoring of aging effects may be used as a means to modify component aging limits.

(5) Monitoring and Trending: 10 CFR 50.49 does not require monitoring and trending of component condition or performance parameters of in-service components to manage the effects of aging. EQ program actions that could be viewed as monitoring include monitoring how long qualified components have been installed. Monitoring or inspection of certain environmental, condition or component parameters may be used to ensure that a component is within its qualification or as a means to modify the qualification.

(6) Acceptance Criteria: 10 CFR 50.49 acceptance criteria is that an in-service EQ component is maintained within its qualification including (a) its established aging limits and (b) continued qualification for the projected accident conditions. 10 CFR 50.49 requires refurbishment, replacement or requalification prior to exceeding the aging limits of each installed device. When monitoring is used to modify a component aging limit, plant-specific acceptance criteria are established based on applicable 10 CFR 50.49(f) qualification methods.

(7 & 8) Corrective Actions & Confirmation Process: If an EQ component is found to be outside its qualification, corrective actions are implemented in accordance with the station's corrective action program. 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. When an emerging industry aging issue is identified that affects the qualification of an EQ component, the affected component is evaluated and appropriate corrective actions are taken, which may include changes to the qualification bases and conclusions. Confirmatory actions, as needed, are implemented as part of the station's corrective action program.

(9) Administrative Controls: EQ programs are implemented through the use of station policy, directives and procedures. EQ programs will continue to comply with 10 CFR 50.49 throughout the renewal period including development and maintenance of qualification documentation demonstrating a component will perform required functions during harsh accident conditions. EQ program documents identify the applicable environmental conditions for the component locations. EQ program qualification files are maintained at the plant site in an auditable form for the duration of the installed life of the component. EQ program documentation is controlled under the station's quality assurance program.

(10) Operating Experience: EQ programs include consideration of operating experience to modify qualification bases and conclusions, including aging limits. 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.

REFERENCES

Code of Federal Regulations, Title 10, Part 50, Section 49, *Environmental Qualification of electric Equipment Important to Safety for Nuclear Power Plants.*

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

DOR Guidelines, *Guidelines for Evaluating Environmental Qualification of Class 1E Electrical Equipment in Operating Reactors*, November 1979.

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